International Journal of Energy Economics and Policy
Vol. 3, Special Issue, 2013, pp.41-51
ISSN: 2146-4553
www.econjournals.com

Multivariate Granger Causality between Electricity Generation, Exports, Prices and Economic Growth in Turkey

Halil Altıntas
Erciyes University, Faculty of Economics and Administrative Sciences,
Turkey. Email: haltintas@erciyes.edu.tr

Melike Kum
Erciyes University, Faculty of Economics and Administrative Sciences, Turkey.
Tel: +90 352 076666/30455. Email: mkum@erciyes.edu.tr

ABSTRACT: This study is the first employing annual data for Turkey from 1970 to 2010 to examine the short and long-run causal relationship between economic growth, electricity generation, exports and prices in a multivariate model. According to the bounds test results, when electricity generation and economic growth are the dependent variable there are two cointegrating relationships. According to the results, long-run equilibrium relationship and long-term causality are found between economic growth, electricity generation, export and price. Hence, in the short-run, there are bi-directional causalities between economic growth- electricity generation, economic growth-export and electricity generation-export with feedback effect.

Keywords: Electricity generation; economic growth; bounds testing; Granger causality; Turkey.
JEL Classifications: O4; Q4

1. Introduction

Turkey has seen the fastest growth in energy demand in the OECD over the last two years. According to the International Energy Agency (IEA), energy use in Turkey is expected to double over the next decade, while electricity demand growth is expected to increase at an even faster pace. Turkey's energy use is still relatively low, although it is increasing at a very fast pace. Turkey's total electricity generating capacity was 49.5 million kilowatts in 2010. Total net electricity generation amounted to 217 billion kilowatt-hours in 2011. Turkey's electricity demand has seen a 70-percent increase between 2001 and 2010, with much of the growth occurring between 2002 and 2008. Although demand fell in 2009 compared with the previous year because of the economic slowdown, in 2010 consumption increased by about 10 percent compared with the previous year (EIA, 2013).

The relationship between energy consumption and economic growth has been much studied using the concept of Granger causality. But, Diebold (2004) mentioned that there is a lack of consensus in the literature about predicting the causality between X and Y in the Granger causality framework. Diebold claim that Granger causality does not imply: "X causes Y". It means; "X contains useful information for predicting Y". According to Diebold, the reason for the lack of consensus is that many Granger causality tests suffer from omitted variables bias. At this point, studies applying Granger causality tests in a bivariate framework are likely to be biased due to omission of relevant variables. So, some of the studies examining the relationship between energy consumption and economic growth have started to add the other relevant variables such as capital and/ or labour, employment, exports, pollutant emissions, prices and urbanization (Lean and Smyth, 2010: 3640). Most of the studies employing a bivariate framework about energy-GDP nexus for Turkey also suffer from omitted variables bias. Therefore, it is important to reexamine the relationship between energy and economic growth in Turkey including other relevant variables in the Granger causality framework.

There are a lot of studies examining the relationship between electricity consumption and economic growth. But, the causal relationship between electricity generation and economic growth has been rarely investigated in the literature. The World Bank reported that non-technical transmission and distribution (T&D) losses in developing countries are two to four times higher than in OECD countries. Electricity generation rather than consumption is also used in this study because T&D losses are around 15 per cent in Turkey which is very high compared to other countries. The aim of this paper is to examine the short and long-run causal relationship between economic growth, electricity generation, exports and prices in a multivariate model for Turkey for the period 1970-2011. The rest of the paper has the following structure: Section 2 extends the literature review; Section 3 explains the hypotheses used in the study. Section 4 presents the methodological framework. Section 5 analyzes data, methodology and empirical results and Section 6 presents the conclusion and some policy recommendations.

2. Review of Literature

The topic of causal relationship between energy consumption and growth has been well-studied in the energy economics literature. This relationship firstly examined by a study of Kraft and Kraft (1978). To date, several studies have attempted to establish the relationship between energy consumption and economic growth. As Ozturk (2010) mentioned, a conclusion of all these studies is that there is no consensus in the literature about the results. The causal relationship between energy consumption (electricity consumption) and economic growth can be tested by four types of hypotheses. These are neutrality, conservation, growth and feedback hypotheses. Some important studies testing these hypotheses are Altınay and Karagöl (2005), Soytas and Sarı (2007), Apergis and Payne (2009), Narayan and Popp (2012). However, the causal relationship between electricity generation and economic growth has been newly investigated in the literature. Yoo and Kim (2006) is the first study examining this relationship for Indonesia for the period of 1971-2002. The authors found causality from economic growth to electricity generation.

