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Exploring the Trade Openness, Energy Consumption and Economic Growth Relationship in Iran by Bayer and Hanck Combined Cointegration and Causality Analysis

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Abstract

This paper aims to investigate the direction of causality between economic growth, energy consumption and trade openness in case of Iran for the period 1967–2012. We apply the newly developed combined cointegration test proposed by Bayer and Hanck (2013). Vector Error Correction Model (VECM) is applied to determine the direction of causality between these three variables. The result of Bayer-Hanck cointegration test reveals the existence of cointegration between variables. The causality analysis indicates just a unidirectional causality from energy consumption to trade openness in short run. The long run causality test explores the bidirectional causality between economic growth and energy consumption, and between openness and energy consumption as well as unidirectional Granger causality from openness to economic growth. In addition, we used variance decomposition method and impulse response functions to show the dynamics of these relationships that confirmed low energy efficiency. This paper provides policy makers with insights to design policies for economic growth with a view to energy consumption and trade.

Keywords: Trade Openness, Economic Growth, Energy Consumption, Bayer and Hanck Combined Cointegration.
JEL Classification: F43, Q43.

1. Introduction

During the past decades, attention to the factors affecting economic growth has increased in both developed and developing countries.

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Among the factors, energy consumption and trade openness have important roles. The relationship between energy consumption and economic growth has been an important issue in recent decades (e.g. Odhiambo, 2009). There are four testable hypotheses which show the direction of causality between energy consumption and economic growth: growth, conservation, feedback, and neutrality (Payne, 2009). In order to investigate the causality direction, Granger causality is a popular approach. The growth hypothesis suggests a unidirectional Granger causality from energy consumption to economic growth; the conservation hypothesis supports a unidirectional Granger causality from economic growth to energy consumption, and the feedback hypothesis supports bidirectional causality between energy consumption and economic growth. Finally, with the neutrality hypothesis, there is no causality relationship between energy consumption and economic growth.

In the context of causal relationship between energy consumption and economic growth, there are numerous studies that support different hypotheses. For example, Soytas et al. (2001) and Lee (2005) discovered the growth hypothesis in their studies. Lise and Van Montford (2007), and Zhang and Cheng (2009) noted that economic growth led to energy consumption, and confirmed the conservation hypothesis. Ghali and El-Sakka (2004), Erdal et al. (2008), Belloumi (2009), and Nasreen and Anwar (2014) found a bidirectional relationship between energy consumption and economic growth; so, their result supported feedback hypothesis. Finally, empirical evidence provided by Fatai et al. (2002), Halicioglu (2009), and Payne (2009) found no significant relationship between energy consumption and economic growth that confirmed neutrality hypothesis.

The other factor affecting economic growth is trade openness. The relationship between openness and economic growth is an issue which researched widely in applied economics and has been controversial subject among economists. The theoretical relationship between trade openness and economic growth was suggested by Grossman and Helpman (1992), Young (1991), and Lee (1993). An increase in trade openness may raise economic growth via technology spillovers which can improve productivity, competitiveness at international level, and export revenues. But on the other hand, the other view affirms negative impact of trade openness on economic growth, especially in the case of developing countries with low income stemming from structural characteristics of low-income developing countries that tend to reverse the terms of trade at their disadvantage (Tekin, 2012). Therefore, causality relationship between trade openness and economic growth can be bidirectional.

Some studies that confirm significant positive effect of trade openness on economic growth include Easterly and Levine (2001), and Musila and Yiheyis (2015); while other studies such as Harrison and Hanson (1999), and Tekin (2012) found no significant impact of trade openness on economic growth. Kumar et al. (2015) revealed bidirectional causality between openness and economic growth. Also in 2010, Vlastou found negative unidirectional causality from openness to economic growth.

In addition to examining the causal relationships between economic growth and energy consumption, economic growth and trade openness, investigating the relationship between trade openness and energy consumption is important. If it is found a unidirectional Granger causality from energy consumption to trade, then a reduction in energy consumption will reduce trade and the benefits of trade. This in turn will compensate trade liberalization policies designed to increase economic growth. If it is found an inverse causality direction or found that there is no Granger causal relationship between these two variables, then trade liberalization policies (in order to promote economic growth) will not be affected by energy reduction policies (Sadorsky, 2012). The effect of trade openness on energy consumption is dependent on the economic conditions of countries, and on the extent of relationship between economic growth and trade openness (Shahbaz et al., 2014). As Nasreen and Anwar (2014) mentioned, by trade openness, developing countries were able to import advanced technologies from developed countries which helped reduce energy intensity and produce more output. It is also possible for changes in energy consumption to affect trade via various ways. One way is that energy is a key input of production; because it is necessary for machinery and equipment in the process of production. Second, in order to trade manufactured goods or raw materials, energy is required for fuel transportation. If there is no adequate energy supply, trade openness will be influenced adversely. So, energy has an important role in expansion of trade, and for this purpose, adequate consumption of energy is necessary.

