

Energy Consumption and Economic Growth In Turkey: An Empirical Analysis

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ABSTRACT

Energy is one of the most important fundamental inputs of the economy and social life. Globally; increasing population, economic growth, urbanization, and technological developments have been increasing energy needs of countries. However, the fact that the fossil fuels such as oil, coal and natural gas is limited and rising energy prices led countries to find alternative sources of energy. The country's energy dependency is increasing day to day. Relationship between energy and economic growth for developed and developing countries is a hotly debated topic. Especially for developing countries requires more energy to achieve economic growth. In term of Turkey which is particularly dependent on foreign energy is important to determine the direction of the relationship. The ampirc literature related with causality between energy consumption and economic growth show different results according to periods and methods used. In some studies a uni-directional causality is found running from energy consumption to economic growth and in some studies a uni-directional causality is found running from economic growth to energy consumption. While some results indicate no causality between variables, the others indicate bi-directional causality.

The aim of this study is to examine relationship between electricity consumption and economic growth in Turkey during the period 1970-2009. Real GDP per capita and electricity per capita variables are used. Firstly, NG Perron and Phillips Perron unit root tests are used to verify the order of integration of the variables. Johansen cointegration test and vector error correction model are employed to examine the relationship. All variables are found stationary in the first difference. According to Johansen cointegration test it is concluded that there is long run cointegration between variables. The results indicate that there is a cointegration vector between the real GDP and the electricity consumption in the long- run. Both short and long-run uni-directional causality from real GDP to electricity consumption is observed. Besides, according to Toda Yamamoto Granger Causality test there is found uni-directional causality from real GDP to electricity consumption. This results can be interpreted as advancement of the countries' economy, there has been increase in energy consumption, particularly in electricity consumption. Due to high income, consumers consume more and more electricity. According to the findings obtained from this study, energy conservation policies may be applied in order to reduce energy consumption in Turkey. The uni-directional causality running from economic growth to energy consumption implies that energy conservation policies may not unfavourable effects on economic growth.

Keywords: Energy Consumption, Economic Growth, Johansen Cointegration Test, VECM, Toda Yamamoto Granger Causality

Type of Study: Research

Türkiye'de Enerji Tüketimi ve Ekonomik Büyüme: Ekonometrik Bir Analiz

ÖZET

Enerji ekonominin ve sosyal yaşamın en önemli girdilerinden biridir. Dünyada, nüfusun, ekonomik büyümenin, kentleşmenin ve teknolojik gelişmelerin artması ülkelerin enerji ihtiyacını yükseltmektedir. Petrol, kömür ve doğal gaz gibi fosil yakıtların sınırlı olması ve yükselen enerji fiyatları ülkeleri alternatif enerji kaynakları bulmaya yöneltmiştir. Ülkelerin enerjiye bağımlılıkları günden güne artmaktadır. Enerji ve ekonomik büyüme ilişkisi gelişmiş ve gelişmekte olan ülkeler için tartışılan bir konudur. Özellikle gelişmekte olan ülkeler ekonomik büyümeyi gerçekleştirmek için daha çok enerjiye ihtiyaç duymaktadır. Enerji konusunda dışa bağımlı olan Türkiye açısından ilişkinin yönünün belirlenmesi önemlidir. Enerji tüketimi ve ekonomik büyüme arasındaki nedenselliklerle ilgili ampirik literatür zaman ve kullanılan yöntemlere göre farklı sonuçlar göstermektedir. Bazı çalışmalarda enerji tüketiminden büyümeye doğru, bazı çalışmalarda büyümeden enerji tüketimine doğru tek yönlü nedensellik bulunmuştur. Bazı çalışmalarda ise değişkenler arasında nedensellik ilişkisi bulunamazken, bazılarında çift yönlü nedensellik bulunmuştur.

