8. STRUCTURAL BREAKS, ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH: EVIDENCE FROM TURKEY

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Abstract

This paper investigates the short-run and long-run causality issues between electricity consumption and economic growth in Turkey by using the co-integration and vector error-correction models with structural breaks. It employs annual data covering the period 1968–2005. The study also explores the causal relationship between these variables in terms of the three error-correction based Granger causality models. The empirical results are as follows: i) Both variables are nonstationary in levels and stationary in the first differences with/without structural breaks, ii) there exists a long-run relationship between variables, iii) there is unidirectional causality running from the electricity consumption to economic growth. The overall results indicate that "growth hypothesis" for electricity consumption and growth nexus holds in Turkey. Thus, energy conservation policies, such as rationing electricity consumption, may harm economic growth in Turkey.

Keywords: Electricity consumption, economic growth, structural breaks, cointegration, causality

JEL classification: C32, C52, Q43

1. Introduction

The relationship between energy consumption and economic growth has been widely discussed in the literature since the seminal work of Kraft and Kraft (1978) who found evidence of a uni-directional causal relationship running from GNP to energy consumption in the US[1]. Whether the economic development takes precedence over energy consumption or whether energy itself is a stimulus for economic development has motivated curiosity and interest among economists and policy analysts over the past decade to investigate the direction of causality between energy consumption and

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[1] *See Narayan and Prasad (2008) for a literature survey.*

economic variables such as GNP, GDP, income, employment or energy prices. The directions of causal relationship between electricity consumption and economic growth can be categorized under four hypotheses (Jumbe, 2004):

(1) G*rowth hypothesis:* It implies that causality running from electricity consumption to economic growth. This suggests that electricity consumption plays an important role in economic growth. Any reducing (increasing) in electricity consumption could lead to a fall (rise) in income (Altinay and Karagol, 2005; Shiu and Lam, 2004).

(2) C*onservation hypothesis:* It is also called unidirectional causality running from economic growth to electricity consumption. This indicates that a country is not dependent on energy for growth and development and then electricity conservation policies will have little or no effect on economic growth. Furthermore, a permanent increase in economic growth may result in a permanent increase in electricity consumption (Ghosh, 2002).

(3) *Feedback hypothesis:* It implies that there is two-way (bidirectional) causality between electricity consumption and economic growth. This suggests that electricity consumption and economic growth complement each other (Jumbe, 2004; Yoo, 2006).

(4) N*eutrality hypothesis*: The neutrality hypothesis is supported by the absence of a causal relationship between electricity consumption and real GDP. This means that neither conservative nor expansive policies in relation to electricity consumption have any effect on economic growth. Thus, it is important to ascertain empirically whether there is a causal link between electricity consumption and economic growth and the way of causality for designing and implementation of its electricity policy implications.

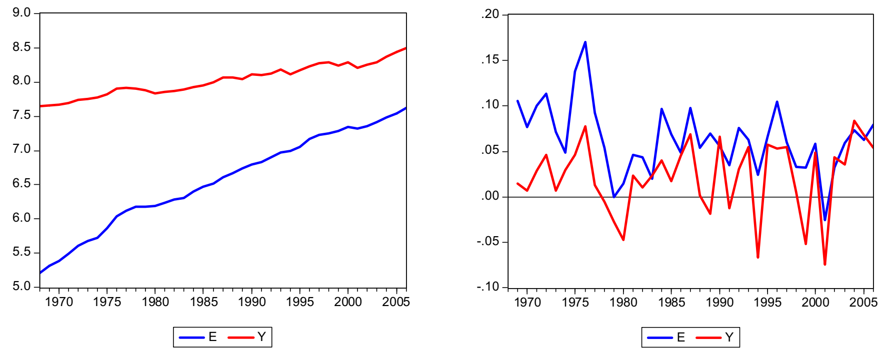
The share of major energy resources of the world are %22.5 for coal, %23.9 for natural gas and %37.5 for petroleum (EIA, 2009). Thus, energy prices have allegedly been a significant factor for the economy, especially for the energy importing countries. Projections for Turkey made of?cially indicate a continuing increase in demand for energy, especially for electricity, in the next two decades (ESMAP Report, 2000). Turkey's electricity demand tends to increase by a rapid average of %7.5. Having been realized as 191.5 TWh in 2007, its electricity generation is expected by 2020 to reach 499 TWh with an annual increase of around %7.7 according to the higher demand scenario, or 406 TWh with an annual increase of %5.96 according to the lower demand scenario. As of 2008, its installed power is 41,987 MW, and its electricity consumption is 198.4 billion kWh. In Turkey, electricity generation came from three main sources: natural gas by %48.17, coal by %28.98, and hydroelectric by %16.77 in 2008 (www.enerji.gov.tr).

