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Renewable energy and its impact on economic growth in Bangladesh

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Abstract
Energy is a necessary component of modern civilization and a need for long-term growth. Bangladesh, a developing country where socioeconomic development and energy scarcity have become key issues in recent years. In Bangladesh, fossil fuels are commonly used to generate energy, resulting in increased CO2, NOx, and SOx emissions. The electricity deficit problem in Bangladesh, and the greenhouse impact, can be remedied by generating electricity with renewable energy (solar, biomass, hydropower, and wind).
This study examines the impact of Renewable Energy on Economic growth in Bangladesh. The analysis uses annual secondary data from the World Bank, Bangladesh Bureau of Statistics, UNDP from 1990 to 2018. The empirical results reveal that a 1% increase in renewable energy consumption equals a 2.269 % increase in GDP. The result also shows that an increase in population growth of 1 % reduces GDP by 1.8867 % which is significantly related at the 5% level.

Keywords: renewable energy, economic growth, Bangladesh

Introduction

In Bangladesh, renewable energy refers to the utilization of renewable energy to generate power. Bangladesh is one of the world's most populous countries, with a population of 160 million people. The main source of income for the people of this country used to be agriculture. However, in 2016, Bangladesh's Gross Domestic Product (GDP) was 7.05 percent. Energy plays a critical role in any country's economic growth, poverty eradication, long-term infrastructural development, and security. Electricity is the most extensively used form of energy in Bangladesh. Biogas, hydropower, solar, and wind are the current sources of renewable energy. As a result, the availability of power will have a considerable impact on future economic growth. The government of Bangladesh should ensure that people have access to affordable and environmentally sustainable electricity. However, since its independence from Pakistan in 1971, the country has struggled to generate enough electricity to meet its needs. Large energy shortages plague the state-owned electricity utilities. Furthermore, due to bad pricing practices and other impediments, the energy sector has been unable to attract adequate private investment in the power business. This lack of investment is a factor in the current energy crisis. Furthermore, adequate energy supply is a foundation of contemporary civilization and a prerequisite for a country's long-term socioeconomic development.

Renewable energy and energy efficiency, as well as technological diversification, would provide Bangladesh with major energy security and economic benefits. In this regard, Bangladesh's government has set a target of 20 percent nuclear, renewable, and cross-border generation by 2030, out of a total generation capacity of 40000 MW (power division, 2014). The reliance on fossil fuels will be reduced to a sustainable level, reducing load shed and allowing the national grid to be extended to remote rural areas.In this regard, Bangladesh's government has set a goal of generating 5% of its electricity (800MW) from renewable sources by 2015 and then 10% (2000MW) by 2020. (Power Division, 2014).

