# Dynamic Impact of Development and Energy Consumption Pattern on Environmental Quality: A Case Study of Selected Populous Asian Countries

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**Research**

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**Author's Contribution**
This research paper is completed by the collaborative efforts of four authors.
**Author 1 (Corresponding Author):** He wrote the initial draft of manuscript and performed statistical analysis under supervision of author 2.
**Author 2:** He guided author 1 during statistical analysis.
**Author 3:** He contributed in model estimation and by editing and refining this research paper to its final draft.
**Author 4:** He assisted author 1 in data collection and paper formatting.

**Conflict of Interest**
All authors read the manuscript carefully and declared no conflict of interest with any person or institution.

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## Abstract

The present study aims to examine the long-run and short-run effects of economic development, energy consumption pattern, trade openness and urbanization on environmental quality in ten Asian most populous economies. The analysis examines panel data from 1988 to 2018 by employing an Autoregressive Distributed Lag (ARDL) approach. The results indicate that the struggles to raise development are increasing the $CO_2$ emissions in these emerging populous countries. Moreover, the utilization of non-renewable energy sources (gas, coal, oil) is associated with high carbon emissions affecting environmental quality adversely and worsening the atmosphere at the zonal level too. Furthermore, the empirical findings highlight that urbanization and trade openness partake to the reduction of $CO_2$ emission and hence are considered environmental friendly. Finally, the government should formulate the strategies which help to reduce the use of non-renewable energy sources and promote the consumption of efficient gas energy source to raise development and better environmental quality in populous countries of Asia and hence the strategies will be helpful for the comfort and happiness of this part of the emerging region.

**Keywords**: Environmental quality, Economic development, energy consumption pattern,

ASIAN Populous countries, panel data

## 1. Introduction

The issue of environmental quality has been a primary discussion for more than 30 years in development and environmental economics on account of its several harmful effects. Carbon dioxide is a main greenhouse gas which is the major reason of the global warming and the climatic crisis. Therefore, it has caught the immense recognition of policy makers and scholars

around the world. $CO_2$ emissions are always increasing globally because of economic development, urbanization, consumption pattern, industrialization, trade openness and increased population. Among 34% of the greenhouse gas concentration from 1990 to 2013, $CO_2$ is accountable for almost 80% of that rise (NASA, 2016). IEA (2015) also announces that, $CO_2$ emissions have increased by 2.2% worldwide and 3.5% for the Asian zone in 2013 as compared to 2012.

The problem of environmental quality is the most debatable topic on account of its worldwide importance these days. Although the adverse consequences, $CO_2$ is related with development directly, such as huge emissions of $CO_2$ are produced by fuels utilization namely gas, coal and oil which are the central bases of industry and transportation (Hossain, 2012, Lamb et al., 2014). Scholars and policy makers examine that decrease of the global temperature should be important regardless of the stages of development to sustain the environmental quality. On the contrary, it is observed that forceful application of emission decrease strategies will harmfully influence the growth and development capacities of various nations (Nain et al., 2017). The empirical investigation of Andersson, F. N., & Karpestam, P. (2012), Wang et al. (2011), Narayan and Smyth (2008) & Shahbaz et al. (2013), several others endorse the second part of the debate suggesting that the sustainable economic development for an economy will be attainable by decrease of $CO_2$ emissions with appropriate improvement of low carbon technologies. Therefore, additional empirical analysis of the link between environmental quality, development & energy consumption pattern combining additional significant variables is very important in the discussion on development-energy-environment nexus.

Human activities are supposed to be the major contributors to the increase of the universal temperature as they are constantly generating greenhouse gases, for example $CO_2$ into the air. Similar to a blade, economic development can increase the welfare of the public but side by side it can harm the nearby environment, principally forests. Forests contribute to the economy and have become the chief economic source for various countries. Forests are dynamic sources that can be exploited to realize national development aims, comprising employment, investment, cleaner environment and development (FAO, 2016).

A renowned theory of Kuznet identified that there is a negative link among the growth and the environmental quality as the second is a negative outcome of the incidence of the first. Varvarigos ( 2008) examined in his academic work that environmental quality could affect the long-term economic growth. Another research by Azam (2016) pointed out that environmental quality can unfavorably influence the economic growth. Hence, in examining the development, energy and environmental quality nexus, economic development should be considered as an important variable.

Urbanization may be the important indicators for economic development and environmental quality in Asian countries. The rapid population growth will result in the growing demand for food, water, energy and other means, which in turn might lead to too much pressure and manipulation to the environment. Bran et al. (2013) analyzed that such a link will become more complex when the most population dependable on natural inputs. This situation possibly aggravates the environmental degradation and even might result in natural calamities.

The world population was about 6 billion, in the early twentieth century. 80 percent of global population was living in developing Asian countries. Indonesia and Brunei have the largest and the smallest population (Nazeer and Furuoka, 2017). The effects and rate of urbanization is different in diverse regions globally. Asia continues to urbanize rapidly and even it includes closely half of the world's largest cities. The urban population of Asian states is likely to become double, in less than 20 years. Hence, it is showing its current annual growth rate. The origins of various global environmental quality issues interrelated to water and air contamination are found in cities. (Reddy, 2004).Hence, in investigating the economic development, energy consumption and environmental quality nexus, urbanization should be taken as an important variable.

Additionally, trade openness has been interrelated together with development, energy consumption and environmental quality. Export orientated trade is an essential dynamic in clarifying inter-country changes in progression of income with investment and labor. Moreover, the increase of exportable goods is determined by the extent of energy utilization in the industry. The technology and tools employed in manufacturing and transportation for exportable goods needs resources to utilize (Sadrosky, 2011). Academically, that resources, trade & consumption

indicate a long term link however there is little observed study of this forceful link. Hence, in analyzing the environmental quality, development and energy consumption nexus, trade openness should be taken as an important variable.

Furthermore, for empirical investigation of the link among environmental quality, development and energy consumption pattern (technology) is disaggregating as 1.electricity production from gas resources (% of total), 2. electricity production from coal resources (% of total), 3. electricity production from oil resources (% of total), containing some other significant variables which is more relevant in this analysis

Fossil energy sources are becoming scarce, so the countries are also seeking for other energy fuels. For instance, in this viewpoint, for electricity production, renewable energy resources are exploited currently. Utilization of electricity is much growing for both industry & local as a result of development of the countries. (Ali, S., Anwar, S., & Nasreen, S. 2017).