In addition, this relation can be observed in Figure 1, which shows that (i) both series are moving smoothly with an upward trend, but (ii) electricity consumption has a higher growth rate than GDP. This means that the higher demand for electricity in Turkey is growing rapidly due to the technical, social and economic development.

The contractionary results in the empirical literature for electricity consumption-economic growth nexus are also confirmed in the study of Payne (2010) and Ozturk (2010) and Turkey has no exception.

Figure 1

The electric power consumption per capita and real GDP per capita



(a) in log-levels (b) in growth rates

According to Payne (2010), the results for the speci?c countries surveyed show that 31.15% supported the neutrality hypothesis; 27.87% the conservation hypothesis; 22.95% the growth hypothesis; and 18.03% the feedback hypothesis. The survey also show that the empirical results have yielded mixed results in terms of the four hypotheses (neutrality, conservation, growth, and feedback) related to the causal relationship between electricity consumption and economic growth. The empirical results of related studies on electricity consumption–growth nexus for Turkey are summarized in Table 1.

Table 1

Summary of empirical studies on electricity consumption–growth nexus for Turkey

Authors	Period	Variables	Methodology	Conclusion
Murry and Nan (1996)	1950-197(	Electricity consumption, GDP	Granger causality, VAR	$E \rightarrow Y$
Altinay and Karagol (2005)	1950-200(	Electricity consumption, GDP	Granger-causality, Dolado–Lutkepohl causality	$E \rightarrow Y$
Halicioglu (2007)	1968-200:	Residential electricity consumption, GDP, residential electricity price, the urbanization rate	Granger causality, ARDL cointegration	$Y \rightarrow E$
Narayan and Prasad (2008)	1960-200:	Electricity consumption, GDP	Bootstrapped Granger-causality	$E \neq Y$

Notes: *$\rightarrow$ and $\neq$ represent unidirectional causality and no causality, respectively. Abbreviations are defined as follows: VAR=vector autoregressive model, ARDL=autoregressive distributed lag, E= electricity consumption, Y= real gross domestic product.*

Since the question of whether electricity consumption causes economic growth or economic growth causes electricity consumption is an unresolved issue, this paper may be considered as a complementary study to the previous studies. The aim of this study is to investigate the causal relationship between energy consumption and economic growth with structural breaks for period of 1968-2005 by using the co-integration and vector error-correction models for Turkish economy. The rest of the paper is organized as follows. The next section presents the model and data description. The third section discusses the methodology and the fourth section reports the empirical results of the study. The last section concludes the paper.

2. Model and Data Description

In empirical literature on energy consumption - economic growth or electricity consumption - economic growth, it can be seen that most of the studies are using only GDP and energy or electricity consumption variables in their models (See Payne, 2010; Table 1 for details). In other words, bivariate models were used in many of these empirical studies. Thus, we also prefer to apply bivariate model (by using per capita GDP and electricity consumption per capita variables) to compare and evaluate our results with others' in this study. Following the empirical literature, the standard log-linear functional specification of long-run relationship between the real GDP and the electricity consumption may be expressed as:

$$Y_t = \beta_0 + \beta_1 E_t + \varepsilon_t \tag{1}$$

where Y and E are real GDP per capita (constant LCU, 1998=100) and electricity power consumption (kWh per capita), respectively. The annual time series data consists of Turkish observations over the 1968-2005 period. The data source is the World Development Indicators (WDI) online. All variables used are in natural logarithms.

