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Environmental Kuznets Curve (EKC) for Bangladesh: Evidence from Fully Modified OLS Approach

Bangladeş için Çevresel Kuznets Eğrisi (EKC): Tam Modifiye Edilmiş OLS Yaklaşımından Kanıtlar

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ÖZ

Bu çalışma, birçok araştırmacının çevresel bozulma ile ekonomik büyüme arasındaki ilişkiye ilişkin ampirik kanıt ve ilişkiye ilişkin kanıtlar sunmasına rağmen, metodolojik ve kapsam yönlerinden benzersizdir. Bu çalışmanın amacı, Bangladeş için Çevresel Kuznets Eğrisi (EKC) hipotezini tahmin etmektir. 1972'den 2013'e kadar mevcut veriler kullanılarak, uzun dönem için FMOLS (Tam Değiştirilmiş Sıradan En Küçük Kareler) yaklaşımı, Engle-Granger ve Phillips-Ouliaris eşbütünleşme testi ve kısa dönemli ilişkinin araştırılması için Granger nedensellik testi kapsamında EKC hipotezinii tahmin ettik. Çalışma, ekonomik büyümenin artmasıyla enerji tüketiminin arttığını ve dolayısıyla kirliliğin arttığını göstermektedir. Ayrıca Bangladeş'te yenilenemeyen enerji tüketiminin, kirliliğin (sera gazı emisyonu) başlıca nedeni olduğunu ortaya koymaktadır. Çalışma ayrıca Bangladeş için ters U şeklinde bir EKC'yi doğrulamaktadır. Başlıca politika önerisi, kirliliği azaltmak ve daha yüksek ekonomik büyümeyi teşvik etmek için yenilenebilir enerji kaynaklarının kullanımını teşvik etmektir.

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ABSTRACT

This study is unique from methodological and contextual aspects despite many researchers show the empirical evidence and nexus between environmental degradation and economic growth. The goal of this study is to estimate Environmental Kuznets Curve (EKC) hypothesis for Bangladesh. Using the data available from 1972 to 2013, we estimated EKC under FMOLS (Fully Modified Ordinary Least Square) approach, Engle-Granger, and Phillips-Ouliaris cointegration test for the long run, and Granger causality test for a short-run relationship. The study shows that energy consumption increases with the increase in economic growth, thereby pollution increases Moreover, it reveals that non-renewable energy consumption is the primary cause of pollution (greenhouse gas emission) in Bangladesh. The study also confirms an inverted U-shaped EKC for Bangladesh. The major policy recommendation is to stimulate the use of renewable energy sources to reduce pollution and to promote higher economic growth.

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1. Introduction

Simon Kuznets, the recipient of the Third Nobel Prize (1971), explains the correlation between economic growth and the degree of income disparity in society (Kuznets, 1955). It postulates that the degree of income inequality rises in the first step of economic growth and then declines. This correlation, commonly known as the Kuznets curve, is seen by the concave curve (inverted U-shape). The Environmental Kuznets Curve (EKC) hypothesis introduced by Grossman and Krueger (1991) with the analysis of the effects of NAFTA on environmental pollution indicates that economic growth contributes to environmental devastation at the early stage, but after a certain time, as income surges, the quality of the environment begins to improve.

Globally, the climatic condition is one of the key aspects of green sustainability. With the Industrial Revolution worldwide, greenhouse gas emissions (GHGs) have risen sharply in recent years. Carbon emissions (Emissions of greenhouse gases) trigger surface temperature, directly affecting precipitation, glacier and sea ice melt, sea level, and other effects. Bangladesh is one of the coastal countries prone to be suffered from the consequences of climatic changes Bangladesh's geographic position is from 20'34N to 26'38N latitude and from 88'01E to 92'41E longitude. To the south of Bangladesh are the Bay of Bengal and the Indian Ocean. As a consequence, the nation is now in peril from the climatic change viewpoint.

Over the past decade, Bangladesh has a relatively steady growth rate (approximately 6 percent). Real Gross Domestic Product (GDP) Per-capita (Constant 2010 US$) of Bangladesh continues to grow at an average of 5.16% annually throughout 2008-2013. This increase in earnings has raised energy consumption demand to an enhanced degree. Energy consumption (kg of oil equivalent) grew on average 4 percent, and total Carbon Dioxide Emissions (CO2) raised on average 7.83 percent in these years. Environmental effects are also fatal : sulfur dioxide pollution, CFC emissions, deforestation, and water pollution have detrimental impacts on the environment. The recent increase in GDP per capita and the increase of environmental deterioration like CO2 pollution, the environmental responsibility across the region, on the other hand, rendered Bangladesh a fascinating and appealing candidate for an empirical study to evaluate what track ecological damage and income pursue.