Empirical exercises about the relationship between energy consumption and trade openness indicated different results for different countries. For instance, Nasreen and Anwar (2014) and Kyophilavong et al. (2015) demonstrated bidirectional causality between energy consumption and openness; but Sohag et al. (2015) found unidirectional causality from trade openness to energy consumption.

Iran is a developing country with rich energy resources and dependent foreign trade. Following to the structural changes in the economy of Iran, development of industries and use of new equipment, and also the growth of urbanization, especially since 1961, energy consumption increased. By the 1979 revolution, the Iran-Iraq War, and political-economic evolutions in Iran, total production and consumption of energy in country dropped. After the Islamic Revolution and liberalization of petroleum products consumption, since 1989, energy consumption re-increased. About the trade in Iran's economy, it can be said that its main characteristic is heavily reliant on oil exports, and its non-oil exports include traditional, agricultural and consumable commodities. On the other hand, most of the imports of Iran are intermediate and capital goods which depend on exchange from oil exports. Generally, like energy consumption, Iran's trade has changed in terms of quantity and quality in different periods when domestic and global economy changed.

In Iran's empirical literature, the relation between trade openness and economic growth (Rahimi and Shahabadi, 2011; Ahmadi and Ganbarzadeh, 2011; Ahmadi and Mohebbi, 2012; Shahiki and Sheidaei, 2012), and also energy consumption and economic growth (Abbasian et al., 2010; Gudarzi Farahani and Sadr, 2012) have been examined separately. This study, to obtain a better understanding of the dynamic relationship between these three variables, tries to investigate the causal relationship between trade openness, energy consumption and economic growth in one model. In the present circumstances of Iran's economy, development of non-oil exports is one of the most important issues in economic growth that must be considered by authorities. So, in this paper, trade openness is imports as well as non-oil exports. In addition, newly developed Bayer and Hank cointegration analysis is used and Granger causality from the VECM framework, and also impulse response functions are used to investigate direction of causality.

The remainder of paper proceeds as follows. Section 2 represents the method and data which were used to study the relationship between economic growth, energy consumption and trade openness in case of Iran. Section 3 shows basic results gained by utilizing unit root tests, cointegration test and VECM Granger causality, and forecasting error variance decompositions and impulse response functions. Conclusions and policy implications are presented in Section 4.

2. Data and Methodology

In this research, to investigate the relationship between economic growth, energy consumption and trade openness in case of Iran, a log-linear model was employed which was proposed by Kyophilavong et al. (2015). Empirical relationship between these three variables can be modeled as follows:

$$lnGDP_t = \beta_1 + \beta_E lnEn_t + \beta_O lnO_t + \mu_t \quad (1)$$

where, $lnGDP_t$, $lnEn_t$ and lnO_t are, respectively, real non-oil GDP per capita (constant 1997), total energy consumption per capita (million barrels of oil equivalent), and real trade openness (real non-oil exports per capita + imports per capita). The μ_t is the error term.

The study used annual data over the years 1967–2012 for the case of Iran. The annual data on energy consumption were collected from Energy Balance Sheet of Iran, and the data concerning annual non-oil GDP and trade openness (non-oil exports + imports) are taken from Central Bank of Iran. We converted these variables into per capita terms by dividing them on total population.

2.1 Methodology

In this study, in order to investigate causality relationship between variables, vector error correction model was used. For this purpose, before estimating the model, we surveyed following stages, respectively: testing stationary of variables, specifying the optimal lag length, testing cointegration among variables, estimating VECM, testing Granger causality according to the VECM; finally we studied variance decomposition and impulse response function methods.

The first stage to estimate time series models is investigating the stationary of variables. In this study, Ng-Perron (2001) and Philips-Perron (1988) unit root tests were employed. If variables are integrated of 1, it is possible to test cointegration among variables.