3. Methodology

The relationship between the electricity consumption and economic growth will be performed in two steps. First, we define the order of integration in series and explore the long run relationships between the variables by using two types of unit root tests. Second, we test the existence of a long-run relationship between electricity consumption and output, and then causal relationship within VEC models.Given that unit root tests are widely used in literature, to conserve space, we provide a brief explaination of the unit root tests without/with structural breaks.

3.1. Integration Analysis without Structural Breaks

The standard regression form of the ADF (Dickey-Fuller, 1979) unit root test below:

$$\Delta y_t = \mu + \gamma y_{t-1} + \beta t + \sum_{i=1}^{k} \alpha_i \Delta y_{t-i} + \varepsilon_t \tag{2}$$

Where μ is intercept, t is linear time trend, Δ denotes the first difference, k is the number of lagged first differences, and ε_t is error term. The null hypotesis is unit root ($\gamma = 0$) and the alternative hypothesis is level stationarity ($\gamma < 0$). Phillips and Perron (1988, hereafter PP) modified the t-ratio of γ coefficient so that serial correlation does not affect the asymptotic distribution of test statistic. Elliott *et al.* (1996, hereafter DF-GLS) propose a simple modification of the ADF tests in which the data are detrended. This modified version of the Dickey-Fuller t test has substantially improved power when an unknown mean and trend is present. Statistics from these tests have to be compared with MacKinnon (1991, 1996) critical values. Ng and Perron (2001, hereafter NP) construct a test statistics that are also based on GLS detrended data yt. Asymptotic critical values based on Ng and Perron (2001, Table 1). These tests have not allowed any structural breaks.

3.2. Integration Analysis with Structural Breaks

Because the structural break in a time series is of great importance for the stationary analysis, we employed recently developed four unit root tests: Zivot-Andrews (1992; hereafter ZA), Perron (1997, hereafter P97), and Lee and Strazicich (2004, hereafter LS1) unit root tests that take into account this possible a structural break. Besides this, Lee and Strazicich (2003, hereafter LS2) unit root test allows two structural breaks. The break points in these tests are endogenously determined from the data.

Zivot and Andrews (1992) test accounts for structural break in data with endogeneous timing (T_B). Following the notation of Perron (1989), model (A) permits an exogenous change in the level of the series, model (B) allows an exogenous change in the rate of growth and model (C) admits both changes.

Perron (1997) considers the date of possible change as unknown and re-examines the findings of Perron (1989) and showed the results of the ZA test to be valid without any trimming at the end points. The first model allows a change in the intercept under both the null and alternative hypotheses. This was termed “innovational outlier model”.

Under the second model, both a change in the intercept and the slope are allowed at time T_B. Under the third model, a change in the slope is allowed but both segments of the trend function are joined at the time of break. By using two-step procedure, first, the series detrended. The unit root test is performed using the *t*-statistic for testing $\alpha = 1$ in the all regressions.

Lee and Strazicich (2004) consider two models of structural break. Model (A) is known as the “crash” model, and allows for a one-time change in intercept under the alternative hypothesis. Model (C) allows for a shift in intercept and change in trend slope under the alternative hypothesis. Lee and Strazicich claimed that the one-break minimum Lagrange multiplier (LM) unit root test tends to estimate the break point correctly and is free of size distortions and spurious rejections in the presence of a unit root with break. Lee and Strazicich (2004) argued that augmented Dickey-Fuller (ADF) type endogenous break unit root tests (like Zivot and Andrews test, 1992) (1) will exhibit size distortions such that the unit root null hypothesis is rejected too often, and (2) incorrectly estimate the break point. When utilizing such tests, researchers may incorrectly conclude that a time series is stationary with break when in fact the series is nonstationary with break. As such, "spurious rejections" might occur and more so as the magnitude of the break increases (see, Nunes *et. al.*, 1997; Vogelsang and Perron, 1998; and Lee and Strazicich, 2001).

