



CAUSALITY AMONG ENERGY PRICE, TRADE OPENNESS AND ECONOMIC GROWTH IN EMERGING COUNTRIES: A PANEL COINTEGRATION ANALYSIS

Debasish Kumar Das*, Peya Ghosh and Tasnim Murad Mamun

Economics Discipline, Khulna University, Khulna9208, Bangladesh

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Abstract: This paper investigates the possible existence of dynamic causality between energy price, trade openness and economic growth using data of thirty-six emerging economies over the period 1980 to 2014. Panel unit root tests, panel cointegration, fully modified least squares (FMOLS) methods and panel causality tests are used to investigate this relationship. The FMOLS estimation reveals that higher international reserve, trade openness and energy consumption increase economic growth, whereas higher energy price leads to lower GDP growth. The results also indicate that there is a short-run unidirectional panel causality running from energy price and economic growth. Moreover, there is a bidirectional panel causality operated from trade openness and the total energy consumption. The major policy implication based on the general result of the study is that emerging economy should take necessary steps in making energy management and trade openness policies on the basis of the causal relationship of the variables.

Keywords: Emerging countries, energy price, energy consumption, trade openness, economic growth

Introduction

Rapid population growth, industrialization, technological innovation and trade liberalization have escalated the demand for global energy consumption, in particular emerging economies¹during the last few decades. According to the International Energy Agency (IEA) statistics, emerging economies continue to dominate the demand in global energy consumption. These overwhelming energy demands put energy price more volatile and creates macroeconomic uncertainty in the global economy. As the energy price, energy consumption, trade openness, economic growth moves together, hence it is significant to explore more about whether energy price has influential relationship with energy consumption, economic growth, trade openness and international reserve. However, energy price is supposed to affect economic growth through its impact on inflation, interest rate, exchange rate, investment, urbanization, consumption, employment, stock price and so on. Thus, stable energy price gears up economic growth while fluctuated energy price adversely affects this growth. However, over during the last three decades or so world energy price is fluctuating and influencing macro economic variables differently.

* Corresponding author: <dkdas.econ@gmail.com>; <dkdas@econ.ku.ac.bd>

¹countries that are considered to be in a transitional phase between developing and developed status

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Instability in energy prices may temporarily reduce aggregate output as it hinders business investment by raising uncertainty or by inducing expensive sectoral resource reallocation (Guo and Kliesen, 2005). Fig. 1 demonstrates a direct linkage between energy price volatility and economic growth. With the increase of energy price economic growth also goes up and vice-versa. In the year 2008, both the energy price and the economic growth are in the lowest level and in the 2011, both are in the highest position. The probable cause of the consequence is supposed to be due to increase in energy price decreases the consumption of energy and decrease the growth rate (Berk and Yetkiner, 2014).

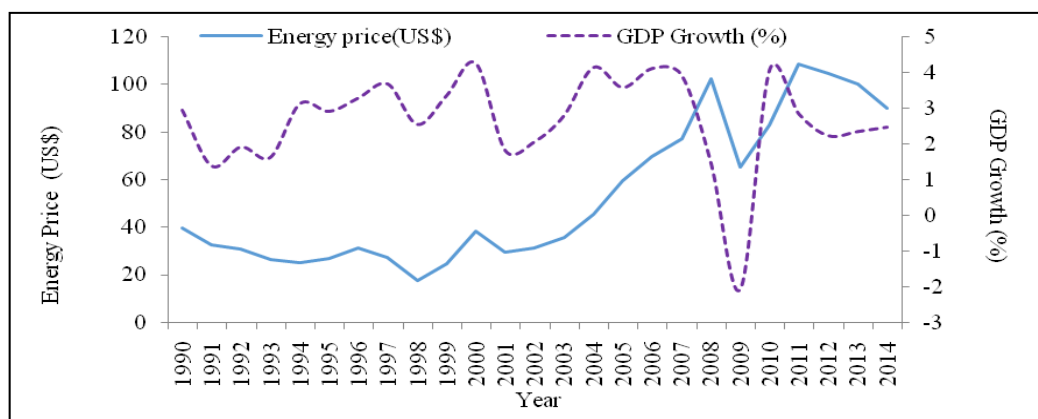


Fig. 1: Energy Price and Economic Growth (adapted from OECD Statistics and Penn World Table, 2015)

Trade openness is also an essential component of economic growth and expansion in international trade induces economic activities and the energy demand (Sadorsky, 2012). The impact of trade openness on energy consumption depends on economic condition of the country and the extent of relationship between economic growth and trade openness (Cole, 2006). Trade openness and consumption of energy are related in two ways. Trade openness enables emerging economies to import advanced technologies from developed economies that produces more output but lowers energy intensity. On the other hand, energy is an important input of production with imported machinery. Besides, transportation for exporting of manufactured goods and importing of raw materials is done through fuel run vehicle. Thus energy price, energy consumption and trade openness are closely related.

