Unit Root Properties Of Energy Consumption And Production In Turkey

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Abstract

In this study, unit root properties of total and sectorial energy production and consumption series of Turkey are investigated. This study is the first to investigate unit root properties of Turkish energy production. The unit root null hypothesis for energy variables are tested by using unit root tests based on LM considering without structural break and with one and two structural breaks. The results of the unit root test without structural break show that the unit root hypothesis is rejected only for consumption of natural gas. The unit root hypothesis is

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rejected for 15 out of the 33 series by the LS test with one structural break. When two structural breaks are taken into account, 25 out of the 33 series are found to be stationary around a deterministic trend. The production of hydraulic and the consumption of lignite, electricity, petroleum, coal and electricity, total energy and petroleum consumption in Transportation sector are found to be non-stationary, which indicates that the impacts of innovations on these variables will be permanent. The policy implication of the results suggests that the impacts of shocks on energy consumption and production will be temporary and not have a long memory for most of variables.

Keywords: unit root, energy production, energy consumption, structural break, Turkey

1.INTRODUCTION

The unit root properties of energy variables for the formulation and implications of economic policies are crucial in several aspects, especially on structural transitions from shocks in energy markets towards key macroeconomic variables (Mishra et al., 2009; Narayan and Smyth, 2007). Impact of shocks on energy variable can be permanent or transitory according to its unit root properties. If the energy variable is stationary, impact of shocks will be transitory and long short term. On the other hand, if the energy variable is not stationary, the impacts of shocks will be permanent and have a long memory. Hendry and Juselius (2000) indicate that economic variables can inherit unit root properties from related economic variables and can in turn transmit this property to other related variables. They argued that relationship between economic variables can spread unit root properties throughout the economy. In this context, knowledge of unit root properties of an energy variable is of importance, since this property can be inherited by related macroeconomic variables. The impact of energy demand on economic activity can be serious. The literature has shown that energy price shocks, via their substantial impact on energy consumption, have significant impacts on output (Chang and Wong, 2003; Du et al., 2010; Hamilton, 1996, 2007; Huang et al., 2005; Jayaraman and Choong, 2009; Jiménez-Rodríguez, 2008; Lardic and Mignon, 2008; Lee et al., 2001; Lorde et al., 2009; Zhang, 2011), inflation (Berument and Taşçı, 2002; Chang and Wong, 2003; Cologni and Manera, 2008; Cuñado and Pérez de Gracia, 2003; Du et al., 2010; Ewing and Thompson, 2007), unemployment (Carruth et al., 1998; Chang and Wong, 2003; Doğrul and Soytas, 2010; Rafiq et al., 2009), employment (Papapetrou, 2001), stock market (Arouri et al., 2011; Basher et al.; Filis et al., 2011; Huang et al., 2005; Papapetrou, 2001; Park and Ratti, 2008; Sadorsky, 1999), investment (Rafiq et al., 2009), the budget deficit (Rafiq et al., 2009), exchange rate (Ayadi, 2005; Basher et al.; Chen and Chen, 2007; Narayan et al., 2008a; Özturk et al., 2008), interest rate (Lowinger et al., 1985; Park and Ratti, 2008), exports (Chiou-Wei and Zhu; Faria et al., 2009; Zhang, 2011), fluctuations in business cycle (Kim and Loungani, 1992) and money supply (Zhang, 2011).

Besides shocks on energy demand, Hamilton (2007) showed that disruptions on energy supply can also have significant impact on economic activity by presenting a model based on Cobb-Douglas production function relating output (Y) produced by a firm to inputs of labour (L), capital (K) and energy use (E) as below:

$$Y = F(L, K, E) \tag{1}$$

The profits (π) of the firm can be calculated as follows:

$$\pi = PY - WL - rK - QE \tag{2}$$

Where P is the price of output per unit, W is the nominal wage paid for labour, Q is the nominal cost of energy used in the production process and r is the nominal rate of rented capital. The maximum energy price for a price-taking and profit-maximizing firm will be at a level where marginal product of energy is equal to its relative price:

$$F_E(L,K,E) = Q/P \tag{3}$$

Where FE(L,K,E) is the partial derivative of F(.) regarding E. The following equation will be obtained in case both sides of the equation (3) are multiplied by E and divided by Y:

$$\partial \ln F / \partial \ln E = QE/PY \tag{4}$$

Eq (4) indicates that the elasticity of output regarding change in energy consumption used in the production process can be derived from the cost of the energy expenditure in total output. Disruptions in energy production will affect energy prices and a change in energy prices used in production process will also have a significant impact on output of an economy as shown in Eq (4). Therefore, shocks on non-stationary energy production series will be permanent and affect economic activity perpetually , while shocks on stationary energy production series will be transitory and affect economic activity temporarily, via transmission mechanism (Narayan et al., 2008b).