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Bu çalışmanın amacı, Türkiye’de 1970-2009 döneminde elektrik tüketimi ve ekonomik büyüme arasındaki ilişkiyi incelemektir. Çalışmada kişi başına reel gayrisafı yurtiçi hasıla ve kişi başına elektrik tüketim verileri kullanılmıştır. İlk olarak, NG Perron ve Phillips Perron birim kök testleri kullanılarak değişkenlerin bütünlüşme dereceleri saptanmıştır. İlişkiyi incelemek amacıyla Johansen eşbütünlüşme testi ve vektör hata düzeltme modeli kullanılmıştır. Tüm değişkenler birinci farklarında durağan bulunmuştur. Johansen eşbütünlüşme testi sonucu değişkenler arasında uzun dönemli kointegrasyon olduğu tespit edilmiştir. Sonuçlar uzun dönem de reel GSYİH ve elektrik tüketimi arasında eşbütünlüşük bir vektörü göstermektedir. Hem kısa dönemde hem de uzun dönemde reel GSYİH’den elektrik tüketimine doğru tek yönlü nedensellik gözlemlenmiştir. Ayrıca Toda Yamamoto Granger nedensellik testine göre reel GSYİH’den elektrik tüketimine doğru tek yönlü nedensellik bulunmuştur. Türkiye’de ekonomik büyüme daha yüksek enerji tüketimine neden olmaktadır. Bu sonuç ülke ekonomisinin gelişmesi ile birlikte enerji tüketiminde, özellikle elektrik tüketiminde yükseliş olarak yorumlanabilir. Tüketiciler daha yüksek gelir düzeyi nedeniyle daha çok enerji tüketmektedir. Çalışmadan elde edilen bulgulara göre Türkiye’de enerji tüketimini azaltmak amacıyla enerji tasarruf politikaları uygulanabilir. Ekonomik büyümeden enerji tüketimine doğru nedensellik bulunması enerji tasarruf politikalarının ekonomik büyüme üzerinde olumsuz etkileri olmayacağı anlamına gelmektedir.

Anahtar Kelimeler. Enerji Tüketimi, Ekonomik Büyüme, Johansen Eşbütünlüşme Testi, VECM, Toda Yamamoto Granger Nedensellik

Çalışmanın Türü: Araştırma

1.Introduction

Energy is one of the main inputs of economic and social life. A country needs energy to suspend its economic development and sustain social life. Due to importance of energy, this issue has been debated in both devoleped and devoloping countries for a long time. It is particulary essential in developing countries to determine the direction of relationship between energy and economic growth while making their economic policies. The empirical evidence is mixed ranging from bi and uni-directional causality to no causality. The results can change even for the same countries according to data, period and method used.

The relationship between energy and growth relationship is examined in two ways in the literature. According to the pro-energy approach, energy’s impact on economic growth is clear and energy is used as a main input factor such as labor and capital. In other words, energy is the main factor has an effect on economic growth. But according to the neoclassical approach, the growth rate is determined by population growth rate and it is assumed that technological progress is the only factor in the increase of the growth rate. Also it is claimed that, energy has no impact on economic growth because its share in GDP is insignificant (Bulut etc., 2014:1; Aytaç, 2010: 483).

The aim of this study is to examine long run relationship between energy consumption and economic growth for Turkey. Annual data for Turkey between 1970-2009 are used for the analysis. The data includes electricity consumption per capita and real GDP per capita. Johansen cointagration method and error correction model are used to determine long run relationship and direction of causality. Also Todo Yamamoto causality test is applied to determine relationship between variables.

The study includes six section. Firstly, the theoretical and empirical literature about subject will be summarized. Secondly, methodology and data will be given and then, empirical results will be presented. The last section will consist of empirical results and opinion.

2. Theoretical Approaches To Realitionship Between Energy and Economic Growth

Recently, with the contribution of both neoclassical economists like Hamilton (1983), Burbridge and Harrison (1984) and endogenous growth models in Barro (1988), Lucas (1988), it has been demonstrated that, energy is an important factor on economic growth (Bulut etc., 2014:1; Aytaç, 2010: 483).

While examining the relationship between energy and economic growth, capital, labor and energy are being treated as separate inputs in the traditional single-sector production tehnolohy. So the production function is defined as follows:

$$Y=f(K, L, E) \quad (1)$$

Where Y is aggregate output; K is capital stock; L is the level of employment and E is total energy consumption. In this production function, the rises in industrial energy consumption is assumed to increase production and income (Ghali and El-Sakka, 2004; 228). As a result of this, energy becomes effective factor in the production function such as labor and capital.

