Journal of Accounting, Finance and Economics
Vol. 8. No. 3. September 2018 Issue. Pp.72-87

Renewable Energy Consumption and Foreign Direct Investment: Reports from Bangladesh

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Foreign direct Investment (FDI) is a source of investment which allows any business or sector to grow. It works as a catalyst in developing countries for enhancing total output level. Beside this, FDI also promotes energy efficiency and clean energy. To the best of our knowledge no studies have been conducted to explore the relationship between FDI and renewable energy consumption in the context of Bangladesh. Therefore, the aim of this paper is to reveal the relationship between FDI and renewable energy consumption in Bangladesh with the help of time series data spanning from 1980 to 2015. Johansen's cointegration test confirms that variables are cointegrated in the long run and Granger causality test reveals that there is a bidirectional causality between our variables of interest. Through Vector Error Correction Model (VECM), we found no causality between the variables in the short run. We employed CUSUM test to check the stability of our variables and result indicates that our variables are stable. Policies regarding attracting more FDI should be considered to increase the investment in Renewable energy sector.

Field of Research: Economics

1. Introduction

Among all the South Asian countries, Bangladesh has performed remarkably well for sustaining a stable economic growth and achieving many targets of millennium development goals (MDGs) of the United Nations. Aiming to further fulfil Sustainable Development Goals (SDGs) of the United Nations by 2021, Bangladesh already established itself as the lower middle income country by World Bank. Since, trade reform policy in 1980s, Bangladesh has attracted a large amount of foreign investment (FDI). Gaining comparative advantages in cheap labour, stable economy and financial condition, Bangladesh experienced a rapid increase in FDI inflow. According to the neoclassical model, FDI tends to increase the investment rate, which leads to increase in per capita income, keeping technological progress and labour growth exogenous. However, the new growth theory endogenized technological progress and FDI as these variables has the potential to initiate long term growth effect in the host country by technological progress and spill over. Being an open economy, these technological progresses and spill over could facilitate trade and promote economic growth.

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But according to the industrial flight hypothesis, foreign enterprises are inclined to invest in the economy where their production costs are minimized and as a result, the resources and environment of the host country gradually deteriorate over time. (Asghari 2013). This enabled the controversial debate of environmental concerns for the increased FDI inflow in any developing nation. Moreover, a stable energy supply is a pre-requisite to economic development prospective of any nation. Many studies such as: Omri (2013); Achour & Belloumi (2016) indicated that higher economic growth requires more energy consumption. Also, more efficient energy use requires a higher level of economic growth (Saidi & Hammami 2015; Omari 2015, 2013; Komal & Abbas 2015).

Mostly dependent on the fossil-based fuel, Bangladesh still suffers due to lack of energy security and the consumption level is among the lowest in the world. For such situation, usage of renewable energy could potentially solve the energy-crisis in Bangladesh and increase the efficiency of the production process to attract FDI inflows.

To the best of our knowledge, no empirical study emphasized on the direct relationship between FDI inflows and renewable energy consumption in Bangladesh from 1980 To 2015. Most of the studies mainly focused on energy consumption and FDI (Lin & Linh 2015), (Kivyiro & Arminen 2014), but none of them specified renewable energy consumption in Bangladesh. In addition to that, studies mainly focused on the relationship between non-renewable energy demand, FDI and economic growth or energy consumption, foreign direct investment and economic growth. However, renewable energy consumption and FDI inflow was not explored in Bangladesh and identifying their causality could overall stimulate the economy by not only accelerating GDP growth but also, protecting and promoting environment. Our paper address questions mentioned as followed: Is there any short run and long run causality between renewable energy consumption and foreign direct investment? Is the bivariate model stable?

The effect of renewable energy consumption and foreign direct investment maybe direct or indirect. As they both could affect economic growth directly or indirectly through affecting each other or other channels. Therefore, we used a bivariate analysis for its appropriateness to distinguish the causality and formulate the relationship based on empirical evidence. The rest of the paper is organized as following: section 2 provides a concise literature review, section 3 briefly discusses about the current scenario of Bangladesh's foreign direct investment and renewable energy consumption, section 4 describes the methodology and data set we used and the result of the econometric analysis is explained in section 5. Finally, in section 6, we conclude the paper by summarizing our assumptions and findings.