Over the year statistical analysis demonstrates a negative relationship between energy price and trade openness (Fig. 2). That means with increase in oil price or without adequate energy supply, trade openness is adversely affected. Theoretically it is evident that there is a direct association between energy price and economic growth. Barsky and Kilian (2002); Apergis and Tang (2013); Bhuiyan and Naser (2015) note that an increase of the energy price yields inflationary pressure in the economy which has a direct and indirect effect on the economic growth of the economy. Investigation on relationship between energy consumption and economic growth has been extensively executed that search out three

types of causal relationship on different economies. For example, Kraft and Kraft (1978) for USA, Masih and Masih (1997) for Taiwan and Korea, Aqeel and Butt (2001) for Pakistan, Wolde-Rufael (2006) for African countries, Narayan and Singh (2007) for Fiji, Reynolds and Kolodziejci (2008) for Soviet Union, Chandran et al. (2010) for Malaysia, Narayan and Smyth (2009) for Middle Eastern and Yoo and Kwak(2010) for South American countries explore that increased energy consumption is positively linked with economic growth. Besides, some studies also find positive relationship between economic growth and energy consumption (Akarca and Long, 1979; Yu and Choi, 1985; Abosedra and Baghestani, 1989 and Sbia et al., 2013). Mazumder and Marathe (2007) observes the causal relationship between per capita GDP and per capita electricity consumption in Bangladesh and discovers that energy is an important contributing factor for increasing the economic growth of Bangladesh. Noor and Siddiqi (2010) finds causal relationship between per capita energy consumption and per capita GDP in five South Asian countries. Literature also find opposite causality in the study of Altinay G, Karagol (2004) and Halicioglu (2009) for Turkey, Squalli (2007) for OPEC Yuan et al. (2007) for China and Odhiambo (2009) for Tanzania. Asafu-Adjaye (2000) in a study on Thailand and the Philippines finds bivariate causality between energy consumption and economic growth.

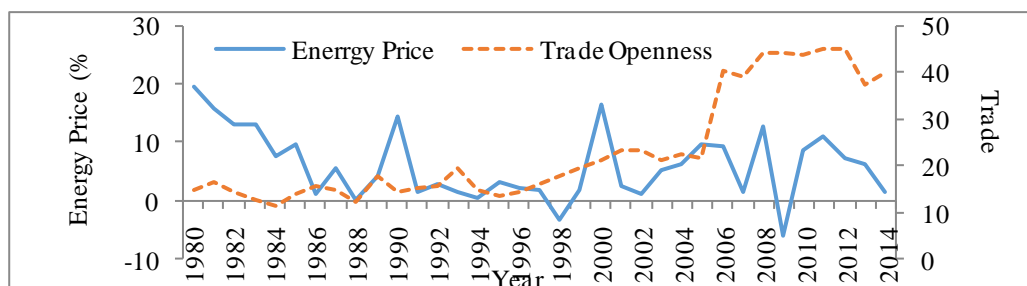


Fig. 2: Energy Price and Trade Openness (adapted from OECD Statistics and Penn World Table, 2015)

Empirical evidences provided by Yu and Choi (1985),Zahid (2008), Amirat and Bouri (2010), Noor and Siddiqi (2010), Ferguson et al. (2000), Toman and Jemelkova (2003) and Apergis and Payne (2010) are conflicting about the direction of causality. Cowan et al. (2014) in a study on BRICS countries find no link between electricity consumption and economic growth. However, Studies in G7 countries (Soytas, 2003), Asian developing countries (Asafu-Adjaye, 2000) and 14 MENA countries (Omri, 2013) discover that there lies bidirectional causality from economic growth to energy consumption.

Mork (1989) and Setyawan (2014) analyzed and concluded a short run negative correlation between oil price increase and output growth. For OPEC countries Hossein et al. (2012) finds short run causal relationships between energy consumption and economic growth. In 10 Asian countries Chen et al. (2007) finds a long run relationship between energy consumption and economic growth. Loganathan and Subramaniam (2010) based on ARDL bound testing approach explores the existence of long-run relationship between energy consumption and economic growth in Malaysia. For a panel of 19African countries

Nondo and Kahsai (2009) find the long-run relationship between energy consumption and economic growth. There exists a long term negative relationship between oil price movements and macroeconomic performance (Jayaraman and Choong, 2009; Cologni and Manera, 2011; Apergis and Tang 2013; Berk and Yetkiner, 2014; Mulhall and Bryson, 2014; Katircioglu, 2015). Lee (2005) analyzes the cointegration relationship between energy consumption and economic growth in 18 developing countries and gets the evidence of a long-run cointegration relationship. Naser (2015) find a long-run relationship exists between economic growth and energy resources in all emerging economies except in Russia.

