Do Energy Consumption and Environmental Degradation (CO$_2$ Emissions) Matter for Economic Growth? Fresh Evidence from a Developing Economy

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ABSTRACT

The main objective of this study is to examine the impact of energy consumption and environmental degradation (CO$_2$ emissions) on economic growth in Bangladesh covering the periods of 1972–2018 by employing the Johansen cointegration test, VECM approach, and Granger causality test. The Johansen cointegration result indicates that gross capital formation (GCF), labor, Electricity power consumption (EPC), energy consumption (EC) has a positive and statistically significant effect on economic growth (RGDP) while environmental degradation (carbon dioxide emissions) has an inverse effect on it. The results of VECM show that there exists a long-run causal nexus among the variables and there is short-run causality running from the capital formation and electricity power consumption to the economic growth while there is no short-run causality from the labor, energy consumption, carbon emission to the economic growth. The causality test shows that there exist a unidirectional causal relationship from economic growth to labor, EPC to RGDP, GCF to labor, EC to GCF, carbon emissions (CO$_2$) to GCF, labor to EPC, EC to labor, CO$_2$ to labor, and carbon emissions to EPC and a bi-directional causal nexus between GCF and RGDP; GCF and labor; EPC and carbon emission in Bangladesh. However, the study suggests that a huge change of low carbon advancements like renewable energy and energy sufficiency may contribute to decrease emissions and thus support the long-run economy.

Keywords: Economic Growth, Electricity, Energy Consumption, Environmental Degradation, Vector Error Correction Model
JEL Classifications: E31, K32, Q53

1. INTRODUCTION

Energy consumption is essential to all human well-being and economic activities for the expansion and development of a country. The supplied energy is a precondition for poverty mitigation and therefore the accomplishment of the sustainable improvement goals. The more is the consumption of energy, the more would be the emission of carbon dioxide resulting from the consumption of energy as the petroleum derivative (Oil and Gas) establishes very nearly 70% of energy utilization while the sustainable power source goes about as a negligible role. Global warming problem soaring anxiety for the partial source of nonrenewable resources especially energy and also becomes an emerging pattern move on the green economy, the connection between economic process and counter-productive natural discharge coming about because of carbon outflow captivates the attention to investigator, scholar, and strategy producer. The release of CO$_2$ is a key base of worldwide warming. Kuznets

(1995) examines the predictable connection between energy use and economic growth that causing environmental degradation in his prominent Environmental Kuznets Curve.

Energy consumption has become a prerequisite in modern times for the growth and development of every nation. For this reason, it is essential to identify the connection between the consumption of energy and economic growth and also find out its impacts on the overall economic growth of a nation. But this provided numerous interrogations in neoclassical production function because they regarded land, labor, and capital is the key components of production. This study has been modified by introducing energy as an additional variable in the production function. Nevertheless, the size of energy power within the economy has been passionately questioned by macroeconomists. Therefore, endeavors are made to determine the particular association between energy and different elements of production with respect to energy supplements with different components of production. The growth rate of electricity consumption has significant consequences for business and open methodology. Increasing usage of electricity generally supports the income of power producers. The facilities of energy consumption to business, transportation, industrial, household, and all other sectors can't be over underscored. By using the effective supply and consumption of energy, the Gross Domestic Product (GDP) would be remarkable. As a significant factor of national area, energy (electricity and petroleum produce) are the main miscarries of national improvement and enhancement in the way of life of the individuals by moving different segments like wellbeing, instruction, farming, trade, transportation, and organization, and so on. At an individual level, increasing consumption of energy is probably going to be one of the most significant reasons for advancement in government assistance of the individuals. At the national level, it's impossible to imagine the development of a country expects the utilization of energy.

Bangladesh is a low income developing nation although it has proceeded with great advancement in financial development and improvement. In 2021, Bangladesh attempts to turn into a middle income. To accomplish this objective, Bangladesh needs to crate nonstop GDP growth with the help of the garments sector, agriculture and industry sector, trade, and outside the straight speculation (Sadekin et al., 2015). It likewise needs to oversee the urbanization process all the more successfully and take readiness to adjust environmental alter and therefore the natural disasters. If the Bangladeshi government accelerates decision making, intensive labor, and repair export that can turn into an export powerhouse and increment twofold digits of GDP growth. In Bangladesh, the GDP growth rate is 8.13% in 2018 however nearly 31.5% of people are still beneath the poverty line. Bangladesh is enduring a deficiency of gas and electricity ministration in contrast with demand. Among public and private sectors, the production of electricity raises, however to the fulfillment of the creating need is uncontrolled. Electricity demand is expanding day by day due to the improvement of economic activities with economic progress. At present, to produce electricity almost 99% utilize the non-renewable energy source. In view of the BPDB data (2018), natural gas, heater oil, diesel, and coal contribute 53.13%, 25.34%, 11.43%, 2.72% respectively

to produce the electricity. The Bangladesh Bureau of Statistics narrates that 95% of individuals in Bangladesh access with electricity grid in 2018 but it is only 59.6 in 2013. The mission statement of BPDB describes that nation will ensure electricity accessible for all residents in the nation by 2021.