Lee and Strazicich (2003) propose an endogenous two-break LM unit root test that allows for breaks under both null and alternative hypotheses. Model (A) allows for two shifts in level while model (C) includes two changes in level and trend.

3.3. Cointegration Analysis

Johansen (1988) and Johansen and Juselius (1990; hereafter JJ) maximum likelihood (ML) procedure is a very popular cointegration method. The main attraction of this procedure is that it tests for the possibility of multiple cointegrating relationships among the variables. The model is based on the error correction representation given by

$$\Delta Z_t = \Pi Z_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta Z_{t-i} + \mu_0 + \mu_1 t + \varepsilon_t \qquad t = 1,...,T \tag{3}$$

where Z_t is an (m, 1) column vector of p variables, Γ and Π are (m, m) matrices of coefficients, μ_0 and μ_1 are m-vectors of constant and trend coefficicients, Δ is a difference operator, and ε_t is p-dimensional Gaussian error with mean zero and variance matrix (white noise disturbance term). The coefficient matrix Π is known as the impact matrix and it contains information about the long-run relationships.

The vector error correction (VEC) method equation above allows for three model specifications: (a) If Π is of full rank, then Z_t is stationary in levels and a VAR in levels is an appropriate model. (b) If has zero rank, then it contains no long run information, and the appropriate model is a VAR in first differences (implies variables are not cointegrated). (c) If the rank of Π is a positive number, r and is less than p, there exists matrices α and β, with dimensions (p, r), such that $\beta\alpha'=\Pi$. In this representation, â contains the coefficients of the r distinct long run cointegrating vectors that render $\beta' Z_t$ stationary, even though Z_t is itself non-stationary, and á contains the short-run speed of adjustment coefficients for the equations in the system (Awokuse, 2003).

Johansen's methodology requires the estimation of the VAR Equation (3) and the residuals are then used to compute two likelihood ratios (*LR*) test statistics that can be used in the determination of the unique cointegrating vectors of Z_t. The first test which considers the hypothesis that the rank of Π is less than or equal to r cointegrating vectors is given by the trace test below:

$$Trace = -T \sum_{i=r+1}^{p} \log(1-\lambda_i) \tag{4}$$

The second test statistic is known as the maximal eigenvalue test which computes the null hypothesis that there are exactly r cointegrating vectors in Z_t and is given by:

$$\lambda_{\max} = -T \log(1-\lambda_{r+1}) \tag{5}$$

The distributions for these tests are not given by the usual χ^2 distributions. The asymptotic critical values for these likelihood ratio tests are calculated via numerical simulations (see Johansen and Juselius, 1990; and Osterwald-Lenum, 1992).

3.4. Causality Analysis

Cointegration implies the existence of Granger causality, however, it does not point out the direction of the causality relationship. Granger (1988) emphasizes that a vector error correction (hereafter VEC) modeling should be estimated rather than a VAR as in a standard Granger causality test, if variables in model are cointegrated. Following Granger (1988), to test for Granger causality in the long-run relationship, we employ a two step process: The first step is the estimation of the long-run model for Equation (1) in order to obtain the long-run relationship as error-correction term (ECT) in the system. The second step is to estimate the Granger causality model with the variables in first differences and including the ECT in the systems. In our case, the VEC multivariate systems take the following forms:

$$\Delta Y_t = \beta_1 + \alpha_{11}\Delta Y_{t-1} + \alpha_{21}\Delta E_{t-1} + \psi_1 ECT_{t-1} + \varsigma_{1t} \tag{6.a}$$

$$\Delta E_t = \beta_2 + \alpha_{12}\Delta Y_{t-1} + \alpha_{22}\Delta E_{t-1} + \psi_2 ECT_{t-1} + \varsigma_{2t} \tag{6.b}$$

Residual terms, ς_{1t} are ς_{2t}, independently and normally distributed with zero mean and constant variance.