The research aims to quantify the EKC hypothesis and investigate how the variables are led to the onset and provide decision-makers with some feasible recommendations. This work is formed based on annual data sets obtained from the data bank of World Bank, and FMOLS is used to quantify the variables. We use the Engle-Granger cointegration test (Engle & Granger, 1987) and Phillips-Ouliaris cointegration tests to analyze the long-term relationship (P. C. B. Phillips & Ouliaris, 1990).

From both theoretical and political perspectives, the analysis has made a significant contribution. As the mixed results of the EKC hypothesis have already been disclosed by numerous studies, the ongoing study has made a meaningful contribution to the established body of information about the nexus between economy and the environment. It developed a curve form that will add value to the available curves in current literature. Furthermore, through this analysis, the significance of different economic forces in environmental sustainability has been freshly assessed. The research has indicated how greenhouse gases are tied to the economic growth of Bangladesh as a developing nation.

The findings from this research supported decision leaders in a variety of areas. Bangladesh, as a developing nation, has managed to maintain a steady development over the past decade. Subsequently, to ensure sustainable growth, the prospect of its environmental devastation must be of utmost relevance. The proposed findings of this study would assist the nation's legislators in devising effective green policies in Bangladesh.

Apart from thisBangladesh is prone to climatic changes as a coastal region. It is also possible for the international community dealing with the environmental climate change globally to plan strategies to save the Bay of Bengal coastal zone.

2. Review of Literature

We organized the current research on this issue into two categories. Firstly, many empirical research supports the prevalence of the Environmental Kuznets Curve (EKC) for numerous environmental depletion indicators, Such as Panayotou (1993), Selden and Song (1994), Balaguer and Cantavella (2016), Saboori, Sulaiman and Mohd (2012),. Secondly, several studies found that there is no recognition of EKC (Holtz-Eakin & Selden, 1995), (Cole & Elliott, 2003), (Roca & Alcántara, 2001), (Al-Mulali, Solarin, & Ozturk, 2016). Nevertheless, Fodha and Zaghdoud (2010) explored diversified outcomes for different environmental variables.

The existing researches may also be separated into two further groups: (a) analyses utilizing the EKC model's quadratic specification, and (b) research papers including the EKC model's cubic term. In addition, N-shaped correlations were observed in previous studies (Özokcu and Özdemir, 2017); (Pal and Mitra, 2017). But in Tunisia, Fodha and Zaghdoud (2010) discovered EKC for sulfur dioxide and a rising carbon-di-oxide emission relationship. Acaravci and Ozturk (2010), however, considered the EKC hypothesis in their EU analysis for only two nations: Denmark and Italy. Besides, the long-run nature of EKC was discovered by Nasir and Ur Rehman (2011), where no relationship was identified in the short-run in Pakistan.

Some recent studies have also yielded conflicting results; Yıldırım, Yıldırım, and Demirtas (2019) discovered a bidirectional causality between energy consumption and economic growth for BRICS-T countries while analyzing the relationship between energy use and economic growth. Another research in Kenya confirms an inverted U-shaped curve, concluding that energy consumption increases CO2 emissions by 3.6 percent over time (Sarkodie & Ozturk, 2020). Erdoğan (2019) finds that a 1% rise in economic growth raises carbon emissions by 0.79 percent, but a 1% increase in carbon emissions contributes to 0.5 percent economic growth in a separate analysis on BRICS-T countries. Increased carbon emissions decrease life expectancy at birth and escalate child mortality rates (Erdoğan, Yıldırım, & Gedikli, 2019). The presence of an inverted U-Shape curve in the Malaysian economy was also verified using the Quantile Autoregressive Distributed Lag (QARDL) process (Suki, Sharif, Afshan, & Suki, 2020). When using ecological footprint, nevertheless, Arshad Ansari, Haider, and Khan (2020) found a mixed bag of findings for the existence of EKC. EKC, therefore, works for countries in Central and East Asia, but not for those in West, South, or Southeast Asia.

