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THE RELATIONSHIP BETWEEN ELECTRICITY CONSUMPTION, ELECTRICITY PRICE AND ECONOMIC GROWTH IN TURKEY: 1984-2007 [**]

The experience of economic development and industrialization of countries has revealed the increasing importance of the energy factor, which is a basic production input in the production process. Empirical studies have shown that a positive causality relation exists between the energy consumption and economic growth performance of countries. Another variable the effects of which need to be studied alongside the relation between these two variables, is energy price. In this study, the Granger causality between energy price, energy consumption and economic growth of Turkey is examined for the 1987-2007 period using a VAR model and quarterly data. The results indicate that a bidirectional causality relation appears to exist between electricity consumption and GDP, and that there is a causality relation that runs from real GDP to electricity price.

Keywords: Energy Consumption, Energy Price, Economic Growth
JEL Classification Codes: O40, Q48, Q43, Q41, Q40

INTRODUCTION

Energy is one of the basic production inputs and is very important in terms of socio-economic, fiscal and strategic issues for countries. These features of energy distinguish it from other markets and force countries to develop policies in this field. In terms of economic theory, market failures in the energy market form the economic rationale for the government intervention in this market (Helm 1991: 2). Externalities[1], natural monopoly[2], the influence of the time horizon on the choice of the energy

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[1] Externalities are some costs or benefits, not transmitted through prices, incurred by a party who did not agree to the action causing the cost or benefit.

[2] Natural monopoly is defined as an industry where the fixed cost of the capital goods is so high that it is not profitable for a second firm to enter and compete.

market, and income distribution are the foremost market failures in the energy market (Helm 1991: 2-5). Governments can use different instruments to improve the efficiency and equity consequences of the energy market. They can intervene in the market by using instruments such as public production units, regulation policies, taxes and subsidies.

The elements that determine the price of a commodity are fees, depreciation of capital, raw material costs and energy costs. Therefore, while public policies based on the above mentioned intervention instruments affect energy prices, energy as the basic input of industry directly affects the price of goods and services. As energy costs worldwide on average represent 8% of total costs, increases in energy prices, as a cost element, can be said to cause an increase in the prices of commodities (Thoresen 1981: 146). In sectors where energy input is high, such as the iron and steel sector, energy costs constitute approximately 15-20% of the total production costs. Thus, the effects of increases in energy prices are felt far more in these types of sectors than in others. When other cost elements are considered to be equal, it can be said that countries with relatively high energy prices have a competitive disadvantage, especially in sectors with high energy input. Therefore, energy price and energy tax policies implemented by countries for attaining certain economic, fiscal and social goals may negatively affect the country's competition power and, thus, its growth performance.

Because of the aforementioned imported influences of the energy factor on economic growth, countries carefully form their energy policies and market structures. Although differences in practice are observed among countries, energy markets have been controlled through state monopolies in many developing countries and historically in Europe (Helm 1988: 2). In Turkey in the 1980s, energy production was led by the state monopolies as in European countries. The period after 1980 can be seen as the time in which the state-controlled economy was replaced with a liberal economy. Compatible with the liberal policies followed by the government, public investments, including electricity investments, have been gradually cut to decrease the public share in the economy (Yılmaz and Uslu 2007:262). "In 1984, the monopoly of the Turkish Electricity Authority came to an end by a law. In 1993 the Turkish Electricity Authority was divided into two public companies named the Turkish Electricity Generation and Transmission Company (TEDAS) and the Turkish Electricity Distribution Company (TEAS) by decision of the Council of Ministers" (Yılmaz and Uslu 2007:262). In 2001, the Energy Market Regulatory Authority (EPDK) was established to regulate and supervise the energy market. Furthermore, in

2001, TEAŞ was divided into two public companies according to their production (EÜAŞ), and transmission (TEİAŞ) facilities. With these processes, the private sector's share in electricity production has grown and has reached nearly 42% of the total electricity production, while the public sector share has fallen to 48%. Yet, transmission and distribution facilities have been implemented under public ownership. Consequently, although the private sector holds a growing share in electricity production, there are public-weighted transmission and distribution facilities in Turkey. As a result of this structure, it can be said that the government has a control power over electricity prices. TEDAŞ, which is a public company, assesses electricity tariffs that are composed of retail sale, distribution, retail sale service and transmission tariffs, which are approved by the EPDK. After all government levies taxes (VAT, municipal tax) on electricity consumption, the total tax burden on electricity is approximately 20%. In addition to electricity, natural gas and crude oil import and pricing policies are controlled by state economic enterprises. The Petroleum Pipeline Corporation (BOTAŞ) still has monopoly rights on natural gas import, distribution, sales and pricing. Similarly, Turkish Petroleum Refineries Corporation (TÜPRAŞ), which was a state economic enterprise until 2005 and privatized in 2005, had a franchise in the Turkish petroleum industry. Since 2005, The Turkish petroleum industry has been regulated by the Energy Market Regulatory Authority (EPDK). Thus, it can be said that the government has substantially controlled the energy markets in Turkey from past to present.

