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Exploring the Effect of Energy Consumption on the Economic Growth of Albania

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Albania is one of the most energy-resource abundant country, however faced with high domestic electricity demand. Moreover, the country is the largest crude oil producer in Europe. In this study, we investigate the following questions: (i) Is there a long-run association between energy consumption and output in Albania? (ii) What is the magnitude of energy effect in the short- and long-run on output in Albania? (iii) Which of the four hypotheses on the energy-growth nexus describes most appropriately the energy-growth nexus in the case of Albania? (iv) How do the results compare with those of earlier studies? Thus, the study examines the effect of energy consumption on the economic growth of Albania over the periods 1980 to 2014 using a Cobb-Douglas production function whilst controlling for multiple structural breaks. The short-run and long-run estimations are carried out using the autoregressive distributed lag (ARDL) bounds procedure. Causality is examined using the vector error correction method. Also, we conduct consistency and robustness checks using other regression methods. The results from the ARDL procedure indicate that the elasticity of income with respect to energy is 0.36. This implies that ceteris paribus, a 1 % increase in energy consumption will increase output by 0.36 %. The causality result supports the conservation hypothesis which implies that economic growth drives energy consumption, which is consistent with some of the earlier studies.

Keywords: *Energy; Economic Growth; Co-Integration; Causality; Albania.*

Introduction

World energy consumption has grown exponentially over the past few years. The degree of integration of energy consumption to other sectors of the economy such as transportation, aviation, and shipping among others underscores its role in facilitating economic activity.

In this study, we examine the role of energy consumption in Albania, a founding member of the Energy Community (EC), over the periods 1980 to 2014. We aim to investigate the following questions in this study: (i) Is there a long-run association between energy consumption and output in Albania? (ii) If yes, what is the magnitude of energy effect in the short- and long-run on output in Albania, in relative terms? (iii) Which of the four established hypotheses on the energy-growth nexus describes most appropriately the energy-growth nexus in the case of Albania? (iv) How do our results compare with those of earlier studies?

The study is motivated by the fact that Albania is, on one hand, an energy-resource abundant country, and on the other hand, it was not able to cover the domestic electricity demand in the recent years. Albania is the largest producer of crude oil in Europe and its oil reserves are estimated to be 500 million barrels. The Patos-Marinza oilfield is the largest onshore oil field in continental Europe. In 2016, crude oil was the second most important export good (11 % of all exports) with a revenue of $249 million.

According to Heckscher and Ohlin (1991), a country will specialize in the production of goods in which it has relatively abundant factors. Thus, from a theoretical perspective, Albania should have a comparative advantage in energy production similar to the other Eurasian oil exporting countries (Hasanov, Bulut, & Suleymanov, 2017), and the growth hypothesis regarding the energy-growth nexus should hold. Not surprisingly, the US Department of Commerce has highlighted that the Albanian energy sector is the ‘best prospect industry sector for this country’ (International Trade Administration, 2019). In contrast, some recent studies (Ozturk & Acaravci, 2010; Kumar *et al.*, 2014; Kumar *et al.*, 2017) find either no relationship between energy and growth or support the conservation hypothesis. Therefore, a *de novo* empirical investigation, with more data and more sophisticated methods, is imperative to either confirm earlier results or reject them. Moreover, by accounting for structural breaks, we minimise the possibility of bias in the results – an aspect that was overlooked in the earlier studies on Albania.

There has been a steady increase in energy consumption per capita and per capita income, at least since 1997 (see Figures 1 and 2). From 1946 to 1990, Albania was a Socialist People's Republic, which acted economically like the People's Republic of Korea. Like the Kim dynasty in North Korea, the Albanian long-term (1946–1986) dictator Enver Hoxha kept the planned economy running more or less in autarky at least since 1978. The political and economic collapse of the system in 1991 coincided with the breakdown of the Soviet Union and the dissolution of the Socialist Federal Republic Yugoslavia. The 1990s were a period of political and economic transition, which was characterized by political and social unrest and a very slow economic recovery with bitter setbacks resulting from the economic downturn associated with the collapse of the planning economy (GDP growth in 1990 and 1991 was -11 % and -29 %, respectively) (World Bank, 2017). The current (2016) industrial structure is characterized by a strong service and agricultural sector, contributing about 53 % and 23 %, respectively, to Albania's value added, and 40 % and 42 %, respectively to employment. The Albanian energy sector is also very specific because nearly all electricity consumed is produced by hydropower or imported. Albania imports on average 10 % of its electricity (Ebinger, 2010) due to fluctuations in the rainfall on which hydropower depends and due to losses in the distribution system. Both effects have caused power shortages and outages in the past, for instance, in the dry year of 2007 when the average duration of the daily power outage was 3.4 hours (Bidaj *et al.,* 2015). The yearly production ranged between 2788 GWh (2007) and 5895 GWh (2015). The dependence of the electricity sector on climate causes some challenges for the future. On the one hand, with an average increasing temperature caused by the climate change, the rainfall is expected to become scarcer in Albania. On the other hand, the electricity consumption per capita, although still relatively low with 2,500 kWh per year/capita (Bidaj *et al*., 2015), has quintupled since 1991. Because of this and a doubling of the total energy consumption since 1992, Albania imports between 14 % (2014) to 53 % (2002) of its total energy. According to Bidaj *et al* (2015), the electricity consumption is mainly by households (54 % of total electricity consumption), followed by the service sector (23 %), industry (20 %) and agriculture (1 %).

In 2012, half of the household's energy demand was caused by heating (22 %) or by heating of water (23 %) (Bidaj *et al.,* 2015). Moreover, all imported oil is used for transportation, and the gas imports are mostly demanded by the service sector including tourism.

The share of renewable energy was between 12 % (2007) and 31 % (2010). Because of the huge technical and non-technical losses of electricity, the Albanian government sold the distribution infrastructure company of the state-owned and biggest producer of electricity KESh to the Czech electricity giant CEZ. However, the partnership between the private shareholders and the government endured from 2010 to 2013 and eventually was settled via arbitration (Ali, 2015).