In endogenous growth models, for instance in the Romer model, the production function is defined as follows:

$$Y=f(A, K, L) \quad (2)$$

Where Y denotes reel output, A denotes technology; K denotes real capital stock and L denotes total employment. Energy is seen as factor which is providing technology usage and energy is available through high technology investments. The output level is increased by the energy factor which is created by the help of technology (Mucuk and Uysal, 2009; 106-107).

3. Empirical Literature

Kraft and Kraft (1978) found evidence to support uni-directional causality running from income to energy consumption in the US during 1947-1974. However, Yu and Hwang (1984) did not find any Granger causality between GNP and economic growth in the US during 1947-1979, similarly, Yu and Jin (1992) observed no relationship between income and economic growth in the long run. Masih and Masih(1996) concluded mixed results in India, Indonesia, Pakistan, Malaysia, Singapore and Philippines. Asafu-Adjaye (2000), Stern (2000), Shiu and Lam (2004), Wolde-Rufael (2004) identified uni-directional Granger causality running from energy to economic growth. Conversely, Ghosh (2002) and Yoo (2006) found causality running from economic growth to energy consumption. Masih and Masih (1996), Asufu-Adjaye (2000), Glasure (2002), Yang (2000), Hondroyannis et al. (2002), Oh and Lee (2004), Yoo (2005; 2006), Zachariadis and Pashourtido (2007) found bi-directional Granger Causality from energy to income. The empirical evidence is mixed ranging from bi and uni-directional causality to no causality.

In Turkey, the studies concerning the causal relationship between energy consumption and economic growth have show mix results, too. Soytaş et al. (2001), Sarı and Soytaş (2004), Altınay and Karagöl (2005), Karagöl et al. (2007) observed uni-directional causality running from energy consumption to income in Turkey. On the other hand, Lise and Montfort (2007), Özata (2010), Uzunöz and Akçay (2012) found uni-directional causality running from GDP to energy consumption. In some studies like Altınay and Karagöl (2004), Jobert and Karanfil (2007), Çetin and Seker (2012) results indicated no causality between these two variables in Turkey, although Erdal et al.(2008), Akpolat and Altıntaş (2013), Bayar (2014) detected bi-directional relationship. Table 1 gives summary information of the mentioned studies regarding to Turkey.

Table 1. Energy, Electricity and Economic Growth Relationship in Turkey

Author-Country	Periods	Methods	Findings
Soytaş et.al. (2001)	1960-1995	Johansen Cointegration Methodolgy Vector Error Correction Modeling	EC → GDP
Soytaş and Sarı (2003) Top 10 emerging markets and G-7 countries	1950-1992 (Argentinan: 1950-1990) Indonesia (1960-1992), Korea (1953-1991), Poland (1965-1994))	Johansen Cointegration Methodolgy Vector Error Correction Modeling	In the long-run for Turkey,France, Germany, Japan: EC → GDP; In Italy and Japan: GDP → EC; In Argentina: EC↔ GDP In the short run for Turkey: EC↔ GDP
Altınay and Karagöl (2004)	1950-2000	Endogenous break unit root test, Granger Causality	EC ≠ GDP
Altınay and Karagöl (2005)	1950-2000	Granger Causality, Dolado-Lütkepohl Test	EC → GDP
Sarı and Soytaş (2004) Turkey	1969-1999	Generalized Forecast Error Variance Decomposition Analysis	The total energy consumption explains 21% forecast error variance of GDP And employment explains from 23% to 26% of the forecast error variance in Turkey GDP.
Karagöl et al. (2007)	1974-2004	Bound Test	In short run EC → GDP
Lise and Montfort (2007)	1970-2003	Cointegrasyon	GDP → EC
Jobert and Karanfil (2007)	1960-2003	Cointegrasyon, Granger Temporal Causality	EC ≠ GDP (general and in industry)
Erdal et al., (2008)	1970-2006	Johansen-Juselius Cointegration, Granger Causality	EC↔ GDP
Özata (2010)	1970-2008	Granger Causality, VECM	GDP → EC
Uzunöz and Akçay (2012)	1970-2010	Johansen Cointegration, Granger Causality	GDP → EC
Çetin and Seker (2012)	1970-2009	Toda-Yamamoto Causality Test	EC ≠ GDP
Akpolat and Altıntaş (2013)	1961-2010	JohansenCointegration,VECM	EC↔ GDP
Bayar (2014)	1961-2012	ARDL, Toda-Yamamoto Causality	EC↔ GDP

