

CAUSAL RELATIONSHIP BETWEEN ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH IN TURKEY

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ABSTRACT

Consumption of electricity has been known in many countries to be correlated with economic activities. The reasons for increase of electricity demand are higher living standards and industrialization. Like in other developing countries, in Turkey, the demand for energy and electricity is growing rapidly due to social and economic developments and increase of the population of the country. In this paper, the Granger causality between electricity consumption (EC) and Gross National Product (GNP) is examined for Turkey using annual data covering the period 1970-2004. As economic growth and electricity consumption variables used in empirical analysis have same order of integration (I(1)), Granger causality test is employed. In this study it was found that bidirectional causal relationship between electricity consumption and GNP in the short-run, and unidirectional causality running from GNP to electricity consumption exists in the long-run.

Keywords: Electricity Consumption, Economic Growth, Causality, Cointegration

TÜRKİYE'DE ELEKTRİK TÜKETİMİ VE EKONOMİK BÜYÜME ARASINDA NEDENSELLİK İLİŞKİSİ

ÖZET

Elektrik tüketiminin pek çok ülkede ekonomik aktivitelerle ilişkili olduğu bilinmektedir. Elektiriğe olan talebin sebebi yüksek yaşam standartları ve endüstrileşmedir. Diğer gelişmiş ülkelerde olduğu gibi Türkiye'de de enerjiye ve elektriğe olan yüksek talebin nedeni, ülke nüfusundaki artış ve, sosyal ve ekonomik gelişmelerin hızla artmasındandır. Bu makalede, Türkiye'nin 1970-2004 dönemindeki yıllık verilerle elektrik tüketimi ve GSMH arasındaki nedensellik araştırıldı. Yapılan analiz sonunda elektrik tüketimi ve GSMH değişkenleri aynı derecede (I(1)) bütünleşik olduklarından Granger nedensellik testi uygulandı. Çalışmada, kısa dönemde elektrik tüketimi ve GSMH arasında iki yönlü nedensellik, uzun dönemde ise GSMH'dan elektrik tüketimine tek yönlü bir nedensellik bulundu.

Anahtar Kelimeler: Elektrik Tüketimi, Ekonomik Büyüme, Nedensellik, Eşbütünleşme

1. INTRODUCTION

Turkish economy, the world's 16th largest economy, is a dynamic and emerging. Population of Turkey is about 70 million, almost 30% of whom are under 15 years old and 52% of the population lives in urban centers. The population growth rate is 1.6%, the highest among IEA countries and it is assumed to increase by about 1.5% per year in the next 20 years. Total population is expected to exceed 83 million in 2022. The economy has also undergone a significant shift away from agriculture towards the industrial and especially the services sector in the last three decades, although some 40% of the active population is still employed in agriculture. The net effect of all these factors is that Turkey's energy demand has grown rapidly almost every year and is expected to continue growing (Ozturk vd., 2007: 184).

It is generally recognized that the energy including electricity plays a significant role in economic development, not only because it enhances the productivity of capital, labour and other factors of production, but also that increased consumption of energy, particularly commercial energy like electricity signifying high economic status of a country (Jumbe, 2004: 61). Many studies have shown that the energy consumption is positively correlated with economic growth. For example Kraft and Kraft (1978), Ghosh (2002), and Mozumder and Marathe (2007) found unidirectional causality running from GNP to energy consumption. Shiu and Pun (2004) reported unidirectional causality running from energy consumption to GNP. Jumbe (2004) found bidirectional causality between energy consumption and GNP. However, Akarca and Long (1980), Erol and Yu (1987), Yu and Choi (1985), and Yu and Hwang (1984) found no causal relationships between GNP and energy consumption.

The direction of causation between energy consumption and economic growth has significant policy implications. If, for example, there exists unidirectional Granger causality running from income to energy, it may be implied that energy conservation policies may be implemented with little adverse or no effects on economic growth. In the case of negative causality running from employment to energy, total employment could rise if energy conservation policy were to be implemented. On the other hand, if unidirectional causality runs from energy consumption to income, reducing energy consumption could lead to a fall in income or employment (Adjaye, 2000: 616). This is why, the purpose of this paper is to investigate empirically the existence and direction of causal relationship between electricity consumption and economic growth in Turkey.

The paper is organized in the following fashion. Section 2 describe the econometric methodology. Subsequent sections report data sources and empirical results. Final section contains the conclusions.

