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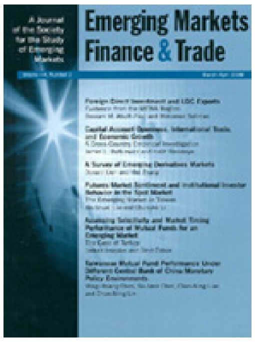

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Financing renewable energy projects in major emerging market economies: Evidence in the perspective of sustainable economic development

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Abstract

This research paper aims to explore the role of FDI inflows and stock market development on the promotion of renewable energy consumption. Further, study investigates the effect of renewable energy consumption on CO_2 emissions and economic output across a panel of Brazil, China, India and South Africa. Study utilizes annual data from 1990 to 2012 and employs various robust panel econometric techniques. The findings confirm that both FDI inflows and stock market development play an important role in promoting renewable energy consumption. The results also reveal that renewable energy consumption helps to mitigate the growth of CO_2 emissions and promotes economic development.

Keywords: FDI inflows, stock market development, renewable energy, CO_2 emissions, sustainable economic development

1. Introduction

According to the Intergovernmental Panel on Climate Change (IPCC, 2014), carbon dioxide (CO_2) emissions contribute 76% of the World's Greenhouse gas emissions, of which, 68% comes from energy related sources. Over the next 25 years energy consumption and energy related CO_2 emissions are projected to rise by 56% and 46%, respectively (EIA, 2013). Further, World Resource Institute (WRI) report that the conventional energy sources produce more than one-third of global greenhouse gas emissions.[1] As a result, several countries including Brazil, China, India and South Africa have announced climate change commitments by initiating significant investments into renewable energy projects and energy efficiency technologies.[2] The aim of *Sustainable Energy for All* (SE4ALL) is to increase the share of renewable energy from 18% to 36% during 2010-2030 against the global energy mix. The estimates show that the renewable energy contributes only 19.1% of total global final energy consumption in 2013 (REN21, 2015).

Therefore, the countries are focusing on to increase the share of renewable energy in total energy consumption. This will serve the two purposes; first renewable energy replaces conventional energy sources (e.g. coal, gas, oil) to meet the increasing demand for energy and second it will also significantly reduce the CO_2 emissions across developed and developing economies.[3] In spite of its unique advantages, the generation of renewable energy is demotivated due to its

[1] http://www.wri.org/our-work/topics/energy
[2] Recognizing the importance of renewable energy and energy efficiency, United Nations has declared the decade 2014-2024 as Decade of Sustainable Energy for All (SE4ALL, REN21).
[3] In 2014, nearly 30 countries reduced or eliminated their fossil fuel subsidies to shift their focus towards renewable energy consumption (REN21, 2015).

expensive nature and capital-intensive. However, over the last few years, the governments of developed and developing economies have started initiating investments into renewable energy sector and also making it more attractive to the private investors by providing lucrative incentives. As a result, the renewable energy investments in developed and developing economies have increased from 36.0 billion and 9.0 billion in 2004 to 138.9 billion and 131.3 billion US dollars in 2014, respectively. Among the renewable energy sources, 92% of renewable energy investments went into solar ($149.6 billion) and wind ($99.5 billion) in 2014, respectively (REN21, 2015). However, the realized renewable energy investments in 2012 are far from the forecasted. For instance, the IEA (2012) projected that the required renewable energy investments are 6.4 trillion US dollars during 2012-2015.[4]

Given the significance of renewable energy uses, the recent literature has started to explore the sources of renewable energy funding. In this context, there are two pioneering studies by Paramati, Ummalla and Apergis (2016) and Paramati, Apergis and Ummalla (2017). The first study (Paramati, Ummalla et al., 2016) explored the role of FDI inflows and stock market capitalization on clean energy consumption in a sample of 20 emerging market economies. Authors find that both FDI inflows and stock market capitalization play an important role in promoting clean energy uses. Similarly, the second study (Paramati, Apergis et al., 2017) investigated the effect of FDI inflows and stock market development on clean energy promotion across the panels of EU, G20 and OECD economies. Overall, their findings establish that FDI and stock markets play vital role in promoting clean energy uses across those economies.

[4] Rafiq and Salim (2009) suggest that the Asian emerging economies should initiate effective environmental policies, which should be aiming to reduce the energy intensity, improve the energy efficiency, and develop the markets for emission trading.

Authors also suggested that the political cooperation among the nations has an important role in minimizing the level of CO_2 emissions. However, these studies fail to examine the role of FDI inflows and stock market development on renewable energy projects. Therefore, this motivates us to empirically examine the role of FDI inflows and stock market development on renewable energy consumption in major renewable energy investing emerging market economies.

The present study considers four major renewable energy investing emerging market economies such as Brazil, China, India and South Africa. These countries stand in top 10 renewable energy investing countries in 2014 across the globe. For instance, the four sample countries have invested 103.8 billion US dollars in renewable energy projects in 2014. This is more than one-third of global renewable energy investments. The majority of these renewable energy investments went into solar and wind energies. The reason for these countries to investment more money into renewable energy projects is due to their increasing level of CO_2 emissions in the recent past. Their share of global CO_2 emissions has increased from 16% to 37% during 1990-2012. For the same time period, their share of global gross domestic product (GDP) has also increased from 7% to 17%. This implies that these four major emerging market economies share more than one-third of global CO_2 emissions and less than one-fifth of global GDP. Due to higher level of CO_2 emissions, these countries are facing significant pressure from the international organizations to mitigate the growth of CO_2 emissions. Consequently, these countries have started to minimize the consumption of fossil fuel by increasing the share of renewable energy in total energy-mix.

