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A MULTIVARIATE CAUSALITY ANALYSIS OF ECONOMIC GROWTH AND ELECTRICITY CONSUMPTION IN TURKEY

Halil Altıntaş[1+]
Kassouri Yacouba[2]

[1]*Faculty of Economics and Administrative Sciences. Erciyes University, Kayseri, Turkey*
[2]*PhD (c), Department of Economics. Erciyes University, Kayseri, Turkey*

(+ Corresponding author)

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ABSTRACT

This study uses time series data to examine the long-run and short-run effects of electricity consumption, real GDP per capita, exports and financial development in Turkey between 1970-2011. The study adopted structural break unit root test, ARDL bounds tests methods to test cointegration to achieve robust results. Inter-variable causal relationships were determined using the Toda and Yamamoto (1995) framework. The findings were that electricity consumption, financial development and exports are cointegrated in the long run. Following this development, financial development was found to create a significant increase in both economic growth and electricity consumption in Turkey. The findings were that electricity consumption positively impacts on the economic growth in addition to the fact that bidirectional causality between economic growth and electricity consumption were established. These results also support that, feedback hypothesis is confirmed in Turkey.

Contribution/ Originality: This study contributes to the existing literature by incorporating financial development and exports into neo-classical production function in addition to using ARDL and Toda Yamamoto estimation methodologies to measure electricity consumption and economic growth in Turkey.

1. INTRODUCTION

Prominent studies on energy economic have established that electricity consumption is an important contributor to national productivity. The importance of electricity consumption in economic growth is one of the issues that have attracted attention of both researchers and policymakers over the last fifty years. Energy economics literature predicate at least four testable hypotheses related energy-growth nexus which are as follows (Jumbe, 2004): (1) Neutrality hypothesis: This hypothesis states that electricity conservation policy has no effect on GDP and the hypothesis is justified by the lack of a causal relationship between electricity consumption and real gross domestic product (GDP). (2) Conservation hypothesis: This hypothesis is also known as unidirectional causality running from economic growth to electricity consumption. If this is so, electricity conservation policies aimed at reducing electricity consumption and waste will have minimal or no effect on economic growth. (3) Growth hypothesis: This asserts that causality runs from electricity consumption to economic growth. The growth hypothesis suggests that electricity consumption plays a key role on the economic growth. In this case, the reduction in electricity consumption due to electricity conservation-oriented policies may have a detrimental impact on economic growth. (4) Feedback hypothesis: this hypothesis postulates that there is two-way causality between electricity consumption and economic growth.

Empirical findings have shown that there are mixed results in terms of the four hypotheses and electricity consumption - economic growth nexus is still an issue that remains to be resolved. There exist the contractionary results and no consensus about the existence of relationship and direction of causality in the literature and Turkey is no exception. Several of these studies employ bivariate models to estimate the relationship between energy consumption and economic growth. An unidirectional causality relationship running from GNP to energy consumption but not vice versa as found by Kraft and Kraft (1978). Eden (1984) apply Sims' technique and use the updated data US (1947–1979) to reexamine the relationship between energy consumption and GNP. They find that find no viable relationship between energy consumption and GNP. Kouakou (2011) investigates the causal relationship between the electric power industry and the economic growth for the case of Ivory Coast by adopting data from 1971 to 2008. The eventual of his study found that there is a bidirectional relationship running from electricity consumption to economic growth and from economic growth to electricity use in the short run. The model supports also evidence of short run unidirectional causality running from electricity consumption per capita to industrial value added. Shahbaz *et al.* (2011) studies the relationship between energy (renewable and nonrenewable) consumption and economic growth by employing Cobb–Douglas production function in the case of Pakistan between the periods 1972–2011. The results from the Granger causality analysis confirm the existence of feedback hypothesis between renewable energy consumption and economic growth, nonrenewable energy consumption and economic growth, economic growth and capital.