2. Literature Review

Acknowledging the importance of a sustainable energy and economic growth, many researchers have studied the relationship between FDI, energy consumption and economic growth. Mostly, the studies are focus on the relationship between energy consumption and economic growth, on the other hand, FDI and economic growth

mainly. However, no studies addressed the issue of FDI and renewable energy consumption, particularly in Bangladesh.

In a recent paper, Doytch & Narayan (2015) analysed 74 countries from 1985 to 2012, to determine if FDI affects renewable and non-renewable energy consumption by using a Blundell–Bond dynamic panel estimator in order to control for endogeneity and omitted variable biases in their panels. Their result suggested that total FDI encourages green-energy advancing practices and reduced the use of non-renewable energy in high- income countries and low and lower middle-income countries. However, if these countries could emphasize more on the energy source, they would be able to accommodate the usage of greener energy and incline firm's energy consumption toward renewable energy. For ow and lower middle-income countries, FDI also encouraged the transfer of energy-saving practices and reduce the usage of non-renewable energy sources. Although, the study was not able to find link between renewable energy consumption and mining FDI or any other sectoral FDI or total FDI for these countries, but their findings supported FDI halo effect, which suggests that FDI contributes to reducing the usage of non-renewable energy.

Using variables such as: using carbon dioxide (CO2) emissions, energy consumption, economic growth, and foreign direct investment (FDI) variables, implemented Toda–Yamamoto causality test and indicated that from 1974-2010, carbon emissions and FDI, energy consumption, and CO2 emissions have bidirectional causal relationships. However, there are unidirectional causal relationships running from economic growth and energy consumption to FDI and from economic growth to energy consumption. Their studies also provided empirical evidence for the "pollution haven hypothesis", "scale effect", and the environmental Kuznets curve (EKC) hypothesis for the case of Turkey (Gökmenoğlu & Taspinar 2016). Also, establishing the support to EKC and the pollution haven hypothesis, Lin & Linh (2015) investigated the dynamic causal relationships among environmental degradation, economic growth, foreign direct investment (FDI) and energy consumption in the 12 densely populated countries in Asia and found both short and long-run causality relationships among these variables, and economic growth, FDI, energy consumption and CO2 emissions. To explore the relationship between foreign direct investment, clean energy, trade openness, carbon emissions and economic growth of UAE, Sbia, Shahbaz & Hamdi (2014) used ARDL bounds and VECM Granger causality approach. Their empirical findings indicated that the existence of co-integration between the variables, where, foreign direct investment, trade openness and carbon emissions decline energy demand. On the other hand, economic growth and clean energy has positive impact on energy consumption.

Kivyiro & Arminen (2014) investigated the relationship between (carbon dioxide) emissions, energy consumption, economic development and FDI (foreign direct investment) in six Sub Saharan African countries by using econometrics techniques such as: autoregressive distributed lag model and Granger causality. Their studies resulted with a contradictory note as different variables Granger causality varied for different countries. Whereas, Xu, Zhou and Li (2016) used the same methodology in the case of Shanghai from 1991 to 2013 and resulted that energy consumption has a significantly positive impact on FDI in the short and long run, but is only significant in the

short run. And energy consumption Granger causes FDI. Islam *et al.*(2013) used Vector Error Correction Model (VECM) and resulted that energy consumption is affected by influenced by economic growth and financial development, both in the short and the long run in Malaysia.

Many researchers observed the relationships between these variables by using data for group of countries. Abdouli & Hammami (2017) used generalized method of moments (GMM) for MENA countries from 1990 to 2012 and established that is a bidirectional causal relationship between FDI inflows and economic growth, same relationship was found for energy consumption and economic growth. Likewise, there is a unidirectional causal relationship between energy consumption to FDI inflows. They examined the impact of transport energy consumption, foreign direct investment and income on CO2 emissions for ASEAN countries using co-integration and Granger causality methods and concluded that there is a bi-directional causality between economic growth and CO2 emissions in Malaysia and also, between transport energy consumption, FDI and CO2 emissions in Thailand and Malaysia.