Several studies have major contribution in literature on environment- development-energy nexus and point out causes and solutions for environmental quality. But, the scope of these studies is also limited due to the use of incomplete data analyses and, therefore, may not be too much effective for formulating policies. Furthermore, various dependent variables and various pollutants are applied by diverse studies and this could lead to result in different consequences. The current study allows investigating the effect of disaggregated technology into three other energy variable coal, gas and oil to determine the influence of non-renewable energy utilization pattern on environmental quality for Asian populous countries.

## 1.1 Objective of the study

The primary purpose of this analysis is to investigate the impact of disaggregated technology variable into three energy variables of coal, gas and oil on environmental quality by using STIRPAT identity for Asian populous economies. The additional aim of this analysis is to examine the effect of development, consumption pattern, urbanization and trade openness on the environmental quality of 10 largest populous Asian countries and also to develop appropriate policy based on the estimated results. The largest populous Asian countries are selected for this analysis because development, energy consumption pattern and urbanization are the major causes for environmental quality.

**1.2 Significance of the study**

The primary contributions of this analysis in the literature are discussed as: (a) as far as we know, it is the important empirical analysis of this type which contains 10 largest populous Asian countries. (b) We incorporated 'energy consumption (electricity production from gas, coal and oil)' as main variable to analyze the nexus of emissions-growth-energy that was generally not considered in the energy literature of former studies and this more likely assist to alleviate the "omitted variable bias." (c) Lastly, we started a strategy debate that could benefit the policy makers of largest populous Asian economies. This analysis is significant as our study results could offer novel opportunities for policy makers to formulate and implement an effective trade openness, development, urbanization and energy policy for the environmental quality in these largest populous Asian countries.

This paper is organized as follows: section 2 provides literature review, comprising theoretical and empirical evidence on the subject under discussion. Section 3 discusses model specification, data source and methodology. Section 4 shows empirical analysis and results of the study. Finally, section 5 shows conclusion and policy implication based on the estimated results.

## 2. Literature review

Several research studies have been investigated for the economic development analysis in developing Asian countries. These studies examine the effect of various indicators as well as the measurement of development in Asian zone. In the nationwide and worldwide perspective, the concept of development is explained with focal studies like Din (2004), Shirazi and Manap (2004), Noor and Siddiqi (2010), Halder at el. (2015), Azam (2016) and Charfeddin et al. (2018).
Many studies have a strong concern in showing whether the Environmental Kuznets Curve (EKC) overcomes in every research framework. Several studies have an interest to verify the concept that economic growth will influence environmental degradation in the way the economic stage of the nation under analysis. However, a number of other studies have made an effort to prove whether an environmental quality and consumption pattern can have either a direct or an indirect impact on economic development. Research by Omri et al. (2015) revealed that the environmental quality measuring in $CO_2$ emissions

in Northern Africa & Middle Eastern influences the economic development and conversely.

A study on the related link between environmental quality and economic development was also managed by (Toman, 2003). The study revealed that government strategies that consider investment in the natural resource sector as well as focusing on savings rates and human resource investment. Additionally, Toman (2003) emphasized that in reality factors of productions are not allocated resourcefully. It is the failure of the institution and market influencing the factors of productions & the environment that slow down the development as well. Furthermore, these factors are responsible for usage of the unnecessary natural resources too.

Din (2004) explored proposition of the growth oriented exports for South Asian nations with combining the function of importable goods. Side by side, they recommend that there is long term association amongst the exports, imports and GDP for Bangladesh and Pakistan even though a short term bi- directional causation established in India, Bangladesh and Sri Lanka after directing for imports. However, no long run link established for Sri Lanka, Nepal and India too.

Ghali and El-sakka (2004) suggest a bi-directional causation association among them. They research the long run association and causation direction among energy and gross domestic product for Canadian economy by applying VECM and co-integration technique.

Khan and Qayyum (2005) revealed that energy shows a dynamic character in the Asian states to promote and improve economic development employing ARDL method and yearly dataset over the span of 1972-2004. On the other hand, energy shortage can impede the development.

Bahmani-Oskee et al. (2005) recommends in his academic work that exports and GDP growth have co-integrating link if GDP is considered as dependent variable. It was concluded on the base of panel of 62 developing nations from the time span of 1960 to1999. However the reverse was not established true and they backing the growth oriented export postulate.

Awokuse (2008) examined the dominance of export oriented and import oriented growth postulate by applying a classical production function in the economies of Peru, Argentina, Colombia and measuring it by VAR approach. He revealed that the findings supported the import oriented growth postulate such as for the three particular countries. On the other hand impulse reaction reinforced for export oriented postulate in Argentina and Peru.

Lee and Chang (2008) endorse a long run association among capital stock, labor, energy consumption & GDP employing panel co-integration method over the yearly span of 1971-2002. They found out that their results confirm growth postulate such as one way causation moving from energy consumption to GDP as well.

Varvarigos (2008) presented in his study that environmental quality, quality of life and the total capital had an influence on the development. Moreover, when technology creates pollution beyond the critical point, then In the long run, economy will face a falling growth phase and will restore to the stable position. On the other hand, when technology creates pollution lower than the critical point, in the long run it will approaches towards improved development. In consequence, this study endorsed in the first place that environmental quality is negatively correlated to economic development.

Noor and Siddiqi (2010) investigated his academic work and revealed a negative long term association among energy and GDP in developing Asian nations. Appling FMOLS and panel cointegration, consequently, they revealed in the short term, unidirectional causation moving from energy to GDP.

Dahmardeh et al. (2012) presented his study a feedback link for 10 selected Asian developing nations between GDP & energy utilization. For the time span 1980-2008, they applied panel technique for the related elements. In short run, unidirectional causation however, in the long run, a bi-directional causation revealed among energy utilization to GDP.

Borhan et al. (2012).They analyzed that the environmental quality estimated with $CO_2$ had a considerably adverse influence on the growth by means of budget from the public. They claim that a rise in pollution will cause a fall in income and it directly reduces the output by lowering the efficiency of labor and capital. For instance, pollution could cause serious health problems and as result a number of absentees and lateness of workers may be increases at work places. Moreover, there will be worsening in the quality of the industrial tools for the reason of the air or water pollution as well. The measurements of air pollution indicate the significant impact of the population density. Population density has a negative association with $CO_2$. Consequently, this recommends that when the pollution rises, the population density might fall because it might result in human death as well.

Research by Omri et al. (2015) and Azam (2015) were similar with studies presented by Ejuvbekpokpo (2014) the study suggested, environmental quality and development have negative and significant link where CO2 is taken as measure for environmental quality. Additionally, Nigeria is well-known for the high degree of gas discharges in the world. The bigger number of discharges released into the air causes to reduce the efficiency and economic development in that state.

