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The causality between human capital, energy consumption, co$_2$ emission and economic growth: evidence from Bangladesh

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Abstract
This study is to investigate the causality between human capital, energy consumption, CO_2 emissions, and economic growth in Bangladesh. The data used world development indicator has obtained from the World Bank database during 1986-2017. The analysis method used the vector error correction model (VECM). The finding of this study, first, neither CO_2 emissions nor employment cause economic growth in the long-run causality. Secondly, there is no causal evidence from the human capital, CO_2 emission per capita, and real GDP to consumption energy per capita. The third is there is no causal evidence from the human capital, consumption energy per capita, and real GDP per capita toward CO_2 emission per capita. Forth, there is no causal evidence from the human capital, consumption energy per capita, and CO_2 emission to real GDP in the long-run causal. Therefore, in the last findings, there is no causal evidence between human capitals, carbon emission to GDP. There is the validity of long-run balance causality that exists only for the model of neither human capital nor energy consumption.

Keywords: human capital, energy consumption, carbon dioxide emission, economic growth, vector error correction model, granger causality

1. Introduction

At present, the most important challenge for developing economies, such as Bangladesh is to generate stable economic growth without deteriorating environmental quality. The industrial sector of Bangladesh, whose contribution to the GDP accounted for 33.71% during the fiscal year 2017-18 which was 27.75% during the previous fiscal year. So, the industrial sector is considered as a driving sector of the economy. As per the economic theory, to accelerate the economic growth with the help of the industrial sector a lot of Human assets or Human resources or more recently Human Capital is required along with the huge amount of energy consumption. Human capital encompasses the intellectual knowledge, education, technical training, skills, fitness, and capability of the firm's workers. So, Human capital is considered the valuable factor of production of a firm. In changing the global business environment, nowadays human capital is considered not only as an essential resource for a business but also act as a key player of competitive advantage and long-term sustainability of a business (Khan, M. Zaman, *et al*. 2010). To accelerates economic growth and reduces poverty human capital plays a significant role. In production function, human capital is considered as a key factor of production because it improves labor productivity, enhances technological innovations, increase returns to scale of capital, and makes economic growth more stable that ultimately reduces poverty and enhanced the economic welfare as a whole. The GDP growth rate of Bangladesh is accounted for 7.8 percent during the fiscal year 2017-18 in which human capital has a direct contribution. In Bangladesh, approximately half of its labor forces engaged in the agricultural sector and others are involved in RMG, leather & leather goods, textile, pharmaceuticals, jute, fish, vegetables, ceramics, fruits and other valuable product produce. Besides these, a significant portion of its labor forces work as overseas employees in the Middle East, and every year they send a huge amount of remittances which is considered the major sources of foreign earnings; other main sources of foreign earnings are RMG, textile, leather & leather goods, and pharmaceuticals.

To understand the development of the human capital of Bangladesh the aggregate total percent data of selected years are taken in Table1. This represents the Government expenditure on education (% of GDP), Health expenditure (% of GDP) and Gross domestic product (GDP growth annual %).

Table 1: Human Capital Development on Education and Health

Year	Government expenditure on education (% of GDP)	Health expenditure (% of GDP)	Annual percentage growth of GDP
2000	2.13	2.00	5.29
2003	2.07	2.19	4.74
2006	2.13	2.32	6.67
2009	1.94	2.40	5.05
2012	2.18	2.57	6.52
2015	1.47	2.46	6.55

Source: World Bank (2018).

In table 1, it is seen that health expenditure is higher than of expenditure on education. This also raises economic growth of a country. That indicates expenditure on health improves the health status of individuals, improving their productivity and therefore employment, further resulting economic growth. More and more of economic growth increase the employment and government expenditure on health. Increase in economic growth also increases the energy use of a nation and gross capital formation (investment). On the other side, public expenditure on education signifies the importance government gives to the building up of knowledge base of the people. Education attainment is an indicator of accessibility of education facility and the number of the patent applications reflects the quality of knowledge base created by the education system in a nation. It is the indicator of ability to contribute to innovation made by the human resources. These indicators together define the education index of a nation.

