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Impact of Co_2 Emission, Per Capita Income and HDI on Environmental Performance Index: Empirical Evidence from Bangladesh

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ABSTRACT: *The Environmental Performance Index is wide ranging dimension of environmental parameters which need to be assessed with different socioeconomic indicators with a view to examine environmental sustainability. The endeavor is given in this study to scrutinize the transitory and long run relationship between CO_2 emission, Per Capita Income, HDI and Environmental Performance Index of Bangladesh. It appears that, there is a cointegrating relationship between CO_2 emission, Per Capita Income, HDI and EPI found in the Johansen cointegration test. Since the variables are cointegrated Vector Error Correction model has been run to assess the long run causality. Here, long term associationship emerged among the variables and causality is found to be running form the explanatory variables to EPI; meaning that Per Capita Income, Human Development Index and CO_2 emission has influence on Environmental Performance Index in the long run. Transitory effect analysis have flickered no short run relationship between HDI, CO_2 emission and EPI but Per Capita Income. Furthermore, multiple regression model signifies the negative relationship between EPI and Per Capita Income, marginal positive association between CO_2 emission and EPI and remarkable impact on EPI by Human Development Index.*

KEYWORDS: CO_2 Emission, Environmental Performance Index, HDI, Impact Assessment, Per Capita Income, Sustainable Development, VEC Model

INTRODUCTION

Environmental Performance Index (EPI) is a prominent indicator of the state of environment which signifies overall environmental performance of a country. More Explicitly, EPI ranks how better the countries perform on top notch environmental issues. EPI scores the progress of state in nine concern areas comprised of twenty indicators. Indicators in the EPI assess how much near the countries are to meeting globally established targets on selected environmental elements. The economy of Bangladesh is growing persistently over the period along with combating the series of natural disasters, environmental degradation, climate variability, political unrest, poverty and inequality. In this state it deserves to examine how the environmental parameters which are combindly expressed by EPI are performing. In a developing country like Bangladesh growth is highly reliant on environmental resources and its healthiness. Here attempt has been made to evaluate how much the EPI impacted by certain environmental and socio-economic parameters such as CO2 emission, per capita income and Human Development Index (HDI) over the years. Besides, the existing state of environment is also indecent due to numerous polluting activities which are degrading the environmental sustainability perilously. Although the per capita carbon emission is mere 0.4 metric ton in Bangladesh, which is 1.4 tons for all South Asia and the ecological footprint is also remarkably lower which is counted 0.62 hectares per person compared to the world average of 2.53 (WB, 2010; Global Footprint Network, 2010). Our rivers are dying,

