PANOECONOMICUS, 2024, Vol. 71, Issue 3, pp. 345-371
Received: 02 November 2021; Accepted: 17 October 2022.

UDC 330.34:338.2"1990/2019"
https://doi.org/10.2298/PAN211102024S
Original scientific paper

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Economic Growth, Energy Consumption, and Trade Openness Nexus: Evidence from Net Energy Importing Middle-Income Countries

Summary: The study explores both the long- and short-run liaisons between three conceptual dimensions: economic growth, energy consumption, and trade openness in 29 net energy importing middle-income economies using annual data from 1990 to 2019. We hereby assess ARDL models which examine the long-run links by integrations in between these three conceptual variables, and additionally Dumitrescu-Hurlin and Granger causality tests for panel and individual country models, respectively. For panel country samples, we reveal bidirectional causality connection between trade openness and economic growth along with unidirectional causalities from economic growth to energy consumption and from energy consumption to trade openness in the short-run. Bidirectional positive feedback relationships stand between economic growth - energy consumption and trade openness - energy consumption in the full sample and the upper middle-middle economies subsample in the long-run. Findings for individual country estimations reveal significant long-run relationships between energy consumption and economic growth in 12, energy consumption and trade openness in 6, and economic growth and trade openness in 9 of the middle-income economies examined.

Keywords: Economic growth, Energy consumption, Trade openness, Middle-income countries, Cointegration, Causality.

JEL: C22, C23, F14, Q43, O50.

Energy is a critical resource and a vital input factor in economic production activities as it eventually stimulates economic growth. The widely accepted argument for net energy importing low-income and middle-income countries, which are relatively more sensitive to fluctuations in energy prices, is that large amounts of energy import payments create unrelenting macroeconomic stress on these financially unstable economies. Therefore, understanding the economic growth-energy consumption nexus is especially essential for net energy importing low-income and middle-income countries, where the need to import energy may naturally pose unique economic challenges. In this context, the first intention of this study is to contribute to the economics literature by considering the link between energy consumption and economic growth focusing on net energy importing middle-income countries. The other phenomenon, which is frequently examined in the economics literature, is the economic growth and trade openness nexus. The effect of trade openness on growth can be either positive or negative especially in net energy importing low-income and middle-income countries. The second intention of this study is to explore the liaison between trade openness and economic growth in net energy importing middle-income countries. Whether the increase in trade causes an increase or a decrease in energy demand in net energy importing low-income and middle-income countries is another empirical question. However, the association between these variables in net energy importing low-income and middle-income countries remain as an understudied area. The last intention of this study is then to scrutinize the trade openness-energy consumption nexus in net energy importing middle-income countries.

We aim to add value to the existing literature by scrutinizing the liaisons in between economic growth, energy consumption, and trade openness with a particular focus on the net energy importing middle-income countries and to the potential policy implications which will add up the sustainability of their economic growth in the first place.

1. Conceptual Framework

It is prevalent in related literature that economic growth (*ecgrw*) drives energy consumption (*encon*), therefore energy consumption may determine the levels of economic growth as well. There are multiple assertions on the link between economic growth and energy consumption in the recent economics literature. Empirical studies performed to determine the causal relationship between *ecgrw* and *encon* are based on four hypotheses, namely growth, conservation, neutrality, and feedback hypothesis (James E. Payne 2010; Ilhan Ozturk and Ali Acaravci 2013). The unidirectional causality running from *encon* to *ecgrw* is discussed under the growth hypothesis where *encon* plays an important role in stimulating economic growth. Policies aiming to reduce energy consumption may have an adverse effect on *ecgrw*. The other unidirectional causality, this time from *ecgrw* to *encon*, is implied as the conservation hypothesis. In this hypothesis, it is argued that energy conservation policies will have no effect on *ecgrw*. The neutrality hypothesis assumes the absence of causal relationship between *ecgrw* and *encon*. Finally, the feedback hypothesis states the presence of a bidirectional causality between two variables. This hypothesis states that the reduction in energy supply for any reason will have a negative impact on the *ecgrw* which will result in lower energy demand (Emrah Beşe and Salih Kalayci 2021).

Trade openness (*trdop*) has a positive contribution to economic growth in several ways. Through technological progress and factor endowment, *trdop* enables a country to specialize in producing goods for which it has comparative advantage. Another expected effect of *trdop* is the increase in the market size and the lead in competition that allows for the efficient allocation of scarce resources. Moreover, *trdop* enables the transfer of managerial expertise and technical know-how from one country to another. In addition, investors from abroad can play an important role in providing positive net factor payments by participating in projects in the domestic country (Alexander Bilson Darku and Richard Yeboah 2018). Numerous theoretical and empirical studies in economics literature reveal that the expansion of trade improves economic growth indicators of an economy contributing to poverty reduction. Trade openness, which also increases energy use, is therefore considered a stimulus for economic activity (Perry Sadorsky 2012). However, *trdop* might have negative effects on economic growth in the economies which are not able to manufacture high quality products, or which have economies based on agriculture (Ricardo Haussmann, Jason Hwang, and Dani Rodrik 2007; Yaya Keho 2017).

The increase in international trade volume that emerges alongside openness in a country also upsurges economic activities and energy demand. Energy is eventually an essential input for machinery and equipment in the production process. Moreover, transportation of raw materials, parts, and finished products from one country to another requires energy. Inadequacy of energy supply may adversely affect *trdop* (Sadorsky 2012; Muhammad Shahbaz, Saleheen Khan, and Mohammad Iqbal Tahir 2013). The economic conditions of a country, the size of the *ecgrw*, and the *trdop* nexus are also among the determinants of the effect of *trdop* on *encon*. Theoretically, *trdop* impacts *encon*, whereas the feedback effect is not obvious. Trade openness and energy demand nexus emerges in terms of scale effect, technical effect, and composite effect. The scale effect is commonly referred to as the increase in domestic production leading to a shift in energy demand due to the expanded production. The determinants of the impact of *trdop* on *encon* are the economic conditions of the country and the association degree of the link between *trdop* and ecgrw. Trade openness enables developing economies to import modern technologies that will positively impact the manufacturing industry by lowering energy intensity and enabling more output to be produced. The transformation based on advanced technology in manufacturing is generally considered as the technical effect. The shift from agriculture to industry and from industry to services in an economy denote the composite effect. The increase in energy consumption is relatively less during the developments in the agricultural sector, which is accepted as the initial stages of economic development. As economic development shifts from agriculture to industry, the energy consumption level increases. Finally, economic development evolves from industry to services when *encon* is less (Shahbaz et al. 2014).

2. Empirical Literature

Although there has been extensive literature produced on the causal association between *ecgrw* and *encon* conflicting research results have emerged on the direction of causality. Jude C. Eggoh, Chrysost Bangake, and Christophe Rault (2011) focused on 21 African countries and their subgroups as net energy importing and net energy exporting economies. Panel test results of their study reveal a cointegrating relationship between real GDP and *encon* for both subgroups as well as for the whole sample. Kosta Josifidis, Radmila Dragutinović Mitrović, and Olgica Ivančev (2012) explored the heterogeneity of growth and estimated the growth determinants in the Western Balkan and Emerging European economies. The results indicated that trade openness had played an important role in boosting economic growth in both groups of countries from 1997 to 2009. Abdul Jalil (2014) investigated the association of *encon* and *ecgrw* in 19 net energy exporting and 29 net energy importing countries from 1970 to 2012 and observed unidirectional causality running from *encon* to *ecgrw* for net energy importing countries sample. Ömer Esen and Metin Bayrak (2017) examined the impacts of *encon* on *ecgrw* by using the data of 75 net energy-importing countries from 1990 to 2012. Evidence from the panel data and some individual country estimations reveal significantly positive log-run associations between *encon* and *ecgrw*. Afees Salisu et al. (2018) studied the relationship between *encon* and *ecgrw* in five oil exporting and six oil importing countries using annual data spanning throughout the years 1980-2014. The findings of the Panel ARDL estimations indicate a significantly positive influence of *ecgrw* on *encon* in the long-run both for the oil exporting and oil importing countries samples. Obindah Gershon, Nnaemeka Emmanuel Ezenwa, and Romanus Osabohien (2019) examined the impacts of oil price shocks on net oil-importing developing countries from 1980 to 2015. The findings obtained from the Granger causality test indicate that oil prices causes GDP *per capita* in Liberia and Sierra Leone. From the empirical analysis based VAR model and Impulse response, they found that, the increase in oil prices temporarily increases GDP *per capita* in the examined countries. Adem Üzümcü, Ülker Çam-Karakaş, and Adem Karakaş (2019) explored the association between the change in energy import and *ecgrw* within the context of energy consumption in the sample of 23 net energy importer developed and developing countries by employing panel cointegration and Granger causality tests. They found that a change in energy import increases *ecgrw* in a way that supports growth hypothesis, and the existence of bilateral causality between two variables confirming feedback hypothesis. Jeffrey Kouton (2019) analyzed the asymmetric heterogeneous association of *encon* and *ecgrw* by using the data of 19 African countries from 1971 to 2014. Empirical results indicate the existence of asymmetric association in the series both in the long-run and the short-run.

Although there are various studies investigating the relationship between *ecgrw*, *encon*, and *trdop* in net energy importing or developing countries, there is still a lack in the literature particularly focusing only on net energy importing low-income and/or middle-income economies. However, some country-specific or country-group studies presented in Table 1 explicitly include some of these countries.