In Turkey, the government influences the energy prices by determining prices directly and/or by imposing taxes on it indirectly as in other countries. The aim of this study is to examine whether there is a conflict between economic growth objectives and economic, fiscal and social goals attempted to be attained through energy price and energy tax policies in Turkey. That is, the question of whether there is an alternative cost, in the form of a decrease in the economic growth rate, of the high energy prices and tax policies prevailing in Turkey will be addressed. To this purpose, the relationship between electricity consumption, real GDP and electricity retail price is estimated using quarterly data, with a structural break test and the VAR method in the study. In the second section, a review of the related literature is presented. Following sections contain the information about data, methodology and results of the VAR analysis. In the final part of the study, the results and potential policy implication will be discussed.

1. RELATED LITERATURE

A pioneering study to test the causality relation between energy and growth is that by Kraft and Kraft (1978). In their study, the relation between energy consumption and GDP was examined by using annual USA data for the period 1950-1970 and the Sim's Causality Test. It was found that there was a unidirectional causality running from GDP to energy consumption. Their results were supported by the study of Akarca and Long (1979). However, later studies like Akarca and Long (1980), and Yu and Hwang (1984) found no relation between income and energy consumption. In the causality analysis based on the time series mentioned above bivariate models were used. Bivariate models bring some advantages, especially when used for countries that do not have reliable time series data that include price and production factors. However, bivariate models are preferred less compared to multivariate models as the latter are compatible with economic theory and can prevent econometric problems caused by excluded variables (Zachariadis 2007: 1236).

Using the Vector Autoregression (VAR) model, Stern (1993) introduced the multiple causality test. It is stated that the multivariate Granger test is more advantageous than the bivariate Granger test because the former prevents unreal correlations and because it helps in the general validity analysis of causality tests. In the study based on the USA economy, the relationship between energy consumption and GDP for the period 1947-1990 was analyzed using the energy, labour, capital and GDP variables. The results indicated that a causality ran from quality weighted final energy use to GDP. In Stern (2000), a multivariate cointegration test was used with the same variables as in Stern (1993) for the period 1948-1994, the results of which support the 1993 study. In a study in line with Stern's multivariate production side model, Oh and Lee (2004) and Sarı and Soytaş (2007), formed multivariate models in their analysis and found causality relations between GDP and energy consumption. These conflicting findings are a result of the different methodologies used alongside the institutional, structural, and political differences. The variation in results across different studies (Masih and Masih 1997: 419) is caused by differences in determination of the explanatory variables, the causality techniques, and the structure of lag lengths.

The argument that in energy-dependent countries energy prices may have significant effects on energy consumption and income (Dunkerly: 1982) has directed scholars to trivariate (energy consumption, income, energy price) demand function based models. In Masih and Masih (1997) the relationship between three variables is analyzed through a VECM model for the two highly energy dependent countries, Korea and Taiwan, and in both countries the price, energy, and income variables were found to be mutually causal and internal. Masih and Masih (1998) studied the 1955-1991 period in Sri-Lanka and Thailand and found a unidirectional causality relation running from energy consumption to income. Asafu-Adjaye (2000) analyzed the relationship between energy and growth in developing Asian countries using annual time series of the variables energy consumption, GDP and consumer price index (CPI) for the period 1971-1995, and the VECM model. It is stated that the CPI was used as no data were available for energy prices. The results revealed a unidirectional causality relation from energy consumption to income in India and Indonesia. In Thailand and the Philippines, bidirectional causality among variables was identified. In the long term, a unidirectional causality from energy and price to income was found in India and Indonesia. In Thailand and the Philippines, energy, income and prices were found to be bidirectional causal. Mahdevan and Asafu-Adjaye (2007) used panel data to analyze the relation between the variables: per capita GDP, per capita kilogram worth of oil energy use and consumer price index. In the study, countries were classified as net energy importing or net energy exporting. When net energy importing countries were analyzed as a whole, a unidirectional causality relation running from GDP to energy was found. However, the causality ran from energy to GDP when the net energy exporting countries were analyzed as a whole.

Changes in economic structure that involve energy policies and economic growth can result in significant changes in the widely studied energy-growth relationship. Macroeconomic series are affected by these regime changes and external shocks (Lee and Chang 2007: 1207). Consequently, in some studies analyzing the energy-growth relationship, structural breaks in time series are examined. Altınay and Karagöl (2004) have analyzed the relationship between energy consumption and GDP using annual data covering the period 1950-2000, when only one structural break occurred in Turkey. They found that there was no causality among the series that detrend according to breakpoints. After this study, Lee and Chang (2007) studied the energy-growth relationship with the bivariate panel VAR method using multiple break analysis. An evaluation in the framework of less developed countries (LDCs) and highly developed countries (HDCs) revealed that in LDCs a unidirectional causality runs from GDP to energy consumption, whereas in HDCs a bidirectional causality runs from energy consumption to GDP.

