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Economic Growth, Energy Consumption And Environmental Pollutants: The Case Of Turkey

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ABSTRACT

Turkey is an emerging economy, a candidate country for full membership to the European Union (EU) and one of the important countries which has a high carbon emission in the world. Turkey will likely to face significant pressures to decrease her emission of carbon dioxide. Energy conversations policies are one of the most important elements of Turkey's policy package reduce its carbon dioxide emission. In this Study, we examine the long run and short run relationshipsbetween economic growth, carbon emissions, energyconsumption , controlling for capital and employment variables in Turkey by using autoregressive distributed lag boundstesting approach of cointegration and error-correction based Granger causalitymodels for Turkey over 1970–2007 period.Our findings suggest thatenergy conservation policies will have adverse effect on economic growth and such policies by themselves are not adequate for reducing environmental pollution as the energy consumption reduction may hinder the economic growth. However, it was found that that controlling for carbon emissions is likely to have desirable effect on the real output growth of Turkey.

JEL Classification: C32, O55,Q20,Q43.

Key Words: Carbon dioxide emission, economic growth, energy consumption, Bounds test,causality.

INTRODUCTION

Global warming has been one of the most important environmental problems of our ages. The ever increasing amount of Carbon Dioxide (CO2), the dominant contributor to the greenhouse effect, seems to be aggravating this problem. Turkey has experienced a significant rise in energy consumption and carbon emissions in recent decades. While the amount of CO2 generated from the consumption of fossil fuel doubled within the period from 1971 to 200, the consumption of the fossil fuel itself increased by 160 percent (Based on World Bank Development Indicators 2010).Figure 1 illustrates the trends of energy consumption, economic growth, CO2 emissions, employment ratio and fixed capital formation in Turkey during the period from 1972 to 2007. As seen from this figure all variables had an upward trend except for employment ratio which sharply decreased over the period under investigation. Figure 2 also illustrates how abovementioned variables moved during the period from1971 to 2007.

Turkey is an emerging economy, a candidate country for full membership to the European Union (EU) and one of the important countries which has a high carbon emission in the world (Ozturk and Acaravci, 2010). Turkey signed Kyoto Protocol in 2009, will be obligated to reduce its emissions by 2020, will likely to face significant pressures from EU during negotiations to introduce its national plan on climate change and global warming along with specific emission targets and the associated abatement policies (Ozturk and Acaravci, 2010).

One of the most important policies adopted by Turkeys' government is to reduce the consumption of energy implementing the energy conservation measures. However, it is not clear what would be the impact of the reduction in energy use on the economic growth. Besides, as Turkey reduces it energy consumption it is expected to reduce the environmental pollutants associated to the consumption of fossil fuels. However, the impact of reducing the fossil fuel related emission on the economic growth of Turkey's is rather unknown. In prospect of Turkeys desire to ratify the Kyoto protocol, it will be interesting to look at the Turkeys potentials and whether or not Turkey can achieve her targets i.e. reducing the Co2 emissions and energy consumption without forgoing the economic growth. The results of the study will provide the great information for the policy makers to choose the most desirable policy among its alternatives. Hence the investigating the relation between economic growth, environmental pollutants and energy consumption constitute the prime motivation of this study.

Several studies have been conducted to find out the relation between energy consumption, economic growth and CO2 emissions in Turkey. However, previous studies have mainly focused on the relation between these variables and ignored the important role that labour and capital may play in the direction of such linkages in Turkey. To the best of our knowledge, this study is the first effort to investigate the relation between energy consumption, economic growth and carbon emissions while controlling for capital and labour inputs.

LITERATURE REVIEW

As discussed by Zhang and Cheng (2009), there is basically three research strands in literature on the relationship between economic growth, energy consumption and environmental pollutants. The first strand focuses on the environmental pollutants and economic growth nexus. It is closely related to testing the validity of the so-called Environmental Kuznets curve (EKC) hypothesis, which postulates an inverted U-shaped relationship between the level of environmental degradation and income growth. That is to say, environmental degradation increases with per capita income during the early stages of economic growth, and then declines with per capita income after arriving at a threshold. The second strand of the research is related to energy consumption and output nexus. This nexus suggests that economic development and output may be jointly determined, because economic growth is closely related to energy consumption as higher economic development requires more energy consumption.The third strand is a combined approach of aforesaid two methods which can be implied to investigate validity of both nexuses in the same framework. This approach investigates the dynamic relationships between economic growth, environmental pollutants and energy consumption. Table 2 overviews the several related studies have been done for Turkey using different methodology and time frame.