The studies examining the tripartite association between *ecgrw*, *encon*, and *trdop*, which are few in the literature, are mainly based on three assumptions: the existence of bidirectional causality between any of the two variables; the presence of a unidirectional causality running from one of the variables to a variable remained; and non-existence of causal relationship between the variables (Sofien Tiba and Mohamed Frikh 2018). Ozturk and Acaravci (2013) explored the causal association between economic growth, energy consumption, trade, financial development, and carbon emissions in Turkey. The findings of the bounds F-test indicate the existence of long-run association between energy consumption, *per capita* real income, and openness. Phouphet Kyophilavong et al. (2015) analyzed the relationship between *ecgrw*, *encon*, and *trdop* in Thailand using annual data from 1971 to 2012. Bayer and Hanck cointegration test results of their study reveal that *encon* and *trdop* stimulate *ecgrw* in the long-run. The causality tests indicate that bidirectional causality exists between *ecgrw* and *encon*, and between *encon* and *trdop* in Thailand. Ramphul Ohlan (2018) tested the association between *ecgrw* and *encon* in India spanning from 1971 to 2016. The empirical estimations provide evidence that *ecgrw* is stimulated by *encon* in India.

Table 1 Literature Review Summary

	Author(s)	Methodology	Time interval	Country	Causality
Energy Consumption – Economic Growth Nexus	Apergis and Tang (2013)	Toda-Yamamoto-Dolado-Lütkepohl causality	1975-2007	Brazil, Chile, Congo Republic, Costa Rica, Dominican Republic, Guatemala, Honduras, India, Jamaica, Paraguay, Peru, Thailand, Turkey	*encon → ecgrw*
	Bozoklu and Yilanci (2013)	Granger causality	1970-2011	Turkey	*encon ≠ ecgrw*
	Tsangyao Chang, Hsiao-Ping Chu, and Wen-Yi Chen (2013)	Panel causality analysis	1970-2010	India	*ecgrw → encon*
				Thailand, Vietnam	*encon ↔ ecgrw*
				China	*encon ≠ ecgrw*
	Dinçer Dedeoğlu and Hüseyin Kaya (2013)	Granger causality	1980-2010	Chile	*encon ↔ ecgrw*
	Jalil and Mete Feridun (2014)		1952-2008	China	*encon → ecgrw*
	Ertugrul Yıldırım, Alper Aslan, and Ozturk (2014)	Granger causality	1971-2009	Thailand	*encon ↔ ecgrw*
	Yıldırım, Deniz Sukruoglu, and Aslan (2014)	The bootstrapped AR metric procedure, Granger non-causality test	1980-2011	Turkey	*ecgrw → encon*
				Bangladesh	*encon ≠ ecgrw*
	Jiahai Yuan, Yan Xu, and Xingping Zhang (2014)	Toda and Yamamoto causality	1953-2008	China	*encon ↔ ecgrw*
	Komain Jiranyakul (2016)	Granger causality test	2001-2014	Thailand	*encon ↔ ecgrw*
	Rodríguez-Caballeroa and Ventosa-Santaulària (2016)	Toda and Yamamoto causality	1971-2011	Costa Rica, Honduras, Paraguay	*encon → ecgrw*
				Panama	*ecgrw → encon*
				Brazil, Chile, El Salvador, Guatemala, Peru	*encon ↔ ecgrw*
	Baris Kablamaci (2017)	Toda and Yamamoto causality	1970-2013	Côte d'Ivoire, Guatemala, Honduras, India, Peru	*encon → ecgrw*
				Albania, Bulgaria, Chile, China, Democratic Republic of the Congo, Ghana, Jamaica, Myanmar, Nepal, Panama, Turkey, Zimbabwe	*ecgrw → encon*
				Brazil, El Salvador	*encon ↔ ecgrw*
				Benin, Costa Rica, Dominican Republic, Paraguay, Thailand	*encon ≠ ecgrw*
	Khalid M. Kisswani (2017)	Toda and Yamamoto causality	1971-2013	Thailand	*encon ↔ ecgrw*
	Eléazar Zerbo (2017)	ARDL, Toda and Yamamoto causality	1971-2013	Gabon	*encon → ecgrw*
				Benin, Côte d'Ivoire, Democratic Republic of the Congo, Ghana	*encon ≠ ecgrw*
	Michael Owusu Appiah (2018)	ARDL, Toda-Yamamoto and Granger causality	1960-2015	Ghana	*encon → ecgrw*
	Jianlin Wang, Jiajia Zhao, and Hongzhou Li (2018)	Granger causality	1992-2016	China	*ecgrw → encon*
	Rajesh Sharma and Pradeep Kautish (2019)	Granger causality	1980-2015	India	*ecgrw → encon*
	Abrham Tezera Gessesse and Ge He (2020)	ARDL, Granger causality	1971-2015	China	*encon ≠ ecgrw*
	Kamaljit Singh and SimmiVashishtha (2020)	Pairwise Granger causality tests	1970-2015	India	*ecgrw → encon*
	Gülfen Tuna and Vedat Ender Tuna (2020)	Hacker-Hatemi-J and Hatemi-J causality	1992-2015	Kyrgyzstan	*ecgrw → encon*
	Md. Monirul Islam and Md. Saiful Islam (2021)	ARDL, Toda-Yamamoto causality test		Bangladesh	*encon ↔ ecgrw*
	Zhang et al. (2021)	Panel causality	1990-2015	China, Hungary	*encon → ecgrw*
				India, Thailand, Ukraine	*ecgrw* → Energy

Trade Openness – Economic Growth Nexus	Akilou Amadou (2013)	Granger causality	1962-2005	Côte d'Ivoire	*trdop → ecgrw*
				Benin, Mali, Togo	*trdop ≠ ecgrw*
	Kojo Menyah et al. (2014)	Panel causality	1995-2005	Benin, Sierra Leone	*trdop → ecgrw*
				Madagascar	*ecgrw → trdop*
				Gabon	*trdop ↔ ecgrw*
				Burkina Faso, Burundi, Congo, Côte d'Ivoire, Gambia, Kenya, Togo	*trdop ≠ ecgrw*
	Qazi Muhammad Adnan Hye and Wee-Yeap Lau (2015)	ARDL, Granger causality test	1971-2009	India	*trdop → ecgrw*
	Jacob W. Musila and Zelealem Yiheyis (2015)	Granger causality	1982-2009	Kenya	*trdop → ecgrw*
	Keho (2017)	ARDL, Toda and Yamamoto, Granger causality	1965-2014	Côte d'Ivoire	*ecgrw → trdop*
	Hong Xie et al. (2018)	ARDL, Granger causality	1978-2015	China	*trdop ↔ ecgrw*
Energy Consumption – Trade Openness Nexus	Shahbaz et al. (2014)	Homogenous and non-homogenous causality analysis	1980-2010	Albania, Bangladesh, Benin, Peru	*trdop → encon*
				Brazil, Chile, Costa Rica, Côte d'Ivoire, Gabon, Ghana, Guatemala, India, Turkey	*encon → trdop*
				Honduras, Jamaica, Panama, Paraguay, Togo	*trdop ↔ encon*
				Bulgaria, Congo Dem Rep., Dominican Republic, Ecuador, El Salvador, Hungary, Kenya, Mozambique, Nepal, Thailand, Zimbabwe	*trdop ≠ encon*

Notes: →, ↔, and ≠ stand for unidirectional causality, bidirectional causality, and no causality, respectively.

Source: Authors' compilation.

3. Research Methodology

3.1 Data

This empirical study examines annual time serial data on net energy importing middle-income economies over the period 1990-2019. According to the Umar Serajuddin and Nada Hamadeh 2020), 29 economies are lower income, 50 are lower middle-income, and 56 are upper middle-income. Low-income countries are not included in the study due to the absence of available data. The World Bank data is used to determine the net energy importing countries. Based on data availability, the final dataset includes 29 middle-income countries of which 11 are lower middle-income (Bangladesh, Benin, Côte d'Ivoire, El Salvador, Ghana, Honduras, India, Kyrgyz Republic, Pakistan, Ukraine, Zimbabwe) and 18 are upper middle-income economies (Albania, Belarus, Brazil, Bulgaria, China, Costa Rica, Cuba, Dominican Republic, Guatemala, Jamaica, Jordan, Lebanon, Namibia, Panama, Paraguay, Peru, Thailand, Turkey). Data relating to economic growth, energy, trade, capital, and labor was obtained from the World Development Indicators database of the World Bank (2021)[1] (Table 2).

[1] **World Bank.** 2021. World Development Indicators. https://databank.worldbank.org/source/world-development-indicators (accessed September 01, 2021).

Table 2 Descriptions of Variables

Variables	Code	Description
Economic growth	*ecgrw*	Gross domestic product per capita (constant 2010 USD).
Energy consumption	*encon*	Energy use (kg of oil equivalent per capita).
Trade openness	*trdop*	The share of the sum of exports and imports of goods and services in gross domestic product.
Gross fixed capital formation	*gfcaf*	The ratio of spending on land improvements; construction of roads, canals and railways, residential commercial and industrial buildings; purchases of plant, machinery, and equipment to GDP (constant 2010 USD).
Labor force participation	*lbfop*	The proportion of the country's working-age (15-64) population that is economically active.

Source: Authors' compilation based on data from the World Bank (2021).