Ghosh (2009) examines this relationship for India for the period of 1970-2006. Author prefers and uses a multivariate approach because of specification bias due to omission of relevant variables. This study includes a variable for employment along with electricity supply and GDP. Author finds out unidirectional short term causality from economic growth to electricity supply. Later on, Sarker and Alam (2010) extended Yoo and Kim's study by examining the nexus between electricity generation and economic growth for Bangladesh. Bayraktutan et al., (2011) also analyzes the relationship between electricity generation from renewable resources and economic growth in OECD countries for the period of 1980-2007. The results indicate that there is a long term positive relationship between renewable electricity generation and economic growth, and bidirectional causality between these variables. But, Lean and Smyth (2010) is the first study contributing to the literature through considering electricity generation, economic growth, exports and prices in a multivariate model for Malaysia.

3. Hypotheses

Four sets of hypotheses are examined during the study. The first set of hypothesis concerns the relationship between electricity generation and GDP. These are the conservation, neutrality, growth and feedback hypotheses. These hypotheses have important policy implications. If there is unidirectional Granger causality running from GDP to electricity generation (conservation hypotheses) or no Granger causality in either direction (neutrality hypotheses), it means that energy conservation policies have little or no adverse effect on economic growth. If unidirectional Granger causality runs from electricity generation to GDP (growth hypotheses), reducing electricity generation will also decrease the income. So, increases in electricity generation contribute to economic growth. If also there is a bidirectional Granger causality between these variables (feedback hypotheses) reducing electricity generation still negatively affects economic growth but it is a complementarily effect and the same policies as growth hypothesis should be applied to avoid negative impact on economic growth. The second set of hypotheses is about the causal relationship between exports and GDP. According to this relationship Granger causality runs from exports to GDP. As we know, exports increase GDP because exports are a component of GDP in national accounting. The third set of hypotheses concerns the relationship between exports and electricity generation. If unidirectional Granger causality runs from electricity generation to exports it means that reducing electricity generation could impede attempts to expand exports as an engine of economic growth. But, if the Granger causality runs from exports to electricity generation or no Granger causality running in either direction, energy conservation policies can be expected to have no adverse effect on export growth. The last set of hypotheses is about the relationship between prices and electricity generation, economic growth and exports. Hereunder, an increase in prices will lead to an increase in electricity generation while an increase in electricity generation will result in a fall in prices. According to Friedman (1977), higher mean inflation increases inflation volatility and that higher inflation volatility reduces the rate of economic growth. Also, Devereux (1989) shows that an increase in uncertainty about real output reduces the optimal level of wage indexation and induces the Central Bank to engineer more inflation surprises in order to obtain favourable real effects. Thus, uncertainty surrounding real output has a positive effect on the average inflation rate. Finally, the exports will fall if an increase in prices make domestically produced goods less competitive relative to the goods produced overseas (Lean and Smyth, 2010: 3642-3643, Yoo and Kim, 2006: 2890-2891).

In this study, several hypotheses concerning the Granger causality relationship between electricity generation and GDP, exports and GDP, electricity generation and exports, electricity generation and prices, exports and prices and GDP and prices are tested.

4. Methodological Framework

In this study, the relationship between economic growth, electricity generation, exports and prices is examined by a three stage approach. Firstly, the order of integration of the variables searched using unit root test. Once the order of integration is determined, we test if there is a cointegration relationship between the variables with in an autoregressive distributed lags model. Finally, we test whether there is a causal relationship between economic growth, electricity generation, exports and prices.

4.1 Unit Root Test

We firstly employ the unit root tests to ascertain the order of integration for each series. Apart from using the conventional unit root tests e.g., Augmented Dickey-Fuller (ADF, 1979, 1981) and Phillips and Perron (PP, 1988), we also employ the Zivot and Andrews (ZA, 1992) unit root tests with one structural break respectively. Perron (1989) demonstrated that the standard unit root tests can lead to false acceptance of a unit root null hypothesis when the series is confronted with structural break(s). Moreover, the sample period of our study (1970-2010) covers a number of shocks and crises, especially the 1973 oil price shock, the 1997 Asian financial crisis, the 1994, 2000 and 2001 Turkey' financial crises. We expect that these major shocks have significant impact to economic growth and electricity generation in Turkey. Hence, application of Zivot and Andrews (1992, hereafter ZA) unit root tests with structural breaks is essential.

However, these tests can yield misleading results when the data series exhibits socks. Therefore, we performed the ZA test in our analysis, as it treats the selection of the break points as the outcome of an estimation procedure. ZA tests consider one unknown structural break with a deterministic trend. We present two versions of the ZA test for one structural break which is the most restrictive. The first one is model A, which allows for a structural break in the intercept and the second one is model C, which allows for a structural break in the intercept and slope. The model A and model C have the following specification:

Model A: $$\Delta y_t = \kappa + \varphi y_{t-1} + \beta t + \theta_1 DU_t + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \quad (1)$$

Model C: $$\Delta y_t = \kappa + \varphi y_{t-1} + \beta t + \theta_1 DU_t + \gamma_1 DT_t + \sum_{j=1}^{k} d_j \Delta y_{t-j} + \varepsilon_t \quad (2)$$

Where Δ is the first difference operator, the residuals ε_t are assumed to be normally distributed and white noise. The incorporated Δy_{t-i} terms on the right-hand side of equation (1) and (2) are to remove the serial correlation if any. Eventually, DU_t is the dummy variable for structural break in the intercept occurring at time TB_t and DT_t is the dummy variable for trend shift, where

$$DU_t = \begin{cases} 1 & \text{if} \quad t>TB \\ 0 & \text{otherwise} \end{cases}$$

and

$$DT_t = \begin{cases} t-TB & \text{if} \quad t>TB \\ 0 & \text{otherwise} \end{cases}$$

The optimal lag length (k) is selected using the "t-significant" method and the potential breakpoint (TB) is chosen where the ADF t-statistics is maximized in the absolute term.

