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Articles and Statements

The Dynamic Causal Links between Energy Consumption, Trade Openness and Economic Growth: Time Series Evidence from Upper Middle Income Countries

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Abstract

This study investigates the dynamic causal links between energy consumption, trade openness and economic growth for upper middle income countries over the period 1971-2014. The ARDL bounds test is used to examine the presence of cointegration between the variables. The VECM Granger causality method is also used to explore causality between the variables. Empirical results indicate that i) the variables are stationary at first differences, ii) there exists cointegration between the variables in Turkey, China, Colombia, Ecuador, Jamaica and Peru, iii) there exists important causal linkages among the variables in the long run, iv) the energy-led-growth and trade-led-growth hypotheses are demonstrated for Turkey, China, Colombia, Jamaica and Peru.

Keywords: energy, openness, growth, cointegration, causality.

1. Introduction

The energy consumption-income link has been significantly discussed in economic growth literature. Especially, the causal linkages between these variables lead us to the several theoretical approaches. In this context, there exists four hypotheses related with energy-growth link. According to the growth hypothesis, energy is a vital source for production function. This hypothesis implies that energy consumption causes economic growth (Masih and Masih, 1998). The conservation hypothesis expresses that economic growth causes energy consumption. A reduction in energy demand does not affect economic growth very much. The presence of a bi-directional causal linkage between the variables is called as the feedback hypothesis. Finally, the neutrality hypothesis assumes that there exists no causality between energy consumption and economic growth (Kumar et al., 2015).

The growth literature has also discussed the importance of trade opennes on economic growth. The Heckscher-Ohlin model suggests that trade openness can increase productivity and incomes in countries (Stensnes, 2006). According to Krugman (1979), the total output increases in a free trade environment. Grossman and Helpman (1995) explain that free trade can promote the rate of economic growth through the diffusion of knowledge and technology across countries.

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Romer (1991) states that trade openness can stimulate economic growth through innovation, efficiency and technological improvement.

In this context, this study deals with the dynamic causal links between energy consumption, trade openness and economic growth for upper middle income countries over the period 1971-2014. The ARDL bounds test and VECM Granger causality method are employed to examine the presence of cointegration and causal links between the variables.

The remainder of the study is outlined in five sections. Section two deals with the literature. Section three presents the model specification and data. Section four reports the methodology. The empirical results are provided in section five. Finally, the study provides a conclusion and policy implication.

2. Literature Review

Kraft and Kraft (1978) analyses the link between energy consumption and economic growth. This study indicates that economic growth causes energy consumption and energy consumption causes economic growth. This finding implies that there exsists empirical evidence supporting the conservation hypothesis for USA.

Using the Granger causality approach, Yu and Choi (1985) examine the link between these variables. In the study, it is found that economic growth causes energy consumption in South Korea. This implies the presence of conservation hypothesis. No causality is found for USA, UK and Poland implying the presence of neutrality hypothesis.

Glasure and Lee (1997) investigate the economies of Singapore and South Korea. The study presents the bi-directional causal linkage between the variables indicating the existence of feedback hypothesis.

Stern (2000) uses a VAR model for USA economy. In 3 of the 5 models, the causality from energy use to economic growth is found. In the other models, the presence of bi-directional causality between the variables is found. The study presents empirical findings supporting the presence of growth and feedback hypotheses.

Asafu-Adjaye (2000) adds energy prices to the analyses in the Asian developing countries. This study uses the Johansen-Juselius test and VECM Granger causality method. In the long run, it is found that energy consumption causes economic growth in India and Indonesia. In the long run, it is also found that economic growth causes energy consumption in Thailand and Phillippines. The results imply the validity of growth hypothesis for India and Indonesia, and conservation hypothesis for Thailand and Phillippines.

Soytas and Sari (2003) test the causal link between energy consumption and GDP in G-7 countries and emerging economies. The VECM Granger causality analysis reveals the existence of the bi-directional causality between these variables in Argentina. It is determined that economic growth causes energy consumption in Italy and Korea. It is also determined that energy consumption causes economic growth in Turkey, France, Germany and Japan. The study supports the presence of feedback hypothesis for Argantina, conservation hypothesis for India and Indonesia. The study also supports growth hypothesis for Turkey, France, Germany and Japan.