3.2 Estimating Models

Theoretical discussions and the findings of econometric studies summarized in the previous section reveal evidence that energy consumption and trade openness have roles in stimulating economic growth. We assume that the Cobb-Douglas production function (C-D) can capture the relationship between these variables. The most standard form of the C-D is:

$$Y = AK^{\beta_1}L^{\beta_2}e^{u_t}, \tag{1}$$

where Y, A, K, L and e represent the total production, total factor productivity, capital, labor, and white noise, respectively. The model is expanded to include *encon* and *trdop* by taking inference from theories and existing empirical studies asserting that energy consumption and trade play vital roles in economic growth, both directly and as a complement to labor and capital in the production process.

$$Y = AK^{\beta_1}L^{\beta_2}encon^{\beta_3}trdop^{\beta_4}e^{u_t}. \quad (,2)$$

The final augmented C-D of the study is constructed as in Equation (3) by including *ecgrw*, *gfcaf* and *lbfop* instead of Y, AK, and L, respectively, where variables are converted into natural logarithms:

$$lnecgrw_{i,t} = \beta_0 + \beta_1 lnencon_{i,t} + \beta_2 lntrdop_{i,t} + \beta_3 lngfcaf_{i,t} + \beta_4 lnlbfop_{i,t} + u_{i,t}, \tag{3}$$

where $\beta_0 = lnA_0$ is the constant term, β_i (i = 1, 2, 3, 4, 5) is the parameter that needs to be estimated. u and t represent the error term and the year respectively. i indicates the country in single country estimations and the country index in panel data form. Within the framework of the ARDL approach, the Equation (3) is modelled for each dependent variable as:

Model-1

$$\Delta lnecgrw_t = \beta_0 + \sum_{e=1}^{a1} \beta_{2e} \Delta lnencon_{t-e} + \sum_{f=1}^{b1} \beta_{3f} \Delta lntrdop_{t-f} + \sum_{g=1}^{c1} \beta_{3g} \Delta lngfcaf_{t-g} + \sum_{h=1}^{d1} \beta_{3h} \Delta lnlbfop_{t-h} + \lambda_1 lnencon_{t-1} + \lambda_2 lntrdop_{t-1} + \lambda_3 lngfcaf_{t-1} + \lambda_4 lnlbfop_t + u_t; \tag{4}$$

Model-2

$$\Delta lnencon_t = \beta_0 + \sum_{e=1}^{a1} \beta_{2e} \Delta lnecgrw_{t-e} + \sum_{f=1}^{b1} \beta_{3f} \Delta lntrdop_{t-f} + \sum_{g=1}^{c1} \beta_{3g} \Delta lngfcaf_{t-g} + \sum_{h=1}^{d1} \beta_{3h} \Delta lnlbfop_{t-h} + \lambda_1 lnecgrw_{t-1} + \lambda_2 lntrdop_{t-1} + \lambda_3 lngfcaf_{t-1} + \lambda_4 lnlbfop_t + u_t; \quad (5)$$

Model-3

$$\Delta lntrdop_t = \beta_0 + \sum_{e=1}^{a1} \beta_{2e} lnecgrw_{t-e} + \sum_{f=1}^{b1} \beta_{3f} lnencon_{t-f} + \sum_{g=1}^{c1} \beta_{3g} lngfcaf_{t-g} + \sum_{h=1}^{d1} \beta_{3h} lnlbfop_{t-h} + \lambda_1 lnecgrw_{t-1} + \lambda_2 lnencon_{t-1} + \lambda_3 lngfcaf_{t-1} + \lambda_4 lnlbfop_t + u_t. \quad (6)$$

The panel ARDL representations of the models are formulated as follows:

Model-1

$$\Delta lnecgrw_{i,t} = \beta_0 + \sum_{e=1}^{a1} \beta_{2e} \Delta lnencon_{i,t-e} + \sum_{f=1}^{b1} \beta_{3f} \Delta lntrdop_{i,t-f} + \sum_{g=1}^{c1} \beta_{3g} \Delta lngfcaf_{i,t-g} + \sum_{h=1}^{d1} \beta_{3h} \Delta lnlbfop_{i,t-h} + \lambda_1 lnencon_{i,t-1} + \lambda_2 lntrdop_{i,t-1} + \lambda_3 lngfcaf_{i,t-1} + \lambda_4 lnlbfop_{i,t} + u_{i,t}; \quad (7)$$

Model-2

$$\Delta lnencon_{i,t} = \beta_0 + \sum_{e=1}^{a1} \beta_{2e} \Delta lnecgrw_{i,t-e} + \sum_{f=1}^{b1} \beta_{3f} \Delta lntrdop_{i,t-f} + \sum_{g=1}^{c1} \beta_{3g} \Delta lngfcaf_{i,t-g} + \sum_{h=1}^{d1} \beta_{3h} \Delta lnlbfop_{i,t-h} + \lambda_1 lnecgrw_{i,t-1} + \lambda_2 lntrdop_{i,t-1} + \lambda_3 lngfcaf_{i,t-1} + \lambda_4 lnlbfop_{i,t} + u_{i,t}; \quad (8)$$

Model-3

$$\Delta lntrdop_{i,t} = \beta_0 + \sum_{e=1}^{a1} \beta_{2e} lnecgrw_{i,t-e} + \sum_{f=1}^{b1} \beta_{3f} lnencon_{i,t-f} + \sum_{g=1}^{c1} \beta_{3g} lngfcaf_{i,t-g} + \sum_{h=1}^{d1} \beta_{3h} lnlbfop_{i,t-h} + \lambda_1 lnecgrw_{i,t-1} + \lambda_2 lnencon_{i,t-1} + \lambda_3 lngfcaf_{i,t-1} + \lambda_4 lnlbfop_{i,t} + u_{i,t}. \quad (9)$$

3.3 Econometric Methodology

Testing for unit root in the data is considered as the natural start of any cointegration or causality analyses method using time series. Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) conventional unit root tests were performed to examine the stationarity of the individual country data series. However, applying the stationary method without considering the cross-sectional dependence may cause biased estimation analysis in panel data. Therefore, it is important to conduct the cross-section dependence (C-D) test for panel datasets (M. Hashem Pesaran 2006). A second-generation panel unit root test (CIPS), and Levin-Lin-Chu, (LLC), Im-Pesaran-Shin (IPS), Fisher-ADF and Fisher-PP first-generation panel unit root tests were utilized to determine the integration order of variables in panel settings. Another requirement is the evaluation of optimal lag lengths since autoregressive models are sensitive to the number of lags. This study chose the optimal length lags by means of the Schwarz information criterion.

ARDL bounds test F-statistic was used to see whether a cointegration relationship existed between variables in the individual country models. The ARDL cointegration approach of Pesaran and Yongcheol Shin (1999) and Pesaran, Shin, and Richard J. Smith (2001), which has some advantages over conventional cointegration techniques, was preferred to capture the long-run association between variables. One of the major benefits of this approach is that the variables may have different optimal lags and it employs a single reduced form equation. Furthermore, entirety of the series in the model does not need to be of equal order of integration. However, the critical values for bound test to cointegration (Pesaran, Shin, and Smith 2001; Paresh Kumar Narayan 2005) will not be valid if the order of integration of one of the variables to be used in the analyses is two or greater. When calculating the first bound, it was assumed that all variables in the ARDL model were integrated of zero order (I(0)). The calculation of the second bound is done under the assumption that the variables are integrated in the first order (I(1)). The robustness of the estimated individual country ARDL models were examined by utilizing Breusch-Godfrey to test for autocorrelation in the errors in the models by Breusch-Pagan-Godfrey to measure how errors increase across the explanatory variables, by Jarque-Bera to confirm normality, and by CUSUM and CUSUM square to monitor the stability of parameters. For panel ARDL models, the Hausman Test (Jerry A. Hausman 1978) was conducted to decide between the Mean Group (MG) and Pooled Mean Group (PMG) estimators. PMG estimations are considered as more efficient than MG if the parameters are homogeneous. The h_0 of the Hausman Test between MG and PMG is that both MG and PMG are consistent, while MG is inefficient against the h_1 of PMG being consistent. In other words, MG is used in panel ARDL estimations if the outcome of the Hausman Test gives a *p*-value greater than 0.05, while PMG is preferred if the test statistic is significant at 0.05 level.

Finally, causality tests were employed to capture the direction of the association between series in the short-run. If the findings of cointegration tests reveal long-run equilibrium relationships, then there must be a unidirectional or a bidirectional causality between the variables (Robert F. Engle and Clive W. J. Granger 1987). Granger Pairwise Causality test was employed to see the cause and effect between *ecgrw*, *encon*, and *trdop* series of individual countries. For panel series, Dumitrescu and Hurlin causality test was preferred. The methodology proposed by Elena-Ivona Dumitrescu and Christophe Hurlin (2012) proceeds by testing the Homogeneous Non-Causality hypothesis where h_0 is rejected if a causal link exists between two variables in the cross-section units of the panel.

4. Empirical Results

4.1 Panel Models

Before employing unit root tests, the presence of cross-sectional dependence in panels was explored by utilizing the C-D test. Based on the results (Appendix Table A1), the null hypothesis of no cross-sectional dependence was rejected in all models. Therefore, CIPS panel unit root test was conducted alongside the first-generation unit root tests LLC, IPS, ADF-Fisher and PP-Fisher. The findings revealed that the variables were I(0) or I(1) and did not have order two of integration (Appendix Table A2). Furthermore, Hausman test was employed to see whether group means were consistent. The test results for Panel-1 (χ^2= 28.196, p = 0.042), Panel-2 (χ^2 = 22.016, p = 0.044), and

Panel-3 (χ^2 = 31.046, p = 0.000) revealed that PMG was consistent for panel ARDL estimations. Alongside the Hausmann Test, we performed PMG-ARDL in which h_0 of no cointegration against h_1 of cointegration was tested to capture the existence of the cointegrated combination of the series. The findings of PMG-ARDL estimations (Table 3) show that *ecgrw* is significantly and positively influenced by both *encon*, and *trdop* in Panel-1 and Panel-3 in the long-run. However, for Panel-2, which includes lower middle-income countries, it was observed that neither *encon* nor *trdop* have significant impact on *ecgrw* in the long-run. In Model-2, where *encon* is the dependent variable, the long-run effect of *ecgrw* on *encon* is significant and positive in all panels as it was expected. The impact of *trdop* on *encon* was significantly negative in Panel-3. It was determined from the Panel-1 PMG-ARDL estimations that *trdop* is significantly negatively affected by *ecgrw* in the long-run. For all the panels, test results show that *encon* had significantly positive effect on *trdop* in the long-run.