In some researches, short run unidirectional and long run bidirectional relationship is found (Ahamad and Islam, 2011; Ouedraogo, 2010). Yoo (2006) with Granger causality test on ASEAN countries find a unidirectional relationship between Growth and electricity consumption in Indonesia and Thailand and a bidirectional relationship in Malaysia and Singapore. Considering G7 countries the research from Narayan and Smyth (2008) set up unidirectional causality from energy consumption to economic growth. However, Belke et al. (2011); Costantini and Martini (2010) discover bi-directional relationship between energy consumption and real GDP when OECD countries are applied. Chen et al. (2007) conducts a similar study in 10 newly industrializing and developing Asian countries using both single data sets and panel data procedures that empirically results that the causality directions in the 10 Asian countries are mixed while there is a unidirectional short-run causality running from economic growth to electricity consumption and a bi-directional long-run causality between electricity consumption and economic growth if the panel data procedure is implemented. A research conducted on South Korea (Oh and Lee, 2004) finds that there is no causal relationship between energy consumption and GDP in the short term, but there exists a long run unidirectional causal relationship from energy consumption to GDP.

To explore the relationship between trade openness and energy consumption, by using data of 32 countries a study (Cole, 2006) discovers that trade liberalization promotes economic growth which boosts energy demand. Jena and Grote (2008) examines the impact of trade openness on energy consumption. For a panel of six Middle Eastern countries (Narayan and Smyth, 2009) explores the causal relationship between energy consumption and economic growth by introducing exports as an indicator of trade openness in the production function. According to the study, a short-run Granger causality exists between energy consumption to real GDP and from economic growth to exports but a neutral effect exists between exports and energy consumption. Subsequently, Sadorsky (2011) with panel cointegration and panel Granger causality approaches for the panel of 8 Middle Eastern countries discovers the causal relationship between total economic growth, energy consumption and trade openness that gives evidence of a long-run relationship between the variables. Using data of 52 developed and developing economies, Ghani (2012) explores the relationship between trade liberalization and energy demand that indicates that in short run trade liberalization has minor impact on energy consumption but after certain level of trade liberalization energy consumption is affected.

Alternative data sets based on different time spans, countries, energy policies and econometric approaches result in diverse outcomes and raises controversial causal relationships between energy consumption and economic growth. Emerging countries use more energy for industrial production as they are shifting to the industrial sector. Besides,

the households of these countries also use a lot of amenities run by energy. So, the energy price movement may affect more the economic activity and economic growth of emerging economies. There are many studies to investigate the causal relationship between energy consumption and economic growth in some specific countries. However, this investigation specifically for emerging economies is merely found. For energy conservation policy in emerging economies there is an utmost need to examine this relationship closely. This study attempts to analyze the nexus between energy price and economic growth in emerging countries. It also incorporates the effect of trade openness and international reserve on economic growth that creates a new dimension in this area of research.

Materials and Method

Data collection. The sample includes five variables, real gross domestic product (in constant 2005 US\$) as a measured for economic growth, energy price (percentage change from the previous year), international reserve (thousand billion US\$), trade openness (export plus import as a share of GDP) and total energy consumption (metric ton) from thirty-six emerging countries over the period of 1980–2014. Sampled countries are Argentina, Colombia, Indonesia, Mexico, Philippine, Slovenia, Bangladesh, Egypt, Israel, Morocco, Poland, South Korea, Brazil, Estonia, Latvia, Nigeria, Qatar, Thailand, Bulgaria, Greece, Lithuania, Oman, Romania, Turkey, China, Hungary, Malaysia, Pakistan, Russia, Ukraine, Chile, India, Mauritius, Peru, South Africa and Vietnam. Data on real gross domestic product, percentage change of energy price, total energy consumption, international reserve and trade openness is obtained from the Penn World Tables Version 8.1², Energy Information Administration (EIA)³, British Petroleum's 2015 statistical review of world energy⁴ and World Development Indicators (WDI)⁵ of the World Bank respectively. The panel data series used in this study are strongly balanced.

Estimation Strategy. For examining the relationship between energy price and economic growth, which is a combination of the direct and indirect impact of the energy price for both the exporting and the importing countries, Naser (2015), Jayaraman and Choong (2009) and many others⁶ have used a long-run relationship model.