Pao& Tsai (2010) analysed BRIC (Brazil, Russian Federation, India, and China) countries) using Multivariate Granger causality from 1980 to 2007.Supporting Environmental Kuznets Curve (EKC) hypothesis, pollution effect and both halo and scale effects, the study indicated a strong bidirectional causality between emissions and FDI and unidirectional strong causality running from output to FDI. In Addition to this, strong output-emissions and output-energy consumption bidirectional causality, while there is unidirectional strong causality running from energy consumption to emissions. Using simultaneous-equation models to examine the nexus between CO2 emissions, energy consumption and economic growth in 14 MENA countries, Omri (2013) showed that there exists a bidirectional causal relationship between energy consumption and economic growth. Using the same context, in Omri (2013) resulted that foreign direct investment and economic growth have a bi-directional causality in 54 countries. Finally, Omri & Kahouli (2014) examined the energy consumption-foreign direct investment-economic growth nexus of 65 countries and found there is mixed result about the causal relationship between income, FDI inflows and energy consumption. Other studies have formulated and investigated how these variables indirectly affect one another. Through expansion of industrialization, transportation and urbanization, FDI tends to induce energy consumption (Sadorsky2010; Bekhet & Othman 2011; Doytch & Narayan 2016).

After the wide discussion of different literatures, we can set our hypothesis relevant to our research question. The considered set of null hypothesis is as follows,H_1:FDI does not cause renewable energy consumption and H_2: renewable energy consumption does not cause FDI.

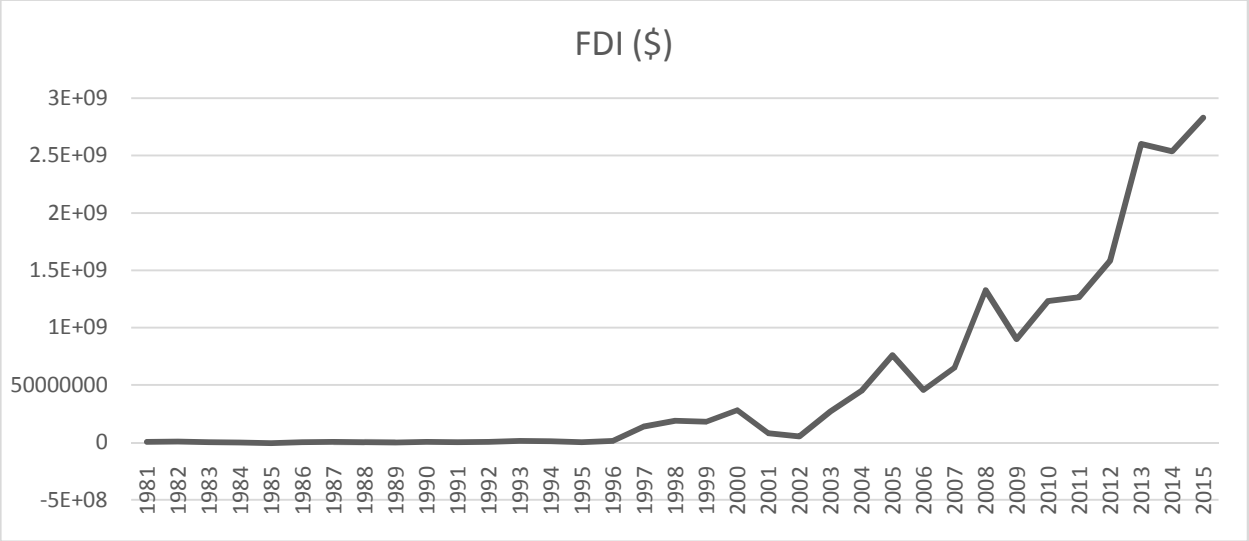
3. Bangladesh's Scenario

Once entitled as the "endless basket case" by Henry Kissinger, Bangladesh has demonstrated significant growth and development through restructurings in economic policy and public management. Currently, the country has a stable GDP growth with the potential to grow even further. Bangladesh benefitted from the export-oriented growth

from 1980s by introducing privatization, trade liberalization and enhancing financial development. Among other components, foreign direct investment played a crucial role in the sustainable economic growth and development of Bangladesh as it accelerates capital accumulation, capacity development, productivity efficiency and introduction of latest technology and knowledge. Other than GDP per capita, it also influences other key components of the economy such as: foreign reserve, gross capital formation, human capital, trade, employment opportunities and financial development of the country (Omri 2013). Moreover, it is frequently used to pay off the external debt, import volume and further facilitate FDI inflow by reinvested earning. By influencing all the key determinants of economic growth, FDI inflow helps a country to attain sustainable development (Kabir & Hoque 2007).