Since 2014, the World Bank has supported the government financially and technically to reform the Albanian electricity market (World Bank, 2014). The intention was to reduce electricity losses from 44 % in 2013 to 16 % in 2019, and to stabilize the financial situation of the Albanian electricity sector. Besides technical improvements, the World Bank plan is based on a hike of the electricity price from 9.5 Albanian Lek (ALL)/KWh in 2012 to 11.5 ALL/KWh in 2022 and to 13.5 ALL/KWh in the long-run, to get the electricity sector profitable. Simultaneously, the World Bank required the abolishment of the subsidized price of 7.7 ALL/kWh for the first 300 KWh of each household (Ali, 2015).

Against these developments, the study aims to contribute to the energy-growth literature by examining the effect of energy consumption in Albania using multiple estimation methods. The set-up of the paper is as follows. In Section 2, we provide a brief review of the energy-growth literature. In Section 3, we discuss the model and framework, followed by the results in Section 4. Lastly, in Section 5, some concluding remarks follow.

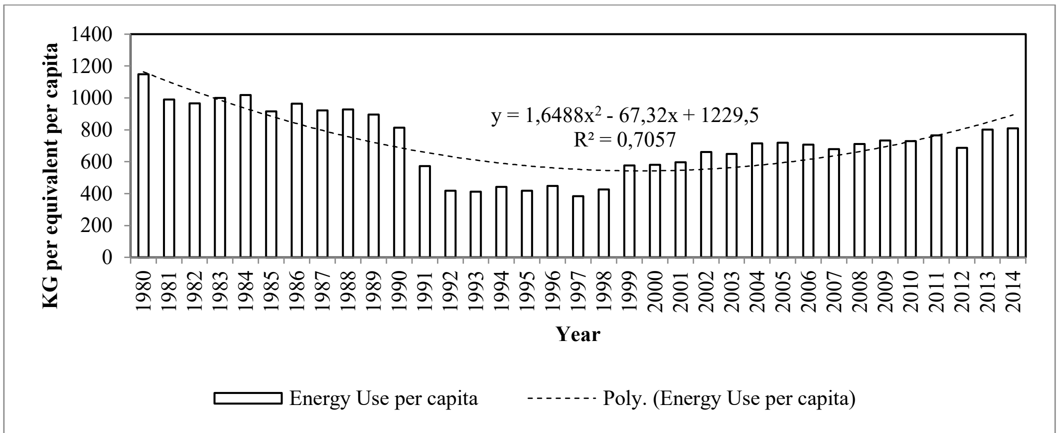

Figure 1. Energy Consumption. *Source: World Bank (2018)*

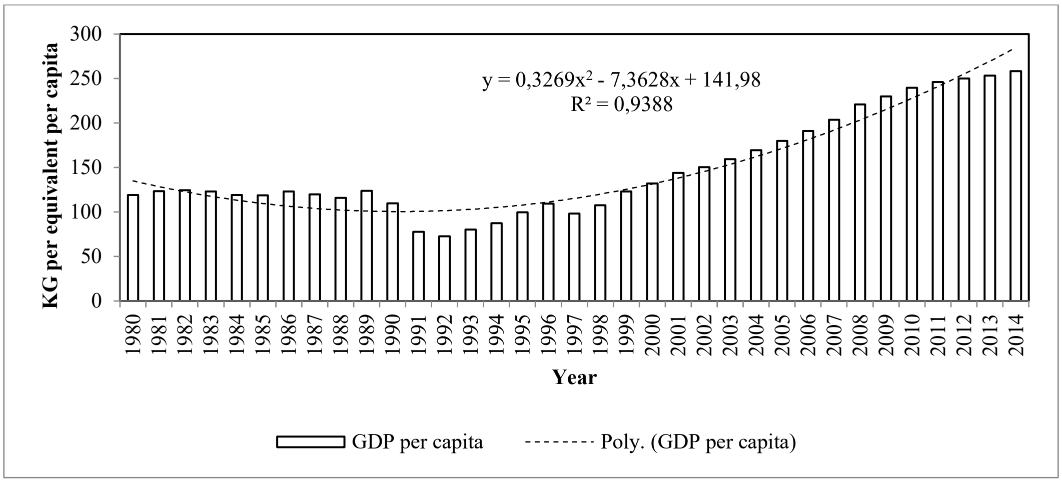

Figure 2. GDP per Capita. *Source: World Bank (2017)*

Literature Review

This section provides a brief survey of economic growth and energy consumption literature. The neo-classical and new growth theories are discussed. The energy consumption-growth nexus is summarized based on Payne's (2010) four hypotheses. The *growth hypothesis* notes a unidirectional causality from energy consumption to economic growth; the *conservation hypothesis* notes a unidirectional causality from economic growth to energy consumption; the *feedback hypothesis* asserts a bi-directional causality; and the neutrality hypothesis implies that no relationship exists between energy consumption and economic growth.

Neo-Classical and New Growth Theory

Neo-classical growth theory of Solow (1956) asserts that exogenous technical progress is the only determinant of long run growth. Capital accumulation produces transitionary growth in excess of the steady state growth rates and the growth rates converge monotonically to the constant steady state growth rates over the process of many decades. Mankiw *et al.*'s (1992) extension includes human capital as a shift and variable Senhadji (2000) uses a growth accounting approach to show a way to estimate the determinants of productivity growth within a single equation framework.

The new growth theory was popularized by Romer (1986; 1990) through a series of papers which endogenize Solow's total factor productivity. Many models of endogenous growth have been proposed because almost any factor hypothesized to influence productivity can be modelled within the complex system of equations describing each model. Most endogenous models work through positive externalities and are known for their micro foundations and optimizing agent framework. Additionally, the new growth theory can be considered as nested within the exogenous growth models and hence extensions of the Solow (1956) model based on new growth theory (Rao, 2010).