Another recent study (Erdoğan, Yıldırım, Yıldırım, & Gedikli, 2020) found that the Environmental Kuznets Curve (EKC) hypothesis is null and that developments had no statistically significant impact on the electricity, transportation, and other sectors in the long run. Furthermore, while increased innovation in the manufacturing sector results in lower carbon emissions, increased innovation in the construction industry results in higher carbon emissions. A more recent study (Dogan & Inglesi-Lotz, 2020) gathered evidence from European countries and concluded that economic structure, while not confirming the EKC hypothesis, does corroborate a U-shaped relationship. The manufacturing sector lowers pollution by designing and implementing energy-efficient and environmentally friendly technologies. EKC hypothesis is not true, according to Dogan, Ulucak, Kocak, and Isik (2020), and energy intensity and energy structure are crucial determinants of environmental degradation.

The number of works on ecological concerns is distinctly limited in BangladeshSAARC countries, like Bangladesh, were researched by Rehman and Rashid (2017). Islam and Shahbaz (2012), on the other hand, analyzed Bangladesh's business openness, fuel use, population density, and environmental sustainability. "A few other analyses comprise waste and pollution and suspended specific matter (Shahbaz, Mahalik, Shah, & Sato, 2016) (Miah, Masum, Koike, Akther, & Muhammed, 2011). Nevertheless, Shahbaz, Salah Uddin, Ur Rehman, and Imran (2014) reached the EKC hypothesis based on the research they conducted on industrial growth and greenhouse gas emissions. Although these studies demonstrated an inverted U shaped curve utilizing simple OLS, no one has so far conducted any investigation in Bangladesh using the Fully Modified Ordinary Least Squares (FMOLS)

3. Data and Research Methodology

To consider the scenario in Bangladesh, the analysis contains annual frequency details for the period 1972-2013. The rationale for choosing time series data up to 2013 is after this period, the present government of the country has adopted some policies of an intricate blending of adaptation and mitigation based schemes to achieve energy efficiency and conservation, such as Mujib Climate Prosperity Plan up to 2030, Forest and Carbon Inventories, and Energy Efficiency and Conservation Master Plan up to 2030. For the study, statistical data on CO2 release (in metric tons per capita), energy usage (in kg of oil corresponding per capita), real GDP per capita (GDP, constant 2010 US dollar) trading openness (measured by utilizing imports and exports as a share of Gross Domestic Product) and urban development (assessed considering urban population growth as a share of the national population) have been gathered/collected from the online database of the World Development Indicator (WDI).

Although the EKC is analyzed in a number of analytical research, the majority of them use polynomial regression, commonly defined as the parametric model. There can be both pros and cons to this function. For example, in contrast to non and semi-parametric models, the parametric model of the EKC function is indeed simple to implement. It is a kind of black box since it covers much than it reveals (Panayotou, 1997). Turning point is one of the complexities because for majority of the cases, this sort of model indicates an estimated and conveniently feasible turning point. In the real world, though, this might not be accurate. Apart from parametric methods, the use of semiparametric methods also does not remove these difficulties. As a result, the use of reduced form functions in the experiments could be favored in spite of its drawbacks.

There are very few attempts in the history of literature to evaluate the extent of environmental damage with the effects of FDI, Trade Accessibility, Resource Use, and Population only for Bangladesh combined. The attempts to evaluate the extent of environmental damage with the effects of FDI, Trade Accessibility, Resource Use, and Population in Bangladesh are extremely few. Up to date, only four articles have independently analyzed the quality of the environment in Bangladesh. . However, the influence of FDI on the environment cannot be evaluated by any researcher. The EKC model's econometric specification describes the estimated pollution of environmental contaminants from the country. Since CO2 gas is the country's dominant force as well as worldwide environmental damage, we will introduce a model to assess Bangladesh's CO2 emissions. The EKC model's general form can be written as: -

$$\boldsymbol{CO_{2t} = \beta_1 + \beta_2 Y_t + \beta_3 Y_t^2 + \beta_4 EC_t + \beta_5 UP_t + \beta_6 IFDI_t + \beta_7 TO_t + e_t} \quad (1)$$