In the last decade, energy demand raises for conservative, mechanical, and technological development. In addition, the quick development of urbanization and industrialization is the reason for expanding energy utilization in the nation. To lift the general expectation for everyday comforts and alleviate the demand for energy, customary and non-traditional energy is likewise fundamental. In 2016, essential vitality utilization for Bangladesh was 1.38 quadrillion but. Somewhere in the range of 1997 and 2016, essential vitality utilization of Bangladesh developed considerably from 0.4 to 1.38 quadrillion but increasing at an expanding yearly rate that arrived at a limit of 11.13% in 1999 and afterward diminished to 8.69% in 2016. Continuously 2020, expected force requests will build 185% and top interest are 17,304 MW. The absolute essential supply of energy is expanding 2.59% in a year where the utilization of per capita energy has expanded 400% from 1992 to 2018 in Bangladesh. The entire CO$_2$ emission is evaluated by 80.17 mtoe in 2014 which is expanded by 504.67% contrasted with the emission of 15.94 mtoe in 1991. Therefore, the emission of carbon dioxide (CO$_2$) and per capita discharge has also given a rising trend over the time of 1991 to 2018. In Bangladesh, it shows that the expansion than the expansion of energy utilization and GDP. According to Sarkar (2016), the average growth in CO$_2$ output was estimated at 6.7%, which is higher than the average growth of 5.25% of GDP and 4.77% of energy consumption. This situation calls for sincere concern on the part of the nation for the reduction of CO$_2$ emissions.

Recently, energy use is integrated as a fundamental factor of production. Consequently, several studies (Aali-Bujari et al., 2017; Alshehry and Belloumi, 2015; Aydın and Esen, 2017; Bildirici, 2012; Chandio et al., 2019; Elfaki et al., 2018; Farabi et al., 2019; Hu et al., 2015; Inglesi-Lotz, 2016; Khobai and Roux; 2018; Liu, 2018; Mezghani and Ben-Haddad, 2017; Mohammed et al., 2012; Nguyen et al., 2019; Raheem and Yusuf, 2015; Saad and Taleb, 2018; Shiu and Lam (2004). Soava et al. (2018); Taghvaee et al. (2017) have inspected the causal connection between energy use and economic growth. It therefore reveals that the previous studies in this field of study abandon the intersection of economic development with the environmental integration of energy usage. Moreover, it is importance to the current work. In this study, we try to determine whether energy consumption and environmental degradation incite or hinder economic growth.

The remaining sections of this study are arranged as follows. Section 2 describes research methodology of the study. In section 3 the results and discussion of this study are explained and section 4 describes the conclusion and policy implication of the results of this study.

The main aim of the study is to investigate the impact of the consumption of energy and CO$_2$ emission on economic growth in Bangladesh covering the periods of 1972–2018.

The particular objectives are as follows:

i.   To investigate the impact of energy consumption on economic growth.
ii.   To analyze the impact of carbon emission on economic growth.
iii. To investigate if there is a causal nexus between energy consumption and carbon emission on economic growth.

2. RESEARCH METHODOLOGY

2.1. Data
This study is used secondary data that are collected from World Bank (2019). The variables of uses in this study are real GDP per capita is proxy by economic growth, Electricity power consumption, Energy consumption and therefore capital is intermediary by the gross capital formation and labor is proxy by total labor force and environmental degradation is proxy by carbon emission (CO_2).

2.2. Theoretical Structure
The study incorporates the theoretical structure of the Robert Solow (1956) model which is focused on four variables like output, capital labor, and the effectiveness of labor or knowledge. Anytime, the economy has the quantity of capital, labor, and knowledge (Romer, 2009) that are joined to generate output. Hence, the production function follows the structure mentioned in equation 1 in the appendix section.

Thus, the Cobb Douglas production function is derived (see equation 2 to 5 in the Appendix) which is extremely valuable for the structure of the current investigation and adjusts to joining the factors of investigation.