Given the fact that bivariate models are employed in these studies, the studies may lose important variable(s) and obtain biased results. Therefore, some of the studies investigate electricity consumption-growth nexus by adopting multivariate causality analysis to prevent the omitted variable bias. For instance, Ozturk (2010) provided a survey of the literature to show the relationship between energy consumption and economic growth; electricity consumption and economic growth causality nexus. There are some other researchers who have highlighted this relation (see (Iwata, 2010; Wang, 2011)). Shahbaz (2014) studied the interrelationship among FDI, electricity consumption, and CO2 in Bangladesh. Hamdi (2014) employed the ARDL and VECM models to investigate the relationship between economic growth, foreign direct investment (FDI), and electricity consumption in Bahrain. Their result suggested unidirectional causal relationships run from FDI and electricity consumption to economic growth. Their result found that FDI and trade openness have a positive impact on energy pollutants. However, different researches have utilized time series models and Granger causality analysis to test the relationship between electricity consumption (ELC) and economic growth in different countries. Some studies have been based on the VAR model (e.g., (Yang, 2000; Aqueel, 2001; Ghosh, 2002; Yoo, 2006; Huang, 2008)). In addition, several studies have been used the VEC model (see, (Bekhet and Othman, 2001; Jumbe, 2004; Shiu and Lam, 2004; Chen, 2007; Yuan, 2008; Narayan and Smyth, 2009; Yoo and Kwak, 2010; Odhiambo, 2011; Lee and Chang, 2008)). The following group of studies has employed the ARDL model, for instance, Fatai (2004); Squalli (2007); Ouédraogo (2010); Narayan and Smyth (2009); Narayan and Smyth (2007); Tang (2009).

To contribute to the existing academic literature on electricity, the electricity consumption-growth nexus, this paper puts into consideration the causal relationship between electricity consumption, real GDP per capital, financial development and exports in Turkey over the period of 1970-2011. The causal relationship among variables is carried out by applying Toda-Yamamoto multivariate and the Modified Wald (MWALD) causality techniques.

Other sections of the paper are organized as follows: Section II presents the data and methodology used; Section III also presents the empirical results while Section IV is the conclusion of the paper.

2. DATA AND METHODOLOGICAL FRAMEWORK

The study applied times series data from 1960 to 2011. The data sets for this study were obtained from the World Bank Development Indicators through the Bank's data portal. The variables used in this study are real GDP, electricity consumption (measured in Kwh), financial development (as measured by the ratio of total credit provided by banks to the private sector) and real exports ; each in per capita terms.

Following Ehrlich (1977); Cameroun (1994) and Layson (1983) the study employs log-linear specification to explore the relationship between electricity consumption and economic growth is as follows:

$$\ln Y_t = \alpha_0 + \alpha_1 \ln X_t + \alpha_2 \ln EC_t + \alpha_3 \ln CR_t + u_t \quad (1)$$

Where lnY_t, lnX_t, $lnEC_t$ and $lnCR_t$ represent real GDP, export of goods and services, electricity consumption and real domestic credit to private sector, each is transformed into logarithm and expressed in per capital terms. U_t is a random error term assumed *N(iid)*.

The study follows a three-stage procedure. In the first stage to testing for cointegration, the stationarity of each series was checked using the ADF, PP and KPSS unit root tests. The study noted the inability of this test to capture the presence of structural breaks in the series. Therefore, the study continues to apply the Zivot and Andrews (1992) unit root tests to identify the possibility of an existing structural break within the series. After running these tests, the second stage involves testing of the long-run and the short-run dynamics of the variables. The Pesaran (2001)) ARDL bounds testing approach to cointegration is used. According to Inder (1993) this test is found to have serial advantages over the Johansen cointegration methods. These include, the provision of consistent results irrespective of the order of the variables in so far they are within the mix order of *I(0)* and *I(1)* or where there is mutual integration. In addition to that, the ARDL model can efficiently correct for omitted lag variable bias. To implement the ARDL bounds testing approach in this study. Equation. (1) is transformed into the unrestricted error correction model (UCEM) as indicated below:

$$\Delta \ln Y_t = \beta_0 + \sum_{i=1}^{m} \beta_{1i} \Delta \ln Y_{t-i} + \sum_{i=0}^{m} \beta_{2i} \Delta \ln X_{t-i} + \sum_{i=0}^{m} \beta_{3i} \Delta \ln EC_{t-i} + \sum_{i=0}^{m} \beta_{4i} \Delta \ln CR_{t-i}$$

$$+\theta_1 \ln EC_{t-1} + \theta_2 \ln CR_{t-1} + \theta_3 \ln Y_{t-1} + \theta_4 \ln X_{t-1} + u_t \quad (2)$$