This approach allows us to distinguish between “short-run” and “long-run” Granger causality. The Wald-tests of the “differenced” explanatory variables give us an indication of the “short-term” causal effects, whereas the “long-run” causal relationship is implied through the significance or other wise of the t test(s) of the lagged error-correction term that contains the long-term information since it is derived from the long-run cointegrating relationship. Nonsignificance or elimination of any of the “lagged error-correction terms” affects the implied long-run relationship and may be a violation of theory. The nonsignificance of any of the “differenced” variables reflects only short-run relationship. However, it does not involve such violations. Because, theory typically has little to say about short-term relationships (Masih and Masih, 1996).

In equations 6.a and 6.b, causal relationships can be examined in three ways:

First, short-run or weak Granger causalities are detected through the F-statistics or Wald test for the significance of the relavant α_{ij} coefficients of the first differenced series. Masih and Masih (1996) and Asafu-Adjaye (2000) interpret 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.

Second, Masih and Masih (1996) point out that another possible source of causation is the ECT in equations. The coefficients of the ECT’s represent how fast deviations from the long run equilibrium are eliminated following changes in each variable. The long-run causalities are examined through the t-test or Wald test for the significance of the relavant ψ coefficients on the lagged error–correction term (see Euation 6.a and

6.b). For example, if ψ_1 is zero, *Y* does not respond to the deviations from the long-run equilibrium in the previous period. $\psi_i = 0$, $i = 1,2$ for all *i* is equivalent to both Granger non-causality in the long-run and the weak exogeneity (Hatanaka, 1996).

Third, Asafu-Adjaye (2000) emphasizes that the joint test of two sources of causation indicates which variable(s) bear the burden of short run adjustment to re-establish long run equilibrium, following a shock to the system. Lee and Chang (2008) referred it as strong Granger causality tests that are detected by testing $H_0 : \alpha_{21} = \psi_1 = 0$ and $H_0 : \alpha_{12} = \psi_2 = 0$ in equations (6.a) and (6b), respectively.

4. Empirical Results

Time series univariate properties were examined using two types of unit root tests. First group tests, have not allowed any structural breaks, are the ADF, the PP, the DF-GLS and the NP unit root tests. Second group tests have allowed structural break/breaks. The ZA, the P97, and the LS1 unit root tests have allowed one structural breaks, while the LS2 unit root test has allowed two structural breaks.

It has been observed that the size and power properties of the unit root tests are sensitive to the number of lagged terms (*k*) used. Several guidelines have been suggested for the choice of *k*. The optimal lags for unit root tests are to include lags sufficient to remove any serial correlation in the residuals. k is determined according to the recursive t-statistics procedure proposed by Hall (1994). As discussed by Campbell and Perron (1991), and Ng and Perron (1995), this procedure has better size and power properties than alternative methods based on information criteria, such as AIC.

For the all unit root tests, k is determined according to the recursive t-statistics procedure proposed with significance determined at 5% level of asymptotic normal distribution. The break points are determined endogenously. For the unit root tests with structural break, the subsequent literature has primarily applied model (A) and/or model (C). In a recent study, Sen (2003) shows that if one uses model (A) when in fact the break occurs according to model (C) then there will be a substantial loss in power. However, if break is characterized according to model (A), but model (C) is used then the loss in power is minor, suggesting that model (C) is superior to model (A). Based on these observations, we choose model (C) for our analysis of unit roots.

Results from first group tests (the ADF, the PP, the DF-GLS and NP unit root tests) are reported in Table 2. Neither of these tests fails to reject the null hypothesis of a unit root in each time series at 5 percent significance level but strongly rejected at their first difference. This implies that variables Y and E are non-stationary at levels but stationary at the first differences. The results from second group tests (the ZA, the P97, the LS1 and the LS2 unit root tests) are presented in Table 3. These results (except the LS1 unit root test for variable Y) suggest that we do not reject the null of unit root for variables Y and E at 5 percent significance but rejected at their first difference.