Halder at el. (2015) pointed out in his academic work that South Asian nations are extremely populous and keeping other factors same the populace causes to reduce economic development.

Azam (2016) presented his study that environmental quality and development have a negative and significant link and it is estimated by means of CO2 releases in nations located around ASEAN e.g. Thailand, Vietnam, Bangladesh, China, India, Indonesia, Mongolia, Malaysia, Pakistan, Philippines, and Sri Lanka. Both research by Omri et al. (2015) and Azam (2016) revealed the resemblances that CO2 emission is a proxy for the environmental quality indicator.

Obradović and Lojanica (2017) examined that energy consumption and CO2 discharges, in the short term, had no association. On the other hand, in Greece and Bulgaria, there could be a significant link in the long term such as energy consumption and CO2 discharge able to effect the economic development at the same time.

Charfeddin et al. (2018) analyzed that without compromising the economic development, improvement of better environmental quality was very challenging. Moreover, the findings of the study pointed out that by lowering the energy and electricity consumption improvement in the quality of the environment could lower the productivity and hence, slow the economic development further.

All these above studies on environment- energy-development nexus have made beneficial contributions to examine the issue of environmental quality in diverse countries. But, we could not find any empirical study that contains the analysis of measuring technology variable and allows the disaggregating energy consumption variable into three other variables for largest populous Asian countries.

## 3. Methodology and Data Analysis

To start this analysis on the effect of development and energy consumption pattern on environmental quality (which is shown and measured by CO2 emissions) in the selected Asian populous economies. In this context, the annual data has been drawn from the "World Development Indicators (WDI)" and ENERGY-stats-review-2020 for the period 1981 to 2018. We organized the countries on the basis of 10 largest populations and accessibility of annual dataset, observing that dataset on energy consumption pattern (shown as electricity production from coal, oil and gas (% of total) such as Pakistan and Philippines are mostly insufficient. For the purpose of data continuity and statistical standards, other Asian countries were not included from investigation whereas statistics of "variables of interest" showed inadequate. The ultimate choice of selected Asian populous nations is illustrated as: Iran, China, India, Indonesia, Japan, Pakistan, Philippine, Turkey, Vietnam and Thailand. However, obviously distinct, these states measure joint structures containing great dependency on non-renewable energy sources, increasing populations, topmost carbon-emission levels, and faster speed of industrial progress over the past thirty years.

**Description of the variables**

**Table 1**

| Variables | Definition | Units of measurement | Source |
|-----------|------------|----------------------|--------|
| EQ | Environmental Quality | $CO_2$, the yearly rate of per capita carbon emissions in metric tons | WDI & ENERGY-stats-review-2020 |
| DEV | Economic development | GDP per capita | WDI |
| ELG | Electricity production from gas | Electricity production from gas resources(% of total) | WDI & ENERGY-stats-review-2020 |

| | | | |
|---|---|---|---|
| ELC | Electricity production from coal | | WDI & ENERGY-stats-review-2020 |
| ELO | Electricity production from oil | Electricity production from oil resources(% of total) | WDI & ENERGY-stats-review-2020 |
| UB | Urbanization | % of urban population in total population | WDI |
| TOPP | Trade openness | Trade as a percentage of GDP | WDI |

Source: compiled by author

Environmental quality ($CO_2$ emissions is used as proxy to measure) explains the yearly rate of per capita emissions of carbon in metric tons and Urbanization estimated as %age of urban population in total population. Shahbaz et al. (2013), Pastpipatkul & Panthamit (2011), Sulaiman & Saboori (2013), Shaista Alam (2017) & Gago-de-Santos and Hanif (2017) also used the same measures in their analysis.

In the same way, economic development is estimated with GDP per capita while identical measures applied by Hanif (2017), Shahbaz et al. (2013), Sulaiman & Saboori (2013), Poumanyvong et al. (2012) & Lung and Liddle (2010). In addition, trade openness shows trade as share of GDP as well as the same measures used by Rana, R. H., et al. (2019), Ameer et al. (2016), Shahbaz et al. (2017) & Koengkan and Matheus (2018).Moreover, the STRIPAT model allows to investigate the effect of disaggregated non-renewable energy into electricity production from gas, coal and oil on environmental quality. The similar measures employed in the study of Ali, S., et al. (2017), Zaidi et al. (2018) & Shaista Alam et al. (2007)

The study applied panel data from 1981 to 2018 to analyze the influence of development, energy pattern, urbanization and trade openness on environmental quality in the Asian populous emerging nations. A Panel Auto Regressive Distributed Lag Approach is applied to analyze the long-run relationship among dependent and independent variables. In addition, the bound test is applied to check the long-run association among environmental quality and the determinants.

Lastly, "Error Correction Model (ECM)" is applied to examine the annual "speed of adjustment" from short to long run to achieve equilibrium.

## 3.1 Model specification

To investigate the effect of development and energy consumption pattern on environmental quality, the present study has employed the STIRPAT flexible ecological identity. The framework of STIRPAT can be measured as:

$$I = \alpha_0 P_t^{\alpha 1} A_t^{\alpha 2} T_t^{\alpha 3} \epsilon_t \text{--------------------------------eq(1)}$$

Where, I shows effect on environment, P shows urbanization, T shows Technology contain energy consumption. The STIRPAT method allows disaggregating the technology dynamic into numerous socioeconomic dynamics apart from the dynamics formerly involved in the STIRPAT identity. Here, $\alpha_o$ is a constant term, and $\alpha_1$, $\alpha_2$, $\alpha_3$, are the powers of urbanization, affluence, and technology and $\varepsilon$ represents the error term. Currently, we extend our study work and extended STRIPAT identity can be expressed as;

$$CO_{2t} = \alpha_0 + UB_t^{\alpha 1}.DEV_t^{\alpha 2}.\ ELG_t^{\alpha 3}.\ ELC_t^{\alpha 4}.ELO_t^{\alpha 5}.\ TOPP_t^{\alpha 6}.\varepsilon_t \text{--------------------eq (2)}$$

The linear technique of econometric model based on the STIRPAT equation can be described after taking log of equation (2) as below:

$$\ln CO_{2t} = \alpha_0 + \alpha_1 \ln UB_t + \alpha_2 \ln DEV_t + \alpha_3 \ln ELG_t + \alpha_4 \ln ELCt + \alpha_5 ELO_t + \alpha_6 \ln TOPP_{t+} \varepsilon_{it} \text{----------------------}$$
$$\text{-eq (3)}$$

Eq. (3) points out the long-run link among the regressors & regressands. Now, we combine short-run aspects into long-run eq. (3) to apply the Autoregressive Distributed Lag (ARDL) framework.