Where Δ denotes the first difference operator, *lnY* is the log of real GDP per capita (proxy for economic growth), *lnEC* is the log of electricity consumption per capita, *lnX* is the log of total investment as a share of GDP and *lnCR* is the log of total credit provided by banks to the private sector. The procedure of the ARDL bounds testing approach has two steps. The first procedure done is F-test for the joint significance of the lagged level variables. The second step is to choose the optimal lag orders of the variables using Akaike Information Criterion, and estimated the long-run and short run parameters by applying the error correction model (ECM).

$$\Delta \ln Y_t = \beta_0 + \sum_{i=1}^{m} \beta_{1i} \Delta \ln Y_{t-i} + \sum_{i=0}^{m} \beta_{2i} \Delta \ln X_{t-i} + \sum_{i=0}^{m} \beta_{3i} \Delta \ln EC_{t-i} + \sum_{i=0}^{m} \beta_{4i} \Delta \ln CR_{t-i} + \varphi ECT_{t-1} + \mu_t \quad (3)$$

Where φ represents the speed of adjustment parameter, and ECT_{t-1} represents a one-period lagged error correction term. All other variables are as previously defined. The coefficient on the error correction term indicates the speed of adjustment back to equilibrium following shock to the system and it should have a statistically significant negative sign. To ensure the goodness of fit of the model we performed diagnostic tests for serial correlation, functional form, normality and heteroscedasticity.

The third stage involves applying Toda and Yamamoto procedure. The existence of a long-run relationship between economic growth, financial development, real exports and electricity consumption requires to detect the dynamic causality relationships between the variables by applying the Toda and Yamamoto approach. The Toda and Yamamoto (1995) develop a different approach that involves estimating a vector autoregression (VAR) model in levels. In testing causality, a modified Wald test (MWALD) is adopted as proposed by Toda and Yamamoto (1995). This procedure requires testing each of the times series to determine maximal potential order of integration, d_{max}. Causality test is used after estimating an augmented VAR with p = k + d order, where k is the optimal lag length in the VAR model. Toda and Yamamoto (1995) Granger-Causality approach has an advantage in that it can be applied even when the variables are integrated at the different order. The Toda Yamamoto model is as follows:

$$v_t = \alpha_v + \varphi_1 v_{t-1} + ...\varphi_n v_{t-n} + \omega_{v,t} \quad (4)$$

The model in Eq. (4) can be written in following four different equations

$$\ln Y_t = a_1 + \sum_{i=1}^{k} \delta_{1i} \ln Y_{t-i} + \sum_{j=k+1}^{d_{\max}} \delta_{2i} \ln Y_{t-j} + \sum_{i=1}^{k} \beta_{1i} \ln X_{t-i} + \sum_{j=k+1}^{d_{\max}} \beta_{2i} \ln X_{t-j}$$

$$+ \sum_{i=1}^{k} \alpha_{1i} \ln EC_{t-i} + \sum_{j=k+1}^{d_{\max}} \alpha_{2i} \ln EC_{t-j} + \sum_{i=1}^{k} \phi_{1i} \ln CR_{t-i} + \sum_{j=k+1}^{d_{\max}} \phi_{2i} \ln CR_{t-j} + \omega_{1,t} \quad (5)$$

$$\ln X_t = a_1 + \sum_{i=1}^{k} \beta_{1i} \ln X_{t-i} + \sum_{j=k+1}^{d_{\max}} \beta_{2i} \ln X_{t-j} + \sum_{i=1}^{k} \delta_{1i} \ln Y_{t-i} + \sum_{j=k+1}^{d_{\max}} \delta_{2i} \ln Y_{t-j}$$