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biodiversity is disappearing, wetlands are squeezing, water, air and soil pollutions are also taking place dangerously (Alam, 2009). Climate change impacts, anthropogenic actions, poor planning and management, extreme water and environmental contamination, degradation of rivers ecosystem also humiliate the environmental health and performance in Bangladesh (Islam, 2005). Collectively all of them are causing to debase the environmental quality and ecosystem services and thus have aapparent economic outlay as well as adverse impact on environmental sustainability. Maccari (2014) analyzed the environmental sustainability and human development and shows a global picture of the relationship between human development and environment, through a U-shaped relationship between HDI and EPI and found a positive correlation between them. Further, Mukherjee et. al (2010) attempted to explore the relationships among Environmental Quality (EQ), Human Development (HD) and political and governance regime in a cross-country framework. Here they find the closer association between the socio-economic and socio-political factors in a country and its environmental performance. Jaffer (2011) attempted to explore the relationship environmental performance and sustainable development in Sri Lanka. The study shows that Sri Lanka's performance in air pollution category and environmental burden on diseases are relatively weak. The environmental performance category analysis signifies that the rising demand on scarce resources and pollution play an crucial role in environmental stresses. The increasing trend of CO2 release contributes to the environmental burden of diseases and air contamination in Sri Lanka. American Coalition for Clean Coal Electricity (2014) assessed the impacts and benefits of carbon dioxide (CO2) and then judged against these to estimates of the social cost of carbon (SCC). The ultimate finding of the study is that, the benefits of CO2 overpoweringly outweigh accounted CO2 costs. In fact, the SCC estimates are relatively so small as to be in the statistical noise of the estimated CO2 benefits. Attah (2010) examined the global effort to minimize the impact of environmental degradation for attaining sustainable growth. The paper found excessive effort on environmental sustainability using some control measures could hurt the economic activities of a country through job loss and societal mishaps while on the other hand too much emphasis on economic growth could result into health risks, global warming and environmental humiliation within the society. Samimi et. al (2013) evaluated the relationship between Environmental Performance and Human Development in 114 countries around the World during 2006- 2010. Based on the data of EPI and HDI the study found a positive and significance relationship between EPI and HDI for all the selected developed countries. However, in case of developing countries the results suggests, higher human development index does not necessarily improve the Environmental Performance. The study suggests more public awareness and government role in this regard. Abelinde (2012) investigated the causal relationship of human development and governance to environmental performance using multivariate linear regression on cross-country data. It is appeared that human development and governance are significantly related with environmental performance. The study revealed that, a country's economic development category is not a significant predictor of environmental performance. Alam and Kabir (2013) assessed the linkage between economic growth and environmental sustainability in the East and South-East Asian countries focused on the environmental Kuznets curve hypothesis, considering the data of environmental performance index. They found that, there is a positive impact of GDP per capita on pollution activities. The study proved that, the hypothesis of environmental Kuznets curve works partially not entirely. The paper suggests putting serious endeavor to the eco-efficiency initiatives along with pollution measures in order to make certain the environmental sustainability in the process of economic development. So, examine the environmental performance index along with the influencing variables are obligatory for the environmental planning and management for the all state and particularly

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for the developing states as well. Thus, the study intends to identify the causal realationship and impact of CO2 emission, per capita income and HDI on the Environmental Performance Index of Bangladesh, which is categorized as one of the most climate vulnerable and environmentally unsustainable state of the world.

OBJECTIVE OF THE STUDY

The purpose of this study is to inspect the collision of CO2 emission, Per Capita Income, and HDI on Environmental Performance Index of Bangladesh and provide credible and justifiable information for the environmental health centric macroeconomic planning and policy making. The specific objectives of this study are:

i. to examine the short run and long run causality between CO2 emission, Per Capita Income, HDI and EPI of Bangladesh
ii. to assess the impact of CO2 emission, Per Capita Income, HDI on EPI
iii. to generate scientific knowledge on the long term interaction of environmental and socio-economic indicators of Bangladesh, and
iv. to provide rational support to the eco-friendly policy formulation in order to achieve green growth, sustainable development and resilient building.

METHODOLOGY

A set of quantitative techniques have been exercised in this study to scrutinize the relationship between different variables based on the available time series data for the period 2000-2013. In order to ascertain linkage between Environmental Performance Index and major influencing variable i.e. CO2 emission, Per Capita Income and HDI multiple regression model has been employed to estimate the value of relevant equation. Besides, the time series econometrics has been used to check the unit root, cointegration, long run association and forecasting the parameters. Econometric methods those are adopted to analyze the data of selected variables are illustrated as follows.

Log Linear Model

For better analyzing the time series data of different variables the significance of finding growth rate is high. For the estimation of constant growth rate of EPI, HDI, CO2emission and Per Capita Income following semi log model has been estimated.

$$LogY = \beta_0 + \beta_1 T + U_i$$

Where, Y is the depended variable, ß0 designates intercept, ß1 indicates regression co-efficient, T represents time, and U is regarded as the stochastic term.

Augmented Dicky-Fuller (ADF) Test

Time series stationarity is the statistical attributes of a data series such as its mean and variance over the period. If both are steady over time, then the series is thought to be a stationary progression (i.e. is not a random walk/has no unit root), otherwise, the series is depicted as being a non-stationary process (i.e. a random walk/has unit root). Differencing a series using differencing procedure constructs other sets of observations such as the first-differenced values, the second-differenced values and so on.

