Renewable Energy Consumption and Foreign Direct Investment

Bangladesh's Case

By: Sumaya Tasnim

Supervisior: Mats A Nilsson

Södertörn University | Institution for Social Sciences
Master Essay 30 hp
National Economics | Autumn 2020

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Abstract

FDI investment is a vital factor for the developing countries economic growth. Apart from working as a catalyst of increasing total output level, FDI is a source of clean energy, technology transfer and energy efficiency. There have been very limited studies on the impact of FDI on renewable energy consumption in the context of Bangladesh. In fact, to my best knowledge there hasn't been any studies on Bangladesh regarding this relationship with recent data available. Therefore, the aim of this paper is to reveal the relationship between FDI and renewable energy consumption in Bangladesh with annual Data spanning from 1980 to 2016. Johansen's cointegration test showed that variables are cointegrated in the long run. Through Vector Error Correction Model (VECM), the paper shows there is short run and long run causality between FDI and Renewable Energy Consumption and the causality is negative. Granger causality test reveals that the direction of causality is running from FDI to Renewable Energy Consumption. Policies regarding attracting more sectoral FDI should be considered to improve investment scenario in Renewable energy sector.

Keywords: economic growth, Renewable energy consumption, FDI, Vector Error Correction model

Introduction

Energy is one of the most important factors of production alongside with labor and capital in today's economy. The popular notion is that higher energy consumption leads to higher economic growth. However, concern over achieving production efficiency at the expense of environmental degradation has raised over past decades. During the UN conference on the Human Environment in Stockholm in 1972 the issue of environmental degradation was brought up for the first time. Ever since, the logic and impact of achieving growth at the expense on environment has been discussed on different literatures. One of the influential researches regarding relationship between per capita income and pollution is known as the Environmental Kuznets Curve (EKC) literature (Brock and Taylor, 2004).

Throughout the world there has been concerns over the economic impact of adopting non fossil fuel-based production. There has also been studies about how sustainable measures can affect economy and growth. In fact, there has been specific concern over how it will impact lower- and middle-income countries where growth is the first priority. For such economies, foreign investments are integral part of growth and this focus on growth comes with a higher demand for energy. Bangladesh gained her middle-income status in 2018 and has maintained a sustained growth throughout past decade. After the trade reform policy and trade liberalization in 1980, Bangladesh has attracted a large amount of foreign investment (FDI) (Khandekar, Amin and Khan 2018). Due to comparative advantage over cheap labor, access to sea port and stable economy, Bangladesh has experienced rapid increase of FDI investments.

According to neo classical model, enhanced FDI inflow will increase the investment rate thereby increasing per capita income while keeping technological progress and labor growth exogeneous (Khandekar, Amin and Khan 2018). However, the new growth theories have endogenized the technological change and FDI inflow. The reason for treating technological change and FDI inflow as endogenous is because these two elements have long run impact on host countries economy through “spill over” effects. Theoretically, the technology spill over and technological progress can promote economic growth as they provide the “know how” which developing economy wouldn’t have gotten otherwise. However, according to the industrial flight hypothesis, the foreign investors are inclined to invest where the labor is cheap and the production cost is low. Now to attain low production cost the environmental standards are compromised which results in deterioration of resources and environment of host country (Asghari 2013). This brings up the debate about the environmental concern and FDI inflow in developing nations.

Since energy consumption is prerequisite for economic growth, many studies have been done to determine the causality between these two. For example, Omri (2013); Achour & Belloumi (2016) stated that higher economic growth requires more energy consumption while other indicated that more efficient energy use requires a higher level of economic growth (Saidi & Hammami 2015; Omari 2015, 2013; Komal & Abbas 2015). Bangladesh’s energy sector is mostly dependent on fossil fuels and the country has lack of energy supply and the energy consumption level is among the lowest in the world. Therefore, the increased use of renewable energy can improve the growth and attract FDI investments. There haven’t been substantive empirical studies that focuses exclusively on the relation between FDI inflow in renewable energy consumption in Bangladesh. Most study on Bangladesh’s energy sector focuses on relation between energy consumption as whole and economic growth. Identifying causal relation between renewable energy and FDI in Bangladesh can provide useful insights about policy formation and prospects for sustained economic growth. Therefore, the goal of this paper is to determine if there is any relation between renewable energy and FDI in Bangladesh’s context. The relation can be short run or long run but this paper aims to analyze the causality among these two factors.

Research Questions

The main research question of this study is whether there any short run and long run causality between renewable energy consumption and foreign direct investment? If there is any causality among these variables then what is the direction of causality?

Data

The data source for this paper is from World Bank data and OECD world data. The time period of the data is from 1880 to 2016. Annual data is used for this study. The main variables used in this model and renewable energy consumption, FDI inflow and GDP per capita is added to avoid omitted variable bias.

Method

In order to answer the research question Vector Error Correction Model (VECM) model is used and to determine the direction of causality Granger causality test is done. Johansen Cointegration is used to see if variables are cointegrated in the long run and this determines the long run relation among variables.

Main Results

The variables are cointegrated in the long run. There is both short run and long run causality among Renewable Energy Consumption and FDI inflow. The causality is running from to FDI inflow to Renewable Energy Consumption.

Contribution

Since there are not substantive studies focusing only on renewable energy, this study gives an insight about a specific kind of energy mode within the energy sector. This will help the policy makes to frame policies the directs FDI towards a sustainable economic growth that doesn’t compromise the resources for future generations.

Literature Review

The economic literature explaining the relation between economic growth, FDI, CO2 emission and energy consumption have received increased attention by many researchers in many different countries. The existing literature mostly focuses on the relation between economic growth and energy consumption. Others have focused on FDI inflow and economic growth. However, there hasn't been studies that focuses on the relation between FDI and renewable energy consumption, especially in Bangladesh with recent available data.

Barini et al, in their paper investigates the relation between renewable energy consumption, International trade, oil price and economic growth for Tunisian economy. The data used for the study extends from 1980-2011 and ARDL and granger causality tests were used to find correlation and direction of causality. In their study they considered international trade as sum of export and import divided by GDP and Renewable energy consumption is defined as consumption of hydropower, solar, wind, geothermal, biofuel and biomass. When they considered Log GDP as dependent variable, the model shows that GDP negatively related to renewable energy consumption. The direction of causality is running from renewable energy consumption to economic growth in the long run while in the short run its opposite. There is short run unidirectional causality running from international trade to renewable energy consumption which support the notion that variation of International trade will affect renewable energy consumption.

Doytch and Narayan (2015) in their paper discusses about the impact of FDI on renewable and nonrenewable energy consumption. Doytch and Naryan studied the effects of sectoral FDI impact on energy consumption controlling variables like GDP and energy price. Their result supports "halo effect" which is foreign investment improves the environmental economy by inducing "green capital spillover effect". The sectoral impact of FDI on renewable energy consumption is significant in manufacturing and service sector for high and upper middle-income countries. For lower income countries the impact is limited to mining sector, making correlation between FDI and renewable energy consumption not so significant.

