Environmental Degradation, Energy consumption, Population Density and Economic Development in Lebanon: A time series Analysis (1971-2014)

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Abstract

This study has investigated the impact of energy consumption, financial development, economic development, population density and secondary school education on environmental degradation in Lebanon over the period of 1974 to 2014. ADF unit root test and ARDL bound test method of co-integration have been used for empirical analysis. The results show that energy consumption, financial development and population density have positive and significant relationship with environmental degradation in Lebanon. The results show that economic development has positive but insignificant relationship with environmental degradation. The results show that secondary school education has negative and significant relationship with environmental degradation in Lebanon. The estimated results show that for reducing environmental degradation, the Lebanese government should increase energy efficient methods of production as well as increase the educational level.
Keywords: economic development, population density, environmental degradation
JEL Codes: O1, Q56, Q53

1. Introduction

With every step of socio-economic development, environmental changes are becoming one of the most important policy issues of this modern age. There are number of factors which added to environmental changes. Most of the empirical studies warn about the rising level of oceans, increasing desertification and their impacts on global warming. It is the energy consumption which is becoming one of the main causes of environmental degradation but if demographic changes are added then this impact is sever. The reduced child mortality and increasing life expectancy are causing world population to grow exponentially since after industrial revolution. Currently world population growth rate is 1.5 percent which means every year 80 to 85 million people are added in world total population. UN mentions that this rise in population mainly concentrated in Asian and African developing countries. CO2 is the main greenhouse gas, having 76.7 percent share in total greenhouse gases (IPCC, 2007). UNFCCC (1997) consensus reveals that the developing countries have large share in CO2 emissions as compare to developed countries. Recently, most of developing countries show a motivational behavior for reducing CO2 emissions (Winkler et al., 2002) but still CO2 emissions share is more than 50 percent. This trend will expect to grow if the current path, in terms of energy consumption is remained same. In the last 50 years, the massive human population increases the human economic activities, the rising of economic activities demands more fossil fuels as well as CO2 emissions that tend to

have dramatically risen in these years too. Following the Environmental Kuznets Curve Hypothesis (EKC), there is an inverted U-shaped relationship between CO2 emissions and economic development. Number of empirical studies investigating the causal relationship between environmental quality and economic development are available (Grossman and Krueger, 1995).

Following the last of 20th century decade, the interaction between economic growth and energy consumption as well as environmental and economic degradation are topic of discussion among policy makers and economists. First time Kraft and Kraft (1978) discovered that there is strong causal relationship between environmental degradation and economic development. Mostly the empirical studies in this area of research have focused on developed countries as case studies (De Bruyn et at., 1998). Although some studies have focused on environmental quality of developing countries (Dijkgraaf and Vollebergh, 2001) but Lebanon is exclusively ignored in this regards. Moreover, available literature on the topic has ignored the impact of demographic changes on environmental degradation. This study has investigated the impact of energy consumption, financial development, economic development, population density and secondary school education on environmental degradation in Lebanon over the period of 1971 to 2014. This type of study is hardly done in Lebanon, so this study will be a health contribution in the respective literature.

2. Literature Review

This study has investigated the impact of energy consumption, financial development, economic development, population density and secondary school education on environmental degradation in Lebanon. In this globalized era, there is vast body of theoretical and empirical literature available which investigate the determinants of environmental degradation. Despite this large amount of research, the exact link among determinants of environmental degradation is still controversial. Some of the most relevant studies are presented here as literature review. Grossman and Krueger (1995) have investigated the relationship between economic development and environmental pollution. They concluded that there is an inverted U-shaped relationship with economic development and environmental degradation. After that, a number of studies investigated the existence of an inverted U-shaped relationship between economic development and environmental degradation. There are number of studies which investigate the relationship between environmental quality and economic development. Shafik, (1994); Holtz-Eakin and Selden, (1995); Grossman and Krueger, (1995); Carson et al. (1997); Jaekyu, (1997); McConnell, (1997); Moomaw and Unruh, (1997); De Bruyn et al. (1998); Rothman, (1998) and Suri and Chapman, (1998) mention that there is an inverted U-shaped relationship between economic development and environmental degradation. Kaufmann et al. (1998), Perman and Stern, (2003), Vehmas et al. (2007) and Johansson and Kristrom (2007) mention that there is no evidence of an inverted U-shaped relationship between economic growth and environmental degradation. Spangenberg (2001) argues that EKC may exist in some cases but not for all. This implies that there is no solid indication of inverted U-shaped between economic growth and environmental degradation.