THEORETICAL FRAMEWORK

From the neoclassical perspective of the production function, a general production function can be represented as:

$$GDP = Af(CAP, EM, EC \qquad (1)$$

Where denotes the output, the , *EM* and *EC and* represent various inputs such as capital, labor, energy and environment, respectively. Energy inputs refer to the different energy inputs such as oil, gas and coal. *A* is the state of technology as defined by the total factor productivity indicator.

To investigate the long-run relationship between carbon emissions per capita, energy consumption per capita, and real GDP per capita, we employed the following equation:

$$gdp_t = \alpha_1 + \alpha_2 co_t + \alpha_3 ec_t + \alpha_4 em_t + \alpha_5\, ca\rceil \qquad (2)$$

Where $gdp_t = \ln(GDP_t/N_t), co_t = \ln(C($), $ec_t = \ln(EC_t / N_t), cap_t = \ln(C\text{/}$),

$em_t = \ln(E$) and = error term

The long run and causal relationships between economic growth, carbon emissions and energy consumption in Turkey will be performed in two steps. Firstly, we will test the long-run relationships among the variables by using the ARDL bounds testing approach of co-integration. Secondly, we test causal relationships by using the error-correction based causality models. ARDL approach to cointegration is preferable to other conventional cointegration approaches such as that of Engle and Granger (1987), Johansen (1988), Johansen and Juselius (1990) and Gregory and Hansen (1996). Among the advantages of ARDL method are : (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.

Basically, ARDL approach involves two steps for estimating long run relationship. The first step is to investigate the existence of long-run relationship among all variables in the equation. The ARDL model for the standard log-linear functional specification of long-run relationship between carbon emissions per capita, energy consumption per capita, employment ratio and real GDP per capita may follows as:

$$\Delta gdp_t = \alpha_1 + \sum_{i=1}^{a1} \emptyset_{1i}\, \Delta gdp_{t-i} + \sum_{j=0}^{b1} \beta_{1j}\, \Delta co_{t-j} + \sum_{p=0}^{c1} \theta_{1p}\, \Delta ec_{t-p} + \sum_{q=0}^{d1} \varphi_{1q}\, \Delta em_{t-q} + \sum_{q=0}^{e1} \mu_{1q}\, \Delta cap_{t-q} + \delta_1 gdp_{t-1} + \delta_2 co_{t-1} + \delta_3 ec_{t-1} + \delta_4 em_{t-1} + \delta_5 cap_{t-1} + \varepsilon_{1t} \qquad (3)$$

Where and are the white noise term and the first difference operator, respectively.

The first step in the ARDL bounds test approach is to estimate Equation 3 by ordinary least square (OLS) method. The bounds testing procedure is based on the joint F-statistic or Wald statistic that is tested the null of no cointegration .The F-test is conducted to test the existing of long-run relationship among the variables. The null hypothesis in the equation is: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$. This means non-existence of long-run relationship while the alternative indicates to existence of long-run relationship. The calculated F-statistics value is compared with two sets of critical values given by Narayan (2005) for small samples. If the calculated F-statistics exceeds the upper critical value, then null hypothesis of no cointegration would be rejected irrespectively of whether the variable is *I (0)* or *I (1).* If it is below the lower value then the null hypothesis of no cointegeration cannot be rejected. If it is between the critical values bound, the test is inconclusive. At this stage of estimation process, the researchers may have to carry out the unit root tests on variables entered into the model (Pesaran and Pesaran, 1997).

In order to choose optimal lag length for each variable, the ARDL method estimates number of regressions. Where ***p***is the maximum number of lags and ***k*** is the number of variable in the equation. The model can be selected on the basis Schwartz-Bayesian Criteria (SBC) and Akaike's Information Criteria (AIC). The SBC is known as parsimonious model, as selecting the smallest possible lag length, while AIC is known for selecting maximum relevant lag length.