4.2. Cointegration Test

In this stage, the bounds test is used to examine the existence of a long-run equilibrium relationship between electricity generation, real income and export and prices. The bounds testing approach is involved to cointegration to investigate the long run equilibrium relationship between electricity generated, real GDP per capita, exports and the inflation within the autoregressive distributed lag (ARDL) model. Numerous cointegration approaches are available in empirical literature to test cointegration between the series but the ARDL bounds testing is considered to be superior and preferable due to its various advantages. For instance, order of integration of the series does not matter for applying the ARDL bounds testing if no variable is found to be stationary at I(2). The ARDL bounds testing approach of cointegration is developed by Pesaran and Shin (1999) and Pesaran et al. (2001). The ARDL cointegration approach has numerous advantages in comparison with other cointegration methods such as Engle and Granger (1987), Johansen (1988), and Johansen and Juselius (1990) procedures: (i) no need for all the variables in the system be of equal order of integration, (ii) it is efficient estimator even if samples are small and some of the regressors are endogenous, (iii) it allows that the variables may have different optimal lags, and (iv) it employs a single reduced form equation. Pattichis (1999) stated that the ARDL cointegration test tend to have better statistical properties because it does not push the short run dynamic into the disturbance terms as in the case of Engle and Granger (1987) two-step cointegration approach. Furthermore, the bounds testing approach has superior properties in finite sample (Narayan and Narayan, 2005; Narayan and Smyth, 2006). Apart from that, the bounds testing approach is applicable irrespective of whether the underlying variables are purely I(0), purely I(1), or mutually cointegrated. To examine the long run relationship with bounds testing approach, we estimate the following ARDL model.

The ARDL method proposed by Pesaran et al.(2001) involves investigating the existence of a long-run relationship using the following unrestricted error correction model (UECM):

$$\begin{aligned}\Delta LEG_t = a + \sum_{i=1}^{k}\alpha_i \Delta LEG_{t-i} + \sum_{i=0}^{l}\beta_i \Delta LPCY_{t-i} + \sum_{i=0}^{m}\delta_i \Delta LXY_{t-i} + \sum_{i=0}^{m}\phi_i \Delta P_{t-i} \\ + \theta_1 LEG_{t-1} + \theta_2 LPCY_{t-1} + \theta_3 LXY_{t-1} + \theta_4 P_{t-1} + \varepsilon_t\end{aligned} \tag{3}$$

$$\begin{aligned}\Delta LPCY_t = a + \sum_{i=1}^{k}\beta_i \Delta LPCY_{t-i} + \sum_{i=0}^{l}\alpha_i \Delta LEG_{t-i} + \sum_{i=0}^{m}\delta_i \Delta LXY_{t-i} + \sum_{i=0}^{m}\phi_i \Delta P_{t-i} \\ + \theta_1 LEG_{t-1} + \theta_2 LPCY_{t-1} + \theta_3 LXY_{t-1} + \theta_4 P_{t-1} + \varepsilon_t\end{aligned} \tag{4}$$

$$\begin{aligned}\Delta LXY_t = a + \sum_{i=1}^{k}\delta_i \Delta LXY_{t-i} + \sum_{i=0}^{l}\beta_i \Delta LPCY_{t-i} + \sum_{i=0}^{m}\alpha_i \Delta LEG_{t-i} + \sum_{i=0}^{m}\phi_i \Delta P_{t-i} \\ + \theta_1 LEG_{t-1}\theta_2 LPCY_{t-1} + \theta_3 LXY_{t-1} + \theta_4 P_{t-1} + \varepsilon_t\end{aligned} \tag{5}$$

$$\begin{aligned}\Delta P_t = a + \sum_{i=1}^{k}\phi_i \Delta P_{t-i} + \sum_{i=0}^{l}\beta_i \Delta LPCY_{t-i} + \sum_{i=0}^{m}\alpha_i \Delta LEG_{t-i} + \sum_{i=0}^{m}\delta_i \Delta LXY_{t-i} \\ + \theta_1 LEG_{t-1} + \theta_2 LPCY_{t-1} + \theta_3 LXY_{t-1} + \theta_4 P_{t-1} + \varepsilon_t\end{aligned} \tag{6}$$