By considering the direct effect the long-run relationship in our model is specified as-

$$\ln(\text{RGDP})_{it} = \gamma + \alpha_1 \text{EP}_{it} + \alpha_2 \ln(\text{TEC})_{it} + \alpha_3 \text{TO}_{it} + \alpha_4 \ln(\text{IR})_{it} + \varepsilon_{it} \quad (1)$$

Here, the subscript $i(i = 1, 2, \dots, N)$ and $(t = 1, 2, \dots, T)$ represents country and time respectively. $\ln(\text{RGDP})$ is the natural logarithm of real GDP, EP means annual percentage change of energy price, $\ln(\text{TEC})$ represents the natural logarithm of total energy consumption, TO is the trade openness, $\ln(\text{IR})$ stands for the natural logarithm of

² available for download at www.ggd.net/pwt

³ available for download at <http://www.eia.gov/petroleum/data.cfm>

⁴ available for download at <http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html>

⁵ available for download at <http://data.worldbank.org/data-catalog/world-development-indicators>

⁶ Adjaye. (2000), Killian and Hicks (2013), Berkand Yetkiner (2014), Katircioglu et al. (2015), Etornam and Denis (2015)

international reserve. $\alpha_1, \alpha_2, \alpha_3$ and α_4 are the long-run magnitude of economic growth ($\ln(\text{RGDP})$) with respect to the given covariates.

The main goal of this paper is to explore whether there is a long-run and dynamic causal relationship between economic growth, energy price, total energy consumption, trade openness and international reserve. The testing procedure consists of the following steps. *First*, the stationary properties are examined using panel unit root tests of the underlying variables. If these variables are found non-stationary in level and at least stationary in first-difference, next to test whether there is a cointegrating relationship between the series, using appropriate panel cointegration techniques. Then, if the variables are cointegrated, the long-run impact will be estimated using the fully modified OLS technique. Finally, we examine the interactions between short and long-run dynamics of the series using panel vector autoregressive or error correction models.

Stationarity test. To test the stationarity, five types of unit root tests are used to examine the order of integration of the series. Therefore, the augmented Dickey and Fuller (ADF) (1979), Phillips and Perron (PP) (1988), Breitung (1999), Im et al. (2003) and Hadri (2000) panel unit root tests were performed to check whether the data are unit root at the level and at least stationary in first-difference. Accordingly, we test the null hypothesis of a unit root against the alternative hypothesis for all five tests. We also check whether all the variables are integrated of order one.

Panel cointegration test. There are several testing procedures available for co-integration test, e.g. Maddala and Wu (1999), Kao (1999), Pedroni (1999, 2004) and Westerlund (2007). In this paper, we use Pedroni and Kao tests for testing the co-integrating relationship between economic growth, annual percentage change of energy price, energy consumption, trade openness and international reserves. *First*, in Pedroni Residual Co-integration Test, it uses four⁷ panel statistics and three⁸ group statistics to test H_0 : no co-integration versus H_1 : co-integration. *Second*, Engle and Granger based Kao (1999) residual co-integration test uses ADF statistics to check null and alternative hypotheses following similar way as Pedroni. *Third*, the number of co-integrating vector is determined by using Fisher trace statistics⁹ and maximum eigenvalue¹⁰ statistics.

The seven tests of Pedroni are based on the estimated residuals derived from the following long-run model:

$$Y_{it} = \alpha_i + \lambda_i t + \sum_{j=1}^m \beta_{ij} X_{ij} + \varepsilon_{it} \quad (2)$$

⁷ Panel v-Statistics, Panel rho-Statistics, Panel PP-Statistics and Panel ADF-Statistics

⁸ Group rho-Statistics, Group PP-Statistics and Group ADF-Statistics

⁹ Trace Statistics: $\lambda_{\text{trace}}(r) = -T \sum_{i=r+1}^n \ln(1 - \lambda_i)$

¹⁰ Maximum Eigenvalue Statistics: $\lambda_{\text{max}}(r, r+1) = -T \ln(1 - \lambda_{r+1})$

Where, the subscript $i(i=1,2,\dots\dots,N)$ and $(t=1,2,\dots\dots,T)$ and m indicate the number of cross-sectional units, the number of time observations, and the number of regressors respectively. In addition, Y and X are assumed to be integrated of order one in levels. The structure of estimated residuals is as follows:

$$\varepsilon_{it} = \rho_i \varepsilon_{it-1} + u_{it} \tag{3}$$

Under the null hypothesis, all seven tests indicate the absence of co-integration by $H_0: \rho_i=1; \forall I$. Whereas the alternative hypothesis is given by $H_1: \rho_i < 1; \forall I$. The seven statistics are normally distributed. The statistics can be compared to appropriate critical values, and if critical values are exceeded then the null hypothesis of no co-integration is rejected implying that a long-run relationship between the variables does exist. Kao test has also been tested to accommodate correlation both within and between the individual cross-sectional units. It is also constructed on the similar approach as the Pedroni (1999, 2004) did.