$$+ \sum_{i=1}^{k} \alpha_{1i} \ln EC_{t-i} + \sum_{j=k+1}^{d_{\max}} \alpha_{2i} \ln EC_{t-j} + \sum_{i=1}^{k} \phi_{1i} \ln CR_{t-i} + \sum_{j=k+1}^{d_{\max}} \phi_{2i} \ln CR_{t-j} + \omega_{2,t} \quad (6)$$

$$LEC_t = a_1 + \sum_{i=1}^{k} \beta_{1i} \ln EC_{t-i} + \sum_{j=k+1}^{d_{\max}} \beta_{2i} \ln EC_{t-j} + \sum_{i=1}^{k} \phi_{1i} \ln CR_{t-i} + \sum_{j=k+1}^{d_{\max}} \phi_{2i} \ln CR_{t-j}$$

$$+ \sum_{i=1}^{k} \delta_{1i} \ln Y_{t-i} + \sum_{j=k+1}^{d_{\max}} \delta_{2i} \ln Y_{t-j} + \sum_{i=1}^{k} \beta_{1i} \ln X_{t-i} + \sum_{j=k+1}^{d_{\max}} \beta_{2i} \ln X_{t-j} + \omega_{3,t} \quad (7)$$

$$\ln CR_t = a_1 + \sum_{i=1}^{k} \phi_{1i} \ln CR_{t-i} + \sum_{j=k+1}^{d_{\max}} \phi_{2i} \ln CR_{t-j} + \sum_{i=1}^{k} \delta_{1i} \ln Y_{t-i} + \sum_{j=k+1}^{d_{\max}} \delta_{2i} \ln Y_{t-j}$$

$$+ \sum_{i=1}^{k} \beta_{1i} \ln X_{t-i} + \sum_{j=k+1}^{d_{\max}} \beta_{2i} \ln X_{t-j} + \sum_{i=1}^{k} \alpha_{1i} LEC_{t-i} + \sum_{j=k+1}^{d_{\max}} \alpha_{2i} LEC_{t-j} + \omega_{4,t} \quad (8)$$

Now we demonstrate how MWALD test works. For example in Eq. (5), we can test the hypothesis that electricity consumption does not Granger cause economic growth if $\alpha_{1i} = 0 \forall_i$; similarly in Eq. (6), electricity consumption does not Granger cause export if, $\alpha_{1i} = 0 \forall_i$; in Eq. (7) economic growth does not Granger cause electricity consumption if $\delta_{1i} = 0 \forall_i$; and investment does not Granger cause electricity consumption if $\beta_{1i} = 0 \forall_i$. In the similar way the Granger causality test can be performed for remaining equations from 5 to 8.

3. EMPIRICAL RESULTS

To make our investigation robust, the study starts with the assessment of the unit root test. This is to examine the stationarity properties of the variables. To ensure this, the study applied the ADF, PP and KPSS unit root tests. The results of ADF, PP and KPSS are reported in table1. The results show that all the variables are not stationary at a level. However, after taking the first difference of all the variables, the series were stationary at 5% or 1% level of significance. All the variables are I(1) integrated of one series.

The major problem with ADF, PP and KPSS unit root tests is that they do not provide information on the structural breaks position of the series. This development could in actual sense provide an ambiguous result if no action is taken. To resolve this problem, the study used the Zivot and Andrews (1992) unit root test method. The results of the test are shown in Table 2, the finding from that table shows additional evidence against the unit root hypothesis relative to the unit root tests without a structural break. For *lnY* and *lnCR* series, we are unable to reject the unit root null hypothesis at the 1% level, confirming that the series are I(1). But for *lnEC* and *lnX* series, we are not unable to reject the unit root null hypothesis at the 1% level, confirming that series are I(0). The test indicated structural breaks dates to be 1971, 1975, 1979, 1981, 1998 and 2003. While 1971, 1975, 1979 were periods of strong recession and oil shocks years, 1981 was year of structural adjustment policies and 2003 was the year of great output recovery and continued disinflation in Turkey.