According to the Bangladesh Board of Investment (2004), FDI has three components: Equity Capital, Reinvested Earnings, and Intra-company Loans. Equity capital represents the ownership and a foreign investor's purchase of shares of an enterprise that is in another country. Reinvested earnings are the investor's share of earnings, which are not distributed back to him. And finally, intra-company loans consist of the debt transactions (short and long-term) loans by the foreign parent company to its affiliates. Countries like: USA, UK, South Korea, Singapore, Hong Kong. Norway, Malaysia, India, Netherlands and China are the main contributors of FDI inflow in Bangladesh.

Figure 1: Foreign Direct Investment in Bangladesh



Source: The World Bank 2015

From the graph, we can see that after trade liberalization and privatization, from 1995 onward, Bangladesh has seen a positive impact of FDI on GDP per capita, with occasional fluctuation for the instable political condition and presence of inefficient bureaucracy. The main sectors that attracted the maximum FDI inflows are Textile, telecommunication, Banking, Gas& petroleum and power. During January-June, 2016, Bangladesh acquired US$ 166.68 million as Equity capital, US$ 605.36 million as Reinvested earnings and US$ 92.96 million as Reinvested earnings. It is evident that for a developing country like Bangladesh, FDI contributes in the rapid economic growth

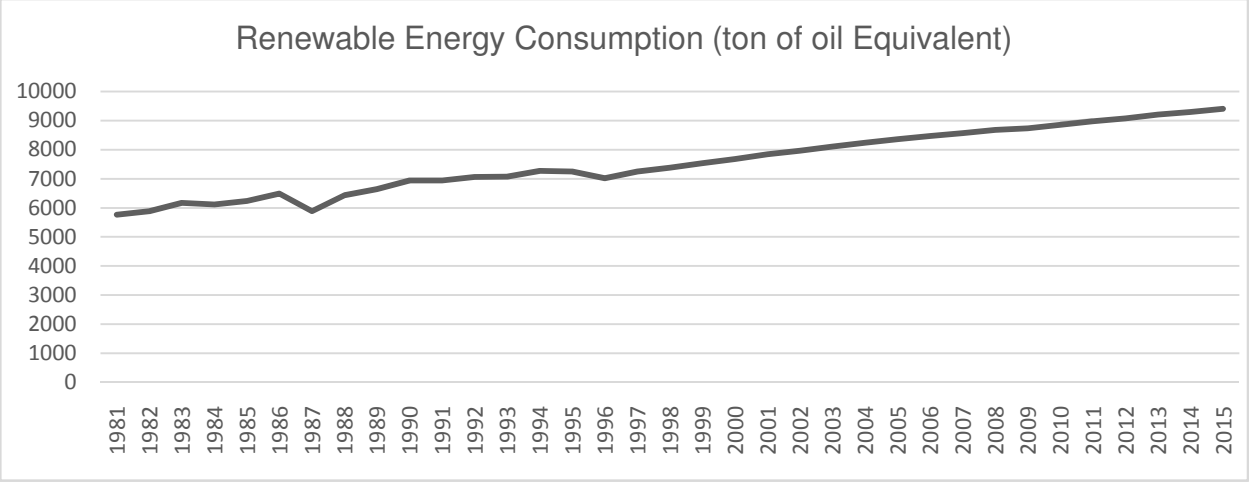
through export oriented sectors also demonstrated that foreign investment can expand economic production and growth (Amin, 2007). However, many researchers also argued that it is economic growth that attracts FDI. As foreign investors prefer to invest in the country with higher growth rate to ensure a stable rate of return. Many statistical analyses have developed to identify the causal relation, but all concluded with the same notion that FDI inflows plays a crucial part in any country's development process (Islam *et al*. 2013).

For rapid growth of population, along with higher growth in urbanization and industrialization in Bangladesh has dramatically increased energy consumption. In 2000, energy consumption was 12.7 Mtoe which almost doubled in a year, reaching 24.3 Mtoe in 2011. (BP Statistical Review of World Energy 2012) Furthermore, by 2020, the power demand is expected to increase by 185%. (REN21 2012). Comparing with other developing country, per capita consumption is still lower which signals a potential for development as per capita energy consumption is a measure of development.