Where Δ is the first difference operator, LEG is the log of electricity generated per capita, LPCY is the log of real GDP per capita, LXY is the log of total export as a percentage of GDP and P is annual percent change in the consumer price index. The F- test is used to determine whether a long-run relationship exists between the variables through testing the significance of the lagged levels of the variables. We set $H_0: \theta_1 = \theta_2 = \theta_3 = \theta_4 = 0$ versus $H_0: \theta_1 \neq \theta_2 \neq \theta_3 \neq \theta_4 \neq 0$. The computed F-statistics under the null hypothesis of no long-run relationship are denoted as F(LEG|LPCY,LXY,P), F(LPCY|LEG,LXY,P), F(LXY|LPCY,LEG,P), F(P|LPCY,LEG,LXY) for each equation respectively. With small sample sizes the relevant critical values potentially deviate substantially from the critical values reported in Pesaran et al. (2001). Hence, we use the small sample critical values provided by Narayan (2005). If the computed F-statistics exceeds the respective upper critical bounds value, we are able to conclude that the variables are cointegrated. If the F-statistics fall below the respective lower critical bounds, we fail to reject the null hypothesis of no cointegration. If the F-statistics fall between its upper and lower critical bounds values, the inference is inconclusive and it is necessary to know the order of integration of the variable to reach a conclusion

4.3. Granger Causality

The analysis of Granger causality will involve the process of examining the stationarity of the time series and verifying the order of co-integration by using the Engle-Granger test. In order to conduct the Engle-Granger test, the series of variables are required to be stationary. This is done by testing for unit root test by using ADF and PP tests at level I(0). If we failed to reject the null hypothesis $\left[H_o : Y_t \sim I(0)\right]$, we have to proceed with stationarity test at first difference I(1) (Studenmund, 2006). When cointegration exists among the variables, the causal relationship should be modeled within a dynamic error correction model (Engle and Granger, 1987; Granger, 1988).

If evidence for cointegration is found, then there must be Granger causality in at least one direction, but the cointegration analysis does not indicate the direction of temporal causality between the underlying variables. Inferring causal relations among variables if the cointegration analysis does not yield conclusive results can be carried out with a vector autoregressive (VAR) model by using the conventional first difference forms proposed by Engle and Granger (1987). Since the Granger representation theorem relates cointegration to error correction models and provided time series are cointegrated, the short-term disequilibrium relationship between them can be expressed in the error correction form. When cointegration among the variables in the underlying model is detected, the Granger causality analysis can be augmented with a lagged error correction term and the causality tests can be carried out under the vector error correction model (VECM) representation, which is capable to capture short-run deviations from its long-run equilibrium path through the error correction mechanism. If evidence for a long-run relationship among the variables is found, the multivariate Granger causality model between LEG, LPCY, LXY and P based on the ECM is specified as follow:

$$\Delta LEG_t = \theta_1 + \sum_{i=1}^{n} \alpha_{11}(i)\Delta LEG_{t-i} + \sum_{i=1}^{n} \varphi_{12}(i)\Delta LPCY_{t-i} + \sum_{i=1}^{n} \phi_{13}(i)\Delta LXY_{t-i} + \sum_{i=1}^{n} \beta_{14}(i)\Delta P_{t-i} + \psi_1 ECT_{t-1} + \varepsilon_{1t} \tag{7}$$

$$\Delta LPCY_t = \theta_2 + \sum_{i=1}^{n} \alpha_{21}(i)\Delta LPCY_{t-i} + \sum_{i=1}^{n} \varphi_{22}(i)\Delta LEG_{t-i} + \sum_{i=1}^{n} \phi_{23}(i)\Delta LXY_{t-i} + \sum_{i=1}^{n} \beta_{24}(i) LP_{t-i} + \psi_2 ECT_{t-1} + \varepsilon_{2t} \tag{8}$$

$$\Delta LXY_t = \theta_3 + \sum_{i=1}^{n} \alpha_{31}(i)\Delta LXY_{t-i} + \sum_{i=1}^{n} \varphi_{32}(i)\Delta LEG_{t-i} + \sum_{i=1}^{n} \phi_{33}(i)\Delta LPCY_{t-i} + \sum_{i=1}^{n} \beta_{34}(i) LP_{t-i} + \psi_3 ECT_{t-1} + \varepsilon_{3t} \tag{9}$$

$$\Delta P_t = \theta_4 + \sum_{i=1}^{n} \alpha_{41}(i)\Delta P_{t-i} + \sum_{i=1}^{n} \varphi_{42}(i)\Delta LEG_{t-i} + \sum_{i=1}^{n} \phi_{43}(i)\Delta LPCY_{t-i} + + \sum_{i=1}^{n} \beta_{34}(i) LXY_{t-i} + \psi_4 ECT_{t-1} + \varepsilon_{4t} \tag{10}$$