Pramati et al (2016) in their paper tested one of their hypotheses whether FDI inflow promotes clean energy production and their uses. The data is spanning from 1991 to 2012 and the sample was 20 emerging economies. The finding suggested that FDI has an overall positive impact on clean energy consumption and the direction of the causality is running from FDI to clean energy. Lee (2013) examines the impact of FDI on clean energy, CO2 emission and economic growth for G20 countries. Contrary to Pramati et al (2016), Lee (2013) documents no statistically significant relation between FDI inflow and increased renewable energy consumption.

Since correlation between FDI inflow and renewable energy consumption is inconclusive in many studies, some authors have considered CO2 emission and energy intensity as a proxy to capture improvement of a countries source of energy. For example, List and Co (2000) argues that FDI inflow improves energy efficiency of the host country by reducing CO2 emission. As in some cases FDI brings new technology and production efficiency in the firm level, the aggregate level CO2 emission decrease in the long run. However, opposite findings also can be found as Pao and Tsai (2011) documents positive relation between FDI and CO2 emission in the case for BRIC countries and the data span was from 1980 to 2007. The authors argue that there is bidirectional causality between FDI and CO2 emission.

Kivyiro & Arminen (2014) have investigated the relationship between CO2 emissions, energy consumption, economic development and FDI in six Sub Saharan African countries. They used autoregressive distributed lag model and Granger causality to determine the relation. The result of the studies showed inconclusive results as the granger causality among variables varied across. However, Xu, Zhou and Li (2016) have also used the same methodology to test the hypothesis in the case of China and the result was that energy consumption has a positive impact on FDI and their data frame was from 1991 to 2013. In the granger causality they found that the causality is running from energy consumption to FDI. Islam et al. (2013) used Vector Error Correction Model (VECM) and granger causality test to determine relation between energy consumption and economic growth in Malaysia. The result showed that economic growth and financial development affects energy consumption, both in the short and the long run.

Chapter Summery

As it can be seen, different studies have different results regarding the relation between FDI and renewable energy. Generally speaking, there is not many studies that have isolated the effect of only renewable energy from energy as total. Most studies have also focused on the relation between energy consumption and Economic growth but few studies have focused on FDI aspect of economy. Therefore, this paper presets the relation between FDI and renewable energy.

Theoretical Framework

Theories about the impact of FDI

Previous studies about the impact of FDI inflow on renewable energy consumption have been inconclusive. Depending on the nature of economy such as developed or developing the impact may vary. Therefore, individual study on how FDI impacts the renewable energy consumption on any specific region or economy is worth to measure. However, there are two overarching concepts about FDI impact one is technology spillover and other is pollution heaven hypothesis. These two concepts are discussed below to illustrate the theoretical background that is been used to formulate hypothesis of this paper.

Technology Diffusion

FDI flows from countries where industries maintain high environmental standard due to strict environmental regulation. In that sense, the foreign firms are inclined to use clean energy in their production process. Foreign industries thus fuel the energy efficiency in the production process. Then the host country can imitate the green technology that foreign investments tend to transfer to the host countries. In this context, FDI can improve the host countries environmental standard through transferring the clean energy technology and hence the local industries might become more inclined to use renewable energy to meet standard of foreign investors. In other words, the adoption of efficient energy in production may initiate decrease in use of non-renewable energy by local industries (Mabey et al., 2003, p. 7).

Technology diffusion can be described as “dynamic consequence of adoption” of new technology and is it characterized by accumulation of technology by the adopter over a period of time (Comin and Mestieri, 2013, p. 3). Previous studies have established that FDI is an important channel of technology diffusion and it benefits the GDP of host country. The impact of FDI on host countries production pattern occurs in several ways. Firstly, through transferring the technological "know how" from foreign firm to local industry the human capital of host country improves and hence the productivity level rises as well. Secondly, MNCs brings new ideas and competition in the local economy, which pushes the monopolistic local firms to undertake efficient and sustainable production to sustain in the market. Thus, the spillover effect of FDI brings efficiency by "breaking bottlenecks to investments[1]" and increased competition in local economy induces faster industrial development (Lee et al., 2011, p. 3).

For an effective and sustainable technology transfer to the host country, the transfer must be suitable to the existing local industry so that the local firms can replicate the technology easily and FDI industries must be located near to local firm to facilitate the spillover effects. This type of technology transfer is called horizontal technology transfer and it is characterized by long term implicating process of technology by local industry (Wilkins, 2002, p. 43-44). In practice, the technology diffusion is more successful when the host country has certain level of technological advancement that can absorb the new technology that the foreign company is bringing into. This notion is confirmed in the study where US technological transfer to LDC showed that there is no significant technological diffusion (Xu, 2000, p. 479). Therefore, if we consider the technology diffusion hypothesis, due to positive spill over effect and technology transfer the host countries are likely to use renewable energy or energy that uses less fossil fuel somehow. If so, then based on this theory, the FDI will be positively related to renewable energy consumption.

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[1] A bottleneck is a symbolic term that defines the slowing down of a production process and it could be anything from poor infrastructure to corruption (Vyas, 2015, p. 27-28)

Pollution Heavens

Another possible outcome of FDI is that it may negatively impact the host countries environment by bringing "dirty industry" into the market. This theory is known as pollution heaven hypothesis where FDI tends to flow from countries with high environmental standard to countries where environmental regulations are less-functioning (Cole, 2004, p. 73).

The pollution heaven hypothesis is a counter argument to the ECK argument. According to ECK hypothesis an economy's pollution level follows an inverted U shape where economy that are heading towards industrialization emits the maximum but after a certain level of growth structural changes happen and the emissions declines gradually. According to this hypothesis when the economy is still moving towards its "peak" the use of renewable energy is less likely but after it achieved the threshold level of growth the economy moves towards green technology due to structural changed and environmental regulations within the economy (Suri and Chapman, 1998, p. 195).

The PHH hypothesis says that this fact is not entirely true but accounts for the fact that the difference in environmental regulations in developed and developing economies can lead to establishment of pollution intensive industry. PHH theory adds another aspect of ECK hypothesis. According to ECK hypothesis, after a certain level of growth the developed economics will be inclined less polluting production but these economies will push polluting industries to developing countries due to their lower environmental standard. As a result, the developing countries will see an increased FDI and growth rate (due to increased capital flow) but will also face increased environmental degradation (Cole, 2004, p. 73). Finally, the increased energy demand due to increased production will also make the consumption of renewable energy less likely (Cole, 2004, p. 73). Countries with capital intensive industry where capital is cheap is more prone to become pollution heaven as theoretically capital-intensive industry is less efficient and produces more pollution due to overly cost minimizing production process (Cole and Elliot, 2005, p. 531).