Moomaw and Unruh (1997) investigate the relationship of economic development and environmental degradation by using cross-sectional data of selected developed countries. They

mention that there is an inverted U-shaped relationship between economic development and environmental degradation after a threshold level. McConnell (1997) concludes that there is inverted U-shaped relationship between economic development and environmental degradation in the US.

Rothman (1998) investigates the relationship of economic development and environmental degradation in case of some selected developed countries by using the data of different point of time. He concludes that there is an inverted U-shaped relationship between economic growth and environmental degradation. Junyi (2006) investigates the relation of EKC and income per capita in case of Chinese provinces, for that he uses data from 1993 to 2002. He uses simultaneous equation model (SEM) for investigation of relationship of pollutant emission per capita and income per capita and 2SLS is used for estimation of SEM. He uses Hausman methodology for understanding the exogeneity of income in his model, the results of the Hausman test confirms that there is simultaneity between pollution emissions and income per capita. The overall results of the study confirm that in some provinces there is inverted U-shaped relation between income and pollution, but in case of poor provinces they need more wealth for improved environmental conditions.

Vehmas et al. (2007) analyze the relationship among direct material input, domestic material consumption and economic development from the aspect of material flows using the EKC theory. They mention that there is EKC in the case of EU countries. Brajer et al., (2011) test the EKC hypothesis in case of China. The results of the study confirm the existence of EKC in case of China.

Kaygusuz (2009) examines the impact of energy consumption on environmental degradation in Turkey. The results of the study show that energy consumption has strong relationship with CO2 emissions in Turkey. Lisea (2006) examines the impact of multi-dimensional use of energy on CO2 emissions in case of Turkey over the period of 1980 to 2003. According to the results of the study, the CO2 emissions show a rising trend in fast growing developing countries due to their changing energy composition. So there is an intense relationship between CO2 emissions and energy consumption in Turkey. If the intensity of the energy consumption comes down, the emissions of CO2 can also be decreased.

Halkos and Tzeremes (2011) reinvestigate the relationship between economic development and environmental quality using annual data of 1965-2009. They expose that an N-shaped relationship exists between both variables but China has improved environmental quality after 1990s. Li and Li (2011) incorporate coal consumption in energy emissions function in case of China and India over the period of 1965-2006. Their results report that coal consumption Granger causes economic development both in India and China. They suggest for efficient technology to reduce CO_2 emissions and to achieve sustainable level of development in both economies.

3. Historical prospective of Lebanon

Lebanon was stuck into civil war from 1975 to 1990 a change in which seriously damaged its economic infrastructure. Before the civil war Lebanon was the banking hub in the Middle East

and considered one of the big powers among its neighbors. After the whole scenario, the Lebanese government regained control of the country, collects taxes and control key ports of it . As a result in 1990's expansion in per capita GDP was recorded 353 percent. Foreign remittances, medium and small scale manufacturers, international aid for reconstruction, manufactured and farm exports and financially sound banking system are the helping hand to government for economic recovery. The government gets impressive gains by launching the "Horizon 2000" program in 1993. Before Israel's Operation "Grapes of Wrath" in 1996, the real GDP growth rate is recorded 8% in 1994, 7% in 1995, 3 percent in 1997 and 1998 and only 1 % in 1999. Inflation rate reduced from 100% to 5% during the period of 1992 to 1998, whereas foreign exchange reserves reached $6 billion during this period. Burgeoning capital inflows have generated foreign payments surpluses, and the Lebanese pound has remained relatively stable. Progress also has been made in rebuilding Lebanon's war-torn physical and financial infrastructure. Solidere, a $2-billion firm, managed the reconstruction of Beirut's central business district; the stock market reopened in January 1996, and international banks and insurance companies are returning. The government nonetheless faced serious challenges in the economic arena. It has had to fund reconstruction by tapping foreign exchange reserves and boosting borrowing. Reducing the government budget deficit is a major goal of the current government. The gap between rich and poor grew in the 1990s, resulting in popular dissatisfaction over the skewed distribution of the reconstruction's benefits and leading the government to shift its focus from rebuilding infrastructure to improving living conditions. Figures-1, 2, 3 and 4 respectively give the historical overview of CO2 emissions, energy consumption, population density and economic development in case of Lebanon.