This is illustrated as equation (4).

$$\Delta \ln EQ_{it} = \varphi_0 + \sum_{j=0}^{k} \varphi 1j \Delta lnEQ_{t-j} + \sum_{j=0}^{k} \varphi 2j\ \Delta lnELG_{t-j}$$

$$+ \sum_{j=0}^{k} \varphi 3j\ \Delta lnELC_{t-j} + \sum_{j=0}^{k} \varphi 4j\ \Delta lnELO_{t-j}$$

$$+ \sum_{j=0}^{k} \varphi 5j\ \Delta lnDEV_{t-j} + \sum_{j=0}^{k} \varphi 6j\ \Delta lnTOPP_{t-j}$$

$+ \sum_{j=0}^{k} \varphi 7j \, \Delta lnUB_{t\text{-}j} + \alpha_1 lnEQ_{t\text{-}1} + \alpha_2 lnUBt\text{-}1 + \alpha_3 lnDEV_{t\text{-}1} + \alpha_4 lnELG_{t\text{-}1} + \alpha_5 lnELC + \alpha_6 ELO_{t\text{-}1} + \alpha_7 lnTOPP_{t\text{-}1+} \, \varepsilon_{it} \text{----} \, (4)$

Here, αs denotes the long-run coefficients, Δ is the first difference operator, φs indicates the short-run coefficients & εit denotes error term with zero mean is normally distributed. In addition, to confirm the "long-run co-integration, the joint null hypothesis of no co-integration" can be illustrated as:

$H_0: \alpha_1 = 0, \alpha_2 = 0, \alpha_3 = 0, \alpha_4 = 0, \alpha_5 = 0, \alpha_6 = 0, \alpha_7 = 0$

Whereas the alternative hypothesis of the presence of co-integration can be explained as follows:

$H_1: \alpha_1 \neq 0, \alpha_2 \neq 0, \alpha_3 \neq 0, \alpha_4 \neq 0, \alpha_5 \neq 0, \alpha_6 \neq 0, \alpha_7 \neq 0$

Hence, the bound test approach is applied to check the $H_o$ & the F-test of the bound approach is supposed to observe the co-integration association among the regressors & regressands. (Hanif, I., 2017). The estimated F-test of the bound approach matches with the critical values organized by (Pesaran et al., 2016). If F-statistic exceeds the upper bound critical value, this approves the long run co-integration. This will decide the "speed of convergence of the model from short-run to long-run" by employing the equation (5):

$\Delta LnEQit = \beta_o + \sum_{i=1}^{n} \alpha i \Delta lnEQ_{t\text{-}i} + \sum_{i=1}^{n} \gamma 2i \Delta lnUB_{t\text{-}i}$

$+ \sum_{i=1}^{n} \sigma 3i \Delta lnDEV_{t\text{-}i} + \sum_{i=1}^{n} \theta 4i \Delta lnELG_{t\text{-}i}$

$+ \sum_{i=1}^{n} \tau 5i \Delta lnELC_{t\text{-}i} + \sum_{i=1}^{n} \omega 6i \Delta lnELO_{t\text{-}i}$

$+ \sum_{i=1}^{n} \vartheta 7i \Delta lnTOPP_{t\text{-}I} + \alpha_1 lnUB_{it} + \alpha_2 lnDEV_{it} + \alpha_3 lnELG_{it} + \alpha_4 lnELCit + \alpha_5 ELO_{it}$

$+ \alpha_6 lnTOPP_{it+} \, \delta EC_{it\text{-}1} + \varepsilon_{it} \text{---------------------------} \text{-}(5)$

## 4. Empirical Estimation and Results

### 4.1 Summary statistics

Without logarithm, mean, median, maximum, minimum and standard deviation of all the variables are included summary statistics in table 2.

**Table 2**

|  | EQ | ELG | ELC | ELO | DEV | TOPP | UB |
|---|---|---|---|---|---|---|---|
| Mean | 163.3249 | 33.39023 | 76.66681 | 18.97252 | 11018998 | 54.21537 | 45.71222 |
| Median | 2.150905 | 24.58574 | 25.02037 | 14.1134 | 68276.78 | 45.43714 | 42.543 |
| Maximum | 9507.11 | 401.45 | 4765.048 | 92.18604 | 88948077 | 208.3067 | 91.616 |
| Minimum | 0.263108 | 0 | 0 | 0.165618 | 2780.73 | 12.21927 | 19.625 |
| Std. Dev. | 988.3295 | 47.1055 | 407.5039 | 17.82185 | 21115508 | 35.68017 | 18.88762 |

Source: Author's own calculation.

## 4.2 Testing for variance inflation factor matrix for multicollinearity.

**Table 3:**

|  | lnEQ | LnELG | LnELC | LnELO | lnDEV | LnTOPP | LnUB | VIF |
|---|---|---|---|---|---|---|---|---|
| LnEQ | 1.0000 |  |  |  |  |  |  | - |
| LnELG | 0.3882 | 1.0000 |  |  |  |  |  | 1.33 |
| LnELC | 0.2222 | -0.2259 | 1.0000 |  |  |  |  | 1.37 |
| LnELO | -0.1994 | 0.0067 | -0.4598 | 1.0000 |  |  |  | 1.52 |
| LnDEV | 0.1166 | 0.2973 | -0.2546 | 0.2869 | 1.0000 |  |  | 1.32 |
| LnTOPP | -0.0607 | 0.0597 | 0.1403 | -0.3099 | 0.1243 | 1.0000 |  | 1.33 |
| LnUB | 0.4710 | 0.3700 | -0.0594 | 0.0393 | 0.2028 | -0.2605 | 1.0000 | 1.33 |

Source: author's own calculation.

According to the condition of multicollinearity i.e VIF $\geq$ 10, the projected results of Variance inflating factor (VIF) estimates that there is no matter of multicollinearity in the model as the

VIF values of all repressors are less than 10 and it ranges from 1.32 to 1.57.

## 4.3. Testing for stationarity

Non-stationary variable produces misleading or spurious consequences. For this reason, in the panel data, stationarity is significant to evaluate the consistency of consequences as well. As a result, "the Lavin, Lin and Chu (LL&C) and Im, Pesaran, Shin (IPS) tests" are implemented to analyze the stationarity in dataset and to evade meaningless regression consequences. The results of "Panel unit root tests" are illustrated in Table 4:

Results of the "Lavin Lin and Chu (LL&C) and Im, Pesaran, Shin (IPS) tests" states that environmental quality (EQ), electricity production from gas (ELG), electricity production from coal (ELC), electricity production from oil(ELO) variables are stationary at level 1while the development (DEV), trade openness(TOPP) and urbanization(UB) variables are level stationary. Therefore, they are showing mixed integration order, I (0), I (1) for "Liven Lin and Chu (LL&C) and Im, Pesaran, Shin (IPS) unit root tests". Hence, for co-integration analysis ARDL bound approach is applied in this study.

