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ENERGY CONSUMPTION AND ECONOMIC GROWTH IN TURKEY: COINTEGRATION AND CAUSALITY ANALYSIS

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Abstract

This paper examines the causal relationship between energy consumption and economic growth for Turkey during 1971–2006. We employed two multivariate models, namely demand model and production model, based on vector error correction model. Then, we tested Granger causality after finding cointegration among variables for the both models. The results indicate that energy consumption and economic growth are cointegrated and there is bidirectional causality running from energy consumption to economic growth and vice versa. This means that an increase in energy consumption directly affects economic growth and that economic growth also stimulates further energy consumption. Consequently, we conclude that energy is a limiting factor to economic growth in Turkey and, hence, shocks to energy supply will have a negative impact on economic growth and vice versa.

Keywords: Energy consumption, Economic growth, Causality, Cointegration, Turkey

JEL classification: C3, O4, Q43

1. Introduction

The topic of causal relationship between energy consumption and income has been well-studied in the energy economics literature for both developing and developed countries. It is important for policymakers to understand the relationship between energy consumption and economic growth in order to design effective energy and

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environmental policies. Hence, several studies have attempted to establish the relationship and the way of causality between energy consumption and economic growth for developing and developed countries (Ozturk, 2010). A general observation from these studies is that the results have been mixed and Turkey has no exception (Table 1). From Table 1 it can be concluded that, almost all types of causality results (uni-directional causality, bi-directional causality and no causality) have been reported in the literature for Turkey. In other words, the question of whether energy consumption causes economic growth or economic growth causes energy consumption is an unresolved issue for Turkey. The empirical outcomes of these studies have been varied and sometimes found to be conflicting due to the different time periods, different variables used, countries studied and different econometric methodologies used.

According to the official energy projections for Turkey, there is continuing increase in demand for energy in the next two decades. The higher demand for energy consumption in Turkey is growing rapidly due to the technical, social and economic development. Since energy will play an increasingly vital role in Turkey, examining this issue will highlight a potentially significant relationship.

The objective of this paper is to investigate the causal relationship between energy consumption and economic growth in Turkey using annual data for 1971-2006 period. In the most of the previously studies, a bivariate models had been employed to examine this relationship. In other words, they were using only two variables in their models which cause an omitted variable problem. Thus, to avoid omitted variable problem, in this study we employed a multivariate model by adding real energy prices, capital and labor variables into model in order to examine causality relationship between energy consumption and economic growth.

The rest of the paper is organized as follows: The next section describes the model, data and methodology. Section 3 presents results from this empirical analysis. Finally, Section 4 summarizes the paper.

Table 1

Summary of empirical studies on energy consumption – economic growth nexus for Turkey

Authors	Period	Methodology	Variables	Conclusion
Soytas et al. (2001)	1960–1995	Cointegration	Energy consumption, GDP	GDP ← EC
Altinay and Karagol (2004)	1950–2000	Hsiao’s version of Granger causality	Energy consumption, GDP	GDP ---- EC
Lise and Van Montfort (2007)	1970-2003	Cointegration test	Energy consumption, GDP	GDP → EC
Karanfil (2008)	1970-2005	Granger causality test, Cointegration test	Energy consumption, GDP	GDP → EC GDP----EC (when unrecorded economy is taken into account)
Erdal et al. (2008)	1970-2006	Pair-wise Granger causality,	Energy consumption, GNP	EC ←→ GDP

Authors	Period	Methodology	Variables	Conclusion
		Johansen cointegration		
Halicioglu (2009)	1960-2005	Granger causality, ARDL, cointegration test	Carbon dioxide emissions, Energy consumption, GDP, foreign trade	GDP----EC
Soytas and Sari (2009)	1960-2000	Toda-Yamamoto causality test	Carbon dioxide emissions, Energy consumption, GDP	GDP----EC
Ozturk and Acaravci (2010)	1968-2005	ARDL bounds testing cointegration	Carbon dioxide emissions, Energy consumption, GDP employment	GDP----EC

Note: EC → GDP means that the causality runs from energy consumption to growth (GDP).
GDP → EC means that the causality runs from growth to energy consumption.
EC ←→ GDP means that bi-directional causality exists between energy consumption and growth.
EC----GDP means that no causality exists between energy consumption and growth.