Where CO2t is the per capita emission of CO2 in metric tonnes,, Yt is per-capita GDP (constant at 2010 US dollar), Y2t is the square of per-capita GDP, ECt is per-capita consumption of energy (kg 0f oil equivalent), UPt for the growth rate of the population in urban areas, IFDIt for Bangladesh's internal FDI, TOt for trade openness proportion, t denotes time and et for the error term. The coefficients of β2 and β3 should be positive and negative if the EKC hypothesis is valid. The β4 sign is supposed to be positive since economic activity can be improved, and CO2 pollution can be induced by a large rise in energy use (Farhani, Chaibi, & Rault, 2014) and (Kohler, 2013). The β5 sign is indicated by two previous studies (Sharma, 2011) and (Sharif Hossain, 2011) that stated countries with comparatively middle and low incomes are urbanized less than countries with large incomes. This means that the expected sign of urban population will be diverse as it depends on the economic standard of the respected country, and as a result, the sign of β6 is expected to be mixed. . The inflow of FDI positively affects the emission level of the country when it boosts industrialization, but it has a negative or reduced effect on emission when it maximizes the inflow of higher technology. Generally, the technologically lower developed countries expect negative internal FDI. . Finally, the predicted β7 sign is complicated in that it depends on the level of economic growth of the nation (Halicioglu, 2009), its output policy and the extent of conformity with the environment. For other emerging economies, this metric is projected to be negative when it adopts a lower production strategy for pollution-intensive goods and services. They like to buy or grow companies in countries that depend on comparatively low environmental regulations. Thus, if the country has stringent environmental laws and therefore does not export pollution-intensive goods, the outcome would be negative.

Initially, the Fully Modified Ordinary Least Squares (FM-OLS) regression was developed by two researchers (Peter C. B. Phillips & Hansen, 1990) to incorporate optimum estimates of cointegrating regression in work. The method alters least squares to account for the serial correlation consequences and for the endogeneity in the independent variables that arise from the presence of interaction of cointegrating. It facilitated polynomial regression of deterministic variables, stationary error, and integrated procedures. The errors can serially be associated, and the regressors can be endogenous (Hong & Wagner, 2011). To measure the cointegration of the factors, we used the FMOLS in this article. The FM estimator functions well with other ways of estimating cointegrating associations, such as (P. C. Phillips & Loretan, 1991), (Hargreaves, 1994), (Hargreaves, 1994), (Cappuccio & Lubian, 1992). This method (FMOLS) is capable of estimating nonstationary I(1) data where it can use standard regression techniques (OLS) of the nonstationary (unit root) data to add to the problem of spurious regressions.

4. The Model and Diagnostic Tests

4.1. Unit-root test

Testing the order of data, the integration for each variable is crucial. We applied two widely used approaches: the Phillips Perron (PP) test and the Augmented Dickey-Fuller (ADF) test with the trend and intercept to analyze the existence of a unit root in each variable.

Table 1: Unit root test results for all variables

a) Augmented Dickey-Fuller (ADF) Test

I(0)			I(1)		
Variable	t-statistics	P-value	Variable	t-statistics	P-value
CO_{2t}	1.777	1.00	$D(CO_{2t})$	-5.015	0.00
Y_t	3.871	1.00	$D(Y_t)$	-5.596	0.00
Y_t^2	10.190	1.00	$D(Y_t^2)$	-8.912	0.00
EC_t	0.344	0.998	$D(EC_t)$	-7.888	0.00
UP_t	-2.504	0.324	$D(UP_t)$	-3.849	0.02
$IFDI_t$	0.052	0.995	$D(IFDI_t)$	-5.342	0.00
TO_t	-2.377	0.385	$D(TO_t)$	-11.280	0.00

b) Phillips Perron (PP)

I(0)			I(1)		
Variable	t-statistics	P-value	Variable	t-statistics	P-value
CO_{2t}	0.271	0.997	$D(CO_{2t})$	-6.611	0.00
Yt	5.712	1.00	$D(Y_t)$	-5.559	0.00
Yt^2	11.547	1.00	$D(Y_t^2)$	-8.954	0.00
EC_t	0.882	0.997	$D(EC_t)$	-7.888	0.00
UP_t	-2.562	0.298	$D(UP_t)$	-3.939	0.01
$IFDI_t$	-1.297	0.874	$D(IFDI_t)$	-8.122	0.00
TO_t	-2.372	0.387	$D(TO_t)$	-7.668	0.00

The null hypothesis for both approaches for testing the unit root of the data is:-

$H_0 = CO2_t/ Y_t/ Y_t{}^2/ EC_t/ UP_t/ IFDI_t/ TO_t$ has a unit root.

For each variable, we tested this hypothesis independently. We'll accept or reject the null hypothesis according to the P-value. There are two simple criteria:

1. P-value > 0.05 data is not stationary.
2. P-value < 0.05 data is stationary.

All data is stationary at level I(1), according to the outcome of table 2. Since the P-values for all variables are greater than 0.05 at I(0).

