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Renewable Energy, Foreign Direct Investment and Sustainable Development: An Empirical Evidence

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ABSTRACT

Renewable energy is replenished on a human timescale. The concern for the use of renewable energy is growing across the globe due to depleting non-renewable sources and various environmental issues. We construct a model of sustainable development to demonstrate the causality and co-integration between Foreign Direct Investment (FDI) inflows and renewable energy consumption. We consider data of select 43 countries for the period from 2005 to 2017 and apply panel data analysis. The results reveal a unidirectional causality from renewable energy consumption to FDI inflows and the presence of a long-run relationship. Consequently, the constructed model will assist the government, non-government organizations, and companies in evaluating the significance of renewable energy and FDI inflows in sustainable development.

Keywords: Renewable Energy, Foreign Direct Investment, Sustainable Development, Causation Effect, Co-integration
JEL Classifications: Q2, F14, F21, F23

1. INTRODUCTION

"Access to clean, affordable, and reliable energy are necessities in achieving sustainable development in the modern world" (Emodi and Boo, 2015). Considering the growing concerns over the degradation of climatic conditions, this becomes even more necessary. An important option for greenhouse gas reduction is renewable energy (Bloyd and Bloyd, 2001). A country prioritizing renewable energy sources reflects its vision towards sustainable development goals. Sustainable development has taken worldwide attention (Kurian, 2012). Government support is necessary for promoting renewable energy resources (Gallagher, 2013). The factors which could influence a Government's decision to adopt favorable policies for renewable energy include cultural factors and attitudes, economic motives, political system, and a low endowment for non-renewable energy sources and high endowment for renewable sources. Such countries giving significant importance to sustainable development will attract foreign investments.

The main source of flows to developing countries is a foreign direct investment (FDI) and as compared to other capital flows, FDI does not show pro-cyclical behavior and it is less volatile (Ozturk, 2007). The FDIs once established in the host country should also promote sustainable development utilizing renewable energy resources. The economic policy reforms should channelize foreign capital inflows to an environmentally healthy direction (Khan and Ozturk, 2019). The control over environmental pollution may attract FDI inflows to achieve sustainable development in the long-run (Phuong and Tuyen, 2018).

When a country prioritizes renewable energy resources, whether it attracts FDI inflows or when the FDIs establishes in the host country, it promotes renewable energy consumption remains to be a debatable question. We will address this issue and examine the causal variations and co-integration between FDI inflows and renewable energy consumption. We also construct a model of sustainable development demonstrating the influence of renewable energy and FDI inflows.

Further, in Section 2 we provide a review of literature; Section 3 illustrates the research methodology; Section 4 focusses on data analysis and results; and finally, Section 5 provides conclusions.

2. LITERATURE REVIEW

In this section, we present theoretical insights about past literature relating to FDI inflows and renewable energy consumption. We see Leitão (2015) examined the relationship between FDI and Energy Consumption for the period 1990–2011 using Panel Data Analysis. The study found a positive impact of political globalization and per capita income with energy consumption. The cultural, social, and political components of globalization were found to promote Portuguese FDI. The study also considered the exchange rate and trade openness as control variables that were positively correlated with FDI. In a similar study but using a contrasting methodology, Abidin et al. (2015) examined the linkages between FDI, energy consumption, financial development and trade for Indonesia, Philippines, Malaysia, Thailand, and Singapore using Johansen cointegration test, autoregressive distributed lag (ARDL) Model and Granger causality test. The study evidenced a long-run relationship among FDI inflows, financial development, trade, and energy consumption which was also confirmed by the ARDL model. The Granger causality test revealed unidirectional causality from FDI inflows to energy consumption, energy consumption to financial development, and energy consumption to trade. Also, bidirectional causality was noticed between trade and energy consumption, energy consumption and FDI inflows, trade and FDI inflows, energy consumption and financial development, and between trade and financial development. Sanchez-Loor and Zambrano-Monserrate (2015) examined the relationship between gross domestic product, FDI, human development index, and remittances with the electricity consumption for Ecuador, Mexico and Colombia and found the evidence of electricity consumption causing FDI in the short run. In a similar study conducted concerning Vietnam, Nguyen and Wongsurawat (2017) evidenced the cointegration between energy consumption and FDI. The study also witnessed bi-directional causality between energy consumption and exports. In another study related to Vietnam, Long et al. (2018) used the ARDL approach and Toda-Yamamoto approach and revealed the evidence of the positive impact of energy consumption and FDI on economic growth in short-run as well as in long-run. Warsono et al. (2020) evidenced the direct effect of FDI to energy use. However, a significant negative relationship between energy consumption and FDI inflows were found by Olaoye et al. (2020) for Nigeria.