Because of population increases, urbanization, and rapid economic growth, global primary energy demand is expanding. Since 1973, global primary energy consumption has increased by 5.6 percent on average (Islam *et al*., 2014). Fossil fuels such as natural gas, oil, and coal, as well as renewable energy, are the primary sources of energy. Fossil fuels are expected to dominate the main energy supply until at least 2020. (Islam *et al*., 2014). According to the 2013 World Energy Statistics, fossil fuels produced 78.4 percent of total energy, while renewables produced 19 percent. Because of rising electrical demand around the world, fossil fuel usage has expanded considerably in recent decades (World Energy 2015). In 1973, around 6131 TWh of electricity was generated by fuel, and in 2013, roughly 23322 TWh was generated by fuel. Oil and other petroleum products are used in transportation and other industrial processes, and consumption increased by 28.56 percent between 1991 and 2011. (Islam *et al*., 2014). However, overall primary energy supply is increasing by 2.59 percent per year, but per capita energy consumption has climbed by 200 percent in Bangladesh from 1992 to 2011. (BPDB 2016). Bangladesh's overall consumption was 39,533 GWh in 2011, and it is anticipated that by 2035, the total power demand will be 192.70 TWh (Halder *et al*., 2015). In 1999-2000, the maximum power demand was 3149 MW, while in 2014-2015, it reached 10,283 MW (Halder *et al*., 2015). As seen above, the maximum electricity demand has increased more than threefold in the last 15 years. Despite the fact that power generation grows every year, it is insufficient to meet Bangladesh's growing electrical consumption. Currently, fossil fuels such as gas, furnace oil, diesel, and coal are used to generate more than 98 percent of power. According to BPDP data (2016), natural gas accounts for 61.82 percent of power generation, while furnace oil accounts for 21.68 percent, diesel accounts for 7.75 percent, and coal accounts for 2.03 percent. In contrast, fossil fuels account for 98 percent of total electricity generation. Bangladesh will face major problems in the near future due to a lack of electrical supplies. Climate change, global warming, and greenhouse gas emissions, on the other hand, are major impediments to long-term growth. Explicit fossil fuel consumption resulted in Bangladesh emitting 0.21 metric tons of CO2 in 2000, rising to 0.37 metric tons in 2010. (World Bank, 2016). Furthermore, in order to alleviate electricity shortages and minimize reliance on fossil fuels, the country is promoting a renewable energy policy. Renewable energy currently accounts for about 5% of total energy supply in Bangladesh, and it will account for 10% by 2021. (BPDB, 2016). Renewable energy currently accounts for approximately 19% of total global energy supply and is expected to account for 60% by 2035 (World Energy, 2016).

Natural gas, furnace oil, coal, and diesel are the most commonly used fossil fuels in Bangladesh, which are scarce. In Bangladesh, nearly 98 percent of electricity is generated using fossil fuels, which emit greenhouse gases and have a negative impact on the environment. In that instance, renewable energy can help fulfill rising demand while also protecting the environment. This is despite the fact that Bangladesh has a large potential for renewable energy sources such as solar, small hydro, biomass, biogas, and wind. Renewable energy, on the other hand, is still in its infancy due to a lack of ambition and technology. In such circumstances, renewable energy production could be one of the most essential solutions for reducing fossil fuel dependency, protecting the environment, and promoting long-term growth. According to the renewable energy policy of 2009, the government is dedicated to encouraging both public and private sector investment in renewable energy consumption and GDP growth in Bangladesh. It also aims to encourage both the public and private sectors to invest in renewable energy in order to fulfill future energy demand while simultaneously protecting the environment.

Objective of the study

The relationship between renewable energy and GDP growth in Bangladesh will be investigated in this study. As a result, by contributing to the pool of knowledge, we want to attain the many goals indicated below.

- To establish a link between renewable energy and economic growth.

Methodology and Research Design

Data Description and model

The data in this study is derived from secondary sources. Time series data on economic growth as GDP growth (annual %), renewable energy consumption (annual %), and population growth (annual %) were employed in this study. Twentynine years of time series data from 1990 to 2018 were used in this study. Data was gathered from the World Bank dataset, international energy statistics, the Bangladesh Bureau of Statistics, and the United Nations Development Program (UNDP). To analysis the data, STATA statistical software has been used in this study.

Hypothesis

Null, H_0 = Renewable Energy does not Enhance Economic Growth.

Alternative, H_1= Renewable Energy enhance Economic Growth.

Model Specification

Simple regression analysis has been used to see the relationship between GDP growth and Renewable energy consumption. In this paper the following static models have been used:

$$y_i = \alpha + \sum_{i=0}^{n} \beta_i X_i + \varepsilon_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

Where,

y_i = Dependent Variable

α_i = Intercept of the Equation

β_i = Coefficient of X_i Variables

ε_i= Error terms

To see the relationship between GDP growth and renewable energy, the following model is used in this paper:

$$GDP_t = \alpha + \beta_1 REC_t + \beta_2 PG_t + \mu_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Where,