4.2. Fully Modified Ordinary Least Squares (FMOLS)

FMOLS illustrates robust results from an estimated model. This confirms the robustness of the long-term outcome. FMOLS estimators are clear of serial correlation, issue of endogeneity and often have small samples of unbiased outcomes. Therefore, it is not necessary to explore serial correlation problems and endogeneity problems when calculating FMOLS as different kernels for estimating FMOLS are available. The two commonly used kernels are i) the kernels of Bartlett and Quadratic Spectral (QS) ii) and for different bandwidth alternatives. We have considered both kernels here to determine whether the selection of the kernel has any noticeable effect on the efficiency of the estimator and measure. We decided to use Andrews Bandwidth (Data Based Rule) for both kernels in this test. Table 2 shows the result

Table 2: Result of FMOLS

i. Test with Bartlett kernel

Dependent Variable: CO_2 emission Method: Fully Modified Least Squares (FMOLS) Sample duration (after adjustments): 1973-2013 Observations Included: 41 adjusted Cointegrating equation deterministic: C Long-run covariance estimate (Bartlett kernel, Andrews bandwidth =38.9599)				
Variable	Coeff.	Std. Error	t-Statistic	Prob.
Y	0.00027	3.30E-05	8.363	0.00
Y2	-1.04E-07	1.46E-08	-7.121	0.0000
EC	0.002565	8.09E-05	31.710	0.000
UP	-0.00039	0.000149	-2.665	0.011
IFDI	-0.00697	0.001558	-4.479	0.000
TO	-0.00039	8.51E-05	-4.620	0.000
C	-0.24384	0.005180	-47.07	0.000

ii. Test with Quadratic Spectral (QS)

Dependent Variable: CO_2 emission Method: Fully Modified Least Squares (FMOLS) Sample (after adjustments): 1973-2013 Included observations: 41 adjusted Cointegrating equation deterministic: C Long-run covariance estimate (Quadratic-Spectral kernel, Andrews bandwidth = 57.2105)				
Variable	Coeff.	Std. Error	t-Statistic	Prob.
Y	0.000274	1.77E-09	155120.7	0.000
Y2	-1.02E-07	7.81E-13	-130902.8	0.000
EC	0.002563	4.33E-09	591627.3	0.000
UP	-0.000413	7.99E-09	-51754.62	0.000
IFDI	-0.006966	8.34E-08	-83499.75	0.000
TO	-0.000389	4.56E-09	-85416.50	0.000
C	-0.243108	2.77E-07	-876218.8	0.000

According to the results of two different kernels, the differences in the result are insignificant.

The probability for all variables in each test is highly significant. In the long run, the coefficient for GDP was found positive (0.00027), and the coefficient for GDP square was found negative (-1.02/ -1.04), and both are significant. , Thus, our results showed that the situation as B2 > 0, B3 < 0, that confirms the presence of the Environmental Kuznets Curve in the long run for Bangladesh.

4.3. Cointegration test

A statistical feature of time series variables is cointegration. If each of the variables is integrated with order 1 [I(1)], and there are variable coefficients integrated with order 0 [I(0)], so the variables are integrated with each other. In time-series research, cointegration has become a significant property. In several instances of the cointegration test, two approaches are generally employed. The Engle-Granger test (Engle & Granger, 1987) and the test developed by Phillips-Ouliaris (P. C. B. Phillips & Ouliaris, 1990). We formulate and illustrate both tests in this article to ensure the robustness of cointegration. Table 3 and 4 shows the test result for both.

Table 3: Result of Engle-Granger Cointegration test

Engle-Granger Cointegration Test Equation: UNTITLED Specification: CO_2 Y Y^2 EC UP IFDI TO C H_0: No cointegration among the series Lag specification Automatic (Lag=1 based on Schwarz Information Criterion, maximum lag=3)		
	Value	Prob.*
Engle-Granger z-statistic	-123.0555	0.000
Engle-Granger tau-statistic	-7.820084	0.000
Long-run residual variance	0.000113	
Number of lags	1	
Number of observations	40	
Rho – 1	-1.382072	
Rho S.E.	0.176734	
Residual variance	2.29E-05	
Number of stochastic trends**	7	

Engle-Granger Test Equation: Dependent Variable: D(RESID) Method: Least Squares				
Variable	Coeff.	Std. Error	t-Statistic	Prob.
RESID(-1)	-1.382	0.176	-7.820	0.000
D(RESID(-1))	0.550	0.132	4.159	0.000

i. Result of Phillips-Ouliaris Cointegration test

Equation: UNTITLED
Specification: CO_2 Y Y^2 EC UP IFDI TO C
Cointegrating equation deterministic: C
Null hypothesis: Long-run variance Series have no cointegration
Estimate (Bartlett kernel, Andrews bandwidth = 0.8653)
No degrees of freedom adjustment for variances

