

Is There Any Asymmetry in Causality between Economic Growth and Energy Consumption?*

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The aim of this study is to investigate the causation linkage between economic growth and electricity consumption as an indicator of energy consumption in the Turkish economy between year 1967 and 2014. In this regard, we employ recently developed asymmetric causality analysis developed by Hatemi-J and Roca (2014) which allows testing asymmetric relations. Test results imply that there is a bi-directional causality between economic growth and electricity consumption. Moreover, an increase in electricity consumption does not affect economic growth positively and but a decrease in consumption of electricity induces a decrease in economic growth. On the other hand, economic growth affects electricity consumption in both positive and negative shocks. Results imply an asymmetric causation linkage between economic growth and energy consumption in the Turkish economy.

Keywords: Economic Growth, Energy Consumption, Asymmetric Causality, Turkey.

JEL Classification: C32, O41, Q43.

1. Introduction

The relation between the amount of energy usage and economic growth highly debated among researchers since 1970s (Hu and Lin, 2013: 76). The motivation in investigating such a relation is to better understand whether economic growth induces energy consumption increase or

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economy of a country grows as a consequence of energy consumption. By doing so, policymakers will be able to design energy policies to promote economic growth and/or to provide energy sources to sustain economic growth.

Designation of the right energy policy in the context of development projects is crucial for especially Turkey, an energy dependent country. The share of energy import in total import volume is about 25% and the ratio of energy deficit to GDP which measures the energy dependency of a country is about 6-7 % (World Bank, 2014: 1). Moreover, the ratio of annual energy deficit to total trade deficit is 58 %.

In the light of the statistics provided by World Bank (2014), implementation of energy conservative policy would reduce energy dependency and current account deficit. But it would hurt growth performance of the Turkish economy, in the case of existence of a causality relation running from energy consumption to economic growth, growth hypothesis is valid. On the other hand, it would not affect growth path of the economy if there is a causation linkage running from economic growth to energy consumption, conservation hypothesis is valid. In this case energy conservative policies have little adverse or no effect on economic growth (Nazlioglu, 2014: 315).

There are two more options in possible relation between the variables. The bi-directional causality between variables can be explained by feedback hypothesis. According to feedback hypothesis, negative energy shocks and/or energy conservation policies may be associated with a decrease in output growth, a growth in economy stimulates energy consumption (Hatemi-J and Irandoust, 2005: 88). Neutrality hypothesis claims that there is no interaction between variables (Wolde-Rufael, 2005: 1108). Thus there is no need to coordinate to policies aiming sustainable economic growth and planning energy sources.

Although there is a vast literature related to the topic, there is no consensus between them. According to Kayhan et al. (2010: 170), conflicting results may come from country or time period investigated as well as methodology differences. On the other hand, existing literature does not take asymmetries in the relationship between variables into account and this may be an important reason of inconclusiveness in the literature.

Existing studies analyze the relation symmetrically and claim an increase in one of them increase other or vice versa. But the relation may be asymmetric. To say that, an increase in economic growth may reduce energy consumption due to technological innovation which saves energy requirement and/or R and D development as a consequence of economic growth. This would indicate a negative relation between economic growth and energy consumption. Moreover, while a positive shock in economic growth induces increases in energy consumption, a negative shock in the same variable may not reduce energy consumption because of existing production setup. In this regard, it is important to identify whether there is an asymmetric relation between variables as well as direction of causation linkage.

In this study, we analyze the re-investigate the relation economic growth and energy consumption in the Turkish economy between years 1967 and 2014 by employing Hatemi-J and Roca (2014). By doing so, we will be able to find possible negative and asymmetric relation between variables. Results would help to better understand the relation to construct development policies while providing most efficient energy policies. Also we will be able to contribute the literature by employing an asymmetric causality test.

In the following section, literature is summarized. In the third section, model and data employed are presented. After the methodology identified in the fourth section, empirical results are interpreted in the fifth section. In the final section, results are concluded and policy implications are presented.