In the recent past, as documented by Paramati, Ummalla and Apergis (2016) and Paramati, Apergis and Ummalla (2017), FDI inflows are becoming as the main source of financing for renewable energy projects. FDI inflows may transfer technology and innovative production process to host countries, which can easily promote and speed up renewable energy generation. Further, FDI allows businesses cheaper or easier access to financial capital, which can be used to accelerate the deployment of renewable energy technologies. With higher FDI inflows, nations can strengthen their energy efficiency and develop a low-carbon economy, i.e. reduction in CO_2 emissions. Similarly, stock markets provide a platform to the investment community to diversify their investments across different assets for obtaining higher risk-adjusted returns. Stock market development can provide additional funding for the renewable energy projects by listing renewable energy stocks on the stock exchanges. Therefore, both FDI inflows and stock markets can play an important role for funding renewable energy projects.

Given this background, the present study aims to investigate the role of FDI inflows and stock market development on renewable energy consumption and also explore the effect of renewable energy consumption on CO_2 emissions and economic output across a panel four major emerging market economies. Study uses annual data from 1990 to 2012. A number of panel econometric techniques are applied to achieve the study objectives. More specifically, the long-run equilibrium relationship among the variables is explored using Fisher-Johansen panel cointegration test while the long-run renewable energy, CO_2 emissions and economic output elasticities are examined using Group-Mean fully modified ordinary least squares (FMOLS) method. Finally, the direction of causality among the variables is investigated by applying heterogeneous panel non-causality test.

The present study makes following contributions to the existing body of knowledge. To the best of our knowledge, this is the first study to investigate the role of FDI inflows and stock market development on renewable energy consumption in major renewable energy investing emerging market economies. Therefore, the findings derived from this study will be very crucial for the policy makers and practitioners. For instance, if both FDI inflows and stock markets play an important role for the promotion of renewable energy uses then the policy makers have to initiate effective policies to convert FDI inflows and stock market capital into renewable energy projects. This will therefore increasing the renewable energy share in total energy consumption and ensures sustainable economic development in those countries. Our study also adds value to the literature in terms of identifying the role of renewable energy consumption on CO_2 emissions and economic output. More specifically, it is important for the policy makers to know to what extent renewable energy consumption reduces CO_2 emissions and increases economic output. These findings will assist the policy makers to take additional initiatives to promote the renewable energy consumption to mitigate the CO_2 emissions without harming the economic development in those countries.

The rest of the paper is organized as fallows. Section 2 presents the review of literature. Section 3 documents the nature of data, variable construction and estimation strategy. Section 4 reports empirical results and discussion. Finally, section 5 provides conclusion and policy implications of the study.

2. Review of Literature

2.1 FDI, stock market development and renewable energy consumption

Foreign direct investment may transfer the technology, innovative production process, and managerial skills to the host countries. Given that, the FDI inflows can have a positive impact on economic growth, which may then have a considerable effect on energy uses. For instance, Tang (2009) documents that FDI has a positive impact on energy consumption in Malaysia during 1970-2005. Author also finds bidirectional causality between FDI and energy consumption. Ibrahiem (2015) examines the relationship between renewable energy consumption, FDI and economic growth in Turkey during 1980-2011. The results reveal unidirectional causality from FDI inflows to economic growth and bidirectional causality between FDI inflows and renewable energy consumption. However, Sadorsky (2010) finds that FDI has no significant impact on energy consumption in 22 emerging market economies, spanning the period 1990-2006. Most recently, Salim et al. (2017) report that FDI has a positive impact on energy consumption in the short-run and negative impact in the long-run in China during 1982-2012. Further, they document that FDI has a negative impact on non-renewable energy consumption.

Similarly, financial development may affect negatively or positively energy consumption via economic growth. Financial development increases additional source of funding for economic activities. Therefore, financial development may play a major role in energy consumption. Ozturk and Acaravci (2013) find that financial development causes energy consumption in

Turkey. Islam et al. (2013) find financial development reduces energy consumption in Malaysia. Further authors find bidirectional causality between financial development and energy consumption. Komal and Abbas (2015) state that financial development has a significant positive impact on energy consumption in Pakistan. Similarly, Alam et al. (2015) document that financial development significantly increases demand for energy consumption. More specifically, by considering banking and stock market development variables as financial development, Sadorsky (2010) finds that stock market development variables have a significant positive impact on energy consumption in a panel of 22 emerging market economies over the period 1990-2006.[5] Sadorsky (2011) also documents that stock market development has a positive impact on energy consumption in 9 Central and Eastern European frontier market economies over the period 1996-2006. Another study by Chang (2015) reports that stock market development has a positive impact on energy consumption in both developing and emerging market economies. A recent study by Paramati, Bhattacharya et al. (2017) investigate the role of stock markets on energy demand in African frontier markets. Their empirical results show that the growth in stock markets has considerable positive impact on energy demand.

The recent literature also examined the effect of FDI inflows and stock market development on clean energy consumption. For instance, Paramati, Ummalla et al. (2016) report that both FDI inflows and stock market capitalization have considerable positive impact on clean energy consumption in a sample of 20 emerging market economies. Similarly, Paramati, Apergis et al. (2017) also examine the role of FDI inflows and stock market development on clean energy uses

[5] In this study, authors used three stock market development indicators .i.e. stock market capitalization, stock market value traded and turnover ratio.

across the panels of EU, G20 and OECD economies. The empirical findings of their study show that FDI inflows and stock market development promote clean energy consumption. Authors also suggest that the political cooperation among the nations is very important to fight against the growth of CO_2 emissions and also for financial and technical assistance. A very recent study by Paramati, Mo and Gupta (2017) investigate the role of stock market development and FDI inflows on CO_2 emissions in a panel of G20 nations. Authors make use of several panel econometric techniques and annual data from 1991 to 2012. Their findings confirm that the growth in stock markets and FDI inflows significantly reduce CO_2 emissions in developed and developing economies, respectively. Authors suggest that the stock market development in developing economies has not reached to a level where it can effectively reduce its adverse effect on the environment.[6] It is clear from the existing literature that there is no research, which examined the role of FDI inflows and stock market development on renewable energy consumption in major emerging market economies.