Table 3 PMG-ARDL Long-Run Coefficients

	Time interval	Selected model	*lnecgrw*	*lnencon*	*lntrdop*
Panel-1	1991-2014	Model 1 (1, 1, 1)	–	2.541 S5	2.345 S5
		Model 2 (1, 1, 1)	8.669 S1	–	–0.414
		Model 3 (1, 1, 1)	–1.991 S5	5.548 S1	–
Panel-2	1991-2014	Model 1 (1, 1, 1)	–	1.557	–1.825
		Model 2 (1, 1, 1)	14.174 S1	–	1.643
		Model 3 (1, 1, 1)	0.300	2.883 S1	–
Panel-3	1991-2014	Model 1 (1, 1, 1)	–	5.784 S1	4.416 S1
		Model 2 (1, 1, 1)	11.858 S1	–	–3.171 S1
		Model 3 (1, 1, 1)	–1.715	5.066 S1	–

Notes: The dependent variable is *ecgrw*, *encon*, and *trdop* in Model-1, Model-2 and Model-3 respectively. The maximum lag lengths presented in parentheses are selected by Schwarz information criterion. S1 and S5 indicate statistical significance at 0.01 and 0.05 level respectively.

Source: Authors' calculations.

Finally, the Dumitrescu and Hurlin heterogeneous panel causality tests were employed on each panel to capture the short-run causal relationship between *ecgrw*, *encon*, and *trdop*. The findings indicate unidirectional causality running from *ecgrw* to *encon* and running from *encon* to *trdop* for all-panel samples. It was revealed that bi-directional causality exists between *ecgrw* and *trdop* for net energy importing upper middle-income countries sample and for the full sample, while no significant causality relationship was captured between *ecgrw* and *trdop* for the sample including lower middle-income economies. However, the results do not validate causality running from *encon* to *ecgrw* and from *trdop* to *encon* for any of the panel samples in the short-run (Table 4).

Table 4 Dumitrescu and Hurlin Panel Causality Test Results

	H_0	W	Zbar	Prob.	Causality direction
Panel-1	*ENC ≠ >EGR*	3.174	1.885	0.059	*ecgrw → encon*
	EGR ≠ >ENC	4.470	4.578	0.000	
	TOP ≠ >EGR	3.993	3.586	0.000	*ecgrw ↔ trdop*
	EGR ≠ >TOP	5.925	7.601	0.000	
	TOP ≠ >ENC	2.755	1.015	0.310	*encon → trdop*
	ENC ≠ >TOP	7.077	9.993	0.000	
Panel-2	*ENC ≠ >EGR*	2.928	0.846	0.398	*ecgrw → encon*
	EGR ≠ >ENC	5.454	4.078	0.000	
	TOP ≠ >EGR	3.295	1.315	0.188	*ecgrw ≠ trdop*
	EGR ≠ >TOP	3.727	1.869	0.062	
	TOP ≠ >ENC	2.201	–0.083	0.934	*encon → trdop*
	ENC ≠ >TOP	4.874	3.336	0.001	
Panel-3	*ENC ≠ >EGR*	3.324	1.731	0.083	*ecgrw → encon*
	EGR ≠ >ENC	3.869	2.623	0.009	
	TOP ≠ >EGR	4.419	3.523	0.000	*ecgrw ↔ trdop*
	EGR ≠ >TOP	7.269	8.187	0.000	
	TOP ≠ >ENC	3.094	1.354	0.176	*encon → trdop*
	ENC ≠ >TOP	8.423	10.076	0.000	

Notes: H_0: x does not homogeneously cause y (x ≠ > y). →, ↔, and ≠ represent unidirectional causality, bidirectional causality, and no causality respectively.

Source: Authors' calculations.

4.2 Individual Country Models

The ARDL cointegration approach has the advantage of incorporating I(0) and I(1) variables in the same estimation. However, if any variable has second-order integration, the generated F-statistics will be invalid in examining the cointegration relationship. In this context, we first explored the stationarity of the series of each country *via* the ADF and PP tests. The findings imply that the variables do not have second-order integration except the series of Bangladesh, Belarus, China, Côte d'Ivoire, Cuba, Ghana, Kyrgyz Republic, and Ukraine (Appendix Table A3). Following unit root tests, the estimated equations were tested to see how robust they were. Results reveal that individual country models passed diagnostic tests except Benin, Bulgaria, Costa Rica, Dominican Republic, El Salvador, Jamaica, Lebanon, Namibia, Pakistan, and Peru in Model-1; Benin, Lebanon, Namibia, and Panama in Model-2; and Benin, Costa Rica, Dominican Republic, Honduras, India, Lebanon, Panama, Peru, and Zimbabwe in Model-3. Diagnostic test findings are presented in Appendix Table A4. The charts showing the results of CUSUM and CUSUM-Square tests within the critical bounds of 5 percent level of significance are available on request from the corresponding author.

An ARDL Bounds test was employed on the models to see the cointegration association between the series for the models: (i) which had variables to have different integration order I(0), I(1), or a combination of both; and (ii) passed diagnostic tests. The F-statistic of Model-2 for Bulgaria and Costa Rica, and Model-3 for Brazil and Paraguay, which were falling below the lower bound, indicate that cointegration is not possible for these models of the above-mentioned countries. The F-statistic of Model-1 for Guatemala and Thailand; and Model-2 for El Salvador, Jamaica, and Jordan;

Model-3 for Jordan was falling between the bounds, so conclusion was made that cointegration in these models is inconclusive. The F-statistic of the rest of the models was exceeding the upper bound which means that a cointegration relationship exists between series (Table 5). In other words, when *ecgrw* was considered as the dependent variable, a cointegration relationship was found between *encon*, *trdop*, *gfcaf* and *lbfop* for Albania, Brazil, Honduras, India, Jordan, Panama, Paraguay, Turkey and Zimbabwe. In the model where *encon* was the dependent variable, a cointegration relationship between the variables was observed for Albania, Brazil, Dominican Republic, Guatemala, Honduras, India, Pakistan, Paraguay, Peru, Thailand, Turkey, and Zimbabwe. It was determined that cointegration exists between variables for Albania, Bulgaria, El Salvador, Guatemala, Jamaica, Namibia, Pakistan, Thailand, and Turkey in the model where *trdop* was the dependent variable.

Table 5 ARDL Bounds Test F-statistics for Individual Country Models

	Model-1	Model-2	Model-3		Model-1	Model-2	Model-3
Albania	94.969 ^{S1}	23.192 ^{S1}	14.931 ^{S1}	Bulgaria	–	2.189	7.972 ^{S1}
Brazil	17.822 ^{S1}	8.295 ^{S1}	2.067	Costa Rica	–	2.357	–
Dominican R.	–	16.638 ^{S1}	–	El Salvador	–	3.710	4.885 ^{S5}
Guatemala	3.113	5.550 ^{S5}	5.048 ^{S5}	Honduras	10.348 ^{S1}	6.740 ^{S1}	–
India	41.460 ^{S1}	15.194 ^{S1}	–	Jamaica	–	3.115	11.821 ^{S1}
Jordan	13.630 ^{S1}	3.698	3.086	Namibia	–	–	8.809 ^{S1}
Pakistan	–	22.115 ^{S1}	8.477 ^{S1}	Panama	15.071 ^{S1}	–	–
Paraguay	7.898 ^{S1}	5.151 ^{S5}	2.623	Peru	–	5.995 ^{S1}	–
Thailand	3.177	4.674 ^{S5}	4.707 ^{S5}	Turkey	14.316 ^{S1}	11.095 ^{S1}	3.898 ^{S5}
Zimbabwe	5.981 ^{S1}	20.918 ^{S1}	–				

Notes: Critical values for finite sample *n* =30 are I (0) = 3.058, I (1) = 4.223 at 0.05 significance level, and I (0) = 4.280, I (1) = 5.840 at 0,01 significance level. ^{S1} and ^{S5} stand for statistical significance at 0.01 and 0.05 level respectively.

Source: Authors' calculations.

After identifying the existence of cointegration relationships, we explored the long-run equilibrium association between the variables. The results of the ARDL bounds test presented in Table 6 show that the variables are significantly cointegrated with all cointegrating vectors: (i) between *ecgrw* and *encon* in Albania, Brazil, Honduras, India, Jordan, Pakistan, Panama, Paraguay, Peru, Thailand, Turkey and Zimbabwe; (ii) between *ecgrw* and *trdop* in Albania, Bulgaria, Guatemala, Jamaica, Pakistan, Panama, Paraguay, Thailand and Zimbabwe; (iii) between *encon* and *trdop* in Albania, Bulgaria, India, Pakistan, Thailand and Zimbabwe.