In the second step, the long-run relationship is estimated using the selected ARDL model through AIC or SBC. When the long-run relationship exists among the variables, then there is an error correction representation. Thus, the following error correction model, equation 3.6, is estimated in the third step

$$gdp_t = \alpha_2 + \sum_{i=1}^{a1} \emptyset_{2i}\, gd\, p_{t-i} + \sum_{j=0}^{b1} \beta_{2j}\, \Delta co_{t-j} + \sum_{p=0}^{c1} \theta_{2p}\, ec_{t-p} + \sum_{q=0}^{d1} \varphi_{2q}\, em_{t-q} + \sum_{q=0}^{d1} \mu_{2q}\, cap_{t-q} + \varepsilon_{2t} \qquad (4)$$

$$gdp_t = \alpha_3 + \sum_{i=1}^{a1} \emptyset_{3i}\, \Delta gd\, p_{t-i} + \sum_{j=0}^{b1} \beta_{3j}\, \Delta co_{t-j} + \sum_{p=0}^{c1} \theta_{3p}\, \Delta ec_{t-p} + \sum_{q=0}^{d1} \varphi_{3q}\, \Delta em_{t-q} + \sum_{q=0}^{d1} \mu_{3q}\, \Delta cap_{t-q} + \psi ECT_{t-1} + \varepsilon_{3t} \qquad (5)$$

Here, is the coefficient of error correction term (hereafter ECT).

Additionally, ECT, defined as:

$$ECT_t = gdp_t - \alpha_2 - \sum_{i=1}^{\alpha 1} \emptyset_{2i}\, gdp_{t-i} - \sum_{j=0}^{b1} \beta_{2j}\, co_{t-j} - \sum_{p=0}^{c1} \theta_{2p}\, ec_{t-p} - \sum_{q=0}^{d1} \varphi_{2q}\, \epsilon$$

$$- \sum_{q=0}^{d1} \mu_{2q}\, cap_{t-q} \qquad (6)$$

The error correction model shows how quickly variables converge to equilibrium after a short-run shock. correction term The error it should have a statistically significant coefficient with a negative sign.

EMPIRICAL ESTIMATION

In this study, we use the time series data of Turkey from 1971 to 2007 to investigate the long run and short run relationship between energy consumption, economic growth and carbon emissions. All data are available in the World Bank indicators 2010, an online database.All variables are employed with their natural logarithms form to reduce heteroscedasticity and to obtain the growth rate of the relevant variables by their differenced logarithms.GDP is real GDP at constant price of 2000 in terms of US$, CO2 is carbon dioxide emissions in terms of metric kilo gram,and EC is energy use (kg of oil equivalent), EM is total labor force and CAP is gross fixed capital formation at constant prices of 2000 in terms of US$. It should be noted that the starting choice of the variable is motivated by the availability of data for all the variables from 1971.

As suggested by Pesaran and Shin (1999) and Narayan (2004), since the observations are annual, we choose *2* as the maximum order of lags in the ARDL and estimate for the period of 1971-2007. In fact, we also used the Schwarz-Bayesian criteria (SBC) to determine the optimal number of lags to be included in the model, while ensuring there is no evidence of serial correlation, as emphasized by Pesaran et al. (2001). The lag length that minimizes SBC is one. The calculated *F*-statistics for the cointegration test is displayed in Table 2. The critical value is reported together in the same table which based on critical value suggested by Narayan (2004) using small sample size between 30 and 80. The calculated *F*-statistic (F-statistic = 5.4756) is higher than the upper bound critical value at 5 per cent level of significance (4.088), using restricted intercept and no trend. But the F-statistic is only higher than the upper bound critical value at 10 per cent level of significance (4.150), using restricted intercept and trend. This implies that the null hypothesis of no cointegration cannot be accepted at 5 per cent and 10 per cent level and therefore, there is a cointegration relationship among the variables.