GDP= GDP growth at time t

REC= Renewable Energy Consumption at time t
PG= Population Growth at time t

Estimation Procedure
Augmented Dickey Fuller Unit root test
There may be a problem with auto-correlation in the Dickey-Fuller test. Dickey Fuller devised the Augmented Dickey Fuller (ADF) test to address the autocorrelation problem. The unit root test technique of Augmented Dickey Fuller (ADF) is used to assess the stationary property of time series and to determine the integration order of non-stationary time series. To form the stationary qualities of the time series variables, unit root tests are first performed. Because non-stationary properties disrupt long-run mean reversion, using non-stationary variables leads to erroneous regressions and non-objective policy consequences. The following are the ADF models that were employed in this study:

$\Delta y_t = a_0 + \gamma y_{t-1} + \varepsilon_t$ .... (a)
$\Delta y_t = a_0 + \gamma y_{t-1} + a_1 t + \varepsilon_t$ ....(b)

The first model only includes the intercept term a_0 and the second model include both the trend (t) and intercept term. Here, Y variable is used for unit root test, and ε_t is the white noise process.

Hypothesis
Null, H_0: Variable is non-stationary or has unit root
Alt, H_1: Variable is stationary or doesn't have unit root

We reject the null hypothesis if the absolute value of the test statistic is greater than the 5% critical threshold. This indicates that the variable is stationary and has no unit root. We accept the null hypothesis if the absolute value of the test statistic is less than the 5% critical threshold, indicating that the variable is non-stationary and has a unit root. If all of the variables are stationary at the level of form, the series does not have a unit root and is of order zero integration (0). If one of the variables turns out to be non-stationary, the first difference should be tested for stationarity. If the first difference is stationary, it signifies the series has a unit root and the integration is of order one (1).
We can make our decision based on the sample probability value (P value). Do not reject the null hypothesis of a non-stationary series if the P value is greater than 0.05. If the P value is less than or equal to 0.05, the null hypothesis is rejected, indicating that the series is stationary.

Empirical Results and Discussions
The data analysis begins with descriptive statistics, which aid in the discovery of the variables' time series features. The descriptive statistics, also known as summary statistics, of the study are shown in Table 1. Descriptive statistics of variables, on the other hand, are a technique for determining whether or not data is normally distributed.

Descriptive Statistics
The data analysis begins with descriptive statistics, which aid in the discovery of the variables' time series features. The descriptive statistics, also known as summary statistics, of the study are shown in Table 1. Descriptive statistics of variables, on the other hand, are a technique for determining whether or not data is normally distributed.

Table 1: Descriptive Statistics

	GDP	rec	PG
Mean	5.589655	.3222414	1.617241
Maximum	7.9	0.49	2.4
Minimum	3.5	0.22	1.1
Std. Dev	1.111416	.0646533	.4773954
Skewness	.1109403	.572652	.1338855
Kurtosis	2.294982	2.938399	1.346579
Variance	1.235246	.0041801	.2279064
Obs	29	29	29

The summary of the selected variables, Gross Domestic Product (GDP), Renewable Energy Consumption (rec), and Population Growth (PG), is shown in the table above. The average annual GDP growth rate is 5.58 percent, with a standard deviation of 1.11 percent. The variance is really too great. As a result, GDP growth has remained quite consistent throughout the year. Renewable energy consumption has a mean value of 0.322 and a standard deviation of 0.646, indicating that renewable energy consumption has not been steady over time. Over the period, the average population growth rate was 1.4 percent, with a standard deviation of 1.61 percent. Because all of the variables' skewness is close to 0, and Kurtosis is close to 3, the data is normally distributed.