The unit root properties of energy variables are of importance for forecasting these variables. Accurate forecasts are crucial for energy planning and policy formulation. Future values of a stationary energy variable can be forecasted based on its past behavior (Chen and Lee, 2007), while past data about a nonstationary energy variable are useless in forecasting (Mishra et al., 2009).

Stationarity of energy consumption can be due to a multitude of factors. Hsu et al. (2008) suggested that abundance of energy resources, less energy consumption, introduction of new environmental laws by governments and middle income level may lead to stationarity of energy consumption.

The goal of this study is to analyze the unit root properties of energy consumption and production in Turkey by employing a Lagrange Multiplier based unit root test without structural break proposed by Schmidt and Phillips (1992) (SP) and a unit root test considering one structural break proposed by Lee and Strazicich (2004) (LS) and two structural breaks proposed by Lee and Strazicich (2003) (LS). If the time series of the variable to be tested for the unit root properties has structural breaks, conventional unit root tests cannot reject the unit root hypothesis reducing the power of the test (Perron, 1989). Monte Carlo simulations point that statistical performance of LS is better than other alternatives (Narayan et al., 2010). This study is the first to investigate the unit root properties of energy production and sectorial energy consumption in Turkey. The next section briefly summarizes the literature on studies investigating the unit root properties of energy consumption and production. Section 3 describes data used in the analysis. Section 4 summarizes the unit root tests used in this study. Section 5 presents results of the unit root test. Section 6 discusses main findings and implications of the results for policy formulation and implication.

2. Brief Overview of the Literature

Although there have been numerous studies analyzing the unit root properties of energy consumption series, only a handful of studies have investigated energy production. Barros et al. (2011) examine the time series behavior of oil production for 13 OPEC member countries and find that oil production series have mean reverting persistence with breaks identified in

10 out of the 13 countries examined. The results of the study indicate that the impact of shocks on oil production in these countries will be persistent in the long run for all countries.

Narayan et al. (2008b) analyze the unit root properties of crude oil production for 60 countries by conducting panel data unit root tests with and without structural breaks between 1971 and 2003. The results of tests without a structural break are inconclusive, while the results of test with one structural break are conclusive and indicate the stationary structure of crude oil and natural gas liquids production series.

Maslyuk and Smyth (2009) test for non-linearity and unit root in crude oil production by using a threshold autoregressive model with an autoregressive unit root. They used monthly crude oil production for 17 OPEC and non-OPEC countries between January 1973 and December 2007. The results of their study show the presence of threshold effects on the crude oil production and unit root for 11 of the countries in both regimes and a partial unit root for the others.

In contrast to the dearth of studies investigating unit root properties of energy production series, there are numerous studies on unit root properties of energy consumption. Narayan and Smyth (2007) employ univariate and panel data unit root tests to analyze the stationarity properties of per capita energy consumption of 182 countries for the period of 1979 to 2000 by using annual data. The results of univariate unit root test indicate that the series of 56 countries are nonstationary at the 10% level or better. The panel data unit root test indicate that there is overwhelming evidence about stationary of energy consumption.

Chen and Lee (2007) investigate the stationarity of energy consumption per capita for 7 regional panel sets for the period of 1971 to 2002 by employing panel unit root testing procedure, and find that all regional-based panels of energy consumption per capita are stationary. A substantial literature review about the unit root properties of energy consumption can be found in Chen and Lee (2007), Hsu et al. (2008) and Aslan and Kum (2011).

3. Data and Econometric Methodology

Energy production data are obtained from TURKSTAT (Turkish Statistical Institution) and energy consumption data are obtained from Ministry of Energy and Natural Resources (MENR) of Turkey. The periods of analysis are determined by data availability. All data used in this study are transformed to natural logarithmic form prior to unit root tests.