For the growing concern over the negative impact on the environment for using up the finite energy resource of fossil fuels, many developed and developing countries are now inclining toward various forms of renewable energy like: solar power, wind power, bio-energy, hydro power etc. (Amin et al., 2016). Although, natural gas and other deplorable energy sources are still used as the primary source of energy, still Bangladesh has emphasized on Renewable Energy to mitigate energy crisis in the near future. Renewable Energy policy of Bangladesh, initiated at 2009, is dedicated to have 20% power from renewable energy by 2020. To promote renewable energy and mitigate energy deficiency, Government of Bangladesh has also established Sustainable and Renewable Energy Development Authority (SREDA) and it is also a member of International Renewable Energy Agency (IRENA), the only inter-governmental agency working exclusively on renewable energy, which is an inter-governmental agency working exclusively on renewable energy. In addition to this, Bangladesh has stressed the development of renewable energy plan in the crucial policy document such as: National Plan, Power System Master plan, Industrial Policy 2010 and implemented programmes such as Bangladesh Climate Change Strategy and Action Plan. Now, renewable energy options are also available in the Bangladesh National Building Code for the rapid increase in domestic consumption over time.

With the fast-paced energy demand, Bangladesh has explored different renewable energy options (Amin, 2015). Biomass, supplying energy to the 65% of the population of the country resides at rural areas and 44% are living under the poverty line, sharing 46% of the total energy supply. It accounts for 48% of the total energy consumption in Bangladesh. For the geographical advantage, Bangladesh has the potential to utilize solar power as the annual solar radiation available is over 1900 kWh/m2. Underpinning the abundance, many technologies such as: concentrating solar power (CSP), solar PV power system, Solar home system (SHS) are gaining popularity for the success and availability across country. Other sources such as: bio gas, bio fuel, wind power, hydro-energy have a promising aspect to contribute to the energy supply in Bangladesh. (Islam *et al*. 2014)

Figure 2: Renewable Energy Consumption in Bangladesh



Source: The World Bank 2015

In the graph 3.2, we can clearly see an upward trend of renewable energy consumption over time. With only two relative decline in 1987 and 1966, almost every year observed a positive growth of renewable energy consumption. Now, renewable energy is no more an ambitious project, but still there are still more opportunity and potential to grow. Emphasizing in research and development, increasing public awareness and inclusive approach adaptation by local government could accelerate the growth with a higher and sustained rate, providing energy security to all the citizens.

4. Methodology and Data Set

To check the stationarity of the variables, existence of unit root has to be tested. Macroeconomic and financial data are well known because of their non-stationarity. There are several ways to find out the existence of unit root of the variables. For example, Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) test are broadly employed. For our study, we have performed the (ADF) test to test the existence of unit root and found that all of the variables are non- stationary at levels and thus cannot be regressed without making them stationary. After the ADF test, we performed cointegration test to investigate possible linear combination of the variables that can be considered stationary. If cointegration is established, then we ran the causality test to check the possible direction of causality between the variables of interest.

Non stationary data may lead to specious regression in the context of time series analysis unless there is at least one cointegration relationship (Amin, 2011; Amin and Rahman, 2011). The Johansen technique is employed to test for cointegration. A unified framework of estimation and testing cointegration relations are provided in the context of Vector Autoregressive (VAR) error correction models. Here one has to estimate Unrestricted Vector of Autocorrelation of the form:

$$\Delta x_t = \alpha + \theta_1 \Delta x_{t-1} + \theta_2 \Delta x_{t-2} + \theta_3 \Delta x_{t-3} + \cdots\cdots + \theta_{k-1} \Delta x_{t-k+1} + \theta_k \Delta x_{t-k} + u_t \quad (1)$$

In the equation above, Δ is the difference operator, $x_t\ (n\times 1)$ is a vector of non-stationary variables (in levels) and is the vector of random errors. The information on long run relationship is articulated by the matrix θ_k the variables are not cointegrated, if the rank of θ_k =0. Nevertheless if rank (usually represented by r) is equal to one, there exists one cointegrating vector and in conclusion if, $1<r<n$ there are multiple cointegrating vectors. Johansen & Juselius (1990) have derived two tests for cointegration, which are trace test and the maximum Eigen value test. The trace statistic assesses the null hypothesis that there are at most r cointegrating vectors while the maximal eigen value test, estimates the null hypothesis that there are r exactly cointegrating vectors in x_t

If two variables are cointegrated, then there is at least one direction of causality. Granger-causality is one of the important issue that has been enormously studied in empirical finance of macroeconomics. Granger-causality is introduced by Granger (1969, 1980 & 1988). Engle & Granger (1987) asserted that the presence of non-stationary can lead to distorted conclusions in Granger-causality test. In this test, we can only infer long run relationship between non stationary time series when the variables are cointegrated.