2. Model, Methodology and Data

2.1. Model and Methodology

In the empirical literature, it is observed that two different modeling strategies have been adopted in the analysis of the subject, namely, bivariate and multivariate approaches. Following the literature, to test whether there is a causal relationship between energy consumption and economic growth, we will adopt multivariate approach similar to Oh and Lee (2004), Stern (2000) and Asafu-Adjaye (2000). Furthermore, two different multivariate models (demand side and production side models) will be constructed and estimated using Vector Error Correction Model (VECM). The advantage of this formulation and estimation procedure is that it allows a straightforward test of the direction and the source of causality as will be discussed shortly. While the long-run multivariate demand model is obtained from Oh and Lee (2004), Asufe-Adjaye (2000), and Masih and Masih (1997), the production model is obtained Oh and Lee (2004), and Stern (1993, 2000). The long-run multivariate demand and production equations subject to empirical analysis can be shown as follows.

Demand Model:

$$ec_t = \alpha_0 + \theta_1 rgdp_t + \theta_2 rep_t + \varepsilon_{dt} \quad (1)$$

Production Model:

$$rgdp_t = \alpha_1 + \theta_3 ec_t + \theta_3 rk_t + \theta_4 rl_t + \varepsilon_{pt} \quad (2)$$

where $ec, rgdp, rep$ represent the natural logarithm of energy consumption, real GDP and real energy prices respectively. $rk,\ and\ rl$ are the log of real capital stock and the number of labour employed. ε is the usual error term.

The corresponding VEC representations of the demand model can be written as:

$$\Delta ec_t = \alpha_e + \sum_{i=1}^{r} \rho_{ei}\, ECT_{i,t-1} + \sum_{i=1}^{n} \delta_{ei}\, \Delta ec_{t-i} + \sum_{i=1}^{n} \gamma_{ei}\, \Delta rgdp_{t-i} + \sum_{i=1}^{n} \varphi_{ei}\, \Delta rpe_{t-i} + \epsilon_{et} \quad (3)$$

$$\Delta rgdp_t = \alpha_y + \sum_{i=1}^{r} \rho_{yi}\, ECT_{i,t-1} + \sum_{i=1}^{n} \delta_{yi}\, \Delta ec_{t-i} + \sum_{i=1}^{n} \gamma_{yi}\, \Delta rgdp_{t-i} + \sum_{i=1}^{n} \varphi_{yi}\, \Delta rpe_{t-i} + \epsilon_{yt} \quad (4)$$

where ECT represents error-correction term.

Using the VECM, we can test the long-run and short-run causality between energy consumption and economic growth. 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 the energy equation (3) and $\delta_{yi} = 0$ in the GDP equation (4). To determine whether energy consumption causes economic growth /or visa vice in the long-run, we look at the coefficients on the ECT's in equations (3) and (4). 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 (3) and $\rho_{yi} = 0\ and\ \delta_{yi} = 0$ in equation (4). The rejection of the joint hypothesis implies that following a shock to the system, both these sources of causation are responsible for the re-establishment of long-run equilibrium.