Table-1. Unit Root Analysis

Variables	ADF		PP		KPSS	
	Level	First difference	Level	First difference	Level	First difference
lnY	-0.324(0)	-7.310***(0)	-0.251(4)	-7.136***(3)	315.26**(0)	0.037(0)
lnEC	-1.663(2)	-4.611***(0)	-2.796(5)	-4.656***(2)	71.603***(1)	0.085(0)
lnCR	-0.691(1)	-6.041***(0)	0.007(3)	-6.038***(5)	4.987***(0)	0.098(0)
lnX	-1.802(0)	-7.811***(0)	-0.263(0)	-4.169***(0)	53.87***(0)	0.335(2)

Note: ***indicates that unit root tests are rejected at 1% level. Lag length of variables are show in small parentheses.

Table-2. Zivot-Andrews test for unit roots in the presence of structural one break

	lnY		*lnX*		*lnEC*		*lnCR*	
	Model A	Model C	Model A	Model C	Model A	Model C	Model A	Model C
TB	1979	1979	1981	1981	1971	1975	2003	1998
ϕ	-0.414 (-3.895)	-0.558 (-4.495)	-0.562*** (-5.747)	-0.649*** (-6.678)	-0.244 (-3.859)	-0.544*** (-5.804)	-0.207 (-2.792)	-0.399** (-5.198)
θ	0.052*** (2.69)	-0.082*** (-3.468)	0.176*** (4.969)	0.704*** (5.954)	0.065*** (2.677)	0.072*** (3.516)	-0.244*** (-4.149)	-0.293*** (-4.458)
γ	-	-0.004*** (-2.066)	-	0.0197*** (2.720)	-	-0.015*** (-4.305)	-	0.052*** (6.278)
k	0	0	0	0	1	1	1	1
Exact critical values fot t_ϕ								
1%	-5.34	-5.57	-5.34	-5.57	-5.34	-5.57	-5.34	-5.57
5%	-4.93	-5.08	-4.93	-5.08	-4.93	-5.08	-4.93	-5.08

Notes: TB denotes the time of structural break. Model A means break only in drift and Model C means in the drift and slope. *** and ** denotes statistical at the %1 and %5 respectevily. The critical values for structural break dummy variables follow the asymptotic Standard normal distribution. The critical values for t_ϕ are calculated based on 5000 replications of a Monte Carlo simulation.

This study applied the ARDL bounds testing approach to investigate the existence of cointegration among the variables in the presence of structural breaks. In addition to that, the SIC is also used in the lag selection exercise, the study found the maximum lag length to be 5. Based on confirmation, the study continues to estimate the F-statistic, which will confirm the existence of cointegration among the variables or otherwise. The commonest rule here is, if the calculated F-statistic is found to be higher than the critical bounds, then we may reject the hypothesis of no cointegration. The result of this analysis is reported in Table 3. The findings of the Table shows that calculated F-statistic for the bounds test 12.112 is greater than 1% upper bounds critical value provided by Narayan (2005). Therefore, there is a cointegration between the series which confirms that economic growth, electricity consumption, exports and credit are cointegrated for long-run relationship over the period of 1960-2011 in case of Turkey.

Table-3. The results of ARDL Cointegration Test

Bounds testing to cointegration		F-test statistics			
Dependent variable: ΔlnY	Optimal Lag length				
$F_Y(Y \mid EC, CR, X)$,	*1,0,4,5*	***12.112****			
Diagnostic tests					
$\chi^2_{NORMAL}=1.386$ $\chi^2_{ARCH}=[1]:1.962$	$\chi^2_{RESET}=[2]:0.833$ $\chi^2_{SERIAL}=[2]:3.446$				
**Asymtotic critical value (T=55)*					
Significant level ***%1***		***%5***		***%10***	
Lower I(0)	*Upper I(1)*	Lower I(0)	*Upper I(1)*	Lower I(0)	*Upper I(1)*
4.828	6.195	3.408	4.623	2.843	3.920

Notes: Critical values are calculated using stochastic simulations for *T=55* and *k=3* based on 40.000 replications. *The small sample Critical values for bounds test are derived from Narayan (2005). χ^2_{NORMAL} J-B test implies that the error terms are normally distributed, χ^2_{SERIAL} B-G test implies that there is no serial correlation, χ^2_{ARCH} ARCH LM is no ARCH up to the selected lag, χ^2_{RESET} Ramsey RESET test null is no specification errors with one term using LR. The optimal lag structure is determined by SIC.