According to intertemporal analysis, to make the economic growth sustainable, energy should be utilized at present time in such a way that it will be available for the future generation. Total energy consumption is the sum of energy spent by household and industrial sector in the economy. In Bangladesh the most important measure of energy balance of energy consumption is 53.65kWh electric energy per year and per capita this is an average 326kWh. Self-producing energy is main sources of energy consumption of Bangladesh and its total self-producing electric energy capacity is 61 billion kWh. Other energy sources are gas and crude oil.

However, Human activities are responsible for increasing greenhouse gas (GHG) emissions, which increase atmospheric concentrations of carbon dioxide (CO_2), hydro fluorocarbons (HFCs), methane (CH_4), per fluorocarbons (PFCs), nitrous oxide (N_2O), and sulphur hexafluoride (SF_6) (EPA, 2014). According to IPCC's report (2007), contribution of carbon dioxide (CO_2) was 77% of the total world greenhouse gas (GHG) emissions, whereas contribution of CH_4, N_2O and other gases were 14%, 8%, and 1% respectively. Global concentration of CO_2 gas emission reached nearly double during the last four decades. In 2006, Bangladesh emitted one tenth of global CO_2 gas emission although its population was only 2.4% of world's population. It emitted low CO_2 gas emission because low energy consumption which was one twentieth of the world average per capita electricity consumption. Only the study of Azad *et al*, (2006) suggested some simple estimation of future CO_2 gas emission of Bangladesh although many other studies estimated global, regional and country-specific CO_2 gas emission.

Economic production and the process of long-term economic growth largely depend on energy consumption and its availability in production process (Stern, 1999). At the present time, world's energy consumption largely depends on fossil fuels. In order to identify the causal relationship between energy consumption and economic growth many researchers have conducted research based on the area of global, regional and country-specific. Some of them found one way, two ways or no causal relationship between energy consumption and economic growth. Shahbazetal., (2012) in their study demonstrated that energy consumption increases economic growth which in turn increase CO_2 gas emission both in short-run and long-run. According to Environmental Kuznets Curve (EKC) hypothesis, which was simulated by a noble prize winner Kuznets (1955), hypothesized that there is an inverted U-shaped relationship between economic growth and environmental degradation. Based on this theme, there is a relationship among economic activities, pollution emission, per capita income, and level of environmental quality.

In South Asian economy, Bangladesh is one of fast-growing emerging economy which is maintaining macroeconomic stability despite its structural limitation; domestic political unrest, and Global financial crisis (World Bank, 2015a). Although it is a small country but its population was 168.95 million in 2015 and it ordered was 9th in the world. The GDP of this country has expended 7.8% in 2018 which was 7.28% in 2017 (2018b). It observed its GDP growth rate more than 6% during the last one decade. Due to the demand for large number of its population and expansion of economic activities the energy consumption gradually increases that in turns increase greenhouse gas (GHG) concentration in its atmosphere. According to IEA report of 2014, Bangladesh produced only 0.19% of global greenhouse gas (GHG), and its average per capita emission was very low but still now it is highly affected by global warming. Nevertheless, the greenhouse gas (GHG) concentration particularly the CO_2 gas emission increases in Bangladesh due to the higher demand of its population and increasing economic activities.

Meanwhile, Figure 1 shows the fluctuating trend of energy consumption, CO_2 gas emission, economic development, and human capital of Bangladesh. From 1986 to 2017 the average growth rate of energy consumption reached at 5.39%, at the meantime, average CO_2 gas emission, GDP, and human capital reached at 6.11%, 3.52%, and 1.25% respectively.