Unit root test

The ADF test has been used to test the stationarity of the variables is as follows:

Table 2: ADF unit root test result of the variables

Variables	Level	5% critical value	P value	Decision
Gdp_t	-4.411	-3.588	0.0021	I (0)
Rect	-2.921	-1.706	0.0036	I (0)
Pg_t	-1.719	-1.706	0.0044	I (0)

The absolute value of the test statistic for the variable economic growth is 4.411, and the absolute 5 percent critical value is 3.588 for the models, according to the ADF test. We can see that because the absolute value of the test statistic is bigger than the absolute value of the 5% critical value, we may reject the null hypothesis that the variable economic growth has a unit root (gdp). That is, in level form, the variable is stationary ((0). The absolute value of the test statistic for renewable energy consumption (rec) is 2.921, and the absolute 5 percent critical value is 1.706. The absolute value of the test statistic for the variable population growth is 1.719, and the absolute 5 percent critical value is 1.706. We can see that because the absolute value of the test statistic is higher than the absolute value of the 5% critical value, we may reject the null hypothesis that the variable population growth has a unit root (pg). That is, in level form, the variable is stationary ((0). Because all of the variables in the given table are integrated of order zero, i.e., I (0) at all levels, we will merely run a simple regression function in this case.

Table 3: Result of the Regression function of the variables (Equation-2)

Source	Ss	df	MS	Number of OBS	=	29
				F(2, 26)	=	16.56
Model	19.3753249	2	9.68766247	Prob>F	=	0.000
Residual	15.2115726	26	.585060485	R-squared	=	0.5602
				Adj R-squared	=	0.5264
Total	34.5868976	28	1.23524634	Root MSE	=	.76489

Table 4

Gdp	Coef.	Std. Err.	t	p>|t|	95% Conf.	Interval
Rec	2.269615	2.642066	0.86	0.003	-3.161229	7.700458
pg	-1.88673	.3578132	-5.27	0.000	-2.622225	-1.151234
Cons	7.909589	.7448993	10.62	0.000	6.378426	9.440751

The probability of F-statistics for the equation 2, is 0.000, indicating that the F-statistics is less than 5%, demonstrating that the test is significant at the 5% level. The adjusted R-squared value is 0.5264, indicating that the independent variables can explain 52.64 percent of the dependent variables. According to the preceding table, renewable energy has a beta coefficient of 2.269 and a P-value of 0.003, indicating that renewable energy is positively associated with GDP at a 5% significant level. That is a 1 % change in renewable energy consumption will increase gdp by 2.269 %. The findings shows that renewable energy has positive impact on economic growth. The population growth beta coefficient is 1.8867 with a P-value of 0.000, indicating that population growth is inversely associated with GDP and significantly related at the 5% level. That means, a 1 % change in population growth will reduce gdp by 1.886 %. There exists negative relationship between population growth and GDP.

Table 5: The diagnostic tests

Item	Test Applied	Chi-square	Prob
Serial Correlation	B Godfrey test	1.203	0.2727
Normality	Jarque-Bera (Residual)	1.076	0.584
Heteroscedasticity	White Test	8.98	0.1100

Model 2 does not have an autocorrelation or normality problem, according to the diagnostic tests.

The B-Godfrey test and the White test, respectively, identify serial correlation and heteroscedasticity. As p-value for serial correlation test is 0.2727 means it is not significant at 5 % level of significance and cannot reject the null hypothesis of no serial correlation that means there exists no serial correlation in the model. We can see that the calculated regression passes the serial correlation problem in diagnostic checking. The p-value for normality test is 0.584 means that we cannot reject the null hypothesis of normality. The residuals passed the Jarque-Bera normality test, indicating that they are normal. For heteroscedasticity test, the p-value is 0.1100 which is greater than 5 % level of significance means that we cannot reject the null hypothesis of constant variance. So, data is free of heteroscedasticity.

Model Stability Check

The estimated results suggest that the model has a reasonably good fit with diagnostic tests for error processes such as absence of serial correlation, presence of normality and homoscedasticity. The plots of CUSUM test in the following figure shows that the regression is stable within 5% critical bound.