After providing the evidence for the existence of cointegration among the variables, the next step is where Eequation 3 is estimated to ARDL method. An ARDL model of order ARDL (*1, 1, 1, 1, and 0)* is selected. Table 3Shows the Autoregressive Distributed Lag Estimates,ARDL *(1, 1, 1, 1, 0)*selected based on Akaike Information Criterion.To ascertain the goodness of fit of the ARDL model, the diagnostic test and the stability test are conducted. The diagnostic test examines the serial correlation, functional form, normality and heteroscedasticity associated with the model. Table 4 shows the statistics related to test the null hypothesis of no serial correlation, no functional form misspecification, normality and homoscedasticity.As indicated in this table, the results suggest that we cannot reject he null hypothesis of no serial correlation, no functional form misspecification, normality and homoscedasticity.To confirm the stability of the estimated model, the tests of CUSUM (Cumulative Sum) and CUSUMSQ (CUSUM of Squares) of recursive residuals are employed in this study. Figure 3 and 4 respectively provide the graphs of CUSUM and CUSUMSQ tests. Figure 3 indicates that the plot of CUSUM is completely stable within 5% of critical bands. Figure 4 is also the evidence confirming that there is deviation is not inside the critical bands; the plot ofCUSUMSQ statistic returns completely back to inside the criteria bands.Thus, judging from this, we can argue that the estimated model is stable.

Long Run Results

The long-run results are presented in Table 5; the long-run coefficients and statistics indicate a strong correlation between real GDP and all other variables except for employment. These findings suggest that in the long-run, energy consumption, investment and environmental quality enhancement stimulates the economic growth in Turkey.However, there is no statistically significant relationship between Economic growth and employment. This finding suggests that in the long-run, employment policies can affect the economic growth in Turkey.Overall, the econometric evidence suggests that Turkey has to sacrifice economic growth for reducing its energy dependent level. However, the carbon abetment policies will increase the economic growth. In the long-run however, it is possible to meet the energy needs of the country and at the same time reduce CO2 emissions by developing energy alternatives to fossil fuel based energy.

Error Correction specification

The short run dynamics of the model is shown in Table 6; according to the statistics indicated in this table, the error correction model can be specified as follows:

$$ECM = LNGDP + 4.3120 * LNCO2 - 6.1850 * LNENE - .28238 * LNEMP - .63581 * LNCAP + 35.2527 * C$$

The coefficient of DLNCAP is statistically significant.This implies that investment is a significant determinant of real GDP in the short-run. The coefficient of DLNCO2 is also significant at 90 percent significant level, implying that environmental policies can affect the real GDP in the short run. However, energy consumption is not statistically significant similar to long-run coefficient. The speed of adjustment coefficient *ECM (-1)*to restore equilibrium in the dynamic model has negative sign, and statistically significant at the 1 percent level, ensuring that long-run equilibrium can be attained. The coefficient of -0.356 implies that adjustment to long-run equilibrium values quitefast. When the policy shocks are implemented, the equilibrium point can be attained about 3 years. In other words, 35 percent of distortion which is caused by the economic policies will be removed each year.

CONCLUSION

Appraisals of the linkages among the environment, energy consumption and economic growth are among the most critical issues and have often been at the center of discussions in the countries aiming at reducing their carbon emission among which Turkey is not exempted. As the government of Turkey aims at reducing its carbon dioxide emission and reduces its energy dependency level, it is therefore essential to investigate the impact of such policies on the economic growth of the country. This study employs the autoregressive distributed lag bounds testing approach of cointegration and error-correction based Granger causality models to investigate the relationship among economic growth, energy consumption and CO2 emissions for Turkey over 1970–2007. Our finding suggests thata reduction in energy consumption will reduce economic growth in the long run, implying that energy conservation policies including energy taxes and subsidies have adverse effect on economic growth. Therefore, such policies by themselves are not adequate for reducing environmental pollution. Additionally, the study found that controlling for carbon emissions is likely to have desirable effect on the real output growth of Turkey implying that the environmental friendly practices such as associated carbon abatement policies in Turkey may have a positive effect on economic growth. The results also suggest that because of Turkey’s dependence on external sources for energy, it is clear that any problem or crisis in energy supply can negatively affect the development. Thus, Turkey’s energy policies should be such that they should diminish the country’s dependency for external energy sources. Policies that provide supply security should also be put into practice, which is critical because of Turkey’s geographic and geopolitical location.

The findings of this study have important policy implications and it shows that this issue still deserves further attention in future research.One limitation of this study is that it only examined fossil fuels when considering primary energy sources, and future work should also consider alternative sources of energy and their linkages with economic growth. Additionally, the future studies might disaggregate the fossil fuels into different types of fuel such as crude oil, natural gas and coal in order to see if there exists any causality running from different types of energy to economic growth. Additionally, future studies could consider various sources of environmental pollutants.