Energy-Growth Nexus

The energy-growth nexus summarized by Payne (2010) and Ozturk (2010) highlights four plausible causality directions. Countries for which the growth hypothesis is confirmed are: Philippines (Yu & Choi, 1985), Japan (Erol & Yu, 1987), the USA (Stern, 1993; 2000; Bowden & Payne, 2009), India and Indonesia (Masih & Masih, 1996), Singapore (Glasure & Lee, 1998), Turkey, France, Germany (Soytas & Sari, 2003; Altinay & Karagol, 2005), China (Soytas & Sari, 2003; Yuan *et al*., 2007), Benin, Congo, Tunisia (Wolde-Rufael, 2004; 2006), Tanzania, South Africa, Kenya (Odhiambo, 2009; Kumar & Kumar, 2013a; Kumar *et al*., 2015b), Nigeria (Akinlo, 2009), Lebanon (Abosedra *et al*., 2009), Gibraltar (Kumar *et al*., 2015a), Belgium, Spain (Omri *et al*., 2015), Malaysia (Azam *et al*., 2015), G7 countries (Bilgili & Ozturk, 2015), Denmark, Norway, Finland and Sweden (Hamit-Haggar, 2016; Irandoust, 2016), 20 European countries (dos-Santos-Gaspar, Marques, & Fuinhas, 2017), and 10 oil exporting countries (Hasanov, Bulut, & Suleymanov, 2017).

There are some studies which confirm the conservation hypothesis for certain countries. Among these countries are: the USA (Kraft & Kraft, 1978; Abosedra & Baghestani, 1989; Menyah & Rufael, 2010), India (Yu & Choi, 1985; Ghosh, 2002), West Germany (Erol & Yu, 1987), Indonesia and Thailand (Masih & Masih, 1996; Yoo 2006; Yoo & Kim, 2006), Korea and Italy (Oh & Lee, 2001a; Soytas & Sari, 2003), Australia (Narayan & Smyth, 2005), France, Japan (Lee, 2006), Congo (DRC) (Odhiambo, 2009), China (Zhang, 2009), Albania, Bulgaria, Hungary, Romania (Kumar *et al*., 2014a), Canada, Netherlands and Sweden (Omri *et al*., 2015; Kyophilavong *et al.,* 2015),

Countries for which a bi-directional causality between energy and economic growth is confirmed are: Japan, Italy (Erol & Yu, 1987), Taiwan (Hwang & Gum, 1992), Pakistan (Masih & Masih, 1996), Tanzania, Nigeria (Ebohon, 1996), South Korea, Singapore (Glasure & Lee, 1998; Oh & Lee, 2004b), Philippines, Thailand (Asafu-Adjaye, 2000), Greece (Hondroyiannis *et al.*, 2002), Argentina (Soytas & Sari, 2003), Canada (Ghali & El-Sakka, 2004), the USA (Lee, 2006), Malaysia (Tang, 2008), Egypt, Gabon, Morocco (Wolde-Rufael, 2006), Korea, Malaysia, Singapore (Yoo, 2005, 2006), Venezuela, Burkina Faso, Portugal (Yoo & Kwak, 2010; Shahbaz *et al*., 2011), Nasreen and Anwar (2014) for 15 Asian countries, China (Bloch *et al*., 2015; Bhattacharya *et al*., 2015), Argentina, Brazil, France (Omri *et al*., 2015), Indonesia (Azam *et al*. (2015), MENA countries (Kahia, Aissa, & Lanouar, 2017), Balkan countries (Kocak & Sarkgunesi, 2017), and 17 European countries (Zortuk & Karacan, 2018).

On the other hand, some studies note support for neutrality hypothesis. Among these include countries like: Kenya, South Africa, Sudan and the USA (Akarca & Long, 1980; Yu & Hwang, 1984; Yu & Choi, 1985), Malaysia, Singapore, Philippines, South Korea (Masih & Masih, 1996; Glasure & Lee, 1998), Indonesia, India, Turkey (Asafu-Adjaye, 2000; Altinay & Karagol, 2004), the UK, Germany, Sweden, Algeria, Congo Republic (Lee, 2006; Wolde-Rufael, 2006), Finland, Hungary, India, Japan, Switzerland (Omri *et al.*, 2015), Thailand (Azam *et al.*, 2015), 42 Sub Saharan African countries (Menegaki & Tugcu, 2017), USA (Menegaki & Tiwari, 2017) and Turkey (Bulut & Muratoglu, 2018).

Few things are clear from the literature. The effect of energy on economic growth and the direction causality differs for countries and regions, because of the differences in the sample size, model specification, methodology and the measurement variables used for energy and economic growth. Also, lesser focus is on the magnitude (elasticity) effects, mainly because estimating elasticity is not straight forward. The model specification requires a well-established theory and the model needs to minimise the problem of misspecification.

Moreover, some studies use the augmented Solow (1956) framework for model specification. For small samples, estimation methods like the autoregressive distributed lag (ARDL) procedure of Pesaran, Shin and Smith (2001) is recommended (Odhiambo, 2009) to minimise endogeneity. Additionally, accounting for structural breaks, and the magnitude effects may provide important policy insights (Smyth & Narayan, 2014).

Energy Growth Nexus in Albania

Ozturk and Acaravci (2010) examine the causal effect of energy consumption on real output in Albania over 1980-2006 using the ARDL method. The authors conclude that there is no long run relationship between energy consumption and per capita output. Additionally, they find no evidence of any causality. Kumar *et al.* (2014) apply an extended Solow (1956) framework over 1980–2011. They use the ARDL method and examine causality using the Toda and Yamamoto (1995) procedure. The capital stock elasticity is 0.55 and the elasticity of income with respect to energy consumption is 0.07. The causality results indicate a unidirectional causation from output per worker to energy consumption per worker. Kumar *et al*. (2017) re-examine the energy-growth relationship for 12 Balkan nations. For Albania, they find capital stock share is 0.22 and the energy elasticity is 0.29, and like Kumar *et al.* (2014), confirm conservation hypothesis.

From these studies (Ozturk & Acaravci, 2010; Kumar *et al.*, 2014; Kumar *et al.*, 2017), a few points emerge. First, a sound theoretical framework deliver more plausible outcomes of the effect of energy consumption on output; second, there is a contention on the strength of the effect of energy on output; and third, conservation hypothesis is shown to exist (Kumar *et al.*, 2014; Kumar *et al.*, 2017). However, these studies use a single estimation method. Also, Kumar *et al*. (2017) identify structural breaks using the single break tests of Zivot and Andrews (1992) and Perron (1997). We apply multiple break tests and use more than one method of estimation to obtain robust and consistent results.