Applying a multivariate cointegration analysis, Ghali and El-Sakka (2004) examine the link between energy consumption and growth in case of Canada. The findings reveals the presence of the bi-directional causal linkage between the variables. The result implies the persence of feedback hypothesis for Canada.

Using panel data methodology, Lee (2005) examines the relationship between the variables in developing countries. The results reveal that energy consumption causes economic growth. This is an empirical evidence for the growth hypothesis.

Caraiani et al. (2015) deal with the causal link between the variables by applying a three-step analysis for emerging European countries. The results support the conservation hypothesis for Hungary, Poland and Turkey. The results indicate the existence of growth hypothesis for Romania. The feedback hypothesis is valid for Bulgaria.

Sharmin and Khan (2016) analyze the African caountries using the Johansen-Juselius cointegration test and Granger causality technique. The existence of bi-directional causality between the variables for Ethiopia, Morocco and Mozambique is detected in the long run. This means that the feedback hypothesis is valid for these countries. The results show that

economic growth causes energy consumption. This indicates the validity of conservation hypothesis for Angola.

From the empirical perspective, there exists a wide range of paper dealing with the link between trade openness and growth. Applying the Granger causality analysis, Jung and Marshall (1985) examine the exports-economic growth link for 37 countries. The causality analysis reports that there exists no causality between these variables.

Hsiao (1987) also examines the exports-economic growth link for Asian countries. The study indicates that economic growth causes exports in case of Hong Kong.

Frankel and Romer (1999) deal with the link between trade and economic growth using panel data analysis. The study does not analyze causality between the variables. This study show that trade is not linked with economic growth. Hassan (2005) investigates the link between international trade and economic growth in case of Bangladesh. The empirical results show that there exists the uni-directional causality from trade openness to economic growth.

Gries and Redlin (2012) examine the relationship between trade openness and economic growth through a panel causality analysis. The panel GMM estimation results indicate the peresence of the long run bi-directional causality between the variables. This means that trade openness is a crucial factor of economic growth in the long term.

Okuyan and Ozun (2012) test the relationship between the variables in developing countries. This study usess the ARDL boundst test and Toda-Yamamoto causality method. The Toda-Yamamoto causality analysis revals that in four countries there exists a causal linkage from trade openness to economic growth. The Toda-Yamamoto causality analysis also revals that economic growth causes trade openness in the other countries.

Arif and Ahmad (2012) analyze the link between trade openness and economic growth using the Granger causality approach. The empirical results indicate that there exists the bi-directional causal linkage between trade openness and economic growth.

In recently, there has been an empirical literature investigating the relationship between energy consumption, trade and economic growth. This encompasses the studies of Shahbaz et al. (2013); Kumar et al. (2015); Kyophilavong et al. (2015) and Katırcıoğlu et al. (2016). Shahbaz et al. (2013) explore the link between energy use, trade openness, financial development, capital and economic growth in China. This study uses the ARDL bounds test and VECM Granger causality method. The Granger causality analysis shows that there exists the uni-directional causal link from energy use to economic growth. This indicates that the growth hypothesis is valid for China. In addition, the bi-directional causal link between the variables is determined.

Using the ARDL bounds test, Bayer and Hanck cointegration technique and Toda-Yamamoto causality approach, Kumar et al. (2015) investigate the South African economy. The results reveal that energy consumption causes economic growth. The results also reveal the presence of the bi-directional causal link between these variables. Therefore, the growth and feedback hypotheses are valid for South Africa.

Applying the Bayer and Hanck cointegration method, Kyophilavong et al. (2015) examine the link between energy use, openness and growth in Thailand. The study reveals that the feedback hypothesis is valid for Thailand. The study also reveals that there exists the bi-directional causal linkage between openness and growth in the long run.

Katırcıoğlu et al. (2016) deal with the relationship between energy consumption, trade and real income in case of Canada. This study uses the ARDL bounds test and VECM Granger causality approach. The causality test reveals the existence of the bi-directional causal link between energy consumption and economic growth. The study also reveals the existence of the bi-directional causality between trade and growth. The results support the presence of feedback hypothesis.