While many studies of the relationship between energy and growth are based on general energy consumption, in some studies that categorize energy types, the relationship between electricity consumption and growth is analyzed. The fact that electricity is a high quality fuel and therefore, has increased its share in energy consumption over the years (Cleveland et al. 2000) and has led to an increase in the number of studies on the electricity-growth relationship. Ghosh (2002), Jumbe (2004), Narayan and Smyth (2005), Shui and Lam (2004), Yoo (2005, 2006) studied the causality relationship between electricity consumption and growth. Whereas a unidirectional causality from economic growth to electricity consumption was found by Gosh for the period 1950-1977 in India, and by Narayan and Smyth for the 1966-1999 period in Australia, bidirectional causality was found by Jumbe for the 1970-1999 period in Malawi, and by Yoo for 1970-2002 in Korea. Yet a unidirectional causality from electricity consumption to economic growth was found by Shiu and Lam for the 1971-2000 period in China.

The results of studies on Turkey present results similar to, as well as different from, those mentioned above. These differences are caused by differences in data, time period and methods used. Soytaş and Sarı (2003) used the VECM model with annual data for the 1950-1992 period in Turkey and found a unidirectional causality running from energy consumption to per capita GDP in the long run. Sarı and Soytaş (2004) used annual data for the period 1969-1999 and found that energy consumption accounted for 21% of the estimated error variation. To assess the relationship between energy and growth for the period 1968-2002, Soytaş and Sarı (2007) used the VECM model and annual data for total employment in manufacturing, total electricity consumption in industry, total fix industrial investment, and value added GNP manufacturing. Results indicate that for Turkey in that period, a unidirectional causality runs from electricity consumption to value added GNP manufacturing and that electricity seems to Granger cause labour and fix investment in the long run. Şengül and Tuncer (2006) analyzed the causality relations between economic growth, commercial energy use and an index of real energy price index (which was calculated by authors) using annual data for the period 1960-2000. The empirical results suggest unidirectional causality from real energy prices to commercial energy use and a bidirectional causality between real energy prices and GDP. The results also suggest a unidirectional causality from energy use to GDP. Another case study on Turkey was conducted by Lise and Montfort (2007), who used the Error Correction Model and annual data of GDP and total primary energy consumption for the 1970-2003 period. Energy consumption and GDP were found to be cointegrated and causality was found to run from GDP to energy consumption. Jobert and Karanfil (2007) used annual data on industry, energy consumption in dwellings and total energy consumption, value added GDP manufacturing, and real GDP covering the period 1960-2003 to run cointegration and Granger causality tests. The results reveal a neutral relationship between total energy consumption and real GDP, between industrial energy consumption and value added generated by industry.

All these studies shed light on the policy making of countries. The absence of a relationship between energy consumption and growth eliminates the probability of a conservation policy[3] to negatively affect growth. Conversely, a causality relation from energy consumption to growth may cause energy conservation policies to affect growth negatively. As mentioned in the Introduction, state intervention aimed at energy markets directly affects prices and is expected to affect growth through its negative effect on energy use. Unlike other studies, in this study on public sector energy price and tax policies, the aim is to include energy prices as a separate variable. Ideally, a weighted price index for all energy forms would be used in studies. However, the absence of price data with a time dimension for all forms of energy has forced the researchers to use the consumer price index as a variable in the analysis. The consumer price index used as price variable in Masih and Masih (1997) Asafu-Adjaye (2000) Mahdevan and Asafu-Adjaye (2007) is replaced by the national electricity price index in the present study. Moreover, the relationship between electricity consumption, real GDP and electricity price is estimated using quarterly rather than annual data, with a structural break test and the VAR method. The fact that the electricity price index is used as energy price variable, that a price variable for Turkey is included in the analysis and that this study employs VAR methods are all features that distinguish this study from others and that contribute to its originality.

2. DATA AND METHODOLOGY

In this study, for examining energy consumption, energy price and economic growth relation we use trivariate VAR technique, as Masih and

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[3] Energy conservation policy: reduction in the amount of energy consumed in a process or system, or by an organization or society, through economy, elimination of waste, and rational use.

Masih did in their studies. Three monthly GDP (YR) series which are calculated with the 1987 real prices obtained from the statistics of the Central Bank of the Republic of Turkey, are used as three monthly growth data. Electricity is an energy type derived from other energy sources and for which there is an increasing demand. As such, electricity price data is used to represent energy prices. The electricity price series (PE) data is obtained from the report titled Energy Prices and Taxes published by the International Energy Agency (IEA) in 1984-2007 and the data is adjusted taking 1987 as the base year. The electricity consumption series (EC) data is calculated by the researchers into three-monthly periods. In the calculations, data published by TEK (the Electricity Board of Turkey), EÜAŞ (Electricity Production Company), TEAŞ (Turkey Electricity Company), and TEDAŞ (Electricity Distribution Company of Turkey) is used for the period 1987-2002, and for the period 2002-2007 data from DPT (State Planning Organization) (DPT 2003-2008) is used. With the data obtained, first the net energy consumption data is derived using the equation below, and then this data is transformed into quarterly series.

Monthly Gross Energy Supply = Monthly Energy Production + Monthly Import

Monthly Net Consumption = Gross Supply – Line Losses

All the series obtained in this way are first translated into logarithmic form. Then, in order to prevent seasonal effects that may be caused by the use of quarterly series, the series are seasonally adjusted with the Census X12 method (after this procedure the series are referred to as LYR_SA, LEC_SA, and LPE_SA).