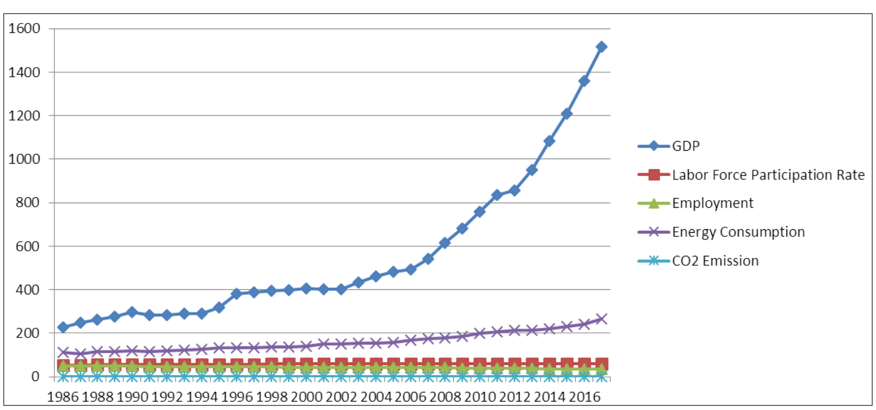

Fig 1: Energy consumption, economic growth, CO_2 emissions, and human capital (labor force participation rate and employment) (FY 1986-2017). Source: World Bank (2018).

A suitable strategy is required to enhance economic growth when consuming a huge amount of energy without deteriorating environmental quality. Soytas *et al*., (2010) conducted a study by using Granger causality test for the case of the United States, and they found that Granger's energy consumption caused carbon emissions, but there is no causal relationship between energy consumption and economic growth. This result demonstrates that economic growth is not the prime solution to encounter the current global environment.

This paper investigates the causality between human capital, energy consumption, CO2 emission and economic growth in the context of Bangladesh. This paper also aims at the presence of a long-run relationship between economic growth, human capital, energy consumption, and CO2 emission in Bangladesh from 1986-2017. We could not extend the period of research due to the unavailability of the data. The remaining part of this paper designed as follows: Section 2 represents a review of literature, section 3 shows mainly about data, variables and econometric model, section 4 represents the trend between regressors and regressands, section 5 contains empirical research and section 6 ends with the conclusion.

2. Review of literature

The study of the relationship between economic development and energy consumption was first conducted by Kraft and Kraft (1978) using the data of the United States from 1947-1974. He found the causality between energy consumption and the gross national product in his study.

Some other researchers have also found the causal relationship between economic growth and the use of energy (Al. Mamun in 2014; Yildirim in 2014; Bimanatya and Widodo in 2018) [2, 3].

The relationship between economic growth and environmental pollution has widely been taken into account. Environmental Kuznets Curve (EKC) assumed that there exists an inverted U-shaped relationship between environmental degradation and income per capita. The hypothesis of Environmental Kuznets's Curve (EKC) was first advocated by Grossman and Krueger (1993) [4]. Pollution first increased along with the per capita Gross Domestic Product of a country but later decline with the further increase of Gross Domestic Product. This was the result of Grossman and Krueger's analysis (1993) [4]. Some other famous researcher named Selden and Song (1994) [6] also shown that there is an inverted U-shaped relationship between per capita GDP and environmental pollution. Carson, Jeon, and McCubben (1997) [7] have shown the same result. China is one of the best examples of this relationship.

Masih (1997) [8], another researcher also shows in his study that there is a long-run relationship between energy consumption and economic growth in Korea and Taiwan. There exists a similar causality between energy consumption and economic growth.

Paul and Bhattacharya (2004) [9] observed the same relationship between energy consumption and economic growth in India using the data from 1950-1996. They use the Granger causality test to find a two-way causal relationship between economic growth and energy.

Dinda (2004), another renowned researcher also showed that there is no empirical evidence that environmental degradation declines with economic growth.

Stern (2011) [11] estimated that there is a long-run relationship between energy usage and economic development in the United States of America and the result affirmed previous research which was developed by the researcher using the Granger causality test. According to himself, the methodology for studying the relationship between economic growth and energy consumption is multivariate analysis.