Data & Method

Model

We use an augmented Cobb-Douglas production function similar to the Solow (1956) which is applied by Sturm (1998) and others (Rao 2010; Rao & Hassan, 2012; Jawaid & Raza, 2016; Hassan, Chowdhury & Bhuyan 2016; Park & Seo, 2016; Kumar et al., 2017; Kumar et al., 2018a, b). The model assumes Hicks neutral technical progress, where output per worker, $y_t$is given as:

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

where A_t is the stock of technology and knowledge, k_t is per worker capital stock α is the capital share and with constant returns to scale assumption. The model assumes that the evolution of technology is given by:

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

where A_0 is the initial stock of technology and t is time trend. We introduce energy consumption per worker (eng) as a shift variable (Rao, 2010).

$$\Psi_t = f(eng) = eng_t^{\vartheta} \tag{3}$$

Where $\vartheta > 0$ represents the elasticity of energy consumption per worker, hence:

$$A_t = \Phi_t \Psi_t = A_0 e^{gt} eng_t^{\vartheta} \tag{4}$$

Finally, including this information in (1), we arrive at:

$$y_t = A_0 e^{gt} eng_t^{\vartheta} k_t^{\alpha} \tag{5}$$

For estimation we take the log of (5) and add an error term:

$$\ln y_t = \ln A_0 + gt + \alpha \ln k_t + \vartheta \ln eng_t + u_t \tag{6}$$

where y_t is real GDP per worker, k_t is real capital stock per worker, eng_t is energy consumption per worker, ϕ is the constant term, t is the time trend and u_t is the error term.

Lag Estimate, Long Run & Dynamic Estimation

Lags are suitable to model the effects of persistence and inertia, and they can capture institutional and behavioural characteristics. Hence, following Stauvermann *et al.* (2016), we specify following lagged equation:

$$\ln y_t = \beta_0 + \beta_1 T + \sum_{i=1}^{p_1} \gamma_{1i} \ln y_{t-i} + \sum_{i=0}^{p_2} \delta_{1i} \ln k_{t-i} + \sum_{i=0}^{p_3} \theta_{1i} \ln eng_{t-i} + \varepsilon_t \tag{7}$$

Using (7), we can derive the long run coefficients in (6) as:

$$lnA_0 = \frac{\beta_0}{1-\sum_{i=1}^{p_1}\gamma_{1i}};\ g = \frac{\beta_1}{1-\sum_{i=1}^{p_1}\gamma_{1i}};\ \alpha = \frac{\sum_{i=0}^{p_2}\delta_{1i}}{1-\sum_{i=1}^{p_1}\gamma_{1i}};\ \vartheta = \frac{\sum_{i=0}^{p_3}\theta_{1i}}{1-\sum_{i=1}^{p_1}\gamma_{1i}};\ u_t = \frac{\varepsilon_t}{1-\sum_{i=1}^{p_1}\gamma_{1i}} \sim N(0,\sigma^2)$$

The estimation of equation (7) could result in a spurious regression problem and/or could show a large degree of multicollinearity effectively deflating the computed t-statistics. To overcome this short coming, we transform equation (7) into an error correction model.

$$\Delta \ln y_t = \sum_{i=1}^{p_1} \gamma_{1i} \Delta \ln y_{t-i} + \sum_{i=0}^{p_2} \delta_{1i} \Delta \ln k_{t-i} + \sum_{i=0}^{p_3} \theta_{1i} \Delta \ln eng_{t-i} - \lambda[\ln y_t - \ln A_0 - gt - \alpha \ln k_t - \vartheta \ln eng_t] + \varepsilon_t \quad (8)$$

Equation (8) is consistent with many estimation methods such as the general to specific (GETS) (Hendry, 1987), the Johansen Maximum Likelihood (Johansen, 1988; 1991) and ARDL approach (Pesaran *et al*., 2001). Moreover, equation (8) is also consistent with the data generating process and cointegration theory. Additionally, the one-step estimation avoids the small sample bias present in the Engle and Granger (1987) two-step approach. Estimates of equation (8) can be obtained by imposing steady state equilibrium restrictions on equation (8). Stability of equation 7 requires that the coefficient of $\ln y_{t-1}$ is between zero and positive unity. The error correction term, which measures the speed of adjustment to the equilibrium, is equal to one minus this coefficient.

We use the ARDL approach (Pesaran, *et al*., 2001). Equation (8) is first estimated using the OLS technique and then the restrictions are applied to the lagged level variables. The advantages of the approach are that: (i) cointegration can be examined with the combination of stationary and non-stationary series, (ii) it is suitable for small samples, (iii) it minimizes endogeneity bias through its dynamic structure, and (iv) it does not require symmetry in lags for each explanatory variable.

Causality Analysis

The vector error correction method (VECM) is used to examine causality. Advantages of the VECM is that: (i) it is congruent with the data generation process, (ii) it handles the non-stationarity problems of time-series data, (iii) all variable are assumed to be endogenous, and (iv) it can be used to implement the Johansen's cointegration test to identify the number of cointegrating vectors within the sample. Subsequently, the following vector error correction models are:

$$\Delta \ln y_t = \phi_{10} + \vartheta_{10} T + \sum_{i=1}^{p_1} \gamma_{1i} \Delta \ln y_{t-i} + \sum_{i=0}^{p_2} \delta_{1i} \Delta \ln k_{t-i} + \sum_{i=0}^{p_3} \theta_{1i} \Delta \ln eng_{t-i} - \lambda_1 ECT_{1,t-1} + \varepsilon_{1t} \quad (9)$$

$$\Delta \ln k_t = \phi_{20} + \vartheta_{20} T + \sum_{i=1}^{p_1} \gamma_{2i} \Delta \ln y_{t-i} + \sum_{i=0}^{p_2} \delta_{2i} \Delta \ln k_{t-i} + \sum_{i=0}^{p_3} \theta_{2i} \Delta \ln eng_{t-i} - \lambda_2 ECT_{2,t-1} + \varepsilon_{2t} \quad (10)$$

$$\Delta \ln eng_t = \phi_{30} + \vartheta_{30} T + \sum_{i=1}^{p_1} \gamma_{3i} \Delta \ln y_{t-i} + \sum_{i=0}^{p_2} \delta_{3i} \Delta \ln k_{t-i} + \sum_{i=0}^{p_3} \theta_{3i} \Delta \ln eng_{t-i} - \lambda_3 ECT_{3,t-1} + \varepsilon_t \quad (11)$$

The test of causality is a test of joint restrictions in equations 9-11. In equation (9), short run causality from $\ln vis_t$ to $\ln y_t$ and from $\ln k_t$ to $\ln y_t$ implies that $\theta_{1i} \forall i \neq 0$ and $\delta_{1i} \forall i \neq 0$; In equation (10) short run causality from $\ln eng_t$ to $\ln k_t$ and from $\ln y_t$ to $\ln k_t$ implies that $\theta_{2i} \forall i \neq 0$ and $\delta_{2i} \forall i \neq 0$; and in equation (11) short run causality from $\ln k_t$ to $\ln eng_t$ and from $\ln y_t$ to $\ln eng_t$ implies that $\theta_{3i} \forall i \neq 0$ and $\delta_{3i} \forall i \neq 0$. The long run joint causality depends on (i) significance of the error correction term, (ii) the correct sign of the error correction term, and (ii) the number of cointegrating vectors in the system.