After establishing long-run relationship between the variables, we the proceeded to investigate the long-run and short-run impacts of electricity consumption, exports and credit on economic growth using the associated ARDL and ECM. The results for long run are presented in Table 4, and the findings of the study found that there is a positive and statistically meaningful relationship between economic growth, electricity consumption, financial development and exports in Turkey. The study found that the electricity consumption prospects to be positively and statistically related with economic growth. The findings of this study discovered that a 1% increase in electricity consumption will lead to a corresponding increase of 0.303% in economic growth in Turkey holding another factors constant. Like in this line, the results indicate that financial development has positive and meaningful relationship with real GDP per capita. As a result, a 1% increase in financial development increases economic growth by 0.082 in the long run. The Turkish exports were, on the other hand, found to be positively related with economic growth. The result of the long-run analysis indicates that any 1% increase in the Turkish exports will have a significant impact on economic growth by a cumulative rise of 0.045%.

As showed from Table 4, there is no problem of heterogeneity and the error term has homogenous variance. The Ramsey reset test attest to the fact that functional form of the model is well specified.

The results of the short-run analysis are also reported in the lower level of Table 5. The results indicate that electricity consumption and credit are positively and significant impacts on real GDP per capita whereas the short-run coefficient of export variable is statistically insignificant. The value of the ECM is found to be negative and statistically significant. The estimate of ECM is -0.351 which indicates that convergence to equilibrium after a shock takes slightly over 2.84 years. The results of diagnostic tests basically show that the error terms of the short-run model are normally distributed in all models. There is no heteroskedasticity, serial correlation and no ARCH problem. The value of the Ramsey reset test shows that the functional form for the short-run models is well specified.

Table-4. Estimated long-run coefficients based on ARDL (1,2,4,5)

Dependent variable : lnyt	Coefficient	Std.Error	t-statistics
lnY(-1)	0.2708	0.1329	2.037**
lnEC	0.3058	0.1139	2.684***
lnEC(-1)	0.0766	0.1680	0.455
lnEC(-2)	-0.1599	0.1054	-1.516
lnCR	0.0595	0.0277	2.143**
lnCR(-1)	0.1469	0.0487	3.015***
lnCR(-2)	-0.196	0.0549	-3.571***
lnCR(-3)	0.1677	0.0512	3.275***
lnCR(-4)	-0.129	0.0333	-3.892***
lnX	-0.0489	0.0211	-2.318**
lnX(-1)	0.0537	0.0307	1.748*
lnX(-2)	-0.0497	0.0284	-1.751*
lnX(-3)	0.0543	0.0251	2.160**
lnX(-4)	-0.0337	0.0250	-1.350
lnX(-5)	0.0560	0.0172	3.255***
Constant	4.6188	0.8940	5.236**
Estimated long-run coefficients			
Variables	Coefficient	Std.Error	t-statistics
Constant	6.662	0.213	31.186***
lnEC	0.303	0.019	15.455***
lnCR	0.082	0.030	2.655**
lnX	0.045	0.021	2.072**
R^2 = 0.997	Adj-R^2= 0.995	F-statistic = 735.91	
Diagnostic Test			
χ^2_{SERIAL} =0.716 (0.469)	χ^2_{NORMAL} =1.799(0.406)	χ^2_{RAMSEY} =1.552(0.222)	χ^2_{ARCH} =0.066(0.797)

Note: *, ** and *** show the significance at 10%, 5% and 1% level respectively, the optimal lag structure is determined by AIC

Table-5. Estimated Short-run Coefficients based on ARDL(3,1,5,0)