Mehari in his research in 2011 assessed that there is unidirectional causality between economic growth and energy consumption in Ethiopia using the Granger causality test.

Sustainable development can be achieved with sustainable environmental conversion as explained by Shahbaz and Lean (2012) [13]. Soytas and Sari (2007) [14] showed that CO2 emissions upsurge with energy consumption in Turkey. So, based on the above discussion it is clear that with the increase of national income, CO2 emission rises. A further increase in national income ensures further environmental degradation (Ang, 2007). CO2 emissions granger cause to the output which is conflicting to the EKC hypothesis found by the same author.

3. Methodology

3.1 Data Collection and Data Sources

In this thesis, the causality between Human Capital, Energy Consumption, CO2 Emission and Economic Growth of Bangladesh are analyzing. The analysis is doing with data from 1986 to 2017. The secondary data are collected from World Development Indicators published by the World Bank database and the World Investment Report (WIR) posted by UNCTAD. All the sources are thought of as the original source of data collection. The dependent variable of the study is the Gross Domestic Product, and the main explanatory variables are Human Capital, Energy Consumption and CO2 Emission. Here the proxy variables used as for Human Capital are Labor Force and Employment. For improving the relationship between Human Capital, Energy Consumption, CO2 Emission and Gross Domestic Product we use the co-integration method as well as the vector error correction model.

As the VECM shows us the long-run relationship among variables and the short-run adjustment coefficient so the VECM is accomplished. Before that, the unit root test of the variables is needed to check and also ensure that there is at least one co-integrating equation to run the VECM.

3.2 Model Specification

The assumption is that human capital, energy consumption, CO_2 emission affect economic growth. The functional form of the relationship is,

$$GDP=f\ (LF, EMP, ECM, CO_2) \qquad (1)$$

Where, GDP is the gross domestic product, LF represent labor force rate, EMP represent employment, ECM is the energy consumption and CO_2 is the carbon dioxide emission. Thus, the gross domestic product is a function of labor force, employment, energy consumption, CO_2 emission.

The econometric model can be evaluated according to this research as,

$$GDP=\beta_0+\beta_1 LF+\beta_2 EMP+\beta_3 ECM+\beta_4 CO_2+\square_t \qquad (2)$$

Here β_0 is the intercept of the model and β_1, β_2, β_3, β_4 measure the slope coefficient.

3.3 Method of Estimation

Unit Root Test

In the time series data set the unit root problem is a very common feature (Fasanya and Onakoya, 2012). The existing unit root problem means the data set is non-stationary. To analyze long-run stability and short run dynamic effect of any data set, the stationary test is crucial. The widely used test to stationary data test is the Augmented Dickey-Fuller [3] test (ADF test) criteria. If a time series data is not stationary at zero order (level), then the level is found at the first difference and second difference. Before doing the ADF test, it is essential to pay attention to the plot of data to be tested. This test presents the following equation:

$$\Delta Y_t=\beta_1+\beta_2 t+\delta\ Y_{t-1}+\gamma_i\sum_{i=1}^{m}\Delta Yt-1+\square_t \qquad (3)$$

Here ΔY_t is the first difference form of Y; β_1 is a constant value; β_2 is the regression coefficient for trends; δ is the regression coefficient for Y lag; γ is the regression coefficient for Y lag difference; $\square$ is error term; m is lag and t is the time period.

Johansen Co-integration Test

The most common cointegration test is the Johansen test. This test is used to see if there is a maximum possibility of the Johansen co-integration test (Johansen, 1988) to determine the long-term relationship between the variables being discussed. In checking Granger causality analysis also needs to be done to get good results from the test results by preferring the right optimal lag length.