If x and y are variables of interest, they by applying Granger-causality test we can determine whether past value of y augment the explanation of present values of x given that by information in past values of x itself. y does not Granger cause x if changes past values of y does not explain changes in x values at present. Likewise, we can probe whether x Granger causes y. There are four probable outcomes in the Granger causality test:

a. neither variable Granger cause each other
b. y causes x but not otherwise
c. x causes y but not otherwise
d. both x and y Granger cause each other

Following two sets of equation will be estimated:

$$x_t=\alpha_0+\alpha_1x_{t-1}+\cdots\cdots+\alpha_lx_{t-l}+\beta_1y_{t-1}+\cdots\cdots+\beta_ly_{t-l}+u_t \qquad (2)$$

$$y_t=\alpha_0+\alpha_1y_{t-1}+\cdots\cdots+\alpha_ly_{t-l}+\beta_1x_{t-1}+\cdots\cdots+\beta_lx_{t-l}+v_t \qquad (3)$$

It is for all possible pairs of (x,y) series in the group. The stated F-statistics are the Wald statistics for the joint hypothesis $\beta_1=\beta_2=\beta_3=\cdots\cdots=\beta_l=0$.

Engle & Granger (1987) asserted that a vector error correction model (VECM) is an appropriate method to model the long-run as well as short-run dynamics among the

cointegrated variables. Causality inferences in the multi-variate framework are made by estimating the parameters of the following VECM equations.

$$\Delta Y = \alpha + \sum_{i=1}^{m} \beta i \Delta Y_{t-i} + \sum_{j=1}^{n} \gamma_j \Delta X_{t-j} + \sum_{k=1}^{0} \delta \Delta M^{s} + \sum_{l=1}^{p} \zeta \Delta N + \theta Z_{t-1} + \varepsilon_t \quad (4)$$

$$\Delta X = a + \sum_{i=1}^{m} b_i \Delta Y + \sum_{j=1}^{n} c_j \Delta X_{t-j} + \sum_{k=1}^{0} d \Delta M^{s} + \sum_{l=1}^{p} e \Delta N + f Z_{t-1} + \xi_t \quad (5)$$

z t-1 is the error-correction term which is the lagged residual series of the cointegrating vector. Deviations of the series from the long run equilibrium relation is measured by the error-correction term. For instance, from equation (5), the null hypothesis that X does not Granger-cause Y is rejected if the set of estimated coefficients on the lagged values of X is jointly significant. Furthermore, in those instances where X appears in the cointegrating relationship, the hypothesis is also supported if the coefficient of the lagged error-correction term is significant. Changes in an independent variable may be interpreted as representing the short run causal impact while the error-correction term provides the adjustment of Y and X toward their respective long run equilibrium. Thus, the VECM representation allows us to differentiate between the short- and long-run dynamic relationships. The Chi-Square test statistic is used to determine the short run causalities between pairs of variables in the model.

Usually we use CUSUM test to investigate any systematic changes or movements in which there are possibilities of change in values of the coefficient revealing structural instability. Let us assume a linear regression model with K coefficients over the time period t

$$Y_t = X_t \beta_t + \varepsilon_t \text{ , } t\text{= 1,2 ,..., } T \quad (6)$$

Estimated coefficient by OLS method based on our time period t will be,

$$\widehat{\beta_t} = (X'_t X_t)^{-1} X'_t Y_t \text{ , } K \text{ ,..., } T \quad (7)$$

$\widehat{\beta_t}$ of β_t is actually identical to the OLS estimator. Thus, recursive estimators can be written as follows,

$$\widehat{B_{t-1}} = (X'_{t-1} X_{t-1})^{-1} X'_{t-1} Y_{t-1} \quad (8)$$

Therefore, the estimator $\widehat{\beta_t}$ of β_t can be written finally as,

$$\widehat{\beta_t} = \widehat{B_{t-1}} + (X'_{t-1} X_{t-1})^{-1} x_t \frac{y_t - x' \widehat{B_{t-1}}}{1 + [x'_t (X'_{t-1} X_{t-1})^{-1} x_t]} \quad (9)$$

Coefficient stability test based on recursive residuals through one step error prediction approach was proposed by Brown, Durbins & Evans (1975). We can write down the one step prediction error term below

$$e_t = y_t - x'_t \widehat{\beta_{t-1}} = x'_t \left(\beta_t - \widehat{\beta_{t-1}}\right) + \varepsilon_t \quad (10)$$