Results and Discussion

Data Sources

We use a total of 35 years of annual data over the periods 1980-2014.The data for real GDP is from 1980 to 2016, total population is from 1960 to 2016, labour force participation rate is from 1990 to 2016, gross fixed capital formation (% of GDP) as a proxy investment is from 1980 to 2016, and energy consumption (kg of oil equivalent per capita) is from 1971 to 2014. The data is sourced from the *World Development Indicators and Global Development Finance* database (World Bank, 2017). Real GDP and gross fixed capital formation are measured in constant 1996 Albanian Lek (ALL). The physical capital stock series is constructed using the perpetual inventory method where the initial capital stock is set to 1.5 times the 1962 real GDP. The depreciation rate is assumed at 5 percent. The labour stock is computed as the average of the participation rate (averaged at 58.7 % from 1990 to 2016) multiplied by the respective year's population. Given the different starting points of the series, for consistency, the sample from 1980 to 2014 is used for the analysis.

Descriptive Statistics

Table 1 presents the descriptive statistics and correlation matrix.

Table 1

Descriptive Statistics and Correlation Matrix 1980–2014

Statistics	$\ln y_t$	$\ln k_t$	$\ln eng_t$
Panel a: descriptive statistics			
Mean	12.37	13.51	7.07
Median	12.25	13.35	7.10
Maximum	12.99	14.26	7.58
Minimum	11.73	12.63	6.48
Standard deviation	0.36	0.44	0.31
Skewness	0.27	0.21	-0.44
Kurtosis	2.12	2.20	2.17
Normality	1.55	1.18	2.11
	[0.50]	[0.55]	[0.35]
Panel b: correlation matrix			
$\ln y_t$	1.00 --		
$\ln k_t$	0.82*** [<0.01]	1.00 --	
$\ln eng_t$	0.36** [0.03]	-0.12 [0.51]	1.00--

*Notes: [ ] contains p-value. *** and ** indicates significance at 1 % and 5 % level.*

The (natural) log values of k_t and eng_t are positively correlated with y_t. Moreover, based on a skewness-kurtosis (Jarque-Bera) test, the variables are normally distributed.

Unit Root

Table 2

Unit Root

Variables	ADF test statistic		PP test statistic	
	Level	1st Difference	Level	1st Difference
$\ln y_t$	-2.06 (0) [0.54]	-4.40 (0)*** [<0.01]	-1.56 (1) [0.79]	-3.75 (0)*** [<0.01]
$\ln k_t$	-3.00 (0) [0.15]	-5.22 (8)*** [<0.01]	-2.14 (3) [0.51]	-2.26 (2)** [0.02]
$\ln eng_t$	-1.22 (0) [0.88]	-4.49 (0)*** [<0.01]	-1.38 (2) [0.85]	-4.49 (1)*** [<0.01]

*Notes: Lag used in ADF and Bandwidth in PP are indicated in round parenthesis and determined using the Schwarz criterion. P value reported in square parenthesis, *** - stationary at 1 percent, ** - stationary at 5 %, null hypothesis – series has unit root, test conducted with constant and trend; test statistic reported is t-statistic for ADF and adjusted t-statistic for PP test.*

Table 2 presents the individual unit root test results. All variables are integrated of order 1 and appropriate for the estimation procedures.

Lag Length Tests

Lag length tests (Table 3) are based on a number of information criterions. The maximum lags indicated by the SC criteria are 3. Setting the lags to 3 yields the optimum lag combination of ARDL (1, 2, 1).[1]

Table 3

Lag Selection Tests

Lag	LL	LR	FPE	AIC	SC	HQ
1	159.97	--	1.2×10^{-8}	-9.74	-9.32	-9.60
2	183.41	37.81	4.7×10^{-9}	-10.67	-9.83***	-10.40
3	195.76	17.52***	3.9×10^{-9}***	-10.88***	-9.64	-10.48***
4	201.88	7.51	5.1×10^{-9}	-10.70	-9.03	-10.16

*Notes: LL – log likelihood; LR – likelihood ratio; FPE – Final prediction error; AIC – Akaike information criterion, SC – Schwarz criterion, HQ – Hannan-Quinn criterion, -- not applicable, *** indicates optimal lag length at 5 %.*

Structural Breaks

Structural breaks are examined using the Bai and Perron (1998; 2003) multiple break test (Table 4). The advantages of this approach are: (i) the existence of multiple breaks can be identified which then can be used to analyse real events that characterize the break periods, and (ii) using breaks, regimes in the data can be identified and accounted for, thus improving the forecasting ability of the model. Additionally, the responsiveness of the dependent variable due to the structural breaks can be ascertained. This can be information for policy makers (Stauvermann *et al*., 2016; Ahmad and Aworinde, 2015 and Das *et al*., 2014).

Table 4

Break Test

Null hypothesis	Scaled F-statistic	Critical Value
0 vs. 1	51.35***	8.58
1 vs. 2	13.86***	10.13
2 vs. 3	3.56	11.14
Break dates:	1995; 2007	

*Source: estimated in Eviews 9, critical value from Bai-Perron (1998; 2003), *** - significant at 5 %*

Cointegration Tests

We perform three tests of cointegration: (i) the ARDL procedure of Pesaran *et al.* (2001) (Table 5a), (ii) the trace and maximum eigenvalue tests of Johansen (1988) and Johansen and Juselius (1991) (Table 5b) and (iii) the residual based cointegration tests of Engle and Granger (1987), and Phillips-Ouliaris (1990) (Table 5c). The tests (ii) and (iii) are performed to examine the consistency of the results with respect to the results obtained from the ARDL method.

