VALIDITY OF ENVIRONMENTAL KUZNETS CURVE (EKC) IN PAKISTAN: A CO-INTEGRATION ANALYSIS

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ABSTRACT

The aim of this study is to evaluate the validity of Environmental Kuznets Curve (EKC) in the context of Pakistan. Time series data for the periods between 1990-2015 were collected from World Development Indicator (WDI). Time series data were tested for stationarity employing Augmented Dickey-Fuller (ADF) test, as all the variables are integrated at different orders 1(0) and 1(1). The ADF test resut suggest that the Autoregressive Distributed Lag Model (ARDL) is the most suited model to estimate the selected variables of carbon dioxide emission, GDP per capita and GDP per capita square. The results suggested a positive association between carbon emissions and GDP per capita while GDP per capita square has negatively associated with carbon emissions, both in long and short run. The final results indicated the valid application of Environmental Kuznets Curve on Pakistan. The study concluded that the shape of EKC curve, in Pakistan, is inverted U due to the association between GDP and carbon emissions. The study suggested that the Government of Pakistan can take concrete steps in the form of different policies and strategies to minimize the negative effects of growth on environment. This could be in the form of levies, green productions, taxes on pollution productions, and increasing the use of renewable resources for cleaner energy and consumption.

Keywords; *GDP per capita, Carbon dioxide emission, Environmental Kuznets Curve, ARDL.*

Introduction

The ecosystem depends on all the living things such as humans, plants, and animals. As a manufacturing process, there is a beneficial interaction between economic activity and the environment. Resources are taken from the environment and excessive pollution, as well as production and consumption, are supported by the environment. The association between environmental degradation and economic growth was explained by the Kuznets curve theory. Many studies and empirical checks have shown that there is an inverted U-shaped relationship between economic growth and environmental degradation. Carbon emissions are used to evaluate environmental degradation, while per capita income is used to assess economic growth. According to the U-shaped curve, while per capita income rises, carbon emissions rise as well; however, after a certain threshold, carbon emissions decrease when per capita income grows. This environmental pattern was called the Environmental Kuznet Curve (EKC) because of the similarities between Kuznets' level of GDP per capita and inequality (1955*).* Energy is the primary driver of economic development as well as climatic change. One reality is that growth is directly related to CO_2 emissions. There's no such proof of a single country growing without carbon dioxide. Renewable energy sources such as geothermal, wind, biofuels, and solar were developed in some nations, however, they are insufficient because they account for only 1% of the total energy supply Narain*et al.*, (2015).

OBJECTIVE OF THE STUDY:

- To check the validity of the Environmental Kuznets Curve (EKC) in Pakistan.

LITERATURE REVIEW

The relationship between EKC variables i-e economic growth and carbon emissions has been tested in few countries. In Malaysia, for the period between 1980-2009, this relationship was tested by Sabooriet *al.*, (2012). For the purpose time series analysis techniques were used, subsequently with the application of Auto Regressive Distributed Lag (ARDL) model. The study resulted in showing a positive relationship, in inverted U shaped curve. The result also authenticated the long run association between GDP per capita and per capita emissions. Data was also processed through Vector Error Correction Model (VECM). The results of VECM showed no causality between carbon emissions and economic growth in the short run, however in the long run, causality was noted.

Soytas and Sari (2007) researched the relationship between the two variables i-e economic growth and carbon dioxide emissions. However the authors also included a third variable, energy consumption, in the study. The result confirmed positive relationship between all three variables. To further the research, the authors included variables of fixed capital formation and labour. The causality tests results indicated that there is one dimensional relationship between carbon emission and energy consumptions, however no evidence of long term association was noted between income and carbon emissions.

Lotfalipour . *al.*, (2010) in Iran to establish association between carbon emission and economic growth. For the purpose the time series technique of Toda-Yamamoto methods was applied using data from the periods between 1968-2008. The model included variables of economic growth, carbon emission and fossil fuel consumption. The results of the study shown that there is exists an association between energy consumption and carbon emission. The prolonged use of energy consumption such as petroleum products and natural gas led to increased carbon dioxide emissions. However no causal relationship was noted in between fossil fuel and CO2 emissions.

The application of EKC was carried out on various regimes between the periods of 1971-2008 by Kanjilal and Ghosh (2013) through threshold of con-integration method. The results showed, based on signs and parameters, that EKC is applicable to India. The elasticity of carbon dioxide showed to be 1.43 for per capita emissions and 1.45 for energy consumptions. Similarly the results of the variables of per capital income, per capital energy consumption and per capital trade openness indicated to being consistent with expectations.