2. Literature Review

In the literature, it is possible to classify studies into four groups in the context of possible relation between energy consumption and economic growth, conservation, growth, feedback and neutrality hypothesis. We can classify the studies according to geographical location of countries also. By doing so, inconclusiveness among the analyses may be seen clearly. Initial study of Yu and Choi (1985), they find uni-directional causality from energy consumption to economic growth for Filipinas located in Asia. In latter studies, Masih and Masih (1996) for India, Masih and Masih (1997) for South Korea, Chang et al. (2001) for

Taiwan, Shiu and Lam (2004) for China, Yemane (2004) for Shanghai, Narayan and Singh (2007) for Fiji Island reach similar results.

Contrariwise relation is found by Masih and Masih (1996) for Indonesia, Yu and Choi (1985) for South Korea, Cheng and Lai (1997) for Taiwan and Soytas and Sari (2003) for South Korea. The feedback hypothesis is supported for Asian economies by Asafu-Adjaye (2000) for Thailand, Glasure (2002) and Oh and Lee (2004) for South Korea, Hwang and Gum (1992) for Taiwan, Squalli (2007) for Iran and Qatar, Meng and Niu (2015) for China.

A number of studies analyze the African economies to understand the relation between economic growth and energy. Belloumi (2009) and Odhiambo (2009) indicate that there is a causation linkage from energy consumption to economic growth in Tunis and Tanzania. Ziramba (2015) supports them in the case of South Africa. Contrary to findings of Belloumi and Odhiambo, Wolde-Rafuel (2006) claim reverse relation in Cameroon, Ghana, Nigeria, Senegal, Zambia and Zimbabwe. The same study finds bi-directional causality implying feedback hypothesis for Egypt, Gabon and Morocco and non-causality implying neutrality hypothesis for Algeria, Congo, Kenya and South Africa. Bildirici (2013) also finds bi-directional causality for Gabon, Guatemala and Ghana. Bildirici (2012) reports similar results for Algeria, Egypt, Morocco, Nigeria, South Africa, Sudan, Togo, Tunisia and Zimbabwe.

Cheng (1997) is one of the initial studies investigating Brazil economy. The study finds no linkage between them in Brazil. On the other hand, Soytas and Sari (2003) finds bi-directional causality for Argentina. Akarca and Long (1980) and Yu and Hwang (1984) finds neutrality hypothesis is valid for United States of America. In the latter study of Narayan and Prasad (2008), similar results are obtained for U.S. and Mexico economies.

The studies investigating European economies have conflicting results similar to literature. Kayhan et al. (2010), Narayan and Prasad (2008) and Hatemi-J and Irandoust (2005) find uni-directional causality from energy consumption to economic growth in Romania, Iceland, Italy, Portugal, Slovakia and Sweden. Hondroyiannis (2002) for Greece and Aktas and Yilmaz (2008) for Turkey find bi-directional causality supporting feedback hypothesis. On the other hand, Yu and Choi (1985)

for Poland and United Kingdom and Narayan and Prasad (2008) for Belgium, Denmark, France, Germany, Ireland, Luxemburg, New Zealand, Norway, Poland, Spain, Sweden, Switzerland and Turkey find non-causality indicating the existence of neutrality hypothesis.

The studies about the Turkish economy have conflicting results too. Asafu-Adjaye (2000), Soytaş and Sari (2003 and 2007), Altınay and Karagöl (2005) and Aslan (2014) claim uni-directional causality running from energy consumption to economic growth in the Turkish economy. On the other hand, Karagöl et al. (2006), Halicioğlu (2007), Lise and Monfort (2007) Karanfil (2008), Bayat et al. (2011) and Kula (2014) find evidences implying reverse relation contrary to Asafu-Adjaye (2000), Soytaş and Sari (2003 and 2007). Doğan (2015) finds results supporting feedback hypothesis for Turkey. Finally, Altınay and Karagöl (2004), Aktas and Yılmaz (2008) and Narayan and Prasad (2008) find that neutrality hypothesis is valid for the Turkish economy.