2.2 Renewable energy consumption and CO_2 emissions

In the past two decades, a number of studies have reported that higher fossil fuel energy consumption leads to higher CO_2 emissions across the developed and developing countries around the world. Therefore, various governments and policy makers recognized the importance of renewable energy for meeting the energy demand and to reduce CO_2 emissions. As a result of that a number of studies emerged to explore the dynamics of renewable energy consumption and CO_2 emissions. For instance, Jaforullah and King (2015) report a negative relationship between

[6] Paramati and Gupta (2011) establish significant long-run association between stock market performance and economic growth in India.

renewable energy consumption and CO_2 emissions in the US during 1960-2007. Further, Rafiq et al. (2016) find renewable energy consumption reduces CO_2 emissions and energy intensity in 22 urbanized emerging economies during 1980-2012. Similarly, Bloch et al. (2015) find coal consumption increases CO_2 emissions, while renewable energy consumption reduces. Menyah and Wolde-Rufael (2010) find nuclear energy consumption helps to reduce CO_2 emissions, while renewable energy doesn't reduce CO_2 emissions in the US during 1960-2007. Further, authors find that nuclear energy causes CO_2 emissions, while no causality exists between renewable energy consumption and CO_2 emissions. Salim and Rafiq (2012) report CO_2 emissions have a positive impact on renewable energy consumption. Authors also detect unidirectional causality from renewable energy consumption to CO_2 emissions in India and the Philippines while bidirectional causality between renewable energy consumption and CO_2 emissions in Brazil, China and Indonesia. Rafiq et al. (2014) document unidirectional causality from CO_2 emissions to renewable energy generation in the short-run, while bidirectional causality between two variables in the long-run in both China and India during 1972-2011. Al-Mulali et al. (2015) find fossil fuel energy consumption has a positive effect on CO_2 emissions, while renewable energy consumption significantly reduce CO_2 emissions in Kenya during 1980-2012.

For cross-country analysis, a few studies have examined the impact of renewable and non-renewable energy consumption on CO_2 emissions. For instance, Apergis et al. (2010) examine the dynamic relationship between CO_2 emissions, nuclear energy, renewable energy for a panel of 19 developed and developing countries over the period 1984-2007. Their results report that nuclear energy has a significant negative impact on CO_2 emission, while renewable energy consumption has a positive effect on CO_2 emissions. Authors argue that renewable energy could not reduce CO_2 emissions due to lack of appropriate technology for storage. However, Shafiei and Salim (2014) find renewable energy consumption reduce CO_2 emissions, whereas non-renewable energy consumption increases in 29 OECD countries over the period 1980-2011. Apergis and Payne (2014) provide evidence in support of the view that an increase in CO_2 emission raises renewable energy consumption, which then reduces CO_2 emissions across a panel of 25 OECD countries over the period 1980-2011. Similar results are also found by Apergis and Payne (2015) in 11 South American countries over the period 1980-2010. A recent study by Bilgili et al. (2016) report renewable energy consumption has a negative impact on CO_2 emissions in 17 OECD countries, spanning the period 1977-2010. Overall, these findings establish that the renewable energy consumption plays an important role in reducing CO_2 emissions across the countries. The findings of recent study by Paramati, Mo, et al. (2017) also establish that the renewable energy consumption significantly reduces CO_2 emissions in G20 nations. Another study by Paramati, Sinha and Dogan (2017) also confirms that the renewable energy uses reduce the CO_2 emission while non-renewable energy consumption increases in the next 11 developing countries.

2.3 Renewable energy consumption and economic growth

Over the past few decades, numerous studies have examined the relationship between energy consumption and economic growth. More recently, the attention has shifted to examine the nexus between renewable energy consumption and economic growth across developed and developing countries. Apergis and Payne (2010) investigate the nexus between renewable energy consumption and economic growth in 13 Eurasian countries over the period 1992-2007. They document that renewable energy consumption has a positive impact on economic growth. Further, they find bidirectional causality between them. Salim and Rafiq (2012) find economic growth has a positive impact on renewable energy consumption. Further they detect bidirectional causality between renewable energy consumption and economic growth in Brazil, China, the Philippines and Turkey. Lin and Moubarak (2014) report that renewable energy consumption has a positive impact on economic growth, while there also exists a bidirectional causality between renewable energy consumption and economic growth in China during 1977-2011. The similar results are also found by Apergis and Payne, (2011), Sebri and Ben-Salha (2014), and Dogan (2016). Most recently, Inglesi-Lotz (2016) finds that renewable energy consumption has a significant positive impact on economic growth in 34 OECD countries over the period 1990-2010.

A recent study by Bhattacharya et al. (2017) estimate the effect of renewable energy consumption and institutional quality on economic growth in a panel of 85 developed and developing economies, using data from 1991 to 2012. Their empirical findings indicate that both renewable energy consumption and institutional quality contribute for higher economic growth. Similarly, Paramati, Sinha et al. (2017) explore the impact of renewable energy uses on economic output in a sample of the next 11 developing economies. Their long-run estimates suggest that the renewable energy consumption has a more positive effect on the economic growth than that of non-renewable energy uses. Bhattacharya et al. (2016) examine the effect of renewable and non-renewable energy consumption on economic output across a panel of 38 top renewable energy consumption countries around the world. Their findings establish that both renewable and non-renewable energy consumption have considerable positive impact on economic growth. Authors also carried out country-specific long-run output elasticities. The results show that the renewable energy consumption has positive effect on economic growth in majority of the sample countries. Tugcu et al. (2012) find bidirectional causality between renewable and non-renewable energy consumption, and economic growth in G-7 countries over the period 1980-2009.