Panel FMOLS estimate: To explore the long-run relationship among the economic growth, annual percentage change of energy price, energy consumption, trade openness and international reserves, we proceed to estimate Eq. (1) using fully modified OLS (FMOLS) method of Pedroni (2000), which allows for estimating heterogeneous co-integrated vector for panel countries. The main advantage of this method is that it corrects for both serial correlation and simultaneity bias. Another reason is that in the case of dynamic relationship OLS is not appropriate as its estimation produces biased and spurious results. Pedroni (2000) considers the following co-integrated system for panel data:

$$Y_{it} = \alpha_i + \beta_{it} X_{it} + \varepsilon_{it} \tag{4}$$

where Y and X are co-integrated. Pedroni (2001) proposes another equation that augments the co-integrating regression with lead and lagged differences of the regressors to control for the endogenous feedback effect. Hence, Eq. (4) is specified as:

$$Y_{it} = \alpha_i + \beta_{it} X_{it} + \sum_{k=K_i}^{K_i} \gamma_{ik} \Delta X_{it-k} + \varepsilon_{it} \tag{5}$$

Panel Granger causality test: The co-integrating relationship indicates the existence of causal relationship among the variables, at least in one direction. However, it does not provide information on the direction of causality. To investigate the direction of short-run and long-run causal relationship among the variables, we specify a panel-based vector autoregressive model. Basically, we follow the Engel and Granger's (1987) two step approach. In the first step, the long-run parameters presented in Eq. (1) and Eq. (2) are estimated, using the FMOLS procedure, to obtain the residuals and Granger causality test in the second step. The Granger causality test is specified as follows:

$$\begin{aligned} \Delta RGDP_{it} = & \gamma_{i1} + \sum_p \alpha_{11ip} \Delta EPI_{it-p} + \sum_p \alpha_{12ip} \Delta RGDP_{it-p} + \sum_p \alpha_{13ip} \Delta TEC_{it-p} \\ & + \sum_p \alpha_{14ip} \Delta IR_{it-p} + \sum_p \alpha_{15ip} \Delta TO_{it-p} + \theta_{1i} ECT_{it-1} \\ & + \varepsilon_{1it} \end{aligned} \quad (6)$$

$$\begin{aligned} \Delta EPI_{it} = & \gamma_{i2} + \sum_p \alpha_{21ip} \Delta EPI_{it-p} + \sum_p \alpha_{22ip} \Delta RGDP_{it-p} + \sum_p \alpha_{23ip} \Delta TEC_{it-p} \\ & + \sum_p \alpha_{24ip} \Delta IR_{it-p} + \sum_p \alpha_{25ip} \Delta TO_{it-p} + \theta_{2i} ECT_{it-1} \\ & + \varepsilon_{2it} \end{aligned} \quad (7)$$

$$\begin{aligned} \Delta TEC_{it} = & \gamma_{i3} + \sum_p \alpha_{31ip} \Delta EPI_{it-p} + \sum_p \alpha_{32ip} \Delta RGDP_{it-p} + \sum_p \alpha_{33ip} \Delta TEC_{it-p} \\ & + \sum_p \alpha_{34ip} \Delta IR_{it-p} + \sum_p \alpha_{35ip} \Delta TO_{it-p} + \theta_{3i} ECT_{it-1} \\ & + \varepsilon_{3it} \end{aligned} \quad (8)$$

$$\begin{aligned} \Delta IR_{it} = & \gamma_{i4} + \sum_p \alpha_{41ip} \Delta EPI_{it-p} + \sum_p \alpha_{42ip} \Delta RGDP_{it-p} + \sum_p \alpha_{43ip} \Delta TEC_{it-p} \\ & + \sum_p \alpha_{44ip} \Delta IR_{it-p} + \sum_p \alpha_{45ip} \Delta TO_{it-p} + \theta_{4i} ECT_{it-1} \\ & + \varepsilon_{4it} \end{aligned} \quad (9)$$

$$\begin{aligned} \Delta TO_{it} = & \gamma_{i5} + \sum_p \alpha_{51ip} \Delta EPI_{it-p} + \sum_p \alpha_{52ip} \Delta RGDP_{it-p} + \sum_p \alpha_{53ip} \Delta TEC_{it-p} \\ & + \sum_p \alpha_{54ip} \Delta IR_{it-p} + \sum_p \alpha_{55ip} \Delta TO_{it-p} + \theta_{5i} ECT_{it-1} \\ & + \varepsilon_{5it} \end{aligned} \quad (10)$$

Based on the above methodology, the annual panel data of thirty-six emerging countries for five variables will be tested. The data have taken on economic growth, energy price, trade openness, international reserve and energy consumption.