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xlevel	x_t
x1st -diiferenced value	$x_t - x_{t-1}$
x 2nd -diiferenced value	$x_t - x_{t-2}$

Augmented Dicky-Fuller test is widely used to test the unit root of time series data. ADF Unit Root Test is based on the following three regression forms:

a. Without Constant and Trend: $\Delta y_t = \delta y_{t-1} + u_t$

b. With Constant : $\Delta y_t = \alpha_0 + \delta y_{t-1} + u_t$

c. With Constant and Trend: $\Delta y_t = \alpha_0 + \beta T + \delta y_{t-1} + u_t$

Hypothesis:

H_0 :δ = 0 (Unit root or Non stationary)
H_1 :δ≠ 0 (Stationary)

Decision rule:

If t* > ADF critical value, => not reject the null hypothesis, i.e., unit root exists.

If t* < ADF critical value, => reject the null hypothesis, i.e., unit root does not exist.

In Dicky-Fuller (DF) test there is a probability to arise autocorrelation. Thus, to avoid such setback Augmented Dicky-Fuller test has been used numerously to test the unit root of the variables.

Johansen Cointegretion Test

Johansen test is an advanced modus operandi for testing cointegretion of several time series variables. Usually, Johansen Cointegration (JC) test is exercised for a series that are integrated of the similar order. It is much safe to proceed with JC test if all the variables are stationary subsequent to first difference in Augmented Dicker Fuller (ADF) unit root test. JC test sanctions more than one cointegrating relationship. Thus, it is said to be a more usually pertinent than the Engle–Granger method which is mostly based on the augmented Dickey–Fuller test for unit roots in the residuals from a single cointegrating relationship. Johansen test has been used in the study because it addresses several restrictions of the Engle-Granger method. It avoids two-step estimators and provides inclusive testing in the existence of multiple co-integrating relations. Its maximum likelihood approach integrates the testing process into the procedure of model estimation, avoiding restricted estimates. Moreover, the test provides a structure for testing restrictions on the cointegrating relations B and the correction speeds A in the Vector Error Correction Model (VECM).

There are two types of Johansen test, either with trace or with eigenvalue, and the inferences might be a little bit unusual. The null hypothesis for the trace test is the quantity of cointegration vectors. Just like a unit root test, there can be a consistent term, a trend term, both, or neither in the model. For a general Vector Auto Regressive (p) model:

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$$X_t = \mu + \phi D_t + \pi_p X_{t-p} + \ldots + \pi_1 X_{t-1} + e_t, \ t = 1,\ldots,T$$

The method infers the cointegration rank by testing the quantity of eigenvalues that are statistically dissimilar from 0, and then carry out model estimation under the rank constraints. Although the method appears to be extremely unlike from the Engle-Granger method, it is fundamentally a multivariate generalization of the augmented Dickey-Fuller test for the unit roots.

Vector Error Correction Model (VECM)

If cointegration is detected between the series it is assumed that a long-term equilibrium relationship exists between them. Hence, VECM has been applied in order to assess the short run properties of the cointegrated series. The vector error correction model extends the single equation error correction model to let x and y to evolve together over the period as in a VAR system. Moreover, a VECM is a restricted VAR that has cointegration restrictions built into the specification, so that it is designed for use with nonstationary series that are recognized to be cointegrated.

The VEC model specification limits the long-run behavior of the endogenous variables to congregate to their cointegrating relationships while considering a large range of short-run dynamics. Cointegration term is recognized as an error correction term since the deviation from long-run equilibrium is corrected steadily through a series of partial short-run amendment. There are two probable specifications for error correction:

1. The long run VECM:

$$\Delta X_t = \mu + D_t + \pi X_{t-p} + \Gamma_{p-1}\Delta X_{t-p+1} + \ldots + \Gamma_1 \Delta X_{t-1} + \varepsilon_t, \ t+1,\ldots,T$$