Hypothesis

As the theory's relation to FDI has been discussed above, now we can set hypothesis which is relevant to our research question. This study investigates the impact of FDI Inflow on renewable energy consumption in Bangladesh over the period 1980 to 2016. Since the aim of the study is to investigate whether FDI inflow has any casual impact on the host country´s share of renewable energy, the hypothesis as follows:

H1: FDI does not affect renewable energy consumption

H2: Renewable energy consumption does not affect FDI

Chapters Summery

There are two popular hypotheses about the FDI impact on host country's economy. The technology diffusion hypothesis suggests that the positive "spill over effect" will have a positive impact on host countries economy. According to this hypothesis FDI can improve the host countries environmental standard through transferring the clean energy technology. Therefore, and local industries might become more inclined to use renewable energy to meet environmental standard of foreign investors. However, this hypothesis also says that to have a positive spillover effect the host countries needs to have certain level of technological advancement already existing in the country. On the other hand, the pollution heaven hypothesis (PHH) says that the FDI tends to flow from countries with high environmental standard to countries where environmental regulations are less-functioning. In that case the FDI will bring into more pollution intensive industry in the host countries economy and hence it will negatively impact the use of renewable energy. The hypothesis of this paper has been formulated keeping these two hypotheses into consideration.

Scope of the Study

This section first provides an overview of Bangladesh. Then it describes the present FDI and renewable energy scenario in Bangladesh. This section also discusses the factors affecting FDI inflow in Bangladesh and in the next section it describes the overall energy consumption tread and what portion of energy consumption is actually renewable energy. It also describes the role on government in energy generation scheme and also in renewable energy generation scheme.

Country overview

Bangladesh is a country located in South Asia between 20°34″ to 26°38″ north latitude and 88°01″ to 92°41″ east longitude. The population density is density of 1222/km2. The country has a total land area of 147,570 km2 [30] with US$ 1314 per capita income (Baky et al, 2017). Since Bangladesh was unaffected by the global economic crisis, the growth of economy of Bangladesh maintained its stability and secured a growth of 6.5% of GDP (Gross Domestic Product) in 2015 (Baky et al, 2017). This became possible because of higher growth of the industrial sector and the service sector. Agriculture, industry and the service sector contribute 17.2%, 28.9% and 53.9% of the Bangladesh’s economy, respectively (Baky et al, 2017). The geographical map of Bangladesh is presented in the figure below.

Figure 1: Map of Bangladesh

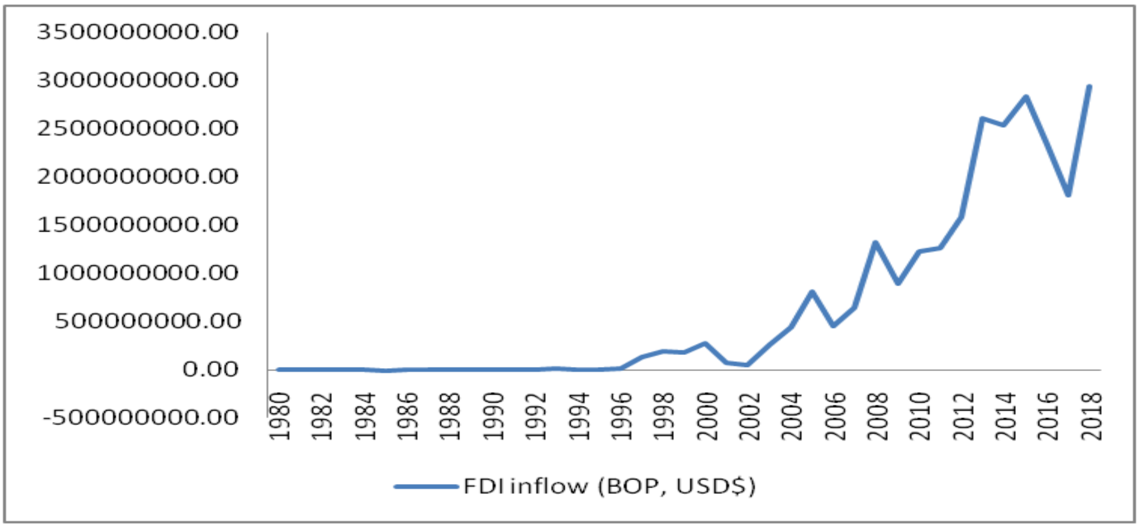
Image is excluded from the electronic version.

FDI scenario of Bangladesh

For last decade, Bangladesh has made significant growth and development through restructuring the economic policy and public management. The economy has witnessed a steady growth in the past decade as the in year 2010 when GDP growth was 5.5, Bangladesh has made it to 7.9 in 2018. According to a forecast by the Centre for Economics and Business Research (CEBR), the economy is poised to increase by 7% on an average by 2033 (Rashid, 2018). Since 1980, Bangladesh has economically benefitted from export-oriented market a large share of which consists of Readymade garments industry. By introducing privatization, trade liberalization and export-oriented zone Bangladesh made progress in attracting FDI in past two decades. The increased FDI has played a crucial role in improving GDP growth in Bangladesh capital accumulation, capacity development, productivity efficiency and technology transfer (Khandekar, Amin and Khan 2018). Apart from GDP per capita, the FDI inflow also affects 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). Additionally, according to Kabir & Hoque FDI is useful to pay off external dept and the import volume helps to facilitate reinvestment earning in the economy (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 funds and the share of stock that foreign investors own when they invest on any venture in another country. Reinvested earnings are the investor's share of earnings, which are not given back to them as liquid asset (Khandekar, Amin and Khan 2018). Finally, intra-company loans represent the debt transactions which involves both long and short term, loans by the foreign parent company to its affiliates (Khandekar, Amin and Khan 2018). According to Bangladesh Bank report, foreign direct investment (FDI) inflow stood at USD 2.58 billion at the end of June 2019. The prominent FDI contributing countries are USA, UK, South Korea, Singapore, Hong Kong. Norway, Malaysia, India, Netherlands and China. However, in the fiscal year 2018-19 the major FDI contributing countries were: China People's Republic (P.R) (US$ 1159.42 million), Netherlands (US$ 802.84 million), United Kingdom (US$ 358.85 million) , Singapore (US$ 254.01 million), United States of America (US$ 187.35 million), Hong Kong: SAR of China (US$ 134.37 million), Norway (US$ 133.40 million), India (US$ 113.70 million), Sri Lanka (US$ 90.84 million) and Japan (US$ 72.91 million) and in percentage term they were respectively 29.81%, 20.64%, 9.23%, 6.53%, 4.82%, 3.46%, 3.43%, 2.92%, 2.34% and 1.87% towards the contribution of net FDI inflow (Bangladesh Bank, 2019).

Figure 2: FDI inflow trend in Bangladesh (1980-2018)



Source: Data from World Bank and own plotting

From the graph it is visible that from trade liberalization and privatization in 1995 onwards Bangladesh has seen a positive impact of FDI on GDP per capita. However, there is occasional fluctuations in the graph and the reasons can be political instability and inefficient bureaucracy. The main sectors that attract most FDI are Textile, telecommunication, Banking, Gas& petroleum and power. During the year 2019 FDI inflows (net) in Equity capital reached to US$ 408.97 million and Reinvested earnings reached to US$ 671.34 million. Additionally, Intra-company loans arrived to US$ 611.35 million during January-June, 2019 (Bangladesh Bank, 2019). From the past data, it is evident that a developing country like Bangladesh benefits from FDI from its export-oriented sectors and also expands growth (Amin, 2007). However, some researchers also suggest that economic growth attracts FDI as the foreign investors prefers to invest on countries that exhibits macroeconomic stability so that the investors can expect a stable return from their investment (Khandekar, Amin and Khan 2017). However, in general many statistical analyses have confirmed the causal relation that FDI plays a crucial role in a country’s development process (Islam et al. 2013).