In Pakistan various authors attempted to investigate similar relationships. For the purpose Ahmad and Long (2013), carried out research to study EKC in the context of Pakistan environment. For this purpose the technique of ARDL was applied on the time series data figures from the periods between 1991-2008. The authors also identified other factors that are contributing to environmental degradation of Pakistan including energy usage, population density and trade openness.

Ahmad and Qazi (2013) investigated the association between carbon dioxide emissions and economic growth through the methods of co-integration and causality in Mongolia. The results indicated that there is both short and long run existence of EKC in Mongolia indicated that there is positive association among economic growth, energy consumptions, and carbon dioxide emissions.

The relationship between the variables of GDP per capita , GDP per capita squared, financial development and per capita carbon dioxide emissions was studied by Muhammad and Fatima (2013). The purpose of the study was to apply ECK framework on Pakistan environment for both long and short run. For the long term association between the variables f test was used. The results showed that there significant positive association between the variables. Study concluded that Financial development can be achieved, however, at the expense of environmental deficiencies. The study further suggested that carbon dioxide emissions has no remarkable effect on globalization of trade, long or short run.

To test the relationship between carbon emission and economic growth, Hasseb and Azam (2015) carried out research using data between the periods 1975-2013. For the purpose variables of economic development, carbon emissions and energy consumptions were used. Data was tested using time series analysis techniques. Following the confirmation of stationarity test via ADF, F test was used for co-integration. Results confirmed, through VECM model, that there is long term relationship between the selected variables. The objectives concluded that although energy consumption is required for economic development, however it comes it the cost of carbon emissions leading to environmental harms.

METHOD AND MATERIALS

The unit root test

The analysis of data from the time series point of view always has unit root problem. In case of existence of unit root in the data, the results from the analysis are flawed and cannot be relied on. Therefore for conclude the existence of unit root, several tests are carried out. However, the current study will be based on Augmented Dickey-Fuller (ADF) test, which is based on the following equations.

$\Delta Y = \beta 1 + ZYt\text{-}1 + ai + et$ ---------- (i)
$\Delta Y = \beta 1 + \beta 2t + ZYt\text{-}1 + ai + et$ ---------- (ii)
$\Delta Y = ZYt\text{-}1 + ai + et$ ---------- (iii)

All the three equations represent different scenarios between the intercept, trend and the absence of both. The first equation indicates just the intercept factor. The second equations shows both intercept and trend factors. However, the last equations shows neither of these two factors. The existence of trend shows the slope of the time series data. The specification of these equations are used to determine the stationarity in the time series data. The purpose is to determine the stationarity along with intercept, along with trend and then finally with the absence of both, trend and intercept. Similarly the variables are tested with the help of above equations to determine the existence of unit root. The existence of

no unit root, indicates that data is stationary. Otherwise, the next step if carried, by carrying out the first difference, and repeating the process.

ECONOMETRIC MODEL

Simon Kuznets, an American economist, was the first to establish the notion of the Kuznets Curve (KC) (1995). According to his theory, the KC's shape is U-inverted, indicating a link between per capita income and inequality. As a result, Panayotou's (1993) concept bears a striking resemblance to Kuznets' idea. According to the Environmental Kuznets Curve (EKC), environmental degradation increases initially as economic growth increases, but after reaching a certain level, environmental degradation reduces as economic growth increases.

The general form of the model is bellowed;
CO_2=f (Y, YY,)
CO_2 = carbon dioxide taken as a proxy variable for Environmental degradation. It can be measured in terms of metric per capita ton.
Y= GDP per capita has been taken as a proxy variable for economic growth rate per capita income in the US dollar in Pakistan.
YY= GDP Per Capita Square that to check the existence of EKC in Pakistan whereas the square portrays the quadratic nature of the curve of the EKC; an inverted U-shape (Wang, 2012).

Multiplicative form of equation-1 is;
$\boldsymbol{CO2} = \boldsymbol{\beta 0 \beta 1 Y \beta 2 YY \mu}$ …….. (2)
The logarithm of the explicitly estimated econometric model is as follows:
$(\boldsymbol{CO2})\boldsymbol{t} = \boldsymbol{\beta 0} + \boldsymbol{\beta 1 lnYt} + \boldsymbol{\beta 2 lnYYt} + \mathbf{et}$ ….(3)

βi= parameters/coefficient of independents variables
$\mathbf{et}$ = Error term

Autoregressive Distributed Lag Model (ARDL)

To check for the long term association between the variables, Co-Integration test would be applied. This procedure was first employed by Granger (1988) in similar situation. According the co-integration approach of Granger, if there is simultaneous movements between the variables, there are chances that the variables are co-integrated in the long run. The existence of co-integrations indicates that there is always long term association.

However, if there is no co-integration between the variables, it indicates that there is no long term association between these variables (Dickey et al., 1979).