Salim and Shafie (2014) document that renewable and non-renewable energy consumptions have positive impact on economic growth. Further, authors find unidirectional causality from economic growth to renewable energy consumption in the short-run, and economic growth to renewable and non-renewable energy consumption in the long-run. Salim et al. (2014) demonstrate unidirectional causality that runs from renewable energy consumption to economic growth, while bidirectional causality between non-renewable energy consumption and economic growth in 29 OECD countries during 1980-2011. Further, they find bidirectional causality between both renewable and non-renewable energy consumption and industrial output. Rafiq et al. (2014) also report unidirectional causality from renewable energy generation to economic growth in the short-run, whereas bidirectional causality between these two variables in the long-run in India. In the case of China, they find unidirectional causality from economic growth to renewable energy in the short- and long-run.

Similarly, Bloch et al. (2015) examine the coal, oil, renewable energy consumption and economic growth in China. They find China's economic growth has been driven by three sources of energy consumption. Pao and Fu (2013) examine the effect of disaggregate renewable energy and non-renewable energy consumption on economic growth in Brazil during 1980-2010. Their results show that renewable energy consumption has a significant positive impact on economic growth, while non-renewable energy has no impact on economic growth. Further, bidirectional causality between total renewable energy consumption and economic growth, whereas unidirectional causality from non-renewable energy to economic growth. Dogan (2015) investigates the impact of renewable and non-renewable energy consumption on economic growth in Turkey during 1990-2012. Author documents that renewable energy consumption has a negative impact on economic growth, while non-renewable energy has positive. Further, results reveal unidirectional causality from renewable energy consumption to economic growth and bidirectional causality between non-renewable energy and economic growth. Another study, by Dogan (2016), reports that renewable energy consumption has an insignificant impact on economic growth while non-renewable energy consumption has a significant positive impact. Further, author finds bidirectional causality between renewable energy and economic growth, non-renewable energy and economic growth, spanning the period 1988-2012. However, Ocal and Aslam (2013) document renewable energy consumption has a negative impact on economic growth in Turkey. Further, authors report unidirectional causality from renewable energy consumption to economic growth. By contrast, Menyah and Wolde-Rufael (2010) find unidirectional causality from economic growth to renewable energy consumption during 1960-2007.

However, there are also some studies which could not establish any relationship between renewable energy consumption and economic growth. For instance, Menegaki (2011) documents no causal relationship between renewable energy consumption and economic growth in 27 European countries over the period 1997-2007. Similarly, Yildirim et al. (2012) find no causality between renewable energy consumption and economic growth in the USA. Further, Ben Aissa, Ben Jebli, and Ben Youssef (2014) also find no causality between renewable energy consumption and economic growth in 11 African countries, spanning the period 1980-2008. Overall, these findings confirm that there is no specific study which examined the relationship between renewable energy consumption and economic growth in major renewable energy investing economies. This therefore motivates us to empirically examine the nexus between renewable energy consumption and economic growth.

3. Data and methodology

3.1 Nature of data and measurement

In this study, we make use of annual data from 1990 to 2012 on four major emerging market economies such as Brazil, China, India and South Africa. The selection of the sample period is restricted by the availability of total renewable energy data. Similarly, we only consider major renewable energy investing emerging countries in this study. The variables of the study are described as follows: renewable energy consumption (REC) in thousand terajoules (TJ); CO_2 emissions (CO_2) in thousand kilotons (kt); GDP (EO) at market prices (constant 2010 million US$); GDP per capita (PI) (constant 2010 US$); foreign direct investment (FDI), net inflows (% of GDP); stock market capitalization (SMC) (% of GDP); stock market total value traded (SMTVT) (% of GDP); non-renewable energy consumption (NREC) is the sum of coal, petroleum and gas (Quadrillion Btu); capital (CAP) is measured as gross fixed capital formation (constant 2010 million US$); total labor force (LBR) in million; technology (TECH) is proxied with total patent applications by the residents and non-residents; and finally total population (POP) is measured in million. All of these data, except REC and NREC, are sourced from the World Development Indicators (WDI) online database published by the World Bank. Similarly, data on REC and NREC are obtained from the Sustainable Energy for All published by the World Bank and the US Energy Information Administration (EIA) online database, respectively. Given the nature of these data, we convert all the data series into natural logarithms before the beginning of the empirical analyses.

3.2 Model specification

The main focus of this research is to explore the role of FDI inflows and stock market development on renewable energy consumption and also investigate the effect of renewable energy consumption on CO_2 emissions and economic output in major emerging market economies. To achieve these research objectives, we frame the following models using the existing theoretical and empirical approaches:

$$REC_{it} = f\ \left(CO_{2it},\ PI_{it},\ TECH_{it},\ FDI_{it},\ SMC_{it},\ v_i\right)$$

(1)

$$REC_{it} = f\ \left(CO_{2it},\ PI_{it},\ TECH_{it},\ FDI_{it},\ SMTVT_{it},\ v_i\right)$$

(2)

The models in equation (1) and (2) provide a general specification, which aim to examine the role of FDI inflows and stock market indicators (SMC and SMTVT) on renewable energy consumption. Where, renewable energy consumption is treated as a dependent variable while CO_2 emissions, per capita income, technology, FDI inflows and stock market indicators are treated as explanatory variables in the models. v_i represents for individual fixed country effects and, countries and time period are indicated by the subscripts i $(i = 1, \ldots\ldots, N)$ and t $(t = 1, \ldots\ldots., T)$, respectively.