Renewable Energy: Definition

Generally, a uniformed definition of renewable energy and renewable energy source is difficult to pinpoint due to diverse understanding of these terms by various stakeholders. For example, the definition of RE varies according to organizations like Article III of the Statute of the International Renewable Energy Agency (IRENA), the EU Directive 2009/28/EC on the development and progression of the utilization concerning electricity from sustainable resources, the Glossary of Statistical Terms of Organization for Economic Co-operation and Development (OECD), and the International Energy Agency (IEA) in its 2010 Renewable Information Report. However, the overarching definition of renewable energy according to these organizations is that electricity produced from solar sources, wind, geothermal, biomass, and hydropower assets, etc.

In the case of Bangladesh, according to section 2 of the Sustainable and Renewable Energy Development Authority Act, 2012 (Act No. 48 of 2012), “renewable energy” is defined as the energy and power originated from biomass, biofuel, biogas, hydropower, solar energy, wind power, hydrogen cell, geothermal, tide and wave or energy and power generated from any other sources declared by the government as renewable energy through official declaration (Karim et al, 2019). On the other hand, the same section defines non-renewable energy as energy and power generated from mineral gas, coal, peat coal, natural oil, any other fossil fuel, nuclear power, and any other non-renewable energy resources declared by the government as non-renewable energy officially. For this paper, renewable energy is considered as totally consumed which includes all sorts of renewable energy produced within Bangladesh (Karim et al, 2019).

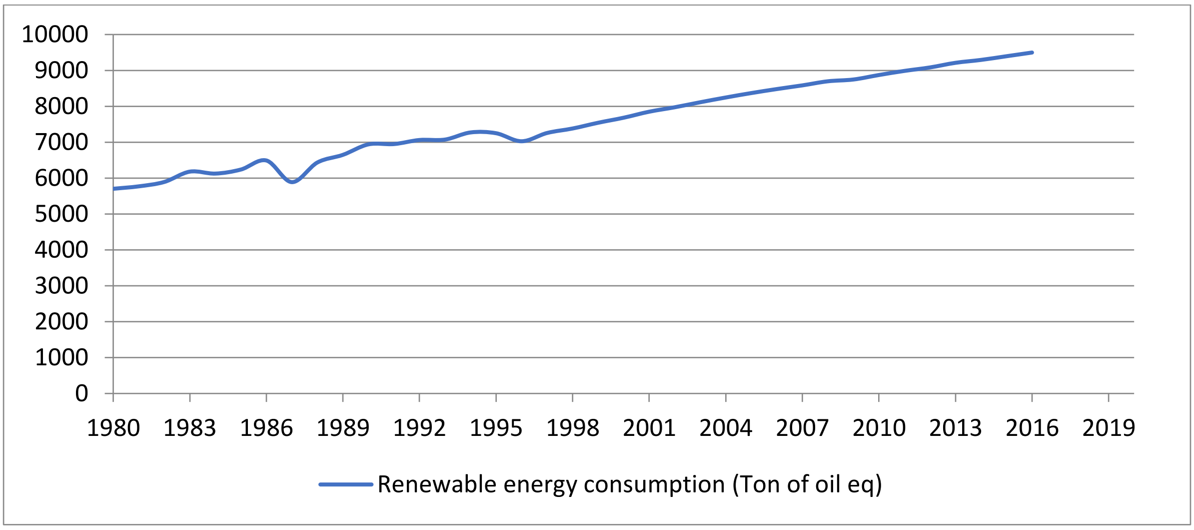
Renewable Energy Consumption scenario in Bangladesh

Due to rapid urbanization, population growth and shifting towards industrialization, Bangladesh is facing an increased demand of energy consumption. While in 2000 the energy consumption was 12.7 Mtoe, in the next year in 2011 the energy consumption doubled to 24.3 Mtoe (BP Statistical Review of World Energy 2018). Moreover, by 2020 the power demand is expected to increase by 185% (Khandekar, Amin and Khan 2018). However, the per capita energy consumption is still low in Bangladesh in compared to other developing nation indicating the fact that with increased energy consumption there will be a rise in development in the country.

In the recent years the growing concern over negative impact of fossil fuels on environment prompted many developed and developing countries to increase the use of renewable energy such as solar power, wind power, bio energy, hydro power etc. (Amin et al., 2016). Natural gas is the main source of energy in Bangladesh accounting for 72% of total energy use. In the year 2018, Bangladesh has used approximately 2.132 million metric tons of coal, 175.69 kilo barrels of oil per day and 28.37 billion cubic meters of natural gas. However, in 2018 the demand for electricity was 11,534 MW while the supply was 7148 MW. Such high gap in demand and supply is resulting in financial and innovative impediments for the nation. Although energy generation throughout the country has expanded significantly, the generation altogether relies mainly on non-renewable energies. In fact, non-renewable means of production actually accounts for 40% of the absolute carbon dioxide (CO_2) emission in Bangladesh (Karim et al, 2019). However, the government has adopted policies to increase the use of renewable in the household electricity generation and to mitigate future energy crisis (Karim et al, 2019). According to Renewable Energy Act, initiated in 2009 the government is aiming to 20% of total power generation by using renewable energy sources.

Currently, renewable energy contributes 560 Megawatt (MW) of the total electricity production of 20,430 MW, which can be a sustainable solution to the demand-supply crisis (Masud et.al, 2010). With growing energy demand with a 7% yearly GDP growth, the government is exploring different renewable energy options (Amin, 2015). Biomass is commonly used energy means in rural areas constituting 65% of total energy and also it accounts for 44% total energy used by people living under poverty line. On average Biomass constitutes for 48% total energy consumption in Bangladesh. Due to geographical advantage, Bangladesh has potential to utilize the available solar radiation up to 1900 kWh/m2. Along with that other complimentary technologies concentrating solar power (CSP), solar PV power system, Solar home system (SHS) are also gaining popularity in Bangladesh.

Figure 3: Renewable Energy consumption Trend in Bangladesh (1980-2018)



Source: Data from OECD world data and own plotting

In the graph, it appears that there is an upward trend in renewable energy consumption over time. There are only two relative declines in the consumption pattern and those are in 1987 and 1996 and apart from that, almost every year observed a growth in consumption. Since renewable energy consumption has an upward trend, investing in such sector is no more an ambitious project. Measures like emphasizing on research and development and inclusive approach of public awareness with new kind of energy adaptation by local government can provide energy security as well as sustainable development for the country.

Methodology

In this section, first descriptive statistics of the data are presented. For measuring the causality among variables, Vector Error Correction (VECM) model is used and the model specification is presented after descriptive statistics.