To discuss the relationship between GDP per capita, GDP per capita square and Carbon dioxide emissions, the procedure of ARDL, as proposed by Pesaran *et al*., (2001) is used. There are several authors that have used several different techniques to investigate the long term co-integration between different variables. However, in this study, the authors will be applying the technique of ARDL on selected time series data. The reason for this application is the simplicity and straightforwardness of the estimation process of single equation. The model can also be applied if there are different integration orders between he variables such as 1(0) and 1(1). Similarly this will help, not only in determining the long term association between the variables, but will also help in concluding the integration in application of different delays. Pesaran *et al*., (2001) suggests, that this will produce reliable results, provided that data is modest.

ARDL model is developed through the following methodology. The first procedure is to estimate the coefficients, both long and short run. This is followed by the determination of lag length with the help of Akaike Information Criteria (AIC). Lastly the long run association between the variables is checked with the help of F statistic and Bound's test, as proposed by Pesaran *et al*., (2001). After the establishment of co-integration between the variables of the model, this is followed by error correction test. In this test the long term association between the variable between explanatory and explained variables is determined through regression.

ARDL equation is subject to different other tests for effective results such as stability tests, normality tests, and heteroscedasticity and correlations tests to ascertain that the model is in correct functional form. Following model shows the conversion of our model into ARDL specified model.

$$\Delta \log CO_2 = \alpha_0 + \sum_{i=1}^{n} . \ \Delta \log CO_{2_{t-k}} + \sum_{i=1}^{n} \alpha 2 \Delta \log Gdp + \sum_{i=1}^{n} \alpha 3 \Delta \log YY + \varepsilon_t$$

Where,
CO_2=Carbon dioxide emission
GDP= GDP Per Capita
YY= GDP Per Capita Square
α_i, α_0 = Drift factor and white noise respectively
ε_t = error term

Following these steps, Bound's test that is based on the value of F statistic, can be checked to conclude the long term association between the selected variables (Pesaran et al., 2001).

This is followed by evaluating the hypotheses. In case where the outcomes of the calculation indicates co-integration between the null hypothesis and variables will be rejected, and alternate is accepted indicating long term association between the variables. The error correlation mechanism is defined as following;

$\Delta \ln (CO2) = \alpha 0 + \sum \alpha 1 i \Delta \ln (CO2) - i + \sum \alpha 2 i \Delta lnYt - i + \sum \alpha 3 iYYt - i + \varphi ECMt - 1 + \varepsilon t - i$

φ in the above model represents adjustment speed. Its value is likely to be in minus indicating model equilibrium.

Result and Discussion

ADF test Result

The unit root test is used to determine whether the variables in the model are stationary. We also discovered the sequence in which the variables were integrated. All series are tested for stationary behavior and the order of integration is defined using the Augmented Dickey-Fuller test (ADF) along constant and trend lines. According to the ADF test, the null hypothesis for the series is that it has a unit root; if the series has a unit root, it is nonstationary. When non-stationary series are estimated, the model is regarded as erroneous or inaccurate. As a result, the stationary is crucial because based on the ADF test result, any researcher will know whether the approach is utilized in predicting either the long-run or short-run relationship among the variables.

Co-integration Analysis (Bound's Test)

To test the co-integration between variables, Bound's test is used. This test is developed by Pesaran and Shin (1999) and Pesara et al. (2001). As the variables are con\-integrated in different manners such as 1 (0) and 1(1), therefore, to assess the co-integration between the variables of this study, same Bound's test is used. The following table shows the value of F-statistic for co-integration, as well as with critical values that are based on the proposition of Narrayan (2004), although on a limited sample size.

Table -1 F- Bound Test Result

Test Statistic	Value	Significance	Lower value 1(0)	Upper value 1(1)
F-statistic	12.87641	5%	4.6	4.6

For the existence of no co-integration between the variables, null hypothesis is rejected if the values of F statistic is larger the upper critical value of Bound. In this case the value of F statistic is 12.8, which is quite larger than the upper Bound's value that is 4.6, as well the lower value which is also 4.6. These values are based on the confidence interval of 5%. These results leads to the conclusion of rejection of null hypothesis i-e rejection of no co-integration between variables. Therefore accepting the alternative hypothesis of existing of co-integration between the variables, as indicated in the preceding table.

tegrating Form

Table-2; ECM Regression

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GDP	0.08160	0.001555	5.248639	0.000
YY	-4.2206	7.990787	-5.286972	0.000
CointEq(-1)*	-0.592875	0.11401	-5.200045	0.000

The table above provided an explanation of the relationship between the variables in the short-run dynamic system. This research has shown the reliability of the Environmental Kuznets curve in Pakistan. A nation's environmental quality initially declines when it experiences rapid economic growth. The quality of the environment gets better after a certain point. Positive correlations exist between GDP per capita and carbon emissions. With a statistically significant 5 percent rise, carbon emissions rose by 81 percent as a result of a unit increase in GDP per capita income. Although the per-capita GDP and carbon emissions are inversely correlated, an increase in GDP per capita of just 1% will cause a reduction in carbon emissions of 43%. The error correction value is negative and statistically significant at 5%, implying that the adjustment of disequilibrium variables toward equilibrium occurs at a rate of 59 percent each year.