Stationarity analysis is the first procedure performed on the seasonally adjusted series. Many macroeconomic series include unit roots (Nelson and Ploser: 1982) and unit root containing series lose their stationarity. As the non-stationarity of the series will affect the results or even render them invalid, unit root tests are important in the estimation process. Many unit root tests exist in the literature, the major ones being the Dickey Fuller (Dickey and Fuller 1979, 1981, 1986) and Phillips-Perron (Phillips and Perron 1988) tests. In this study, the unit root tests are performed with the Augmented Dickey Fuller and Phillips-Perron tests. To test the nature of the unit roots of the series, the regression equation (1) below is used.

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \emptyset Y_{t-1} + \sum_{i=1}^{n} \psi \Delta Y_{t-i} + \varepsilon_t \qquad (1)$$

In this equation, Δ represents the first difference operator, Y_t the series used, n the lag operator and ε_t the error term. Another stage in unit root testing is determining the lag length. The aim behind determining the appropriate lag length is to reach the lag length that eliminates autocorrelation. The criteria used to determine lag length include Akaike Information Criteria (AIC), Schwarz Information Criteria (SC), Hannan-Quinn (HQ) and Akaike's Final Prediction Error (FPE) criterion. In the analysis, the lag length that renders these criteria the smallest is used. Non-stationarity of the series forms the null hypothesis whereas stationarity is the alternative hypothesis. If in the ADF test the Ø parameter is negative and statistically significant, the null hypothesis is rejected.[4] Another unit root test used in this study is the Phillip-Perron test. The Dickey-Fuller tests mentioned assume that the error terms are independent from each other, that they are normally distributed and that their variance is constant. However, Phillips and Perron (1988) have examined this test for cases with dependent error terms and heteroscedasticity. The common feature in both tests is that when the t statistic is higher than the critical value, the unit root null hypothesis is rejected.

Table 1

ADF and Phillips-Perron (PP) Unit Root Tests

Variable	**ADF statistics (level)**	**MacKinnon 5% critical value**	**PP statistics (level)**	**MacKinnon 5% critical value**
LNYR_SA	0.295575(4)	-2.898623	-0.374339(1)	-2.896779
LNEC_SA	-0.426224(2)	-2.897678	-0.548164(7)	-2.896779
LNPE_SA	-2.271492(10)	-2.901779	-2.534843(4)	-2.896779

Source: authors' own

Note: Critical values are from MacKinnon (1996)

The results presented in Table 1 show that the null hypothesis is not rejected for the three variables and that the variables are not stationary. However, time series can have a stationary structure for sub-periods around

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[4] In addition, if in the estimations made with programs the absolute value of the DF test statistic is lower than the absolute values of the critical values calculated by MacKinnon (1991, 1996) at 1%, 5% and 10% significance level, the null hypothesis is accepted and it is decided that the series has a unit root, and thus, is not stationary. If the absolute value of the DF test statistic is higher than the absolute value of the critical values calculated by MacKinnon, the null hypothesis is rejected and the series is stated not to have a unit root and thus, to be stationary (Gujarati,1995).

a deterministic trend. These time series can be affected by structural changes in the level and/or trend parameters in the sub-periods. The reasons for this change, referred to as structural break, are economic changes (such as crises) and political changes (such as war) or sector related differentiations. In this context, in cases when these kinds of structural breaks occur in the economy, that is, when time series are exposed to a structural break in the intercept and/or slope, not including these structural breaks in unit root tests means the rejection of a null hypothesis explaining non-stationarity. Consequently, using series that look non-stationary, when in fact they are, affects the results to be obtained in the estimations.

One of the criticisms raised against standard unit root tests (Augmented Dickey Fuller and Phillips-Perron, and the like) is that stationary series exposed to structural breaks can be treated as non-stationary. When structural breaks are not included in unit root tests, this may result in faulty rejection of the null hypothesis (Patterson, 2000: 278).

With regard to structural breaks in time series analysis, Perron pioneered with an article published in 1989. The article was based on a study by Nelson-Plosser in 1982 and which concluded that macroeconomic time series for America were not stationary. Perron (1989) points out that in the analysis of a series that has a deterministic trend function with structural breaks, the unit root may appear to be present when it in fact is not. In this study, Perron developed a unit root test that can be applied under the assumption of a single structural break that is known to be exogenous. Yet, the test can only be used when there is one structural break and when this break is known. Therefore, it cannot be used when there are multiple structural breaks, when the structural break period is not known and when the trend is not linear. Perron (1989) was criticized for the weaknesses of his test and this led to the development of different methods. The first study was by Christiano (1992) in which the assumption that the structural break period is known was criticized, and which stressed that the break point needs to be determined endogenously. In following studies by Banerjee, Lumsdaine and Stock (1992), Zivot and Andrews (1992), Perron (1997), the break point was determined endogenously. These studies were followed by multiple break tests covering more than one structural break.