2. ECONOMETRIC METHODOLOGY

2.1. ADF Unit Root Test

Many macroeconomic time series contain unit roots dominated by stochastic trends, as developed by Nelson and Plosser (1982). Unit root tests are important in examining the stationarity of a time series because a nonstationary regressor invalidates many standard empirical results and thus requires special treatment. Granger and Newbold (1974) have found by simulation that the F-statistic calculated from the regression involving the nonstationary time-series data does not follow the Standard distribution. This nonstandard distribution has a substantial rightward shift under the null hypothesis of no causality. Thus the significance of the test is overstated and a spurious results is obtained. The presence of a stochastic trend is determined by testing the presence of unit roots in time-series data. Several tests for the presence of unit roots in time-series data have appeared in literature (Chang v.d., 2001: 1047). In this study, unit root is tested using Augmented Dickey Fuller (ADF).

Non-stationarity or the presence of a unit root can be tested using the Dickey and Fuller (1979, 1981) tests. To test if a sequence y_t contains a unit root, three different regression equations are considered.

The first equation includes both a drift term and a deterministic trend; the second excludes the deterministic trend; and the third does not contain an intercept or a trend term. In all three equations, the parameter of interest is γ . If $\gamma = 0$, the y_t sequence has a unit root. The estimated t -statistic is compared with the appropriate

$$\Delta y_t = m_o + m_2.t + \gamma.y_{t-1} + \sum \beta_i \Delta y_{t-i+1} + u_t \quad (1)$$

$$\Delta y_t = m_o + \gamma.y_{t-1} + \sum \beta_i \Delta y_{t-i+1} + u_t \quad (2)$$

$$\Delta y_t = \gamma.y_{t-1} + \sum \beta_i \Delta y_{t-i+1} + u_t \quad (3)$$

critical value in the Dickey-Fuller tables to determine if the null hypothesis is valid (Dua and Pandit, 2002: 859).

2.2. Cointegration and EC Version of Granger Causality

Granger (1981, 1983) proposes the concept of cointegration and; Engle and Granger (1987) make further discussion in depth. The components of the vector x_t are said to be cointegrated of order d, b , denoted by $x_t \sim CI(d, b)$, if (i) x_t is $I(d)$ and (ii) there exists a nonzero vector α such that $\alpha' x_t \sim I(d-b)$, $d \geq b > 0$. The vector α is called the cointegrating vector. Cointegration suggests that there exists the long-run equilibrium relationship linking these variables, or they tend to move together over time. Therefore, cointegration reveals long-run effects between time series variables. To check for whether or not a cointegrating relationship exists between

two I(1) time series x_t and y_t , Engle and Granger (1987) propose a regression of y_t on x_t and thus check if the regression residual μ_t is stationary:

$$y_t = \alpha + \beta \cdot x_t + \mu_t \quad (4)$$

Eq. (4) is a cointegrating regression. If the two series are cointegrated, then μ_t is going to be stationary. One can use the ADF test technique to check for stationarity of the residuals μ_t . However, Dickey et al. (1991) argue that the Engle–Granger cointegration test is sensitive to the choice of dependent variables; therefore, the results of the test may not be consistent. Johansen (1991, 1995) suggests an alternative method to perform the cointegration test. The Johansen methodology is presently widely used and takes the form of

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \varepsilon_t \quad (5)$$

where $\Pi = \sum_{i=1}^p \Lambda_i - I$, $\Gamma_i = -\sum_{j=i+1}^p \Lambda_j$,

y_t is a k -vector of non-stationary I(1) variables, x_t is a d -vector of deterministic variables, and ε_t is vector of white noises with zero mean and finite variance. The number of cointegrating vectors is represented by the rank of the coefficient matrix Π . Johansen's method is to estimate the Π matrix in an unrestricted form, then test whether one can reject the restrictions implied by the reduced rank of Π . The likelihood ratio (LR) test for the hypothesis that there are at most r cointegration vectors is called the trace test statistic. It is to be noted that the variables under consideration should have identical order(s), and in particular are integrated of order one (Zou and Chau, 2006: 3646-3647)

The dynamic Granger causality can be captured from the vector error correction model (VECM) derived from the long-run cointegrating relationship (1988). Engle and Granger (1987) showed that if the two series are cointegrated, the VECM for the GNP and EC series can be written as follows:

$$\Delta GNP_t = \alpha_y + \beta_y ECT_{t-1} + \sum_{i=1}^n \gamma_{yi} \Delta EC_{t-i} + \sum_{i=1}^m \delta_{yi} \Delta GNP_{t-i} + \varepsilon_{yt} \quad (6)$$

$$\Delta EC_t = \alpha_e + \beta_e ECT_{t-1} + \sum_{i=1}^n \gamma_{ei} \Delta EC_{t-i} + \sum_{i=1}^m \delta_{ei} \Delta GNP_{t-i} + \varepsilon_{ei} \quad (7)$$

where Δ is a difference operator, ECT is the lagged error correction term derived from the long-run cointegrating relationship. The β_i (i=y,e) are adjustment coefficients and the u and ε_{it} 's are disturbance terms assumed to be uncorrelated and random with mean zero.