The recent studies are based on a single country and do not provide comperative results. The present study empirically examines the causal linkages between energy consumption, trade openness and economic growth for 12 upper middle income countries. For this purpose, the stationarity properties of the variables are analyzed by the Augmented Dickey-Fuller (ADF) and Dickey-Fuller GLS (DF-GLS) tests of Dickey and Fuller (1981) and Phillips-Perron (PP) test of Phillips and Perron (1988). The presence of cointegration between the variables is investigated by the ARDL bounds test presented by Pesaran et al. (2001). Finally, the study examines the causal linkages between the variables through the VECM Granger causality method presented by Engle and Granger (1987).

3. Model Specification and Data

The present study aims at dealing with the link between energy use, trade openness and economic growth by employing the log-lineer model. Following Kyophilavong et al. (2015), the relationship between the variables is specified as follows:

$$lnY_t = \alpha_0 + \alpha_1 lnEC_t + \alpha_2 lnTR_t + \varepsilon_t \quad (1)$$

where, lnY_t, $lnEC_t$ and $lnTR_t$ represent per capita real GDP (in constant 2010 US dollars), per capita energy consumption (in kg of oil equivalent) and trade openness which is obtained by dividing the sum of exports and imports by GDP. All the variables are transformed into logarithm. α_o is the constant, α_1 and α_2 denote the elasticity coefficient of energy concumption per capita and trade openness, respectively. The term ε_t is a random error term. The study covers 12 upper-middle income countries (Turkey, China, Colombia, Costa Rica, South Africa, Malaysia, Thailand, Mexico, Tunusia, Ecuador, Jamaica and Peru). Annual time series from 1971 to 2014 are obtained from World Development Indicators (World Development Indicators, 2016). According to the World Bank classification, the main feature of these countries is that they have the same per capita income level in 2016. Table 1 presents the descriptive statistics.

Table 1. Descriptive Statistics

Country	*Variables*	*Mean*	*Median*	*Max.*	*Min.*	*Std. dev.*
Turkey	lnY_t	8.80	8.79	9.31	8.33	0.28
	$lnEC_t$	6.87	6.88	7.35	6.30	0.28
	$lnTR_t$	3.46	3.56	4.05	2.20	0.50
China	lnY_t	6.87	6.78	8.63	5.45	1.01
	$lnEC_t$	6.74	6.64	7.70	6.14	0.43
	$lnTR_t$	3.22	3.45	4.17	1.60	0.71
Colombia	lnY_t	8.39	8.40	8.86	7.95	0.23
	$lnEC_t$	6.48	6.46	6.61	6.37	0.06
	$lnTR_t$	3.48	3.51	3.65	3.16	0.12
Costa Rica	lnY_t	8.57	8.49	9.07	8.19	0.25
	$lnEC_t$	6.45	6.45	6.94	6.05	0.30
	$lnTR_t$	4.33	4.35	4.64	3.98	0.18
South Africa	lnY_t	8.79	8.78	8.93	8.67	0.06
	$lnEC_t$	7.84	7.87	7.99	7.59	0.10
	$lnTR_t$	3.95	3.95	4.28	3.65	0.14
Malaysia	lnY_t	8.50	8.53	9.21	7.61	0.46
	$lnEC_t$	7.23	7.35	8.01	6.25	0.55
	$lnTR_t$	4.93	4.99	5.39	4.29	0.32
Thailand	lnY_t	7.80	7.96	8.63	8.85	0.56
	$lnEC_t$	6.68	6.73	7.59	5.88	0.56
	$lnTR_t$	4.32	4.35	4.94	3.54	0.45
Mexico	lnY_t	8.92	8.93	9.13	8.56	0.14
	$lnEC_t$	7.19	7.25	7.36	6.68	0.17
	$lnTR_t$	3.56	3.63	4.19	2.79	0.44
Tunusia	lnY_t	7.82	7.79	8.34	7.20	0.31
	$lnEC_t$	6.42	6.42	6.88	5.76	0.30
	$lnTR_t$	4.40	4.44	4.74	3.88	0.19
Ecuador	lnY_t	8.24	8.23	8.57	7.85	0.14
	$lnEC_t$	6.46	6.45	6.88	5.87	0.24
	$lnTR_t$	3.76	3.78	4.22	3.30	0.24
Jamaica	lnY_t	8.42	8.46	8.59	8.16	0.12
	$lnEC_t$	7.06	7.09	7.36	6.61	0.20
	$lnTR_t$	4.50	4.49	4.83	4.06	0.15
Peru	lnY_t	8.19	8.16	8.66	7.87	0.18
	$lnEC_t$	6.29	6.28	6.57	6.01	0.17
	$lnTR_t$	3.47	3.49	4.03	2.57	0.35

4. Econometric Methodology

Firstly, the stationarity properties of the variables are examined through the ADF, DF-GLS and PP tests. Secondly, the cointegration analysis is implemented by the ARDL bounds test. Thirdly, the study investigates the causal links between the variables through the VECM Granger causality test. In this stage, both short-run and long-run causality between the variables is analyzed.