$$CO_{2it} = f\ (POP_{it},\ PI_{it},\ TECH_{it},\ NREC_{it},\ REC_{it},\ v_i)$$

(3)

The equation (3) is built based on the theoretical model such as, IPAT environmental model (Ehrlich & Holdren, 1971). This theoretical model suggests that the environmental pollution (I) is mainly determined by total population (P), per capita income or consumption or affluence (A) and technology (T). Based on this approach, we empirically explore the effect of renewable and non-renewable energy consumption on the CO_2 emissions. More specifically, CO_2 emission is a function of total population, per capita income, technology, non-renewable and renewable energy consumption.

$$EO_{it} = f\ (CAP_{it},\ LBR_{it},\ NREC_{it},\ REC_{it},\ v_i) \tag{4}$$

Finally, using the neo-classical growth model, we frame the equation (4). The objective of this equation is to examine the role of renewable energy consumption on economic output. Specifically, economic output is a function of capital, labor, non-renewable and, renewable energy consumption.

As the first step of the empirical analysis, we employ two panel unit root tests to investigate the order of integration of the variables as this determines selection of econometric models for the analysis. For instance, the common unit root process is examined using Levin, Lin, and Chu (2002) (LLC) test, while the individual unit root process is investigated by employing Im, Pesaran, and Shin (2003) (IPS) test. For both the tests, the null hypothesis of a unit root is tested as against the alternative hypothesis of no unit root in general. If all of the variables are integrated in the same order i.e. I (1), then this indicates that all of the variables are non-stationary at levels and stationary at their first order differentials. This finding may suggest that these variables, as a group, may have a cointegration relationship in the long-run.

Therefore, to test the long-run equilibrium association among the variables of equation (1), (2), (3) and (4), we employ Fisher-type panel cointegration test based on the methodology suggested by Maddala and Wu (1999). This test has been developed using the Johansen (1991) framework. Maddala and Wu (1999) argue that this test performs better than the conventional panel cointegration tests which are based on the Engle-Granger two-step procedure. A number of researchers (e.g. Alam and Paramati, 2015; Alam et al., 2017; Paramati, Alam, et al., 2017) also suggest that Fisher-type panel cointegration test provides more reliable findings on the long-run equilibrium relationship among the variables.

Further, to find out the long-run renewable energy consumption, CO_2 emission and economic output elasticities, we estimate a single cointegrating vector, based on the equation (1), (2), (3) and (4). Pedroni (2000, 2001) argues that the application of ordinary least squares (OLS) on the equation which suffers from the issue of serial correlation and endogeneity can provide undesirable results. Therefore, to address the issue of serial correlation and endogeneity in the models, we employ Group-Mean FMOLS framework based on the recommendations of Pedroni (2000, 2001). This technique uses a non-parametric approach to handle the issue of serial correlation and endogeneity in the analysis.[7]

Finally, we aim to identify the direction of short-run dynamic bivariate panel causality among the variables using a model that supports the presence of heterogeneity across the cross-sections.[8] Dumitrescu and Hurlin (2012) propose a simple approach for testing the null hypothesis of homogeneous non-causality against the alternative hypothesis of heterogeneous non-causality. Under the null hypothesis, no causality in any cross-section is tested against the alternative hypothesis of causality at least for some cross-sections. Since this test is designed for testing the short-run dynamics among the variables, hence we apply this test on the first difference data series. The suitable lag length for this test is selected based on the Schwarz information criterion (SIC).

3.3 Average annual growth rates

We present the average annual growth rates for the selected variables of the emerging market economies in Table 1. Among the sample countries, Brazil (2.71%) and South Africa (1.68%) have higher renewable energy consumption growth rates. CO_2 emission growth rates are significantly higher in China (6.74%) and India (5.56%) while South Africa has the lowest

[7] A number of recent studies (e.g. Alam and Paramati, 2016, 2017; Alam, et al., 2015; Paramati, Shahbaz and Alam, 2017) use panel FMOLS models to estimate the long-run elasticities.
[8] A number of recent studies (e.g. Paramati, Mo and Gupta, 2017) use the heterogeneous panel non-causality test to explore the short-run causalities among the variables.

(1.93%). As expected, China has the highest average GDP (EO) growth rates (10.34%) whereas South Africa has the lowest (2.67%). The average growth of per capita (GDP) income is also higher for China (9.48%) and lower for South Africa (0.84%). On the other hand, FDI growth rate is higher in South Africa and lower in China. The average stock market capitalization (SMC) and stock market total value traded (SMTVT) growth rates are highest in China and India, respectively. The China also has highest average growth rates in non-renewable energy consumption (NREC) and capital formation (CAP). However, labor (LBR) growth rate is higher in Brazil and lower in China. Finally, the higher growth rates in technology (TECH) and population is in China and South Africa, respectively. Overall, results suggest that the renewable energy consumption growth rates are higher in Brazil while non-renewable energy consumption growth rates are in China.

3.4 Descriptive statistics

The descriptive statistics are displayed in Table 2. The reported descriptive statistics suggest that the renewable energy consumption was much higher in China and India than that of Brazil and South Africa. Similarly, both China and India releases higher level of CO_2 emissions than other two nations. However, the per capita (PI) income is lower in both China and India. The average FDI net inflows as a percentage of GDP is higher in China and lower in India. The average stock market capitalization (as a % of GDP) and stock market total value traded (as a % of GDP) are higher in South Africa and China, respectively. Finally, the non-renewable energy consumption and population are highest in China and India.