The series analyzed in this part of the study, are analyzed with regard to the structural break analysis of Perron (1997). In this model, which tests breaks at both the intercept and the slope, a t-test is done to test $\alpha = 1$ using the model in equation (2) below.

$$y_t = \mu + \theta DU_t + \beta t + yDT_t + \delta D(T_b)_t + \alpha y_{t-1} + \sum_{i=1}^{k} c_i \Delta y_{t-i} + e_t \qquad (2)$$

The dummy variables used in this model are defined as in (1) and (2):

$$DU_t=1(t>T_b)\ , \tag{3}$$

$$D(T_b)_t=1(t=T_b+1)\ , DT_t=1(t>T_b)_t \tag{4}$$

In all three models, Perron (1997) assumes that *break point* T_b and *lag length* k are not known. Therefore, two methods are suggested to endogenously determine the break point T_b. The first option is to choose the period for which the t-statistic is minimum in the $\alpha=1$ test. This option is used in this study. The second option is to choose the period for which the parameter showing the change in the intercept and the parameter showing the change in the slope is minimum. The first method suggested for determining the lag length endogenously and that is used in this study is the method defined as t-sig. In this method, starting from lag length k-max and reducing it by one unit at a time, the last lag with a statistically significant coefficient is chosen and the two-sided asymptotic normal distribution value at the 10% significance level is taken. In the second approach, a Joint F-test is used to determine whether the lag length of the last added lags has significant effects on the estimated parameters (Perron 1997: 359). While applying the model, the t-sig method is used to determine structural break periods. In addition, to determine lag-length, k-max is set as 8 (k-max=8) for annual data and 12 for quarterly data, as suggested in Perron (1989). After determining the lag length with this method, the structural break points are determined by calculating the minimum t-statistics for the series covering the years 1987Q1-2007Q4.

Table 2

Perron (1997) Unit Root Test Results (Minimizing t_α)

Series	**T**	**T_b**	**k**	**$\hat{\mu}$**	**$\hat{\theta}$**	**$\hat{\beta}$**	**$\hat{y}$**	**$\hat{\alpha}$**	**$t_{\hat{\alpha}}$**
LNYR_SA	80	2000Q3	3	10.068 (6.465)	-0.294 (-5.346)	0.006 (6.406)	0.003 (4.911)	0.396	-6.461*
LNEC_SA	83	2000Q3	0	7.568 (7.591)	-0.138 (-3.529)	0.016 (7.480)	0.001 (1.036)	0.168	-7.569*
LNPE_SA	73	2000Q4	10	1.981 (6.901)	3.435 (6.510)	0.070 (6.401)	-0.057 (-6.560)	0.488	-6.467*

Source: authors' own

Note: (*) denotes significance at level 1% using critical values from Table 1 in Perron (1997).

According to Table 2, structural breaks occur in the LNYR_SA and LNEC_SA series in the third quarter of the year 2000, and in the LNPE_SA series in the fourth quarter of the year 2000. After Perron (1997) treatment on all the three series, the null hypothesis is rejected at 1% statistical significance; that is, the results indicate absence of a unit root.

In the next stage, the relationship between trend stationary series is examined using the VAR method. The VAR model is primarily used to examine the dynamic effects of relationships among macroeconomic variables and of random shocks on the system of variables (Enders 2004). To examine the relationship between electricity consumption, economic growth and electricity prices, the following Vector Autoregressive (VAR) model is employed (equations 5, 6 and 7):

$$\text{LNYR\_SA}_t = \alpha_1 + \tau_1 trend + \sum_{i=1}^{k} \beta_{1i} \text{LNYR\_SA}_{t-i} + \sum_{i=1}^{k} \gamma_{1i} \text{LNCE\_SA}_{t-i} + \sum_{i=1}^{k} \lambda_{1i} \text{LNPE\_SA}_{t-i} + \theta_1 \text{D2000q3} + \psi_1 \text{D2000q4} + \mu_{1t} \tag{5}$$

$$\text{LNCE\_SA}_t = \alpha_2 + \tau_2 trend + \sum_{i=1}^{k} \beta_{2i} \text{LNYR\_SA}_{t-i} + \sum_{i=1}^{k} \gamma_{2i} \text{LNCE\_SA}_{t-i} \sum_{i=1}^{k} \lambda_{2i} \text{LNPE\_SA}_{t-i} + \theta_2 \text{D2000q3} + \psi_2 \text{D2000q4} + \mu_{2t} \tag{6}$$

$$\text{LNPE\_SA}_t = \alpha_3 + \tau_3 trend + \sum_{i=1}^{k} \beta_{3i} \text{LNYR\_SA}_{t-i} + \sum_{i=1}^{k} \gamma_{3i} \text{LNCE\_SA}_{t-i} + \sum_{i=1}^{k} \lambda_{3i} \text{LNPE\_SA}_{t-i} + \theta_3 \text{D2000q3} + \psi_3 \text{D2000q4} + \mu_{3t} \tag{7}$$

In the model α represents the constant, $\tau trend$ the trend, k the lag length, and dummies D2000q3 and D2000q4 the structural break periods.