Now recursive residual can be expressed in the form of normalized prediction errors

$$w_t = \frac{e_t \gamma_\varepsilon}{\gamma_e} = \frac{y_t - x'\widehat{B_{t-1}}}{\sqrt{1+[x'_t(X'_{t-1}X_{t-1})^{-1}x_t]}} \text{(11)}$$

Existence of any unknown break point results rejecting the specification throughout the period. Through hypothesis testing, we can find out whether the model is stable or not by rejecting or accepting null hypothesis (Farhani 2012)

$$W_m = \sum_{t=K+1}^{m} \frac{w_t}{\gamma_w} \text{(12)}$$

Under null hypothesis W_m must be inside the corridor ($-L_m$ toL_m)

$$L_m = \frac{a(2m+t-3k)}{\sqrt{T-K}} \quad \text{(13)}$$

We will reject the null hypothesis (i.e. the model is stable) if W_m cuts the given range of corridor. Which actually means the variables are not stable enough.

The paper is based on annual data covering the period of 1980-2015. Data of Foreign Direct Investment (FDI US$) and Renewable Energy Supply (ton of oil equivalent) are taken from World Development Indicator (WDI) and OECD Data Bank. It should be mentioned here that as Bangladesh got her independence in 1971 and this research paper focuses over the period 1980-2015 for which 36 observations are available at most. Small sample size might be problematic in finding the long run relationship.

5. Results and Discussions

Unit root tests are conducted to determine the order of integration of the data series. Optimal lag is chosen by *Schwartz Information Criterion (SIC).* Table 5.1 shows the ADF statistics and corresponding critical values of all the variables in their level and first differenced forms.

Table 1: Augmented Dickey Fuller Unit Root Test for the Variables

Panel 1: Levels			
Variable	**ADF Statistics (Only Constant)**	**ADF Statistics (Constant & Trend)**	**Decision**
LNRC	-0.92	-4.72	Non Stationary at constant but Stationary at constant and trend
LNFDI	-2.19	-4.66	Non Stationary at constant but Stationary at constant and trend
Panel 2: First Differences			
Variable	**ADF Statistics (Only Constant)**	**ADF Statistics (Constant & Trend)**	**Decision**
LNRC	-3.63	-3.26	Stationary
LNFDI	-5.34	-5.38	Stationary

Table 2: Mackinnon Critical Values for Rejection of Hypothesis of Unit Root

Critical Value	Levels		First Differences	
	No Trend	**With Trend**	**No Trend**	**With Trend**
1%	-3.632900	-4.243644	-3.639407	-4.252879
5%	-2.948404	-3.544284	-2.951125	-3.548490
10%	-2.612874	-3.209699	-2.614300	-3.207094

Unit root tests have non-standard and non-normal asymptotic distribution. These distributions are extremely affected by the inclusion of deterministic terms such as constant, time trend etc. An extraneous regressor whose enclosure reduces the power of the test is called time trend. Yet if the true data generating process were trend stationary, failing to include a time trend also results in a decline in power of the test. Additionally, this loss of power from without a time trend when it should be present is more severe than the reduction in power associated with including a time trend when it is extraneous. One of the main issues in unit root testing is lag length selection. Including a moderately long lag length and select the model by the usual t-test is one of the approach. When the t-statistics on lag p is insignificant at some stated critical value, the regression should be frequently assessed using a lag length (p-1) until the lag is significantly different from zero. From the unit root test, it is clear that all the variables are found to be stationary either at their first differences or levels. From the table it is clear that the variables would yield spurious results unless the variables are cointegrated. The results, however, allow to proceed to the next stage of testing for cointegration. The Johansen cointegration test results indicates that our variables have cointegrating relationship. Maximum Eigen value test and the trace test (Table 3a and 3b) both point out one cointegrating relationships at 95%. After the Contegration test, we performed Granger Causality Test at lag 2.