4.1. Cointegration Analysis

Several cointegration methods suggested by Engle and Granger (1987), Johansen and Juselius (1990), Phillips and Hansen (1990), Stock and Watson (1993) have been used to investigate the long run relationship among the variables in the empirical studies. These are univariate or multivariate cointegration approaches and require that the variables should be integrated at *I*(1).

This study uses the ARDL bounds test to examine the presence of long run link between energy consumption, trade openness and economic growth. The ARDL bounds test is a single cointegration approach and has several important advantages in comparison with other cointegration techniques. In the ARDL approach, the regressors may be integrated *I*(0) or *I*(1). This method provides efficient results for small sample data. In addition, a dynamic unrestricted error correction model (UECM) can be obtained from the ARDL model. The UECM encompasses both short-run and long-run dynamics (Pesaran, Shin, 1999). In this study, the following ARDL model is employed:

$$\Delta lnY_t = \alpha_0 + \sum_{i=1}^{m} \beta_{1i} \Delta lnY_{t-i} + \sum_{i=0}^{m} \beta_{2i} \Delta lnEC_{t-i} + \sum_{i=0}^{m} \beta_{3i} lnTR_{t-i}$$

$$+\theta_1 lnY_{t-1} + \theta_2 lnEC_{t-1} + \theta_3 lnTR_{t-1} + \theta_4 trend + \varepsilon_t \quad (2)$$

where, α_o is the constant, Δ is the first difference operator and ε_t is the random error term. The appropriate lag order is determined by the AIC and SBC. In the bounds testing approach, the computed *F*-statistic is compared with the upper critical bound (UCB) and lower critical bound (LCB). These critical bounds are generated by Pesaran et al. (2001). This cointegration procedure tests the null hypothes $H_0: \theta_1 = \theta_2 = \theta_3 = \theta_4 = 0$ of no cointegration against the alternative hypothesis $H_a: \theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq 0$ of cointegration. The null hypothesis can not be rejected if the computed *F*-statistic exceeds the UCB. This means that there exists a cointegration between the variables. The null hypothesis can be rejected if the computed *F*-statistic below the LCB. This indicates that there exists no cointegration between the variables. If computed *F*-statistic falls between the UCB and LCB, the result is uncertain.

Using some diagnostic tests such as serial correlation, functional form, normality of error term and heteroskedasticity, we can investigate the robustness of the ARDL model. In addition, we can examine the stability of the ARDL parameters through the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMsq) tests of Brown et al. (1975).

4.2. Causality Analysis

This study employs the VECM Granger causality method to estimate the causal links between the variables. After applying a cointegration approach, the VECM Granger causality method can be used. The empirical specification of this causality method is expressed as follows:

$$(1-L)\begin{bmatrix} \ln Y_t \\ \ln EC_t \\ \ln TR_t \end{bmatrix} = \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix} + \sum_{i=1}^{p} (1-L) \begin{bmatrix} a_{11i} a_{12i} a_{13i} \\ a_{21i} a_{22i} a_{23i} \\ a_{31i} a_{32i} a_{33i} \end{bmatrix} x \begin{bmatrix} \ln Y_{t-1} \\ \ln EC_{t-1} \\ \ln TR_{t-1} \end{bmatrix} + \begin{bmatrix} \alpha \\ \varphi \\ \delta \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix} (3)$$

where, (1- L) and ECT_{t-1} is the lag operator and the lagged error correction term obtained from the long run relationship. ε_{1t}, ε_{2t} and ε_{3t} are error terms. The short-run and long-run causal linkages between the variables can be examined by the VECM causality technique. If *t*-statistic on the coefficient of lagged error correction term is significant, there exists a long-run causality

between the variables. If *F*-statistic on the first differences of the variables is significant, there exists a causal linkage between the variables in the short run.