	Value	Prob.*
Phillips-Ouliaris z-statistic	-36.203	0.033
Phillips-Ouliaris tau-statistic	-5.7579	0.029

Phillips-Ouliaris Test Equation:
Dependent Variable: D(RESID)
Method: Least Squares
Sample (adjusted): 1973 2013
Included observations: 41 after adjustments

Variable	Coeff.	Std. Error	t-Statistic	Prob.
RESID(-1)	-0.883	0.155	-5.687	0.000

As per the Engle-Granger test findings, the probability of the test indicates that for both normalized autocorrelation coefficients) and tau-statistic (t-statistic), the zero cointegration (unit root in the residuals) null hypothesis at 5% level is rejected (z-statistic). Another aspect is at a 1 percent level of significance, tau-statistic rejects. This proof strongly shows that the variables are cointegrated.

Using Bartlett Kernel and Andrews Bandwidth 0.8653, this model measured long-term variance and one-sided long-term variance. The P-values of this test demonstrated that the null hypothesis of no cointegration (unit root in the residuals) is rejected at approximately 1 percent significance level. So, it illustrates that the variables are cointegrated together.

4.4. Granger causality test

Correlation does not indicate a consistent causation. There are many correlations available that are actually spurious or irrelevant. Granger (1969) developed a causality test on whether X affects Y and vice versa to analyze the true relationship. Table 5 shows the result.

Table 5: Result of Granger Causality

Null Hypothesis:	**Obs.**	**F-Stat.**	**Prob.**
Y does not Granger Cause CO2	38	7.240	0.000
CO2 does not Granger Cause Y		0.336	0.798
EC does not Granger Cause Y	38	0.628	0.602
Y does not Granger Cause EC		6.423	0.001
EC does not Granger Cause CO2	38	5.730	0.003
CO2 does not Granger Cause EC		1.567	0.217

Here we tested Granger cause for just three of our model's variables. CO2 was the dependent variable, Y and EC are independent variables that have a positive impact on CO2 emission. As a result, we have decided to examine the types of causality they have (Bi-directional or Unidirectional). The test equation has a null hypothesis of Y does not Granger Cause CO2, and P-value < 0.05 suggests rejecting the null hypothesis. According to the result, we see that there is unidirectional causality between all the combinations and it shows that Granger Causality runs between the pairs of Y to CO2, EC to CO2, and Y to EC but not in the other way.

4.5. Normality test

It is necessary to measure the normality condition of the residual to better ensure the robustness of the outcome Because if residuals are usually spread, the outcome of our model is confirmed. We are using the Jarque-Bera test here to test the normality of residuals. The test statistics calculate the disparity between the series' skewness and kurtosis with a regular distribution. It is computed as:

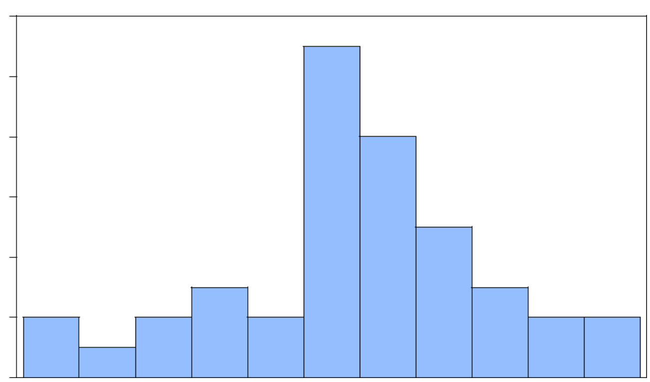
$$JB = \frac{N}{6}\left(S^2 + \frac{(K-3)^2}{4}\right) \quad (2)$$

The hypothesis for this test is:

H_0= Residuals are normally distributed.

A small probability value leads to the rejection of the null hypothesis. The probability for this test shows a significantly high P-value > 0.05 means we cannot reject the null hypothesis of residuals that are normally distributed. Hence, our result is positively significant

Figure-1: Jarque-Bera normality test



Series: Residuals		Mean	-0.000
Sample 1973 2013		Median	-0.000
Observations 41		Maximum	0.010
Std. Dev.	0.005	Minimum	-0.013
Skewness	-0.375	Jarque-Bera	0.980
Kurtosis	3.102	Probability	0.612

4.6. Wald test for coefficient

The Wald test is also regarded as the Wald Chi-square test. It is the way to figure out if the model's explanatory variables are significant and if it implies that the value is not zero. It is easier to remove the variable from the model if it is zero. Table 6 shows the wald test result for this model.