Movement of Labor/knowledge, Capital over time

The growth rate of capital$=\Delta K/K$ $\Delta K = K_{(t)} - K_{(t-1)}$ (6)

The growth rate of labor$=\Delta L/L$ $\Delta L = L_{(t)} - L_{(t-1)}$ (7)

Labor rise in the rate n

Growth rate of the level of knowledge $= \Delta A/A$ $\Delta A = A_{(t)} - L_{(t-1)}$ (8)

Knowledge grows at the rate g. Hence,

$k = K_{(t)}/A_{(t)} L_{(t)}$ (9)

Using the above information we can derive the fundamental Solow equation model

$$\Delta Kt = sY_{(t)} - dK_{(t)}$$

$$\Delta k(t) = sY_{(t)} - dK_{(t)}/A_{(t)}L_{(t)} - k_{(t)}g - k_{(t)}n$$

$$\Delta k(t) = sf(k_{(t)}) - dk_{(t)} - g(k_{(t)}) - n(k_{(t)})$$

$\Delta k(t) = sf(k_{(t)}) - (n+g+d)k_{(t)}$ (General equation of Solow model) (10)

Where, f (k(t)) is showed as the output per unit of the effective labor. On the other hand, $sf(k_{(t)})$ is the actual investment of the effective labor per unit and finally, $(n+g+d)k_{(t)}$ is mentioned as the breakeven investment.

2.2.1. A pattern case: Economic growth, natural resources, and environment
The investigation is expanded to join with the sources of energy (oil and power) and environmental factors since they influence economic growth. This derivation is shown in equation 11 to equation 14 in the Appendix section. So, the expanded representation of the Solow model shows that the rate of growth of Electricity and energy consumption, and environmental degradation (CO_2) are determinants of yield with positive and inverse nexus if there should be an occurrence environmental factor.

2.3. Model Specification
For the objective of this study, the nexus among the dependent and explanatory variables are expressed as follows:

$$RGDP = f (GCF, LP, EPC, EC, CO_2) \qquad (15)$$

Based on these variables we have constructed the following log-linear econometric model

$$LNRGDP_t = \beta_0 + +\beta_1 LNGCF_t + \beta_2 LNLP_t$$
$$+\beta_3 LNEPC_t + \beta_4 LNEC_t + \beta_5 LNCO_{2t} + U_t \qquad (16)$$

Where, RGDP is that the Real Per Capita Gross Domestic Product, GCF for Gross Capital Formation, LP is Participation Rate of Labor, Total (percentage of population ages 15+), EPC is per capita Electricity Power Consumption, EC is Energy Consumption, CO_2 is Carbon Emission Metric Ton Per Capita; $\square_0$ is constant, β_1, β_2, β_3, β_4, and β_5 are coefficients and LN is natural log, U is White Noise Disturbance Error Term, and t is that the time periods.

2.4. Strategies and Model Estimation Technique
The quantitative procedures of analysis are utilized for the study. This would be carried out Johansen Cointegration test, VECM model and Granger Causality test. This study employs time series data to investigate the nexus between dependent and explanatory variables. To ascertain the unit root among the variables, this study is used the ADF test. If all the variables (LNGCF, LNLP, LNEPC, LNEC, and $LNCO_2$) are non-stationary at the level from then finding out a valid long-run connection among the variables, then we need to apply cointegration techniques. Here, we use the Johansen procedure of the cointegration estimation procedure to find out the valid long-run nexus. If it is intended for the use of non-stationary series that are cointegrated and show long-run nexus among the variables then we are also used a VECM model to finds the short-run dynamics. Lastly, the Granger causality test shows the causal relationship among the variables.

3. FINDINGS AND DISCUSSION

3.1. Descriptive Statistics
The descriptive analysis is utilized to determine the statistical characteristic of the variables. From Table 1 the Mean, median as

Table 1: Descriptive statistics of the variables

Variables	Mean	Median	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Probability
LNRGDP	6.244	6.13	7.093	5.776	0.376	0.741	2.355	5.116	0.077
LNGCF	22.763	22.705	25.173	19.504	1.356	−0.183	2.41	0.944	0.624
LNLP	17.431	17.492	18.042	16.556	0.422	−0.417	2.043	3.159	0.206
LNEPC	4.311	4.36	5.974	2.366	1.059	−0.02	1.749	3.066	0.216
LNEC	4.946	4.912	5.553	4.479	0.31	0.466	2.017	3.597	0.166
LNCO$_2$	9.918	10.035	11.375	8.163	0.942	−0.096	1.816	2.819	0.244

Source: Computed by Authors

well as the standard deviation of real per capita GDP (LNRGDP) are seen as 6.244, 6.13, and 0.376 respectively, and the minimum value of 5.776 and maximum value of 7.093. These amounts are in low contrast with other developing nations. The corresponding statistics for the electricity power consumption (LNEPC) are found to 4.311, 4.36, and 1.059 be respectively, thus the minimum value of 2.366 and maximum value of 5.974. These amounts are unbelievably small because of insufficient electricity supply in the nation that has constrained individual sources for different methods for electricity utilization.

The electricity power consumption as well as energy consumption are desired to accelerate the economic growth because they fill in the instrument for the vehicle the motor of growth yet our perceptions from this investigation doesn't bolster the desire. The environmental impact of this energy use through Carbon emission (CO$_2$) is impeding the environment and deadly to the HR that is an operator of economic progress. The mean, median, and standard deviation of CO$_2$ are recorded 9.918, 10.035, and 0.942 respectively, and the minimum value of 8.163 and maximum value of 11.375. The amount of emission is very enormous and fit for having an inverse effect on the efficiency of the human asset and natural assets. The probability values of the Jarque-Bera test are greater than 0.05, so the normality of the distribution is ensured in the present study.

