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Relationship between electricity consumption and GDP in Turkey

Abstract

This paper examines the causal relationship between electricity consumption and GDP in Turkey by using the minimum Lagrange Multiplier (LM) unit root test with two structural breaks suggested by Lee and Strazicich, and the Granger causality test. The obtained results indicate that electricity consumption and GDP in Turkey are stationary in their levels and there is a bi-directional Granger causality among the variables.

Keywords: unit root tests, structural breaks, Granger causality, electricity consumption.
JEL Classification: O11, Q43.

Introduction

The causal relationship between a country's energy consumption and economic growth is a widely studied topic in energy economics literature. The direction of causality can help the policymakers take the most appropriate decisions. From the publication of the seminal paper of Kraft and Kraft (1978), the results of studies in this field can be summarized into three main categories, each of which has important implications in energy policy: (1) no causality, (2) uni-directional causality, (3) bi-directional causality between energy consumption and economic growth. We can divide the uni-directional causality results into two types: (a) energy consumption causes economic growth, and (b) economic growth causes energy consumption.

A finding that there is no causality in any direction between energy consumption and economic growth means that reducing the energy consumption and energy conservation policies may not affect the economic growth. On the other hand, a finding of uni-directional causality from energy consumption to economic growth implies that reducing the energy consumption could lead to a fall in economic growth. If there is uni-directional causality from economic growth to energy consumption, reducing the energy consumption may be implemented with little or no adverse effect on economic growth. A bi-directional causal relationship means that energy consumption and economic growth are jointly determined and affected at the same time.

Different studies on different countries, time periods, and methods for the causality relationship between energy consumption and economic growth give conflicting and mixed results as shown in Table 1. These differences might be due to the different characteristics of the countries such as energy supply, political and economic history, political arrangement, and culture and energy policy (Chen et al., 2007).

Table 1. Summary of the previous studies on the relationship between energy consumption and economic growth for developed and developing countries

Panel A: The previous studies for developed countries			
Study	Countries (period)	Methodology	Finding
Abosedra and Bagnestani (1989)	US (1947-1972,1947-1974, 1947-1979, 1947-1987)	Cointegration, Granger causality	Economic growth → Energy cons.
Akarca and Long (1980)	US (1950-1968, 1950-1970)	Sims' technique	No causality
Cheng (1995)	US (1947-1990)	Cointegration, Granger causality	No causality
Erol and Yu (1988)	West Germany, Italy, Canada, France, UK, Japan (1952-1982)	Granger causality	Economic growth ↔ Energy cons. (Japan), Energy cons. → Economic growth (Canada), Economic growth → Energy cons. (West Germany and Italy), no causality (France and UK)
Ghali and El-Sakka (2004)	Canada (1961-1977)	Cointegration, Granger causality	Economic growth ↔ Energy cons.
Kraft and Kraft (1978)	US (1947-1974)	Sims' technique	Economic growth → Energy cons.
Yu and Hwang (1984)	US (1947-1979)	Sims' technique	No causality
Panel B: The previous studies for developing countries			
Altinay and Karagol (2005)	Turkey (1950-2000)	Granger causality	Electricity cons. → Economic growth
Ghosh (2002)	India (1950-1997)	Granger causality	Economic growth → Electricity cons.
Jumbe (2004)	Malawi (1970-1999)	Granger causality, error correction model	Electricity cons. ↔ Economic growth

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Table 1 (cont.). Summary of the previous studies on the relationship between energy consumption and economic growth for developed and developing countries

Mozumder and Marathe (2007)	Bangladesh (1971-1999)	Cointegration, vector error correction model	Economic growth → Electricity cons.
Shiu and Lam (2004)	China (1971-2000)	Error correction model	Electricity cons. → Economic growth
Wolde-Rufael (2004)	Shanghai, China (1952-1999)	Toda-Yamamoto Granger causality	Electricity cons. ↔ Economic growth
Yang (2000)	Taiwan (1954-1997)	Granger causality	Electricity cons. ↔ Economic growth
Yoo (2005)	Korea (1970-2002)	Error correction model	Electricity cons. ↔ Economic growth
Yoo (2006)	Indonesia, Malaysia, Singapure, Thailand (1971-2002)	Granger causality, Hsiao's version of Granger causality	Economic growth → Electricity cons. (Indonesia) Electricity cons. ↔ Economic growth (Malaysia, Singapore) Economic growth → Electricity cons. (Thailand)

Note: → means that there is uni-directional causality and ↔ means that there is a bi-directional causality.

The aim of this study is to explore the causation between electricity consumption and GDP in Turkey. We apply the recently developed minimum LM unit root test with two structural breaks proposed by Lee and Strazicich and the Granger causality test.