5. Empirical Results

We apply ADF, DF-GLS and PP tests to implement unit root analysis of the variables. The results presented in Table 2 indicate that the variables have an unit root at level but stationary at first difference. The results also indicate that the ARDL bounds test can be employed to analyze the existence of a cointegration between the variables.

Table 2. The Results of Unit Root Tests

Country	Regressor	ADF test			DF-GLS test			PP test	
		SIC lag	*t*-stat	Critical value at 5 %	SIC lag	*t*-stat	Critical value at 5 %	*t*-stat	Critical value at 5 %
Turkey	lnY_t	0	-0.19[a]	-2.93	0	-1.32[a]	-1.94	0.14[a]	-2.93
	$lnEC_t$	0	-1.29[a]	-2.93	0	0.86[a]	-1.94	-1.30[a]	-2.93
	$lnTR_t$	0	-1.36[a]	-2.93	1	-0.60[a]	-1.94	-1.37[a]	-2.93
	ΔlnY_t	0	-6.50[a]	-2.93	0	-6.21[a]	-1.94	-6.51[a]	-2.93
	$\Delta lnEC_t$	0	-6.28[a]	-2.93	0	-4.61[a]	-1.94	-6.38[a]	-2.93
	$\Delta lnTR_t$	0	-5.48[a]	-2.93	0	-5.51[a]	-1.94	-5.48[a]	-2.93
China	lnY_t	2	1.04[a]	-2.93	1	0.15[a]	-1.94	2.24	-2.93
	$lnEC_t$	1	1.62[a]	-2.93	1	1.39[a]	-1.94	2.38	-2.93
	$lnTR_t$	0	-1.75[b]	-3.52	0	-1.38[b]	-3.19	-1.84[b]	-3.52
	ΔlnY_t	1	-2.99[a]	-2.93	0	-2.90a	-1.94	-4.11[a]	-2.93
	$\Delta lnEC_t$	0	-3.85[a]	-2.93	0	-3.88[a]	-1.94	-3.84[a]	-2.93
	$\Delta lnTR_t$	0	-5.24[b]	-3.52	0	-5.36[b]	-3.19	-6.03[b]	-3.52
Colombia	lnY_t	0	-1.23[b]	-3.52	1	-1.93[b]	-3.19	-1.88[b]	-3.52
	$lnEC_t$	0	-1.78[a]	-2.93	0	-1.49[a]	-1.94	-1.87[a]	-2.93
	$lnTR_t$	0	-1.54[a]	-2.93	0	-1.39[a]	-1.94	-1.43[a]	-2.93
	ΔlnY_t	0	-4.64[b]	-3.52	0	-4.37[b]	-3.19	-4.60[b]	-3.52
	$\Delta lnEC_t$	0	-7.07[a]	-2.93	1	-3.36[a]	-1.94	-7.03[a]	-2.93
	$\Delta lnTR_t$	0	-7.33[a]	-2.93	0	-7.17[a]	-1.94	-7.50[a]	-2.93
Costa Rica	lnY_t	1	0.28[a]	-2.93	1	0.79[a]	-1.94	0.40	-2.93
	$lnEC_t$	0	-0.32[a]	-2.93	0	0.52[a]	-1.94	-0.38[a]	-2.93
	$lnTR_t$	0	-1.93[a]	-2.93	0	-1.75[a]	-1.94	-2.02[a]	-2.93
	ΔlnY_t	0	-3.99[a]	-2.93	0	-3.61[a]	-1.94	-3.77[a]	-2.93
	$\Delta lnEC_t$	0	-5.54[a]	-2.93	0	-5.53[a]	-1.94	-5.54[a]	-2.93
	$\Delta lnTR_t$	1	-5.44[a]	-2.93	1	-5.40[a]	-1.94	-5.96[a]	-2.93
Malaysia	lnY_t	0	-1.58[a]	-2.93	1	0.82[a]	-1.94	-1.54[a]	-2.93
	$lnEC_t$	0	-1.00[a]	-2.93	0	1.00[a]	-1.94	-1.55[a]	-2.93
	$lnTR_t$	1	-2.28[a]	-2.93	1	-1.04[a]	-1.94	-1.77[a]	-2.93
	ΔlnY_t	0	-5.56[a]	-2.93	0	-5.22[a]	-1.94	-5.53[a]	-2.93
	$\Delta lnEC_t$	0	-6.70[a]	-2.93	0	-6.31[a]	-1.94	-6.91[a]	-2.93
	$\Delta lnTR_t$	0	-5.05[a]	-2.93	0	-3.97[a]	-1.94	-5.05[a]	-2.93
Thailand	lnY_t	1	-1.26[a]	-2.93	1	0.14[a]	-1.94	-0.97[a]	-2.93
	$lnEC_t$	0	0.26[a]	-2.93	1	0.78[a]	-1.94	0.05[a]	-2.93