Table 2

Unit roots tests results (without structural break)

levels	ADF	PP	DF-GLS	NP
Y	- 2.74 (0) $^{c+t}$	- 2.74 (0) $^{c+t}$	- 2.87 (0) $^{c+t}$	- 2.34 (0) $^{c+t}$
E	- 2.49 (1) $^{c+t}$	- 2.31 (1) $^{c+t}$	- 1.83 (1) $^{c+t}$	- 1.78 (1) $^{c+t}$
C.V. at 5%	- 3.50	- 3.50	- 3.19	- 2.91
1st differences				
Y	- 3.87 (3) ^{c}	- 6.04 (3) ^{c}	- 3.89 (0) ^{c}	- 5.78 (3) ^{c}
E	- 3.88 (0) ^{c}	- 3.83 (2) ^{c}	- 3.44 (0) ^{c}	- 2.52 (2) ^{c}
C.V. at 5%	- 2.93	- 2.93	- 1.95	- 1.98

Notes: Number of lags, k, are in ( ). Models $^{c+t}$ and ^{c} contain constant and intercept, and only constant, respectively.

Table 3

Unit roots tests results (with structural break)

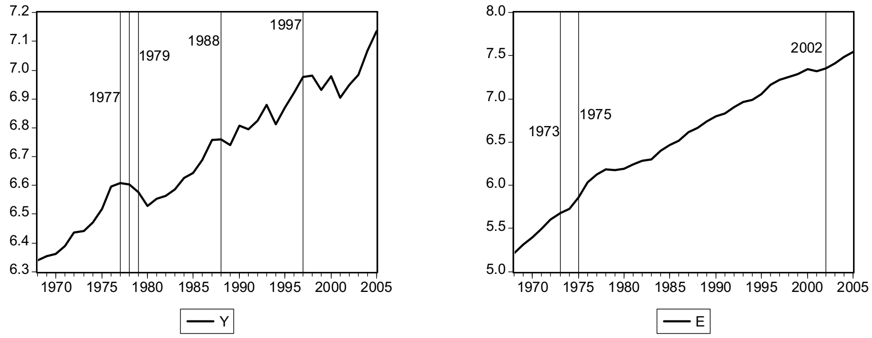
levels	ZA	P97	LS1	LS2
Y	- 3.68 (0) [1979]	- 4.37 (3) [1988]	- 4.55(3) [1977]	- 5.37 (3) [1978,1997]
E	- 4.66 (1) [1975]	- 4.63 (1) [1973]	- 3.36(3) [1973]	- 4.86 (3) [1973,2002]
C.V. at 5%	- 5.08	- 5.59	- 4.51	- 5.74
1st differences				
Y	- 7.04 (0) [1999]	- 7.60 (0) [1997]	- 6.52 (0) [1998]	- 7.21 (0) [1978,1998]
E	- 5.44 (0) [2001]	- 5.66 (1) [1999]	- 4.85 (1) [1983]	- 5.77 (1) [1978,1986]
C.V. at 5%	- 5.08	- 5.59	- 4.51	- 5.74

Notes: Number of lags, k, and break points, TB, are in ( ) and [ ], respectively.
For LS1 test, critical values have changed from -4.45 to -4.51 according to position of break λ(=TB/T) (see, Lee and Strazicich, 2004, table 1).
For LS2 test, critical values have changed from -5.59 to -5.74 according to position of two breaks λ1(=TB1/T) and λ2(=TB2/T) (see, Lee and Strazicich 2003, table 2).
For the LS1 and LS2 tests we put highest values in terms of absolute values as critical values.

For the variable Y, the ZA and the LS1 unit root tests detected Turkish economic crises for the end of 1970s as break points, 1979 and 1977, respectively; the P97 unit root test detected recession in 1988 as a break point; and the LS2 unit root test detected 1978 and 1997 (the effect of East Asian curreny crisis) as two break points (see Figure 2). According to these results, we added dummy variables (D1979, D1988 and D1978-D1997) into VEC models and then tested cointegration relationship and estimated VEC.