Figure-1

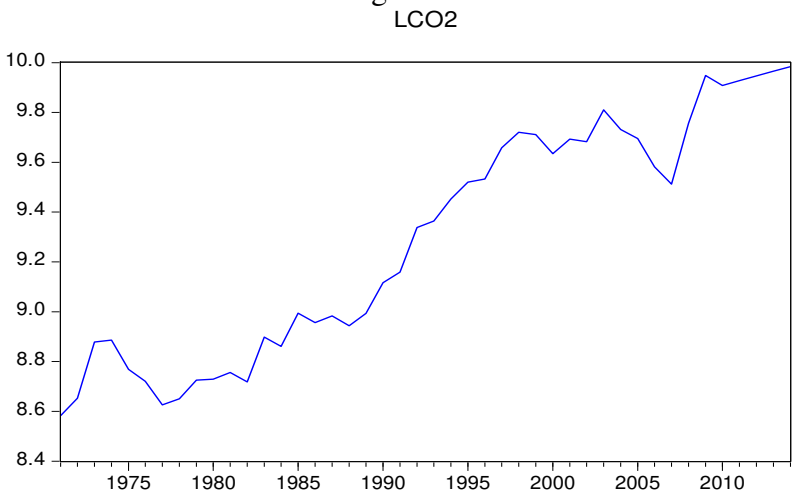


Figure-2
Energy Consumption

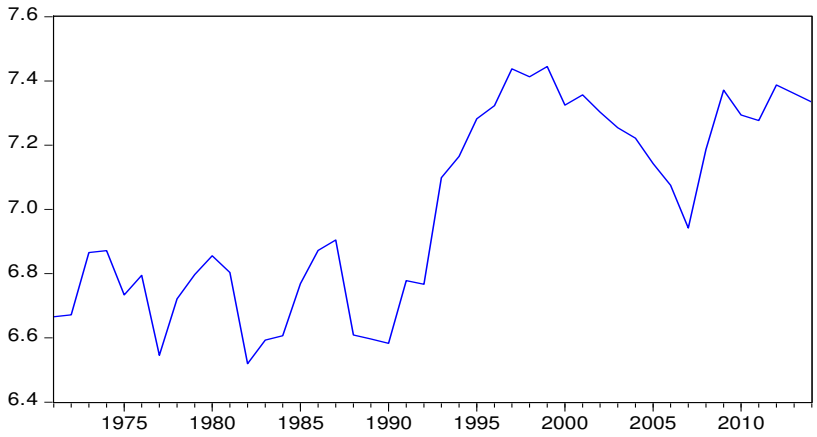


Figure-3
Population Density

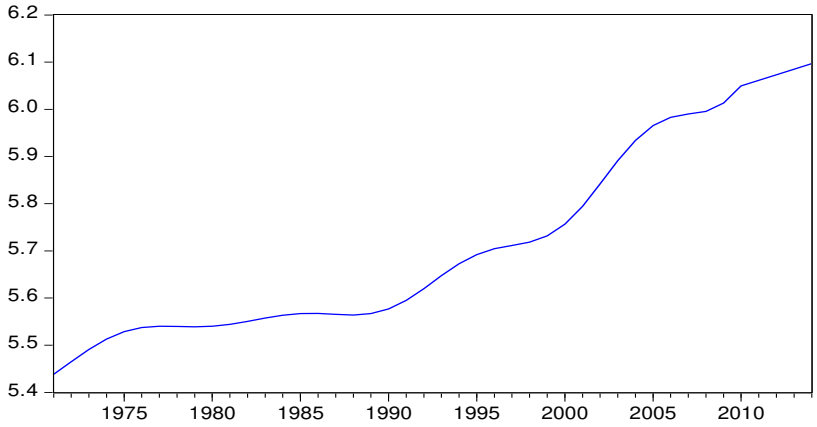
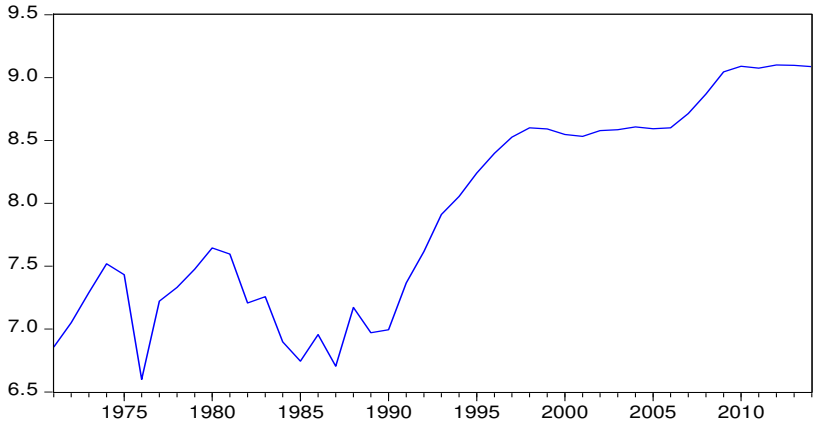


Figure-4
Economic Development



4. Model Specification and Data Sources

CO2 emissions reduction and better environment quality is the main focus of developed countries but the developing countries are still confused about it. The study has investigated the impact of energy consumption, financial development, economic development, population density and secondary school education on environment quality in Lebanon over the period of 1974 to 2014. The data for all the selected variables is taken from The World Development Indicator (WDI) data bases maintained by World Bank. Following the detail literature review, the functional form of the model becomes as:

$$CO2 = F(\mathrm{EN}, \mathrm{M2}, \mathrm{GR}, \mathrm{PD}, \mathrm{ED}) \quad (1)$$

Here
CO2=CO2 Emissions (Environmental Degradation)
EN=Energy Consumption
M2=Money Supply (Financial Development)
GR= GDP per capita (Economic Development)
PD= Population Density (people per sq. km of land area)
ED= Secondary Education

For finding the responsiveness of dependent variable with respect to independent variables, we use the log for both sides. The econometric model of the study become as:

$$LCO2_t = \alpha + \beta_1 L\mathrm{EN}_t + \beta_2 L\mathrm{M2}_t + \beta_3 L\mathrm{GR}_t + \beta_4 L\mathrm{PD}_t + \beta_5 L\mathrm{ED}_t + \varepsilon_t \quad (2)$$

Here
t= Time Period
$\varepsilon =$ Error Term

5. Econometric Methodology

One of the main problems with the time series data, there may be unit root in the data and regression results of that data become spurious (Nelson and Ploser, 1982). This study has used time series of energy consumption, financial development, economic development, population density and secondary school education as independent variables whereas environmental degradation is dependent variable. There are number of unit root tests available for removing non-stationarity problem in time series data. In this study we use Augmented Dickey-Fuller (ADF) (1981) without and with time trend. The possible equation of ADF are as follow:

$$\Delta X_t = \delta X_{t-1} + \sum_{j=1}^{q} \phi_j \Delta X_{t-j} + e_t \quad (3)$$

The null hypothesis in the data is non stationary.
With the help of OLS compute τ statistic of X_{t-1} and compare it with critical τ values. If calculated τ is greater than the critical τ reject null hypothesis and accepts the alternative. We can conclude that the data is stationary and vice-versa is non-stationary.