The LS unit root test is based on Lagrangian Multiplier (LM) for trending data. Lee and Strazicich (2003, 2004) extended Schmidt and Phillips (1992) methodology by considering structural breaks. The form of the test allows endogenous determination of two structural breaks under both the null and alternative hypotheses for a change in both the level and trend.

$$\Delta Y_t = \delta' \Delta Z_t + \varphi \tilde{S}_{t-1} + \varepsilon_t, \tag{1}$$

where $Z_t = [1, t, D_{1t}, D_{2t}, DT_{1t}, DT_{2t}]$ is a vector of exogenous variables, $\delta = [\mu, \gamma, d_1, d_2, d_3, d_4]$ is a parameter vector of Zt and the subsequent dummies, which allow two time changes in the level and trend, are as follows:

$$D_{jt} = \begin{cases} 1 & t \geq T_{Bj}+1 \\ 0 & t < T_{Bj}+1 \end{cases} \quad and \quad DT_{jt} = \begin{cases} t - T_{Bj} & t \geq T_{Bj}+1 \\ 0 & t < T_{Bj}+1 \end{cases}, \quad j = 1, 2. \tag{2}$$

$\tilde{\psi}_x = Y_1 - Z_1\tilde{\delta}$ and $\tilde{S}_t = Y_t - \tilde{\psi}_x - Z_t\tilde{\delta}$ where $\tilde{\delta}$ are coefficients in the regression of ΔY_t on ΔZ_t. The null and alternative hypotheses are:

$$H_0 : \beta - 1 = \varphi = 0 \; vs \; H_1 : \beta - 1 = \varphi < 0 \tag{3}$$

To determine the location of the breaks ($\lambda = (\lambda_1 = T_{B1}/T,\ \lambda_2 = T_{B2}/T)$) LS procedure utilizes a grid search as follows:

$$LM_\tau = \inf \tilde{\tau}_\lambda(\lambda) \tag{4}$$

Break points are where the corresponding test statistic is minimal.

Results

The results for the unit root tests without structural break and with one and two structural breaks are presented in Table 1. Three distinct unit root tests are used in this study to distinguish the impacts of structural break(s) on the energy series. We considered breaks at level and trend of the series. The number of lags is determined according to the general to specific method up to specific number of maximum lag6 running by t-statistics significance at the 10% significance level.

According to the results of unit root tests without structural break, the unit root hypothesis is rejected only for consumption of natural gas. In case of one structural break, the unit root hypothesis is rejected for 15 out of the 33 series by LS test. When two structural breaks are taken into account, 25 out of the 33 series are found stationary. This series is stationary around deterministic trend with breaks. The production of hydraulic and the consumption of lignite, electricity, petroleum, and coal, total energy consumption in the transportation sector and consumption of petroleum in the transportation sector are found to be non-stationary. According to the results, structural breaks in energy variables of Turkey should be taken into consideration when the unit root properties are examined. If the time series of the variable to be tested have structural breaks, conventional unit root tests cannot reject the unit root hypothesis due to weak power (Perron, 1989). Our results verify the theory that the number of rejection of unit root null hypothesis declines when the number of structural breaks is increased.

Table 1: Results of unit root tests

Series	SP		LS - one break			LS - two breaks			
	k	t statistics	k	t statistics	TB	k	t statistics	TB1	TB2
PHC	0	-1.52	6	-3.87	1999	6	-5.04	1983	1993
PGL	0	-2.12	3	-3.58	2006	9	-8.71[a]	1987	2006
PLT	2	-1.45	2	-3.44	1991	3	-6.35[a]	1987	2001
PWD	8	-0.73	9	-4.20[c]	1990	6	-5.79[b]	1984	1996
PPM	8	1.83	7	-3.37	1988	7	-5.40[c]	1988	1994
PCL	0	-1.99	9	-4.73[b]	1994	8	-6.46[a]	1988	1994
PNG	8	-2.16	8	-6.65[a]	1994	2	-16.39[a]	1988	2003
PEY	9	-0.45	9	-3.68	1987	9	-4.51	1944	1973