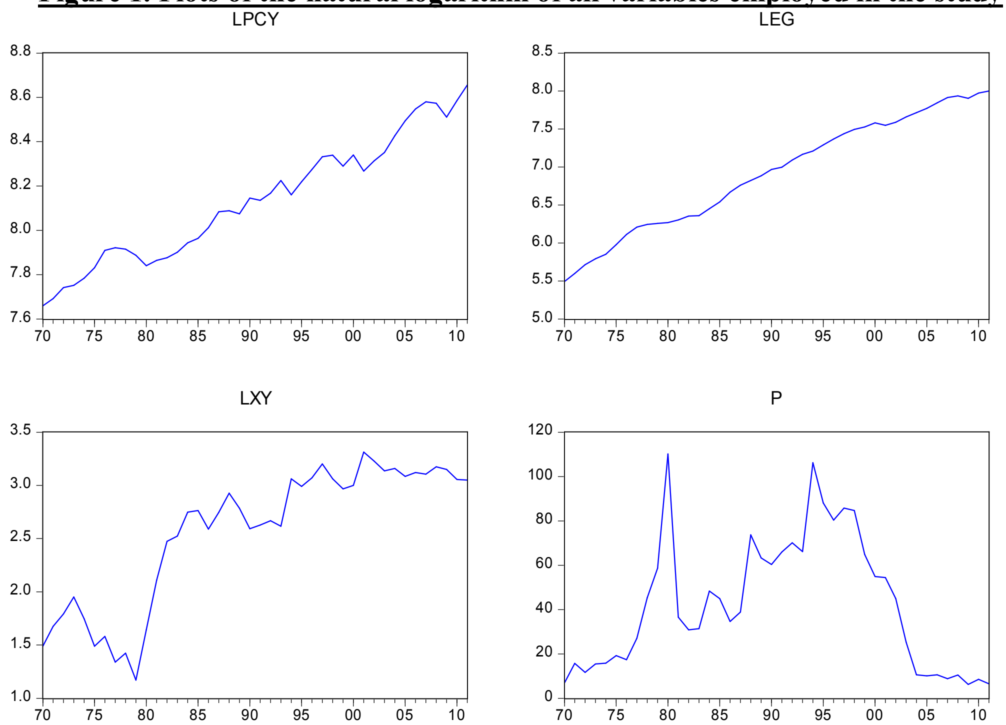
where Δ is the backward shift operator and ECT_{t-1} is error- correction term, the one period lagged error-correction term obtained from the cointegrating equation. This term is included if the variables in the underlying model are cointegrated. This term is included if the variables in the underlying model are cointegrated. The appropriate lag order n is chosen with Akaike information criterion because of its superior properties in small samples. The speed of adjustment to long-run equilibrium, in the context of cointegrated vector autoregressive processes, can be expressed in terms of years by taking the reciprocal of the estimated absolute value of the error correction coefficient. $\alpha, \varphi, \phi, \beta$ and β 's are parameters to be estimated and ε_t 's are the serially uncorrelated error terms. The F-statistics on the lagged explanatory variables of the ECM indicates the significance of the short-run causal effects. The t-statistics on the coefficients of the lagged error-correction term indicates the significance of the long-run causal effect.

5. Data and Econometric Results

5.1. Data

The study employs annual time series data for Turkey from 1970 to 2010 which are taken World Development Indicator database of World Bank. The study uses real GDP per capita (in 2000 constant prices), electricity generation per capita (dividing total electricity generation over annual population), export (dividing total export over gross domestic product) and inflation rate (calculated annual percent change in consumer price index (2005=100). Time series plots for all variables employed in the study are demonstrated in Figure.1

Figure 1. Plots of the natural logarithm of all variables employed in the study



5.2. Unit Root Test Results

Before proceeding with estimating ARDL bound test for cointegration procedure, we need to conduct unit root tests namely augmented Dickey and Fuller (1979) (ADF), Phillips and Perron (1988) (PP), Kwiatkowski, Phillips, Schmidt, and Shin (1992) (KPSS). The time series properties of the variables are checked through ADF, PP and KPSS unit root tests. All of the series appear to contain a unit root in their levels but are stationary in their first difference, indicating that they are integrated at order one i.e., I(1).

Table 1. Unit Root Test Results

	ADF		PP		KPSS	
	Level	First difference	Level	First difference	Level	First difference
LPCY	-0.934(0)	-6.194(0)^{a}	-0.121(3)	-6.190(3)^{a}	141.89(0)^{a}	0.047(0)
LEG	-1.834(1)	-4.089(0)^{a}	-2.566(1)	-4.086(0)^{a}	56.21(2)^{a}	0.726(0)
LXY	-1.527(0)	-5.618(0)^{a}	-1.544(1)	-5.918(0)^{a}	39.31(2)^{a}	0.126(0)
P	-2.078(0)	-4.313(2)^{a}	-2.003(1)	-7.696(5)^{a}	1.936(0)^{a}	0.151(0)