Results and Discussion

Annual panel data of thirty-six emerging countries over thirty-five years are taken into consideration. So, the total number of observation constructed as 1260 (36×35) for each of five variables i.e. annual percentage change of energy price, real gross domestic product, trade openness, total energy consumption and international reserve. The summery statistics (mean value and standard deviation) are given based on the pooled data of every variable, which is presented in Table 1. The mean value of the RGDP is 311 million US\$ and

standard deviation of GDP is 6380 million US\$. The maximum value of the RGDP is 162000 million US\$ and the minimum value is 10.12 million US\$. The value of the real gross domestic product is in constant price (based year 2005), which is used for measuring economic growth. The average change of energy price is 6.54 percent and standard deviation is 17.68 percent. That means the value of energy price is dispersed from the mean value at 17.98 percent. The maximum value of the energy price is 376.60 percent and the minimum value is -28.60 percent. The minus sign before the price implies that the change is negative that is price has decreased from the previous year. The mean value of total energy consumption is 111.51 metric ton. That implies, every country of the thirty-six countries consumes 111.51 metric ton energy on an average. The standard deviation is 269.30 metric ton where the maximum and minimum total energy consumption are 2972.06 metric ton and 3.05 metric ton respectively. The average international reserve of the countries in every year is 45262.58 thousands billion US\$. On the other hand, the average value of the trade openness of the thirty-six countries is 62.21 percent.

Table 1: Summery Statistics (calculated from Penn World Table 8.1, BP Statistics, EIA and World Bank Data, 2015)

Variables	Observations	Mean	Sta. Dev.	Max.	Min.
GDPR	1260	311	6380	162000	10.12
EP	1260	6.54	17.98	376.60	-28.60
TEC	1260	111.51	269.30	2972.06	3.05
IR	1260	45262.58	248480	39000	32.23
TO	1260	62.21	37.47	220.41	8.71

Note: RGDP means real gross domestic product (=2005), EP means percentage change of energy price, TEC means total energy consumption, IR means international reserve and TO means trade openness. Sta. Dev. is the Standard Deviation, Max. is the Maximum value and Min. is the Minimum value. The unit of measurement of real gross domestic product is Million US\$, energy price is percentage, international reserve is thousand billion US\$, trade openness is percentage and total energy consumption is metric ton.

Panel unit root tests are reported in Table 2. The results of tests indicate that the panel series of each variables have a unit root in level and stationary in first difference. Hence, these results lead us to conclude that our panel variables are characterized as an $I(1)$ process. To test the stationary properties, this study used five unit root tests i.e. Breitung t -statistics (Breitung), Augmented Dickey Fuller (ADF) test, Phillips and Perron (PP), Im, Pesaran and Shin W -stat (IPS W -stat) and Hadri. Here, the null hypothesis (H_0) is, there has unit root and alternative (H_A) is, there has no unit root. For panel (a) in Table 2, the result of IPS W -stat shows that the calculated t -value of $\ln(\text{RGDP})$, $\ln(\text{TEC})$, $\ln(\text{IR})$, EP and TO are non-stationary. In Breitung unit root test the coefficient value of $\ln(\text{RGDP})$, $\ln(\text{TEC})$, EP, TO and $\ln(\text{IR})$ are not statistically significant. So, they are non-stationary at the level. For the ADF test the coefficient value is not significant, hence, we cannot but accept the null hypothesis. That means they are non-stationary as well. The PP unit root test also provides the same finding which is in the ADF test.

Table 2: Panel Unit Root Test (Calculated from Penn World Table, BP Statistics, EIA and World Bank Data, 2015)

Test Name	ln(RGDP)	ln(TEC)	EP	TO	ln(IR)
Panel a: Levels					
Breitung	14.49 (1.00)	9.63 (1.00)	-7.98*** (0.00)	2.39 (0.99)	11.51 (1.00)
ADF	44.87 (0.98)	64.05 (0.73)	675.77*** (0.00)	-1.52* (0.06)	60.90 (0.77)
PP	26.09 (1.00)	30.39 (1.00)	1051.59*** (0.00)	87.29 (0.11)	17.56 (1.00)
IPS W-stat	10.66 (1.00)	4.70 (1.00)	-24.30*** (0.00)	-1.52* (0.06)	4.82 (1.00)
Panel b: First Difference					
Breitung	-1.93** (0.02)	-10.29*** (0.00)	-17.89*** (0.00)	-11.15*** (0.00)	2.72 (0.99)
ADF	421.70*** (0.00)	444.59*** (0.00)	721.04*** (0.00)	641.08*** (0.00)	336.07*** (0.00)
PP	419.74*** (0.00)	527.80*** (0.00)	5669.98*** (0.00)	1117.91*** (0.00)	423.85*** (0.00)
IPS W-stat	-15.88*** (0.00)	-18.59*** (0.00)	-28.24*** (0.00)	9.68*** (0.00)	-12.22*** (0.00)
Hadri	7.19*** (0.00)	3.37*** (0.0004)	18.57*** (0.00)	6.81*** (0.00)	6.54*** (0.00)