4.Methodology and Data

In investigating the relationship between electricity consumption and GDP, the emprical analysis take into account linear regression model belows:

$$LEC_t = a_0 + a_1 LRY_t + \varepsilon_t \tag{3}$$

where EC_t and Y_t denote electricity consumption per capita (kWh) and real GDP per capita (constant 1998 price million TL), respectively.

Annual data for Turkey between 1970-2009 are used for the analysis. The data includes electricity consumption per capita and real GDP per capita based on 1998=100 price. All data are obtained from World Bank Statistics. The logarithmic form is used to avoid from heteroscedasticity problem.

Unit root tests are used to determine whether time series have unit root or not. If time series have unit root, in other words, non-stationary, then these series may have stocastic or deterministic trends. Hence, spurious regression is seen in regression models. If the series are non-stationary in the level and stationary in the first difference, then they are said to be integrated of order one. According to Engle Granger (1987), alinear combination of two or more non-stationary series may be stationary. In the analysis, Phillips Perron (PP) and NG Perron unit root tests are used to determine the degree of integration of the two series.

In this study we use Johansen (1988) and Johansen-Juselius(1990) cointegration test. Johansen methodolgy considers in the vector autoregression (VAR) of order p described as:

$$Y_t = A_0 + A_1 Y_{t-1} + \dots + A_p Y_{t-p} + \varepsilon_t \tag{4}$$

where Y_t is the vector of endogenous variables, A_0 is the vector of deterministic terms, A_1, \dots, A_p are the matrices of coefficients to be estimated, p is the lag lengths and ε_t is the vector of error terms. The VECM specification of equation is then written as follows:

$$\Delta Y_t = A_0 + \Pi Y_{t-1} + \Gamma_1 \Delta Y_{t-1} + \dots + \Gamma_{p-1} \Delta Y_{t-p+1} + \varepsilon_t \tag{5}$$

where the Π matrix provides information for the long-run relationships that Π can be decomposed $\Pi = \alpha\beta'$ where α is the error correction term that gives us the speed of adjustment to the long-run steady state equilibrium and β' is the matrix of long-run coefficients. Johansen (1988) ve Johansen-Juselius (1990) assert two test to determine number of cointegration vector and to determine whether cointegration vectors are significant or not. Trace statistics and max eigenvalue statistics present as following equations:

$$\text{Trace Statistics} = -T \sum_{i=r+1}^p \ln(1 - \lambda_i) \tag{6}$$

$$\text{Max Eigenvalue Statistics} = -T \ln(1 - \lambda_{r+1}) \tag{7}$$

$i=(r+1), (r+2), \dots, p$

where T and r represent number of observation and number of cointegrated vector, respectively.

The error correction models are presented as following equations:

$$\Delta LEC_t = \beta_0 + \sum_{i=1}^{p-1} \beta_{1i} \Delta LEC_{t-i} + \sum_{i=1}^{p-1} \beta_{2i} \Delta LRY_{t-i} + \Phi_1 ECT_{t-1} + \varepsilon_{1t} \tag{8}$$

$$\Delta LRY_t = \alpha_0 + \sum_{i=1}^{p-1} \alpha_{1i} \Delta LRY_{t-i} + \sum_{i=1}^{p-1} \alpha_{2i} \Delta LEC_{t-i} + \Phi_2 ECT_{t-1} + \varepsilon_{2t} \tag{9}$$

ECT_{t-1} is error correction term obtained from cointegration equation. Granger causality based on vector error correction model gives both short run and long run causality results. The long run causality is based on testing statistical significance of Φ_1 and Φ_2 . If Φ_1 and Φ_2 are statistically significant, it implies the existence of long run causality.