2.2. Data

The data employed in this study involves annual time series for energy consumption (EC), real GDP (RY), real energy prices (REP), capital (RK) and labour (NL) for the 1971-2006 period for Turkey. Energy consumption is expressed in terms of kt oil equivalent and obtained from the World Development Indicators (2008). The real energy price index is defined as the ratio of energy sector wholesale price index (1987=100) to consumer price index (1987=100). Labour is measured as the number of people employed. The real GDP series is expressed in 1987 constant billion Turkish Lira (local currency). Consumer price index and real GDP series are obtained from the Central Bank of the Republic of Turkey (CBRT) electronic data delivery system (http://evds.tcmb.gov.tr/yeni/cbt-uk.html). The producer prices of energy and labour data are obtained from the Turkish Statistical Indicators 1923-2008 publication (www.tuik.gov.tr). Real capital stock series are calculated by using perpetual inventory method which involves subtracting 5% depreciation and adding that year's constant value of gross fixed capital formation figures to benchmark year's capital stock values. While fixed gross capital formation figures and deflators are taken from the Turkey State Planning Organization (SPO)'s Economic and Social Indicators 1950-2006 publication (www.spo.gov.tr), benchmark year's capital stock values are taken from Ebiri and Culfaz (1977). All data are transferred to natural logarithms.

3. Empirical Results

This section presents the results obtained from an empirical analysis of data and the findings on the causal relationship between energy consumption and economic growth. In our empirical analysis, we first established the level of integration of the series using both the Augmented Dickey-Fuller (ADF) and the Phillips and Perron (1988) (PP) unit root tests before carrying out econometric analysis of the data since non-stationary regressors invalidate most of the standard empirical results. Once it is established that series are I(1), we can proceed to test for a long-run relationship between the series. Then, the long-run cointegration relationship among both demand and production model variables will be tested using the maximum likelihood estimation (MLE) method of Johansen and Juselius (1990). If the cointegration relationship is found, a VECM given above will be estimated and related test of causality will be carried out.

3.1. Unit root test results

For testing a long-run relationship among the variables, as a first stage it is important to determine univariate properties of the series used in this study, i.e. whether these variables are I(1), stationary in first differences. We, therefore, performed the ADF (see Dickey and Fuller, 1981; Said and Dickey, 1984) and PP unit root tests (see Phillips and Perron, 1988) in levels and first differences. The selection of the number of lags is carried out using the Schwarz Information Criteria (SIC) in the ADF regressions. The results of the ADF and the PP tests computed over the sample period for the levels and first differences of variables are presented in Table 2. Test results indicate that the hypothesis of a unit root in level series cannot be rejected at the 10% level of confidence, suggesting that the variables are not level stationary. Table 2 also shows that both the ADF and the PP tests confirm that the five variables subject to empirical analysis are first-difference stationary.

Table 2

Unit root test results

Variables	ADF Statistics			PP Statistics		
	Level		First Difference	Level		First Difference
	τ_μ	τ_τ	τ_μ	p_μ	p_τ	p_μ
Ce	-1.3952	-3.1706	-5.9045*	-1.4246	-3.4606***	-5.9045*
Rk	-0.6794	-4.136**	-4.1553*	-1.8788	-3.0315	-3.658*
Rl	-1.9956	-1.1913	-6.0130*	-2.1219	-1.1165	-6.0139*
Rpe	-2.0671	-1.9608	-4.9128*	-2.1414	-1.9201	-4.8569*
Rgdp	-0.4160	-2.8870	-6.4754*	-0.3968	-3.0074	-6.5140*

Variables	ADF Statistics			PP Statistics		
	Level		First Difference	Level		First Difference
	τ_μ	τ_τ	τ_μ	p_μ	p_τ	p_μ
1% Critical Value	*-3.6329*	*-4.2528*	*-3.6394*	*-3.6329*	*-4.2436*	*-3.6394*
5% Critical Value	*-2.9484*	*-3.5484*	*-2.9511*	*-2.9484*	*-3.5442*	*-2.9511*
10% Critical Value	*-2.6128*	*-3.2070*	*-2.6143*	*-2.6128*	*-3.2046*	*-2.6143*

Note: The τ and p statistics refer to the ADF and PP tests respectively. The subscripts μ and τ indicates the models that allow for a drift term and both a drift and a deterministic trend, respectively. Asterisks (, ** and ***), shows significance at 1%, 5% and 10% levels respectively.*