Note: Unit root tests considered intercept and trend. $\ln(\text{RGDP})$, $\ln(\text{TEC})$, $\ln(\text{IR})$ implies the natural logarithm of real gross domestic product, total energy consumption, and international reserve respectively. EP stands for energy price and TO trade openness. (***), (**), and (*) denote statistical significance at 1%, 5% and 10% level, respectively. The figure in parenthesis, are the p -values. Here, the null hypothesis for the panel is that the variable is non-stationary and the alternative is the variable is non-stationary

For panel (b) in Table 2, the null hypothesis is that the variables are non-stationary and the alternative hypothesis, is the variables are stationary after taking the first differences. The calculated t -values of $\ln(\text{RGDP})$, $\ln(\text{TEC})$, EP, TO and $\ln(\text{IR})$ are stationary after taking of the first difference in all five tests.

The results of seven panel co-integration tests suggested by Pedroni (1999, 2004) are shown in Table 3. In Pedroni test, the value of ν -statistics, PP -statistics, and ADF statistics are 32.92, 1.49 and 1.19 respectively. All of them are greater than the critical value -3.43 (1% significant level). So, the null hypothesis is accepted here. That means in within dimension there has no co-integration within $\ln(\text{RGDP})$, $\ln(\text{TEC})$, $\ln(\text{IR})$, TO and EP. Therefore, the results indicate that there has no long-term relationship among them. They have only short-term relationship. In between dimension all the values of the statistics are greater than the critical value, so the null is accepted and there has no co-integration among the variables. Hence, the results lead us to conclude that there has only a short-term relationship.

Table 3: Pedroni co-integration test (estimated from Penn World Table, BP Statistics, EIA and World Bank Data, 2015)

Within Dimension	Statistic	<i>p</i> -value	Between dimensions	Statistic	<i>p</i> -value
Panel <i>v</i> Statistic	32.92***	0.00	Group rho Statistic	3.88	1.00
Panel rho Statistic	-4.22***	0.00	Group PP Statistic	1.49	0.93
Panel PP Statistic	1.49	0.93	Group ADF Statistic	0.07	0.53
Panel ADF Statistic	1.19	0.88			

*Note: ***, ** and *: statistical significance at 1%, 5% and 10% level respectively. Probabilities are computed using asymptotic Chi-square distribution.*

Table 4 provides the results of panel co-integration test suggested by Kao (1999). Unlike the Pedroni (1999, 2004), value of Kao statistics is -5.65, which is less than the critical value -3.43 (at 1% significant level). So, we cannot accept the null hypothesis. Hence, the test results indicate that variables are panel co-integrated at 1% significance levels.

Table 4: Kao Statistics (estimated from Penn World Table, BP Statistics, EIA and World Bank Data, 2015)

	t-Statistic	Probability.
ADF	-5.65***	0.00

*Note: *** 1% significant level. Probabilities are computed using asymptotic Chi-square distribution.*

As a result, to reach a decision, whether our variables are co-integrated or not, we employ the Fisher co-integration test. The test results of panel co-integration reported in Table 5. As seen in table, the value of trace statistic and maximum eigen value for all the coefficients are greater than the critical value. So, we should accept the null hypothesis. That means, there has no co-integrated relationship among the variables.

Table 5: Fisher Co-integration Test (estimated from Penn World Table, BP Statistics, EIA and World Bank Data, 2015)

Hypothesized No. of CE(s)	Fisher Stat. (from trace test)	Probability	Fisher Stat. (from max-Eigen test)	Probability
None	508.2***	0.0000	359.5***	0.0000
At most 1	268.4***	0.0000	156.8***	0.0000
At most 2	162.0***	0.0000	101.0**	0.0137
At most 3	117.3***	0.0006	93.29**	0.0466
At most 4	114.2***	0.0011	114.2***	0.0011

*Note: **), ** and *: statistical significance at 1%, 5% and 10% level respectively. Probabilities are computed using asymptotic Chi-square distribution*

The FMOLS estimates for models (Eq. 4) are reported in Table 6. The estimated results indicate a positive and significant relationship between international reserve, trade openness and total energy consumption, suggesting that higher international reserve, trade openness and total energy consumption leads to higher GDP. Among the explanatory variables, only energy price has a significant negative relation with real gross domestic product, meaning that change in energy price leads to less GDP of the economy.