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TABLE 1: studies related to energy consumption, economic growth and co2 emissions in Turkey

Study	Method	Period of investigation	result
Ozturk and Acaravci(2010)	ARDL and ECM based Granger causality models	1968–2005	Neither carbon emissions per capita nor energy consumption per capita cause real GDP per capita, but employment ratio causes real GDP per capita in the short run.
Soytas and Sari (2009)	the Toda and Yamamoto (1995) approach	1960–2000	No long run causal link between income and emissions
Ozturk et al. (2010)	Pedroni (1999) panel cointegration method for 51 countries	1971 to 2005	Bidirectional Granger causality from EC to GDP

	Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS) for 51 countries	1971 to 2005	No strong relation between energy consumption and real GDP
Erdal et al (2008)	Granger causality test for Turkey	1970–2006	A bidirectional relationship running from energy consumption to economic growth and from economic growth to energy consumption.
Sinha, Dipendra(2 009),	Pedroni's panel co-integration tests and dynamic panel Vector Error Correction Model (VECM) causality tests for 88 countries		there exist an evidence for two-way short-run, long-run and strong causality between the energy consumption and economic growth
Soytas and Sari (2003)	Johansen (1988) and Johansen and Juselius (1990) maximum likelihood procedure to test for co-integration	in the top 10 emerging markets (excluding China due to lack of data) and G-7 countries	long run bi-directional causality from energy consumption to GDP in Turkey in both short and long run
Huang and Yang (2008)	nonlinear regression model	82 countries, in which Turkey is included, for the period extending from 1971 to 2002	when CO2 emissions, the total primary energy supply to production per $1 of GDP, the ratio of industrial energy consumption to total energy consumption, and per capita energy consumption in a country exceed certain levels, there was no significant positive relationship between energy consumption and economic growth in that country.

TABLE 2: *F*-statistic of Cointegration Relationship

Test statistic	Valu e	ag	Significance level	Bound Critical values* (restricted intercept and no trend)		Bound Critical values* (restricted intercept and trend)	
				I(0)	I(1)	I(0)	I(1)
F-statistic	5.4756	1	1% 5% 10%	4.093 2.9 47 2.4 60	5.532 4.088 3.460	5.3 33 3.7 10 3.0 08	7.063 5.018 4.150
K=	4						
N=	36						

Note: * Based on Narayan (2004)

TABLE 3: Autoregressive Distributed Lag Estimates,ARDL (1, 1, 1, 1, 0)

36 observations used for estimation from 1972 to 2007 Dependent variable is LNGDP			
Regressors	Coefficient	Standard Error	
LNGDP(-1)	.64239	.12054	5.3290[.000]
LNCO2	.065874	.52745	.12489[.902]
LNCO2(-1)	-1.6158	.58480	-2.7630[.010]
LNENE	-.55191	.67797	.81406[.423]
LNENE(-1)	2.7691	.70235	3.9427[.001]
LNCAP	.72078	.075890	9.4976[.000]
LNCAP(-1)	-.48972	.12264	-3.9933[.000]
LNEMP	.10653	.34033	.31301[.757]
C	-12.6781	3.8678	-3.2779[.003]
R-Squared		.99237	
R-Bar-Squared		.99011	
F-stat. F(8, 27)		438.7887[.000]	
DW-statistic 2.0874		2.0874	
Mean of Dependent Variable		7.6880	
S.D. of Dependent Variable		0.65911	
Residual Sum of Squares		.11606	
Equation Log-likelihood		52.1878	
Akaike Info. Criterion Schwarz Bayesian Criterion 36.0619		43.1878	
Schwarz Bayesian Criterion		36.0619	
Durbin's h-statistic		-.37950[.704]	

Source: Estimated Results

TABLE 4: Diagnostic Tests on the Estimated ARDL Model

Test Statistics	LM Version	F Version	Decision on Null hypotheis
Serial Correlation(A)	CHSQ(1)=.12569[.723]	F(1, 26)= .091095[.765]	Not Reject
Functional Form(B)	CHSQ(1)=.91184[.340]	F(1, 26)= .67566[.419]*	Not Reject
Normality (C)	CHSQ(2)=1.8580[.395]	Not applicable	Not Reject
Heteroscedasticity(D)	CHSQ(1)=.1190E-3[.991]	F(1, 34)= .1124E-3[.992]*	Not Reject