Dependent variable: Δ**lnY**$_t$		Coefficient	Std. error	t-statistics
ΔlnY(-1)		-0.2088	0.1566	-1.3331
ΔlnY(-2)		0.0772	0.1408	0.5483
ΔlnY(-3))		0.1429	0.1518	0.9415
ΔlnEC		0.3180	0.1184	2.6847**
ΔlnEC(-1)		0.2676	0.1450	1.8454*
ΔLCR		0.0840	0.0376	2.2302**
ΔlnCR(-1)		0.1399	0.0388	3.6064***
ΔlnCR(-2)		-0.0617	0.0399	-1.5480
ΔlnCR(-3)		0.0342	0.0382	0.8955
ΔlnCR(-4)		-0.0065	0.0406	-0.1603
ΔlnCR(5)		-0.0470	0.0321	-1.4634
ΔlnX		-0.0379	0.0248	-1.5295
ECT(-1)		-0.3518	0.1551	-2.2679**
Constant		-0.0180	0.0118	-1.5288
Estimated Short-run coefficients				
Variables	*Coefficient*	*Std. error*		*t-statistics*
Constant	-0.0182	0.0156		-1.1666
$lnEC_t$	0.5924	0.2169		2.7312***
$lnCR_t$	0.1445	0.0737		1.9606*
lnX_t	-0.0384	0.0245		-1.5673
R^2=0.727	*Adj-R^2=0.620*	*F-statistic=6.788*		
Diagnostic Test				
χ^2_{SERIAL} =0.424 (0.808) χ^2_{NORMAL} =1.799(0.406)				
χ^2_{RAMSEY} =1.552(0.222) χ^2_{ARCH} =0.204(0.654)				

Note: *, ** and*** show the significance at 10%, 5% and 1% level respectively. The optimal lag structure is determined by AIC.

To find the stability of the long-run and short-run parameters, the cumulative sum (CUSUM) and the cumulative sum of squares (CUSUMsq) are used as suggested by Brown (1975). In Figs. 1 and 2 CUSUM and CUSUMsq reveal that plotted data points are within the critical bounds, suggesting that long-run model is correctly is correctly specified and long-run coefficients are stable.

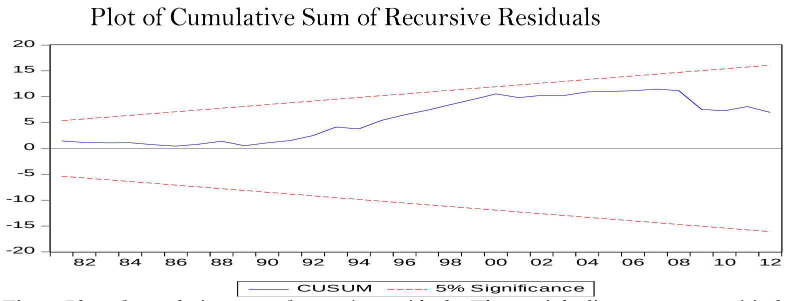

Fig-1. Plot of cumulative sum of recursive residuals. The straight lines represent critical bounds at 5% significance level.
Source: Own estimation

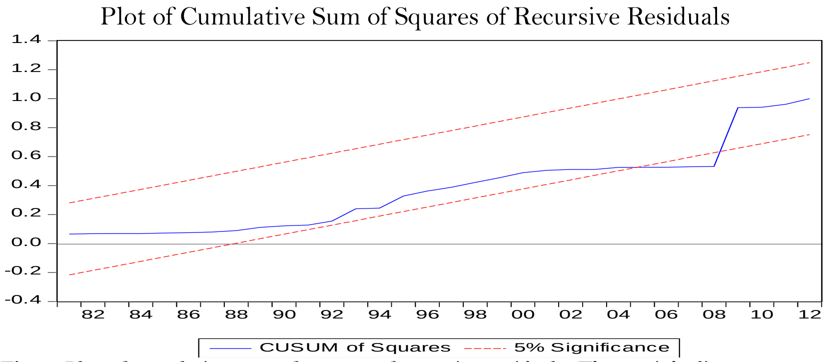

Fig-2. Plot of cumulative sum of squares of recursive residuals. The straight lines represent critical bounds at 5% significance level
Source: Own estimation