5. Empirical Results

According to PP and NG-Perron unit root tests, two series have unit root in their levels and both variables are integrated at order one I(1). Summary results of Philip- Perron and NG- Perron unit root tests are given in the Table 2;

Table 2. NG-Perron and PP Unit Root Test

Variable	NG-Perron Statistics				Philips-Perron (PP) Statistics	
	Mza Statistics		MZt Statistics		Constant Model	Constant+ Trend Model
	Constant Model	Constant+ Trend Model	Constant Model	Constant +Trend model		
LEC	1.8362	-2.1761	7.1567	-0.9196	-2.5083 (0.1215)	-2.8288 (0.1964)
ΔLEC	-13.1550**	-16.6608**	-2.4927**	-2.8839**	-3.9851** (0.0039)	-4.2386** (0.0097)
LRY	1.4070	-11.0686,	1.6078	-2.33405	-0.8311 (0.798)	-2.7423 (0.226)
ΔLRY	-18.8079**	-18.3232**	-2.8985**	-2.9198**	-5.5760* (0.000)	-5.4960* (0.0003)

Note:* Significance at the 1% level, ** Significance at the 5% level, *** Significance at the 10%level, numbers in parentheses are the corresponding p-values. Barlett Kernel spectral estimation method and Newey-West Bandwith criteria are used to determine optimal lag length of PP test and NG-Peron. NG- Perron test concludes 4 basic test. In the table MZA ve MZt tests results were given. %5 critical value of Mza and Mzt for constant model are -8.100 and -1.980, respectively. %5 critical value of Mza and Mzt for constant and trend model are -17.300 and -2.9100, respectively. These values were taken NG-Perron (2001) Table-1.

As shown in table 3, null hypothesis is (r=0), so that, “no cointegration vector exist between variables” is rejected at 5% significance level. Johansen cointegration results showed that there is one cointegration between variables in the long run. The results are given in the Table 3.

Table 3. The Results of Johansen Cointegration Test

Trace Test					
Null Hypothesis	Alternative Hypothesis	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.
r=0	r≥1	0.324156	16.08787*	15.49471	0.0407
r≤1	r≥2	0.042102	1.591510	3.841466	0.2071
Max Eigenvalue Test					
Null Hypothesis	Alternative Hypothesis	Eigenvalue	Max Eigenvalue Statistics	0.05 Critical Value	Prob.
r=0	r=1	0.324156	14.49636*	14.26460	0.0406
r≤1	r=2	0.042102	1.591510	3.841466	0.2071

Notes: r indicates cointegration vector number. * denotes significance at the 5% level. Akaike information criterion (AIC) and HQ criterion are used to determine lag order and 2 is selected.

Short run Granger causality test indicated that there is uni-directional causality relationship from economic growth to electricity consumption. According to results “LRY does not Granger cause LEC” null hypothesis can reject. Yet, “LEC does not Granger cause LRY” null hypothesis does not reject. The result are given in the Table 4.

Table 4. Granger Causality Test

Null Hypothesis	Chi-square Test	Probability
LRY does not Granger cause LEC	15.34089*	0.0001
LEC does not Granger cause LRY	0.391391	0.5316

Note: * Significance at the 1% level

The statistically significant of ECT_{t-1} implies long run causality between variables. VECM model indicates that there is uni-directional causality relationship from LRY to LEC in the long run. The results are given in the Table 5

Table 5. Granger Causality Test based to Error Correction Model

Variable	Coefficient	Standard Error	t-Statistics	Results
DLEC(-1)	0.0324508	0.12668	[0.25622]	
DLRY(-1)	0.386878	0.09878	[3.91675]	
c	0.050696	0.00971	[5.22196]	
ECTt-1	-0.115472	0.03141	[-3.67628]	LRY→LEC

The result obtained from this study is consistent with Lisa and Monfort (2007), Özata (2010), Uzunöz and Akçay (2012). It is observed that there is uni-directional causality running from GDP to energy consumption.