In the current research, among different tests of cointegration, we used newly developed cointegration test suggested by Bayer and Hanck (2013) which has better results than the other cointegration tests. Because by using this test, different results of individual cointegration tests are combined (Govindaraju and Tang, 2013). In order to combine obtained results, this test applies Fisher's formulas:

$$\mathrm{EG-JOH} = -2\left[\ln(P_{EG}) + \ln\left(P_{JOH}\right)\right] \tag{2}$$

$$\mathrm{EG-JOH-BO-BDM} = -2\left[\ln(P_{EG}) + \ln\left(P_{JOH}\right) + \ln(P_{BO}) + \ln(P_{BDM})\right] \tag{3}$$

where P_{EG}, P_{JOH}, P_{BO} and P_{BDM} are, respectively, the p-values of Engel–Granger (EG), Johansen (JOH), Boswijk (BO), and Baneerjee–Doladoe–Mestre (BDM) cointegration tests. The hypothesis of existence of the cointegration will be accepted if the critical value provided by Bayer and Hanck is less than the calculated Fisher's statistic.

If the results show that the variables of the model are cointegrated, then the vector error-correction model (VECM) can be estimated to identify the direction of causality. Otherwise, first difference vector autoregressive model (VAR) will be applied. Assuming cointegration among variables is approved, the VECM for the current study will become as follows to run the Granger causality test:

$$\begin{bmatrix}\Delta\ln GDP_t\\ \Delta\ln En_t\\ \Delta\ln O_t\end{bmatrix} = \begin{bmatrix}\beta_1\\ \beta_2\\ \beta_3\end{bmatrix} + \begin{bmatrix}B_{11,1} & B_{12,1} & B_{13,1}\\ B_{21,1} & B_{22,1} & B_{23,1}\\ B_{31,1} & B_{32,1} & B_{33,1}\end{bmatrix}\begin{bmatrix}\Delta\ln GDP_{t-1}\\ \Delta\ln En_{t-1}\\ \Delta\ln O_{t-1}\end{bmatrix} + \cdots + \begin{bmatrix}B_{11,k} & B_{12,k} & B_{13,k}\\ B_{21,k} & B_{22,k} & B_{23,k}\\ B_{31,k} & B_{32,k} & B_{33,k}\end{bmatrix}\begin{bmatrix}\Delta\ln GDP_{t-1}\\ \Delta\ln En_{t-1}\\ \Delta\ln O_{t-1}\end{bmatrix} + \begin{bmatrix}\delta_1\\ \delta_2\\ \delta_3\end{bmatrix} \times [ECT_{t-1}] + \begin{bmatrix}\mu_{1t}\\ \mu_{2t}\\ \mu_{3t}\end{bmatrix} \tag{4}$$

where, Δ is the first difference operator and μ_{it} is the disturbance term which is assumed to be normally distributed and white noise. ECT_{t-1} is the lagged error-correction term[1]. We can test the short run Granger causality by restricting the first difference explanatory variables in the system with the Wald test. The existence of a significant joint χ^2 statistic for sum of the first differenced lagged for each independent variable provides evidence on the direction of short run causality. For the long run Granger causality, if χ^2 statistic for sum of the first differenced lagged for each independent variable and ECT_{t-1} of the dependent variable, jointly, is significant, it shows the direction of long run causality.

Since the VECM Granger causality does not show the dynamic properties of the system (Erjavec and Cota, 2003), variance decomposition and impulse response functions are applied. Impulse response function illustrates the impact of a shock in an endogenous variable on the other variables of a model, and variance decomposition technique divides the share of each variable in reaction to the shock to the model variables.

3. Empirical Results

3.1 Unit Root Tests

The first step for our research was testing stationary. To do so, statistics of Ng-Perron (2001) and Philips-Perron (1988) unit root tests were presented in Table 1. Results reported in the table showed that

Table 1: Unit Root Test

	Ng-Perron		**Philips-Perron**
Variables	**MZa**	**MZt**	**Adj. t**
$lnGDP_t$	-1.77639 (1)	-0.72024	-2.1396 (3)
$lnEn_t$	-0.39783 (3)	-0.26888	-2.9491 (0)
lnO_t	1.79473 (0)	1.7766	0.2278 (1)
$\Delta\ lnGDP_t$	-15.3525 (0)**	-2.64228**	-3.4462 (4)**
$\Delta\ lnEn_t$	-41.0875 (2)**	-4.48998**	-4.2716 (1)**
$\Delta\ lnO_t$	-21.2114 (0)**	-3.25521**	-5.3443 (1)**

Note: () indicates lag length.