Table -3 Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO2(-1)	0.407125	0.134619	3.024275	0.0067
GDP	0.008160	0.001704	4.789695	0.0001
YY	-4.22E-06	8.98E-07	-4.703294	0.0001
C	-3.406697	0.732873	-4.648413	0.0002

Source: Author'estimates

R-squared 0.966883

The findings of the ARDL estimation of variables demonstrating the relationship between per capita income and per capita GDP on carbon dioxide emissions in Pakistan were shown in Table 2. There is a strong correlation between GDP per capita income and carbon emissions, showing that a 1% rise in GDP per capita increases carbon emissions by 8%, which is statistically significant at 5%. A 1% rise in GDP per capita square will result in a 4% reduction in carbon dioxide emissions, according to the research on the relationship between GDP per capita square and carbon emissions. The whole model is well-fitted as seen by the R-square score of 96%, which shows that the independent variables account for 96% of the variation in the dependent variable.

Heteroscedasticity Test: Breusch-Pagan-Godfrey

The table below concludes the outcomes of Breusch-Pagan-Godfrey technique to ascertain heteroscedasticity in the model. The null hypothesis (H0) indicates that data is homoscedastic, however alternative hypothesis indicates that there is no homoscedasticity. The result is indicated with the help of probabilities scores. The results of chi square test shows alternative can be rejected, leading to the conclusion of homoscedasticity in the model.

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.164934	Prob. F(3,20)	0.9187
Obs*R-squared	0.579428	Prob. Chi-Square(3)	0.9011
Scaled explained SS	0.735641	Prob. Chi-Square(3)	0.8648

Breusch-Godfrey Serial Correlation LM Test:

This test is used to check the serial correlation of error terms between the series. The null hypothesis states that there is no problem of serial correlation in the series, whereas the alternative hypothesis states that there is an issue of serial correlation. According to the table below, the probability value of the F–statistic is insignificant at the 5% level, illustratedthat no evidence of serial correlation was found in the model indicating that the model is free from serial correlation.

F-statistic	0.333530	Prob. F(4,16)	0.8514
Obs*R-squared	1.847158	Prob. Chi-Square(4)	0.7638

Conclusion and Recommendations

This study sought to examine the reliability of the environmental Kuznet curve in Pakistan between 1990 and 2015. The results of the Augmented Dickey Filler (ADF) test show that all of the variables are included into various orders. The ARDL is a better method for estimating the model, according to this study's findings, because the variables are already integrated. To ascertain the short- and long-term associations between variables, the ARDL technique is applied. The results of this study indicate a favourable correlation between per capita GDP and carbon emissions. This makes it clear that, in the short term, Pakistan's economic expansion will result in an increase in carbon emissions. There is a negative relationship between GDP per capita square and carbon emissions in the short run and long run. The plus-minus signs with per capita GDP and per capita squared GDP concludes that EKC is applicable to Pakistan. This further leads to the conclusion towards an inverted U shaped curve showing relationship between economic growth and carbon dioxide in Pakistan. Furthermore, in the long run, its coefficient has the largest absolute value,

therefore, the variable of per capita income is the most critical one that is prompting the carbon dioxide emission in Pakistan. Nonetheless it is understood that in the starting stages of economic development, prompt economic expansions does create and increase existing environmental pollutants. However still, such growths are extremely important for every emerging country because it creates opportunities of employment as well as leads to building supportive infrastructure such as telecommunication, transportation, better health and education systems etc (Gozgor and Can, 2016).

However to confront the direct relationship between economic growth and Carbon Dioxide emission, as we have noted from the case of Pakistan, there can be various policy solutions and effective strategies to address the increasing rates of such emissions. Some such solutions could be in the form imposition of environmental penalties such as taxes etc on such concerns that contribute towards increasing carbon emissions. Others could be more of motivational nature and public awareness form where the use of renewable and cleaner sources, such as wind, solar, and nuclear resources can be encouraged. The use of such policy solutions will help developing countries, such as Pakistan, to play their critical role in developing their countries, and still be able protecting environment from the poisonous damages of carbon emissions.

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