COINTEGRATION RELATIONSHIP AMONG ELECTRICITY CONSUMPTION, GDP, and ELECTRICITY PRICE VARIABLES in TURKEY

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Abstract

This paper analyzes the relationship among electricity consumption per capita, GDP per capita and price of electricity ($/100kWh), and electricity investment in Turkey for the period 1978-2003 using the bound testing procedure to cointegration within Autoregressive Distributed Lag (ARDL) framework. In this study, it has been found that electricity consumption per capita, GDP per capita and price of electricity are cointegrated, and in the long-run, electricity consumption per capita is Granger cause GDP per capita , while in the short-run, there is unidirectional Granger causality running from GDP per capita to electricity consumption per capita and price of electricity. In the long-run, 1 % increase in GDP per capita increases the electricity consumption per capita by 0.18%, which is significant at the 10 % level. Price of electricity has insignificant impact on the electricity consumption per capita. In the short-run, 1 % increase in GDP per capita increases the electricity consumption per capita by 0.064 %.

Keywords: Energy consumption, Cointegration, ARDL, Bound Tests.

Özet

Bu çalışmada, Türkiye'de 1978-2003 dönemi için, kişi başı elektrik tüketimi, kişi başı Gayri Safi Yurt İçi Hasıla (GSYİH), elektrik fiyatı ($/100 kWh) ve elektrik yatırımı arasındaki ilişki eşbütünleşmeye Otoregresif Dağıtılmış Gecikme Modeli yaklaşımı ile sınır testi yöntemi ile analiz edilmiştir. Çalışma sonucunda, kişi başına elektrik tüketimi, kişi bsşı GSYİH ve elektrik fyatının eşbütünleşik olduğu; uzun dönemde kişi başı elektrik tüketimi değişkeninin kişi başına GSYİH'nın Granger anlamda nedeni olduğu; kısa dönemde ise, GSYİH değişkeninden kişi başı elektrik tüketimi ve elektrik fiyatına doğru tek yönlü nedensellik olduğu bulunmuştur. Uzun dönemde, kişi başına GSYİH 'daki %1'lik artış, elektrik

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tüketimini % 0.18 kadar artırmaktadır ve bu durum %10 düzeyde istatistiksel olarak anlamlıdır. Elektrik fiyatı değişkeni, kişi başına elektrik tüketimi değişkeni üzerinde anlamlıo bir etkisi yoktur. Kısa dönemde ise GSYİH'daki %1'lik artış elektrik tüketimini %0.064 kadar artırmaktadır.

Anahtar Kelimeler: Enerji Tüketimi, Eşbütünleşme, ARDL, Sınır Testi

1. Introduction

Causal relationship between energy consumption, economic growth and the other macro economic variables; such as price, employment etc., has been investigated in numerous studies in the last two decades.

Electricity consumption per capita in Turkey has increased rapidly within the past 25 years (Table 1).

The annual average growth in electricity consumption per capita over the period 1978-2003 had been 5.26 % in Turkey, and electricity consumption per capita was 1581 kWh in 2003, while it was 444 kWh in the 1978. As seen from the Table 1, electricity consumption per capita over the period 1978-2003 increased continuously except in 2001, when Turkey was exposed to the harshest economic crisis since the establishment of the Republic in 1923.

The purpose of this study is to determine the long-run relationship among electricity consumption per capita, GDP per capita, price of electricity, and causality relationship among these variables. This study contributes to the literature by using ARDL model to analyze causality.

2. Literature Review

The pioneering study about causal relationships between energy consumption and real income was done by the Kraft and Kraft [21] and they found causality running from GNP to energy consumption for the USA over the period 1947-1974. Akarca and Long (1979,) found no causal relationship between energy consumption and total employment and no causal relationship between energy consumption and GNP for the USA (Akarca and Long, 1980).

In some Asian economies (India, Pakistan, Indonesia, Malaysia, Singapore and Philippines) Masih and Masih (1996) examined the temporal causality between energy consumption and income. For India, Pakistan and Indonesia they found that two variables were cointegrated. They used the Vector Error Correction (VEC) model and showed that energy consumption caused income in India, but income caused energy consumption in Indonesia and bi-directional causality existed in Pakistan.

Masih and Masih (1997) also examined causal relationship between energy consumption and economic growth using a multivariate cointegration and VEC approach for South Korea and Taiwan based on the data on energy consumption, real income and price. Likewise, Glasure and Lee (1997) analyzed causality between GDP and energy consumption for South Korea; however, they found no causal relationship between energy and GDP. In a recent study, Yoo (2005) examined electricity consumption and economic growth for South Korea over the period 1970-2002 and found bi-directional causality between these variables.

Asafu-Adjaye (2000) studied the relationship among energy consumption, energy prices and GDP for India, Indonesia, Philippines and Thailand using cointegration and error correction (EC) methods and found bi-directional causality between GDP and energy consumption for Thailand and Philippines, and unidirectional causality running from energy to income for India and Indonesia.