Notes:

A: Lagrange multiplier test of residual serial correlation

B: Ramsey's RESET test using the square of the fitted values

C: Based on a test of skewness and kurtosis of residuals

D: Based on the regression of squared residuals on squared fitted values

Source: Estimated Results

TABLE 5: Estimated Long Run Coefficients using the ARDL Approach: ARDL (1, 0, 1, 0, 1) selected based on SBC

Variables	Coefficient	Standard Error	t-ratio (p-value)
Dependent Variable	LNGDP		
LNCO2	-4.3120	1.3088	-3.2945[.003]
LNENE	6.1850	1.8982	3.2583[.003]
LNEMP	.28238	1.0256	.27534[.785]
LNCAP	.63581	.15417	4.1242[.000]
C	-35.2527	14.0911	-2.5018[.019]

Source: Estimated Results

TABLE 6: Error Correction Representation for the Selected ARDL Model

Dependent Variable is LNGDP			
Repressor	Coefficient	Standard Error	T ratio[Prob]
dLNCO2	.044759	.54092	.082746[.935]
DLNENE	-.51801	.69844	-.74166[.464]
DLNEMP	.10073	.34671	.29053[.773]
DLNCAP	.72127	.077213	9.3413[.000]
DC	-12.5752	3.9487	-3.1847[.003]
ECM(-1)	-.35671	.12265	-2.9083[.007]
R-Squared	.88092		
R-Bar-Squared	.84428		
F-stat. F(5, 29)	38.4693[.000]		