Keho (2016) investigated whether FDI and trade lead to lower energy intensity in six sub-Saharan countries. The study applied the bounds testing approach to Granger causality and co-integration and revealed the evidence of the energy-reducing effect of FDI in Nigeria and Benin. The study also showed that in the short-run, the energy intensity is caused by FDI. The efficient energy management standpoint with a strategic concentration on demand-side energy savings and renewable energy resource potential in Nigeria was reviewed by Emodi and Boo (2015). Also, the study reviewed the energy situation in Nigeria wit the consumption pattern of fossil fuel resources and examined renewable energy potentials and suggested effective strategies. Mahmood and Alkhateeb (2018) evaluated the contributing factors of FDI inflows in Saudi Arabia and found the evidence of oil price and financial market development positively affecting FDI inflows. Using ARDL bounds testing cointegration approach Roespinoedji et al. (2019) found financial development and FDI to be real drivers of renewable electricity consumption in Malaysia. Doytch and Narayan (2016) examined the relationship between energy demand and FDI and investigated the impact of FDI inflows on renewable and non-renewable energy sources for 74 countries. The study utilized Blundell–Bond dynamic panel estimator to control for endogeneity. The results indicated energy consumption augmenting effects concerning renewable energy and energy consumption reducing effect concerning non-renewable energy sources. Amri (2016) revealed bidirectional linkages between renewable energy consumption and FDI inflows in developed countries. Kiliçarslan (2019) examined the relationship between renewable energy production and FDI in Russia, Brazil, India, China, South Africa, and Turkey using panel ARDL test and Pedroni co-integration test. The results indicated a long-run relationship between FDI and renewable energy production. The literature reveals significant work more inclined towards the examination of FDI inflows and non-renewable energy sources. The present study constructs a sustainable development model by examining the causality between renewable energy and FDI inflows and investigating the long-run relationship.

3. RESEARCH METHODOLOGY

The present study aims to construct a model of sustainable development. For this purpose, we examine the causal relationship between renewable energy and inflow of FDI and investigate the long-run relationship between the said variables. The study applied Panel Data analysis considering the data in annual frequency of Renewable Energy and FDI Inflows for the period 2005 to 2017 of 43 countries namely; Argentina, Australia, Austria, Belgium, Brazil, Canada, Switzerland, Chile, China, Czech Republic, Germany, Denmark, Spain, Estonia, Finland, France, Great Britain, Greece, Hungary, Indonesia, India, Ireland, Iceland, Israel, Italy, Japan, South Korea, Luxembourg, Latvia, Mexico, Netherland, Norway, New Zealand, Poland, Portugal, Russia, Saudi Arabia, Slovakia, Slovenia, Sweden, Turkey, United States, and South Africa. The study utilizes Summary Statistics to understand the nature of the data. The Summary Statistics include Mean which is a measure of performance, Standard Deviation which signifies the variations, Measures of Normality such as Skewness to know the symmetry of the data, and Kurtosis to examine the flatness of data. If the data is found to be non-normally distributed, the study will use the logarithmic for the data for further analysis purposes. The unidirectional causality from renewable energy to FDI inflows, unidirectional causality from FDI inflows to renewable energy, and bidirectional causality between renewable energy and FDI inflows are examined using Granger Causality Test. The study adopts the methodology of Bhattacharya et al. (2016) for this purpose. The Granger causality test equation is given as follows:

$$LFDI_t = \mu_1 + \sum_{i=1}^{p} \alpha_{1,i} LRE_{t-i} + \sum_{i=1}^{p} \beta_{1,i} LFDI_{t-i} + \varepsilon_{1,t} \quad (1)$$

$$H_o : \sum_{i=1}^{p} \alpha_{1,i} = 0$$

$$LRE_t = \mu_2 + \sum_{i=1}^{p} \alpha_{2,i} LFDI_{t-i} + \sum_{i=1}^{p} \beta_{2,i} LRE_{t-i} + \varepsilon_{2,t} \quad (2)$$

$$H_o : \sum_{i=1}^{p} \alpha_{2,i} = 0$$

Where LFDI refers to the Log of FDI inflows and LRE represents the Log of renewable energy. The study examines the long-run relationship between FDI inflows and renewable energy consumption Pedroni residual co-integration test using the methodology provided by Pedroni (2001). The equations developed as per the cointegrated system d for panel suggested by Pedroni (2001) is as follows.