Sources of causation can be identified by testing for significance of the coefficients on the lagged variables in equation 6 and 7. First, by testing $H_0: \gamma_{yi} = 0$ for all i in equation 6, or $H_0: \delta_{ei} = 0$ for all i in equation 7. This can be implemented using a standard F-test. Masih and Masih (1996) and Adjaye (2000) interpreted the weak Granger causality as 'short run' causality in the sense that the dependent variable responds only to short-term shocks to the stochastic environment.

Another possible source of causation is the ECT in equation 6 and 7. In other words, through the ECT, an ECM offers an alternative test of causality (or weak exogeneity of the dependent variable). The coefficients on the ECTs represent how fast deviations from the long run equilibrium are eliminated following changes in each variable. If, for example, β_y is zero, then GNP does not respond to a deviation from the long-run equilibrium in the previous period. Indeed, $\beta_y = 0$ or $\beta_e = 0$ is equivalent to both the Granger non-causality in the long-run and the weak exogeneity. This can be tested using a simple t-test (Mehrara, 2007: 2943).

3. VARIABLE DEFINITIONS AND DATA SOURCES

The data used in this study consist of annual time series of real GNP and electricity consumption for Turkey 1970 to 2004. The real GNP were obtained from the National Statistical Office in Turkey. Electricity consumption were obtained from the Turkish Electricity Distribution Company.

GNP: Gross National Product (1.000.000\$),

EC: Electricity Consumption (GWH).

Figure 1. and 2., respectively, describes electricity consumption and GNP over the period 1970-2004.

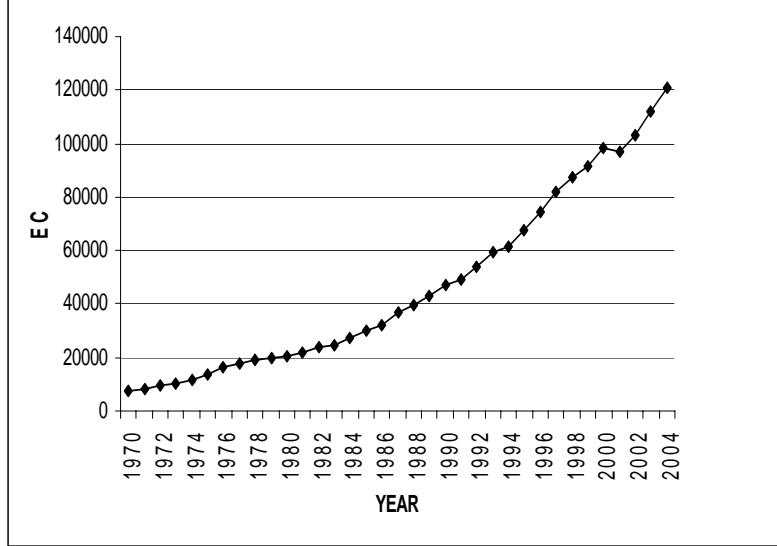


Figure 1: Electricity Consumption in Turkey.

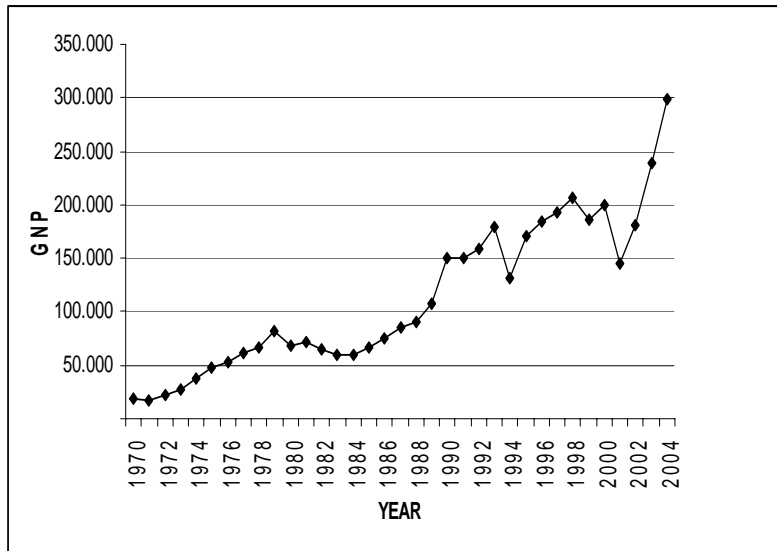


Figure 2: GNP in Turkey.