The ARDL approach has various qualities as it deals with good features of small sample dataset but other traditional co-integration approach is appropriate only for large sample dataset. By using linear transformation, ARDL can reduce the dynamic ECM. The error lag term can be added into the general error correction model. Even though the ECM of the ARDL bound approach incorporates both short-term & long-term aspects (Sulaiman et al., 2013). Hence, this study applies this technique to examine the effect of ELG, ELC, ELO, DEV, TOPP, and UB on environmental quality in Asian populous countries.

**Table 4**

| At Level | | | | At First Difference | | Conclusion |
|---|---|---|---|---|---|---|
| Variable | | Intercept | Intercept & Trend | Intercept | Intercept & Trend | |
| Log EQ | LL & C | | | -10.1495(0.00) | -9.74399(0.00) | I(1) |
| | IPS | | | -7.78006(0.00) | -7.26768(0.00) | I(1) |
| Log ELG | LL & C | | | -7.20458(0.00) | -5.82487(0.00) | I(1) |
| | IPS | | | -7.59278(0.00) | -6.19399(0.00) | I(1) |
| Log ELC | LL & C | | | -6.54169(0.00) | -5.81417(0.00) | I(1) |

|  | IPS |  |  | -7.13384(0.00) | -6.59117(0.00) | I(1) |
| Log ELO | LL & C |  |  | **-**7.15142(0.00) | **-**5.68086(0.00) | I(1) |
|  | IPS |  |  | -7.92374(0.00) | -6.64709(0.00) | I(1) |
| Log DEV | LL & C | -0.32727(0.37) | -1.57304(0.05) |  |  | I(0) |
|  | IPS | 4.95749(1.00) | -1.38372(0.08) |  |  | I(0) |
| Log TOPP | LL & C | -1.52553(0.06) | 1.15353(0.87) |  |  | I(0) |
|  | IPS | -0.56789(0.02) | 0.74199(0.22) |  |  | I(0) |
| Log UB | LL & C | -1.87171(0.03) | -3.25107(0.00) |  |  | I(0) |
|  | IPS | 1.39974(0.91) | -0.33615(0.00) |  |  | I(0) |

Source: (LL&C) and (IPS) illustrate "the Liven Lin and Chu and Im, Pesaran, Shin tests for unit root", correspondingly & probability values are shown in parentheses.

### 4.4. Test for panel dependence

The Pesaran CD test is employed to check the cross-sectional independence. Estimator's efficiency loss and results will be spurious if cross sectional independence in valuation method is not proved. The results of the CD test are illustrated Table 5.The p-value is insignificant; as a result we will not reject H0.We conclude no cross-sectional dependence in the projected model.

**Table 5**

| Null Hypothesis: There is no cross-sectional dependence. | | | |
|---|---|---|---|
| Test | Statistic | d.f. | Prob. |
|  |  |  |  |
| Breusch-Pagan LM | 48.17171 | 45 | 0.3458 |
| Pesaran scaled LM | -0.71977 |  | 0.4717 |
| Pesaran CD | 1.29044 |  | 0.1969 |

Source: Author's own calculation

### 4.5. Bound test

To examine the co-integration association among ELG, ELC, ELO, DEV, TOPP, UB and environmental quality, a bound test method is assumed and the results are illustrated in Table 6. The F-value = 18.60076 is bigger than its upper bound critical value = 3.61at 5%. Hence, results of the "bound test" recommend a "co-integration" association among the regressors & regressands.

**Table 6:**

| Results of bound test | | | |
|---|---|---|---|
| Equation (1) | Bound Test Value | df | Conclusion |
| Log EQ/Log ELG, Log ELC , Log ELO, Log DEV, Log TOPP, LogUB | F-statistics = 18.60076 > 3.61  Probability = (0.000) | 6 | Co-integration exists |

Source: compiled by author

**4.6 Long-run Relationship: Co-integration Analysis**

ARDL approach is applied to investigate the link of electricity production from (gas, coal & oil), economic development, trade openness and urbanization with environmental quality in the long run and its results are illustrated in Table 7.

**Table 7**

| Estimates of panel ARDL approach for the long run. | | | |
|---|---|---|---|
| Dependent Variable = Log EQ Number of Observations: 260/Number of Panels:10 | | | |
| Regressors | Coefficient | Standard Error | t-statistics |
| LNELG | 0.022063* | 0.011923 | 1.850445 |
| LNELC | 0.213754*** | 0.046777 | 4.569605 |
| LNELO | 0.05313** | 0.026159 | 2.03102 |
| LNDEV | 0.1768696*** | 0.0144183 | 12.26705 |
| LNTOPP | -0.29821*** | 0.082015 | -3.63605 |
| LNUB | -0.66647** | 0.30026 | -2.21965 |

Source: compiled by author. (***, ** and *) denotes the significance level at 1%, 5% and 10%, correspondingly.

The results in Table 7 indicate that electricity production from gas (ELG) has positive and significant impact on per capita carbon emissions. More specifically, if all other factors remain same, in the long run, each 1% increase in electricity production from gas (ELG) raises per capita carbon emissions by about 0.02%.Moreover, electricity production from coal (ELC) has positive & significant effect on per capita carbon emissions .In the long run, each 1% increase in electricity production from coal (ELC) raises emissions of carbon by about 0.21%. Furthermore, electricity production from oil (ELO) has positive & significant effect on per capita carbon emissions. In the long run, each 1% increase in electricity production from coal (ELC) raises emissions of carbon by about 0.05%.Thus, non-renewable energy sources (gas, coal, oil) affect quality of environment harmfully in the panel of these Asian populous states in the long run and hence contributing major role in environmental degradation in Asian populous emerging states. These empirical results are not surprising as non-renewable energy sources are utilized to speed up economic development and to face growing energy needs. Similar to other developing states, Asian economies are facing manifold economic issues. These developing states are constantly trying to develop the living standards of their people. For the production of more things, Asian economies are utilizing extra energy fuels and producing wastage. Additionally, the influence of energy sources on $CO_2$ emissions is greater in Asian economies, for the reason that they are utilizing oil-based equipment which is less efficient. They are producing smaller quantity of things even though using extra fuel, exhausting their own atmosphere and boosting health concerns in the zone (Hanif, I., 2018). These findings are consistent with the studies scrutinized by Chiu and Chang (2009), Hossain (2011), Sulaiman et al. (2013), Sadorsky (2014), Salim & Shafiei (2014), Boluk & Mert (2015) and Jebliet al. (2016)

We reveal a positive link among emissions of carbon and economic development, proposing that 1 % increase in development (DEV) contributes per capita emissions by 1.76% on usual. Therefore, the results identify that economic growth in Asian populous countries arrives at the cost of growing carbon discharges and contamination. These results are consistent with Hanif (2018), Kais and Sami (2016), Robalino-Lopez et al. (2014) and Ziaei (2015).