Table 6 ARDL Long-Run Coefficients

Country	Time interval	Selected model	*lnecgrw*	*lnencon*	*lntrdop*
Albania	1992-2014	Model-1 (1, 1, 3)	–	2.805 S1	8.476 S1
		Model-2 (1, 3, 3)	3.611 S5	–	–2.461 S5
		Model-3 (3, 1, 1)	4.169 S1	–0.666	–
Brazil	1990-2019	Model-1 (2, 3, 0)	–	32.226 S1	1.244
		Model-2 (1, 1, 0)	55.177 S1	–	–1.030
Bulgaria	1991-2019	Model-3 (1, 3, 1)	4.798 S1	2.562 S5	–
Dominican Rep.	1990-2016	Model-2 (3, 3, 3)	0.638	–	0.669
El Salvador	1991-2016	Model-3 (2, 3, 3)	–0.178	2.501	–
Guatemala	1991-2016	Model-2 (1, 0, 0)	2.229	–	–0.866
		Model-3 (2, 3, 2)	4.255 S1	–2.117	–
Honduras	1991-2016	Model-1 (2, 3, 0)	–	3.088 S5	0.502
		Model-2 (3, 0, 0)	13.187 S1	–	0.859
India	1991-2019	Model-1 (1, 0, 0)	–	2.060	–1.394
		Model-2 (1, 3, 0)	27.536 S1	–	3.507 S1
Jamaica	1991-2016	Model-3 (1, 2, 3)	11.071 S1	1.676	–
Jordan	1990-2016	Model-1 (2, 2, 0)	–	24.621 S1	1.476
Namibia	1991-2014	Model-3 (2, 1, 0)	1.824	–0.691	–
Pakistan	1990-2014	Model-2 (3, 3, 2)	15.305 S1	–	10.220 S1
		Model-3 (2, 3, 1)	6.567 S1	4.547 S1	–
Panama	1990-2014	Model-1 (3, 1, 2)	–	8.735 S1	2.974 S5
Paraguay	1990-2014	Model-1 (3, 0, 3)	–	3.439 S1	–8.013 S1
		Model-2 (1, 0, 0)	1.754	–	1.990
Peru	1990-2014	Model-2 (1, 2, 1)	12.567 S1	–	–1.623
Thailand	1992-2019	Model-2 (3, 3, 3)	36.210 S1	–	5.334 S1
		Model-3 (1, 2, 1)	–4.400 S1	4.734 S1	–
Turkey	1991-2019	Model-1 (2, 0, 1)	–	7.829 S1	1.173
		Model-2 (1, 0, 0)	11.010 S1	–	0.007
		Model-3 (2, 0, 0)	–0.027	0.691	–
Zimbabwe	1990-2014	Model-1 (2, 1, 2)	–	3.229 S1	2.324 S5
		Model-2 (1, 2, 2)	2.917 S5	–	–7.324 S1

Notes: The maximum lag lengths presented in parentheses are selected by Schwarz information criterion. S1 and S5 indicate statistical significance at 0.01 and 0.05 level respectively.

Source: Authors' calculations.

Furthermore, Granger causality tests were employed to capture the causality relationship between the variables. We found unidirectional causality running from *encon* to *ecgrw* for Panama and Thailand; from *ecgrw* to *encon* for Brazil, Honduras, and Panama; from *ecgrw* to *encon* for Brazil, Honduras and Panama; from *ecgrw* to *trdop* for Albania, Bulgaria, Jamaica and Turkey; from *trdop* to *encon* for Brazil and *encon* to *trdop* for Albania. The absence of causality running from trade openness to economic growth observed for the entirety of countries (Table 7). The findings partially confirm the results of Nicholas Apergis and Chor Foon Tang (2013), Seref Bozoklu and Veli Yilanci (2013), Shahbaz et al. (2014), Carlos Vladimir Rodríguez-Caballeroa and Daniel Ventosa-Santaulària (2016) and Haonan Zhang et al. (2021).

Table 7 Pairwise Granger Causality Test Results

	F-stat.	Causality direction		F-stat.	Causality direction
Albania	1.230	*ecgrw ≠ encon*	Brazil	4.440 [S5]	*ecgrw → encon*
	26.592 [S1]	*ecgrw → trdop*		0.518	*ecgrw ≠ trdop*
	51.443 [S0]	*encon → trdop*		5.139 [S5]	*trdop → encon*
Bulgaria	0.179	*ecgrw ≠ encon*	Dominican Republic	0.814	*ecgrw ≠ encon*
	7.026 [S1]	*ecgrw → trdop*		2.847	*ecgrw ≠ trdop*
	0.118	*encon ≠ trdop*		1.395	*encon ≠ trdop*
El Salvador	3.152	*ecgrw ≠ encon*	Guatemala	1.016	*ecgrw ≠ encon*
	0.562	*ecgrw ≠ trdop*		1.138	*ecgrw ≠ trdop*
	0.134	*encon ≠ trdop*		0.303	*encon ≠ trdop*
Honduras	6.307 [S1]	*ecgrw → encon*	India	2.497	*ecgrw ≠ encon*
	1.190	*ecgrw ≠ trdop*		0.029	*ecgrw ≠ trdop*
	2.254	*encon ≠ trdop*		0.025	*encon ≠ trdop*
Jamaica	0.574	*ecgrw ≠ encon*	Jordan	0.193	*ecgrw ≠ encon*
	11.836 [S1]	*ecgrw → trdop*		0.828	*ecgrw ≠ trdop*
	2.481	*encon ≠ trdop*		1.624	*encon ≠ trdop*
Namibia	3.275	*ecgrw ≠ encon*	Pakistan	2.605	*ecgrw ≠ encon*
	3.361	*ecgrw ≠ trdop*		2.054	*ecgrw ≠ trdop*
	1.267	*encon ≠ trdop*		0.269	*encon ≠ trdop*
Panama	3.697 [S5]	*ecgrw → encon*	Paraguay	7.911 [S1]	*encon → ecgrw*
	0.111	*ecgrw ≠ trdop*		1.454	*ecgrw ≠ trdop*
	0.239	*encon ≠ trdop*		1.509	*encon ≠ trdop*
Peru	2.850	*ecgrw ≠ encon*	Thailand	4.470 [S5]	*encon → ecgrw*
	0.352	*ecgrw ≠ trdop*		0.678	*ecgrw ≠ trdop*
	2.039	*encon ≠ trdop*		0.985	*encon ≠ trdop*
Turkey	2.312	*ecgrw ≠ encon*	Zimbabwe	3.277	*ecgrw ≠ encon*
	3.504 [S5]	*ecgrw → trdop*		0.941	*ecgrw ≠ trdop*
	5.048	*encon ≠ trdop*		0.692	*encon ≠ trdop*

Notes: → and ≠ represent unidirectional causality and no causality respectively. [S1] and [S5] indicate statistical significance at 0.01 and 0.05 level respectively.

Source: Authors' calculations.

5. Discussion

The PMG-ARDL and Dumitrescu-Hurlin causality test results indicate the presence of cointegration and causal relationship among economic growth, energy consumption, and trade openness in all panels. Although the bidirectional positive feedback relationships stand between economic growth and energy consumption in the long-run in the full sample and in the upper middle-middle economies subsample, there are short-run unidirectional causalities running from economic growth to energy consumption in these samples. The findings for the full sample and the upper middle-middle economies subsample express that policies to reduce energy consumption in the long-run may have negative effects on economic activity and may lead to further reduction in energy consumption. The results imply divergences in the lower middle-middle economies subsample indicating a unidirectional causality running from economic growth to energy consumption both in the long- and short-run. Conservation hypothesis suggests that energy conservation policies, which may have no or little adverse effects on the economic growth is valid in the long- and short-run for net energy importing lower middle-income countries, and in the short-run for net energy importing upper middle-income economies.

Although the results show that economic growth and trade openness are impacting each other both in the short- and long-run in the full sample, the causal relationship between these two variables has been proven to be nonexistent for net energy importing lower middle-income countries. Although trade openness appears to be a significant contributor to the economic growth of upper middle-income net energy importing countries in the long-run, bidirectional causality relationship exists in the short-run.

The results show that there is a unidirectional relationship from energy consumption to trade openness in the short-run in all panel samples. Whereas a long-run bidirectional feedback relationship stands between energy consumption and trade openness for the net energy importing upper middle-income countries sample, there is a long-run unidirectional causality showing that energy consumption stimulates trade openness in the net energy importing lower middle-income economies. Short-run unidirectional causal relationship running from economic growth to energy consumption and from energy consumption to trade openness in upper middle-income countries imply that economic growth increases the energy consumption and energy consumption boosts trade openness.

Panel data techniques are advantageous because of the increase in data points, and thus the power of statistical estimation. On the other hand, countries are not treated as independent units and differences between these countries are neglected in panel models. Because the relationship between the variables are strongly dependent on the economic structure, geographic and geological endowments, and institutional design of each country as well as the level of energy conservation and trade openness may differ between net energy importing middle-income countries, the policy implications to be proposed should be based on individual country estimations. Thus, we individually examined the relationship between economic growth, energy consumption and trade openness for net energy importing middle-income countries. Although the full panel includes 29 countries, the ARDL bounds tests for cointegration and the Granger causality tests are applied to the series of 18 net energy importing middle-income economies because the estimated models of 11 countries do not meet the requirements of robustness criteria.

The ARDL estimation findings for individual countries reveal a bidirectional relationship between the energy consumption and economic growth in the long-run in Albania, Brazil, Honduras, Turkey, and Zimbabwe. Because of the feedback effect between the economic growth and energy consumption in the long-run, we recommend that policymakers prioritize the provision of adequate and efficient energy supply by exploring and investing, inter alia, new and alternative sources of energy in these countries.

Unidirectional relationship from economic growth to energy consumption findings reveal that higher energy consumption comes with higher economic growth in India, Pakistan and Peru in the long-run, and in Brazil and Honduras in the short-run. We suggest that policymakers design energy-saving policies and take actions to support the efficient use of energy in these countries because the policies that aim to reduce the energy consumption might have little or no impact on economic growth.

The findings for Paraguay both in the short and long-run, and for Jordan in the long-run support the growth hypothesis, which means that a unidirectional causality relationship exists, running from energy consumption to economic growth. This hypothesis considers energy use as one of the engines of economic growth. The explicit unidirectional causality implies that policies aimed at reducing energy consumption may have negative effects on economic growth in Paraguay and Jordan.

The findings of this study reveal a reverse association between the economic growth and energy consumption in the short- and long-run in Panama and Thailand. The unidirectional causality from energy consumption to economic growth exists in Panama in the long-run, and economic growth Granger causes energy consumption in the short-run, but *vice versa* is observed in Thailand. The results imply the necessity of comprehensive analysis of the potential consequences of energy-oriented policies to be implemented in Panama and Thailand. We suggest that these countries create and apply flexible and sector-specific energy policies.

The neutrality hypothesis which considers that there is no causal relationship between the energy consumption and economic growth is valid for Dominican Republic and Guatemala. Therefore, energy conservation policies might not affect economic growth, and economic growth does not necessarily cause an improvement of the energy sector in these countries.