5.1 Auto-Regressive Distributed Lag (ARDL)

After confirming the stationarity and lag order, ARDL bound testing approach to cointegration of Pesaran et al., (2001) is used for examining the cointegration of the model's variables. It is the most advanced cointegration methods, which has number of advantages over traditional co-integration techniques. It can be applied on mix order of integration and it gives better results for small sample size data. Autoregressive distributed lag model follows this procedure:

$$LCO2_t = \alpha_1 + \alpha_2 t + \alpha_3 LCO2_{t-1} + \alpha_4 LEN_{t-1} + \alpha_5 LM2_{t-1} + \alpha_6 LGR_{t-1}$$

$$+\alpha_7 LPD_{t-1} + \alpha_8 LED_{t-1} + \sum_{h=1}^{p} \beta_h \Delta LCO2_{t-h} + \sum_{j=0}^{p} \gamma_j \Delta LEN_{t-j}$$

$$+ \sum_{k=0}^{p} \phi_k \Delta LM2_{t-k} + \sum_{m=0}^{p} \phi_m \Delta LGR_{t-m} + \sum_{n=0}^{p} \phi_n \Delta LPD_{t-n} \sum_{f=0}^{p} \phi_f \Delta LED_{t-f} + u_{it} \quad (4)$$

$H_0 : \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = \alpha_7 = \alpha_8 = 0$ (No co-integration among the variables)
$H_A : \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq \alpha_6 \neq \alpha_7 \neq \alpha_8 \neq 0$ (co-integration among variables)

Calculated F-Statistic is compared with upper bound value of Pesaran and Pesaran (1997) or Pesaran et al., (2001). If calculated F-test statistic is greater than the upper bound value, the null hypothesis of no co-integration is rejected. Then it is concluded that there is cointegration among the variables of the model.

Vector Error Correction Model (VECM) has been used for short dynamic among the variables. VECM procedure is as under:

$$\Delta LCO2_{it} = \alpha_1 + \alpha_2 t + \sum_{h=1}^{p} \beta_h \Delta LCO2_{t-h} + \sum_{j=0}^{p} \gamma_j \Delta LEN_{t-j} + \sum_{k=0}^{p} \phi_k \Delta LM2_{t-k}$$

$$+ \sum_{m=0}^{p} \phi_m \Delta LGR_{t-m} + \sum_{n=0}^{p} \phi_n \Delta LPD_{t-n} \sum_{f=0}^{p} \phi_f \Delta LED_{t-f} + \omega ECT_{t-1} + u_t \quad (5)$$

ECT_{t-1} represents lagged error correction term. ECM explains the speed adjustment from short run to long run. For investigating the optimal lag length Schwarz Information Criteria (SIC) or Akaike's Final Prediction Error (FPE) are used.

6. Empirical Results and Discussions

This study has investigated the impact of energy consumption, financial development, economic development, population density and secondary school education on environmental degradation in Lebanon over the period of 1974 to 2014. Augmented Dickey-Fuller unit root test is used for finding the stationarity of the variables. The estimated results of ADF unit root test are presented

in table-1. The results of the ADF test show that CO2 emissions, energy consumption, population density, economic development and secondary school education are not stationary at level both in without time trend and with time trend. Only financial development is stationary at level both with time trend and without. But all the selected variables of the model are stationary at first difference both with and without time trend. The results show that there is a mix order of integration among the selected variables of the model which is the best option for using autoregressive distributed lag approach to co-integration.