$$LFDI_{it} = \alpha_i + \beta LRE_{it} + \mu_{it}$$

$$LRE_{it} = X_{it-1} + \varepsilon_{it} \quad (3)$$

Where LFDI refers to the Log of FDI inflows and LRE represents the Log of renewable energy. The co-integration test requires the data to be non-stationary at the level and stationary at first difference. The study will utilise the Levin, Lin & Chu t test, ADF - Fisher Chi-square test, and PP - Fisher Chi-square test to examine the stationarity of the data. The required data relating to FDI inflows and renewable energy consumption has been extracted from the official website of Organisation for Economic Co-operation and Development (OECD) and the analysis is performed using econometric software E-views.

4. DATA ANALYSIS AND RESULTS

4.1. Nature of Data

The results of summary statistics are presented in Table 1. The average FDI inflows were found to be highest in the case of the USA i.e. 263133.2 followed by China (202357.2), Great Britain (101552), Brazil (53063.89), and Canada (48696.08). The FDI inflows were noticed to be least in SVN i.e. 693.2406. The average renewable energy was found to be highest in the case of China i.e. 220535.6 followed by India (191328.6), USA (132918.9), Brazil (112224.7), and Indonesia (69658.59) and least in case of SAU i.e. 6.39. Although for the USA, the FDI inflows were highest, the variations also were significantly high as revealed by Standard Deviation. In the case of renewable energy, similar results were obtained for China wherein the average renewable energy is high and so also the variations. The lower variations in case of FDI inflows were noticed in the case of SVN for which average FDI inflows were also found to be less. Similarly, lower variations in renewable energy were revealed by SAU for which the study had noticed low average renewable energy. This provides us with a clear finding that, higher the average of FDI inflows, higher the variations in FDI inflows, lower the average of FDI inflows, lower the variations in FDI inflows, higher the average of renewable energy, higher the variations in renewable energy, and lower the average of renewable energy, lower the variations in renewable energy as revealed by the select countries.

The study observed 64.46% of the FDI inflows data to be positively skewed and 39.54% of FDI inflows data to be negatively skewed. In the case of renewable energy, 51% of the data was noticed to be positively skewed. In the case of FDI inflows, 39.53% of the data was found to be Leptokurtic, 4.65% of the data to be Mesokurtic and 55.81% of the data to be Platykurtic. In the case of renewable energy, the study noticed 40% of the data to be Platykurtic and 6.98% of the data to be Leptokurtic. The more evidence of positive or negative skewness and the data being Leptokurtic or Platykurtic shows the non-normal nature of the distribution of the data. Thus, the data was converted to logarithmic form for further analysis purposes.

4.2. Causation Effect between FDI Inflows and Renewable Energy

Table 2 highlights the results of the granger causality test. Here, the study investigates the presence of unidirectional causality from renewable energy to FDI inflows, unidirectional causality from FDI inflows to renewable energy, and bidirectional causality between renewable energy and FDI inflows. The study did not evidence bidirectional causality between renewable energy and FDI inflows. However, the study noticed unidirectional causality from renewable energy to FDI inflows where the P = 0.0841 reveals the rejection of null hypotheses (H0: Renewable Energy does not granger cause FDI Inflows) at 10% level of significance. The causality from renewable energy consumption to FDI inflows was also evidenced by Amri (2016). This shows that the FDI Inflows does not cause renewable energy, but renewable energy does cause FDI Inflows. This is justified as the countries which prioritize the use of renewable energy resources, attract the FDI inflows resulting in sustainable development.