Determining the lag length is an important step in estimations using the VAR model. Through the use of different criteria, it is possible to determine the optimal lag length for a VAR model. These criteria are Likelihood Ratio (LR), Final Prediction Error (FPE), Akaike Information Criteria (AIC), Schwarz Criteria (SC) and Hannan Quinn (HQ). The lag length that yields the smallest critical values is chosen as lag length for the VAR model. In the trivariate VAR estimation conducted in this study, lag length 5 is chosen because, according to Table 3, its LR, FPE, AIC values are same directional and it yields the minimum values of these criteria. That is, in the model k=5.

Table 3

VAR Lag Order Selection Criteria

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	232.0656	NA	4.45e-07	-6.112933	-5.733488	-5.961875
1	403.4424	309.4304	4.89e-09	-10.62340	-9.959374*	-10.35905*
2	416.0659	21.74032	4.44e-09	-10.72405	-9.775441	-10.34641
3	426.9056	17.76512	4.25e-09	-10.77516	-9.541961	-10.28422
4	434.8309	12.32822	4.42e-09	-10.74530	-9.227525	-10.14107
5	446.5178	17.20581*	4.17e-09*	-10.81994*	-9.017579	-10.10241
6	449.9569	4.776484	4.98e-09	-10.66547	-8.578526	-9.834651
7	456.6449	8.731599	5.47e-09	-10.60125	-8.229721	-9.657136
8	460.2136	4.361663	6.61e-09	-10.45038	-7.794267	-9.392972
9	465.9885	6.577045	7.61e-09	-10.36079	-7.420099	-9.190094
10	469.3551	3.553547	9.48e-09	-10.20431	-6.979030	-8.920315
11	481.9807	12.27495	9.29e-09	-10.30502	-6.795160	-8.907734
12	497.2700	13.59046	8.63e-09	-10.47972	-6.685279	-8.969143

Source: authors' own

Note: (*) denotes the minimum values of LR, FPE, AIC, SC, HQ criteria.

The results obtained from the Granger causality test to determine the relationship among variables are presented in Table 4.

Table 4

VAR Granger Causality Test Results

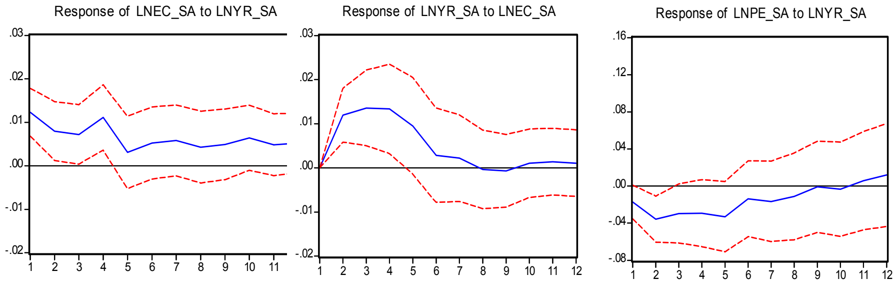
Dependent Variable	**Independent Variable**			**Direction of Causality**
	LNEC_SA	**LNYR_SA**	**LNPE_SA**	
LNEC_SA	———	2.13171 (0.07203)***	1.24124 (0.29965)	LNYR_SA → LNEC_SA
LNYR_SA	4.63344 (0.00107)**	———	0.78000 (0.5.6757)	LNEC_SA → LNYR_SA
LNPE_SA	1.56168 (0.18272)	2.07522 (0.07914)***	———	LNYR_SA → LNPE_SA

Source: authors' own

Note: The values in parentheses are p-values. LNEC_SA → LNYR_SA denotes unidirectional causality running from energy consumption to economic growth and LNEC_SA → LNPE_SA denotes unidirectional causality running from energy consumption to energy prices. ***, ** and * indicate significance at the 10%, 5% and 1% level respectively.

The causality results indicate bidirectional causality relation between electricity consumption and growth, while there is unidirectional causality run from growth to electricity prices. In both cases the null hypothesis is rejected. No other causality than that determined among variables is found. In the light of the above results, whether or not the estimated VAR model includes a structural problem is determined using VAR Residual Normality Tests, Serial Correlation LM Tests, and White Heteroscedasticity Tests. It is observed that there is no autocorrelation or heteroscedasticity problem, and that the residuals are multivariate normal.[5]

Now that the estimated VAR model does not have any structural problem, the next stage in the analysis is to examine the effect of the variables on each other by using impulse-response and variance decomposition methods. Impulse-response analysis is used to analyze the effect of a random one-unit standard deviated shock in any of the variables on the other variables in the system. In this respect, it has an important function in shaping economic policies.


Response of LNEC_SA to LNYR_SA

Response of LNYR_SA to LNEC_SA

Response of LNPE_SA to LNYR_SA

1(a) **1(b)** **1(c)**

Figure 1. Impulse-Response Analysis of LNPE_SA and LNYR_SA to LNEC_SA

Source: authors' own

Note: 1(a) The responses of LNEC_SA to a one standard deviation shock (±2 S.E.) given to the LNYR_SA variable

1(b) The responses of LNYR_SA to a one standard deviation shock (±2 S.E.) given to the LNEC_SA variable

1(c) The responses of LNPE_SA to a one standard deviation shock (±2 S.E.) given to the LNYR_SA variable

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[2] The results are presented in Table 1a, 2a and 3a in the Appendix.