The VECM Granger Causality

Therefore, to analyze the direction of causality between the human capital (HC), energy consumption (ECM), CO_2 emission (CO_2), and economic growth (EG) in the context of Bangladesh the VECM granger causality equation can be shown as follows:

$$\Delta lnGDP_t=\alpha_{0t}\ +\ \sum_{i=1}^{n-1}\rho t\Delta lnLF_{t-1}+\sum_{i=1}^{n-1}\beta t\Delta lnEMP_{t-1}+\sum_{i=1}^{n-1}\gamma t\Delta lnECM_{t-1}+\sum_{i=1}^{n-1}\delta t\Delta lnCO2_{t-1}+ ECT_{t-1}+\square_t \qquad (4)$$

Where t is time period (t=1,…, t);Δ is as the differencing notation; lnLF is labor force per capita; lnEMP is employment rate per capita; lnECM is energy consumption per capita; and $lnCO_2$ is carbon emission per capita; ECT is error correction term and $\square_t$ is error term.

4. Result and Discussion

The diagnostic test indicated that human capital, CO2 emission is negatively associated with economic growth, and on the other hand, energy consumption is positively related to economic growth in the model. An obtained optimal lag length is one that is based on a criterion such as the Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC). At the first stage, a unit root with the ADF test criteria is tested presenting in table 2 below.

Based on the test result in table 2, it is seen that on the ADF or Mackinnon criteria the test statistic value is smaller than the critical value at 5% confidence level and the probability value which is smaller than 0.05. The result indicated that overall, the variable of human capital, energy consumption, CO2 emission, and economic growth is stationary in the first difference.

By using the Johansen maximum likelihood approach table 3 shortens the results of the co-integration analysis by maximum eigenvalue and trace statistics. There is included the intercept term. It is estimated that the vectors are co-integrated at zero degrees for coin vector integration at a 5% significance level that's why both produce evidence to reject the null hypothesis.

On the basis of these results, after testing the variables are co-integrated then VECM can be applied. Residual lags from regressions that co-integrated with the right amount of lag are included in the Granger causality test structure. The length of the lag structure depends on the error correction model that is calculated. The diagnostic test series include serial correlations on the basis of inspection of autocorrelation functions of residuals.

In table 4 given below, the result of the estimation of the five models exhibit that there are two models that have a long-term causality, for instance, the model of the labor force and energy consumption. In table 4 it is seen that the model of employment, CO2 emission, and economic growth have not long-term causality. Statistically, the first model indicates there is a long-term causality of energy consumption, CO2 emission and human capital in economic growth. In the model, there is a negative effect on the previous year's CO2 emissions on the gross domestic product, which is shown from the coefficient value of. 0003. This means that a 1% increase in CO2 emissions will reduce human capital by 0.03%.

Table 2: Unit root test at first difference

Variable	ADF test	t statistic (1%)	5%	10%	Summary
Δ(lnGDP)	-9.79	-3.699	-2.97	-2.63	*stationary
Δ(lnLF)	-5.85	-3.66	-2.96	-2.62	*stationary
Δ(lnEMP)	-6.34	-3.67	-2.98	-2.62	*stationary
Δ(lnECM)	-4.07	-3.66	-2.96	-2.64	*stationary
Δ(lnCO2)	-5.98	-3.68	-2.97	-2.65	*stationary

**Indicates statistical significance at the 1%, 5%, and 10% level.

****Source:*** Authors own calculation by Stata/SE 12.0

Table 3: Johansen co-integration test results Trace test

Null hypothesized(H_0)	Eigenvalue	Trace statistic	Critical value 0.05	Prob**
None*	0.644	86.732	69.819	0.0013
At most 1*	0.558	56.792	47.856	0.0058
At most 2*	0.470	33.083	29.797	0.0202
At most 3	0.363	14.656	15.495	0.0666
At most 4	0.053	1.588	3.841	0.2076

Maximum eigenvalue test

Null hypothesized(H0)	Eigenvalue	Max-eigen statistic	Critical value 0.05	Prob**
None	0.644	29.940	33.877	0.1375
At most 1	0.558	23.709	27.584	0.1452
At most 2	0.470	18.427	21.132	0.1147
At most 3	0.363	13.068	14.265	0.0766
At most 4	0.054	1.588	3.841	0.2076

