The causal relationship between energy consumption and GDP in Turkey

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Abstract

This paper attempts to investigate the short-run and long-run relationship and causality between energy consumption and economic growth during 1960-2006 period for Turkey. Johansen and Juselius cointegration method and vector error correction model (VECM) have been employed to examine this issue. After finding cointegration among variables, a VECM is estimated and the Granger causality tests were carried out based on a VECM. The results have shown that there is no short-run causality in both energy consumption and GDP models. The results also confirmed that there is unidirectional long-run causality among variables of interest and the direction of long-run causality is running from per capita GDP to per capita energy consumption. As a result, conservation hypothesis which postulates unidirectional causality from economic growth to energy consumption is confirmed for Turkey. Taken together, these empirical findings involve valuable information for policy makers.

Keywords: Energy consumption, Economic growth, Causality, Turkey

JEL classification: C3, O4, Q43

1. INTRODUCTION

The topic of causal relationship between energy consumption and economic growth has been well-studied in the energy economics literature for both developing and developed countries. The causality relationship between energy consumption and economic growth has important policy implications. Hence, several studies have attempted to establish the relationship between energy consumption and economic growth1. A general observation from these studies is that the results have been mixed and it can be concluded that, almost all types of causality results have been reported in the literature. The directions that the causal relationship between energy consumption and economic growth has could be categorized into four testable hypothesizes within the literature. First, the "neutrality hypothesis" suggests the absence of a causal relationship between energy consumption and economic growth. Second, the "conservation hypothesis" postulates unidirectional causality from economic growth to energy consumption. Third, the "growth hypothesis" asserts unidirectional causality from energy consumption to economic growth. Fourth, the "feedback hypothesis" emphasizes the bidirectional relationship between energy consumption and economic growth in which causation runs in both directions (Squalli, 2007).

There are few studies in which the energy consumption-growth nexus have been examined for Turkey. Soytas et al. (2001) found that causality is running from energy consumption to growth. However, the causality is running from economic growth to energy consumption according to the study of Lise and Van Montfort (2007). On the other hand, while bidirectional causality is confirmed in the study of Erdal et al. (2008), no causality is investigated in the studies of Altinay and Karagol (2004), and Soytas and Sari (2009). Thus, there is no consensus on the causality between energy consumption and growth for Turkey.

It is not possible to conclude definitely the direction of causality between energy consumption and economic growth. However, it is known that this causality is of major importance for effective energy policy design and implementation. A country that is energy dependent will have a cautious energy policy because any negative shock on energy supply will have negative effects on economic growth. On the other hand, in an economy where energy consumption is determined by economic growth an energy conservation policy will have very little affect on economic growth (Ouedraogo and Diarra, 2010).

The objective of this paper is to investigate the relationship and causality between energy consumption and economic growth in Turkey for the 1960-2006 period by using Johansen and Juselius cointegration method and vector error correction model. The results obtained in this study are dependent on the sample period, the variables used and the methodology employed. The rest of the paper is organized as follows: The next section describes the data and methodology. Section 3 presents the results from empirical analysis. Section 4 concludes the paper.

2. Methodology

The relationship between energy consumption and GDP has been discussed in detail in the empirical literature. However, the results of the empirical studies provide mixed results on the existence of causality and the direction of causality. The existence of cointegration

1 See Ozturk (2010) for detailed literature survey on energy-growth nexus.

relationship between energy consumption and GDP is taken as evidence that there is close relationship between these variables. Then, the direction of causality has been investigated. In this study, we will examine the relationship between energy consumption and GDP estimating vector error correction model (VECM). The VECM representations of energy model can be written as:

$$\Delta lepc_t = \alpha_e + \sum_{i=1}^{r} \rho_{ei} ECT_{i,t-1} + \sum_{i=1}^{n} \delta_{ei} \Delta lepc_{t-i} \quad (1)$$

$$\Delta lpcgdp_t = \alpha_y + \sum_{i=1}^{r} \rho_{yi} ECT_{i,t-1} + \sum_{i=1}^{n} \delta_{yi} \Delta lpcgdp_{t-i} + \sum_{i=1}^{n} \gamma_{yi} \Delta lepc_{t-i} + \epsilon_{yt} \quad (2)$$

where, $lepc\ and\ lpcgdp$ represent the natural logarithm of energy consumption per capita and reel GDP per capita respectively. ECT represents error-correction term and ϵ is the usual error term.

The advantage of this formulation and estimation procedure is that it allows a straightforward test of the direction and the source of causality. Using the VECM, we can test the long-run and short-run causality between per capita energy consumption and GDP per capita. The existence of short-run causality meaning that the dependent variable responds only to short-term socks can be determined by testing the null hypothesis of $\gamma_{ei} = 0$ in equation (1) and $\delta_{yi} = 0$ in equation (2). To determine whether energy consumption cause economic growth /or visa vice in the long-run, we look at the coefficients on the ECT's in equations (1) and (2). While the size of the coefficients on ECT indicates how fast deviations from long-run equilibrium are eliminated, the significance of these coefficients implies the presence of long-run causality among energy consumption and economic growth. We can also determine whether these two sources of causality are jointly significant by testing the joint hypothesis of $\rho_{ei} = 0\ and\ \gamma_{ei} = 0$ in equation (1) and $\rho_{yi} = 0\ and\ \gamma_{yi} = 0$ in equation (2). The rejections of the joint hypothesis imply that following a shock to the system, both these sources of causation are responsible for the re-establishment of long-run equilibrium.