3.2. Cointegration test results

After establishing the level of integration of the data, we use Johansen multivariate cointegration tests to explore any possible long run relationship among the variables involved in the demand and production functions. This involves testing the number of cointegrating vectors. Before undertaking cointegration tests, we first need to determine the number of lags that will be used in the underlying vector autoregression (VAR) model. The relevant order of lags used in the VAR model was determined using the Schwarz Bayesian Criterion (SBC) and Akaike's Information Criterion (AIC). Lag specification results are presented in Table 3. As seen from the Table 3, the number of lags were determined is one for the demand model and two for the production function according to both information criterion, AIC and SIC.

Table 3

Lag specification results for cointegration tests

	Demand Function		Production Function	
Number of Lags	SIC	AIC	SIC	AIC
1	-8.4825*	-9.0322*	-18.246	-19.162
2	-7.7820	-8.7439	-18.343*	-19.992*
3	-6.9608	-8.3350	-17.584	-19.966
4	-6.1883	-7.9747	-17.003	-19.9766

*Note: * indicates lag order selected by the criterion. AIC and SIC stands for: Akaike information criterion and Schwarz information criterion respectively.*

The cointegration test results obtained from the Johansen and Juselius (JJ, 1990) method for the demand function are presented in Table 4 and for the production function in Table 5. The results obtained from Table 4 and 5 show that the null hypothesis of no cointegration, i.e., r=0 is rejected by both the maximum eigenvalue and the trace statistic for both demand and production function. They are both greater than their critical values. However, the null of r=1 can not be rejected in favor of r=2 for both demand and production models. Thus, there is only one cointegrating vector in the demand and production model.

Table 4

Johansen-Juselius maximum likelihood cointegration tests: Demand function

Trace Test				Maximum Eigenvalue Test			
Null	Alternative	Statistic	Critical Values	Null	Alternative	Statistic	Critical Values
							22.299
r = 0	r ≥ 1	42.482*	35.192	r = 0	r = 1	26.285*	15.892
r ≤ 1	r ≥ 2	16.197	20.261	r ≤ 1	r = 2	11.661	9.1645
r ≤ 2	r ≥ 3	4.5355	9.1645	r ≤ 2	r = 3	4.5355	

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

Table 5

Johansen-Juselius maximum likelihood cointegration tests: Production function

Trace Test				Maximum Eigenvalue Test			
Null	Alternative	Statistic	Critical Values	Null	Alternative	Statistic	Critical Values
							28.588
r = 0	r ≥ 1	67.017*	54.079	r = 0	r = 1	33.712*	22.299
r ≤ 1	r ≥ 2	33.305	35.192	r ≤ 1	r = 2	18.112	15.892
r ≤ 2	r ≥ 3	15.192	20.261	r ≤ 2	r = 3	11.751	9.164
r ≤ 3	r ≥ 4	3.441	9.1645	r ≤ 3	r =4	3.4411	

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

3.3. Causality test results

Having determined the presence of cointegration for both models, we estimate a VECM to investigate the short-run and long-run causality and joint causality of both long-run and short-run causality. Table 6 presents the results of the causality tests based on the VECM. Table 6 shows a number of following important results on the causal relationship between energy consumption and economic growth.

Table 6

Granger causality test results

Model	Dependent Variable	Sources of Causation (Independent Variable)				
		Short-run		Long-run		
				ECT	Joint	Joint
		Δ*ce*	Δ*rgdp*		(Δ*ce* and ECT)	(Δ*rgdp* and ECT)
Demand	Δ*rgdp*	3.411***		8.785*	5.601*	
	Δ*ce*		5.127**	28.910*		14.699*
Production	Δ*rgdp*	0.149		7.236*	3.633**	
	Δ*ce*		0.199	6.579**		3.692**

Note: Values are F-statistics. Asterisks (, **, ***) denote statistical significance at 1%, 5% and 10% respectively.*

First, the outcome of the test for the demand model is different from that of the production model. For the demand model, the coefficient on lagged GDP term in the energy equation is statistically significant at 5% level of significance whereas the coefficient on lagged energy consumption term is only significant at 10% level of significance. The corresponding coefficients are found to be insignificant for the production model. Therefore, we can conclude that there is a bi-directional short-run relationship between variables for the demand model but not for the production model.