Data and Variables

Three variables are chosen for this study based on theoretical background and previous studies. The variables considered in this model is inspired by the work of the work of Tamazian and Rao (2010), Doytch and Narayan (2016) and Khandker et al. (2015). The variables are : FDI inflow measured in constant US$ 2010 value, Renewable energy consumption measured in Ton of oil equivalent and GDP per capita expressed in constant 2010 US$. FDI and GDP per capita data collected from World Bank data and Renewable energy consumption data is collected from OECD data Bank. It should be mentioned that Bangladesh got her independence in 1971 and the data used in this paper is from 1980 to 2016, which makes it 37 observations. The small sample size of the data might be a problem when determining long run causality among chosen variables. The table of variables and their sources are given below:

Table 1: Data and Variable

Variable	Measuring unit	Source	Symbol in Model
Renewable Energy Consumption	Ton of oil equivalent	OECD data Bank	LnRenew
FDI Inflow	constant 2010 US$	World Bank data	LnFDI

GDP per capita	constant 2010 US$	World Bank data	LnGDPC

Descriptive Statistics of Variables:

The GDP per capita of Bangladesh was last recorded as 1062.040158 US dollars in 2016. The GDP per capita averaged 567.4964 during the year 1880 to 2016 and the maximum was 1062.04 in 2016. FDI inflow is another variable of interest which was last recorded 2332724780.71 USD in 2016. The average is 5.47e+08 USD and the maximum was 2831152765.16 in 2015. Lastly, Renewable energy consumption was last recorded 9497.673 in 2016 and this is the maximum value as well. The average renewable energy consumed during 1880 to 2016 is 7573.013 kto. A summary of variables is given below:

Table 2: Descriptive Statistics of Variables

Variable	Mean	Maximum	Minimum	Standard Deviation
Renewable Energy Consumption	7573.013	9497.673	5702.417	1157.419
FDI Inflow	5.47e+08	2.83e+09	6660000	8.42e+08
GDP per capita	567.4964	1062.04	359.4563	200.5665

Model Specification

The aim of this study is to determine whether there is any relationship exists among Renewable energy consumption and FDI inflow along with GDP per capita. To determine the relation Vector Error Correction Model (VCEM) is used. VCEM is a special case of VAR model where the variables are cointegrated in the long run. The reason for choosing VAR model is because this model can be used when variable is stationary at their first difference.

Moreover, another reason for choosing this model is because this study presents bivariate approaches as we don't know direction of causality of the variables. Hence running a simple OLS model may cause omitted variable bias and VAR is model that treats all the variables in a multivariate manner and treats each of them as both dependent and independent variable in turn (Payne, 2010).

The VAR model also takes into account the cointegrating relation among variables. To do a cointegration analysis, Johansen and Juselius (1990) method is used which employs VAR system to test for numbers of cointegration vectors. The Johansen cointegration analysis is based on Maximum Likelihood method (ML). The Johansen and Juselius (1990 VAR representation of X_t in P^{th} lag other of K number of variables are as follows:

$$X_t = A_1 X_{t-1} + A_2 X_{t-2} + \ldots\ldots + A_{P-1} X_{t-P} + \varepsilon_t \quad \ldots\ldots\ldots\ldots\ldots (1)$$

As most of the Macroeconomic time series variables are nonstationary at their level, VAR of such models are calculated at their first difference forms. Hence the VAR model becomes:

$$\Delta X_t = A_1 \Delta X_{t-1} + A_2 \Delta X_{t-2} + \ldots\ldots + A_{P-1} \Delta X_{t-P} + \varepsilon t$$

Johansen Julious developed a technique that discovers the long run aspect of any causal relation and they denote this with matrix $\Pi = \alpha\beta'$. Here β is the coefficients for the variables that exhibits long run relationships and α measures the speed of adjustment of the variables towards equilibrium. A VAR model that involves the long run cointegration among the variables is called VEC model or Vector Error Correction Model (VECM). Hence with long run feature Π the VECM becomes

$$\Delta X_t = A_1 \Delta X_{t-1} + A_2 \Delta X_{t-2} + \ldots\ldots + A_{P-1} \Delta X_{t-P} + \Pi X_{t-P} + \varepsilon t$$

Where, X_t = LnGDP, LnRenew, LnFDI

X_t = 3 x 1 vector matrix that are integrated to order one I (1)

By 3 x 1 vector it means that each variable will be dependent variable in turn and on the right-hand side, a lagged term of dependent variable will appear along with other two remaining independent variable. Three models will be run simultaneously.

A = 3 x 3 coefficient matrix.

Π = matrix of long run coefficients (hence there is no Δ term added)

ε = Matrix of error term

Therefore with both long run and short run feature the final VEC model becomes :

$$\Delta X_t = A_1 \Delta X_{t-1} + A_2 \Delta X_{t-2} + \ldots\ldots + A_i \Delta X_{t-P} + \Pi X_{t-P} + \varepsilon_t$$

Considering three chosen variables (Renewable Energy Consumption, GDP per capita and FDI inflow) and VEC model specification as follows:

$$\Delta LnRenew_t = A_1\, \Delta LnRenew_{t-1} + A_2\, \Delta LnFDI_{t-1} + A_3\, \Delta LnGDP_{t-1} + \lambda_1\, ECT_{t-1} + u_i$$

$$\Delta LnFDI_t = A_4\, \Delta\, LnFDI_{t-1} + A_5\, \Delta\, LnRenew_{t-1} + A_6\, \Delta\, LnGDP_{t-1} + \lambda_2\, ECT_{t-1} + u_i$$

$$\Delta LnGDP_t = A_7\, \Delta LnGDP_{t-1} + A_8\, \Delta LnFDI_{t-1} + A_9\, \Delta LnRenew_{t-1} + \lambda_3\, ECT_{t-1} + u_i$$

Here coefficients A1 to A9 determines short run relationship. And the coefficient λ_1 to λ_3 determines existence of long run relation.

The term $ECT_{t-1} = \Pi X_{t-P}$, this term denotes the long run cointegration among the variable of the three equations above. The coefficient of ECT_{t-1} terms, which are λ_i, is called loading coefficients. The loading coefficients determines at what extent the short-run changes would respond to the deviation from the long-run equilibrium, ECM. Hence, when λ_i is not significant, the corresponding variable is referred as weakly exogenous meaning that the long run coefficient contributes nothing on restoring the equilibrium.

Johansen Cointegration Test:

To determine whether there is cointegrating relation exists among the variable (whether the coefficient of ECT term is negative and less than 1), Johansen developed two likelihood tests: the trace test and maximum eigenvalue test, shown in equations below

$$J_{trace} = -T \sum_{i=r+1}^{n} \ln(1-\lambda_i)$$

$$J_{max} = -T \ln(1-\lambda_{r+1})$$

Here T is the sample size and λ_i is the i:th largest correlation.

In the trace test, the null hypothesis is r cointegrating vectors against alternate hypothesis n cointegrating vectors. We reject the null if J_{trace} > critical value

In the maximum eigenvalue test, the null hypothesis of r cointegrating vectors against the alternative hypothesis of r +1 cointegrating vectors. Here also we reject the null if J_{max} > maximum eigen value.

For this paper, constant trend has been used since this specification allows the cointegrating equations to be stationary around a constant mean.