6 Source of the selected data's:

State Statistical Office of Macedonia, www.stat.gov.mk and the Ministry of Finance of RM, www.finance.gov.mk

CHC	0	0.14	0	-2.33	1966	7	-5.39[b]	1968	1993
CGL	3	-1.94	2	-5.74[a]	1989	2	-6.88[a]	1975	1987
CLT	9	-1.93	9	-3.87	1998	9	-4.62	1979	1999
CWD	2	-0.53	5	-4.26[c]	1989	10	-6.18[b]	1972	1990
CPM	6	-0.93	10	-4.30[c]	1991	6	-4.65	1965	2002
CCL	9	-1.80	10	-2.94	1989	5	-5.06	1975	1993
CNG	8	-3.13[c]	5	-5.76[a]	1987	2	-9.17[a]	1988	1990
CEY	11	-0.08	11	-4.68[b]	1981	11	-4.87	1981	1989
IND	0	-2.22	5	-5.03[b]	2000	5	-5.69[b]	1991	2000
IND_PET	5	-1.72	9	-4.14	2003	9	-6.41[a]	1989	1994
IND_ECT	6	1.45	0	-3.98	1985	5	-5.97[b]	1984	2000
IND_NGS	0	-1.53	4	-3.19	1993	6	-8.61[a]	1994	1999
TPT	0	-1.68	0	-4.11	1997	8	-4.68	1987	1991
TPT_PET	0	-2.56	3	-4.25[c]	1997	8	-5.15	1987	1991
TPT_ECT	5	-2.07	9	-3.95	2002	6	-6.99[a]	1986	2002
OSC	0	-1.40	0	-2.53	2001	6	-8.54[a]	1982	1999
OSC_PET	0	-1.15	1	-4.78[b]	2000	2	-7.47[a]	1996	2000
OSC_ECT	0	-0.98	9	-3.94	1985	9	-6.40[a]	1982	1995
RES	0	-1.46	0	-2.42	2001	6	-8.44[a]	1982	1999
RES_PET	0	-1.07	9	-4.97[b]	1993	9	-11.48[a]	1987	1993
RES_ECT	0	-1.11	9	-3.95	1985	9	-7.02[a]	1982	1995
ACL	0	-1.64	4	-3.61	1995	7	-6.82[a]	1993	2006
ACL_PET	7	-2.73	7	-4.48[c]	1994	7	-5.39[c]	1993	1999
ACL_ECT	8	-1.94	8	-4.95[b]	1992	9	-5.64[b]	1994	2006
NEY	1	-3.74[a]	2	-5.01[b]	2003	3	-6.60[a]	1997	2003

Notes: k indicates the number of lags. a, b and c denote significance at the 1% 5% and 10% level, respectively. TB denotes time breaks.

6. CONCLUSION

Specification of unit root properties of energy consumption and production is crucial for energy policy formulations and implications. The impact of shocks on energy variables with a stationary process will be temporary and long short term, while impact of shocks on energy variables with a nonstationary process will be permanent and have a long memory.

In this study, the unit root properties of total and sectorial energy production and consumption series of Turkey are investigated. This study is the first to investigate the unit root properties of energy production and sectorial energy consumption in Turkey. The unit root null hypothesis for energy variables are tested by using the unit root tests based on LM without structural break and with one and two structural breaks. The results of unit root test without structural break show that the unit root hypothesis is rejected only for consumption of natural gas. In the case of one structural break, the unit root hypothesis is rejected for 15 out of the 33 series by LS test. When two structural breaks are taken into account, 25 out of the 33 series are found to be stationary around a deterministic trend with breaks. The production of hydraulic, the consumption of lignite, electricity, petroleum, coal, electricity, total energy consumption and petroleum consumption in the transportation sector are found to be non-stationary, which indicates that the impact of innovations on these variables will be permanent.

The policy implication of these results suggests that the impacts of shocks on energy consumption and production will be temporary and not have a long memory for most of the variables. Therefore, the economic impact of energy stabilization and conservation policies will be temporary in Turkey. The results of this study, which found that most of the variables are stationary, are consistent the consensus about stationarity of energy variables found in

numerous other studies (Narayan et al., 2010). In addition, the historical data on these stationary variables can be taken into account to forecast the future values of these variables.

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