Table 1

Augment Dickey-Fuller Unit Root Test		
I(0) without time Trend		**I(1) without time trend**
LCO2	-0.645377	-6.009989***
LEN	-1.409481	-6.462478***
LPD	-1.433925	-3.291666**
LGR	-0.845651	-7.183423***
LM2	-1.434999	-3.232537**
LED	-2.543081*	-5.266718***
I(0) with time Trend		**I(1) with time Trend**
LCO2	-2.213380	-5.935073***
LEN	-2.304194	-6.380315***
LPD	-1.439305	-3.535918**
LGR	-2.679454	-7.108331***
LM2	-0.931378	-3.461359*
LED	-3.188776*	-5.604950***
* 10%, **5%, ***1%level of significance		

Table 2

VAR Lag Order Selection Criteria
Endogenous variables: LCO2 LEN LPD LGR LM2 LED
Exogenous variables: C
Sample: 1971-2014

Lag	LogL	LR	FPE	AIC	SC	HQ
0	48.85410	NA	4.73e-09	-2.142705	-1.889373	-2.051108
1	320.5539	448.3047	3.68e-14	-13.92770	-12.15437*	-13.28652
2	368.5463	64.78969*	2.29e-14*	-14.52731	-11.23400	-13.33655*
3	402.3298	35.47273	3.63e-14	-14.41649	-9.603185	-12.67615
4	460.6696	43.75484	2.65e-14	-15.53348*	-9.200183	-13.24356

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

Generally, sequential modified LR test statistic (LR), Final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC) and Hannan-Quinn information

criterion (HQ) are used for lag length of the variables. Table 2 presents the results of lag length criterions. So following the sequential modified LR test statistic (LR), Final prediction error (FPE) and Hannan-Quinn information criterion (HQ) maximum 2 lag length is selected for long run empirical analysis.

ARDL bound testing results are presented in table 3, here environmental degradation is dependent variable whereas energy consumption, financial development, economic development, population density and secondary school education are independent variables of the model. F-statistic and W-statistic are used for testing the null hypothesis of no co-integration among the variables of the model. The calculated F-statistic (4.1206) is greater than the upper bound (3.6465) value of Pesaran et al., (2001) at 10 percent and the calculated W-statistic (17.7234) is greater than the upper bound (21.8788) value of Pesaran et al., (2001) at 10 percent. So the null hypothesis of no co-integration is rejected and the alternative hypothesis is accepted which supports co-integration among the model's variables. This confirms that environmental degradation, energy consumption, financial development, economic development, population density and secondary school education have cointegrational relationship in the case of Lebanon.

Table 3

Testing for existence of a level relationship among the variables in the ARDL model				
F-statistic	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
4.1206	2.9369	4.2605	2.4555	3.6465
W-statistic	95% Lower Bound	95% Upper Bound	90% Lower Bound	90% Upper Bound
24.7234	17.6216	25.5628	14.7328	21.8788

As table-3 affirms that co-integration among the selected variables of the model, exist it is now easy to fine the long run relationship among the model's variables. The long run results of the study are presented in the Table 4. The estimated results reveal that energy consumption has positive and significant relationship with environmental degradation in Lebanon. The estimates show that a 1 percent increase in energy consumption brings (0.47754) percent increase in environmental degradation and this relationship is significant at 1 percent. The estimated results reveal that population density has positive and significant relationship with environmental degradation. The results show that 1 percent increase in population density in Lebanon increases environmental degradation by (.53870) percent. The results show that economic development has positive but insignificant relationship with environmental degradation in Lebanon. The long run results reveal that financial development has positive and significant relationship with environmental degradation. The estimates show that a 1 percent increase in financial development brings (.077423) percent increase in environmental degradation in Lebanon and this relationship is significant at 1 percent. The results show that secondary school education has negative and significant relationship with environmental degradation in Lebanon. The estimates show that 1 percent increase in secondary school education decreases environmental degradation by (-.55630) percent in Lebanon and this relationship is significant at 5 percent. The overall long run results show that all the selected independent variables have theoretical correct relationship with dependent variable. Moreover, estimated long run results show that Lebanon is in early stages of economic development so there is no inverted U-shaped relationship existing between economic development and environmental degradation in Lebanon.