The trade openness (TOPP) and urbanization (UB) have a negative & significant effect on per capita emissions in Asian nations. The estimated results show that 1% rise in trade openness (TOPP) and urbanization (UB) reduce per capita emissions by -0.29 % and-0.66 %. Urban sprawl might be environmental-friendly. Urban citizens do not utilize biomass and consume other sources in the more effective way. Hence, urbanization may cause energy transition and may independently reduce $CO_2$ emission. Side by side, trade openness (TOPP) has a negative effect on per capita emissions as a result of positive externalities such as a fall in pollution and an efficient exploitation of natural inputs. These findings are consistent with results of Sadorsky (2014), Sulaiman et al. (2013), Salim & Shafiei (2014), Boluk and Mert (2015) and Jebli et al. (2016) & Bernard et al. (2016)

**Co-integration Analysis to Determine the Short-run Relationship**:

ARDL model is used to analyze the relationship of (electricity production from gas, coal & oil), economic growth, trade openness and urbanization with environmental quality in the short run and results are illustrated in Table 8.

**Table 8**

| Estimates of panel ARDL approach for the short run | | | |
|---|---|---|---|
| Dependent Variable = Log EQ Number of Observations: 260/Number of Panels:10 | | | |
| Regressors | Coefficient | Standard Error | t-statistics |
| LNEQ(-1) | 0.996453*** | 0.008437 | 118.1055 |
| LNELG | -0.00732 | 0.006831 | -1.07171 |
| LNELG(-1) | 0.008223 | 0.006785 | 1.21192 |
| LNELC | 0.027996 | 0.01566 | 1.787721 |
| LNELC(-1) | -0.02872* | 0.015612 | -1.83932 |
| LNELO | 0.03979 | 0.013169 | 3.021519 |
| LNELO(-1) | -0.03697** | 0.013562 | -2.72582 |
| LNDEV | 0.806798 | 0.113275 | 7.122454 |
| LNDEV(-1) | -0.80534*** | 0.113321 | -7.10671 |
| LNTOPP | -0.08625 | 0.030834 | -2.79707 |
| LNTOPP(-1) | 0.097883** | 0.030231 | 3.237866 |

| | | | |
|---|---|---|---|
| LNUB | 0.244036 | 0.485745 | 0.502394 |
| LNUB(-1) | -0.24735 | 0.475983 | -0.51966 |
| C | -0.04891 | 0.077295 | -0.6327 |

Source: compiled by author. (***, ** and *) denotes the significance level at 1%, 5% and 10%, appropriately.

Table 8 illustrates that 0.996% of carbon emissions in a certain period is linked with 1% increase in emissions of carbon in the past period. Additionally, in the short run, electricity production from coal & oil, and development make a negative while trade openness indicates a statistically significant & positive impact to emissions of carbon. The results indicate if all other factors remain same. Each 1% increase in electricity production from coal & oil, development, trade openness contributes to-0.028%, -0.036%,-0.805% & 0.097% carbon emissions in the short run. At the same time, electricity production from gas & urbanization make no significant short-run effect on carbon emissions.

**Table 9**

| Results of panel (ECM) | | | |
|---|---|---|---|
| Dependent Variable = Log EQ Number of Observations: 260/Number of Panels:10 | | | |
| Regressors | Coefficient | Standard Error | t-statistics |
| LogELG | 0.022063* | 0.011923 | 1.850445 |
| LogELC | 0.213754*** | 0.046777 | 4.569605 |
| LogELO | 0.05313** | 0.026159 | 2.03102 |
| LogDEV | 0.1768696*** | 0.0144183 | 12.26705 |
| LogTOPP | -0.29821*** | 0.082015 | -3.63605 |
| LogUB | -0.66647** | 0.30026 | -2.21965 |
| ΔLogELG | 0.052615 | 0.040705 | 1.292612 |
| ΔLogELC | 0.072303 | 0.07753 | 0.932581 |
| ΔLogELO | 0.048421* | 0.027897 | 1.735729 |
| ΔLogDEV | 0.470717** | 0.175514 | 2.681935 |
| ΔLogTOPP | 0.009514 | 0.038489 | 0.247177 |
| ΔLogUB | 3.822772 | 2.648561 | 1.443339 |

| $EC_{t-1}$ | -0.20179** | 0.076728 | -2.62991 |
|---|---|---|---|
| Test Statistics | LM Version | F Version | |
| Serial Correlation | Chi2 (6) = 1.5311(0.216) | F(1,17) = 1.0220(0.326) | |
| Functional Form | Chi2 (6)= .22247(0.637) | F(1,17) = .14124(0.712) | |
| Normality | Chi2 (6)= 0.34427(0.842) | -- | |
| Heteroscedasticity | Chi2 (6)= .45991(0.498) | F(1,25) = .43323(0.516) | |

Source: compiled by author. (***, ** and *) denotes the significance level at 1%, 5% and 10%, correspondingly. First difference operator is Δ.

In conclusion, the "error correction term ($EC_{t-1}$)"has a statistically significant & negative coefficient, which indicates long-run link of electricity production from (gas, coal & oil), economic development, trade openness and urbanization with carbon emissions. Hence, the model converges to reach equilibrium and the 20.1% error will be adjusted each year from short-run to long-run as shown by the negative sign of the error correction term.

The results of several "diagnostic tests" are illustrated in the bottom part of Table 9. The results more indicate that "serial correlation" does not occur among the error term & emissions of carbon. The "sensitivity analysis" permits all "diagnostic tests such as the LM test for serial correlation, the normality test of residual term, and the "white heteroscedasticity test". "The Ramsey RESET test is also employed to test the stability of the model the graphs of the cumulative sum of recursive residual (CUSUM) and the CUSUM of the squares are plotted." These findings are similar to the studies conducted by Hanif (2019).

### 4.7. Stability test

Diagrams 1 & 2 illustrate that the "CUSUM and CUSUM of the squares are plotted graphically between the upper and lower critical bounds of the 5% level of significance". Hence, the two diagrams endorse the stability of the estimated model.