** Shows significance at 5% level.

1. Here, if the variables are not cointegrated, the ECT_{t-1} will be removed from the equations, and the model will become the first difference VAR model. This model can only have short run Granger causality relationships.

GDP, energy consumption and trade openness with logarithmic form were non-stationary; but they became stationary at their first differences. So, the variables of the study were integrated of 1.

2.3 Cointegration Test

Now since it was approved that all variables were integrated of 1, we could use Bayer and Hanck combined cointegration tests (EG-JOH and EG-JOH-BO-BDM tests). But before testing the cointegration, it was essential to select the appropriate lag length. For this purpose, the AIC criterion was used. The result of determining optimal lag showed that maximum lag length would be 4 (see Table 2).

Table 2: The Lag Order Criteria

VAR lag order selection criteria						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**HQIC**	**SBIC**
0	-49.0128		0.002538	2.53721	2.58287	2.6626
1	122.726	343.48	1.3e-06	-5.11596	-4.52241	-3.48597
2	192.861	14.27	1.0e-06	-5.31029	-4.99068	-4.4326
3	131.941	4.1604	1.4e-06	-4.97274	-4.51616	-3.7189
4	143.877	23.872*	9.1e-07*	-5.40127*	-5.21864*	-4.89974*
5	151.293	14.832	1.5e-06	-5.0387	-4.30817	-3/03256

* Lag order chosen by the criterion

Table 3 provides the results of Bayer and Hanck cointegration analysis. The Fisher statistics are greater than the 5% and 10% critical values for the variables of $lGDP_t$ and lEn_t. This indicates that combined cointegration test statistics accept the existence of cointegration relationship between series. Therefore, a long-run relationship exists for economic growth and energy consumption variables in Iran over the period 1967–2012. However, the combined cointegration test statistics failed to reject the null hypothesis of no cointegration for trade openness variable. Thus, in general we had two cointegration series among three series, and as a result we could reject the no cointegration null hypothesis. We may therefore confirm that there is long run relationship between economic growth and energy consumption for the case study of Iran over the selected period.

Table 3: Bayer-Hanck Cointegration Analysis Results

Model specification	Fisher statistics		Cointegration
	EG-JOH	EG-JOH-BO-BDM	
$lnGDP_t = f(lnEn_t, lnO_t)$	8.6977***	205942***	Yes
$lnEn_t = f(lnGDP_t, lnO_t)$	17.6937**	21.3832**	Yes
$lnO_t = f(lnGDP_t, lnEn_t)$	7.3717	10.8534	No
Significance level	Critical values		
5%	10.895	21.106	
10%	8.479	16.644	

Note: ** and *** represent significance at the 5% and 10% levels, respectively.

3.3 VECM Granger Causality

After proving the existence cointegration relationship between variables, we used the Granger causality test within the VECM framework to provide the causality direction between energy consumption, trade openness and economic growth in both short and long run. Table 4 presents the empirical findings of the Wald test of VECM Granger causality analysis. Findings show that the estimation of ECT_{t-1} are statistically significant with negative signs in all the VECM except openness equation, that is insignificant. The results of causality show that in short run, the relationship between energy consumption and economic growth, and also between trade openness and economic growth is independent in Iran, and there is just a

Table 4: The Granger Causality Test

Variables	Direction of causality					
	Short run			Long run		
	$lnGDP_t$	$lnEn_t$	lnO_t	$lnGDP_t, ECT_{t-1}$	$lnEn_t, ECT_{t-1}$	lnO_t, ECT_{t-1}
$lnGDP_t$	-	1.81 (0.6131)	1.01 (0.7993)	-	12.61* (0.0133)	11.14** (0.0250)
$lnEn_t$	2.45 (0.4841)	-	0.52 (0.9156)	15.97* (0.0031)	-	11.85** (0.0185)
lnO_t	3.44 (0.3287)	7.94** (0.0473)	-	3.47 (0.4824)	8.15*** (0.0864)	-

Note: *, ** and *** represent significance at the 1%, 5% and 10% levels, respectively.