Unit Root Test

To perform Vector Error Correction Model and Cointegration test, the variables needs to be stationary. This paper uses Augmented Dicky Fuller test to see if variables are stationary at their first difference. The standard test of Dicky and Fuller (1979) is based on the model:

$$y_t = \beta_o + \beta_1 y_{t-1} + \gamma_t + \varepsilon_t$$

rewritten as,

$$\Delta y_t = \beta_o + (\beta_1 - 1) y_{t-1} + \gamma_t + \varepsilon_t \ \ldots\ldots\ldots.. (2)$$

Where $\Delta y_t = y_t - y_{t-1}$. The time series is non stationary if the coefficient of y_{t-1} is zero. Rewriting equation 2 gives us Augmented Dicky Fuller version of the equation

$$\Delta y_t = \beta_o + (\beta_1 + \beta_2 - 1) y_{t-1} - \beta_2 \Delta y_{t-1} + \gamma_t + \varepsilon_t$$

The model tests null hypothesis $(\beta_1 + \beta_2 - 1) = 0$ that means the model has unit root, i.e the model is not stationary. This hypothesis is tested against alternate hypothesis that is

$(\beta 1 + \beta 2 - 1) < 0$ that means the series is stationary. For this paper, ADF test with constant trend is being used because in this paper I am not focusing on seasonal break in the economy rather I am focusing on over all FDI inflow and GDP per capita performance.

Empirical Findings

This section describes the outcome and the results of the required test before and after estimation. The required tests include Dicky Fuller Unit root test, Johansen Cointegration test, VCEM model estimation and Granger causality test to determine direction of causality of the selected variables. Additionally, Lagrange multiplier test for autocorrelation and Jarque- Bera test for Normal distribution is also carried out. The summary of all the results is discussed at the end of the chapter. All calculations have been done in STATA software.

Unit Root Test

Unit root or stationarity test of the data is the first step to the analysis. It is also a prerequisite to Johansen Cointegration test as the test requires the variables to be stationary at their first difference not in their second difference. Therefore, the dickey fuller test is run and table 3 describes the outcome of the of the test.

Table 4- Dickey-Fuller test for unit root

Variable	**t-statistic**	**Critical value (5%)**	**Variable**	**t-statistic**	**Critical value (5%)**
LnGDPC	2.677	-2.969	d.LnGDPC	-4.277	-2.972
LnRenew	-0.892	-2.969	d.LnRenew	-8.983	-2.972
LnFDI	-0.918	-2.969	d.LnFDI	-6.939	-2.972

* d. shows the first difference of variables.

Source: Own calculations

In the unit root test, the null hypothesis is that the variable is not stationary and has a unit root. On the other hand, the alternative hypothesis is that the variables are stationary. If the t statistic is less than the critical value then the null hypothesis is rejected. In the table it is shown that at level none of the variables are stationary. However, at their first difference all the variables have t statistic lower than critical value. Therefore, the all the variables are stationary at their first difference. In other words, the dicky fuller test shows that the variables are integrated at their first difference. As mentioned in the methodology section, the constant trend has been used for unit root test in this paper.

Cointegration test

After checking for stationarity among variables, now cointegration test is run. The Johansen cointegration test is run to see if there is short or long run causality exists among the variables. The null hypothesis for the test is that there is no cointegration among the variable while the alternate is that there is cointegration among the variable. If in the 0 rank , trace statistic is higher than the critical value, then we reject the null meaning there is cointegration among the variable. By cointegration we mean that any two variables will move together in the long run and at some point, they will converge for equilibrium. The table below represents the finding of the Johansen cointegration test:

Table 5: Johansen test for cointegration

Maximum rank	**Trace statistics**	**5% critical value**	**Maximum eigenvalue statistics**	**5% critical value**
0	39.0290	29.68	31.1952	20.97
1	7.8338*	15.41	6.6848*	14.07
2	1.1491	3.76	1.1491	3.76

Source: Authors own calculation

In the table, the rank 0 represents null hypothesis. The trace statistics for both Johansen value and Maximum eigen value are higher than 5% critical value. That means we can reject the null and there is cointegration exists among the variable in the model. At rank 1 the trace statistic (7.8338) is lower than the critical value (15.41) which shows that there is at least two cointegrating relation exists among the variable. For maximum eigen value statistic, the results are similar to trace statistic.

VECM Estimation

According to the result of root test and Johansen cointegration test the variable of interests (Renewable energy consumption, FDI inflow and GDP per capita) are stationary at their first difference and cointegrated. Therefore, now the next step is to run the VECM estimation. In the VCEM model,

Table 6: VECM Estimation

Dependent Variable		Independent variables			Error Correction Term
		LnRenew	**LnFDI**	**LnGDPC**	
1	**ΔLnRenew**	–	**-.0063243** (0.000)	**.0582306** (0.256)	**-.1733657** (0.000)
2	**Δ LnFDI**	**-5.906455** (0.766)	–	**-5.06517** (0.565)	**.2367239** (0.000)
3	**ΔLnGDPC**	**-.3390931** (0.421)	**.0087977** (0.010)	–	**.2708956** (0.053)

P value in the parenthesis

Source: Own calculation

The VCEM approach investigates short run causal relation among the variables. In the table the Error Correction term shows the speed of adjustment towards equilibrium. If the error correction term λ_i has wrong sign or insignificant that means the variables of the specific equation are weakly exogeneous and does not contribute to restore the equilibrium.

For the **first equation** where Renewable energy consumption is the target variable, the error correction term (-.1733657) and p value (0.000) show that there is long run causality running from GDP per capita and FDI inflow to Renewable Energy consumption. Conventionally, the loading coefficient of the first equation should always be negative and in this case the coefficient of error correction term λ_1 is negative which means it has the correct sign and significant. Therefore, the variable FDI and Renewable Energy Consumption has long run cointegration. The significance of coefficient FDI inflow shows that it can individually explain a short run relation with Renewable Energy consumption. However, the other variable GDP per capita is not statistically significant meaning that there is not short run causality with the independent variable for equation 1. The existence of relation between renewable energy consumption and FDI inflow in the short run answers the first question of whether there is any relation between these two variables. The negative sign in the FDI coefficient shows it affects Renewable Energy Consumption negatively. This outcome is consistent with pollution heaven hypothesis. A detailed discussion and reasoning behind such result will be presented in the chapters **Discussion** section.

The **second equation** has FDI inflow as target variable and the error correction term is positive (.2367239). To confirm any long run relation, signs of the rest of loading coefficients should depend on the sign of the corresponding coefficients in the ECM term. According to the long run table 7 we see that

$$ECM \equiv LnRenew - 0.036LnFDI - 0.008\ LnGDPC$$

According to the second equation in the table 6 we find the positive coefficient of ECT ($\lambda 2$ = .2367239). Thus, the short run Δ LnFDI is positively related to the ECT_{t-1}. Consider a positive ECT_{t-1} was due to a too low LnFDI with a negative coefficient, -.036, in the long run ECT equation in table 7. LnFDI has to go up (a positive ΔLnFDI), to reduce the ECT this period, t. Thus, a positive loading coefficient, λ_2 = .2367239, is consistent to the requirement of resorting the equilibrium. In other words, LnFDI is not weakly exogenous. That means the Independent variables exbibits long run equilibrium feature. There is short run causality running from GDP per capita and Renewable energy consumption to FDI inflow but these relations are not significant.