Source: estimated results

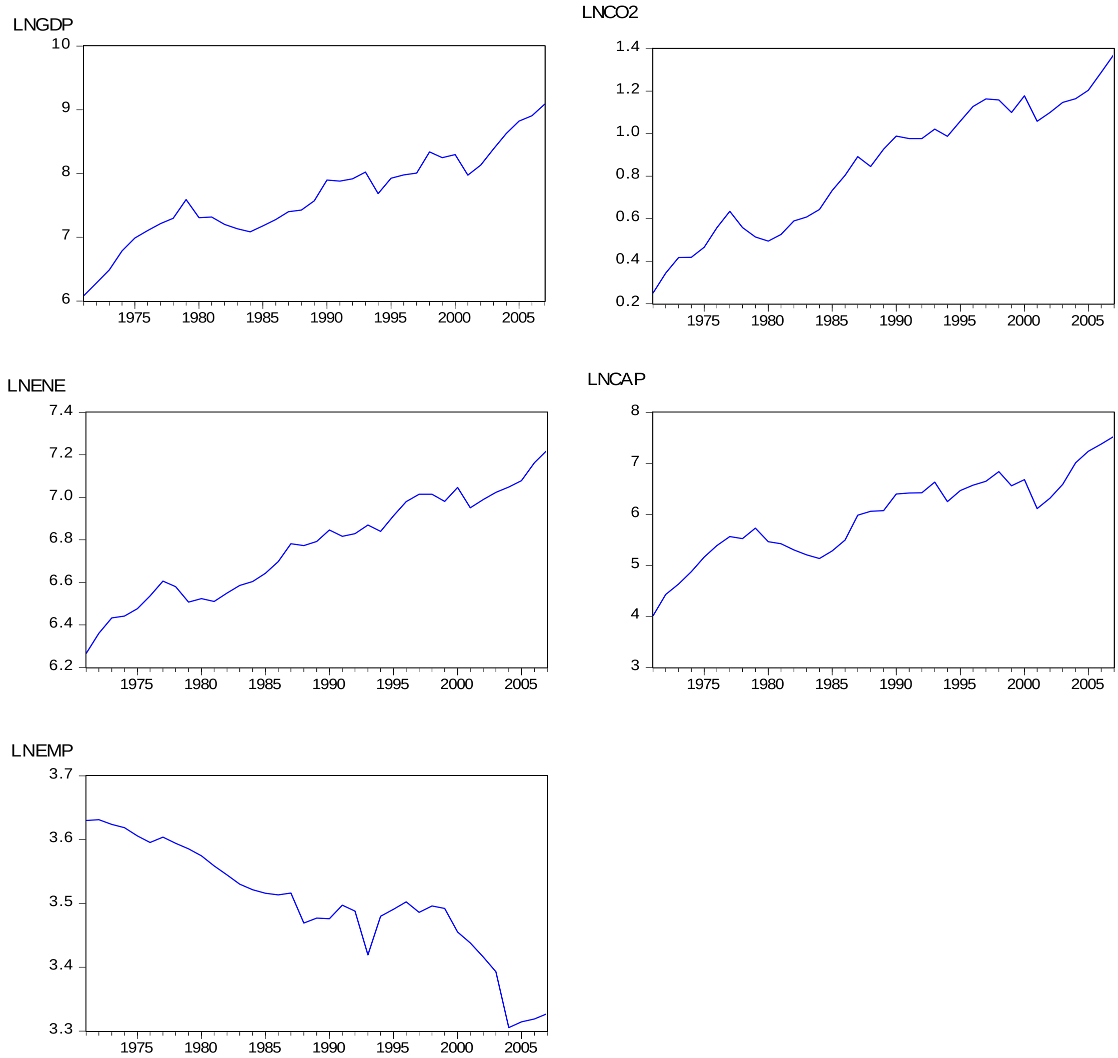

Figure 1: Trends of variables (after taking logarithm).
Source: Based on World Development Indicators (2010)

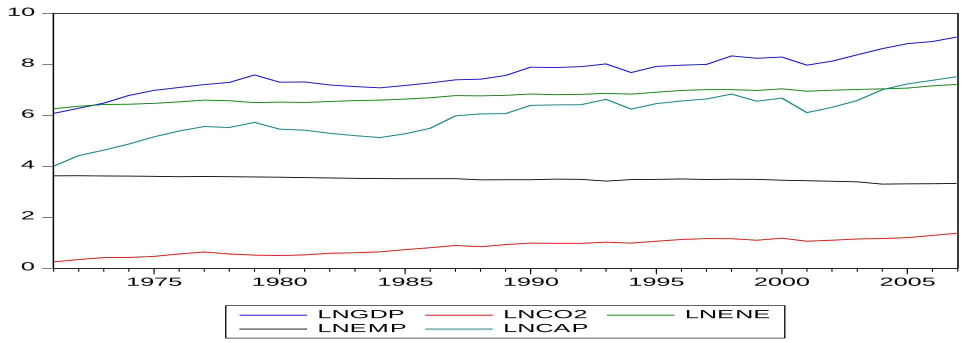

Figure 2: Trends of all variables (after taking logarithm).
Source: Based on World Development Indicators (2010)

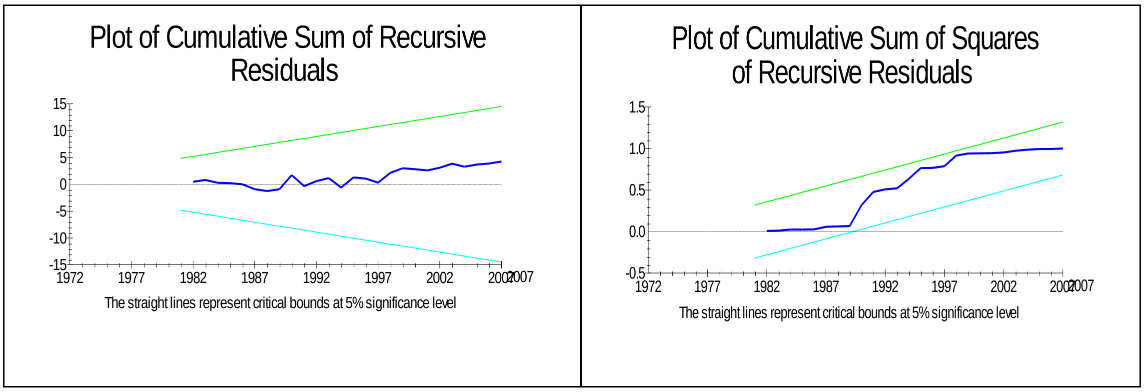

Figure 3: CUSUM and CUSUMSQ tests

Source: Estimated Results