Table 6: Wald test

Test Statistic	Value	Df	Probability
F-statistic	38407.34	(6, 34)	0.000
Chi-square	230444.1	6	0.000

Null Hypothesis: C(1)=0, C(2)=0, C(3)=0, C(4)=0, C(5)=0, C(6)=0

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(1)	0.000276	3.30E-05
C(2)	-1.04E-07	1.46E-08
C(3)	0.002565	8.09E-05
C(4)	-0.000398	0.000149
C(5)	-0.006978	0.001558
C(6)	-0.000393	8.51E-05

Restrictions are linear in coefficients.

joint null hypothesis for this test is:

H_0= [C(1)=0, C(2)=0, C(3)=0, C(4)=0, C(5)=0, C(6)=0]

Here, if the null hypothesis is accepted, it explicitly indicates that the variables in the model are zero. The Eviews results of the test demonstrated F-statistic and Chi-square statistics for P-values. This reveals that we clearly reject the null hypothesis. This implies that the alternate hypothesis of variables with some value or not equal to zero cannot be rejected. For us, that's a positive thing. In the model, all of our variables are significant.

4.7. Stability test

This test is used to test the stability of the variables in the long run. There are two tests to examine the stability of parameters.

1. Cusum test and
2. Cusum of squares test.

Both tests were developed by three researchers (Brown, Durbin, & Evans, 1975). The Cusum test relies on the cumulative sum of the recursive residuals and Cusum square under the hypothesis of parameter consistency. The test statistic for Cusum square is:

$$E(S_t) = (t-k)/(T-k) \quad (3)$$

The Cusum test and Cusum of squares test have provided the pair of 5% critical lines. If the movement of expected value exceeded the critical line suggests instability.

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i. CUSUM Test

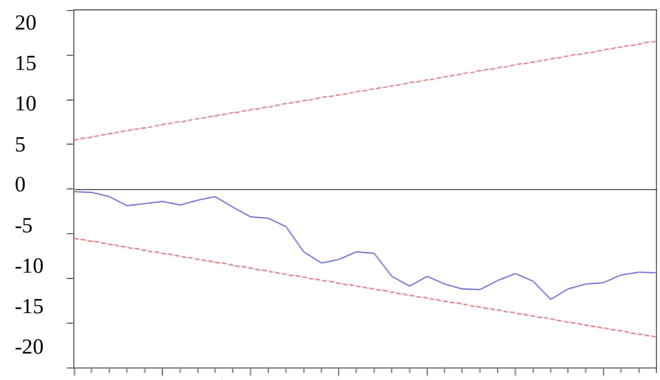

Figure-2: Result of CUSUM and CUSUM SQ Test

Note:--- 5% Significance CUSUM of Squares -----

The result shows that the movement is inside the 5% significance critical lines suggest that the coefficients are stable in the sample period.

ii. CUSUM SQ Test

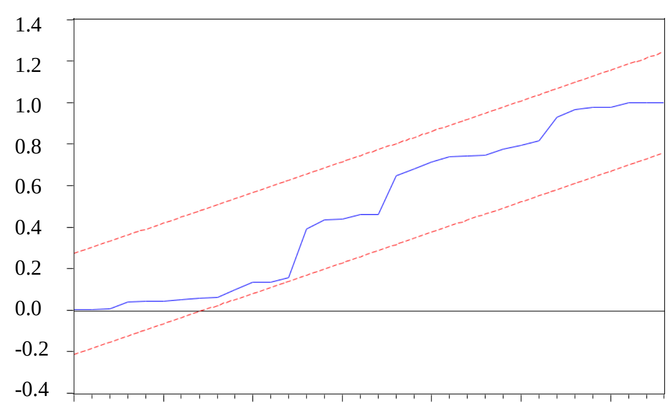

Figure-3: Result of CUSUM and CUSUM SQ Test

Note:--- 5% Significance CUSUM of Squares -----

According to the test result of CUSUM SQ, stability in the long run period suggested that the critical line is within the bound mean. According to both tests, our model variables are robust in the long run, and the model for policy purposes is ideal and accurate.