Table 5a

Bounds test – ARDL (1,2,1)

Model	F-Statistic	
$\ln y_t \vert \ln k_t; \ln eng_t; B1; B2$	5.66**	
$\ln y_t \vert \ln k_t; \ln eng_t$	2.77	
Critical Value Bounds		
Significance	I(0) Bound	I(1) Bound
10 %	3.17	4.14
5 %	3.79	4.85
1 %	5.15	6.36

*Note: *** indicates rejection of the given number of cointegrating vectors*

[1] Using a maximum of 2 or 4 lags gave the same optimal lag combination of ARDL (1,2,1).

Table 5b

Johansen's Cointegration Test

Hypothesized No. of CE(s)	Eigen value	Trace Statistic	5 % CV	P-value	Max-Eigen Statistic	5 % CV	P-value
$\ln y_t \vert \ln k_t, \ln eng_t, B1, B2$							
None	0.57	34.56***	29.79	<0.01	27.05***	21.13	<0.01
At most 1	0.20	7.51	15.49	0.52	7.50	14.26	0.43
At most 2	7.41×10^{-5}	0.01	3.84	0.95	0.01	3.84	0.96
$\ln y_t \vert \ln k_t, \ln eng_t$							
None	0.46	36.02***	29.79	<0.01	20.62	21.13	0.06
At most 1	0.32	15.39	15.49	0.06	12.34	14.26	0.09
At most 2	0.09	3.049	3.84	0.08	3.049	3.84	0.08

*Note: *** indicates rejection of the given number of cointegrating vectors.*

Table 5c

Residual Based Tests

Variable	Engle-Granger		Phillips-Ouliaris	
	Tau statistic	Z statistic	Tau statistic	Z statistic
Cointegrating residual	-4.44^B [0.02]	-25.45^B [0.02]	-4.41^B [0.02]	-22.38^B [0.04]

Note: B – cointegration at 5%.

The cointegrating relationship between $\ln y_t$, $\ln k_t$ and $\ln eng_t$ (specified in equation 6) is accepted at the 5 percent level after the inclusion of structural breaks (Table 5a). Moreover, cointegration is also confirmed in Tables 5b and 5c.

Long & Short Run Estimates

The long and short run results based on the ARDL (1,2,1) are selected on the basis of the Akaike information criteria (Table 6).

Table 6

Estimated Long & Short Run Models – ARDL (1,2,1)

Regressor	Coefficient	LCL	UCL	Standard error	t-statistic	p-value
Panel a: Long run model						
$\ln k_t$	0.49***	0.31	0.67	0.09	5.32	<0.01
$\ln eng_t$	0.36***	0.13	0.59	0.11	3.13	<0.01
B_{1t}	0.15**	0.02	0.28	0.07	2.20	0.04
B_{2t}	0.36***	0.16	0.55	0.09	3.73	<0.01
Constant	3.02***	1.01	5.03	1.01	3.00	<0.01
Panel b: Short run dynamic model						
$\Delta \ln k_t$	3.09***	1.80	4.36	0.64	4.82	<0.01
$\Delta \ln k_{t-1}$	-1.55**	-2.95	-0.15	0.69	-2.22	0.04
$\Delta \ln eng_t$	0.42***	0.24	0.60	0.09	4.66	<0.01
ΔB_{1t}	0.09*	-0.01	0.18	0.05	1.76	0.09
ΔB_{2t}	0.20**	0.05	0.36	0.08	2.66	0.02
ECT_{t-1}	-0.58***	-0.88	-0.28	0.15	-3.86	<0.01
Panel c: Short run dynamics statistics –eq. (9)						
$R^2 = 0.85$, adjusted $R^2 = 0.80$, $\hat{\sigma} = 0.04$, $F(9, 26) = 17.39^A$, DW = 2.09; AIC = -3.39; SIC = -2.98; HQC = -3.25; LL = 65.03						
Panel d: Lag estimate simulation statistics – eq. (8)						
U = 0.001; $U_B = 0.000$; $U_V = 0.005940$; U_{CV}=0.994; RMSE = 0.035; R^2 = 0.99, adjusted $R^2 = 0.99$						

*Notes: *** ,**,* - significance at 1,5,10 percent levels, LCL & UCL- 5 % lower and upper confidence interval, U – Theil's inequality coefficient, U_B , U_C – bias and variance proportions of U, U_{CV} – unsystematic component of U, LL – log likelihood, RMSE – root mean square error.*

As noted from Table 6, the cointegrating coefficient of lnk_t is estimated at 0.49, which indicates that in the long run, a 1 % increase in k_t increases y_t on average by 0.49 %, *ceteris paribus*. This differs from Kumar et al. (2017) where the capital elasticity is noted at 0.22 and is closer to Kumar et al. (2014) who estimate an elasticity of 0.55. According to our results, the capital share exceeds the stylized value of one third, and this is expected for developing and transitional countries where the marginal productivity of capital is notably higher (Kumar & Stauvermann, 2014). In terms of the lower and upper confidence limits, we note that the coefficient of lnk_t ranges from 0.30 to 0.67 at the 5 % level of significance.

The coefficient of lneng_t is 0.36 which implies that a 1 % increase in per worker energy consumption increases y_t by 0.36 %. Kumar et al. (2017) and Kumar et al. (2014) note the share to be 0.29 and 0.07, respectively. Also, in our study, the two break periods have a positive association with real output.

In the short-run (Panel b, Table 6), the capital stock (investment) has a significant and positive association with growth ($\Delta\text{lnk}_t + \Delta\text{lnk}_{t-1} = 1.54$), whereas Kumar et al. (2014) and Kumar et al. (2017) find this to be at 1.92 and 2.49, respectively. The coefficient of energy consumption is positive and statistically significant ($\Delta\text{lneng}_t = 0.42$) which implies that a 1 % increase in energy consumption increase growth of per worker output by 0.42 %, *ceteris paribus*. Kumar et al. (2014) and Kumar et al. (2017) note a slightly lower short-run magnitude of at 0.37 and 0.25, respectively. On ECT_{t-1}, the coefficient is negative (-0.5809) and significant at the 1 % level. This indicates that on average, following exogenous shocks, the convergence to long run equilibrium takes approximately 1.7 years, *ceteris paribus*.