Where,

$$\Gamma_i = \pi_1 + \ldots + \pi_i - I, \ i = 1,\ldots,P-1$$

2. The transitory (short run) VECM:

$$\Delta X_t = \mu + \phi D_t - \Gamma_{p\_1}\Delta X_{t-p+1} - \ldots - \Gamma \Delta X_{t-1} + \pi X_{t-1} + \varepsilon_t, \ t+1,\ldots,T$$

Where,

$$\Gamma_i = (\pi_{i+1} + \ldots + \pi_p), \ i = 1,\ldots,P-1$$

The chief objective of estimating VECM is to define the long run Causal Relationships among EPI, CO2 Emission, Per Capita Income and HDI of Bangladesh. The error correction terms of VECM describe how the time-series adjust to disequilibrium. In VECM the cointegration rank demonstrates the number of cointegrating vectors. For example, a rank of two specifies that two linearly self-determining combinations of the non-stationary variables will be stationary. A negative and significant coefficient of the VECM signifies that any short-term fluctuations between the self-determining variables and the reliant variable will give rise to a constant long run association between the variables.

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Multiple Regression Model

For the evaluation of the impact of different parameters i.e. CO2 emission, per capita income, and HDI on EPI following semi log model has been used in the study.

$EPI = ß_0 + ß_1 lnincome + ß1 lnCO_2 + ß2 lnhdi + U_i$

Where, lnincome denotes the log of per capita income, lnCO2is the log of per capita carbon di-oxide emission, lnhdi signifies log of human development index and Ui is the stochastic term. How much the explanatory variables are responsible to change the reliant variable can be examined by this model.

Data Sources

Necessary data has been used in the study are collected from secondary sources. For HDI, data has been gathered from different issue of Human Development report published by UNDP. Data of CO_2 emission are taken form United Nations Statistics Division. For Environmental Performance Index, latest EPI report (2014) has been searched and congregated required information. Besides, the data of per capita income is collected from e-portal of World Bank.

RESULTS AND DISCUSSION

In this section, a quantitative study has been conducted based on the real time data. In this instance time series econometrics such as Stationary test, Cointegration test, and Post Estimation tests has been used to estimate and interpret the results, as well as provide further explanation of the method behind.

Trend Analysis of EPI, HDI, CO_2 Emission and Per Capita Income

It appears that all the parameters are in increasing trend from initial period. Although EPI and CO_2 experienced some volatility in the mid period at the end of the 2009 they are found in upward trend. It is appeared that trend of HDI and Per Capita income and EPI and CO_2emission are moving in the same pattern. At 2001 EPI was 23.4 which reached to 25.61 at 2012 with some periodic fluctuation. Alongside, from initial 0.25 metric ton CO_2emission eventually reached 0.4 metric ton. Here the actual amount of increment is not so high for the CO_2emission and EPI. Same observation is applicable for HDI, it reached to 0.515 in 2012 from initial 0.43. Among the variables, Per Capita income shows massive increment which is now $840 from preliminary $380.