****Source:*** Authors own calculation by Stata/SE 12.0

Table 4: The long-run causality from VECM estimates result

Error Correction:	D(DCO2_EM)	D(DEMPLO...	D(DENERG...	D(DGDP_PC)	D(LABOR_...
CointEq1	-0.377113 (0.16525) [-2.28203]	-11.36968 (11.2353) [-1.01196]	83.83654 (67.1273) [1.24892]	-676.9657 (342.483) [-1.97664]	2.920023 (3.49686) [0.83504]
D(DCO2_EM(-1))	-0.179354 (0.18853) [-0.95133]	-16.33343 (12.8178) [-1.27428]	-171.1396 (76.5823) [-2.23472]	290.0012 (390.722) [0.74222]	2.905159 (3.98939) [0.72822]
D(DEMPLOYMENT(-1))	-0.003393 (0.00417) [-0.81349]	-0.598921 (0.28354) [-2.11232]	-1.796616 (1.69405) [-1.06055]	6.341407 (8.64301) [0.73370]	0.176950 (0.08825) [2.00515]
D(DENERGY_CON(-1))	-0.000474 (0.00078) [-0.60506]	0.007506 (0.05329) [0.14086]	-0.030669 (0.31836) [-0.09633]	-0.889127 (1.62429) [-0.54739]	-0.014017 (0.01658) [-0.84520]
D(DGDP_PC(-1))	0.000303 (0.00011) [2.70177]	0.001836 (0.00761) [0.24120]	-0.010678 (0.04549) [-0.23476]	0.031142 (0.23207) [0.13419]	-0.001492 (0.00237) [-0.62961]
D(LABOR_FORCE(-1))	-0.000216 (0.00779) [-0.02772]	-0.464987 (0.52979) [-0.87769]	-1.675294 (3.16531) [-0.52927]	1.028299 (16.1494) [0.06367]	0.441890 (0.16489) [2.67991]
C	-0.001165 (0.00279) [-0.41673]	0.079371 (0.19003) [0.41768]	0.964913 (1.13535) [0.84988]	5.153889 (5.79254) [0.88975]	0.061818 (0.05914) [1.04523]

R-squared	0.503834	0.504818	0.405204	0.204235	0.394235
Adj. R-squared	0.368516	0.369769	0.242987	-0.012792	0.229027
Sum sq. resids	0.003870	17.88914	638.5875	16622.64	1.732914
S.E. equation	0.013263	0.901744	5.387644	27.48772	0.280658
F-statistic	3.723333	3.738022	2.497912	0.941060	2.386287
Log likelihood	88.21648	-34.14424	-85.98268	-133.2420	-0.295589
Akaike AIC	-5.601136	2.837534	6.412599	9.671861	0.503144
Schwarz SC	-5.271099	3.167571	6.742635	10.00190	0.833181
Mean dependent	0.000000	0.031724	0.680345	4.882069	0.114138
S.D. dependent	0.016690	1.135883	6.192232	27.31358	0.319637

Determinant resid covariance (dof adj.)	0.051740
Determinant resid covariance	0.013000
Log likelihood	-142.7757
Akaike information criterion	12.60522
Schwarz criterion	14.49115
Number of coefficients	40

Source: Authors own calculation by Stata/SE 12.

Table 5: Data of Gross Domestic Product, Labor force participation rate, Employment, energy consumption and CO_2 emission for the period of 1986 to 2017