5. Model interpretation and findings

The Environmental Kuznets Curve (EKC) main model contains just the model's environmental efficiency and per capita real income. This illustrates the effects of income levels on the environment, but income is yet not the sole cause of the environmental effects. People live in the environment, and the environment is shaped and impacted by it. As well as the climate, any human action is often shaped and impacted by it. In this article, we attempt to incorporate some other environmental effects of human behavior other than income alone. We estimate our model with the FMOLS method. The result shows in Table 3 with two different kernels. It shows the estimated coefficient of income (0.000276 or 0.000274) for different kernels, and the value is positive means if personal income (in terms of GDP) increases by $1, it positively contributes to CO2 emission 0.000276 metric ton approximately. Where a square term of income includes in the model to fulfill the requirement of the EKC hypothesis. According to the hypothesis, we found it negative in value. It implies that after achieving a certain period of income level 1$ increase in income, it decreases (1.04 or 1.02) metric ton CO2 emission. This result fulfills the requirement of the EKC hypothesis and shows a quadratic trend for Bangladesh. Few other researchers (Nasreen et al., 2017), (Islam & Shahbaz, 2012) and (Hanif & Gago-de-Santos, 2017) have also identified the EKC hypothesis in Bangladesh. Thus the environment can be hampered by economic development. This suggests that Bangladesh cannot grow its economy without hindering the environment (Amin, Morshed, & Porna, 2016).

Moreover, energy consumption has a positive impact on CO2 emission in Bangladesh, approximately 0.00256 metric tons. But urban population growth, internal FDI, and trade openness have a negative impact on CO2 emission approximately and gradually (-0.000398 or -0.000413)3, -0.00697, and (-0.000393 or -0.000989) metric tons. The normality test indicates that the model's residuals are normally distributed. The Wald test illustrates that all variables are significant in the model. The long-run stability is verified by CUSUM and CUSUM SQ, and the cointegration test proves the cointegration of the variables. We analyze the causality of two independent variables that are strongly linked to the dependent variable and classify the variables as having unidirectional causality. All these findings thus indicate the model's robustness and confirm the environmental Kuznets Curve hypothesis in Bangladesh.

6. Policy recommendation

Bangladesh is a developing country with a steadily rising demand for energy. But there is a major deficit in the country's energy demand, especially for electricity. The increase in income level triggers the increase in energy use and even CO2 pollution, according to the Granger causality test.

The outcome further reveals that the use of energy would not raise the amount of income. The decision, then, economic growth raises energy use. Energy consumption often rises after reaching the turning point correlated with the income level. So, with development, the government must increase the energy supply. But it still seriously hampers the environment. There is something positive about the reality that rising energy use does not imply economic development. Here, to maintain efficient energy usage, decision-makers should hold an eye on the degree of energy use. Therefore, to satisfy the demands of economic growth, policymakers will need to raise energy supplies. They need to identify new, environmentally friendly forms of energy. In terms of higher technologies, Bangladesh is mostly backward. To improve this situation, IFDI and trade openness can aid because if IFDI outcome improves, international firms will invest with their higher technical instrument here. In this situation, the government must regulate the environmental laws efficiently This is because in lower controlled countries, often international firms want to set up lower grade industries. The government must therefore motivate and restrict the usage of recycling resources for established businesses and may levy taxes for negative externality.

7. Conclusion

We tested the EKC hypothesis by applying FMOLS and found it to be significant in Bangladesh. The long-run relation of the model is verified by the cointegration test of Engle-Granger and Phillips-Ouliaris. As a consequence, in its primary stage of growth, Bangladesh can harm the environment and reduce the damage ratio in its maturity stage of development.

The Granger causality test establishes a unidirectional correlation between income and CO2, income and energy use, and energy use and CO2 emission. Based on this, the magnitude of the usage of energy in Bangladesh depends on the degree of its economic growth. Moreover, energy consumption has a positive impact on CO2 emission in Bangladesh that eventually confirms the EKC hypothesis.

Policymakers should aim to accelerate development in this circumstance and reduce the excess usage of energy. As well as the proposal, renewable energy sources such as solar can be stimulated by them. The quality of the environment or the quality of the air does not depend only on CO2 pollution. They are also affected by several other metrics that were not possible to be used in this model. . There is a shortage of data available for all indicators in Bangladesh as well, and time was also a great restriction of this work. Therefore, we recommend that EKC be investigated for other factors relevant to environmental efficiency and also to explore a large variety of causal variable relationships. To foster economic development, it would help to devise further policies for Bangladesh.

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