For India, Ghosh (2002) and for Australia, Narayan and Smyth (2005 a-b)) and Fatai et al (2004) found causality running from economic growth to electricity consumption.

Bentzen and Engsted (1997) estimated a demand model for Danish residential energy consumption using ARDL approach over the period 1960-1996.

Yang (2000) found bi-directional relationship between energy consumption and GDP for Taiwan. Hondroyiannis et al (2002) also found the same relationship for Greece. In another study, Hondroyiannis (2004) examined the residential demand for electricity for Greece using monthly data over the period 1986-1999 via cointegration technique and VEC model. The results showed that there was stable residential demand for electricity in Greece both in the long- and short-run.

Soytas and Sari (2003) found different results about direction of casuality for G-7 countries and for top 10 emerging countries (Argentina, France, Indonesia, Italy, Japan, Poland, South Korea, Turkey, United Kingdom, West Germany).

Ghali and El-Saka (2004) examined relationship between energy use and output growth in Canada over the period 1961-1997. They used Johansen cointegration technique and showed that long-run movements of output, labor, capital and energy use in Canada were related by two cointegrating vectors. Using VEC model, they found bi-directional causality between output growth and energy use in the short-run.

For Turkey Bakirtas et al (2000) examined the long-run relationship between electricity demand and income over the period 1962-1996 using the cointegration technique and error correction modeling. They found that electricity consumption and income were cointegrated, and estimated short- and long-run elasticities of income. Lise and Van Montfort (2007) examined the linkage between energy consumption and GDP via cointegration analysis for Turkey using annual data over the period 1970-2003. They found that energy consumption and GDP were cointegrated and there was a unidirectional causality running from GDP to energy consumption. In a different study, Ediger and Tatlıdil (2002) forecasted energy demand of Turkey via cycle analysis, a semi-statistical technique.

On the other hand, Altınay and Karagol (2004) investigated a series of unit root and causality test to detect causality between the GDP and energy consumption in Turkey, employing Hsiao's version of Granger causality method over the 1950-2000 period. Results of the study indicated no causality between energy consumption and GDP.

The other studies for Turkey, which the causal relationships between energy consumption and economic growth, are done by Soytas et al (2001), Sari and Soytas (2004), Soytas and Sari (2007) , Lise and Montfort (2007), Erdogdu (2007). Some studies associated with forecasting of some energy demands in Turkey are done by Hamzacebi (2007), Ediger and Akar (2007). Yılmaz and Uslu (2007) investigated energy policies of Turkey over the 1923-2003 period. Tunc et al (2006) examined energy production and cunsumption of Turkey and the world.

Galindo (2005) estimated the demands for different types of energy consumption for the Mexican economy over the period 1965-2001 using the cointegration. Results showed that energy demand in Mexico was driven by income, and the effect of relative prices was basically concentrated on energy consumption in the short-run, with the exception of industrial sector.

Using EC and VEC model, Mozumder and Marathe (2007) examined causality relationship between electricity consumption and GDP in Bangladesh over the period 1971-1999. They showed that there was unidirectional causality from GDP per capita to electricity consumption per capita.

Wolde-Rufael (2006) tested the long-run and causal relationship between electricity consumption per capita and real GDP per capita for 17 African countries (Algeria, Benin, Cameroon, Democratic Republic of the Congo, Congo Republic, Egypt, Gabon, Ghana, Kenya, Morocco, Nigeria, Senegal, South Africa, Sudan, Tunisia, Zambia and Zimbabwe) over the 1971-2001 period using ARDL.

3. Data and Methodology

3.1. Data

This study employs annual time series data for Turkey from 1978 to 2003.

$$EC_t = \alpha_0 + \alpha_1 GDP + \alpha_2 P + \varepsilon_t \qquad (1)$$

EC: Electricity consumption per capita (measured in kWh),

GDP: GDP per capita ($ USA and current prices),

P: Price of electricity ($/100kWh and current prices),

The electricity consumption per capita (kWh was calculated by dividing total electricity consumption into population). Total electricity consumption (data were collected from Turkish Electricity Distribution Incorporation (TEDAS) Statistics 2005. GDP per capita ($ USA) was obtained from Electronical Data Distribution Service of Central Bank of Turkish Republic. Electricity prices data were collected from various issues of International Energy Agency's (IEA) Energy Statistics for OECD Countries. Then price of 100 kWh transformed to $USA (due to the natural logs of 100kWh prices were more suitable). Then all variables transformed to natural logs (Çemrek, 2006).