*Note: All variables except prices (P) in natural logs. Lag length for ADF test is decided based on AIC and are in the parentheses. The maximum number of lags for ADF test is set to be nine. Maximum bandwidth for PP test is decided based on Newey–West Barlett kernel method. For both ADF and PP tests, the critical values of McKinnon are used to test the unit root hypothesis. According to McKinnon's (1991) critical values, ^{a}, and ^{b} indicate that the non-stationary hypothesis is rejected at the 1 and 5 percent respectively. AR spectral-GLS detrended is used as the spectral estimation method. Bandwidth is selected using AIC method. The null hypothesis of for KPSS are stationary

Tablo 2: Zivot - Andrews Unit Root Test

	LPCY		LEG		LXY		P	
Model	A	C	A	C	A	C	A	C
TB	1979	1979	1986	1995	1980	1980	2002	1994
ϕ	-0.164 (-3.649)	-0.534 (-3.837)	-0.229 (-3.080)	-0.355 (-3.64)	-0.452 (-4.357)	-0.409 (-4.798)	-0.487 (-3.657)	-0.695 (-4.584)
θ	-0.21*** (-4.178)	-0.075** (-2.401)	0.062*** (2.827)	0.035 (1.641)	0.481*** (4.348)	0.682*** (6.371)	-39.303*** (-2.554)	21.861* (1.976)
γ	-	-0.004 (-0.719)	-	-0.008*** (-3.091)	-	0.061*** (3.433)	-	-6.114*** (-3.936)
k	0	0	1	1	0	0	0	0
Exact critical values for t_{ϕ}								
1%	-5.43	-5.57	-5.43	-5.57	-5.43	-5.57	-5.43	-5.57
5%	-4.80	-5.08	-4.80	-5.08	-4.80	-5.08	-4.80	-5.08

Notes: ***, ** and * denotes statistical significance at the 1%, 5% and 10 level, respectively, The critical values for the 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 as described in the text.

The results of the Zivot and Andrews (1992) model A and model C unit root tests and corresponding exact critical values are reported in Table 2. They find no additional evidence against the unit root hypothesis relative to the unit root tests without a structural break. The break dates are statistically significant for model A in each case. With real GDP per capita only the break in the slope of the trend is not statistically significant in model C and either the break in the intercept or slope is statistically significant in model C for electricity generation, export and price. Statistically significant breaks are 1979 (real GDP per capita), 1986 and 1995 (electricity generation), 1980 (export), 1994 and 2002 (consumer prices) In each case we are unable to reject the unit root null hypothesis at the 5 % level or better, confirming that the series are I(1).

5.3. Bound Tests for Cointegration

The calculated F-statistics for the cointegration test is displayed in Table 3. The critical value is reported also in Table 3 based on the critical value suggested by Narayan (2005) using a small sample size between 30 and 80.

The results of the bounds test for cointegration are reported in Table 3. The bounds test indicates that cointegration is present when LEG and LPCY are the dependent variables. Because, when the electricity generation is dependent, FLEG(LEG|LPCY,LXY,P), the calculated F-statistic (4.788) is higher than the upper bound critical value at the 5% level of significance using restricted intercept and no trend. Also, when the real GDP per capita is dependent, FLCPY(LCPY|LEG,LXY,P), the calculated F-statistic (6.357) is higher than the upper bound critical values at 1% level of significance. However, the bounds tests indicates that when export [FLXY(LXY|LEG,LPCY,P)] and prices [FP(P|LEG,LPCY,LXY)] are the dependent variables, the calculated F-statistic are lower than the lower bound critical value at the 5% level. Therefore, there is no cointegration when these variables are treated as the dependent variable. This implies that there is only two cointegrating relationship when LEG and LPCY has been considered as a dependent variable.

Table 3. Bounds *F*-tests for Cointegration

Equation No	Function	Without a time trend		With a time trend	
Model 3	$F_{LEG}(LEG\|LCPY,LXY,P)$	4.788^{**}		2.823	
Model 4	$F_{LPCY}(LCPY\|LEG,,LXY,P)$	6.357^{***}		5.206^{**}	
Model 5	$F_{LXY}(LXY\|LEG,LPCY,P)$	1.613		3.060	
Model 6	$F_{P}(P\|LEG,LPCY,LXY)$	1.799		4.321	
	F-Critical values at:	I(0)	I(1)	I(0)	I(1)
	1% level	4.983	6.423	5.150	6.280
	5 % level	3.535	4.733	3.822	4.714
*Note: *** and** denote significant levels at 5% and 1% respectively. Optimal lag selected by AIC. Critical values are taken from Narayan (2005: 1988-1989) for k=3 and n=45.					

5.4. Results of Granger Causality Test

Confirming the existence of cointegration among real GDP per capita, electricity generation, export and prices implies the existence of Granger causality, at least in one direction. However, it does not show the direction of temporal causal relationship among the variables. Hence, to detect to the direction of causality, we examined short-run and long-run Granger causality within the error correction mechanism (ECM). Results of the estimated Granger causality test are presented in Table 4.