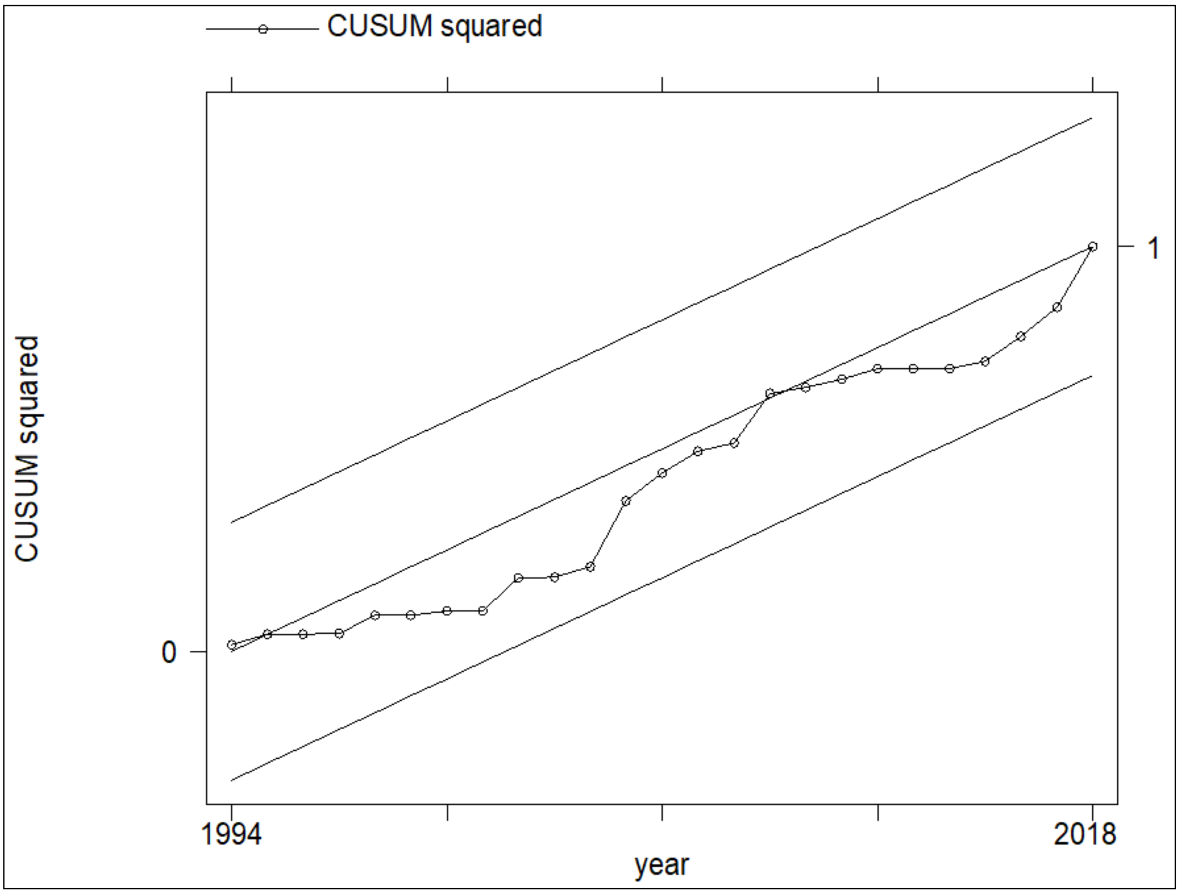

Fig 1: Plot of Cumulative Sum of Recursive Residuals. (The straight line represents critical bounds at 5% significance level)

The figure shows that the recursive residual line is upward but it is significant. This graph suggests no systematic or haphazard changes in the regression coefficients which have remained within the 5% bounds of parameter stability.

Policy Analysis

Bangladesh confronts various obstacles to the development of renewable energy sources. To address these issues, the following policies should be implemented:

Financial hurdles

A renewable energy (RE) policy needs to reconcile its high initial capital costs and long rate of return. The inclusion of financing methods in RE policy is required. Investment incentives should be incorporated into renewable energy legislation. Regulatory support for market-oriented RE initiatives and, where appropriate, the establishment of a feed-in tariff structure.