We need to take into account the structural breaks because Turkey has implemented a reform in the electricity sector in February 2001. There are two main aims behind the electricity reforms in Turkey: to improve the efficiency of the electricity sector and to ensure funds for financing the investment requirements. The main factor behind the Turkish electricity reform is that the Turkish electricity sector experienced a deep crisis in late-1990s. And in the early 2000s, Turkey faced a serious shortage in electricity supply. The poor performance of the public electricity monopolies and the insufficiency of public funds after the economic crises have led to a reform in the electricity sector in Turkey (Özkıvrak, 2005).

The paper is organized as follows. The econometric methodology is specified in Section 1. The data are discussed in Section 2. The empirical results are presented and analyzed in Section 3 and the final section provides the conclusions.

1. Methodology

The causal relationship between electricity consumption and GDP is a well-known topic, in the sense of Granger causality. The Granger causality test is a convenient and general approach for detecting any presence of a causal relationship between two variables, and the application of this test requires the series of variables to be stationary. The causality tests are sensitive to unit roots in the series (Stock and Watson, 1989). Before specifying and estimating the Granger-type models, it is necessary to first examine the stationarity properties. To examine the stationarity, we use the minimum LM unit root test, which is the most flexible unit root test in terms of the number of breaks at unknown time. This test allows structural changes under unit root null hypothesis.

1.1. Unit root tests in the presence of structural breaks. The augmented Dickey-Fuller (ADF) test suggested by Dickey and Fuller (1979) is the most widely used unit root test. Perron (1989) criticizes the ADF unit root test in that the presence of structural change can reduce the power of these unit root tests. An existing break leads to a bias that reduces the ability to reject a false unit root null hypothesis. Assuming the time of the breaks as an exogenous phenomenon, Perron (1989) suggests allowing for one exogenous or known structural break in the ADF test, and shows that the power to reject a unit root decreases when the stationary alternative is true and structural break is ignored.

The alternative tests based on Dickey-Fuller test are proposed by Zivot and Andrews (1992) (ZA) and Perron (1997). ZA and Perron unit root tests allow for one structural break and suggest determining the break point "endogenously". But taking into account only one endogenous break could lead to a loss of information when in reality there is more than one break (Lumsdaine and Papell, 1997). Lumsdaine and Papell (1997) (LP) propose a new unit root test procedure to capture two structural breaks as an extension of the ZA test. They argue that unit root tests that account for two significant structural breaks are more powerful than the tests that allow for a single break. But the critical values of ZA and LP tests are derived under no structural break assumption. Nunes et al. (1997) show that this assumption leads to size distortions in the presence of a unit root with structural breaks. The minimum LM unit root test proposed by Lee and Strazicich (2003) determines structural breaks "endogenously" and avoids the problems of bias and spurious rejections. This test is unaffected by breaks under the null and allows for two endogenous breaks.

1.2. Minimum LM unit root test with one and two structural breaks. The data-generating process (DGP) for the minimum LM unit root test suggested by Lee and Strazicich (2003a, b) with one and two structural breaks is expressed by:

$$y_t = \delta' Z_t + e_t, \quad e_t = \beta e_{t-1} + \varepsilon_t \ , \qquad (1)$$

where Z_t consists of deterministic terms and $\varepsilon_t iiN(0, \sigma^2)$. The LM unit root test with two structural breaks can be considered as follows. Model AA allows for two structural breaks in the intercept, and is described by $Z_t = [1, t, D_{1t}, D_{2t}]$, where:

$$D_{1t} = \begin{cases} 1, \ if \ t \geq TB_1 + 1 \\ 0, \ otherwise; \end{cases}$$

$$D_{2t} = \begin{cases} 1, \ if \ t \geq TB_2 + 1 \\ 0, \ otherwise. \end{cases}$$

Here, TB_1 and TB_2 denote the break dates. Model CC includes two breaks in the intercept and the trend, and is described by $Z_t = [1, t, D_{1t}, D_{2t}, T_{1t}, T_{2t}]$, where:

$$T_{1t} = \begin{cases} t - TB_1, if \ t \geq TB_1 + 1 \\ 0, \ otherwise; \end{cases}$$

$$T_{2t} = \begin{cases} t - TB_2, if \ t \geq TB_2 + 1 \\ 0, \ otherwise. \end{cases}$$

The LM unit root test statistic is obtained from the following regression:

$$\Delta y_t = \alpha' \Delta Z_t + \phi \tilde{S}_{t-1} + \sum \gamma_i \Delta \tilde{S}_{t-i} + \mu_t , \qquad (2)$$

where $\tilde{S}_t$ is a detrended series such that $\tilde{S}_t = y_t - \tilde{\psi}_x - Z_t \tilde{\delta}_t$, $t = 2,..,T$;. $\tilde{\delta}$ is a vector of coefficients in the regression of Δy_t on ΔZ_t; $\tilde{\psi}_x = y_1 - Z_1 \tilde{\delta}$; and y_1 and Z_1 are the first observations of Y_t and Z_t, respectively; Δ is the difference operator.