Table 5: Variance Decomposition Approach

Variance Decomposition of LGDP				
Period	**S.E.**	**LGDP**	**LEN**	**LO**
1	0.054654	100.0000	0.0000	0.0000
2	0.087655	97.31907	0.667943	2.012991
3	0.121798	90.39792	1.329407	8.272677
4	0.148363	81.34337	1.14118	17.51545
5	0.172625	73.61293	0.937247	25.44982
10	0.26342	57.70164	7.160786	35.13757
15	0.333236	53.2899	7.851632	38.85847
20	0.392557	50.56299	8.829998	40.60701
25	0.444572	48.94196	9.334398	41.72364
30	0.491162	47.88987	9.683121	42.427
Variance Decomposition of LEN				
Period	**S.E.**	**LGP**	**LEN**	**LO**
1	0.041048	9.969861	90.03014	0
2	0.061783	18.90803	79.60742	1.484547
3	0.086198	21.38212	71.31194	7.30594
4	0.101333	22.0827	61.11357	16.80373
5	0.114797	20.6891	52.73042	26.58048
10	0.150931	19.54179	31.82787	48.63035
15	0.184551	18.91996	22.89142	58.18862
20	0.212637	18.45957	17.80465	63.73578
25	0.238008	18.1164	14.67269	67.21091
30	0.260886	17.89059	12.57811	69.5313
Variance Decomposition of LO				
Period	**S.E.**	**LGP**	**LEN**	**LO**
1	0.398387	10.26415	1.80638	87.92947
2	0.621322	13.55686	2.708529	83.73461
3	0.827123	17.59837	3.026641	79.37499
4	1.005737	23.47871	2.508799	74.01249
5	1.160133	25.73047	2.460779	71.80875
10	1.669515	28.07463	2.94704	68.97833
15	2.048053	29.48094	2.442456	68.0766
20	2.362652	30.22392	2.254999	67.52108
25	2.640373	30.66922	2.120115	67.21066
30	2.891112	30.97701	2.030325	66.99266

unidirectional causality from energy consumption to trade openness. In the long run, we find that the feedback effect is evidenced between economic growth and energy consumption, and between openness and energy consumption, and unidirectional Granger causality from openness to economic growth.

4.3 Forecast Error Variance Decompositions and Impulse Response Functions

In order to analyze the dynamic properties of the system, we used forecast error variance decompositions (VDCs) and impulse response functions (IRFs). The results of variance decomposition approach of this study are reported in Table 5.

The results reveal that a 47.88% portion of economic growth is explained by its innovative shocks, while innovative shocks of energy consumption and trade openness are found to contribute to economic growth by 9.63% and 42.42%, respectively. The contribution of economic growth and trade openness to energy consumption is 17.89% and 69.53%, respectively for the case study. The share of economic growth and energy consumption in adding trade openness is 2.10% and 3.82% in Iran.

The findings of impulse response function are presented in Figure 1. The results of IRF indicate that the response in economic growth is fluctuating due to forecast error stemming in trade openness. The response of economic growth to shocks in energy consumption is initially increasing; but during the next period declines and becomes negative which means that the efficiency of energy consumption is low. The contribution of economic growth and trade openness to energy consumption is positive with fluctuating trend. This means that economic growth and imports of capital commodities have not helped decrease energy consumption. Trade openness responds positively due to shocks in economic growth; but the contribution of energy consumption is increasing till 3^{rd} time horizon, then declines and becomes negative.

4. Conclusion and Policy Implications

This paper investigated the causality relationship between economic growth, energy consumption and trade openness in logarithmic form of the production function in case of Iran. In this study, we used annual data from 1967 to 2012. The unit root properties of the variables were obtained by applying Ng-Perron and Philips_Perron

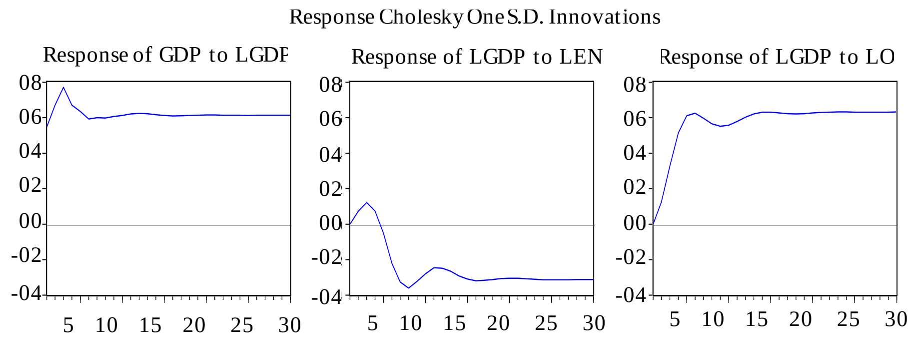

Figure 1: Impulse Response Function

Note: Horizontal axis is period and vertical axis is economic growth (LGDP) response