ARDL Diagnostics

We use the Ramsey reset test to detect omitted variables and incorrect functional form and the Breusch-Godfrey test to detect residual autocorrelation. Additional tests used are the Breusch-Pagan-Godfrey test of heteroscedasticity, Jarque-Bera normality test, and the Durbin-Wu-Hausman test of regressor endogeneity. The parameter stability is examined from the CUSUM and CUSUMQ (CUSUM squared) plots. As noted from the statistics in Table 7 and Figure 3, the model passes the diagnostic and parameter stability tests. Moreover, the results of the Durbin-Wu-Hausman test for endogeneity coincides with the trace and maximum Eigen value tests.

Table 7

ARDL (1,2,1) Diagnostic Tests

Test	Null hypothesis	Test Version 1	
Ramsey RESET	H_0: No omitted variables	$F(1,23) = 0.06$	0.81
Breusch-Godfrey	H_0: No residual autocorrelation	$\chi^2(2) = 0.40$	0.82
Breusch-Pagan-Godfrey	H_0: Homoscedasticity	$\chi^2(8) = 11.02$	0.20
Jarque-Bera	H_0: Residual normality	$\chi^2(1) = 0.28$	0.87
Durbin-Wu-Hausman	H_0: Joint Regressor exogeneity	$\chi^2(6) = 1.90$	0.93

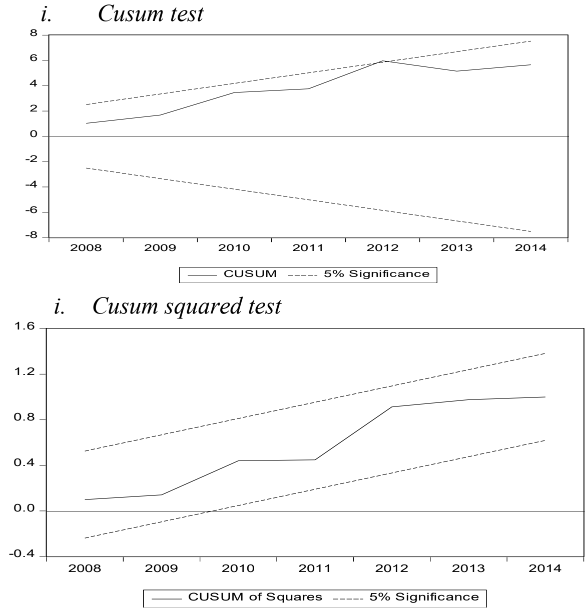

Figure 3. ARDL Cusum stability tests at 5 %.

Causality Tests

The results of the VECM satisfy the statistical conditions of no residual autocorrelation, homoskedasticity, residual normality and stability as noted by the inverse root plot (Figure 4).

Table 8

VECM Causality Results

Excluded	Test Statistic	P Value
Panel a: causality test		
Dependent variable: Δlny_t		
Δlnvis_t	$\chi^2(2) = 1.08$	0.58
Δlneng_t	$\chi^2(2) = 0.25$	0.88
Joint	$\chi^2(4) = 1.67$	0.79
Dependent variable: Δlnk_t		
Δlny_t	$\chi^2(2) = 6.40^{**}$	0.04
Δlneng_t	$\chi^2(2) = 1.77$	0.41
Joint	$\chi^2(4) = 6.69$	0.15
Dependent variable: Δlneng_t		
Δlny_t	$\chi^2(2) = 10.13^{***}$	0.01
Δlnk_t	$\chi^2(2) = 0.32$	0.85
Joint	$\chi^2(4) = 12.42^{**}$	0.015

Panel b: Implied long run elasticity– JML				
Variable	Coefficient	Standard Error	T-Statistic	P Value
lnk_t	0.515111^{A}	0.082	-6.254	<0.01
lneng_t	0.499224^{A}	0.137	-3.640	<0.01

Panel c. VECM diagnostics

SC: $\chi^2(9) = 5.83$ [0.75]; HC: $\chi^2(96) = 104.10$ [0.2687]; RN: $\chi^2(1) = 8.277$[0.22]; $R^2 = 0.4950$; adjusted R^2=0.28; $\hat{\sigma} = 0.08$, AIC = -2.05; SIC = -1.59; F = 2.40^{***}; LL = 42.85

Notes: *** and ** indicate significance at 1% and 5%, respectively. SC – serial correlation, HC – heteroskedasticity, RN – residual normality, p value in square parenthesis and diagnostic test degrees of freedom in round parenthesis in panel c, heteroskedasticity test is based on White's test without cross products, LL – log likelihood.

Causality results based on χ^2 test are presented in Table 8. We note a unidirectional causality from $\Delta\text{lny}_t$to Δlneng_t, and a unidirectional causality $\Delta\text{lny}_t$to Δlnk_t. The causality results are consistent with earlier studies by Kumar *et al.* (2017) and Kumar *et al.* (2014), who also find support for the conservation hypothesis for Albania and other countries in the Balkan Peninsula.

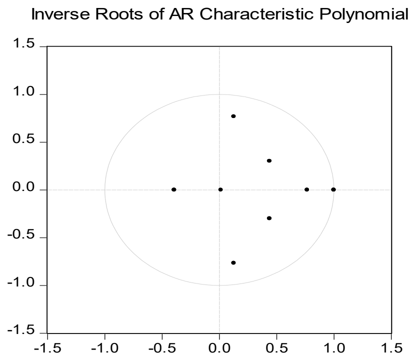

Figure 4. VECM IR stability plot at 5 %

Robustness Tests

For robustness tests, the long-run relationship is estimated using the dynamic OLS (DOLS) procedure (Saikkonen, 1992; Stock & Watson, 1993). To remove long run serial correlation within the error term, the DOLS method constructs an asymptotically efficient estimator by augmenting the cointegrating equation with leads and lags of the differenced explanatory variables. The resulting error term is orthogonal to the entire history of the stochastic regressor innovations.