	$lnTR_t$	0	-1.20[a]	-2.93	0	0.27[a]	-1.94	-1.21[a]	-2.93
	ΔlnY_t	0	-3.93[a]	-2.93	0	-3.63[a]	-1.94	-3.93[a]	-2.93
	$\Delta lnEC_t$	0	-4.82[a]	-2.93	0	-4.78[a]	-1.94	-4.92[a]	-2.93
	$\Delta lnTR_t$	0	-6.91[a]	-2.93	0	-6.83[a]	-1.94	-6.91[a]	-2.93
Mexico	lnY_t	0	-2.21[a]	-2.93	0	0.08[a]	-1.94	-2.14[a]	-2.93
	$lnEC_t$	0	-3.07[b]	-3.52	0	-1.36[b]	-3.19	-2.99[b]	-3.52
	$lnTR_t$	0	-1.19[a]	-2.93	0	-0.03[a]	-1.94	-1.21[a]	-2.93
	ΔlnY_t	0	-5.06[a]	-2.93	0	-4.58[a]	-1.94	-4.99[a]	-2.93
	$\Delta lnEC_t$	0	-5.07[b]	-3.52	0	-5.05[b]	-3.19	-5.09[b]	-3.52
	$\Delta lnTR_t$	1	-5.86[a]	-2.93	1	-5.92[a]	-1.94	-7.62[a]	-2.93
Tunusia	lnY_t	0	-2.70[b]	-3.52	0	-2.16[b]	-3.19	-2.84[b]	-3.52
	$lnEC_t$	0	-3.34[b]	-3.52	1	-1.37[b]	-3.19	-3.24[b]	-3.52
	$lnTR_t$	0	-2.53[a]	-2.93	0	-0.71[a]	-1.94	-2.55[a]	-2.93
	ΔlnY_t	0	-8.95[b]	-3.52	0	-4.98[b]	-3.19	-8.70[b]	-3.52
	$\Delta lnEC_t$	0	-10.52[b]	-3.52	0	-10.27[b]	-3.19	-10.53[b]	-3.52
	$\Delta lnTR_t$	0	-5.96[a]	-2.93	0	-6.03[a]	-1.94	-5.99[a]	-2.93
Ecuador	lnY_t	0	-1.65[a]	-2.93	0	1.12[a]	-1.94	-1.66[a]	-2.93
	$lnEC_t$	0	-1.75[a]	-2.93	0	0.31[a]	-1.94	-1.76[a]	-2.93
	$lnTR_t$	0	-1.64[a]	-2.93	0	-0.68	-1.94	-1.54[a]	-2.93
	ΔlnY_t	0	-4.24[a]	-2.93	0	-4.28[a]	-1.94	-4.21[a]	-2.93
	$\Delta lnEC_t$	0	-6.46[a]	-2.93	0	-6.47[a]	-1.94	-6.46[a]	-2.93
	$\Delta lnTR_t$	0	-7.04[a]	-2.93	0	-7.01[a]	-1.94	-8.66[a]	-2.93
Jamaica	lnY_t	1	-1.67[a]	-2.93	1	-1.60[a]	-1.94	-1.28[a]	-2.93
	$lnEC_t$	1	-2.31[b]	-3.52	1	-2.35[b]	-3.19	-1.82[b]	-3.52
	$lnTR_t$	0	-2.90[b]	-3.52	0	-2.90[b]	-3.19	-2.75[b]	-3.52
	ΔlnY_t	0	-6.14[a]	-2.93	0	-2.41[a]	-1.94	-6.18[a]	-2.93
	$\Delta lnEC_t$	0	-4.77[b]	-3.52	0	-3.87[b]	-3.19	-4.76[b]	-3.52
	$\Delta lnTR_t$	1	-6.53[b]	-3.52	1	-6.62[b]	-3.19	-13.68[b]	-3.52
Peru	lnY_t	1	-0.41[a]	-2.93	1	-0.58[a]	-1.94	0.87[a]	-2.93
	$lnEC_t$	1	-1.05[a]	-2.93	1	-1.00[a]	-1.94	-1.10[a]	-2.93
	$lnTR_t$	0	-1.45[a]	-2.93	0	-1.45[a]	-1.94	-1.44[a]	-2.93
	ΔlnY_t	0	-3.79[a]	-2.93	0	-3.83[a]	-1.94	-3.77[a]	-2.93
	$\Delta lnEC_t$	0	-4.34[a]	-2.93	0	-4.20[a]	-1.94	-4.35[a]	-2.93
	$\Delta lnTR_t$	0	-5.53[a]	-2.93	0	-5.55[a]	-1.94	-5.88[a]	-2.93