Figure 2

Structrual breaks in series of Y and E



The results from JJ cointegration tests without structural break, with one structural break and with two structural breaks indicate that there is a unique long-term or equilibrium relationship between variables (see Table 4). Normalized cointegrating coefficients with one cointegrating vector and dummy variables for real GDP are presented in Table 5. The long-run coefficients for the variable E are positive and strongly statistically significant in all models. But dummy variables are not significant in all models. In addition, the estimated ECTs are presented that their coefficients are negative and statistically significant. ECTs indicate that any deviation from the long-run equilibrium of between variables is corrected about 35% for each period and takes about 3 periods to return the long-run equilibrium level.

Table 4

Johansen-Juselius cointegration tests results

JJ cointegration test without structural break, k=1				
r	Trace Statistics	5 % Critical Value	λ-max Statistics	5 % Critical Value
r=0	20.48	15.49	18.54	14.26
r=1	0.05	3.84	1.94	3.84
JJ cointegration test with one structural break (T_B=1979), k=1				
r	Trace Statistics	5 % Critical Value	λ-max Statistics	5 % Critical Value
r=0	22.01	15.49	20.14	14.26
r=1	1.87	3.84	1.87	3.84
JJ cointegration test with one structural break (TB=1988), k=1				
r	Trace Statistics	5 % Critical Value	λ-max Statistics	5 % Critical Value
r=0	20.49	15.49	18.56	14.26
r=1	1.92	3.84	1.92	3.84
JJ cointegration test with two structural breaks (T_{B1}=1978 and T_{B2}=1997), k=1				
r	Trace Statistics	5 % Critical Value	λ-max Statistics	5 % Critical Value
r=0	18.05	15.49	16.37	14.26
r=1	1.67	3.84	1.67	3.84
Notes: k is # of optimal lags based on FPE, AIC, SIC and HQ information criterias test results. r is # of cointegrating vectors. Critical values used are taken from Osterwald-Lenum (1992). TB is break dates.				

Table 5

Estimated long-run coefficients

variables	without structural break	one structural break (T_B=1979)	one structural break (T_B=1988)	two structural breaks (T_{B1}=1978,T_{B2}=1997)
Constant	4.2269	4.2085	4.2278	4.2441
E	0.3793 [23.91]	0.3822 [24.54]	0.3792 [23.57]	0.3767 [21.83]
D1978				-0.0277 [-0.68]
D1979		-0.0418[-1.05]		
D1988			-0.0226 [-0.56]	
D1997				0.0099 [0.24]
ECT	-0.3533 [-2.17]	-0.3118 [-1.94]	-0.3567 [-2.16]	-0.3425 [-1.92]
R-squared	0.16	0.18	0.17	0.18
LM1 [4]	6.75 (0.15)	7.63 (0.11)	10.96 (0.03)	5.14 (0.27)
LM2 [4]	7.06 (0.13)	6.99 (0.14)	8.18 (0.09)	6.91 (0.14)
White[18]	15.25 (0.84)	15.69 (0.79)	17.74 (0.67)	18.15 (0.80)
J-B [4]	2.99 (0.56)	3.28 (0.51)	3.69 (0.45)	4.00 (0.41)

Notes: t-statistics for coefficients are in [ ]. The null hypothesis of the LM1 and LM2 tests are that there is no serial correlation up to lag order 1 and 2, respectively. White's (1980) test is a test of the null hypothesis of no heteroskedasticity against heteroskedasticity of unknown, general form. The null hypothesis of the Jarque-Bera (J-B) statistic is that there is a normally distributed error. # of degrees of freedom for distribution $\aleph^2$ is in [ ]. Probalities for the diognastic tests are in ( ).