3.2. Test for Stationarity
According to Gujarati and Porter (2009), to analyze stationarity of the variables to decide the suitable test that is estimated by the ADF test Table 2.

The results of the unit root test indicate that the variables (LNGCF, LNLP, LNEPC, LNEC, and LNCO2) at the first difference are non-stationary at a stage but stationary. Integrated order is therefore 1. In addition, the results of the ADF test allow the implementation of the Cointegration Test to confirm the existence of a long-term association between variables.

3.3. Optimal Lag Test
Table 3 shows the selection of the lag based on the Final Prediction Error (FPE), the Akaike Information Criteria (AIC), the Schwartz Information Criteria (SC), and the Hanna and Quinn Information Criteria (HQ). The overall lag period of 2 is chosen based on the Akaike Knowledge Criteria (AIC), LR, and Final Prediction Error criteria and is used in the review of this report.

3.4. Cointegration Test
We use the Johansen procedure to find out multiple cointegrating vectors. For this process, the Vector of Autoregression (Var) is in the following form,

Table 2: ADF test results

Variables	ADF		Decision	Order of
	Level	First difference		Integration
LNRGDP	2.401	−9.888***	Stationary	I(1)
LNEPC	−1.247	−8.244***	Stationary	I(1)
LNGCF	−0.263	−5.280***	Stationary	I(1)
LNLP	−1.742	−3.044***	Stationary	I(1)
LNEC	2.365	−8.655***	Stationary	I(1)
LNCO$_2$	−1.822	−5.527***	Stationary	I(1)

Source: Computed by Authors

Table 3: Optimal lag test results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	286.354	NA	1.18E-13	−12.743	−12.500	−12.653
1	615.017	552.751	2.00E-19	−26.046	−24.343*	−25.415*
2	659.578	62.791*	1.48e-19*	−26.435*	−23.272	−25.262
3	691.941	36.776	2.26E-19	−26.270	−21.647	−24.556

Source: Computed by Authors. * indicates the lag order is selected by the criterion

$$\Delta Y_t = \alpha + \sum_{i=1}^{p-1} \prod_i Y_{t-1} + \Pi Y_{t-p} + v_t \qquad (17)$$

Here Y_t is a column vector of n endogenous factors, Π and Πi are n by matrices of the unknown parameters, and v_t is an error term. The impact matrix Π capture all long-run connection between the variables. All the variables in Y are stationary if the matrix Π has full column rank and the framework is the first differenced VAR including no long-run relation when the matrix Π has 0 ranks. When the rank is intermediate, there remain r cointegrating vectors which make the liner combination of Y_t becomes stationary or cointegrated. Johansen provides two tests for cointegration, these are the Trace test and the Maximal Eigenvalue test.

The Trace test and Maximum Eigenvalue test results from Table 4 show that there exist 2 cointegrating equation. On account of the trace test, the null hypothesis of no cointegrating nexus equation is not accepted as the test statistics of 136.885 and 83.781 is more than a 5% critical value of 95.754 and 69.819 at none and at most 1 respectively. While Max-eigenvalue statistics of 53.104, 37.478 is higher than their critical values of 40.078 and 33.887 at none and at most 1 respectively. In addition, all their probability values are statistically significant at 5% levels. This is often a transparent indication that there existed two cointegrating equations at the 5% level. However, the co-integration test result shows that there exists a long-run nexus among economic growth, and capital formation, labor, electricity power consumption, energy consumption, and carbon emission (CO$_2$).

Table 5 shows the normalized estimated long-run equilibrium nexus among economic growth and capital formation, labor,

Table 4: Cointegration test using the trace test and the maximum eigenvalue test

Hypothesized NO. of CE(s)	Eigen value	Trace statistic	0.05 critical value	Prob.**	Max-Eigen statistic	0.05 critical value	Prob.**
None *	0.701	136.885	95.754	0.000	53.104	40.078	0.001
At most 1 *	0.573	83.781	69.819	0.003	37.478	33.877	0.018
At most 2	0.423	46.303	47.856	0.070	24.189	27.584	0.128
At most 3	0.274	22.114	29.797	0.292	14.100	21.132	0.357
At most 4	0.131	8.013	15.495	0.464	6.169	14.265	0.592
At most 5	0.041	1.844	3.841	0.175	1.844	3.841	0.175

Source: Computed by Authors. * denotes rejection of the hypothesis at the 5% level

Table 5: Normalized long-run cointegrating coefficients

Variables	Coefficient	Standard error	t-statistics
LNGCF	−0.046	−0.062	−0.745
LNLP	−1.658	−0.392	4.234***
LNEPC	−0.5	−0.088	5.700***
LNEC	−2.813	−0.357	7.880***
LNCO₂	1.713	−0.18	−9.543***