4. Empirical findings and discussion

4.1 Order of integration of the variables

As a first step of the empirical analysis, it is important to identify the order of integration of the variables. This is an important step as it will determine the selection of the econometric models for achieving the study objectives. For this purpose, we employ two panel unit root tests such as LLC and IPS. The LLC unit root test works under the assumption of common unit root process while IPS test works under the assumption of individual unit process. The null hypothesis of a unit root (non-stationary) is tested against the alternative hypothesis of no unit root (stationary). The appropriate lag lengths for these tests are selected based on the Schwarz information criterion (SIC). The panel unit root tests' results are presented in Table 3. The results show that the null hypothesis of a unit root cannot be rejected for all of the variables at levels. However, when these tests are applied on the first difference data series then the null hypothesis is strongly rejected for all of the variables at the 1% significance level. This implies that the variables are stationary at the first order difference. The findings confirm that the order of integration for all of the variables is I (1). Since all of the variables are integrated of same order then there may be a long-run association among these variables, which is explored in the following section.

4.2 The long-run equilibrium relationship

Given the findings of panel unit root tests, we explore the long-run equilibrium relationship among the variables of equations (1), (2), (3) and (4) using the Fisher-Johansen panel cointegration test. The appropriate lag length for the analysis has been selected using the SIC criterion. The results of panel cointegration test are reported in Table 4. The findings confirm significant long-run equilibrium relationship among the variables of equations (1), (2), (3) and (4). More specifically, our results show that the renewable energy consumption is cointegrated in the long-run with FDI net inflows and stock market indicators while CO_2 emissions also share long-run equilibrium relationship with renewable and non-renewable energy consumption. Finally, the economic output also has strong cointegration association with renewable and non-renewable energy consumption. Overall, our panel cointegration results imply that despite of the variables dynamics over time they reach to an equilibrium some point in time in the long-run.

4.3 The long-run elasticities of renewable energy, CO_2 emissions and economic output

The above cointegration test results do not imply whether variables are positively or negatively associated over time. Therefore, it is important to identify the role of FDI net inflows and stock market indicators on renewable energy consumption and also to what extent renewable energy consumption reduces CO_2 emissions and increases economic output in a panel of emerging market economies. To achieve these objectives, we employ Pedroni (2000, 2001) Group-Mean FMOLS model. This is a robust technique to explore the long-run elasticities as it accounts for endogeneity and serial correlation, while estimating the long-run elasticities. The empirical results of these models are displayed in Table 5.

The findings confirm that a 1% increase in FDI inflows and stock market capitalization raises renewable energy consumption by 0.009% and 0.002%, respectively. Similarly, a 1% increase in FDI inflows and stock market total value traded raises renewable energy consumption by 0.008% and 0.005%, respectively. These results show that the growth of FDI inflows and stock market indicators (capitalization and total value traded) positively contributes for renewable energy consumption. The results also show that the growth of per capita income and technology also contributes for higher renewable energy consumption. However, the growth of CO_2 emissions negatively effects renewable energy consumption. These findings suggest that the growth of FDI inflows and stock market development are potentially helping renewable energy promotion through various channels. For instance, in the recent past a large amount of FDI inflows and stock market capital are converted into renewable energy projects (Paramati, Ummalla et al., 2016, Paramati, Apergis et al. 2017). Therefore, FDI inflows and stock market development plays an important role for financing renewable energy projects in emerging market economies.

The long-run elasticities of CO_2 emissions show that a 1% increase in non-renewable energy consumption raises CO_2 emissions by 1.036% while renewable energy consumption reduces CO_2 emissions by 0.260%. This means that the non-renewable energy consumption has a significant positive contribution to the CO_2 emissions while renewable energy plays an opposite role. It implies that the growth of renewable energy consumption has a substantial negative impact on the CO_2 emissions. The other indicators such as the growth of population and per capita income also positively contribute for CO_2 emissions while the growth of technology reduces emissions' growth. Overall, these findings reveal that the growth of renewable energy consumption and technology helps to reduce the CO_2 emissions in major emerging market economies. Therefore, it is advised that the policy makers of those emerging market economies to initiate effective policies to promote the renewable energy generation and consumption, which will help to reduce the growth of CO_2 emissions and makes path towards sustainable economic development.

The long-run elasticities of economic output indicate that a 1% increase of non-renewable and renewable energy consumption raises economic output by 0.163% and 1.283%, respectively. These results imply that both non-renewable and renewable energy consumptions positively contribute for economic output. Interestingly, our findings show that the renewable energy consumption has more positive impact on economic output than that of non-renewable energy consumption. Based on this finding, we argue that the policy makers should focus on the promotion of renewable energy sources by shifting tax incentives from non-renewable energy sources to the renewable energy sources. This will eventually attracts both domestic and foreign investors to invest more money into renewable energy projects. The governments of these countries also should initiate public-private-partnership (PPP) investments into renewable energy projects. The direct involvement of governments in renewable energy projects not only makes easy to establish but also builds confidence among the investment community. This will therefore play an important role to increase the share of renewable energy consumption in total energy uses. As theoretically expected, both capital and labor are positively contributing for economic output in emerging market economies.

4.4 The direction of causality

In the final step, we explore the direction of causality among renewable energy consumption, CO_2 emissions, economic output, FDI and stock market indicators. For this purpose, we make use of Dumitrescu and Hurlin (2012) heterogeneous panel non-causality test. This test can only be applied on the series, which is stationary; hence we converted the data series into first order difference. The results of causality test are displayed in Table 6. The findings show that the renewable energy consumption Granger causes CO_2 emissions while we also find unidirectional causality that runs from FDI inflows to renewable energy consumption. However, we couldn't establish any causal relationship between stock market indicators and renewable energy consumption and also among CO_2 emissions, renewable energy consumption and economic output. Overall, our short-run causality test results imply that the growth of renewable energy consumption effects CO_2 emissions while FDI inflows also drive renewable energy consumption in the short-run.