In the **third equation** where GDP per capita is the target variable, the error correction term is positive and not significant (0.053). This shows that the independent variables (FDI inflow and Renewable Energy Consumption) and the dependent variable GDPC are weakly exogeneous as there is insignificant error correction term and these variables as weakly exogenous means do not contribute on restoring the long run equilibrium. However, looking at short run the variable GDPC and FDI inflow we see that the relation is positive and significant (.010). The relation supports growth theory which states that the FDI inflow within the economy will have a positive impact on GDP or growth of the economy. The short run relation between Renewable Energy Consumption and GDPC is not significant (p value = 0.421).

Long Run Estimation: Johansen Normalization Restriction Imposed

The VEC model shows short run relation and also shows if the variables are cointegrated in the long run. Since one long run cointegration has been found in first equation, the long run

"Johansen Normalization Restriction Imposed" model has been run to see the long run aspects of the ECT equations:

Table 7: Johansen Normalization Restriction Imposed

beta	Coef.	Std Err.	z	P > I z I	95% conf Interval	
_cel						
LnRenew	1	.	.		.	
LnFDI	-.0358255	.0060478	-5. 92	0.000	- .047679	-.023972
LNGDPC	-.0079175	.0492922	-0.16	0.872	-.104283	.0886934
_cons	-8.230895	.	.	.	.	

This table above contains the long run parameters of cointegrating vectors for the VEC model. As mentioned in table 6, only the first equation has the negative sign on ECT term and statistically significant which shows that only the variables in the first equation will converge towards equilibrium in the long run. The long run parameters shown in the table 7 above is consistent with the findings of table 6. As in table 6, we see that FDI affects Renewable energy consumption both in the short run and long run but GDPC do not affect Renewable Energy Consumption. In table 7 above, FDI had negative sign and it is significant while GDPC is not significant. That means there is equilibrium relation between FDI and Renewable Energy Consumption (p value is significant). However, GDPC do not affect Renewable Energy Consumption in the long run as the p value is not significant which is also consistent with the result shown in table 6.

Post estimation Tests

Lagrange-multiplier test

To check serial correlation among the variables, Lagrange-multiplier test is used. The null hypothesis is that there is no serial correlation. Based on the probabilities of 3 lag order we see that there is auto correlation in the first lag as it lower than .05 and we reject the null meaning there is auto correlation in the first lag. However, in the second and third lag there is no autocorrelation as the p values are higher than .05 and we cannot reject the null. Now it might be a matter of concern that there is autocorrelation in the model in the first lag but in out model the lag that we are using is actually the second lag. Therefore, in that case there is no problem in the second lag which is out lag of estimation and hence the model is not serially corelated due to the fact that we are using lag 2 which do not have serial correlation. Therefore, it means at lag 2, VECM model is free of the problem of autocorrelation. The result of the LM test is given below

Table 8: Lagrange-multiplier test

Lag	**chi2**	**df**	**Prob > chi2**
1	27.2854	16	0.03842
2	16.9324	16	0.38998
3	20.9286	16	0.18127

H0: no autocorrelation at lag order

Source: Authors calculation

Jarque-Bera test

To check if the variables are normally distributed, the Jarque-Bera normality test has been applied. The null hypothesis for this test in that all the variables are normally distributed. The probabilities of all the equation are higher than .05 so it can be said that all of the variables in the model are normally distributed. Therefore, the residuals in this model do not have problem regarding to normal distribution.

Table 9: Jarque-Bera test

H0: residuals are normally distributed

Equation	**chi2**	**df**	**Prob**
D_LnRenew	5.622	2	0.06013
D_LnFDI	5.564	2	0.06191
D_LnGDPC	2.872	2	0.23793

Source: Own calculations

Granger Causality Test

The VECM method tells us about the short run causality and long run relation among variables through the sign and significance value of error correction term. Since the VECM method treats all the variables endogenous and the only determine the causality, the granger causality test is done to determine the direction of causality. Through this test it can be determined if each individual variable had any short run impact on target variable. Similar to VECM test, the Granger Causality test is also done in lag 2.

Table 10: Granger Causality test

Target Variable	Independent Variable		
	Renewable Energy Consumption	**FDI inflow**	**GDP per Capita**
1. Renewable Energy Consumption	--	46.003 (0.000)	1.4967 (0.473)
2. FDI inflow	2.0821 (0.353)	--	.99111 (0.609)
3. GDP per Capita	5.9859 (0.05)	3.1716 (0.025)	--

H0: Independent variable do not have influence on target variable

Source: Own calculation

The null hypothesis is that the selected variables have zero influence over target variable. From p value (written within brackets) it appears that FDI inflow has unidirectional causality towards Renewable energy consumption. In other words, there is unidirectional causality running from FDI inflow to Renewable Energy Consumption. In the third equation, Renewable energy consumption affects GDP per capita and the direction of causality is running from renewable energy consumption to GDP per capita. However, since in the table 6 and 7 there is neither long run or short run relation confirmed between GDPC and Renewable Energy, the results of granger causality between these two is not considered in this paper.

For the purpose of clarity, a table is given below that states all the significant relation which is derived from granger causality test which are consistent with results of VECM table 6 but the insignificant relations are not included here.

Table 11: Direction of Granger Causality test (Only significant)

Variable Considered	**Direction of Causality**
LnRenew and LnFDI	LnFDI → LnRenew

Summary of Results

The Dicky – Fuller test shows that all three variables are non-stationary at their level but stationary at their first difference. Based on Johansen's cointegration test it is apparent that the variables are cointegrated and hence it confirms the existence of long run relation. Looking at the trace statistic, it shows that there is at least one cointegrating relation among variables (maximum rank 1). In the next step, Vector Error Correction Model (VECM) is applied to determine both long run and short run causality among three variables. The VECM results show that only one target variable Renewable Energy has a negative error correction term and the p value of the term is significant. This means the variable has long run causality. Lagrange-multiplier test shows that at lag 2, VECM model is free of the problem of autocorrelation and for this study the lag 2 is the optimal lag order. Jarque-Bera test results show that the model follows normal distribution.

The empirical findings indicate that there is both long run and short run causality among FDI and Renewable Energy Consumption. The VECM test shows that there is negative relation between FDI and Renewable Energy Consumption and the Granger causality test shows that the direction of causality is running from FDI to Renewable Energy Consumption. The Johansen Normalization table confirms the existence of long run equilibrium relation between FDI inflow and Renewable Energy Consumption.

There is neither short run causality or long run among GDP per capita and Renewable Energy consumption. Therefore, the results of granger causality corresponding these two variables are not considered. The Johansen Normalization in table 7 also shows that GDPC do not affect Renewable Energy Consumption in the long run. A detailed analysis and explanation behind VECM and Granger causality test result is given in the Discussion section next.

Discussion

The empirical finding suggests that there are both short run and long run there is relation between Renewable Energy Consumption and FDI inflow. These two variables were the focus of this paper. The Granger causality tests showed the short run causality and the VECM method shows the long run causality. The results of both VECM and Granger

Causality are significant. This result answers the first hypothesis (H_1) and rejects the second one. The VECM results shows that FDI affects Renewable Energy Consumption negatively in the short run and there is long run relation exists as well. The Granger causality test determines the direction of that causality which is running from FDI to Renewable Energy Consumption. This again supports H_1 hypothesis that is FDI impacts Renewable energy consumption but not the other way round.