The lagged terms $\Delta \tilde{S}_{t-i}$, $i = 1,..,k$, are inserted to correct for serial correlation in equation 2. The number of augmentation terms $\Delta \tilde{S}_{t-i}$, $i = 1,..,k$, is determined by following a "general to specific" procedure (starting with max k = 8) described in Strazicich et al. (2004). The unit root hypothesis is tested via the *t*-ratio of ϕ, this statistic being denoted as $\tilde{\tau}$. The null hypothesis of a unit root is tested against the alternative hypothesis of trend stationarity. Structural break (TB) is determined by selecting all possible break points for the minimum *t*-statistic as follows:

$$LM_\tau = \inf_\lambda \tilde{\tau}(\lambda), \qquad (3)$$

where $\lambda = T_B / T$. The critical values are tabulated in Lee and Strazicich (2003a, b) for the one and two break cases, respectively.

1.3. Granger causality test. Before specifying and estimating the Granger-type models, it is necessary to first examine the stationarity properties because Engel and Granger (1987) and Yoo (2005) point out that though two variables are non-stationary and cointegrated, the standard Granger causality test results will be invalid. However, the standard Granger causality test should be accepted if these two variables are not cointegrated.

If the variables are nonstationary and cointegrated, the adequate method to examine the causal relations is the vector error correction model (VECM); otherwise, a vector autoregression (VAR) model is used in the case of no integration among variables (Granger, 1969). In other words, if we find evidence for cointegration, then we need to augment the Granger-type causality test with a one-period lagged error correction term. The causality relationship on the bi-variate VAR model can be evaluated by estimating the following two regressions:

$$y_{1t} = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} y_{1t-i} + \sum_{i=1}^{k} \alpha_{2i} y_{2t-i} + \varepsilon_{1t} , \qquad (4)$$

$$y_{2t} = \beta_0 + \sum_{i=1}^{k} \beta_{1i} y_{1t-i} + \sum_{i=1}^{k} \beta_{2i} y_{2t-i} + \varepsilon_{2t} , \qquad (5)$$

where k represents the maximum lag order; y_{1t} and y_{2t} denote the two stationary time series; and ε_{1t} and ε_{2t} are assumed to be serially uncorrelated with zero mean and finite covariance matrix.

When the null hypothesis $H_0 : \alpha_{21} = \alpha_{22} = \cdots = \alpha_{2k} = 0$ is true, it suggests that y_{2t} does not Granger-cause y_{1t} in regression [4]. If the null hypothesis $H_0 : \beta_{11} = \beta_{12} = \cdots = \beta_{1k} = 0$ is not rejected, it implies that y_{1t} does not Granger-cause y_{2t} in regression [5].

2. Data

Yearly data on electricity consumption and GDP in Turkey from 1968 to 2005 obtained from the World Bank's "World Development Indicators" (WDIs) database are used in the analysis. Electricity consumption is expressed in units of kilowatt hours (kWh), while GDP is expressed in US dollars at constant 2000 prices. Variables are transformed into logarithms before analysis.

3. Empirical results

To examine the relationship between electricity consumption and GDP in Turkey, a two-step procedure is adopted. The first step investigates the time series properties of the data. The second step explores the casual relationship between electricity consumption and GDP. The first step is an important one because, according to Engel and Granger (1987), if the series are integrated of order one, in the presence of cointegration, VAR estimation in the first differences will be misleading. If the series are stationary, then standard Granger's causality test should be employed. But if the series are non-stationary and cointegrated, VECM approach should be adopted. To determine the time series properties, recently developed minimum LM unit root test with two structural breaks is applied to the natural logs of the series. The LM unit root test has two main advantages. One of them is that this test is the most flexible unit root test in terms of the number of breaks at unknown time. Another advantage is that this test permits to avoid the problem of spurious rejections of the null hypothesis in the presence of unit root with breaks. We need to take into account the structural breaks because there are important energy crises in the past history of Turkey. Turkey has implemented reforms in the electricity sector in February 2001 to improve the efficiency of electricity sector and to ensure funds for financing investment requirements.

The LM unit root test results are reported in Table 2.