The results of the Toda and Yamamoto Granger Causality tests are reported in Table7. Toda and Yamamoto procedure involves two steps. At the first step, the maximum order of integration d and the optimal lag length k are determined. In table 2 the ADF, PP and ZA unit root tests confirm the maximum integration order (d) for the selected variables is 1. The optimal lag lengths (k's) are selected based on the usual information criteria such as, Akaike Information Criteria (AIC), Schwarz Information Criteria (SIC) and Hannan-Quinn. The selected optimal lag lengths (k's) are presented in Table 6. The results provided in Table 6 find that LR, FPE, AIC, AIC and HQ point out that optimum lag length is 2.

Table-6. Selection of the order of the VARs (k's)

Lag	LogL	LR	FPE	AIC	SC	HQ
0	16.788	NA	6.90e-06	-0.532	-0.376	-0.473
1	259.38	434.64	5.49e-10	-9.974	-9.194*	-9.679
2	282.35	37.32*	4.17e-10*	-10.264*	-8.861	-9.734*
3	292.64	15.01	5.49e-10	-10.026	-7.999	-9.260
4	309.68	22.01	5.65e-10	-10.070	-7.419	-9.068

Notes: *indicates lag order of delected by the criterion. LR: sequential modified LR test statistic each test at 5% level) FPE: Final prediction error AIC: Akaike information criterion, SC: Schwarz information criterion. HQ: Hannan-Quinn information criterion

The second step of the Toda and Yamamoto procedure involves the modified Wald procedure to test the VARs ($k+d_{max}$) for causality. The Wald test results are presented in Table 7.

Table-7. TYDL Granger causality test (χ^2 statistics).

Dependent variables	MWALD test				Causality inference
	$\ln Y_t$	$\ln EC_t$	$\ln CR_t$	$\ln X_t$	
$\ln Y_t$	-	12.008*** (0.001)	18.857*** (0.000)	0.309 (0.735)	$Y \leftarrow EC$ $Y \leftarrow CR$
$\ln EC_t$	4.406** (0.019)	-	13.742*** (0.000)	0.280 (0.757)	$EC \leftarrow Y$ $EC \leftarrow CR$
$\ln CR_t$	0.014 (0.992)	2.174 (0.337)	-	0.287 (0.866)	
$\ln X_t$	4.100 (0.128)	1.046 (0.592)	4.010 (0.134)	-	

Notes: ** and * denotes statistical significant level at 5% and 10%, respectively. Figures in parenthesis are *p*-values. $\leftarrow$ denotes a uni-directional causality.

As reported above in Table 7, the results provide evidence of bidirectional relationship between electricity consumption and economic growth for the period considered for study. For Turkey, increases in economic growth raises electricity consumption and increasing electricity consumption increases economic growth. Additionally, using Granger causality test, financial development is found have causal relationship with electricity consumption and economic growth in Turkey.

4. CONCLUSION

This present paper investigated the relationship between economic growth and electricity consumption by incorporating financial development (domestic credit provided by banking sector) and exports. The time span of the study is 1970-2011 using times series data for the Turkish economy. In this study, the traditional and structural break unit root tests were applied before determining the integrating properties of the variables. Cointegration between the variables was tested using the ARDL bounds testing technique. The causality relationship between variable was, on the other hand, investigated using a Toda Yamamoto Granger causality test.

The findings on cointegration established that economic growth, electricity consumption, financial development and exports are cointegrated in the long-run. Basing on this result, the study found the presence of feedback effect between electricity consumption and economic growth. Financial development was found to create a significant increase in both economic growth and electricity consumption in Turkey. Our finding is consistent with Kouakou (2011); Gurgul and Lach (2011); Hu and Lin (2013); Nazlioglu (2014). As a policy implication, Turkey should diversify energy supply and increase the share of renewable energy sources in energy consumption by considering their high reliance on electricity.

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