Notes: [a] and [b] show the model with constant and constant-trend, respectively. The optimal lag length is selected using SBC.

In order to empirically examine the existence of a long run relationship between the variables, the ARDL cointegration method is applied. The bounds test uses the joint *F*-statistic. The optimal lag selection is based on SBC. The cointegration results are reported in Table 3. The bounds-*F* test results show that there exists the long-run relationship among the variables because *F*-statistic (6.71) is higher than the UCB value (5.85) at the 5 % level in China. In addition, the results also show that that there exists the long-run relationship betweent the variables because *F*-statistics (5.70; 5.23; 5.16; 5.61; 5.56) are higher than the UCB value (5.06) at the 10 % level in Turkey, Colombia, Ecuador, Jamaica and Peru, respectively. The results imply that there exists cointegration between the variables in these countries. The results also imply that there exists no cointegration between the varaibles in Costa Rica, South Africa, Malaysia, Thailand and Mexico. The diagnostic tests are also reported in Table 3.

Table 3. The Results of Bounds *F*-test for Cointegration

Panel A: Bounds testing to cointegration		
Country	*F*-statistics	Cointegration
Turkey	5.70*	Yes
China	6.71**	Yes
Colombia	5.23*	Yes
Costa Rica	4.69	No
South Africa	4.90	No
Malaysia	2.72	No
Thailand	4.82	No
Mexico	2.60	No
Ecuador	5.16*	Yes
Jamaica	5.61*	Yes
Peru	5.56*	Yes

Panel B: Peseran et al. (2001) critical value bounds of the *F*-statistic: unristricted intercept and unrestrected trend		
Significance level	Lower bounds, I(0)	Upper bounds, I(1)
1%	6.34	7.52
5%	4.87	5.85
10%	4.19	5.06

Panel C: Diagnostic tests	R^2	*F*-statistics	J-B normality	Ramsey RESET	ARCH LM	B-G LM
Turkey	0.82	10.98***	2.24 (0.32)	[2]: 0.14	[1]: 0.11	[2]: 0.12
China	0.72	2.72**	5.23 (0.07)	[1]: 0.69	[1]: 0.13	[1]: 0.18
Colombia	0.68	2.33**	1.72 (0.42)	[1]: 0.05	[1]: 0.54	[4]: 0.13
Costa Rica	0.85	4.16***	1.26 (0.53)	[1]: 0.00	[1]: 0.59	[1]: 0.46
South Africa	0.74	4.39**	3.82 (0.14)	[1]: 0.84	[1]: 0.72	[1]: 0.85
Malaysia	0.41	2.40**	1.54 (0.46)	[1]: 0.00	[1]: 0.34	[1]: 0.38
Thailand	0.84	5.88***	3.06 (0.21)	[2]: 0.18	[1]: 0.84	[1]: 0.71
Mexico	0.79	7.49**	3.47 (0.17)	[1]: 0.88	[1]: 0.95	[1]: 0.97
Tunusia	0.58	3.14***	1.44 (0.48)	[1]: 0.37	[3]: 0.16	[1]: 0.51
Ecuador	0.79	2.81**	0.75 (0.68)	[1]: 0.63	[1]: 0.27	[1]: 0.55
Jamaica	0.81	4.60***	7.93 (0.01)	[1]: 0.79	[1]: 0.29	[1]: 0.88
Peru	0.68	7.35***	1.52 (0.46)	[3]: 0.05	[1]: 0.27	[1]: 0.25

Notes: Figures in parentheses are probabilities. ***, ** and * denote the significant at 1 %, 5 % and 10 % level of significance, respectively.