3. Data and Empirical Results

All data are annually and gathered from the World Development Indicators (2008), Central Bank of the Republic of Turkey (CBRT) electronic data delivery system, IMF's International Financial Statistics (IFS) website. The series employed in this study are per capita energy consumption (lepc) and per capita real GDP (lpcgdp) and sample period is from 1960-2006 for Turkey. Table 1 provides descriptive statistics of the data used in the study. Per capita energy consumption is expressed in terms of kg of oil equivalent and obtained from the World Development Indicators (2008). The real GDP series is expressed in 1987 constant billion TL (local currency) and obtained from the Central Bank of the Republic of Turkey (CBRT) electronic data delivery system (www.tcmb.gov.tr). Per capita GDP series are obtained from dividing real GDP series by population which is taken from IMF's International Financial Statistics website. All series are expressed in logarithms.

Table 1. Descriptive Statistics of Data

Variables	Mean	Standard deviation	Median	Maximum	Minimum
PCEC	777.2	267.6	739.0	1304.0	274.0

PCGDP	1288.9	388.8	1183.4	2160.3	702.1
Observations	47	47	47	47	47

Note: PCEC stands for the per capita energy consumption (in kg oil equivalent); PCGDP is per capita GDP at 1987 constant Turkish Liras (TL).

The results obtained from preliminary analysis of data and estimation of the VECM equation (1) and (2) on the causal relationship between per capita energy consumption and per capita GDP are presented in this section. It become customary to check unit root of time series before carrying out econometric analysis of the data since non-stationary regressors invalidate most of the standard empirical results. For this reason, we first establish the level of integration of the series using both the Augmented Dickey-Fuller (ADF) and the Phillips and Perron (1988) (PP) unit root test tests. After establishing that series are I(1), we can proceed to test for a long-run relationship between the series. The existence of the long-run cointegration relationship among per capita energy consumption and per capita GDP will be tested using the maximum likelihood estimation (MLE) method of Johansen and Juselius (1990). If the cointegration relationship is found, then a VECM given above will be estimated and related test of causality will be carried out.

We first perform unit root tests in levels and first differences in order to determine univariate properties of the series used in this study. We, therefore, use the classical unit root tests, namely, Augmented Dickey-Fuller (ADF) (see Dickey and Fuller, 1981; Said and Dickey, 1984) and PP unit root tests (see Phillips and Perron, 1988). The number of lags in the ADF regressions is determined by using the Schwarz Information Criteria (SIC). Table 2 provides the results obtained from the ADF and the PP tests over the sample period for the levels and first differences of variables. The test results shows that while the hypothesis of a unit root in levels cannot be rejected, it was rejected in first differences at the 1% level suggesting that the variables are difference stationary, I(1) variable. This is true for both the ADF and PP test statistics.

Table 2: Unit Root Test Results

Variables	ADF Statistics		PP test Statistics	
	Level	First difference	Level	First difference
Lepc	-0.9724	-13.7671*	-0.8301	-12.1625*
Lpcgdp	-0.3770	-7.5360*	-0.3409	-7.5327*
1% Critical Value	-3.5811	-3.5811	-3.5811	-3.5847
5% Critical Value	-2.9266	-2.9266	-2.9266	-2.9281
10% Critical Value	-2.6014	-2.6014	-2.6014	-2.6022

Note: (*) indicate 1% level of significance

Having established that all variables are integrated of the same order , we proceed with the Johansen multivariate cointegration tests, which allow us to test for long run relationship among the per capita energy consumption and per capita GDP. Before undertaking

cointegration tests, let us first specify the relevant order of lags of the vector autoregression (VAR) model. In determination of the relevant order of lags used in the VAR model, we used the Hannan-Quinn (HQI) information criterion, the Schwarz Bayesian Criterion (SBC) and Akaike's Information Criterion (AIC). Table 3 presents the results on lag specification. According to all of the lag selection criteria, the number of lags was determined as one.

Table 3. Selection of Lags

Number of Lags	HQI criterion	AIC criterion	SIC criterion
1	-7.825731*	-7.9163*	-7.6706*
2	-7.621177	-7.7722	-7.3626
3	-7.389001	-7.6004	-7.0270
4	-7.159026	-7.4308	-6.6936

Note: * indicates lag order selected by the criterion. HQI, AIC and SIC stands for:

Hannan-Quinn information criterion, Akaike information criterion and

Schwarz information criterion respectively.