**Diagrams:**
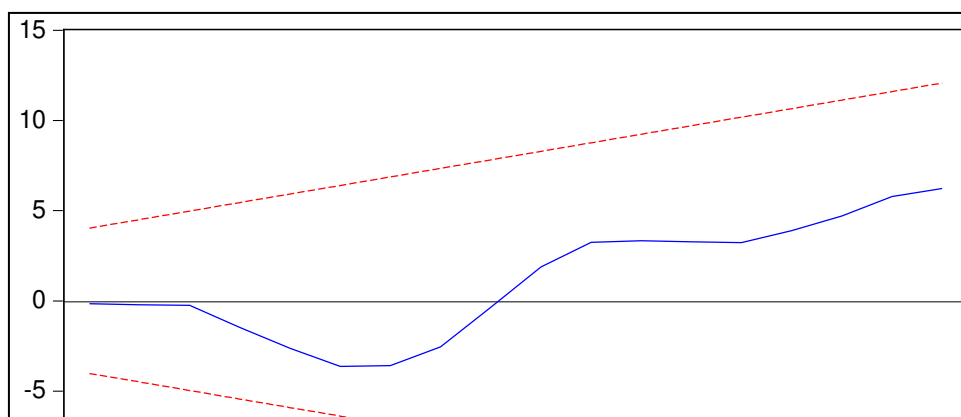
Note: Straight lines represent the critical bounds at the 5% significance level. Diagram. 1. Plot of Cumulative Sum of Recursive Residuals
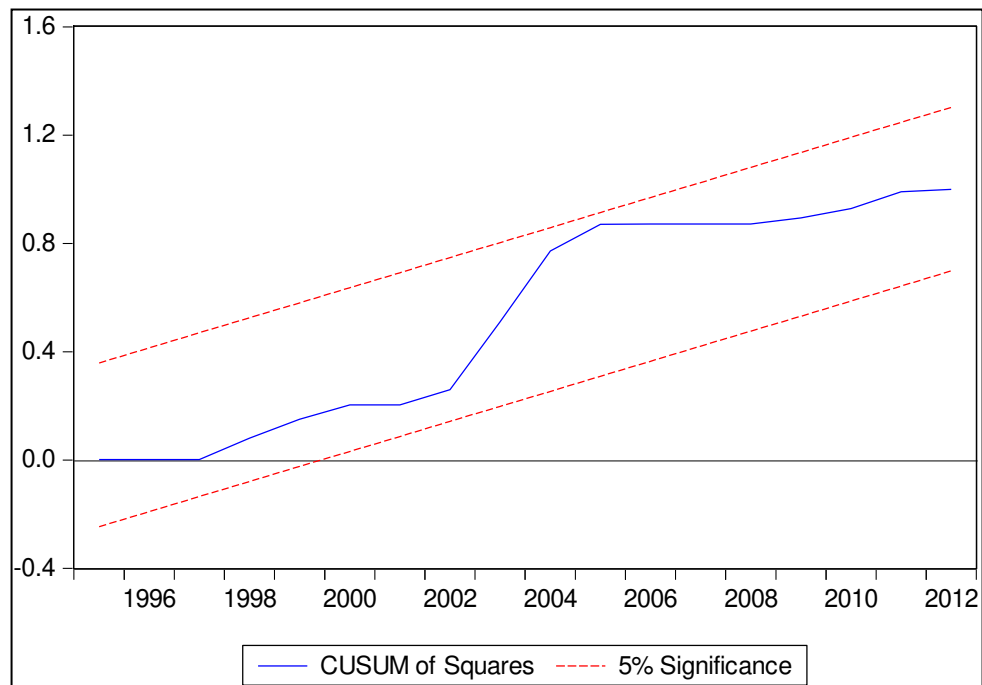


Note: Straight lines represent the critical bounds at the 5% significance level. Diagram 2, graph of Cumulative Sum of Squares of Recursive Residuals.

## 5. Conclusion and Policy Recommendation

This present analysis has tried to support the theories that electricity production from (gas, coal & oil), economic development, trade openness and urbanization partake to the production of emissions of carbon and hence impact on environmental quality in Asian populous countries. We have analyzed the efficiency of disaggregated technology measuring as electricity production from gas resources (% of total), electricity production from coal resources (% of total) and electricity production from oil resources (% of total) also. Many researchers have employed diverse methodologies to scrutinize the association between development and energy consumption pattern in individual and panel of countries with respect to environmental quality. The methodology applied in this paper, highlighted the long-run and short-run effects and analyzes the effect of energy consumption pattern, economic development, trade openness and urbanization on environmental quality.

We can conclude, based on robust empirical results that the speedy degradation of the regionals environment has been due to huge utilization of non-renewable energy sources (gas, coal, oil) to advantage economic growth. In fact, the most of environmental concerns in the Asian region are intensified by the non-renewable energy sources. The study recommends new and efficient energy source to improve development rapidly alongside better environmental quality in Asian countries. The electricity production from gas, coal and oil has significant and positive impact 0.02%, 0.21% and 0.05% respectively on environmental quality. Natural Gas as fuel is more environment-friendly, cheaper and efficient energy source than oil & coal. The results of this paper recommended that Government should formulate the policies which help to promote gas energy source to raise development and better environmental quality in Asian countries.

Our study points out that regional organizations should perform a vigorous participation in augmenting the capability to learning from advanced states regarding awareness programs, good practices and improvements to regional cooperation. Side by side, strong measures should be introduced and implemented to cope with recent environmental challenges in the zone.

Moreover, on the topic of key development and environmental policies, there is a need in Asian populous countries to authorize civil society so that they would be able to predict the widespread Pollution picture. Such zonal level moves will be beneficial in decreasing the utilization of energy fuels and encouraging environmentally friendly economic development. In Asia, zonal discussions should be held to improve strategy structures for cooperation among contributors to grab environmental challenges. In conclusion, rapid development and worldwide environmental issues need both regional and sub-regional cooperation with active environmental governance policies. Future research can be focused to analyze the environmental impacts of other possible dynamics such as population growth, foreign direct investment, industrial development, financial development and renewable energy consumption in this region.