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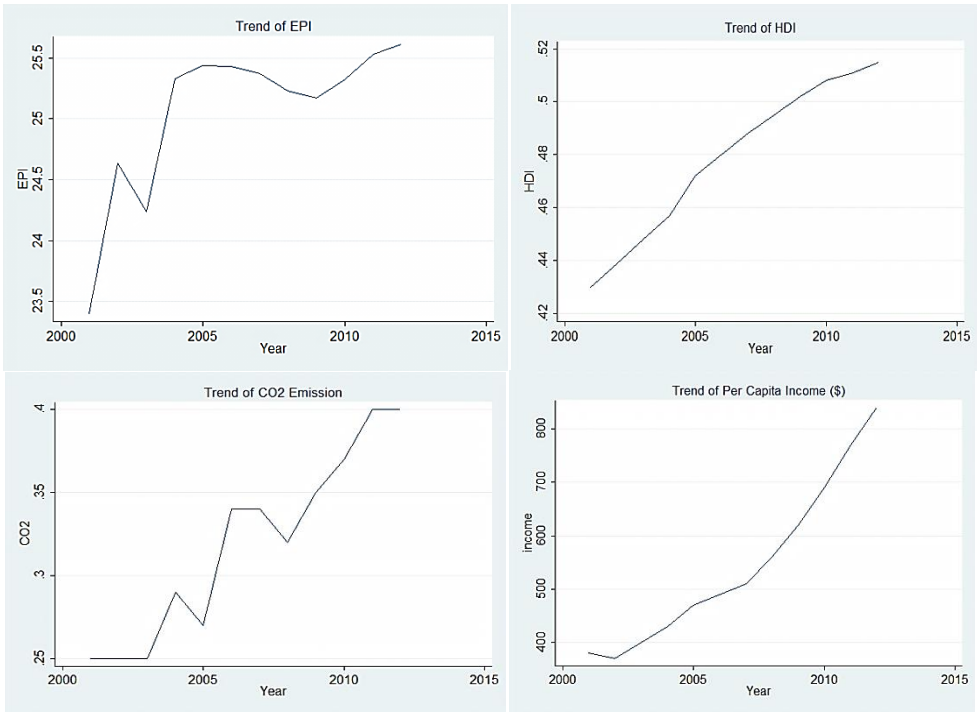
Figure 1: Historical Trend of EPI, HDI, CO_2 Emission and Per Capita Income



Growth of EPI, HDI, CO_2 and Per Capita Income

It is essential to derive the growth rate of EPI, CO_2 Emission, Per Capita Income and HDI of Bangladesh over the time period .The estimated log linear model helps to scan the constant growth rate of stated variables. It is found that except EPI adjusted R^2 for each variable is above 0.90 which denotes the goodness of the model.

Table 1: Results of Semi Log Model (Sample: 2000 to 2012)

	Per Capita Income	CO_2 Emission	HDI	EPI
Co-efficient	0.075	0.047	0.017	0.005
Constant	5.77	-1.46	-0.84	3.18
T-Statistics	19.19***	10.25***	17.67***	3.47**
Std. Error	0.003	0.004	0	0.001
Adj. R^2	0.97	0.9	0.96	0.5
Observation	12	12	12	12

*Note: *p<0.1, ** p<0.05, *** p<0.01*

From the regression co-efficient it is evident that the growth rate of per capita income, environmental performance index, co_2 emission, and human development index is 7.5%, 0.5%, 4.7%, and 1.7% correspondingly and all of them are statistically significant at 1 percent but EPI which is significant at 5 percent level. It is appeared that growth rate of EPI is found least compared to others and growth rate of per capita income is in top notch. It is

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disclosed that there is no any momentous change in EPI over the years which indicates we have enough room for the improvement of EPI.

Unit Root Test

From ADF test it is found that there is a stationarity in level both for the EPI and Per Capita Income. Here the test statistic is remarkably higher than the 5% critical value for these variables, meaning that there is no unit root for EPI and Per Capita Income. Besides, the HDI is seems non stationary up to 1st difference. It becomes stationary at 2nddifference. CO_2 emission has unit root at its level but found stationary at 1st difference.

Table 2: Estimates of ADF Unit Root Test

	EPI	Per Capita Income	HDI			CO_2 Emission	
			Level	1st Diff.	2nd Diff.	Level	1st Diff.
Test Statistic	-3.768	4.416	-2.986	-1.456	-4.468	-0.587	-5.111
1% Critical Value	-3.750	-3.750	-3.750	-3.750	-3.750	-3.750	-3.750
5% Critical Value	-3.000	-3.000	-3.000	-3.000	-3.000	-3.000	-3.000
P Value	0.0033	1.000	0.0363	0.555	0.0002	0.8739	0.000
Stationary	Yes	Yes	No	No	Yes	No	Yes

Co-Integration Analysis

If the log likelihood of the unconstrained model that contains the cointegrating equations is significantly different from the log likelihood of the constrained model that does not consist of the cointegrating equations, the null hypothesis of no cointegration is must be rejected in this case. Johansen's approach derives two likelihood estimators for the cointegration (CI) rank. One is trace test and another one is maximum Eigen value test. The trace statistic either rejects the null hypothesis of no cointegration among the variables or does not reject the null hypothesis that there is one cointegration relation between the variables.