Source: Computed by Authors. In the long-run, the sign of coefficients is reversed

electricity power consumption, energy consumption, carbon emission (CO₂). Thus the estimated long-run equilibrium nexus can be restated as:

$$LNRGDP = 0.046\ LNGCF + 1.658\ LNLP$$
$$+ 0.5\ LNEPC + 2.813\ LNEC - 1.713\ LNC0_2 \quad (18)$$

The obtained empirical results from the estimated model indicate that gross capital formation, labor, electricity power consumption, energy consumption positively affect positive economic growth while carbon dioxide (CO₂) emissions have an inverse effect on it. That is, 1% increase in labor, electricity power consumption and energy consumption tends to increase economic growth by 1.658, 0.5, and 02.813%, respectively. In addition, 1% increase in CO₂ emissions decreases economic growth of 1.713%. Although capital (gross capital formation) have a positive effect on economic growth however the coefficient isn't statistically significant and implies it doesn't bear any importance.

3.5. Vector Error Correction Approach (Short-Run Dynamics)

VECM is another approach of time series to deal with the short-run dynamics, which has cointegration limitation incorporated with the particular, so it is intended to utilize the non-stationary arrangement that is called cointegrated. Permitting a broad scope of short-run elements, the VEC particular limits the long-run conduct of the endogenous factors to merge into their cointegration relationship. The deviation from since quite a long-run nexus is revised slowly through a progression of partial short-run.

On the basis of the equation (16) the VECM model is in the following form:

$$\Delta LNRGDP_t = \alpha + \sum_{i-1}^{p=2} \beta_0 \Delta LNRGDP_{t-j}$$
$$+ \sum_{i-1}^{p=2} \beta_1 \Delta LNGCF_{t-j} + \sum_{i-1}^{p=2} \beta_2 \Delta LNLP_{t-j}$$
$$+ \sum_{i-1}^{p=2} \beta_3 \Delta LNEPC_{t-j} + \sum_{i-1}^{p=2} \beta_4 \Delta LNEC_{t-j}$$
$$+ \sum_{i-1}^{p=2} \beta_5 \Delta LNCO_{2t-j} + \lambda ECM_{t-1} + \Delta_t \quad (19)$$

Where α = Constant term, Δ is first difference operator, p denotes the lag length, and is the speed of modification, ECM_{t-1} is the error term at lag one and ε_t are white noise disturbance error term. The short-run results from the error correction model are illustrated in Table 6.

The VECM result shows that the error correction term ECTt_1 is negative and also statistically significant to ensure that long-run causal nexus from gross capital formation, labor, electricity consumption, energy consumption, and carbon emission (CO₂) to economic growth (RPGDP) are present. The speed of adjustment of the error correction term is −0.281 which implies the deviations from short-run to since quite a while long-run equilibrium are revised by 28.1% each year. Moreover, the short-run results from the VECM model show that economic growth (RPGDP) of 2 years back (2016 and 2017) is positively associated with the RPGDP in the present year (2018). Conversely, capital formation and electricity power consumption in the previous 2 years (2016 and 2017) are negatively related to economic growth in the present year (2018). The findings in Table 6 also show that capital formation and electricity power consumption have a significant inverse impact on economic growth in the short run.

In addition, based on the Wald test, there's short-run causality running from the capital formation and electricity power consumption to the economic growth at a 5% level while there is no short-run causality running from the labor, energy consumption, environmental degradation (CO₂) to the economic growth. From Table 6, the Coefficient of R^2 is 0.852 means that about 85.2% of the variation of economic growth is explained by the explanatory variables gross capital formation, labor, electricity power consumption, energy consumption, and CO₂ emission. Therefore the model is a solid match for the relationship. The result has an F-statistic value of 11.944 with an associated probability of (0.000) less than 5% indicating that the model is overall statistically significant and concludes that exert significant impact of gross capital formation, labor, energy consumption, the electricity power consumption, and environmental degradation (CO₂) on economic growth in Bangladesh.

3.6. Causality Test

The Granger causality tests are employed to investigate if the previous value of a series X_t, will assist with foreseeing the present value of another series Y_t. If Granger causality holds then X might be causing Y. The two series are first tested for stationary utilizing the ADF test, trailed by the Johansen cointegration test before conducting the Granger causality test. The Granger causality test is as follows:

$$Y_t = \sum_{i=1}^{p} \alpha_{yi} Y_{t-i} + \sum_{i=1}^{q} \beta_{xi} X_{t-i} + \mu_t \qquad (19)$$

Where μ_t is white noise error term at time t; p and q are respectively the numbers of lags for Y and X. The parameter β_{xi} measures the influence of X_{t-1} on Y_t. The Granger causality tests the null hypothesis $H0$: $\beta_{xi} = 0$. If the null hypothesis is true then past values of X have no effect on the present value of Y. If the null hypothesis is not accepted then X Granger causes Y.