The findings show that trade openness does not Granger cause energy consumption in any of the net energy importing middle-income countries. However, The ARDL bounds test findings bear significant unidirectional relationship running from trade openness to energy consumption in Albania, India, Thailand, and Zimbabwe. The results imply that, promoting international trade does not significantly increase energy consumption, and designing energy conservative policies may not reduce international trade in the short-run among the net energy importing middle-income countries explored. Nevertheless, promoting international trade significantly increases energy consumption in India and Thailand in the long-run, while reducing it in Albania and Zimbabwe. Policy makers in these economies should consider the long-run significant impact of trade openness on energy consumption when formulating and implementing trade and energy policies. On the other hand, a unidirectional causality running from energy consumption to trade openness is found in case of Bulgaria, where energy consumption boosts trade significantly and positively in the long-run. The findings depict that designing energy conservative policies may reduce international trade in Bulgaria in the long-run.

The results validate the presence of a feedback effect in Pakistan, as energy consumption and trade openness are interdependent in the long-run. The findings indicate that promoting international trade enhances energy consumption, and implementing energy conservative policies may lead to a reduction in international trade. The feedback relationship result suggests that Pakistan should take international trade into account for the future energy prediction efforts and adopt energy expansion policies.

Although the results appear to be robust, some of the net energy importing middle-income countries do not have a complete series for the variables to be included in the panel settings. Because of the absence of available data for these countries, the precision of the panel estimations remains imperfect. The trade openness data, which consists of volume based aggregate foreign trade data may be misleading for assessing the net impact on energy consumption and/or economic growth. Most of the middle-level income countries have import-dependent production activities that end up with exports because of trans-trade activities and international logistics. Moreover, the choice in the mode of production is mainly determined by the local availability of raw materials and energy, as well as by the environmental regulations in the country and policies regarding their implementation (Salih Kalaycı and Cihan Özden 2021). Also, one may argue that both the demand and supply sides affect inflation, which are normally found in the lower- and middle-income group of countries may negatively affect economic growth and trade activities eventually through the increasing cost of energy.

The political and macroeconomic circumstances of economies should also be considered for such assessment because of their risky nature. Although the relatively higher interest rates and devaluation potential of the domestic currency against foreign currencies cover such risks along with the relatively higher debt position, policy-makers must concentrate on how to increase trade openness and how to reach a sustainable economic growth in setting the objectives, which are also the prevailing solutions to shift the level of the economy. In addition, electricity theft and loss rates are high as well the excise tax rates on fuel in some low- and middle-income countries. This is one of the reasons for the cost paradox of energy confining their economic growth in the ongoing high inflation. Furthermore, lower investments are the results of a low propensity to save in these low- and middle-income economies, where a lower concentration of foreign direct investment is most likely to occur because of incompetent sub-structures, a weak legal system, and the lack of trustful politics in meeting future expectations and stability. However, any policies to cope with such problems can still attain an economic growth level that is high enough with respect to their high population growth and low employment rates. Therefore, the results of this study will expectedly help policy authorities to integrate convenient strategies to develop and promote country-level solutions on the main variables of the study.

6. Conclusion

This study has explored the long-run equilibrium and the short-run causal association between economic growth, energy consumption and trade openness in net energy importing middle-income countries. To investigate the difference between country blocks, groups of countries were classified as lower middle-income and upper-income depending on their income characteristics in line with the World Bank classification. Based on data availability, the final dataset included 29 middle-income countries (Panel-1) 11 of which are lower middle-income (Panel-2) and 18 are upper middle-income (Panel-3) economies. We have then assessed the long-run equilibrium relationship between the economic growth, energy consumption, and trade openness of panel samples by employing the PMG-ARDL approach. The findings indicated that both the energy consumption and trade openness have positive and significant effects on the economic growth in the long-run for net energy importing middle-income economies as a whole and for net energy importing upper middle-income economies as a subgroup as well. Moreover, the findings confirm a significantly positive impact of economic growth on energy consumption for all samples examined. The PMG-ARDL estimations reveal that trade openness is significantly and negatively affected by economic growth in the long-run in net energy importing middle-income economies full sample. For all the panel samples, test results depict that energy consumption has a significantly positive effect on trade openness in the long-run. The ARDL estimation findings for individual countries reveal significant long-run relationships between energy consumption and economic growth, energy consumption and trade openness, and economic growth and trade openness in 12, 8, and 6 of middle-income economies explored, respectively.

By employing the Dumitrescu-Hurlin causality tests, we have observed a unidirectional causal relationship running from economic growth to energy consumption and running from energy consumption to trade openness in all panel samples. The findings reveal a bidirectional causality between economic growth and trade openness for the upper middle-income countries sample and the whole sample in the short-run. Economic growth is a Granger cause of energy consumption and trade openness in three and four of the middle-income economies, respectively. Granger causality test results show that there is a unidirectional causality running from energy consumption to economic growth in two, from trade openness to energy consumption in one, and from energy consumption to trade openness in two, one, and one of the net energy importing middle-income countries explored, respectively.

The findings of the study will pave the way for the lower- and middle-income countries of net energy importing nature by clearing the possibilities if any decision on a conceptual dimension will work out for any goals in attaining a sustainable economic growth, in energy strategies, and in policies coping with malignant foreign trade deficit in these economies.

Future studies to be conducted through comparative research between net energy importing low-income, middle-income, and high-income countries will be valuable. Further questions on the connections between economic growth and energy consumption, economic growth and trade openness, and energy consumption and trade openness will require dynamic general equilibrium models. Nonetheless, renewable energy sources, with an increasing part of supply in energy consumption have recently been a new direction to explore for future research in terms of value-added contributions to economic growth and trade openness.

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Appendix

Table A1 Results of Cross-Section Dependence Test

		lnecgrw	*lnencon*	*lntrdop*	*lngfcaf*	*lnlbfop*	*c*
Panel-1	Model – 1	–	16.410 ^{S1}	10.925 ^{S1}	3.133 ^{S1}	2.545 ^{S5}	3.858 ^{S1}
	Model – 2	16.410 ^{S1}	–	–25.594 ^{S1}	1.668	–6.282 ^{S1}	9.771 ^{S1}
	Model – 3	10.925 ^{S1}	–25.594 ^{S1}	–	0.509 ^{S1}	–2.133 ^{S5}	9.278 ^{S1}
Panel-2	Model – 1	–	10.749 ^{S1}	10.464 ^{S1}	2.620 ^{S1}	–2.515 ^{S5}	8.889 ^{S1}
	Model – 2	10.749 ^{S1}	–	–16.813 ^{S1}	–4.259 ^{S1}	–4.599 ^{S1}	3.371 ^{S1}
	Model – 3	10.464 ^{S1}	–16.813 ^{S1}	–	–4.775 ^{S1}	–1.362	2.120 ^{S5}
Panel-3	Model – 1	–	3.223 ^{S1}	2.792 ^{S1}	–0.639	–1.123	13.541 ^{S1}
	Model – 2	3.223 ^{S1}	–	–24.746 ^{S1}	7.600 ^{S1}	–3.220 ^{S1}	8.397 ^{S1}
	Model – 3	2.792 ^{S1}	–24.746 ^{S1}	–	6.835 ^{S1}	–0.879 ^{S1}	6.997 ^{S1}

Notes: ^{S1} and ^{S5} indicate statistical significance at 0.01 and 0.05 level, respectively.

Source: Authors' calculations.

Table A2 Results of Panel Unit Root Tests

		CIPS	LLC	IPS	ADF–F	PP–F
Panel–1	*lnecgrw*	–1.540	1.860	6.829	24.344	22.066
	Δ*lnecgrw*	–3.410 ^{S1}	–10.585 ^{S1}	–11.277 ^{S1}	234.199 ^{S1}	239.561 ^{S1}
	lnencon	–1.689 ^{S5}	–0.915	–0.718	90.643 ^{S1}	88.73 ^{S1}
	Δ*lnencon*	–3.690 ^{S1}	–20.131 ^{S1}	–18.078 ^{S1}	377.883 ^{S1}	414.880 ^{S1}
	lntrdop	–1.884 ^{S1}	–1.122	–2.82947 ^{S1}	106.485 ^{S1}	118.629 ^{S1}
	Δ*lntrdop*	–4.079 ^{S1}	–22.213 ^{S1}	–20.482 ^{S1}	430.171 ^{S1}	481.582 ^{S1}
	lngfcaf	–1.574	–5.3985 ^{S1}	–4.308 ^{S1}	119.632 ^{S1}	98.759 ^{S1}
	Δ*lngfcaf*	–4.315 ^{S1}	–18.554 ^{S1}	–19.122 ^{S1}	399.712 ^{S1}	445.327 ^{S1}
	lnlbfop	–1.516	–1.299	–0.707	88.460	79.649 ^{S5}
	Δ*lnlbfop*	–2.940 ^{S1}	–7.852 ^{S1}	–12.384 ^{S1}	267.167 ^{S1}	650.160 ^{S1}
Panel– 2	*lnecgrw*	–1.409	2.741	4.362	10.432	9.624
	Δ*lnecgrw*	–2.768 ^{S1}	–5.724 ^{S1}	–6.189 ^{S1}	79.962 ^{S1}	79.025 ^{S1}
	lnencon	–1.899 ^{S5}	0.000	–1.367	47.650 ^{S1}	47.365 ^{S1}
	Δ*lnencon*	–3.582 ^{S1}	–12.838 ^{S1}	–11.170 ^{S1}	142.530 ^{S1}	170.317 ^{S1}
	lntrdop	–1.583	0.345	–0.711	34.771 ^{S5}	36.109 ^{S5}
	Δ*lntrdop*	–4.701 ^{S1}	–12.882 ^{S1}	–11.516 ^{S1}	147.823	169.354
	lngfcaf	–1.589	–2.716 ^{S1}	–1.497	36.530 ^{S5}	34.457 ^{S5}
	Δ*lngfcaf*	–4.312 ^{S1}	–12.887 ^{S1}	–13.566 ^{S1}	176.438 ^{S1}	197.867 ^{S1}
	lnlbfop	–0.979	1.446	1.460	20.742	18.121
	Δ*lnlbfop*	–2.606 ^{S1}	–3.521 ^{S1}	–5.402 ^{S1}	73.181 ^{S1}	82.348 ^{S1}
Panel–3	*lnecgrw*	–1.344	0.506	5.256	13.912	12.442
	Δ*lnecgrw*	–3.834 ^{S1}	–8.980 ^{S1}	–9.477 ^{S1}	154.236 ^{S1}	160.536 ^{S1}
	lnencon	–1.709 ^{S5}	–1.203	0.150	42.993	41.366
	Δ*lnencon*	–4.022	–15.537 ^{S1}	–14.215 ^{S1}	235.353 ^{S1}	244.562 ^{S1}
	lntrdop	–1.996 ^{S1}	–2.473 ^{S1}	–3.038 ^{S1}	71.713 ^{S1}	82.520 ^{S1}
	Δ*lntrdop*	–3.898 ^{S1}	–18.084 ^{S1}	–16.993 ^{S1}	282.347 ^{S1}	312.228 ^{S1}
	lngfcaf	–1.884 ^{S1}	–5.2403 ^{S1}	–4.301 ^{S1}	83.101 ^{S1}	64.302 ^{S1}
	Δ*lngfcaf*	–3.844 ^{S1}	–13.614 ^{S1}	–13.660 ^{S1}	223.274 ^{S1}	247.460 ^{S1}
	lnlbfop	–1.383	–2.805 ^{S1}	–2.046 ^{S5}	67.718 ^{S1}	61.529 ^{S1}
	Δ*lnlbfop*	–3.474 ^{S1}	–7.641 ^{S1}	–11.483 ^{S1}	193.986 ^{S1}	567.811 ^{S1}