In the study Toda and Yamamota (1995) causality method is employed. The method includes Modified Wald statistic for testing the significance of the parameters of VAR(k) model. Firstly, it is necessary to determine maximum order of integration of series d_{max}. Secondly, it is necessary to determine optimal lag of Var Model. In the study the lag length, using the Akaike Information Criterion (AIC), is determined to be 2. Thirdly, it is necessary to estimate (k+d_{max})th order of VAR. The estimation of VAR(k+d_{max}) guarantees the asymptotic X² distribution of the Wald statistic. Lastly the hypothesis is tested using a standart Wald statistic test has an asmpotic chi-square distribution with m degress of freedom. According to Toda and Yamamota (1995) causality test model can be written as follows:

$$Y_t = \alpha_0 + \beta_{1i} \sum_{i=1}^k Y_{t-i} + \beta_{2j} \sum_{j=k+1}^{d_{max}} Y_{t-j} + \gamma_{1i} \sum_{i=1}^k X_{t-i} + \gamma_{2j} \sum_{j=k+1}^{d_{max}} X_{t-j} + \epsilon_{1t} \tag{10}$$

$$X_t = \alpha_1 + \lambda_{1i} \sum_{i=1}^k X_{t-i} + \lambda_{2j} \sum_{j=k+1}^{d_{\max}} X_{t-j} + \delta_{1i} \sum_{i=1}^k Y_{t-i} + \delta_{2j} \sum_{j=k+1}^{d_{\max}} Y_{t-j} + \varepsilon_{2t} \quad (11)$$

Here, k is optimal lag order, d is the maximum order of integration of the series, and ε_{1t} and ε_{2t} are error terms.

Table 6. Toda Yamamoto Test Results

Null Hypothesis	Lag(k)	k+dmax	X2-test	Conclusion
LRY does not Granger Cause LEC	2	2+1	50.23530 (0.000)*	Reject
LEC does not Granger Cause LRY	2	2+1	1.617981 (0.4453)	Do not reject

Notes:* Significance at the 1% level.

According to Toda Yamamoto causality test “LRY does not Granger Cause LEC” null hypothesis reject, “LEC does not Granger Cause LRY” null hypothesis does not reject. Consequently, there is observed uni-directional causality running from LRY to LEC. However, the studies used Toda-Yamamoto method for Turkey show different results. For instance, Çetin and Seker (2012) found no causality relationship between real gdp and total energy consumption. On the other hand, Bayar (2014) found bi-directional causality between real gdp per capita and primary energy consumption. This may be because of using different variables and periods.

6. Conclusion

Turkey is a developing country and needs energy to sustain and enhance its economic growth. Yet, like other developing and developed countries, energy dependency is the biggest economic problem for Turkey. Economic growth and energy dependency dilemma is needed to take care while making policy. The large number of studies about this subject, found different results for different countries as well as for different time periods within the same country. For that reason the determination of relationship and direction of these two variables are substantial for all countries.

In this study, the electricity consumption –economic growth linkage in Turkey during the period of 1970-2009 is investigated. Johansen cointegration test is employed to determine long run cointegration and VECM to test causality. Prior to test the causality, PP and NG-Perron unit root test are employed to examine stationary of variables. It is concluded that there is long run cointegration between variables. Also both in short and long run there is uni-directional causality running from real GDP to electricity consumption. The empirical results obtained from this study are consistent with studies done before Masih and Masih (1996), Ghosh (2002), Yoo (2006), Soytaş and Sarı (2003), Lise and Montfort (2007), Özata (2010), Uzunöz and Akçay (2012). According to Toda Yamamoto causality test there is observed uni-directional causality running from LRY to LEC. Due to variables and periods, studies used Toda Yamamoto method for Turkey reached different results. Çetin and Seker (2012) found no causality relationship between real gdp and total energy consumption. On the other hand, Bayar (2014) found bi-directional causality between real gdp per capita and primary energy consumption.

The interpretations and implications of the results can be discussed in some aspects. Economic growth stimulates electricity consumption. Turkey is developing country, so with the advanced of economy the electricity consumption used in various sectors is growing rapidly. Furthermore, due to higher income of households, they use more electricity equipments. According to empirical results, in Turkey an energy conservation policy may not damage to GDP. Turkey should use some combination of policy like energy taxes, energy saving technical process, renewable energy policy and energy efficiency.

Resource

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