The Granger causality result is presented in Table 7 in the Appendix section, it reports the null hypothesis and the probability value which is employed to infer the direction of causality. The result finds that there presence on bi-directional causal connection between capital formation and economic growth; GCF and labor; electricity power consumption and carbon emission (CO$_2$) in Bangladesh. The results also show a unidirectional causal connection from RGDP to labor, electricity power consumption to real GDP, capital formation to labor, energy consumption to gross capital formation, carbon emissions (CO$_2$) to gross capital formation, labor to electricity power consumption, energy consumption to labor, carbon emissions (CO$_2$) to labor, and carbon emissions (CO$_2$) to electricity power consumption.

3.7. Diagnostic Test

The diagnostic tests results in Table 8 in the Appendix section showed that the VECM model is free from the issues of non-normality errors, and serially correlated errors, ARCH effect, and heteroskedasticity from the probability values are greater than a 5% level. The result of stability test considering both the CUSUM and CUSUMQ plot lies within the bounds of the critical line at a 5% level (Figs. 1 and 2) which confirms the stability of the coefficients and therefore the correct specification of VECM model.

Table 6: Results of short-run dynamic nexus between the variables (VECM)

Variables	Coefficient	Std. error	t-statistic	Prob.
ECT$_{t-1}$	−0.281	0.079	−3.539	0.001
ECT$_{t-2}$	−0.089	0.027	−3.260	0.003
ΔLNRGDP$_{t-1}$	0.105	0.119	0.883	0.385
ΔLNRGDP$_{t-2}$	0.229	0.109	2.108	0.044
ΔLNGCF$_{t-1}$	−0.021	0.022	−0.937	0.357
ΔLNGCF$_{t-2}$	−0.078	0.024	−3.196	0.003
ΔLNLP$_{t-1}$	0.508	0.320	1.588	0.123
ΔLNLP$_{t-2}$	−0.190	0.415	−0.457	0.651
ΔLNEPC$_{t-1}$	−0.107	0.038	−2.798	0.009
ΔLNEPC$_{t-2}$	−0.122	0.029	−4.244	0.000
ΔLNEC$_{t-1}$	0.029	0.153	0.191	0.850
ΔLNEC$_{t-2}$	−0.062	0.137	−0.454	0.653
ΔLNCO2$_{t-1}$	0.025	0.072	0.349	0.730
ΔLNCO2$_{t-2}$	0.056	0.064	0.867	0.393
Constant	0.033	0.014	2.351	0.026
R-squared	0.852	Durbin-Watson stat		1.798
Adjusted R-squared	0.781			
F-statistic	11.944			
Prob.(F-statistic)	0.000			

Source: Computed by Authors

Table 7: The pairwise granger causality tests

| Null Hypothesis:	Obs.	F-Statistic	Prob.	The decision about the direction of Causality
LNGCF does not Granger Cause LNRGDP	45	5.528	0.008***	Reject H0
LNRGDP does not Granger Cause LNGCF		4.168	0.023**	Reject H0
LNLP does not Granger Cause LNRGDP	45	0.218	0.805	Accept H0
LNRGDP does not Granger Cause LNLP		2.861	0.069*	Reject H0
LNEPC does not Granger Cause LNRGDP	45	5.735	0.007***	Reject H0
LNRGDP does not Granger Cause LNEPC		1.459	0.245	Accept H0
LNEC does not Granger Cause LNRGDP	45	0.743	0.482	Accept H0
LNRGDP does not Granger Cause LNEC		1.397	0.259	Accept H0
LNCO$_2$ does not Granger Cause LNRGDP	45	1.604	0.214	Accept H0
LNRGDP does not Granger Cause LNCO$_2$		0.204	0.816	Accept H0
LNLP does not Granger Cause LNGCF	45	0.531	0.592	Accept H0
LNGCF does not Granger Cause LNLP		2.732	0.077*	Reject H0
LNEPC does not Granger Cause LNGCF	45	3.788	0.031**	Reject H0
LNGCF does not Granger Cause LNEPC		1.092	0.345	Accept H0
LNEC does not Granger Cause LNGCF	45	3.918	0.028**	Reject H0
LNGCF does not Granger Cause LNEC		0.705	0.500	Accept H0
LNCO$_2$ does not Granger Cause LNGCF	45	2.787	0.074*	Reject H0
LNGCF does not Granger Cause LNCO$_2$		0.026	0.974	Accept H0
LNEPC does not Granger Cause LNLP	45	1.873	0.167	Accept H0
LNLP does not Granger Cause LNEPC		2.484	0.096*	Reject H0
LNEC does not Granger Cause LNLP	45	2.787	0.074*	Reject H0
LNLP does not Granger Cause LNEC		0.206	0.815	Accept H0
LNCO$_2$ does not Granger Cause LNLP	45	2.725	0.078*	Reject H0
LNLP does not Granger Cause LNCO$_2$		1.382	0.263	Accept H0
LNEC does not Granger Cause LNEPC	45	0.176	0.840	Accept H0
LNEPC does not Granger Cause LNEC		1.272	0.291	Accept H0
LNCO$_2$ does not Granger Cause LNEPC	45	6.588	0.003***	Reject H0
LNEPC does not Granger Cause LNCO$_2$		4.210	0.022**	Reject H0
LNCO$_2$ does not Granger Cause LNEC	45	0.749	0.479	Accept H0
LNEC does not Granger Cause LNCO$_2$		2.063	0.140	Accept H0