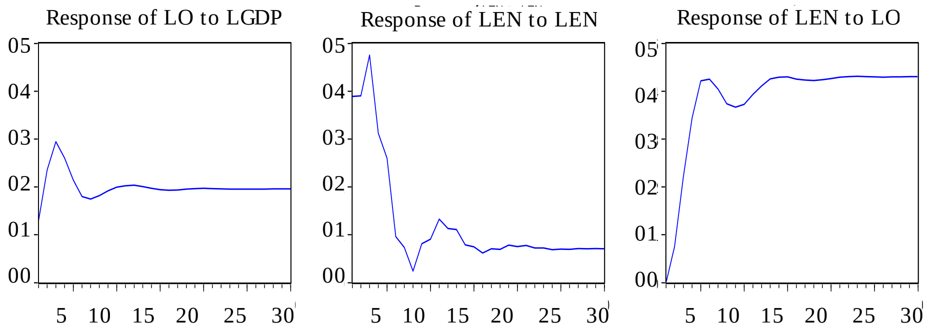

Figure 2: Impulse Response Function

Note: Horizontal axis is period and vertical axis is Energy consumption (LEN) response

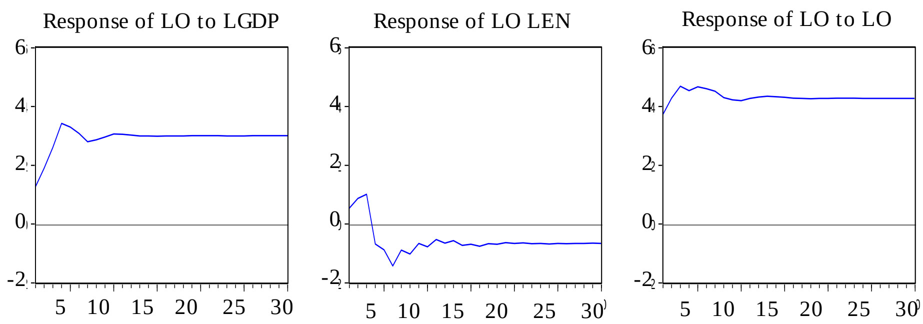

Figure 3: Impulse Response Function

Note: Horizontal axis is period and vertical axis is openness (LO) response unit root tests. The cointegration test which was used for the study was Bayer and Hanck combined cointegration approach. The empirical evidence showed the presence of cointegration amongst the variables. The VECM framework was applied in determining the short run and long run causal relationship between the variables. The results of causality showed that in short run, there was just a unidirectional causality from energy consumption to trade openness. The long run causality test explored the bidirectional causality between economic growth and energy consumption, and between openness and energy consumption and unidirectional Granger causality from openness to economic growth. The results of IRF indicated that the response in economic growth was fluctuating due to forecast error stemming in trade openness. The response of economic growth to shocks in energy consumption was initially increasing; but during the next period declined and became negative which meant that the efficiency of energy consumption was low. The contribution of economic growth and trade openness to energy consumption is positive with fluctuating trend. This shows that imported capital commodities have not been in line with reducing energy consumption. Trade openness responds positively due to shocks in economic growth, but the contribution of energy consumption is increasing till 3rd time horizon then declines and become negative.

These findings have implications for policies as follows. Since the response of economic growth to energy consumption and response of energy consumption to trade openness confirmed the low efficiency of energy consumption, the study proposes the need for the adoption of advanced industrial technology that leads to less energy consumption. This reduces production costs and increases GDP. We also found that openness was Granger cause of economic growth, and the IRF results showed the dynamic positive effect of it in short run, considering that we used non-oil exports and GDP, with the implementation of appropriate policies such as encouraging exports, restricting imports of commodities could be produced in country, and by improving trade relations, it is possible to make comparative advantages in non-oil exports to increase exports and raise economic growth. Attention to comparative advantages and disadvantages leads to increase in production efficiency and decrease in disadvantages in producing goods which lead to economic growth.

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