Notes: Lag length selections are based on the Schwarz information criterion. Δ represents the first difference. ^{S1} and ^{S5} indicate statistical significance at 0.01 and 0.05 level, respectively.

Source: Authors' calculations.

Table A3 Results of Individual Country Unit Root Tests

		lnEGR	*ΔlnEGR*	*lnENC*	*ΔlnENC*	*lnTOP*	*ΔlnTOP*	*lnGFC*	*ΔlnGFC*	*lnLFP*	*ΔlnLFP*
Albania	ADF	–0.891	–5.182[S1]	–0.742	–6.302[S1]	–3.694[S5]	–10.095[S1]	–6.960[S1]	–4.469[S1]	–1.194	–5.085[S1]
	PP	–1.057	–5.262[S1]	–0.707	–6.904[S1]	–3.828[S1]	–8.053[S1]	–3.073[S5]	–4.552[S1]	–0.802	–9.222[S1]
Bangladesh	ADF	2.091	–1.276	0.501	–5.549[S1]	–1.516	–5.054[S1]	–2.870	–2.752	–1.159	–3.511[S5]
	PP	5.179	–1.253	0.697	–5.547[S1]	–1.521	–5.516[S1]	–3.009[S5]	–3.770[S1]	–1.159	–4.182[S1]
Belarus	ADF	–1.288	–2.496	–3.389[S1]	–2.772	–6.251[S1]	–6.759[S1]	–3.389[S5]	–2.772	–0.538	–2.899
	PP	–0.289	–2.422	–3.133[S5]	–2.736	–15.176[S1]	–11.700[S1]	–3.133[S5]	–2.736	–0.479	–2.002
Benin	ADF	–1.580	–5.189[S1]	–0.703	–4.812[S1]	–1.491	–4.723[S1]	–2.287	–6.002[S1]	0.543	–3.947[S1]
	PP	–0.212	–4.271[S1]	–0.703	–4.817[S1]	–1.491	–4.719[S1]	–2.287	–6.015[S1]	0.392	–3.917[S1]
Brazil	ADF	–0.958	–3.820[S1]	–0.256	–6.319[S1]	–1.827	–4.932[S1]	–0.789	–5.937[S1]	–1.796	–4.322[S1]
	PP	–0.978	–3.796[S1]	–0.193	–6.295[S1]	–1.852	–4.932[S1]	–0.789	–6.013[S1]	–1.560	–4.286[S1]
Bulgaria	ADF	–0.331	–4.812[S1]	–3.139[S5]	–4.873[S1]	–1.980	–8.175[S1]	–1.837	–6.777[S1]	–0.112	–4.230[S1]
	PP	0.496	–4.817[S1]	–3.163[S5]	–6.905[S1]	–1.770	–8.684[S1]	–2.310	–7.615[S1]	–0.402	–4.223[S1]
China	ADF	–2.141	–1.843	–1.012	–2.818	–2.135	–3.585	–2.882	–3.562[S5]	–1.996	–2.298
	PP	–1.950	–1.953	0.085	–2.937	–2.142	–3.569[S5]	–2.792	–3.510[S5]	–0.584	–1.972
Costa Rica	ADF	–0.054	–4.457[S1]	–0.879	–4.082[S1]	–1.445	–4.383[S1]	–4.081[S1]	–5.257[S1]	–1.184	–5.252[S1]
	PP	0.152	–4.740[S1]	–1.034	–4.096[S1]	–1.445	–4.369[S1]	–4.132[S1]	–9.566[S1]	–0.716	–17.518[S1]
Côte d'Ivoire	ADF	–1.898	–2.753	–0.802	–5.927[S1]	–1.884	–4.651[S1]	–1.281	–4.638[S1]	0.629	–1.439
	PP	–1.994	–2.753	–0.346	–7.669[S1]	–1.878	–4.652[S1]	–1.384	–4.638[S1]	4.179	–1.426
Cuba	ADF	–1.023	–2.631	–2.326	–4.136[S5]	–3.432[S5]	–3.741[S1]	–3.300[S5]	–4.281[S1]	–3.432[S5]	–3.741[S1]
	PP	–0.170	–2.666	–2.410	–4.137[S5]	–3.395[S5]	–3.681[S5]	–3.300[S5]	–4.281[S1]	–3.395[S5]	–3.681[S5]
Dominican Republic	ADF	0.048	–4.583[S1]	–1.950	–5.331[S1]	–1.082	–5.906[S1]	–2.107	–8.162[S1]	0.291	–5.561[S1]
	PP	0.107	–4.590[S1]	–1.940	–5.331[S1]	–0.933	–11.685[S1]	–2.199	–8.127[S1]	0.291	–5.557[S1]
El Salvador	ADF	–2.000	–4.070[S1]	–2.466	–4.839[S1]	–2.284	–4.959[S1]	–3.297[S5]	–3.912[S1]	–3.346[S5]	–6.079[S1]
	PP	–1.811	–4.087[S1]	–2.533	–4.851[S1]	–2.916	–7.342[S1]	–3.420[S5]	–11.001[S1]	–3.150[S5]	–7.984[S1]
Ghana	ADF	0.049	–2.629	–1.181	–3.930[S1]	–2.663	–4.724[S1]	–2.955	–4.785[S1]	–0.832	–1.777
	PP	0.945	–2.629	–1.320	–3.922[S1]	–2.660	–4.726[S1]	–2.252	–4.785[S1]	0.972	–1.777
Guatemala	ADF	–0.057	–4.398[S1]	1.717	–4.178[S1]	–1.651	–4.691[S1]	–2.411	–5.241[S1]	–5.662[S1]	–8.847[S1]
	PP	0.042	–4.054[S1]	1.856	–4.174[S1]	–1.679	–4.691[S1]	–2.498	–5.241[S1]	–5.669[S1]	–26.027[S1]
Honduras	ADF	–0.166	–5.281[S1]	–0.811	–5.345[S1]	–2.735	–4.482[S1]	–3.333[S5]	–2.121	–3.129[S5]	–5.466[S1]
	PP	–0.166	–5.289[S1]	–0.309	–8.682[S1]	–2.776	–4.482[S1]	–6.950[S1]	–4.192[S1]	–3.086[S5]	–5.860[S1]
India	ADF	1.563	–4.318[S1]	1.222	–4.805[S1]	0.053	–3.311[S5]	–3.331[S5]	–5.239[S1]	–1.382	–5.795[S1]
	PP	3.778	–4.244[S1]	1.184	–4.828[S1]	–1.405	–4.260[S1]	–3.285[S5]	–5.239[S1]	–1.370	–5.776[S1]
Jamaica	ADF	–3.597[S5]	–3.963[S1]	–1.362	–3.398[S5]	–2.976	–8.874[S1]	–1.672	–5.338[S1]	–3.573[S5]	0.313
	PP	–2.774	–7.867[S1]	–1.112	–3.430[S5]	–2.827	–9.742[S1]	–1.905	–5.423[S1]	–1.679	–0.901
Jordan	ADF	–1.213	–3.547[S5]	–1.528	–4.992[S1]	–2.268	–3.970[S5]	–1.483	–4.121[S1]	–3.589[S5]	–3.830[S1]
	PP	–1.160	–3.681[S5]	–1.639	–4.989[S1]	–2.127	–3.925[S5]	–1.679	–4.121[S1]	–1.934	–4.013[S1]
Kyrgyz Republic	ADF	–0.982	–2.980	–4.866[S1]	–3.859[S1]	–1.222	–4.544[S1]	–1.210	–4.725[S1]	–2.357	–3.313[S5]
	PP	–1.467	–2.941	–4.866[S1]	–3.334[S5]	–1.243	–4.549[S1]	–0.891	–7.949[S1]	–3.057[S5]	–3.047[S5]
Lebanon	ADF	–3.739[S5]	–2.004	–0.608	–3.870[S1]	–1.142	–4.217[S1]	–2.209	–2.602	–0.257	–7.178[S1]
	PP	–2.934	–1.946	–0.652	–3.868[S1]	–1.142	–4.216[S1]	–2.662	–3.489[S5]	–2.374	–6.086[S1]
Namibia	ADF	1.182	–4.366[S1]	–1.446	–4.094[S1]	–2.814	–4.063[S1]	–1.305	–5.663[S1]	1.477	–3.333[S5]
	PP	1.182	–4.418[S1]	–1.597	–7.207[S1]	–1.800	–3.259[S5]	–1.185	–6.554[S1]	1.345	–3.317[S5]
Pakistan	ADF	–0.246	–3.129[S5]	–2.218	–3.655[S5]	–1.948	–5.515[S1]	–1.131	–4.150[S1]	–0.409	–3.606[S5]
	PP	–0.324	–3.129[S5]	–2.218	–3.680[S5]	–1.911	–5.513[S1]	–1.131	–4.105[S1]	–0.318	–5.271[S1]
Panama	ADF	1.811	–3.512[S5]	–1.664	–5.485[S1]	–2.332	–4.013[S1]	–3.718[S5]	–4.563[S1]	–3.420[S5]	–3.645[S5]
	PP	1.298	–2.563	–1.673	–5.936[S1]	–2.525	–3.945[S1]	–3.367[S5]	–5.016[S1]	–4.145[S1]	–4.059[S1]
Paraguay	ADF	0.832	–3.692[S5]	–2.636	–3.277[S5]	–1.157	–4.819[S1]	–1.868	–4.432[S1]	–4.150[S1]	–7.064[S1]
	PP	0.515	–3.672[S5]	–1.726	–3.257[S5]	–1.182	–4.819[S1]	–1.970	–4.432[S1]	–4.134[S1]	–11.831[S1]