3.2. ARDL Models and Bound Testing Approach to Cointegration

For testing cointegration, due to small sample size of our study, the bounds test approach proposed by Pesaran et al (2001) was used. We tested for the null hypothesis of no cointegration against the alternative hypothesis of a long-run relationship. This approach has some advantages in comparison with other single cointegration procedures. Firstly, it can be applied irrespective of whether the variables are I (0) or I (1) (Pesaran and Pesaran, (1997, p.302). Therefore, it avoids the pre-test problems associated with the standard cointegration analysis. Secondly, endogeneity problems and inability to test hypotheses on the estimated coefficients in the long-run in Engle-Granger (1987) method are avoided. Another advantage of this approach is that the model takes sufficient numbers of lags to capture the data generating process in a general-to specific modeling framework (Shresta, (2005). Fourthly, long and short-run parameters of the model are estimated simultaneously. A dynamic error correction (EC) model can be derived form ARDL through a simple linear transformation (Banerjee et al, (1993). Using the ARDL approach, problems resulting from non-stationary time series data are avoided.

An ARDL representation of the Equation (1) is formulated as follows:

$$\Delta EC_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \Delta EC_{t-i} + \sum_{i=0}^{p} \delta_i \Delta GDP_{t-i} + \sum_{i=0}^{p} \gamma_i \Delta P_{t-i} + \lambda_1 EC_{t-1} + \lambda_2 GDP_{t-1} + \lambda_3 P_{t-1} + e_t \qquad (2)$$

The presence of a long-run relationship investigation among the variables of equation (1) is tested by means of bound testing procedure. There are two steps in testing cointegration relationship among electricity consumption and its explanatory variables. In the first step, equation (1) is estimated by Ordinary Least Square (OLS) technique. In the second step, the null hypothesis $H_0 : \lambda_1 = \lambda_2 = \lambda_3 = 0$ is tested against the alternative hypothesis H_a: $\lambda_1 \neq \lambda_2 \neq \lambda_3 \neq 0$.

ARDL model can be selected using the model selection criteria such as Shwartz-Bayesian Criterion (SBC) and Akaike's Information Criterion (AIC). After the long-run relationship is established, and then the long-run and error correction estimates of ARDL model can be obtained from the equation (2). The result of EC model indicates the speed of adjustment, the long-run equilibrium return after a short-run shock.

A general error correction representation of the Equation (2) is formulated as follows:

$$\Delta EC_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \Delta EC_{t-i} + \sum_{i=0}^{p} \delta_i \Delta GDP_{t-i} + \sum_{i=0}^{p} \gamma_i \Delta P_{t-i} + \eta ECT_{t-1} + u_t \qquad (3)$$

where η is the adjustment parameter and ECT is the residuals obtained from the estimated cointegration model of Equation (2).

4. Empirical Results

The two-steps ARDL cointegration procedure was implemented in estimating Equation (1) for Turkey using annual data over the period 1978-2003. In the first stage, to ascertain the existence of a long run relationship among variables of Equation (2), the bound testing approach was employed. In the second stage, Equation (2) was estimated by the ARDL cointegration method.

In the first stage of the ARDL procedure, the order of lags on the first-differentiated variables for Equation (2) was usually obtained from unrestricted error correction (UEC) vector autoregression (VAR) by SBC and AIC.

The results of the bound testing approach for cointegration are in Table 2 (The lag length, k=1, was selected based on the SBC) and the results show that the calculated F statistics is 7.011 which is higher than the upper bound critical value of 4.855 at the 5 % level of significance. This implies that the null hypothesis of no cointegration is rejected and there is indeed a cointegration relationship among the variables in the model. Having found a long-run relationship, the ARDL approach was applied to estimate the long-run and the short-run relations. This result indicates that the electricity consumption, income and price of electricity are cointegrated.

In the next step, the ARDL cointegration method was used to estimate the parameters of Equation (2) with the order of lag set to 1. The ARDL (1,0,0) and ARDL (1,1,0) models were selected by SBC and AIC respectively. The model based on SBC was selected because it has lower prediction error than that of the model based on AIC. The main prediction error of SBC based model was 0,0331; while that AIC based model was 0,03923. The key regression statistics and the diagnostic test statistics of the model are given in the Table 3.

As seen from Table 4, in the long-run, GDP per capita have significant impact on the electricity consumption per capita. It can be said that an increase in the GDP per capita has a positive effect on electricity consumption per capita. In the long-run, 1 % increase in GDP per capita increases the electricity consumption per capita by 0.18 %, which is statistically significant at the 10 % level. This value is similar to the results obtained by Lise and Van Montfort (2007) for Turkey. They found that coefficient of GDP in the long – run was 0.322. On the other hand, price of electricity has insignificant impact on the electricity consumption.

ARDL error correction representation of Equation (3), were estimated and results are displayed in the Table 5.