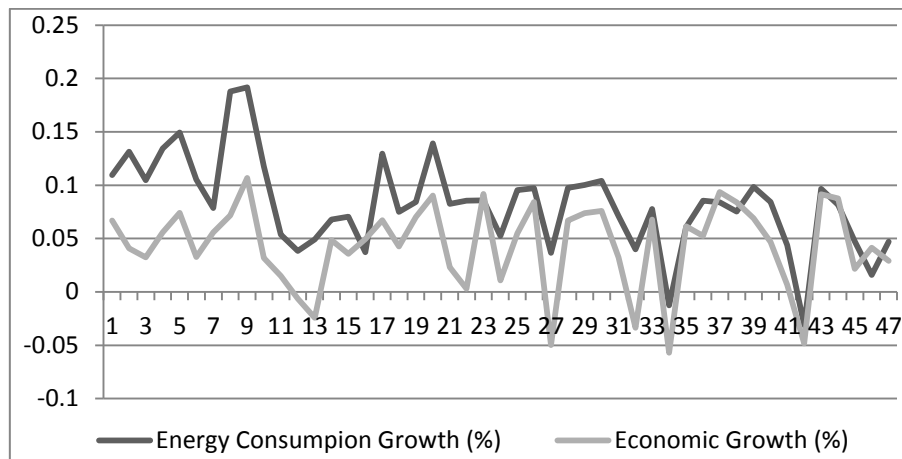
There is a small number of studies investigating asymmetry between economic growth and energy consumption in the literature. One of them belongs to Hatemi-J and Uddin (2012). They analyze the output – energy consumption relation in such a way by employing asymmetric causality test employed in this study. They find that a negative energy consumption shock will cause a negative shock in the output per capita will also decrease. But such a causal impact for positive shocks is not found. Arouri et al. (2014) employ the same method to find possible asymmetry in the French economy and find uni-directional causality running from negative output shocks to negative energy consumption shocks.

3. Data and Model

According to Balat (2009) the Turkish economy one of the emerging market economies invests into energy sector in order to satisfy constantly increasing energy demand. Also energy import dependency still continues. Annual energy demand growth rate is approximately 6 % during the last decade where the Turkish economy has experienced high growth rate and the average growth rate of the same period is approximately 5 %. Energy demand increases more than economic growth. In the light of this explanation, relationship between economic growth and energy consumption is crucial. In the figure 1, it is possible

to see the trend of economic growth and energy consumption in terms of electricity (Gwh).

Figure 1: Annual Growth of Electricity Consumption and Economic Growth (%)



In order to test interactivity between hikes in both variables, we use annual gross domestic product (GDP) variable in order to measure economic growth and electricity consumption in order to measure energy consumption growth (EC) between years 1967 and 2014. The data belonging to electricity consumption is obtained from the Turkish Statistical Institute database and it is measured in the form of Gwh. On the other hand, gross domestic product series with constant prices is obtained from International Financial Statistics database published by International Monetary Fund. We use natural logarithms of all variables to not to live heterojedasticity.

Table 1: Descriptive Statistics of Variables

	Mean	Max	Min	Standart Dev.	Skewness	Kurtosis	Jarque-Bera
EC	10.67	12.24	8.56	1.08	-0.286	1.928	2.952 (0.228)
GDP	3.83	4.78	2.81	0.57	-0.048	1.853	2.646 (0.266)

Note: Value in parentheses shows probability value.

According to descriptive statistics, standard deviation value which is an indicator of volatility is high in the series of energy consumption compare to economic growth series. Also skewness coefficients show that both series are skewed to left. Kurtosis coefficients indicate that both variables are flattened. According to Jarque-Bera test, the null hypothesis claiming series are distributed normally is accepted.

4. Methodology

The basic idea in asymmetric causality test developed by Hatemi-J and Roca (2014) is to investigate causality in different shock types and to determine if causality differs due to shock type. P_{1t} and P_{2t} is two co-integrated variables (Hatemi J, Roca, 2014; 7)

$$P_{1t} = P_{1t-1} + \varepsilon_{1t} = P_{1,0} + \sum_{i=1}^t \varepsilon_{1i} \quad (1)$$

and

$$P_{2t} = P_{2t-1} + \varepsilon_{2t} = P_{2,0} + \sum_{i=1}^t \varepsilon_{2i} \quad (2)$$

t is $t=1,2,\dots,T$, $P_{1,0}$ and $P_{2,0}$ constant terms, $\varepsilon_{1i}, \varepsilon_{2i} : iid(0, \delta^2)$.

Positive and negative changes in each variables are $\varepsilon_{1i}^+ = \max(\varepsilon_{1i}, 0)$, $\varepsilon_{2i}^+ = \max(\varepsilon_{2i}, 0)$, $\varepsilon_{1i}^- = \min(\varepsilon_{1i}, 0)$ ve $\varepsilon_{2i}^- = \min(\varepsilon_{2i}, 0)$, respectively.