5. Conclusion and policy suggestions

The emerging market economies have shown tremendous economic growth for the last two decades. However, their rapid economic growth is strongly associated with fossil fuel consumption. As a result of this, these economies are facing significant higher growth in CO_2 emissions. For instance, the sample countries such as Brazil, China, India and South Africa have contributed for 16% of the global CO_2 emissions in 1990 and their contribution has increased to 36% by 2012. During the same period, their share of global GDP has increased from 7% to 17%.

This implies that these countries contribute less than one-fifth of global GDP but they are responsible of more than one-third of global CO_2 emissions in 2012. As a matter of fact, the higher level of fossil fuel consumption has led to increase the CO_2 emissions in these countries. Hence, increasing internal and external pressure to mitigate the growth of CO_2 emissions, these economies have started to invest more money into renewable energy projects. Consequently, the sample countries alone invested 103.8 billion US dollars in renewable energy projects in 2014 to increase its share in total final energy consumption.

Given this background, the present study aimed to empirically examine the effect of FDI inflows and stock market development on renewable energy consumption and also investigate the role of renewable energy consumption on CO_2 emissions and economic output across a panel of major emerging market economies. The study has undertaken annual data from 1990 to 2012 and employed various robust panel econometric techniques. The empirical results confirmed long-run equilibrium relationship among the variables. The findings also showed that both FDI inflows and stock market indicators play an important role for promoting renewable energy consumption in those of major emerging market economies. Finally, our results established that the renewable energy consumption plays a vital role in mitigating the growth of CO_2 emissions and also promoting economic development.

Given these findings, we argue that both FDI inflows and stock market development have a significant role in promoting the renewable energy consumption. Hence, the policy makers should initiate further policies to make use of both FDI inflows and stock markets to divert additional funds into the renewable energy projects. In this way, the shortage of capital for the renewable energy projects can be overcome easily. However, the governments also have to play an important role in terms of providing tax and non-tax benefits to the renewable energy investors. This will therefore motivate both global and domestic investors to move their investments into renewable energy projects. By increasing the share of renewable energy consumption not only helps to reduce the demand for fossil fuel energy but also reduces CO_2 emissions' growth. In such a way, these economies can move towards the sustainable economic development.

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Table 1*: Annual average growth rate, 1990-2012 (percent)*

Variable	Brazil	China	India	South Africa	Average
REC	2.71	1.48	1.36	1.68	1.81
CO_2	3.84	6.74	5.56	1.93	4.52
EO	3.14	10.34	6.47	2.67	5.66
PI	1.76	9.48	4.69	0.84	4.19
FDI	26.16	10.76	30.56	265.39	83.22
SMC	18.25	23.63	12.11	3.45	14.36
SMTVT	27.70	36.26	43.97	12.81	30.18
NREC	3.70	6.26	5.47	2.31	4.44
CAP	4.33	14.62	8.74	4.53	8.06
LBR	2.46	1.02	1.72	2.30	1.87
TECH	8.04	22.08	14.39	3.76	12.07
POP	1.36	0.79	1.71	1.82	1.42

Note: The growth rates were calculated using original data.

Table 2: *Summary statistics of the variables, 1990-2012*

Variable	Brazil	China	India	South Africa
REC	2814.41	9710.58	6608.20	397.67
CO_2	321.62	4925.12	1139.80	399.64
EO	1650561.06	3056432.38	971962.33	290200.20
PI	9195.06	2361.15	877.25	6524.82
FDI	2.36	3.78	1.06	1.26
SMC	34.24	29.86	45.34	171.21
SMTVT	17.80	43.80	28.91	36.14
NREC	5.21	50.08	13.58	4.60
CAP	304875.77	1177278.34	279590.44	48408.98
LBR	86.52	727.45	415.96	15.81

TECH	16260.48	151017.17	17597.00	6396.87
POP	177.67	1260.38	1070.08	44.06

Notes: REC - renewable energy consumption in thousand terajoules (TJ); CO_2 - CO_2 emissions in thousand kilotons (kt); EO - GDP at market prices (constant 2010 million US$); PI - GDP per capita (constant 2010 US$); FDI - foreign direct investment, net inflows (% of GDP); SMC - stock market capitalization (% of GDP); SMTVT - stock market total value traded (% of GDP); NREC - sum of coal, petroleum and gas (Quadrillion Btu); CAP - gross fixed capital formation (constant 2010 million US$); LBR - total labor force in million; TECH - total patent applications (residents and nonresidents); POP - total population (million).

Table 3: *Panel unit root tests*

Variable	Level				First difference			
	LLC test		IPS test		LLC test		IPS test	
	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
REC	3.886	1.000	7.380	1.000	-3.268***	0.001	-2.660***	0.004
CO2	0.999	0.841	2.904	0.998	-5.525***	0.000	-5.033***	0.000
EO	0.453	0.675	4.802	1.000	-4.340***	0.000	-4.256***	0.000
PI	0.340	0.633	4.315	1.000	-4.209***	0.000	-3.942***	0.000
FDI	3.339	1.000	-1.166	0.122	-8.058***	0.000	-7.232***	0.000
SMC	-1.130	0.129	-0.131	0.448	-5.365***	0.000	-4.265***	0.000
SMTVT	-1.244	0.107	-0.575	0.283	-3.157***	0.001	-4.021***	0.000
NREC	-0.149	0.441	2.269	0.988	-7.856***	0.000	-7.579***	0.000

CAP	-0.600	0.274	2.431	0.993	-5.418***	0.000	-4.991***	0.000
LBR	-0.746	0.228	0.693	0.756	-2.694***	0.004	-1.996**	0.023
TECH	0.297	0.617	1.235	0.892	-7.245***	0.000	-6.957***	0.000
POP	-0.373	0.354	0.936	0.825	-6.668***	0.000	-2.869***	0.002

Notes: Panel unit root tests were estimated using constant in the models; the appropriate lag length was chosen based on SIC (selected lags vary from 0 to 3); ** and *** indicate the rejection of the null hypothesis of a unit root at the 5% and 1% significance levels, respectively.