As can be seen in figure 1a, 1b and 1c, the dotted lines represent one standard deviation band around the point estimate to judge the statistical significance of the impulse response function. In figure 1(a) the response of LNEC_SA to the shock of LNYR_SA, declines till the second month, then begins to increase in the third month and becomes insignificant after the fourth month but this shock shows no dying-out pattern. In figure 1(b) the response of LNYR_SA to the shock of LNEC_SA increases after the first month, reaches a maximum at the third month. This shock from LNEC_SA to LNYR_SA becomes insignificant after the fifth month. As can be seen from the impulse response analysis, the results of impulse response analysis are parallel to the causality relations.

Another method to identify the reasons of change in series is variance decomposition. Variance decomposition results obtained from the dynamic averages part of the VAR model, express sources and effects of the shocks in a variable itself or in other variables in percentages. In addition to providing information on what percent of change occurring in a variable is accounted for by that variable itself and what percent by the other variables, variance decomposition analysis also provides information on the degree of causality relationships between variables (Enders 2004). In the framework of the estimated VAR model in this study, the results obtained from the variance decomposition analysis are parallel to the causality relationship results. The results indicate that after 12 periods 70.83 % of the change in real GDP is accounted for by the variable itself, 26.39% of it by LNEC_SA, and 2.76% of it by LNPE_SA. In other words, while a change in growth (LNYR_SA) is accounted for by LNEC_SA in the first period with a 13.65% share, this percentage reaches 26.39% at the end of the 12 periods. The variance decomposition of LNEC_SA is accounted for by its own innovation about 66.52%, by LNYR_SA about 31.74% and by LNPE_SA about 1.73% after 12 months. At the end of 12 periods, a change in electricity prices is accounted for by LNEC_SA through a continuous increase with 39.16%, by LNYR_SA with 6.77%, and by LNPE_SA with 54.05% to which it dropped at the end of 12 periods.[6]

CONCLUSION

In this study of the 1987-2007 period in Turkey, it is found that a bidirectional causality between electricity consumption and real GDP, as

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[6] See Table 4a in the Appendix.

well as a unidirectional causality from real GDP to electricity prices. When these results are compared with those of previously conducted studies, it is observed that they are in conflict with the findings of Altınay and Karagöl (2004) who found no causality relationship between energy consumption and growth, and also with the findings of Jobert and Karanfil (2007) that the relationship is neutral and the findings of Soytaş and Sarı (2003) and (2004) who found only a unidirectional relation between energy consumption and growth. These empirical results are also in conflict with results of Şengül and Tuncer (2006) who found unidirectional causality from real energy prices to commercial energy use and a bidirectional causality between real energy prices and GDP. The results suggest that, as stated in Stern (1993), it can be said that the hypothesis based on neo-classical economy which states that as a production factor, energy has no effect on economic growth, must be rejected. In this study on Turkey, it is observed that both electricity consumption and growth do affect each other. At this point, energy conservation policy measures aimed at reduction of energy consumption may negatively affect growth in Turkey, which consumes energy intensively and is dependent on other countries energy resources.

That electricity prices have no effect on electricity consumption is another issue to be addressed within the scope of energy policy implementations. Controlling environmental factors, promoting the use of clean fuel in energy, increasing the energy stocks of the public and private sector, are among the goals of government policies. Using the price and tax instruments, government aims at reducing energy consumption and as such directs the energy markets. The finding that prices have no effect on energy consumption eliminates the possibility of prices to negatively affect growth by affecting energy consumption. This may be due to the non-elastic nature of energy demand. That is, energy demand can be said to exhibit very little sensitivity to increases in price.

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APPENDIX

Table 1a

VAR Residual Serial Correlation LM Tests

H0: no serial correlation at lag order h
Sample: 1987Q1 2007Q4
Included observations: 79

Lags	LM-Stat	Prob.
1	12.44354	0.1894
2	4.681658	0.8611
3	4.550326	0.8716
4	12.71866	0.1758
5	11.43143	0.2473
6	8.554671	0.4794
7	5.787143	0.7610
8	6.553938	0.6834
9	7.573275	0.5777
10	8.018051	0.5323
11	5.815030	0.7583
12	8.268774	0.5073

Probs from chi-square with 9 df.

Source: authors' own

Table 2a

VAR Residual Heteroscedasticity Tests:No Cross Terms (only levels and squares)

Sample: 1987Q1 2007Q4
Included observations: 79
Joint test:

Chi-sq	df	Prob.
212.3232	204	0.3302

Source: authors' own

Table 3a
VAR Residual Normality Tests

Orthogonalization: Cholesky (Lutkepohl)
H0: residuals are multivariate normal
Sample: 1987Q1 2007Q4
Included observations: 79

Component	**Skewness**	**Chi-sq**	**df**	**Prob.**
1	-0.007426	0.000726	1	0.9785
2	-0.464600	2.842065	1	0.0918
3	0.685602	6.188994	1	0.0129
Joint		9.031785	3	0.0289

Component	**Kurtosis**	**Chi-sq**	**df**	**Prob.**
1	2.341428	1.427652	1	0.2321
2	2.853570	0.070579	1	0.7905
3	3.122720	0.049573	1	0.8238
Joint		1.547804	3	0.6713