Table 2. LM two break unit root test based on model CC

Country	Series	TB_1	TB_2	k	S_{t-1}	D_{1t}	D_{2t}	T_{1t}	T_{2t}
Turkey	EC	1981	1999	8	-2.1412[b] (-6.0439)	0.0996[a] (3.2391)	0.1008[a] (4.1831)	-0.1736[a] (-5.569)	-0.1152[a] (-6.491)
	GDP	1984	1993	3	-3.8316[c] (-5.3443)	0.0479 (1.2423)	-0.1244[a] (-3.9176)	-0.1421[a] (-4.421)	0.0345[b] (2.2354)

Critical values of the two breaks minimum LM test

λ_2		0.4			0.6			0.8	
λ_1	1 %	5 %	10 %	1 %	5 %	10 %	1 %	5 %	10 %
0.2	-6.16	5.59	-5.27	-6.41	5.74	5.32	-6.33	-5.71	-5.33
0.4	-	--	-	-6.45	5.67	5.31	-6.42	-5.65	-5.32
0.6	-	-	-	-	-	-	-6.32	-5.73	-5.32

Notes: TB_1 and TB_2 are the break dates, k is the lag length, S_{t-1} is the coeffecent on the unit root parameter. The figures in parantheses are t-statistics. Critical values for the cofficient on the dummy variables follow the standard normal distribution. [a, b, c] denote statistical significance at 1%, 5% and 10% respectively. For model CC, critical values depend on the location of the breaks and come from Lee and Strazicich (2003b).

As we can see from the table, the minimum LM test statistics are higher than the critical values at conventional significance levels for electricity consumption and GDP in Turkey. We reject the presence of a unit root. The results indicate that electricity consumption and GDP in Turkey are stationary in their levels and, following a shock, electricity consumption and GDP revert to their trends.

The TB_1 and TB_2 columns of Table 2 show the estimated break points for electricity consumption and GDP. The breaks in the intercept and trend for GDP in Turkey are statistically significant and occur in 1984 and 1993. The breaks in the intercept and trend for electricity consumption are statistically significant at 1% level and occur in 1981 and 1999, in the years that are also marked by energy crises. The per capita electricity consumption has steadily grown from 1980 to 2000 and Turkey faced shortages of electricity supply during the 1980s and the 1990s.

Since the series are stationary in the level, cointegration analysis is not an appropriate tool to investigate the relationship between electricity consumption and GDP. Regarding the absence of cointegration relation, the direction of the causality relationship can be tested by using VAR model[1]. We perform the causality test based on a bi-variate VAR representation. To choose the order of the VAR, AIC and SC information criteria are used. The model with the smallest AIC and SC values is selected when it minimizes the residual sum of squares. The causality test results for the null hypotheses that electricity consumption does not Granger-cause GDP, and that GDP does not Granger-cause electricity consumption are reported in Table 3.

[1] Since the log of electricity consumption has significant break points in 1981 and 1999, and the log of GDP has significant break points in 1984 and 1993, we need to take the break points into account in the Granger causality test. Therefore, we detrend the series through the following regression:

$$y_t = \mu + \beta t + \theta_1 D_{1t} + \theta_2 D_{2t} + \gamma_1 T_{1t} + \gamma_2 T_{2t} + \tilde{y}_t$$

where $\tilde{y}_t$ is the detrended series.

Table 3. Granger causality test results

Country	Lag	Null nypothesis	F statistic	Probability
Turkey	1	GDP —/→ EC	0.13817	0.71248
		EC —/→ GDP	0.75318	0.39174

Note: —/→ denotes "does not Granger cause". The test procedure is based on bivariate VAR(k) model. The optimal *k* is based on the Akaike (AIC) and Schwarz (SC) criteria.

The Granger test results show that there is a bi-directional causality between electricity consumption and GDP in Turkey. A bi-directional causal relationship has significant implications for energy conservation and economic development, and implies that electricity consumption and GDP are jointly determined and affected at the same time. The increase in electricity consumption results in an increase in economic growth, while a permanent increase in economic growth results in a permanent increase in electricity consumption. These findings can help the policymakers make the most appropriate decisions for electricity policy and macroeconomic planning.

Conclusions

There is a large and growing literature on the relationship between electricity consumption and GDP. In this study, we examined the relationship between electricity consumption and GDP in Turkey using the minimum LM unit root test and the Granger causality test. We find the series stationary in the levels. The results of the Granger causality test based on bi-variate VAR representation show a bi-directional causality between electricity consumption and GDP. The study findings have practical policy implications for policymakers in the area of macroeconomic planning and electricity policy.

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