Table 9

Estimated Long-Run Model – DOLS

Variable	Coefficient	LCL	UCL	standard error	*t*-statistic	*p*-value
lnk_t	0.49***	0.36	0.61	0.06	7.59	<0.01
$lneng_t$	0.43***	0.26	0.60	0.08	5.00	<0.01
B_1	0.16***	0.05	0.27	0.05	2.91	<0.01
B_2	0.32***	0.18	0.47	0.07	4.38	<0.01
Constant	2.51***	1.09	3.93	0.71	3.54	<0.01
R^2 = 0.99, adjusted R^2 = 0.99, $\hat{\sigma}$ = 0.05; $\chi^2_{RN}(1) = 0.47$ [0.79]; LQ(1) = 0.69 [0.46] $\overline{VIF} = 7.28$; LC = 0.104 [0.20]						

Notes: **** indicate significance at 1%; RN – residual normality; LQ – Ljung-box serial correlation statistic, degrees of freedom in χ^2 and lags used in LQ indicated in ( ) and p-value for these tests in [ ], LC = Hansen instability test.*

The DOLS result (Table 9) is consistent with the results reported using the ARDL and the JML procedure. Therefore, the capital share is between 0.48 and 0.51, and the energy elasticity is between 0.36 and 0.49.

Instrumental Variables (IV) and GMM Estimates

Except for the Johansen's method which utilizes the maximum likelihood estimators, the other methods use the ordinary least squares (OLS) estimators. The latter may produce biased and inconsistent results in the presence of endogeneity and/or inaccurate model specification. Therefore, we check our estimates by applying the IV and GMM estimates. The IV and GMM estimates are presented in Table 10 and 11, respectively. As noted, the results obtained are consistent with the previous estimation methods, free from endogeneity bias, serial correlation, and heteroscedasticity, and has the correct functional form with its residuals being normally distributed.

Table 10

Estimated Long-Run Model – IV

Variable	Coefficient	LCL	UCL	standard error	*t*-statistic	*p*-value
lnk_t	0.42***	0.22	0.62	0.10	4.12	<0.01
$lneng_t$	0.58***	0.49	0.67	0.05	12.65	<0.01
B_1	0.30***	0.23	0.38	0.04	8.21	<0.01
B_2	0.45***	0.26	0.65	0.09	4.62	<0.01
Constant	2.36*	-0.19	4.91	1.28	1.85	0.08
R^2 = 0.98, adjusted R^2 = 0.98 $\hat{\sigma}$ = 0.05; $\chi^2_{EN}(2)$ = 3.68 [0.15]; $F_{RR}(1, 24) = 1.97$ [0.17]; $\chi^2_{SC}(1)$ = 0.85 [0.35]; $\chi^2_{HT}(2)$ = 2.10 [0.3490]; $A^2_{RN}(1)$ = 0.71 [0.55]						

*Notes: *** and * indicate significance at 1 % and 10 %, respectively, EN – endogeneity Hausman test; RR – Ramsey RESET; SC – serial correlation; HT – heteroskedasticity; RN – residual normality*

Table 11

Estimated Long-Run Model – GMM

Variable	Coefficient	LCL	UCL	standard error	*t*-statistic	*p*-value
lnk_t	0.43***	0.36	0.50	0.04	11.83	<0.01
$lneng_t$	0.58***	0.53	0.63	0.03	22.77	<0.01
B_1	0.30***	0.27	0.34	0.02	19.20	<0.01
B_2	0.45***	0.38	0.51	0.03	13.95	<0.01
Constant	2.27***	1.61	2.94	0.33	6.83	<0.01
R^2 = 0.98, adjusted R^2 = 0.98, $\hat{\sigma}$ = 0.05						

*Notes: *** indicate significance at 1%*

Conclusion

In this study, we examine the energy-growth nexus in the case of Albania over 1980–2014 using the ARDL approach of Pesaran *et al.* (2001) and the JML procedure of Johansen (1988; 1991). Causality is tested using the VECM technique. The existence of a single cointegrating vector is noted. Other methods such as DOLS, IV and GMM procedures also provide consistent results. The average capital share is 0.49 and the elasticity of per worker energy consumption is 0.35. The causality results support the conservation hypothesis for Albania, similar to Kumar *et al.* (2014) and Kumar *et al.* (2017).

Some policy implications can be drawn from the results. It is clear that energy consumption is a consequence of economic activity and important facilitating further economic activity. Our results are also consistent with O'Brien *et al*. (2017), who argue that 15 % of all firms in Albania consider (lack if) electricity as the main constraint in doing business. The World Bank (2017) has ranked Albania in terms of doing business at 157 (out of 190) and in terms of the reliability of electricity, at zero (in the range of zero and eight). The European and Central Asian countries have received on average a value of 5 and high income OECD countries of 7. Under these circumstances, it is not much surprising that Albania's industry sector is not well developed.

One of the main obstacles of Albania's energy sector is the missing reliability and low profitability of the electricity sector. Bidaj *et al* (2015) estimate that 29 % to 52 % of the total electricity supply is lost due to technical and non-technical (theft and unpaid bills) reasons. Ali (2015) states that the technical losses accounted for 16 % of the total electricity supply in 2014.

Recognizing that most of the electricity is consumed by households and that the reliability of electricity supply depends on the rainfall, it is recommended to incentivize private investments in renewable electricity production like solar panels or wind turbines. It should be clear, that all possible foreign investments even in the potential profitable emerging sector like tourism are nearly stalled if the energy supply is not reliable. Noting that Albania is an energy resource-abundant country, a key policy objective should be to transform the economy to become more efficient in energy use and productivity growth. A reliable energy supply is a precondition for the exploitation of other economic advantages such as the country's low wage level to improve economic development.

The government should consider introducing a progressive electricity billing system for households, which can be adjusted according to the available water resources to guarantee the electricity supply for firms. Such a progressive billing system will incentivize the purchase of energy-saving devices and solar panels, ensure the availability of electricity is at an affordable price, and ensure that electricity supply for companies are stable. Additionally, for effective and forward looking plans, the government will need to consider the effects of climate change on the rainfall in the coming decades. It is thus recommended that energy supply is diversified. Because of the relatively low electricity price, the option to use solar water heating panels seems to be economically viable. Also, there is a need to improve water management in the agricultural sector to cater for the water demand for irrigation purposes whilst supporting the energy sector in hot dry summers.

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