Table 3: Results of Johansen CI Test (Trend: Constant)

Rank	Parameters	Eigenvalue	Trace Statistic	5% Critical Value
0	4	.	71.8553	47.21
1	11	0.95442	37.8852	29.68
2	16	0.90736	11.7163*	15.41
3	19	0.65228	0.0964	3.76
4	20	0.00873		

*Note: *p<0.1, ** p<0.05, *** p<0.01*

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Table 3 illustrates that, there is a cointegration between EPI, Per Capita Income, HDI and CO_2 emission. According to the estimates above, the null hypothesis of no cointegration between the variables of rank 0 can be rejected clearly. Besides, the null hypothesis of at most one cointegrating equation among the variables of rank 1 can also be rejected. As per trace statistic we accept the null hypothesis that there is two cointegrating equation in the bivariate model which is statistically significant. Hence, it can be affirmed that, EPI, per capita income, HDI and co_2 emission are cointegrated and move together in the long run.

Fitting the Vector Error Correction Model (VECM)

Since the variables are cointregrated we are allowed run the VECM. It is ascertained in JC test that EPI, Per Capita Income, HDI and CO_2 emission have long run association. So fitting the VECM is now considerable for further analysis.

The first model is discerned as error correction model and this one is our target model where EPI is dependent variable. Here the error correction term is -1.015 and probability value is very small and found less than 5 percent, meaning that error correction term is significant. Since, the co-efficient is negative and statistically significant, it can be alleged that there is a long run causality running form the explanatory variables such as Per Capita Income, HDI and CO_2 emission to EPI; meaning that Per Capita Income, Human Development Index and CO_2 emission has influence on Environmental Performance Index in the long run. Furthermore, it seems first lag of Per Capita Income is significant. So, this variable can explain the dependent variable individually.

Table 4: Estimates of VEC Model (Trend: Constant)

1st dif. of EPI	Coef.	Std. Error	P>|z|	R^2
CE of Lag 1	-1.0154	0.7448	0.04	
lag difference of EPI	0.0183	0.3197	0.95	
lag difference of Co_2emission	-5.58	6.877	0.417	0.88
lag difference of Per Capita Income	0.0383	0.0142	0.007	
lag difference of HDI	54.086	111.57	0.628	

*Note: *p<0.1, ** p<0.05, *** p<0.01*

The table 4 demonstrates that co-efficient of determination for 1st model (also known as targeted model) is 0.88, which signifies the model can explain 88 percent of the total variation. Besides, the models also stipulate very rapid speed of adjustment in the long run, meaning that if there is a disequilibrium in the long run the variables adjust very swiftly. Here, the speed of adjustment is nearly 100 percent ascertained by the coefficient of cointegrating equation of lag 1.

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Transitory Effect Analysis

The long run causal relationship from the explanatory variables to dependent variable is examined previously through VECM. It is similarly significant to check the transitory or short run causality among the variables. Granger causality approach can investigate the transitory effect of the influencing variables on EPI in Vector Error Correction Model.