Table 4. Results of Granger Causality *F*-tests

Dependent variable	***Source of causation (independent variables)***				
	Short-run				**Long-run**
	ΔLEG	$\Delta LPCY$	ΔLXY	ΔP	ECT_{t-1} (t-statistics)
ΔLEG	-	13.299^{a} (0.009)	9.787^{b} (0.020)	13.385^{a} (0.001)	0.044 (0.685)
$\Delta LPCY$	14.395^{a} (0.000)	-	8.959^{b} (0.029)	2.552^{c} (0.064)	-0.852^{a} (0.001)
ΔLXY	9.748^{b} (0.044)	10.849^{b} (0.0283)	-	5.396 (0.249)	-
ΔP	0.260 (0.610)	2.279 (0.516)	5.898 (0.116)	-	-

Notes: F-statistics reported with respect to short-run changes in the independent variables. The sum of the lagged coefficients for the respective short-run changes is denoted in parentheses. *ECT* represents the coefficient of the error correction term. Probability values are in brackets and reported underneath the corresponding partial F-statistic and sum of the lagged coefficients, respectively. Significance at the 1%, 5%, and 10% levels are denoted by "a", "b", and "c"

The F-statistics on the lagged explanatory variables of the ECM indicates the significance of the short-run causal effects. The t-statistics on the coefficients of the lagged error-correction term (ECT) indicates the significance of the long-run causal effect. Beginning with the short-run effects, real GDP per capita, prices and export are significant at the 1% and %5 levels in the electricity generation equation, respectively. Electricity generation, export and prices are statistically significant in the real GDP per capita equation. Real GDP per capita, price and electricity generation are significant at the 5% level in export equation. None of the variables are significant in the price equation as well. This suggests that in the short-run there are strong bi-directional Granger causalities between real GDP per capita – electricity generation, real GDP per capita – export, export – electricity generation. Also there are unidirectional Granger causalities from price to electricity generation and price to real GDP per capita.

Since all the variables in Model 4 were cointegrated, the causality relationship can be examined by VECM. t-statistic on the coefficient of the lagged error-correction term (ECT), with the exception of electricity generation equation, the lagged error-correction term is significant in the real GDP per capita equation at the 1% level, which confirms the result of the bounds test for cointegration. It is not included a lagged error correction term when export and price are the dependent variable because the variables are not cointegrated. The results indicated that price, export and electricity generation have a significant effect to real GDP per capita in the long run at %1 significance level.

6. Conclusions and Policy Implications

This study has employed annual data for Turkey from 1970 to 2010 to examine the causal relationship between economic growth, electricity generation, exports and prices in a multivariate model. The first finding of the study is that there is a bidirectional Granger causality running from economic growth to electricity generation. This finding supports feedback hypotheses for Turkey. The manufacturing sector is a major consumer of electricity in Turkey. So, reducing electricity generation negatively affects economic growth. Also, an increase for the demand of electronic gadgets due to the increase in disposable income will result an increase for the electricity generation. Countries should implement policies aiming at increasing electricity generation in order to meet increasing electricity demand. In order to avoid any adverse effects of electricity shortage on economic activities, it is urgent for Turkey to plan and build new power generating capacity to satisfy the increasing demand for electricity. The second finding is that there is a bidirectional Granger causality running from growth to export. This can be explained by the export-led theories. In general, exports increase GDP because exports are a component of GDP in national accounting. The third finding is that there is again bidirectional causality between export and electricity generation. According to this result, reducing electricity generation could impede attempts to expand exports as an engine of economic growth. Energy conservation policies can have adverse effect on export growth. The fourth finding is that there is a unidirectional Granger causality running from prices to electricity generation. According to this result, an increase in prices will lead to an increase in electricity generation (movement along the supply curve); while an increase in electricity generation will result in a fall in prices (shift the supply curve). The last finding is that there is a unidirectional Granger causality running from prices to growth. So, according to Friedman, higher mean inflation increases inflation volatility and that higher inflation volatility reduces the rate of economic growth.

According to the US Energy Information Administration (EIA, 2013), Turkey's importance in the energy markets is growing both as a regional energy transit hub and as a growing consumer. Over the last few years Turkey's energy demand has increased rapidly and likely will continue to grow in the future. According to the report, energy use in Turkey is expected to double over the next decade, while electricity demand growth is expected to increase at an even faster pace. Large investments in natural gas and electricity infrastructure will be essential because meeting this level of growth will require significant investment in the energy sector. Following the restructuring of the electricity sector, both consumption and generation of electricity have expanded. Most of the electricity is generated with conventional thermal sources, although the government plans to displace at least some of this generation with nuclear power.

References

Altınay, G., Karagöl, E. (2005). Electricity Consumption and Economic Growth: Evidence from Turkey. Energy Economics, 27, 849-856.

Apergis, N., Payne, J.E. (2009). Renewable Energy Consumption and Economic Growth: Evidence from a Panel of OECD Countries. Energy Policy, 38(1), 656-660.