Table 4

Estimated Long Run Coefficients using the ARDL Approach ARDL(1,0,0,1,1,0) selected Dependent variable is LCO2 43 observations used for estimation from 1972 to 2014			
Regressor	Coefficient	Standard Error	T-Ratio [Prob]
LEN	.47754	.14688	3.5211[.003]
LPD	.53870	.26245	2.0526[.048]
LGR	.062604	.10993	.56949[.573]
LM2	.077423	.01235	6.2649[.000]
LED	-.55630	.26070	-2.1339[.040]
C	7.1383	3.4253	2.0840[.045]

Table 5

Error Correction Representation for the Selected ARDL Model ARDL(1,0,0,1,1,0) selected Dependent variable is dLCO2 43 observations used for estimation from 1972 to 2014			
Regressor	Coefficient	Standard Error	T-Ratio [Prob]
DLEN	.31645	.11778	2.6867[.011]
DLPD	.35698	.19887	1.7950[.081]
DLGR	.0017207	.053811	.031978[.975]
dLM2	.059535	.060985	.97622[.335]
dLED	-.36864	.14261	-2.5851[.014]
ECM	-.66267	.13687	-4.8415[.000]
R-Squared .54401 R-Bar-Squared .43672 S.E. of Regression .066869 F-Stat. F(6,36) 6.7606[.000] Mean of Dependent Variable .032584 S.D. of Dependent Variable .089098 Residual Sum of Squares .15203 Equation Log-likelihood 60.3504 Akaike Info. Criterion 51.3504 Schwarz Bayesian Criterion 43.4250 DW-statistic 1.6714			

Vector Error-Correction Model (VECM) is used for examining the short run dynamic among the variables of the model. The results of short run dynamic are presented in Table 5. The results reveal that energy consumption and population density have positive and significant relationship with environmental degradation in Lebanon. A1 percent increase in energy consumption and population density results in a (.31645) percent and (.35698) percent change in environmental degradation respectively in short run. The estimated short run results reveal that economic development and financial development has positive but insignificant relationship with environmental degradation in Lebanon. Secondary school education has a negative and significant relationship with environmental degradation. The results show that a 1 percent increase brings (-.36864) percent decrease in environmental degradation in the case of Lebanon. ECM has significant and negative value (-.66267) which is theoretically correct. The significant negative value of ECM shows the speed of adjustment from short run to long run equilibrium. The estimates of ECM reveal that short run needs 1 year and two month to converge in the long run equilibrium. This shows that for achieving a lowest level of environmental degradation, the

Lebanese government should need to focus on energy consumption, financial development, economic development, population density and secondary school education.

Diagnostic tests are conducted to overview the problem of serial correlation, functional form, normality and Heteroscedasticity among the model's variables. This study has investigated the impact of energy consumption, financial development, economic development, population density and secondary school education on environmental degradation in case of Lebanon over the period of 1974 to 2014. The estimated diagnostic tests results of its presented in Table 6. The results of Lagrange multiplier test of residual serial correlation show that there is no serial correlation among the variables of the model. Ramsey's RESET test using the square of the fitted values reveal that the model has correct functional form. Normality based on Skewness and Kurtosis explains that the time series data of all variables is normally distributed. The results show that there is no heteroscedasticity in the data.

Table 6

Diagnostic Tests		
Test Statistics	LM Version	F Version
A:Serial Correlation*CHSQ(1) = 1.8153[.178]*F(1,33) = 1.4545[.236]*		
B:Functional Form *CHSQ(1) = 1.4313[.232]*F(1,33) = 1.1362[.294]*		
C:Normality *CHSQ(2) = 3.5612[.169]*	Not applicable	*
D:Heteroscedasticity*CHSQ(1) = .98281[.322]*F(1,41) = .95902[.333]*		
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		

Hansen (1996) mentioned that the model misspecification may provide biased results that influence the explaining power of the results. The CUSUM and CUSUMsq tests are employed to test the parameters constancy. Further, Brown et al., (1975) pointed out that these test provide help in testing the gradual changes in parameters. The expected value of recursive residual is zero leading to accept the null hypothesis of parameter constancy is correct, otherwise not. This study has investigated the impact of energy consumption, financial development, economic development, population density and secondary school education on environmental degradation in Lebanon over the period of 1974 to 2014. The plots of both CUSUM and CUSUMsq are shown by Figure-1 and 2 at 5 per cent level of significance. Results indicate that plots of both tests are within critical bounds at 5 per cent level of significance.