Second, the coefficients on the error-correction term (ECT) are statistically significant for models and dependent variables implying the presence of bi-directional long-run causality among energy consumption and economic growth. Values of coefficients of ECT term for the demand model are -1.00 in the GDP equation and -0.74 in the energy equation. The corresponding coefficients for the production model are -0.87 for the GDP equation and -0.77 in the energy equation. These imply that for both models, adjustment coefficients are considerably high indicating that deviations from the long-run equilibrium are eliminated rapidly.

Third, the rejection of the hypothesis that the coefficients on the ECT and the interaction terms are jointly zero also confirm the existence of the bi-directional long-run causality between energy consumption and economic growth.

Finally, taken all the results together given in Table 6, we can conclude that there is a bi-directional causality between energy consumption and economic growth. In addition, while the reason behind the observed causality for the demand model is explained by both short-run and long-run causality channels, bi-directional causality observed in the production model stems from only long-run causality among energy consumption and economic growth. Therefore, *feedback hypothesis*, which implies that there is two-way (bidirectional) causality between energy consumption and economic growth, is confirmed for Turkey.

Comparing with the evidence provided in the empirical literature on the other countries, we can argue that the results of causality tests presented in the paper for Turkey is in general consistent with the results of empirical literature. For the production model, the lack of short-run causal relationship between energy consumption and economic growth is consistent with the neutrality found by Oh and Lee (2004), Yu and Yin (1992) and Masih and Masih (1996) for Korea, India, Indonesia and Pakistan. The evidence of bi-directional Granger causality among energy consumption and economic growth is consistent with the findings of Belloumi (2009), Erdal et al. (2008), Stern (1993, 2000), Yang (2000), Asafu-Adjaye (2000), Glasure and Lee (1998) and Masih and Masih (1996) for USA, Turkey, Taiwan, Tunisia, Korea, and Pakistan.

4. Conclusion

It is important for policymakers to understand the relationship between energy consumption and economic growth in order to design effective energy and environmental policies. A general conclusion from the previous studies is that there is no consensus either on the existence or on the direction of causality between energy consumption and economic growth in the literature.

This paper analyses the causal relationship between energy consumption and economic growth using two multivariate models, namely demand model and production model for Turkey in 1971-2006. Based on a VECM, we tested Granger causality after finding cointegration among variables of both models. The short-run dynamics of the variables indicate that there is bi-directional short-run causal relationship between energy and GDP in the demand model whereas no short-run causality in the production model. For both demand and production models, the coefficients of the ECT terms for all models are statistically significant implying the presence of bi-directional long-run causality among energy consumption and economic growth. As a result, "*feedback hypothesis*" is confirmed in Turkey. This implies that high energy consumption tends to have high economic growth and vice versa in Turkey.

These findings have very important policy implications. The long-run bi-directional causal relationship between energy and GDP shows that the higher the level of economic activity the higher the energy consumption and vice versa. This means that an increase in energy consumption directly affects economic growth and that economic growth also stimulates further energy consumption. Consequently, we conclude that energy is a limiting factor to economic growth in Turkey and, hence, shocks to energy supply will have a negative impact on economic growth and vice versa.

According to the official energy projections for Turkey, there is continuing increase in demand for energy in the next two decades. The higher demand for energy consumption in Turkey is growing rapidly due to the technical, social and economic development. Since energy will play an increasingly vital role in Turkey, examining this issue highlights a potentially significant relationship. Thus, to achieve sustainable economic growth, the results imply that Turkey needs to secure energy resources.

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