Table 4 provides the cointegration test results obtained from the Johansen and Juselius (1990) method for the energy model. In the JJ method, two tests are used to determine the number of cointegrating vectors (r): the trace test and the maximum eigenvalue test. In the trace test, the null hypothesis is that the number of cointegrating vectors is less than or equal to r, where r is 0, 1, or 2. In each case, the null hypothesis is tested against a general alternative. In the maximum eigenvalue test, the null hypothesis r = 0 is tested against the alternative that r = 1, r = 1 against the alternative r = 2, etc.

The results show that the null hypothesis of no cointegration, i.e., r=0 is rejected by both the maximum eigenvalue and the trace statistics since both of these statistics are greater than corresponding critical values. Also, the null of r=1 cannot be rejected in favor of r=2. These results confirm the conclusion that there is only one cointegrating relationship amongst the two variables. Cointegration vector normalized with per capita energy consumption is found to be 1, -0.506, and 1.099.

Table 4: Johansen-Juselius Maximum Likelihood Cointegration Tests results

Trace Test				Maximum Eigenvalue Test			
Null	Alternative	Statistic	Critical Values	Null	Alternative	Statistic	Critical Values
r = 0	r ≥ 1	31.1547*	15.4947	r = 0	r = 1	31.1426*	14.2646
r ≤ 1	r ≥ 2	0.0122	3.8414	r ≤ 1	r = 2	0.0121	3.8414

Notes: Asterisks (*) denotes statistical significance at 5%. r stands for the number of cointegrating vectors.

After we determined that per capita energy consumption and per capita GDP series are cointegrated, we can proceed to test causality among these variables estimating a VECM. Different from the VAR model, VECM allows us to investigate both the short-run and long-run causality as well as joint causality of both long-run and short-run causality. The results of the causality tests based on the VECM are presented in Table 5. The examination of the table shows a number of important results on the causal relationship between per capita energy consumption and per capita reel GDP.

Table 5. Granger causality test

Dependent Variable	Sources of Causation (Independent Variable)				
	Short-run		Long-run		
			ECT	Joint	Joint
	Δ *lpcgdp*	Δ *lepc*		(Δ *lpcgdp and ECT)*	(Δ *lepc and ECT)*
Δ *lepc*	0.905		24.923*	12.784*	
Δ *lpcgdp*		1.250	0.497		0.634

Note: Asterisk (*) denotes statistical significance at 1% level of significance

The coefficient on lagged GDP term in the per capita energy equation and lagged per capita energy term in GDP equation are statistically not significant event at 10% level. These imply that there is no short-run causal relationship between per capita consumption and per capita GDP.

In addition, the coefficient on the error-correction term (ECT) for the per capita energy consumption is statistically significant at 1% level in which its t-value equals to -4.99 and its size is equal to -0.5633 implying that adjustment coefficients are fairly high and deviations from the long-run equilibrium are eliminated rapidly. The coefficient on the error-correction term (ECT) in the per capita GDP equation (which is equal to -0.071 with t-value of -0.71) is however statistically significant at 10% level of significance. Taken these two findings together, the results imply that per capita real GDP variable is weakly exogenous and there is unidirectional long-run causality between lepc and lpcgdp running from lpcgdp to lepc.

Furthermore, while the joint hypothesis that the coefficients on the ECT and the interaction terms are jointly zero is rejected at 1% level in the per capita energy equation, the corresponding hypothesis in the per capita real GDP equation could not be rejected at 10% level. These findings provide further support for the results that there is unidirectional long-run causality between lepc and lpcgdp and the causality is running from real GDP per capita to per capita energy consumption. As a result, conservation hypothesis which postulates unidirectional causality from economic growth to energy consumption is confirmed for Turkey. Thus, energy consumption is determined by economic growth and energy conservation policy will have very little affect on economic growth in Turkey.

Finally, considering the evidences provided in Table 5 together, it can be argued that there is only a long-run causality between per capita energy consumption and per capita real GDP but there is no short-run causality.

4. CONCLUSION

This paper attempted to investigate the causal relationship between per capita energy consumption and per capita GDP employing vector error correction model (VECM) for Turkey. After finding cointegration among variables, a VECM is estimated and the Granger causality tests were carried out based on a VECM. The results have shown that there is no short-run causality in both per capita energy and GDP models. However, the coefficient on the ECT term for per capita energy equation is negative and statistically significant implying the presence of long-run causality among variables of interest. The results also confirmed that there is unidirectional long-run causality among variables of interest and the direction of long-run causality is running from per capita GDP to per capita energy consumption since the ECT's coefficient in the GDP equation is insignificant. This result was also confirmed by the findings obtained from the joint hypothesis that the coefficients on the ECT and the interaction terms are jointly zero. As a result, conservation hypothesis which postulates unidirectional causality from economic growth to energy consumption is confirmed for Turkey. Thus, energy conservation policy will have very little affect on economic growth. Taken together, these empirical findings involve valuable information for policy makers.

It is well known that causality issue between energy consumption and GDP is of major importance for effective energy policy design and implementation. For policy purposes, the presence of long-run unidirectional causal relationship between per capita energy and per capita GDP imply that energy consumption per head will increase in parallel with the level of economic activity and hence it is very important to secure energy resources to achieve sustainable economic growth.

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