Bayraktutan, Y., Yılgör, M., Uçak, S. (2011). Renewable Electricity Generation and Economic Growth: Panel-Data Analysis for OECD Members. International Research Journal of Finance and Economics, EuroJournals Publishing, 59-66.

Devereux, M. (1989). A Positive Theory of Inflation and Inflation Variance. Economic Inquiry, 27, 105-116.

Diebold, F. (2004). Elements of Forecasting. Ohio: Thompson Learning.

Dickey, D.A., Fuller, W.A. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root. Journal of the American Statistical Society, 74, 427–431.

Dickey, D.A., Fuller, W.A. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. Econometrica, 49(4), 1057–72.

EIA (2013), Turkey Report. http://www.eia.gov/countries/analysisbriefs/Turkey/turkey.pdf, Access Date: 21.03.2013.

Engle, R.F., Granger, C.W.J. (1987). Co-integration and Error Correction: Representation, Estimation and testing, Econometrica, 55, 251–76.

Friedman, M. (1977). Nobel Lecture: Inflation and Unemployment. Journal of Political Economy, 85, 451-472.

Ghosh, S. (2009). Electricity Supply, Employment and Real GDP in India: Evidence from Cointegration and Granger-Causality Tests. Energy Policy, 37(8), 2926-2929.

Johansen, S. (1988). Statistical Analysis of Cointegration Vectors. Journal of Economic Dynamics and Control, 12, 231-254.

Johansen, S., Juselius, K. (1990). Maximum Likelihood Estimation and Inference on Cointegration – with Applications to the Demand for Money. Oxford Bulletin of Economics and Statistics, 52, 169-210.

Kraft, J., Kraft, A. (1978). On the Relationship between Energy and GNP. Journal of Energy and Development, 3, 401-403.

Kwiatkowski, D., P.C.B. Phillips, P. Schmidt & Y. Shin (1992). Testing the Null Hypothesis of Stationarity against the Alternative of a Unit Root, Journal of Econometrics, 54, 159-178.

Lean, H.H., Smyth, R. (2010). Multivariate Granger Causality between Electricity Generation, Exports, Prices and GDP in Malaysia. Energy, 35, 3640-3648.

Mackinnon, J.G. (1991). Critical Values for Cointegration Tests, in Engle, R.F. & Granger, C. W. J (eds.), Long-run Economic Relationships, Oxford University Press, Oxford.

Narayan, P.K. (2005). The Saving and Investment Nexus for China: Evidence from Cointegration Tests. Applied Economics, 37(17), 1979-1990.

Narayan, P.K., Narayan, S. (2005). Estimating Income and Price Elasticities of Imports for Fiji in a Cointegration Framework", Economic Modelling, 22(3), 423–438.

Narayan, P.K., Smyth, R. (2006). What Determines Migration Flows from Low Income to High Income Countries? An Empirical Investigation of Fiji-US Migration 1972-2001. Contemporary Economic Policy, 24(2), 332-342.

Narayan, P.K., Popp, S. (2012). The Energy Consumption-real GDP Nexus Revisited: Empirical Evidence from 93 Countries. Economic Modelling, 29, 303-308.

Ozturk, I. (2010). A Literature Survey on Energy-Growth Nexus. Energy Policy, 38, 340-349.

Pattichis, C.A. (1999). Price and Income Elasticities of Disaggregated Import Demand: Results from UECMs and an Application. Applied Economics, 31(9), 1061-1071.

Peron, P. (1989). The Great Crash, the Oil Price Shock and the Unit Root Hypothesis. Econometrica, 57, 1361-1401.

Pesaran M.H., Shin, Y. (1999). An Autoregressive Distributed-led Modelling Approach to Cointegration Analysis. In: Strom S, editor. Econometrics and economic theory in the 20th century the ragnar frisch centennial symposium. Cambridge: Cambridge University Press; 1999.

Pesaran, M.H., Shin, Y., Smith, R.J. (2001). Bounds Testing Approach to the Level Relationship. Journal of Applied Econometrics, 16, 289–326.

Phillips, P.C.B., Perron, P. (1988). Testing for a Unit Root in Time Series Regression", Biometrika, 75, 335–346.

Sarker, A.R., Alam, K. (2010). Nexus between Electricity Generation and Economic Growth in Bangladesh. Asian Social Science, 6(12), 16-22.

Soytaş, U., Sarı, R. (2007). The Relationship between Energy and Production: Evidence from Turkish Manifacturing Industry. Energy Economics, 29(6), 1151-1165.

Studenmund, A.H. (2006). Using Econometrics: A Practical Guide, 5th Edition, Pearson International Edition. US.

Yoo, S., Kim, Y. (2006). Electricity Generation and Economic Growth in Indonesia. Energy, 31, 2890-2889.

Zivot, E., Andrews, D. W. K. (1992). Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis. Journal of Business & Economic Statistics, 10(3), 251-270.