Table 6: Panel Fully Modified Least Squares (Penn World Table, BP Statistics, EIA and World Bank Data, 2015)

	ln(IR)	Trade Openness	ln(TEC)	Energy Price
ln(RGDP)	0.16*** (0.00)	0.01*** (0.00)	0.27*** (0.00)	-0.01*** (0.00)

*Note: ***: 1% significant. Probabilities are computed using asymptotic Chi-square distribution. ln(RGDP) is the dependent variable. ln(RGDP), ln(TEC), ln(IR) are natural logarithm of real gross domestic product, total energy consumption, and international reserve. variable are expressed in natural logarithms except TO and EP*

As the FMOLS does not provide information on the direction of causality between the variables, the results of panel short-run and long-run Granger causality tests are reported in Table 7. From intuition of the Granger based causality test, we know that if the two *p-values* are significant then the variables have a bidirectional or feedback relationship meaning that both variables are caused to change one another. Whereas, a unidirectional relationship implies only one directional relationship. Among the variables, the results indicate that there is a long-run bidirectional panel causality running from trade openness and the total energy consumption. Whereas, energy price change and trade openness as well as real gross domestic product and the energy consumption running a short-run unidirectional panel causality.

The energy price and economic growth has no long-run causality although they have a significant short run negative relationship. In the long-run the producers and consumers adjust themselves with the fluctuation of the energy price. Besides, they can analyze the market and predict the price. So, when there has a possibility of increasing energy price, they can store according to their need. From the analysis, it is also clear that the energy price has a high tends to increase but a low tends to decrease. Analyzing this nature, the producers and consumers take precautionary initiatives. Besides, the per capita income of the people is increasing day by day and they can adjust themselves with a high price. For that reasons, the energy price and the economic growth has short term relationship but no long-term causality.

Table 7: Granger Causality Test (estimated from Penn World Table, BP Statistics, EIA and World Bank Data, 2015)

Null Hypothesis	Value of <i>Chi</i> Square	<i>p</i> -values	Direction of relationship
EPI does not Granger Cause ln(RGDP)	0.32	0.925	No relationship
ln(RGDP) does not Granger Cause EPI	0.66	0.683	
TO does not Granger Cause ln(RGDP)	0.58	0.749	No relationship
ln(RGDP) does not Granger Cause TO	1.07	0.379	
ln(TEC) does not Granger Cause ln(RGDP)	0.36	0.905	Unidirectional
ln(RGDP) does not Granger Cause ln(TEC)	4.43	0.000	
ln(IR) does not Granger Cause ln(RGDP)	0.19	0.980	No relationship
ln(RGDP) does not Granger Cause ln(IR)	0.76	0.602	
TO does not Granger Cause EPI	0.89	0.501	Unidirectional
EPI does not Granger Cause TO	2.67	0.014	
ln(TEC) does not Granger Cause EPI	0.76	0.600	Unidirectional
EPI does not Granger Cause ln(TEC)	3.09	0.005	
ln(IR) does not Granger Cause EPI	1.40	0.211	No relationship
EPI does not Granger Cause ln(IR)	0.18	0.983	
ln(TEC) does not Granger Cause TO	3.27	0.003	Feedback
TO does not Granger Cause ln(TEC)	2.56	0.018	
ln(IR) does not Granger Cause TO	1.53	0.163	No relationship
TO does not Granger Cause ln(IR)	0.82	0.553	
ln(IR) does not Granger Cause ln(TEC)	1.66	0.127	No relationship
ln(TEC) does not Granger Cause ln(IR)	0.84	0.534	

Note: ln(RGDP) is the dependent variable. ln(RGDP), ln(TEC), ln(IR) are the natural logarithm of real gross domestic product, total energy consumption, and international reserve. EP stands for energy price and TO trade openness.

Conclusion

There is no long-run co-integrated relationship between the five variables dealt with here. FMOLS estimation suggests that higher international reserve, trade openness and energy consumption whoop GDP, whereas higher energy price leads to lower GDP. The direction of short-run and long-run causal relationship was also investigated using panel vector autoregressive (PVAR) model. The main findings of this paper are that energy price has a significant negative causal relationship with economic growth in short run but in the long-run they have no link. However, in the long-run energy price and energy consumption have a causal link. Moreover, both in the long-run and short run energy consumption, trade openness and international reserve each of them has a positive significant relationship with economic growth. The major policy implication based on the general result of the study is that as most of the emerging countries are energy importer, hence proper energy conservation policies should be taken to regulate the trade flow for uplifting the GDP. Besides, energy demand side management should be developed efficiently by taking of integrated energy use policy as well as tax or other incentive should be given for productive purpose energy use, which will encourage more foreign and domestic investments.

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