The first equation of VECM table shows that there is negative relation between FDI to Renewable Energy Consumption and the right sign of ECT coefficient confirms the fact that the variables converges in the equilibrium in the long run. The granger causality shows that causality running from FDI to Renewable energy consumption and the relation is negative as table 5 shows. Now the negative unidirectional causality between FDI inflow and Renewable energy consumption can be explained as an outcome of investment in pollution intensive industry. FDI investment in pollution intensive industry hinders the use of Renewable Energy according to the PHH hypothesis. It also has something to do with the kind of economy we are talking about. As Bangladesh is still in the middle-income category with heavy focus on labor intensive and manufacturing based production, this impacts the Renewable Energy Consumption negatively. The main attraction for foreign investors is the affordable labor and production cost in Bangladesh. The focus is to generate more output and hence the means of production is not often ecofriendly. Therefore, in this study the relation between FDI and Renewable energy is negative and significant. Moreover, this study supports the first hypothesis where the negative causality is running from FDI to Renewable Energy Consumption.

There is no short run or long run relation between Renewable Energy Consumption and GDP per capita due to the fact they are weakly exogeneous (Wrong ECT sign). The second equation of table 6 shows no short run or long run relation between FDI and

Renewable Energy consumption when FDI is dependent variable. This also reconfirms the H1 that FDI impacts Renewable Energy Consumption but not the other way round as the results comes insignificant when FDI is dependent variable.

The study shows that FDI affects Renewable Energy Consumption negatively in the short run and there is long run equilibrium as well. The time frame of the study can be an explanation because to see a positive relation between FDI and Renewable Energy, longer time of observation might be required. To support this claim, the Environmental Kuznets hypothesis will be discussed briefly. According to Environmental Kuznets hypothesis an economy's pollution level follows an inverted U shape where economy that are heading towards industrialization emits the maximum but after a certain level of growth structural changes happen and the emissions declines gradually. According to this hypothesis, when the economy is still moving towards its "peak" the use of renewable energy is less likely (Suri and Chapman, 1998, p. 195). If we consider this hypothesis in the case of Bangladesh then the insights tell us that Bangladesh is in the former stage which means it is moving towards the peak and hence the production is mainly manufacturing based and the FDI investments are also directed to those sectors. Therefore, the use of renewable energy will be less likely and FDI will be negatively affecting the use of such energy. This is consistent with outcome of the Granger test and VECM test of this paper as FDI is negatively affecting the renewable energy consumption. However, the EKC hypothesis also says that after the economy has achieved the threshold level of growth the economy moves towards green technology due to structural changed and environmental regulations within the economy (Suri and Chapman, 1998, p. 195). Therefore, to see a positive relation between FDI and renewable energy consumption more longer time frame is needed as the economy needs time to reach its "peak" and then moves towards a gradual decline in emission which translates into higher consumption of renewable energy. Since Bangladesh got her independence in 1970 and the data availability is limited, this might be an issue.

Conclusion

This paper investigates the relationship between FDI and renewable energy consumption in Bangladesh using annual data spanning from, 1980 to 2016. According to result, both long run and short run causality among FDI and Renewable Energy Consumption. In the short run, the causality is negative and granger causality shows direction of causality is running from FDI to Renewable Energy Consumption. There is short run causality among GDP per capita and Renewable Energy consumption but the relation is not significant.

As we know energy is a limiting factor to economic growth and to sustain the growth, alternative version of energy is needed. Hence, apart from conventional energy sources, renewable energies can play a vital role. However, as our results shows that the FDI affects renewable energy and the relation is negative, there is policy implication for this result. The government policies need to balance between environmental standard and economic growth so that the FDI do not impede the use or prospect of renewable energy consumption. Since the results shows there is relation between renewable energy consumption and FDI, policies should be taken that encourages foreign investors to incorporate renewable energy sources in the production process. For example, the companies that has reputation of maintaining environmental standard can be given economic benefits from the government. Additionally, sectoral foreign investment such as foreign investment power generation sector might escalate the development of renewable energy sector. For example, the potential of solar energy and biomass is promising in Bangladesh and foreign investments in such sectors will affect renewable energy consumption. Also, investment such as in off grid areas may also affect the pattern of renewable energy consumption from a long run perspective.

One of the drawbacks of this paper in the small sample size due to unavailability of data before 1980. The incorporation of longer time period might give a positive relation between FDI and Renewable Energy Consumption. Moreover, apart from GDP per capita, more variables can be added such as technology diffusion in the market or the increase in service sector to see if they impact the renewable energy consumption. Moreover, the scope of the paper can be extended such as South Asia to identify any common trend in renewable energy consumption.

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Appendix

Table 7- Johansen tests for cointegration

Trend: constant Number of obs = 35

Sample: 1980- 2016 Lags = 2

Maximum rank	parms	LL	eigenvalue	Trace Statistic	5% critical value
0	12	55.109436	.	39.0290	29.68
1	13	70.707041	0.58987	7.8338*	15.41
2	17	74.049426	0.17386	1.1491	3.76
3	21	74.623958	0.03230		

Maximum rank	parms	LL	eigenvalue	Max Statistic	5% critical value
0	12	55.109436	.	31.1952	20.97
1	13	70.707041	0.58987	6.6848	14.07
2	17	74.049426	0.17386	1.1491	3.76
3	21	74.623958	0.03230		

Table: VECM results

	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]
D_LnRenew					
_ce1 L1.	-.1733657	.0383902	-4.52	0.000	-.2486091 -.0981223
LnRenew LD.	-.2541707	.1157712	-2.20	0.028	-.4810782 -.0272632

LnFDI LD.	-.0063243	.0009422	-6.71	0.000	-.0081711 -.0044775
LnGDPC LD.	.0582306	.0512943	1.14	0.256	-.0423044 .1587657
_cons	.0199988	.0042763	4.68	0.000	.0116173 .0283802

	Coef.	**Std. Err.**	**z**	**P>|z|**	**[95% Conf. Interval]**
D_LnFDI					
_ce1 L1.	.2367239	6.593237	3.59	0.000	10.74988 36.5949
LnRenew LD.	-5.906455	19.88287	-0.30	0.766	- 44.87617 33.06326
LnFDI LD.	-.1839865	.1618234	-1.14	0.256	-.5011545 .1331814
LnGDPC LD.	-5.06517	8.809429	-0.57	0.565	-22.33133 12.20099
_cons	-.0002731	.7344266	-0.00	1.000	-1.439723 1.439177

	Coef.	**Std. Err.**	**z**	**P>|z|**	**[95% Conf. Interval]**
D_LnGDPC					
_ce1 L1.	.2708956	.1398435	1.94	0.053	-.0031926 .5449838
LnRenew LD.	-.3390931	.4217186	-0.80	0.421	-1.165646 .4874601
LnFDI LD.	.0087977	.0034323	2.56	0.010	.0020705 .0155249
LnGDPC LD.	.2080795	.1868492	1.11	0.265	-.1581383 .5742973
_cons	.0366667	.0155773	2.35	0.019	.0061358 .0671976