Source: Computed by Authors. ***, **,* indicates significance level of 1%, 5%, 10%, respectively

Table 8: Diagnostics test result

Test Type	Null Hypothesis	Statistic	Probability	Inference
Normality Test (Jarque-Bera Statistics)	Errors are normally distributed	Jarque-Bera Statistics=1.121	Probability=0.571	Fail to reject H$_0$
Serial Correlation (Breush-Godfrey Serial Correlation LM Test)	No serially correlated errors	F-statistics=0.802	Prob. Chi-square=0.291	Fail to reject H$_0$
ARCH Test (Autoregressive Heteroskedasticity Test)	ARCH effect does not characterize model's errors	F-statistics=0.225	Prob. Chi-square=0.787	Fail to reject H$_0$
Heteroskedasticity Test (Breush-Pagan-Godfrey)	Homoscedasticity	F-statistics=0.492	Prob. Chi-square=0.871	Fail to reject H$_0$

Figure 1: The plot of the cumulative sum (CUSUM)
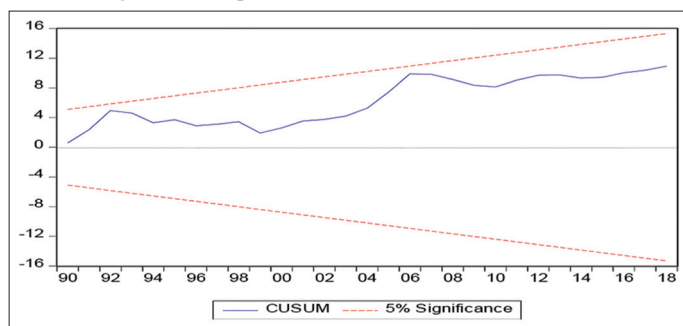
Source: Computed by Author's

Figure 2: The plot of the cumulative sum of squares
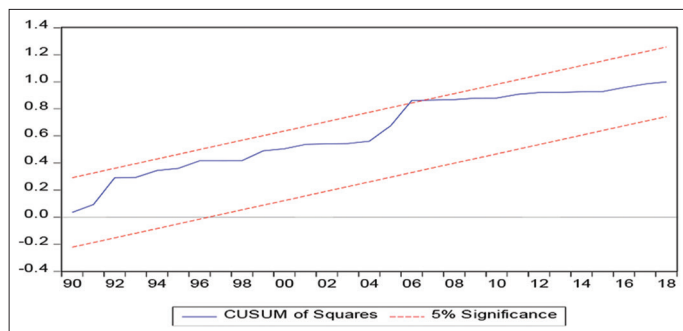
Source: Computed by Author's

4. CONCLUSION

Energy plays an important role in the achievement of development goals in Bangladesh, with consideration of the misfortunes attached to its use in our environment. This study examines the impact of energy usage and CO2 emissions on economic growth in Bangladesh between 1972 and 2018. Moreover, the study follows an econometric approach where Economic growth (RPGDP) is taken as a dependent variable while capital formation, labor, electricity power consumption, energy consumption, and carbon emission (CO$_2$) as explanatory variables. VECM is employed to determine the since quite a while ago run and short-run nexus. Having ensured that all variables (LNGCF, LNLP, LNEPC, LNEC, and LNCO$_2$) are stationary at the first difference and therefore cointegration test is led and since quite a long-run nexus is affirmed exist within the model.

The results from Johansen cointegration indicates that gross capital formation, labor, electricity power consumption, energy consumption is positively contributed to economic growth.

In contrast, environmental degradation (CO$_2$) emissions are negatively contributed to economic growth. The finding shows that energy consumption plays a significant role in the achievement of development goals particularly electricity without inconvenience to the earth. The results of VECM show that there exists a long-run causal nexus running from the gross capital formation, labor, electricity power consumption, energy consumption, and carbon emission (CO$_2$) to economic growth (RPGDP). The speed of adjustment of the error correction term is −0.281 which implies the deviations from the short-run to the long-run. Moreover, short-run results based on the Wald test find that there exists short-run causality running from the capital formation and electricity power consumption to the economic growth at a 5% level while there is no short-run causality running from the labor, energy consumption, carbons emission to the economic growth.