We estimate results as $\varepsilon_{1i} = \varepsilon_{1i}^+ + \varepsilon_{1i}^-$, $\varepsilon_{2i} = \varepsilon_{2i}^+ + \varepsilon_{2i}^-$. So,

$$P_{1t} = P_{1t-1} + \varepsilon_{1t} = P_{1,0} + \sum_{i=1}^t \varepsilon_{1i}^+ + \sum_{i=1}^t \varepsilon_{1i}^- \quad (3)$$

$$P_{2t} = P_{2t-1} + \varepsilon_{2t} = P_{2,0} + \sum_{i=1}^t \varepsilon_{2i}^+ + \sum_{i=1}^t \varepsilon_{2i}^- \quad (4)$$

The accumulation of positive and negative shocks in each variable are

$$P_{1t}^+ = \sum_{i=1}^t \varepsilon_{1i}^+, \quad P_{1t}^- = \sum_{i=1}^t \varepsilon_{1i}^-, \quad P_{2t}^+ = \sum_{i=1}^t \varepsilon_{2i}^+ \text{ and } P_{2t}^- = \sum_{i=1}^t \varepsilon_{2i}^-, \text{ respectively}$$

(Hatemi J, Roca, 2014: 8). $P_t^+ = (P_{1t}^+, P_{2t}^+)$ vector is used in order to test causation linkage between positive shocks. For detailed information about optimal lag length selection and bootstrap processes please see Hatemi-J (2003, 2008) and Hatemi J and Roca (2014), respectively.

5. Empirical Findings

In order to see dynamic relationship between variables, VAR (vector autoregression) model is built. Initially, it is crucial to identify stationary of series to solve the spurious regression problem. In order to find whether series contain unit root we employ Dickey-Fuller (1981, hereafter ADF) unit root test.

Table 2: ADF (1979, 1981) Unit Root Test Results

Level	Variables	ADDF		First Difference	ADDF	
		Variables	ADDF		Variables	ADDF
Level	Constant	EC	-4.203 (0) [0.00]***	First Difference	EC	-4.416 (0) [0.00]***
		GDP	-0.704 (0) [0.83]		GDP	-6.903 (0) [0.00]***
	Constant+Trend	EC	-1.473 (0) [0.82]		EC	-5.526 (0) [0.00]***
		GDP	-3.384 (0) [0.06]*		GDP	-6.841 (0) [0.00]***

Notes: ***, ** and * shows stationary of series in different significance levels %1 (0.01), %5 (0.05) and %10 (0.1), respectively. Values in parenthesis show optimal lag length according to Schwarz information criteria. Values in brackets indicate probability values. For ADF test, Mac Kinon critical values are -3.485, -2.885, -2.579 for model with constant and -3.483, -2.884, -2.579 for model with constant and trend 1 %, 5 % and 10 %, respectively.

According to ADF results, energy consumption variable has no unit root in the model with constant and economic growth variable has no unit root in the model with constant and trend in their level values. On the other hand, they have unit root in the model with constant and trend and in the model with constant, respectively. Due to probability of long run memory in both variables, we employ differentiated series in order to find optimal lag length in VAR model. In the light of these results, we choose optimal lag length as two where there is no autocorrelation problem.

Before we present results of asymmetric causality analysis, conventional Granger causality test results are presented in the table 3 in order to compare them. According to results, there is no causation linkage between variables and support neutrality hypothesis.

Table 3: Conventional Granger Causality Test Results

Direction of Causality	Chi-sq	Probability
EC=>GDP	4.0513	0.1319
GDP=>EC	1.1638	0.5588

In conventional causality analyses, test statistics are calculated for a single period. So the test statistic obtained implies for just a single direction of causal linkage. In the theory of economics, discussions about positive and negative shocks affect economy due to cyclical factors. Moreover, interactions between variables may differentiate due to type of change. Causality test developed by Hatemi-J and Roca (2014) finds the causation linkage mentioned above. The null hypothesis of the test claims non causality between variables. In the decision phase, MWALD test statistics is compared to critical values in different significance level. If MWALD test statistics is bigger than critical values; that means there is a causation linkage between shocks and alternative hypothesis is accepted.