4. EMPIRICAL RESULTS

4.1. Results of Unit Roots and Cointegration Test

The results for the ADF unit roots test for EC and GNP are reported in Table 1.

Table 1: Results of ADF Test for Unit Roots

Variables	Trend and Intercept	CV(LL)*
EC	0,503876(0)	-3,5468
GNP	-1,962472(0)	-3,5468

* CV stands for critical values, which are at the 5% level. The critical values are calculated from MacKinnon. LL stands for lag length. The lag lengths are selected using the Schwarz Bayesian criterion.

Table 1 presents the result of unit root tests of the levels. On the basis of the the ADF statistics, the null hypothesis of a unit root cannot be rejected. When the data are first differenced, the null of nonstationarity can be rejected for all series at the 5% level (Table 2). This indicates that EC and GNP are I(1).

Table 2: Results of ADF Test for Unit Roots the According to First Difference

Variables	Trend and Intercept	CV(LL)*
Δ EC	-5,078988(0)	-3,5514
Δ GNP	-5,336986(0)	-3,5514

* CV stands for critical values, which are at the 5% level. The critical values are calculated from MacKinnon. LL stands for lag length. The lag lengths are selected using the Schwarz Bayesian criterion.

The variables are integrated of the same order, the next step was to test for cointegration using Johansen's maximum likelihood procedure.

The results of the Johansen maximum likelihood cointegration tests are presented in Table 3.

Table 3: Results of Johansen's Cointegration Test

Null Hypotheses	Alternative Hypotheses	Trace Statistic	Critical Value (5%)	Critical Value (1%)
H_0	H_1			
$r=0$	$r=1$	17.10563	15.41	20.04
$r \leq 1$	$r=2$	1.718178	3.76	6.65

According to the results of the Johansen maximum likelihood cointegration tests, the maximal Trace Statistic is 17.10563, which is great the 95 per cent critical value of 15.41. Hence the null hypothesis of $r=0$ rejected at 5 per cent level of significance. Therefore, indicate that there is cointegration relationship between EC and GNP.

4.2. Results of Error-Correction Model

If two variables are non-stationary, but they become stationary after first-differencing, and co-integrated, the ECMs for the Granger-causality test can be specified accordingly as Eq. (6) and (7).

The results of the tests error correction model are presented in Table 4.

Table 4: The Result of Error Correction Model

Null Hypotheses	Source of Causation		
	Short-run		Long-run
	ΔEC	ΔGNP	ECT_{t-1}
	F- statistics		t- statistics
Electricity consumption does not cause economic growth	3.01335*	-----	-1.0371
Economic growth does not cause electricity consumption	-----	11.1581*	-4.1576*

Notes: The lag lengths are chosen by using Schwarz 's information criterion. * Denotes the rejection of the null hypothesis at 5% level of significance.

The results of the tests on causality are presented in Table 4. A significance level of 5% is also used for causality tests. Short-run causality is found to run from electricity consumption to GNP. In addition, the reverse short-run causality also exists. That is, there is bidirectional short-run Granger-causality from electricity consumption to economic growth with feedback. The coefficient of the ECT is found to be significant in Eq. (7), which indicates that long-run Granger-causality from GNP to electricity consumption exists, but the reverse does not.

5. CONCLUSION

This paper examined the short- and long-run causality issues between electricity consumption and economic growth in Turkey by applying modern time-series techniques. It employed annual data covering the period 1970-2004. Tests for unit roots, cointegration, and a Granger-causality based on error-correction model are presented. The empirical results for the case of Turkey suggest the existence of a short run bidirectional causal relationship between electricity consumption and GNP, and long run unidirectional causality running from GNP to electricity consumption.

Economic growth causes expansion in the industrial and commercial sectors where electricity has been used as basic energy input because of its clean and efficient nature. Electricity consumption in agricultural and transport sector has also accelerated to keep pace with country's economic growth. In this situation, the existence of long run unidirectional causality running from economic growth to electricity consumption in Turkey has serious policy implications for decision makers. To cope the expected increase in electricity consumption, electricity generation capacity must increase.

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