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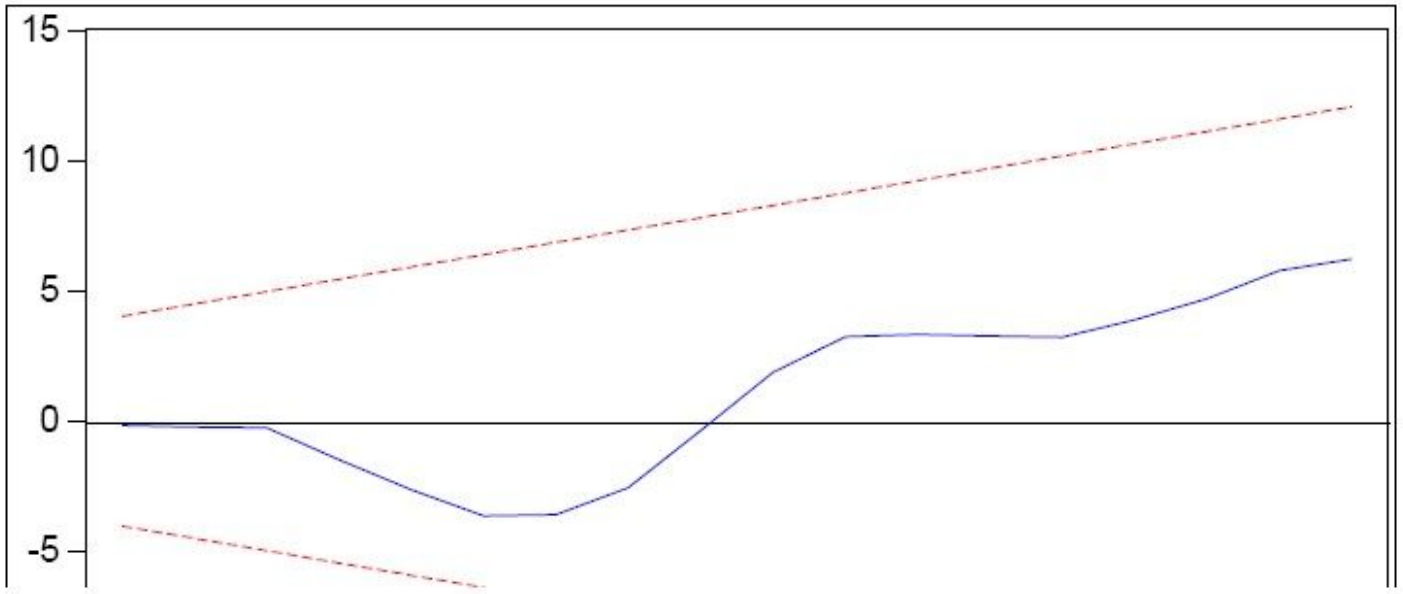# Hafiz Mohammad Afzal Muzammil

# Figures



**Figure 1**

Diagram. 1. Plot of Cumulative Sum of Recursive Residuals. Note: Straight lines represent the critical bounds at the 5% significance level.
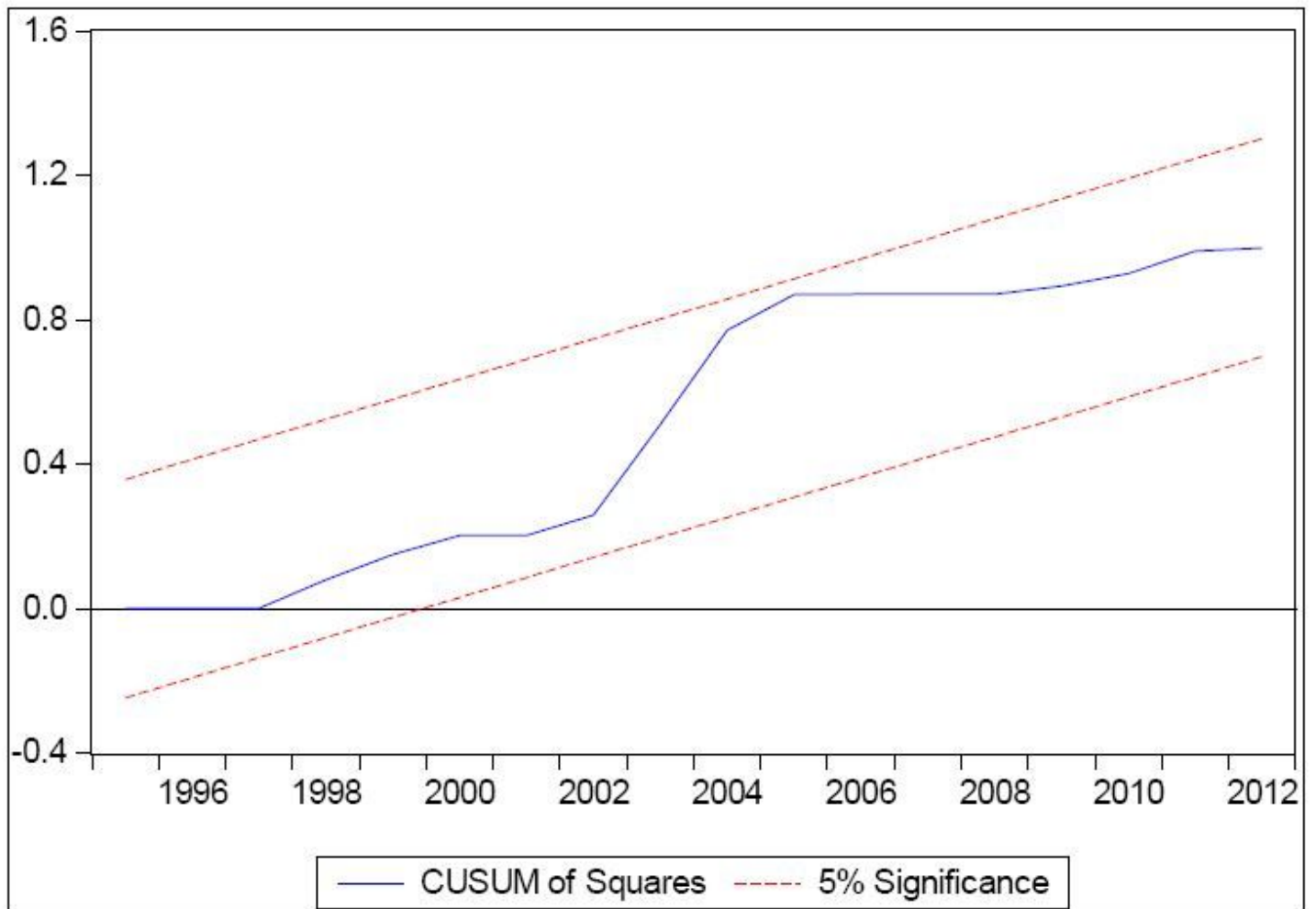
**Figure 2**

Diagram 2, graph of Cumulative Sum of Squares of Recursive Residuals. Note: Straight lines represent the critical bounds at the 5% significance level.