Table 5: Estimates of Granger Causality Test

D_EPI	Chi^2	prob>chi^2
LD.income	7.2	0.007
LD.hdi	0.23	0.623
LD.CO_2	0.66	0.414

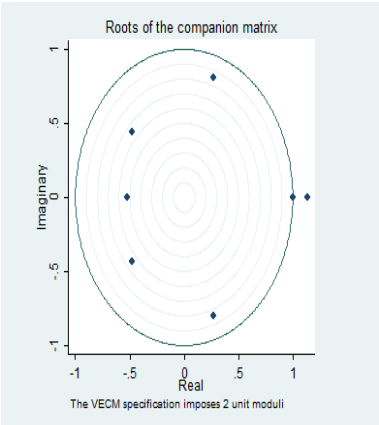
It is flickered in table 5 that, the probability of first lag of per capita income is very small and seems less than 5 percent. So there is a short run causality running from per capita income lag 1 to first difference of EPI, meaning that lag 1 of per capita income can influence the EPI in the short run. Besides, lag 1 of HDI and CO_2 emission does not have any short run causality with EPI, because the probability of these two variables is notably large and exceed the 5% critical level. Thus, it can be consent that there is no short run causality running form first lag of HDI and CO_2 emission to first difference of EPI. Since there is no any short run causality running form HDI and CO_2emission to EPI, short run policy will not be feasible to improve the environmental performance by administering HDI and CO_2emission.Only governing the per capita income can contribute to the EPI in the short run.

Stability Check

By the stability check it can be inveterate that whether number of cointegrating equations are correctly specified. The companion matrix of a VECM with K endogenous variable and r cointegrating equation K-r unit eigenvalues. If the procedure is constant, the moduli of the left over r eigenvalues are strictly fewer than one.

Eigenvalue stability condition

Eigenvalue	Modulus
1.138271	1.13827
1	1
1	1
.2706536 + .804599*i*	.848901
.2706536 - .804599*i*	.848901
-.4756072 + .4375583*i*	.646266
-.4756072 - .4375583*i*	.646266
-.5241191	.524119



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The plotted eigenvalues of the companion matrix can be observed from the above figure. The eigenvalues of the graph denotes that none of the left over eigenvalues near to the unit circle. The outcome of the stability test does not designates that the VECM model is misspecified.

Impact Assessment

The impact of per capita income, HDI and Co_2 emission can be ascertain by following estimates of multiple regression model. Here the robustness of the model escalate the co efficient of determination and reduce the standard error compared to the general procedure of estimation. Hence, the reliability and fitness of the model is enhanced. It can be realized from the estimates that how much the explanatory variables are responsible to change the dependent or target variable.

Table 6: Estimates of Robust Multiple Regression Model

EPI	Coefficient	T-Statistics	Robust Std. Error	Adjusted R^2
lnincome	-2.36	-1.92	1.23	
$lnco_2$	0.84	0.37	2.282	0.61
lnhdi	15.95	1.85**	8.63	

*Note: *p<0.1, ** p<0.05, *** p<0.01*

It is appeared in the estimates that R^2 value is 0.72, meaning that the model can explain 72 percent of total variation which boost up the goodness of fit of the estimated equation. The regression co efficient is found negative for log per capita income which is -2.36. This indicates the adverse relationship between log per capita income and EPI. It is evident that for the developing countries initial rise of per capita income cause to damage the environment (Samimi et. al 2013). After a certain level of development per capita income has a positive impact on environmental perfection which is also confirmed by environmental kuznet hypothesis (Alam and Kabir 2013). Besides, there is a positive relationship found between CO_2 emission and EPI, where the coefficient is very low and insignificant. Furthermore, the coefficient of log HDI is nearly 16 which specify the durable impact of HDI on environmental performance of Bangladesh. In addition, HDI comprises the level of education which works for awareness building among the people that also reinforce the environmental safeguard.

CONCLUSION AND RECOMMENDATION

There are some significant outcomes emanated from the study. It is found that, CO_2 emission, Human Development Index, Per Capita Income, and Environmental Performance Index all have co-relationship and they move together in the long run. Short run shock of influencing variables such as CO_2 emission, HDI, Per Capita Income may not affect the EPI but can significantly affect the EPI in the long run. Short run policy for the improvement of environmental performance through improving HDI and controlling CO_2 emission may not

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much effective for the country like Bangladesh. In this regard an integrated and perspective policy can be very effective to perk up the environmental performance in Bangladesh. Education has a greater role for the awareness building and environmental shield. Thus, spreadness of environmental education can be an indispensable tool in this regard. Necessary steps are much essential to protect the environment and its resources. It is suggested to come up with combined effort of govt., inter govt., and trans-national institutions to sustain and improve the environmental performance and economic prosperity of Bangladesh.

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