Table 4: Hatemi-J and Roca (2014) Asymmetric Causality Test Results

Direction of Causality	MWALD	1% Bootstrap Critical Value	5% Bootstrap Critical Value	10% Bootstrap Critical Value
(EC) ⁺ \nrightarrow (GDP) ⁺	0.042 (0.837)	8.394	4.630	3.078
(EC) ⁺ \nrightarrow (GDP) ⁻	1.572 (0.796)	9.278	5.154	3.864
(EC) ⁻ \nrightarrow (GDP) ⁻	9.742 (0.0)***	11.052	4.078**	3.646*
(EC) ⁻ \nrightarrow (GDP) ⁺	5.782 (0.01)**	9.124	4.843**	3.263*
(GDP) ⁺ \nrightarrow (EC) ⁺	4.989(0.026)**	10.489	6.029	3.729*
(GDP) ⁺ \nrightarrow (EC) ⁻	4.964 (0.03)**	9.233	4.325**	3.107*
(GDP) ⁻ \nrightarrow (EC) ⁻	4.785 (0.02)**	10.458	4.585**	3.431*
(GDP) ⁻ \nrightarrow (EC) ⁺	2.241 (0.142)	9.504	4.874	2.746

Not: \nrightarrow shows null hypothesis where there is no causality. Values in parenthesis show asymptotic probability values. ***,** and * show 1 %, 5 % and 10 % significance levels, respectively. The number of bootstrap iterations is 10.000.

According to results presented in table 4, the causation linkage running from negative energy consumption shock to positive and negative economic growth shocks in 5 % and 1 % significance levels, respectively. On the other hand, a positive shock in energy consumption does not affect economic growth either positive or negative.

Positive and negative economic growth shocks affect energy consumption positively and negatively, respectively. Moreover, energy consumption may decrease as a consequence of economic growth shock.

As a result, there is a bi-directional causality between economic growth and energy consumption. This is consistent with Asafu-Adjaye (2000), Soytaş and Sari (2003 and 2007). Dogan (2015). Different from these studies we find an asymmetry in the relation running from energy consumption to economic growth. While economic growth variable affects energy consumption in either case, energy consumption can affect economic growth only in the case of negative shock. So, the causation linkage from energy consumption to economic growth exists in negative shocks.

6. Conclusion

Despite there is a vast literature related to interactivity energy and economy, there is no consensus among economists how they affect each other. Existing studies are classified into four groups. First group of studies imply economic growth affects energy consumption, second group claims opposite. Third group studies support feedback hypothesis which there is a bi-directional causality. According to last group of studies imply neutrality hypothesis indicating non-causality between variables.

The reason of divergence in the literature may be a consequence of the empirical method employed in analyses as well as variables used and/or period investigated. In this study, we employ asymmetric causality analysis developed by Hatemi-J and Roca (2014) which can capture causation linkage in the case of different shocks in each variable. By employing the method we aim to show asymmetries as a contribution to existing literature. In this regard, we analyze the Turkish economy between years 1967 and 2014 and use annual energy consumption and economic growth data.

Although conventional Granger causality analysis imply neutrality hypothesis, results obtained from asymmetric causality analysis show that bi-directional causality between variables and it is consistent with the studies of Asafu-Adjaye (2000), Soytaş and Sari (2003 and 2007). Dogan (2015). But the asymmetry is found in the relation running from energy consumption to economic growth. While an energy consumption reduction reduces economic growth, an increase in energy consumption does not increase economic growth. The results mean that asymmetric behavior exists in the energy consumption of the Turkish economy. The conventional concept means that energy conservation policies may harm economic growth, if there is a uni-directional causality running from energy consumption to economic growth, vice versa. The findings obtained from asymmetric causality test support the former view, but the reverse does not occur. So, if a policymaker implements energy consumption policies to stimulate economic growth, it will not work.

In the light of these results, economic growth would increase energy demand. Therefore energy policy has to be designed to sustain and increase energy sources in the following years of the Turkish economy. The situation might be similar for emerging economies which have no energy sources like oil, natural gas and etc. On the other hand, a decrease in energy consumption would decrease economic growth performance of Turkey. It is concluded that the Turkish manufacturing sector is sensitive to energy shortage. In any energy policy application such as energy conservation policies and/or higher taxing in energy sector would reduce energy consumption induces slowdown in economic growth.

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