Figure-5

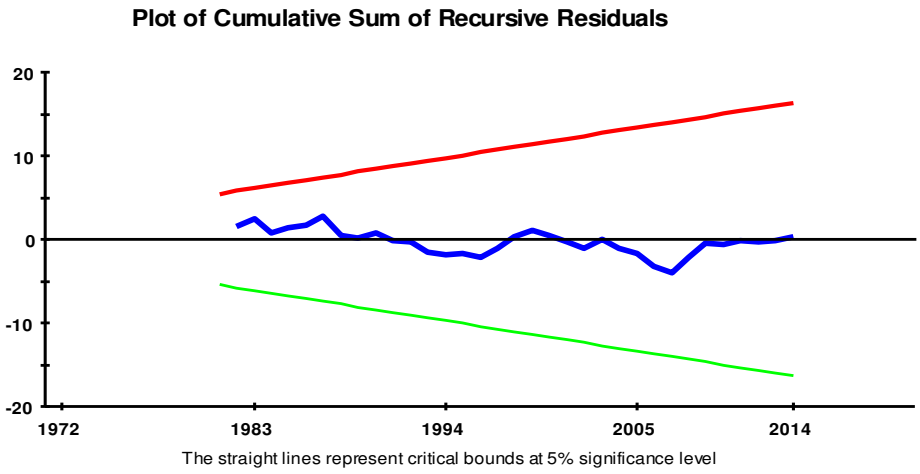
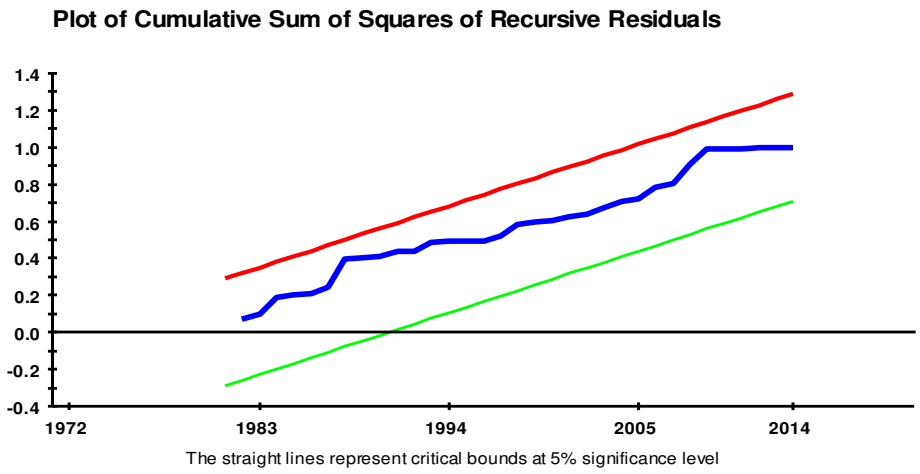


Figure-6



7. Conclusions and Policy Suggestions

This study has investigated the impact of energy consumption, financial development, economic development, population density and secondary school education on environmental degradation in Lebanon. For empirical analysis, data from 1974 to 2014 are used and were taken from the WDI data bases maintained by the World Bank. ADF unit root test has been used for examining the stationarity of the variables. ARDL bound test method has been used to find the co-integration among the model's variables. The estimated results of the study reveal that energy consumption, financial development and population density have positive and significant relationship with environmental degradation in Lebanon. The results reveal that economic development has positive but insignificant relationship with environmental degradation. The results show that secondary school education has negative and significant relationship with environmental degradation in Lebanon. The estimated results show that for reducing

environmental degradation, the Lebanese government should increase the level of education as the estimated results show that educated people like healthy environments as well as increase energy efficient methods of production. On the bases of the estimated results, it is also suggested that there is no inverted U-shaped relationship between economic development and environmental degradation in the Lebanese case.

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