Peru	ADF	1.266	–3.445 ^{S5}	1.595	–4.442 ^{S1}	–0.942	–4.314 ^{S1}	–1.291	–3.208 ^{S5}	–1.946	–5.195 ^{S1}
	PP	1.099	–3.410 ^{S5}	3.058	–4.418 ^{S1}	–0.942	–4.323 ^{S1}	–1.577	–3.184 ^{S5}	–2.579	–5.195 ^{S1}
Thailand	ADF	–0.955	–3.719 ^{S1}	–1.440	–4.607 ^{S1}	–1.944	–5.612 ^{S1}	–4.842 ^{S1}	–5.949 ^{S1}	–3.211 ^{S5}	–3.426 ^{S5}
	PP	0.205	–3.503 ^{S1}	0.222	–4.673 ^{S1}	–1.211	–5.496 ^{S1}	–0.212	–3.993 ^{S1}	–1.638	–3.465 ^{S1}
Turkey	ADF	–0.075	–5.235 ^{S1}	–0.337	–5.897 ^{S1}	0.901	–4.586 ^{S1}	–1.966	–5.336 ^{S1}	–1.916	–1.325
	PP	0.322	–5.235 ^{S1}	0.379	–6.361 ^{S1}	–2.237	–5.091 ^{S1}	–1.988	–5.336 ^{S1}	–1.609	–4.738 ^{S1}
Ukraine	ADF	–1.268	–2.438	–2.247	–5.305 ^{S1}	–5.022 ^{S1}	–5.019 ^{S1}	–0.408	–8.232 ^{S1}	–2.577	–4.127 ^{S1}
	PP	–1.814	–2.276	–2.197	–5.320 ^{S1}	–4.680 ^{S1}	–3.489 ^{S5}	–0.745	–8.251 ^{S1}	–1.850	–5.471 ^{S1}
Zimbabwe	ADF	–3.227 ^{S5}	–3.022 ^{S5}	–1.579	–3.720 ^{S5}	–3.631 ^{S5}	–6.401 ^{S1}	–2.358	–5.960 ^{S1}	–1.938	–2.588
	PP	–1.379	–3.022 ^{S5}	–1.680	–3.697 ^{S5}	–3.661 ^{S5}	–6.583 ^{S1}	–2.358	–6.090 ^{S1}	–1.388	–2.701

Notes: Lag length selections are based on the Schwarz information criterion. Δ represents the first difference. ^{S1} and ^{S5} indicate statistical significance at 0.01 and 0.05 levels respectively.

Source: Authors' calculations.

Table A4 Diagnostic Test Results

Country	Model	BG	BPG	RR	JB
Albania	1	1.599	0.744	2.867	0.385
	2	2.509	0.568	1.093	1.921
	3	0.117	0.920	0.803	1.091
	1	4.690 ^{S5}	5.081 ^{S1}	2.186 ^{S5}	1.089
Bangladesh	2	2.601	0.578	1.216	0.879
	3	1.301	1.020	0.518	1.326
	1	42.148 ^{S1}	1.271	1.187	6.854 ^{S5}
Belarus	2	69.384 ^{S1}	2.229	2.274 ^{S5}	3.879
	3	3.702 ^{S5}	2.679	4.592 ^{S1}	2.304
	1	20.050 ^{S1}	0.193	0.193	1.099
Benin	2	0.115	0.678	0.632	8.836 ^{S5}
	3	3.034	1.129	0.054	0.998
	1	1.291	0.558	1.525	2.022
Brazil	2	1.848	0.571	2.641	0.364
	3	0.987	0.398	1.256	1.325
	1	1.161	2.107	0.572	0.561
Bulgaria	2	0.360	0.846	0.302	1.436
	3	1.338	2.451	3.537	0.311
	1	41.831 ^{S1}	6.479 ^{S1}	4.894 ^{S1}	0.947
China	2	14.442 ^{S1}	1.113	6.946 ^{S1}	1.351
	3	9.524 ^{S1}	1.201	1.405	0.964
	1	85.271 ^{S1}	1.206	0.645	0.85
Costa Rica	2	0.708	1.137	0.003	3.471
	3	45.421 ^{S5}	4.166 ^{S5}	0.013	0.732
	1	4.315 ^{S5}	2.772	1.023	1.032
Côte d'Ivoire	2	1.191	1.579	0.476	0.431
	3	4.529 ^{S5}	0.362	0.125	6.018 ^{S5}
	1	8.482 ^{S1}	2.240	1.210	1.757
Cuba	2	10.860 ^{S1}	0.690	1.465	1.565
	3	7.589 ^{S1}	1.866	4.61	8.300 ^{S5}
	1	85.271 ^{S1}	1.206	0.645	0.85
Dominican Republic	2	0.708	1.137	0.003	3.471
	3	45.421 ^{S5}	4.166 ^{S5}	0.013	0.732

	1	0.045	0.264	5.764 S5	3.388
El Salvador	2	0.301	0.352	1.016	2.510
	3	0.498	0.363	0.000	0.263
	1	1.373	2.546	0.167	1.101
Ghana	2	1.184	1.515	0.761	0.23
	3	2.602	1.758	0.891	1.631
	1	0.083	0.083	2.638	0.149
Guatemala	2	3.301	0.877	0.011	19.078
	3	2.608	0.58	0.242	2.582
	1	1.788	2.001	0.406	3.042
Honduras	2	0.471	0.686	0.038	0.852
	3	0.305	1.43	5.402 S5	0.552
	1	0.619	0.619	0.877	1.023
India	2	5.659	0.761	0.178	1.635
	3	2.442	2.442	8.095	0.751
	1	3.916 S5	2.329	0.33	1.405
Jamaica	2	1.071	0.805	1.383	0.425
	3	4.140	1.938	6.311	1.201
	1	0.336	0.336	1.252	2.647
Jordan	2	0.666	1.539	0.888	0.711
	3	4.306	2.564	0.581	3.202
	1	6.222 S1	1.590	0.680	0.141
Kyrgyz Republic	2	9.414 S1	2.139	3.511 S1	1.887
	3	2.308	1.351	2.234 S5	0.328
	1	1.227	7.362 S1	0.833	0.641
Lebanon	2	0.381	0.443	1.970	6.164 S5
	3	1.195	2.14	2.144 S5	0.799
	1	1.468	1.045	0.062	1.164
Namibia	2	3.049	1.706	1.704	0.486
	3	1.459	0.878	1.071	2.65
	1	0.445	1.324	0.039	0.781
Pakistan	2	0.557	2.651	0.304	0.609
	3	0.713	0.406	0.406	0.461
	1	4.340	0.843	0.622	1.506
Panama	2	87.174 S1	1.438	0.413	1.072
	3	75.478 S1	0.763	1.904	0.151
	1	1.132	1.639	0.133	0.266
Paraguay	2	0.263	0.263	1.610	0.552
	3	0.707	0.364	1.709	1.534
	1	2.301	1.029	0.143	0.708
Peru	2	2.595	0.549	0.035	0.401
	3	3.364	0.853	7.168 S5	1.484
	1	0.308	0.308	2.334	0.49
Thailand	2	2.467	1.203	0.056	1.828
	3	2.268	1.56	0.633	0.089
	1	3.529	0.815	0.001	0.864
Turkey	2	0.315	0.862	0.015	0.410
	3	5.313	1.621	0.201	1.467

Ukraine	1	6.025 S1	0.709	5.286 S1	0.418
	2	6.264 S1	4.284 S1	0.727	0.308
	3	11.112 S1	2.51	4.594 S1	1.04
Zimbabwe	1	4.332	1.589	3.607	0.745
	2	5.889	1.814	2.53	1.185
	3	2.509	0.677	0.042	1.627

Notes: BG, BPG, RR, and JB represent Breusch-Godfrey, Breusch-Pagan-Godfrey, Ramsey RESET, and Jarque-Bera tests, respectively. Lag length selections are based on the Schwarz information criterion. S1 and S5 stand for statistical significance at 0.01 and 0.05 level, respectively.

Source: Authors' calculations.

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