Technical hurdles

Standards and quality control (Star Labeling) for RE equipment are being incorporated. The RE policy should include RE grid operations and RE grid code. Incorporation and promotion of renewable energy equipment production into the policy framework Unused renewable energy equipment must be properly managed. In order to encourage renewable energy expansion, policy should include a renewable energy expansion program that demarcates national grid and off-grid areas. Monitoring and evaluation of the RE program should be included in the policy.

Incentive in Renewable Energy marketing

It is necessary to motivate end-user installation expenses. Guidelines must be included to monitor and manage the market mechanism for trading RE equipment by ensuring that proper licensed vendors are available.

Information accessibility

Renewable energy resource awareness programs, technical or economic information on REs, equipment suppliers, and potential financiers must all be included in policy for the expansion and use of RE in private, public, industrial, utilities, and financial institutions. incorporation of energy efficiency and conservation, as well as promotion of renewable energy in rural communities that are off the grid. Close coordination between the government and renewable energy development organizations, among other things.

Conclusion

Bangladesh's energy sector is mostly reliant on traditional energy sources like coal, natural gas, imported crude oil, and refined petroleum products, with natural gas accounting for 61.82 percent of total electricity output (BPDB, 2016). As a result, natural gas is today the most widely used energy resource in power generation. Despite the fact that coal and hydro power account for a small percentage of total power generation, Bangladesh has a significant potential for small-scale micro hydro power. Renewable energy, on the other hand, accounts for approximately 5% of total energy, indicating that it is still in its infancy in comparison to global energy generation. However, Bangladesh has a diverse range of renewable energy options, including solar, small-scale hydropower, wind, and biomass. In addition, the GOB intends to build a 5000 MW nuclear power station by 2030 to accommodate future demand. However, it would not be enough to fulfill future demand (BPDB, 2016). As a result, in order to provide energy security, protect the environment, and minimize reliance on fossil fuels, the first step in stimulating alternative and sustainable energy solutions in Bangladesh must be taken. Using time series data from 1990 to 2018, this study looked at the beneficial association between renewable energy use and GDP development in Bangladesh. Annual secondary data was gathered from a variety of sources, including the World Bank, the Bangladesh Bureau of Statistics (BBS), the United Nations Development Program (UNDP), and the International Energy Statistics.

The research investigates the relationship between economic growth and renewable energy in Bangladesh during the period 1990-2018 using multivariate time series techniques such as the Augmented Dickey Fuller unit root test, data normality test, and linear regression of the variables. According to the results of the Augmented Dickey-Fuller unit root test, all variables are stationary in the level form. Because the variables economic growth, renewable energy consumption, and population growth are all stationary at the level of, the relationship between economic growth and renewable energy consumption was examined using a simple regression function.

The regression results show that there is a favorable relationship between economic growth and the use of renewable energy. That is, a one percent increase in renewable energy consumption will result in a 2.269 percent rise in GDP. The data shows that renewable energy has a favorable impact on economic growth. With a P-value of 0.000, the population growth beta coefficient is 1.8867, demonstrating that population growth is inversely connected to GDP and significantly related at the 5% level. That is, a one percent increase in population growth reduces GDP by 1.886 percent. Population growth and GDP have a negative relationship.

Bowden and Payne (2010), Payne (2011), Pao and Fu (2013) [25], Ahmed *et al* (2014) [2], Mondal *et al* (2010) [20, 21], and Salim and Rafiq (2013) all support this conclusion (2011). The development of Bangladesh's energy sector. Sustainable energy services can play a critical part in Bangladesh's socioeconomic growth. To increase people's awareness, the government of Bangladesh should collaborate with public and private groups, especially international donor agencies and concerned authorities.

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