Table 4*: Johansen-Fisher panel cointegration test*

REC = f (CO_2, PI, TECH, FDI, SMC)					*REC = f (CO_2, PI, TECH, FDI, SMTVT)*				*CO_2 = f (POP, PI, TECH, NREC, REC)*				*EO = f (CAP, LBR, NREC, REC)*			
Hypothesized: No. of CE(s)	trace test	Prob.	max-eigen test	Prob.	trace test	Prob.	max-eigen test	Prob.	trace test	Prob.	max-eigen test	Prob.	trace test	Prob.	max-eigen test	Prob.
None	196.700***	0.000	103.700***	0.000	175.000***	0.000	83.860***	0.000	233.400***	0.000	99.940***	0.000	39.610***	0.000	39.610***	0.000
At most 1	127.100***	0.000	61.850***	0.000	99.300***	0.000	40.250***	0.000	151.700***	0.000	70.280***	0.000	162.300***	0.000	113.100***	0.000
At most	81.	0.	44.8	0.	67.	0.	37.0	0.	99.	0.	48.7	0.	91.	0.	58.6	0.

2	500***	000	90***	000	900***	000	60***	000	920***	000	60***	000	650***	000	10***	000
At most 3	45.670***	0.000	21.980***	0.005	37.490***	0.000	20.390***	0.009	61.550***	0.000	36.300***	0.000	54.280***	0.000	40.400***	0.000
At most 4	32.660***	0.000	26.230***	0.001	25.540***	0.001	21.950***	0.005	34.130***	0.000	22.220***	0.005	30.210***	0.000	30.210***	0.000
At most 5	21.250***	0.007	21.250***	0.007	14.780	0.064	14.780	0.064	29.140***	0.000	29.140***	0.000				

Notes: The cointegration models were estimated using linear deterministic trend and the appropriate lag length was chosen based on SIC (selected lags vary from 1 to 2); *** indicates the rejection of the null hypothesis of no cointegration at the 1% significance level.

Table 5: *Group-Mean FMOLS models*

Variable	Coefficient	t-Statistic	Prob.
REC = f (CO_2, PI, TECH, FDI, SMC)			
CO_2	-0.253***	-54.934	0.000
PI	0.378***	34.884	0.000
TECH	0.011***	11.494	0.000
FDI	0.009***	18.144	0.000
SMC	0.002*	1.841	0.070
REC = f (CO_2, PI, TECH, FDI, SMTVT)			
CO_2	-0.248***	-54.124	0.000
PI	0.337***	33.187	0.000
TECH	0.009***	8.990	0.000
FDI	0.008***	14.935	0.000
SMTV	0.005***	10.410	0.000
CO_2 = f (POP, PI, TECH, NREC, REC)			

POP	0.470***	7.091	0.000
PI	0.145***	9.059	0.000
TECH	-0.030***	-21.826	0.000
NREC	1.036***	128.071	0.000
REC	-0.260***	-6.462	0.000
EO = f (CAP, LBR, NREC, REC)			
CAP	0.189***	44.132	0.000
LBR	1.269***	70.761	0.000
NREC	0.163***	29.221	0.000
REC	1.283***	65.771	0.000

Note: * and *** indicate the significance level at the 10% and 1%, respectively.

Table 6*: Pairwise Dumitrescu-Hurlin panel causality test results*

Null Hypothesis:	Zbar-Stat.	Prob.
CO_2 does not homogeneously cause REC	0.726	0.468
REC does not homogeneously cause CO_2	2.077**	0.038
PI does not homogeneously cause REC	-0.933	0.351
REC does not homogeneously cause PI	-0.917	0.359
TECH does not homogeneously cause REC	-1.162	0.245
REC does not homogeneously cause TECH	-0.920	0.358
FDI does not homogeneously cause REC	2.643***	0.008
REC does not homogeneously cause FDI	-0.943	0.346
SMC does not homogeneously cause REC	-0.590	0.556
REC does not homogeneously cause SMC	-0.885	0.376
SMTVT does not homogeneously cause REC	-0.829	0.407

REC does not homogeneously cause SMTVT	-1.136	0.256
EO does not homogeneously cause REC	-1.132	0.258
REC does not homogeneously cause EO	-1.044	0.296
POP does not homogeneously cause CO_2	-0.073	0.942
CO_2 does not homogeneously cause POP	0.951	0.342
PI does not homogeneously cause CO_2	-0.060	0.952
CO_2 does not homogeneously cause PI	0.486	0.627
TECH does not homogeneously cause CO_2	-1.151	0.250
CO_2 does not homogeneously cause TECH	-0.230	0.818
NREC does not homogeneously cause CO_2	-0.670	0.503
CO_2 does not homogeneously cause NREC	0.724	0.469
CAP does not homogeneously cause EO	0.846	0.398
EO does not homogeneously cause CAP	1.236	0.217

LBR does not homogeneously cause EO	0.791	0.429
EO does not homogeneously cause LBR	0.710	0.478
NREC does not homogeneously cause EO	1.405	0.160
EO does not homogeneously cause NREC	-0.696	0.486

Note: ** and *** indicate the significance levels at the 5% and 1%, respectively; the selected lags vary from 1 to 3.