Table 3a: Johansen Test for Cointegration (Maximum Eigen value Test)

	Null Hypothesis	Alternative Hypothesis	Statistics	95% Critical Value	Conclusion
LNRC and LNFDI	None	(At Most One)	30.63 (2.859673)	12.5672 (3.841466)	One Cointegrating Relationship

Table 3b: Johansen Test for Cointegration (Trace Test)

	Null Hypothesis	Alternative Hypothesis	Statistics	95% Critical Value	Conclusion
LNRC and LNFDI	None	(At Most One)	32.13090 (2.859673)	15.49471 (3.841466)	One Cointegrating Relationship

Table 4: Granger Causality Test Results

Variable	**Null-Hypothesis**	**F-Statistic**	**P-Value**	**Conclusion**
Granger Causality Test Statistics between LNRC and LNFDI				
LNRC	LNFDI does not causes LNRC	4.57	0.02	Bidirectional Causality
LNFDI	LNRC does not causes LNFDI	12.23	0.0002	

From the Table 5.4, we can see that both of the null hypothesis can be rejected. Thus, we can say that there is a bidirectional causality running between renewable energy consumption and foreign direct investment. It answers the first question (from the long run perspective). Increase in sectoral foreign investment could escalate the development speed of renewable energy sector in Bangladesh and consumption of renewable energy will increase in the long run, especially in the off grid areas of the nation. On the other hand, increase in renewable energy consumption will give signals to foreign investors of a good investment market in Bangladesh. Thus more investment can take place.

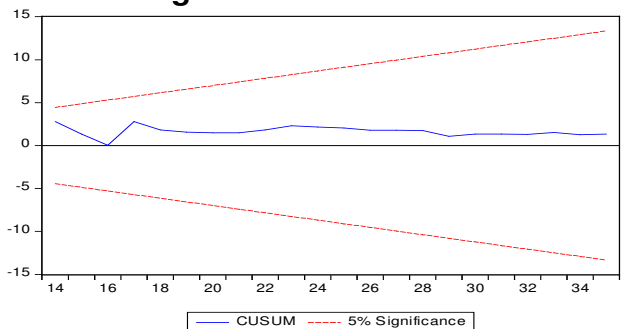
After observing the long run causal relationship, we now move to investigate the short run causal relationship among the variables through VECM approach (with the same set of hypothesis) The results from the VECM approach are given in the table 5.5. According to the VECM results we cannot reject both the null hypothesis. Means, no causality was found between foreign direct investment and renewable energy consumption. It also answers the first research question (from the short run perspective) One of the possible reasons for this is that the intensity effect of both energy consumption and foreign direct investment on the economy are subject to time lag to be observed.

Table 5: VECM Test Results

Variable	Null-Hypothesis	F-Statistic	P-Value	Conclusion
Causality Test Statistics between LNRC and LNFDI				
LNRC	LNFDI does not causes LNRC	0.18	0.8389	No Causality
LNFDI	LNRC does not causes LNFDI	0.35	0.8377	

After investigating short run causal relationships, now we can check the stability of the long run parameters with short run movements of the equation through CUSUM test. The test is relied upon residuals of error correction model. Figure 1 shows that plot stays within the corridor of 5% critical value indicating that the model is stable in terms of systematic movements. Therefore, from the figure we obtained answer of the second research question.

Figure 1: CUSUM Test



6. Conclusion

In this paper we have empirically investigated the relationship between FDI and renewable energy consumption in bangladesh through annual data spaning from, 1980 to 2015. According to the results there is a bidirectional causality btween FDI and renewable energy consumption in the long run. In contrast, there is no causal realtionship between FDI and renewable energy consumption in the short run. Furthermore,the chosen bivariate model is stable as well which is a new contribution to the body of the knowledge.

As we know that energy is a limiting factor of economic growth and also prudential for socio economic development of a nation, it is important to enrich the energy mix so that access to energy is sustained. Hence, beside conventional energy sources, renewable energies can play a very big role. Since, our results show a exsistance of a bidrectional causality between the variables, policies should be taken in favor of creating an environment for foreign direct invesment to develop renewable energy sector which can boost the economoy in the long run and protect the economic activity in any sudden international enery price fluctuations.

One of the major limitations of the paper is small sample size of the time series data set. Results would have been more underpining if we had a big sample size.On the other

hand,we have used a bivarate model in this paper. More variables can be added to enrich the model. Such as, technology panetration in the market, intra sectoral changes in the economy,structural change in the economic welfare etc.This paper can be extended by analyzing the same relationship for South Asian countries(panel analysis) to have a general policy framework to achive prosperity in the region. Moreover, the paper can be even more extended by analyzing the relationship between FDI and renewable energy consumption at disaggregated level to check the relationship for both panel and Bangladesh.

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