Year	GDP	Labor Force participation	Employment	Energy Consumption	CO_2 Emission
1986	227.42	53.46	50.02	111.29	0.12
1987	247.07	53.78	50.06	106.66	0.12
1988	263.22	55.05	50.81	114.16	0.13
1989	277.82	55.81	49.3	116.8	0.13
1990	297.57	56	49.5	119.96	0.15
1991	284.73	57.59	46.93	115.48	0.15
1992	285.1	57.61	46.66	119.15	0.16
1993	291.71	57.66	46.33	123.07	0.15
1994	290.65	57.74	46.14	125.7	0.16
1995	319.61	57.86	46.03	133.95	0.19
1996	382.96	58.01	45.66	131.89	0.2
1997	389.52	58.03	45.08	134.9	0.2
1998	395.3	58.09	44.56	137.75	0.19
1999	397.36	58.18	43.89	136.78	0.2
2000	405.6	58.27	43.29	138.79	0.21
2001	402.6	58.36	43.24	148.96	0.24
2002	400.61	58.38	43.43	149.73	0.25
2003	432.74	58.42	43.88	155.03	0.26

2004	460.76	58.47	43.07	155.35	0.27
2005	484.16	58.5	42.28	158.94	0.28
2006	494.05	58.54	42.43	168	0.3
2007	541.07	58.44	41.75	173.41	0.3
2008	615.78	58.41	40.98	179.97	0.33
2009	681.12	58.37	39.85	187.26	0.36
2010	757.67	58.34	40.45	200.55	0.39
2011	835.79	58.31	39.4	205.67	0.41
2012	856.34	58.31	38.31	213.3	0.43
2013	951.89	58.33	37.16	215.28	0.44
2014	1084.57	58.34	36.46	222.22	0.46
2015	1210.16	58.36	35.76	230.67	0.5
2016	1358.78	58.36	35.12	239.87	0.5
2017	1516.51	58.36	36.79	267.1	0.51

This finding exhibits that increasing CO2 emissions will have a positive impact on the economic growth of Bangladesh; similarly, employment has a positive effect on economic growth (GDP). The coefficient value of employment is 0.002. This implies that a 1% increase in economic growth will increase employment by 0.2%. These findings indicate that economic growth has a positive impact on improving employment in Bangladesh. Labor force and energy consumption have negative effects on economic growth. The estimation results of the third model show that there is a long-term balance between human capital, energy consumption and economic growth on CO2 emissions. However, partially, the estimation results indicated that economic growth has a negative effect on energy consumption, as evidenced from the coefficient value of -.889, which means that increasing economic growth of 1% will reduce energy consumption by 88.9%. This finding indicates that increasing economic growth will have a negative impact on energy consumption. Likewise, the fourth and fifth model indicates that there is no long-term balance between human capital, energy consumption, and CO2 emissions toward economic growth. Statistically, the variables of human capital, energy consumption, and CO2 emission have no effect on economic growth.

5. Conclusions

This study analyzes the long-run causality between human capital, energy consumption, CO2 emission and economic growth in Bangladesh. The study's empirical investigation focuses on time series analysis from 1986 to 2017 by using the VECM based Granger causality models. The empirical result suggests evidence of a long-term causality between variables at 1%, 5%, and 10% significance level. The analysis of the ADF test (Dickey and Fuller, 1981) test discloses that all variables are stationary in the first difference in the context of Bangladesh. With this condition, the result of the Johansen co-integration test reveals that there has a long-run cointegration relationship among the variables. The main results for the existence and direction of Granger causality are as follows:

1. Neither CO2 emissions nor employment influence economic growth in the long-run causality. Therefore, the Bangladesh government's policy in developing economic growth is appropriate for directing labor force and energy consumption reduction.
2. There is no causal evidence from the human capital, CO2 emission per capita, and real GDP to consumption per capita.
3. There is no causal record from the human capital, consumption per capita, and real GDP per capita toward CO2 emission per capita. This also appreciated as no evidence the Environmental Kuznets Curve (EKC) hypothesis at a causal framework that is used the linear logarithmic model in the long-run.
4. The other most interesting result is that there is no causal record from the human capital, energy consumption per capita, and CO2 emission to real GDP in the long-run causal. Therefore, the government policy is conservative in energy policy and CO2 emissions reduction policy in the long run without impeding economic growth.
5. There is the validity of long-run balance causality exists only for the model but neither in the human capital nor in the energy consumption.

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