Finally, we tested three kinds of Granger causality that are short-run (or weak) Granger causality, long-run causality and strong Granger causality for four VEC models. According to three kinds of Granger causality results based on four VEC models, we can reject the null hypothesis that electricity consumption per capita does not cause real GDP per capita. This result implies that electricity consumption per capita weakly and strongly causes real GDP per capita in both short-run and long-run. But we cannot reject the null hypothesis that real GDP per capita does not cause electricity consumption per capita for three kinds of Granger causality results based on four VEC models. This result shows that there is no causal evidence from the real GDP per capita to electricity consumption per capita (see Table 6). Overall results support that "Growth hypothesis" for electricity consumption and growth nexus holds in Turkey.

Table 6

Granger causality test

short-run (or weak) granger causality				
the null hypotheses	without structural break	one structural break (T_B=1979)	one structural break (T_B=1988)	two structural breaks (T_{B1}=1978,T_{B2}=1997)
$\Delta E \Rightarrow \Delta Y$	5.1659 (0.0301)	5.0473 (0.0319)	5.1718 (0.0300)	5.2789 (0.0285)

short-run (or weak) granger causality				
$\Delta Y \Rightarrow \Delta E$	0.0385 (0.8457)	0.0450 (0.8334)	0.0382 (0.8463)	0.0322 (0.8587)
long-run causality				
the null hypotheses	without structural break	one structural break (T_B=1979)	one structural break (T_B=1988)	two structural breaks (T_{B1}=1978,T_{B2}=1997)
$\Delta ECT \Rightarrow \Delta Y$	4.0315 (0.0534)	3.8953 (0.0574)	4.0382 (0.0533)	4.1623 (0.0499)
$\Delta ECT \Rightarrow \Delta E$	0.8064 (0.3761)	0.8594 (0.3611)	0.8037 (0.3769)	0.7550 (0.3916)
strong granger causality				
the null hypotheses	without structural break	one structural break (T_B=1979)	one structural break (T_B=1988)	two structural breaks (T_{B1}=1978,T_{B2}=1997)
$\Delta E, \Delta ECT \Rightarrow \Delta Y$	2.7703 (0.0782)	2.6993 (0.0830)	2.7738 (0.0779)	2.8386 (0.0738)
$\Delta Y, \Delta ECT \Rightarrow \Delta E$	0.5410 (0.5875)	0.5655 (0.5738)	0.5398 (0.5828)	0.5175 (0.6011)

Notes: The null hypothesis is that there is no causal relationship between variables. Values in parentheses are p-values for F tests. Δ is the first difference operator.

5. Concluding Remarks

There is a growing literature that examines the causality relationship between electricity consumption and real GDP in 2000s. This paper attempted to analyze the causal relationship between electricity consumption and economic growth by using the co-integration and vector error-correction models in Turkey for the 1968–2005 period. According to three kinds of Granger causality results based on four VEC models, the electricity consumption per capita weakly and strongly causes real GDP per capita in both short-run and long-run. The results also show that there is no causal evidence from the real GDP per capita to electricity consumption per capita. In other words, there is only unidirectional causality running from electricity consumption to real GDP in Turkey for the period considered. The results obtained in this study are dependent the variables used, on the sample period and the methodology applied.

This implies that high electricity consumption tends to have high economic growth, but not the reverse. The findings of this study suggest that electricity consumption played an important role in economic growth. Therefore, policies to manage the supply of electricity are required to ensure that the electricity is sufficient to support Turkey's economic growth. Thus, energy conservation policies, such as rationing electricity consumption, are likely to have an adverse effect on real GDP of Turkey. For the mentioned reasons, the energy growth policies regarding electricity consumption should be adapted in such a way that the development of this sector stimulates economic growth.

Furthermore, projections for Turkey made of?cially indicate a continuing increase in demand for energy, especially for electricity, in the next two decades. Finally, the Ministry of Energy and Natural Resources of Turkey should continue to explore new resources and expand the electricity supply via hydroelectric power plants, thermal power plants and wind power plants. Because it is environmental friendly, renewable, cost-effective and stable compared with fossilfuel.

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