Component	**Jarque-Bera**	**df**	**Prob.**
1	1.428378	2	0.4896
2	2.912643	2	0.2331
3	6.238567	2	0.0442
Joint	10.57959	6	0.1023

Source: authors' own

Table 4a
Variance Decomposition Analysis

VARIANCE DECOMPOSITION OF LNYR_SA

	S.E.	**LNYR_SA**	**LNEC_SA**	**LNPE_SA**
1	0.023541	100.0000	0.000000	0.000000
2	0.032338	86.34411	13.65437	0.001522
3	0.039432	77.99222	21.02207	0.985707
4	0.044983	74.27579	24.96281	0.761402
5	0.046578	71.81507	27.43034	0.754591
6	0.046830	71.71795	27.51208	0.769967
7	0.047034	71.65947	27.49026	0.850269
8	0.047049	71.63927	27.47879	0.881939
9	0.047185	71.58911	27.33980	1.071096
10	0.047539	71.43410	26.98308	1.582815
11	0.047822	71.09925	26.74770	2.153054
12	0.048185	70.83962	26.39696	2.763422

VARIANCE DECOMPOSITION OF LNEC_SA

	S.E.	**LNYR_SA**	**LNEC_SA**	**LNPE_SA**
1	0.025908	22.61186	77.38814	0.000000
2	0.028821	25.91702	74.08134	0.001649
3	0.030779	28.22362	71.41790	0.358473
4	0.034676	32.53514	66.50817	0.956697
5	0.037234	28.89689	69.34847	1.754642
6	0.038138	29.41562	68.89541	1.688973
7	0.039135	30.15264	67.83160	2.015754
8	0.040049	29.93934	68.13535	1.925310
9	0.040711	30.43948	67.68389	1.876636
10	0.041901	31.08941	67.13702	1.773563
11	0.042601	31.36043	66.84399	1.795582
12	0.043355	31.74221	66.52336	1.734433

VARIANCE DECOMPOSITION OF LNPE_SA

	S.E.	**LNYR_SA**	**LNEC_SA**	**LNPE_SA**
1	0.081297	4.508090	0.405864	95.08605
2	0.108339	13.43408	0.365754	86.20016
3	0.140521	12.42778	0.514618	87.05760
4	0.157638	13.33044	0.421771	86.24779
5	0.169427	15.34883	0.537773	84.11339
6	0.181076	14.01266	5.283025	80.70432
7	0.192773	13.10039	10.77884	76.12077
8	0.207431	11.60456	17.04987	71.34556
9	0.222184	10.11609	23.32462	66.55929
10	0.240133	8.682006	29.20777	62.11022
11	0.257188	7.618437	34.39007	57.99149
12	0.276405	6.779375	39.16698	54.05365

Source: authors’ own

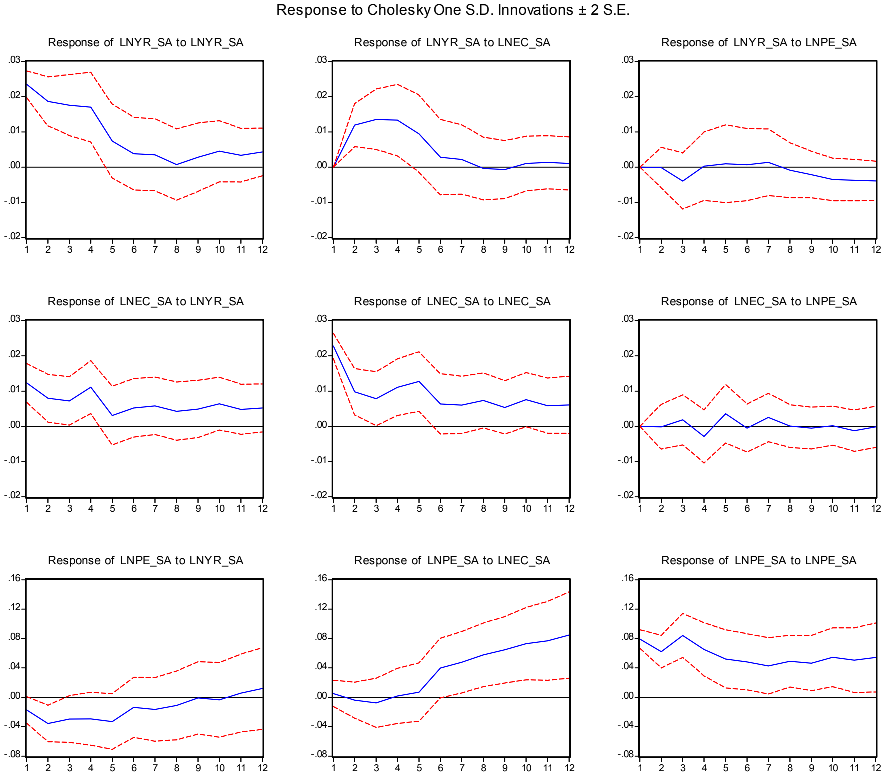

Figure 1a: Impulse Response Analysis

Source: authors’ own