The results of cointegration test used in the study indicate that the VECM Granger causality method can be used to examine the causal linkages between the variables for Turkey, China, Colombia, Malaysia, Ecuador, Jamaica and Peru.

The results of VECM Granger causality method are reported in Table 4. The results indicate that there exists the long-run bi-directional causality between economic growth and energy consumption in Turkey. In the long run, trade openness causes energy consumption and economic growth in Turkey. The results also indicate the presence of the long-run uni-directional causality from energy consumption and trade openness to economic growth in China, Colombia, Jamaica and Peru. For Ecuador, the bi-directional causality between energy consumption and trade openness is determined in the long run. It is also found that in the long run economic growth causes energy consumption and trade openness in Ecuador.

The study also presents the short-run causal links between the variables. Economic growth causes energy consumption and trade openness in Peru. Energy consumption causes economic growth in Colombia.

Table 4. The Results of VECM Granger Causality Analysis

Country	Short run causality (*F*-statistics)			Long run causality
	ΔlnY_t	$\Delta lnEC_t$	$\Delta lnTR_t$	ECT_{t-1} (*t*-statistics)
Turkey				
ΔlnY_t	-	0.87	0.58	-1.76*
$\Delta lnEC_t$	0.98	-	0.97	-1.77*
$\Delta lnTR_t$	1.20	0.30	-	1.128
China				
ΔlnY_t	-	0.16	0.03	-4.06***
$\Delta lnEC_t$	1.08	-	0.08	0.07
$\Delta lnTR_t$	0.71	0.15	-	-0.68
Colombia				
ΔlnY_t	-	3.84**	0.69	-2.06**
$\Delta lnEC_t$	1.49	-	0.06	0.45
$\Delta lnTR_t$	1.55	1.07	-	1.50
Ecuador				
ΔlnY_t	-	0.08	1.08	-0.56
$\Delta lnEC_t$	0.45	-	1.03	2.22**
$\Delta lnTR_t$	0.97	1.56	-	1.76*
Jamaica				
ΔlnY_t	-	0.65	0.62	-3.42***
$\Delta lnEC_t$	1.68	-	1.01	-0.51
$\Delta lnTR_t$	0.37	0.63		-1.38
Peru				
ΔlnY_t	-	0.53	1.54	-4.79***
$\Delta lnEC_t$	2.04**	-	0.04	-0.72
$\Delta lnTR_t$	2.28**	1.39	-	0.91

Notes: The model with constant is used for causality analysis. The optimal lag length is selected using SBC. ***, ** and * denote the significant at 1 %, 5 % and 10 % level of significance, respectively.

6. Conclusion

In recent years, the relationship between energy, trade and economic growth has been significantly discussed by theoretical and empirical studies. This study intensifies on the dynamic causal links among energy consumption, trade openness and economic growth for upper middle income countries over the period 1971-2014. After examining the unit root analysis, The ARDL bounds test is used to investigate cointegration between the variables. The Granger causality test based on VECM approach is also applied to examine the causal links between the variables.

The unit root test results show that the variables used in the study are integrated at $I(1)$. This implies that the ARDL bounds test can be employed to examine the presence of long run relationship between the variables. The ARDL bounds test results show that there exists cointegration between the variables in Turkey, China, Colombia, Ecuador, Jamaica and Peru. The VECM Granger causality results show that there exists the long-run bi-directional causality between economic growth and energy consumption in Turkey. In the long run, trade openness causes energy consumption and economic growth in Turkey. The results also indicate the presence of the long-run uni-directional causality from energy consumption and trade openness to economic growth in China, Colombia, Jamaica and Peru. For Ecuador, the bi-directional causality between energy consumption and trade openness is determined in the long run. It is also found that in the long run economic growth causes energy consumption and trade openness in Ecuador.

The results can present several implications for policymakers in these countries. The long-run causality from energy use and trade openness to economic growth corroborates the energy-led-growth and trade-led-growth hypotheses for Turkey, China, Colombia, Jamaica and Peru. In this

context, the governments should diversify energy resources and export partners to raise and sustain the rate of economic growth. For future research on the links between energy consumption, trade openness and economic growth, the number of countries and independent variables used in the study can be increased. In addition, more comparative analyses can be conducted. Finally, the long-run and short-run coefficients can be estimated through several econometric methods.

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