The granger causality test finds that there exists the unidirectional causal nexus from economic growth to labor, electricity power consumption to real GDP, capital formation to labor, energy consumption to capital formation, carbon emissions (CO$_2$) to capital formation, labor to electricity power consumption, energy use to labor, carbon emissions (CO$_2$) to labor, and carbon emissions (CO$_2$) to electricity power consumption. Also, there have a bi-directional causal nexus between gross capital formation (GCF) and economic growth; GCF and labor; electricity power consumption, and carbon emission (CO$_2$) in Bangladesh. Hence, the study concludes that the consumption of energy has positively contributed to economic growth whereas carbon emission has an inverse impact on it. These results are like those that came to by Bozkurt and Akan, (2014); Ghosh et al. (2014); Gojayev et al. (2002); Yusuf (2014); and Zeshan and Ahmed (2013).

5. POLICY REMARKS

1. Environmental sustainability whereby worldwide warming problem is often alleviated to the minimum by decreasing the fuel consumption which are from fossil and by Substituting a significant energy requirement for economic development with renewable energy sources, which will reduce the CO$_2$ outflow, thus ensuring that our situation is undermined.
2. Since the electricity sector has been distinguished as critical to the financial advancement of Bangladesh, the study suggests that the foundation of preparing establishment where our youth are prepared and collected specialized ability on creating elective power age intends to diminish our fixation on warm methods for power gracefully. This will go far in giving an opening for work to our youth and equipped for meeting the

power required by Bangladesh.

3. The security of energy by not relying mostly upon fossil that is non-inexhaustible as the main wellspring of energy, with the goal that a group of people yet to come can be benefited from this reduce-able and non-sustainable natural assets.

4. Sound approaches structure ought to be given, to be followed carefully by the power generation and conveyance administrators to guarantee that they don't abuse people and corporate Bangladeshi for their own narrow-minded individual intrigue.

5. The government should make a giant attempt to regulate the exercises of pipeline vandals, since they are gracefully disturbing enough with gasoline.

6. ACKNOWLEDGMENT

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APPENDIX

$$Y(t) = f(K(t), A(t), L(t)) \tag{1}$$

Where $Y(t)$ is the output at time t, and $K(t)$ is capital at time t; $L(t)$ is labor at time t, $A(t)$ is the level of knowledge at time t. Therefore, $A(t)$ and $L(t)$ go into the model multiplicatively, and subsequently, $A(t) L(t)$ is effective labor.

$$Y = f(K_{(t)}, A_{(t)} L_{(t)}) = K_{(t)}^{\alpha} A_{(t)} L_{(t)}^{1-\alpha} \, 0 < \alpha < 1 \tag{2}$$

$$Y/AL = K/AL^{\alpha} (AL/AL)^{1-\alpha} \tag{3}$$

$$Y/AL = y \text{ and } K/AL = k \tag{4}$$

$$\text{Hence, } y = k^{\alpha} \, y_{(t)} = f(k_t) \tag{5}$$

Hence the production function (1) is:

$$Y(t) = K_{(t)}^{\beta} EPC_{(t)}^{\lambda} EC_{(t)}^{\theta} CO_{2(t)}^{\delta} (A_{(t)} L_{(t)})^{\gamma} \tag{11}$$

Where, $Y_{(t)}$ is the economic growth, subsequently $A_{(t)} L_{(t)}$ is the effective labor, and $K_{(t)}$ is Capital, $EPC_{(t)}$ is Electricity power consumption, $EC_{(t)}$ is Energy consumption and $CO_{2(t)}$ is Carbon Emission.

Taking log two sides of the equation three

$$\ln Y(t) = \beta \ln K_{(t)} + \lambda \ln EPC_{(t)} + \theta \ln EC_{(t)} + \delta \ln CO_{2(t)} + \gamma (\ln A_{(t)} + \ln L_{(t)}) \tag{12}$$

Differentiating two sides (equation 12) as for time, therefore we get

$$gy = \beta gk + \lambda gEPC + \theta gEC - \delta gCO_2 + \gamma (n+g) \tag{13}$$

At the equalization growth path, the growth rate of Y and capital K is that the equivalent

Thus, $gy = \beta gk$

Along these lines, $gy = gk = \beta gk$

$$gy - \beta gy = \lambda \, EPC + \theta \, EC - \delta \, CO_2 + \gamma (n+g)$$

$$\begin{aligned}
\frac{gy \, (1-\beta)}{1-\beta} &= \frac{\lambda}{1-\beta} (gEPC) + \frac{\theta}{1-\beta} (gEC) \\
&- \frac{\delta}{1-\beta} (gCO_2) + \frac{\gamma}{1-\beta} (n+g)
\end{aligned} \tag{14}$$