The short-run dynamics of the model are shown in the Table 5. The coefficient of ΔGDP is statistically significant at 10 % level. This implies a change in the income associated with a change in the electricity consumption in the short-run. The coefficient of ΔEI is statistically significant at 5 % level. However, Lise and Van Montfort (2007) found that the coefficient of ΔGDP was 0.042 in the short-run.

Error Correction Term (ECT_{t-1}) in the dynamic model, appears with a negative sign and is statistically significant at the 5 % level. This ensures long-run equilibrium. The coefficient of -0.177 shows the slow speed of adjustment. According to this estimation, every 17.7 % of the disequilibrium seen in a given period in relation to electricity consumption per capita will be adjusted in the next period.

5. Concluding Remarks

This study has considered the relationship between electricity consumption per capita, GDP per capita and price of electricity in Turkey using annual data over the period 1978-2003. This study is different from the other studies, which is done for Turkey. Because, bound testing approach to cointegration has been applied in this study, and according to the results, electricity consumption and its proposed determinants are cointegrated. ARDL model was used to estimate the long-run impact of GDP per capita and price of electricity and was found that GDP per capita have statistically significant impact on electricity consumption per capita.

The causal relation was running from GDP to electricity consumption in this study. This result is same as Lise and Montfort (2007), and it is different from Soytas et al (2001), Sari and Soytas (2004) and Soytas and Sari (2003).

In analyzing the short-run behavior of the variables, the ECM based on ARDL (1, 0, 0, 0) model selected via SBC was used. The model's results show that GDP per capita have positive effect on electricity consumption per capita. The coefficient of error correction was estimated at -0.177. This value showed that the adjustment speed was relatively slow.

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Table 1: Electricity Consumption per capita and Its Variation in Turkey over the period 1978-2003

Year	Electricity Consumption per Capita (kWh)	Variation (%)	Year	Electricity Consumption per Capita (kWh)	Variation (%)
1978	444	*****	1991	860	3.24
1979	452	1.80	1992	924	7.44
1980	459	1.55	1993	996	7.79
1981	484	5.45	1994	1014	1.81
1982	505	4.34	1995	1093	7.79
1983	511	1.19	1996	1183	8.23
1984	563	10.18	1997	1311	10.82
1985	591	4.97	1998	1382	5.42
1986	626	5.92	1999	1417	2.53
1987	698	11.50	2000	1457	2.82
1988	739	5.87	2001	1415	-2.88
1989	786	6.36	2002	1479	4.52
1990	833	5.98	2003	1581	6.90

Table 2: Bound Testing for Cointegration Analysis

Computed F statistics : 7.011 (lag number =1)
Critical bound's value at %5 : Lower : 3.793 and Upper : 4.855 (Pesaran and Pesaran, 1997, p.478, case:II)

Table 3: ARDL (1, 0, 0) estimates [a]

Regressor	Coefficient	Standart Error	t Statistics
Constant	0,51107	0,64832	0,79381
EC_{t-1}	0,67912	0,11249	6,03716***
GDP_t	0,08989	0,03554	2.52926**
P_t	-0,01505	0,02125	-0,70823

*:Significant at %10 level , **: Significant at %5 level , ***: Significant at %1level

R^2= 0,9762 $\overline{R}^2$ = 0,94453

Standart error of regression =0,0331

Diagnostic Tests

A: Serial Correlation $\chi^2(1)$ =1,435 (0.187)

B: Functional Form $\chi^2(1)$ =1,7563 (0.225)

C: Normality $\chi^2(2)$ =1,6574 (0.485)

D: Hetroscedasticity $\chi^2(1)$ =02345 (0.574)

a: Dependent Variable is electricity consumption (EC), 26 observations used for estimation from 1978 to 2003.

A: Lagrange multiplier test of residual serial correlation.

B: Ramsey's RESET test using the square of the fitted values.

C: Based on a test of skewness and kurtosis of residuals.

D: Based on the regression of squared residuals on squared fitted values.

Table 4: Estimated long-run coefficient using ARDL (1,0,0,0) model *

Regressor	Coefficient	Standart Error	t statistics (probability)
Constant	-2,9403	5.4794	-0.53661
GDP	0,1759	0,081	**2.1716*** (0,043)
P	-0,13607	0,6280	-0,216672 (0,678)

* Dependent Variable is electricity consumption (EC), 26 observations used for estimation from 1978 to 2003.

Table 5: Error Correction Representation of ARDL (1, 0, 0, 0) Model[a]

Regressor	Coefficient	Standart Error	t statistics (probability)
Δ Constant	-0,10756	0.042863	-0.56039 (0,581)
Δ GDP	0,06437	0,03286	1,95819 (0,059)*
Δ P	-0,049774	0,032640	-1,5249 (0,142)
ECT_{t-1}	-0,17681	0,06254	-2,82715 (0.036)**

a: Dependent Variable is Δ EC *:Significant at %10 level , **: Significant at %5 level , ***: Significant at

%1 level