4.3. Co-integration between FDI Inflows and Renewable Energy

Table 3 demonstrates the results of the pedroni residual co-integration test. We compare the results of seven parameters of which include Panel v-Statistic, Panel rho-Statistic, Panel PP-Statistic, Panel ADF-Statistic, Group rho-Statistic, Group PP-Statistic, and Group ADF-Statistic. The necessary condition to use Pedroni residual co-integration test is the presence of unit root in the data at level and subsequent absence of unit root at first difference. The present study fulfils this condition as illustrated in Appendix Table A1 in Appendix A. The respective statistics obtained and the corresponding P-values reveal the rejection of null hypotheses at 1% level of significance as per Panel v-Statistic, Panel rho-Statistic, Panel PP-Statistic, Panel ADF-Statistic, Group PP-Statistic, and Group ADF-Statistic; and rejection of null hypothesis at 5% level of significance as per Group rho-Statistic. The results indicate the presence of co-integration which shows the long-run relationship between FDI inflows and renewable energy consumption. The results are consistent with Kiliçarslan (2019). The results are justified as the FDI inflows in any country are

Table 1: Results of summary statistics

Country code	FDI inflow				Renewable energy			
	Mean	Std. Dev.	Skewness	Kurtosis	Mean	Std. Dev.	Skewness	Kurtosis
ARG	8201.768	3760.63	0.337295	1.995007	6065.285	765.9328	−0.224921	1.51256
AUS	38745.18	23218.91	−1.888842	6.447119	7224.155	890.1586	0.190656	2.558476
AUT	7214.83	7887.422	0.441623	4.12302	8943.126	1084.383	−0.525894	1.94903
BEL	36018.6	87657.85	0.855768	3.354313	2786.211	1013.688	−0.362066	1.69693
BRA	53063.89	25028.65	0.048308	2.096949	112224.7	9366.959	−0.958964	2.89403
CAN	48696.08	25617.27	1.432363	4.809351	47015.24	2128.692	0.115473	1.601268
CHE	37245.29	33495.95	0.910578	2.72315	4942.641	463.0123	−0.450022	1.839726
CHL	18975.78	8567.944	−0.300126	2.108545	10471.06	976.6985	0.788269	2.227393
CHN	202357.2	65877.16	−0.098466	1.51155	220535.6	21928.04	1.094643	2.71508
CZE	6334.13	3429.482	−0.059755	1.943363	3347.748	879.0646	−0.15411	1.473417
DEU	35601.97	25786.14	0.272724	1.913831	29748.51	7721.292	0.037092	1.860699
DNK	3231.981	5348.321	−0.591691	3.423535	4015.728	917.401	0.476686	2.470525
ESP	34667.88	20038.31	1.122379	3.494545	14041.5	3451.865	−0.47819	1.653692
EST	1435.028	735.8144	−0.032424	2.631612	778.7078	143.151	−0.508992	1.7949
FIN	5422.853	5505.658	1.052166	3.511945	9508.585	994.5009	0.043237	1.892836
FRA	29776.98	15047.22	0.404194	3.521023	20220.46	3070.452	−0.20889	1.819796
GBR	101552	70163.03	0.934732	2.849134	9185.652	4465.873	0.472055	1.880354
GRC	2403.284	1457.288	0.502625	2.591477	2193.565	412.3891	−0.035053	1.418268
HUN	3524.733	7064.971	−1.231783	4.682043	2561.993	538.929	−0.711521	1.782379
IDN	12309.67	6620.665	0.071501	1.39069	69658.59	5105.56	0.04255	1.728713
IND	31297.23	11466.38	−0.407498	2.636381	191328.6	15619.48	−0.506912	1.770271
IRL	40058.27	59965.69	1.997757	7.259087	768.6388	281.7348	0.304583	2.128743
ISL	1401.239	2033.012	1.687246	4.916763	4521.965	889.1632	−1.403558	3.778339
ISR	9764.215	3866.473	0.575453	2.851049	742.0637	289.6384	0.358236	1.618538
ITA	20913.68	14587.25	−0.734696	3.00726	21938.7	4416.762	−0.496215	1.921848
JPN	7300.682	10125.43	0.437658	1.893857	18982.42	2252.024	0.837302	2.378877
KOR	8381.785	3880.225	−1.057097	3.775904	2562.724	1512.913	0.929862	2.715029
LUX	15723.35	17635.03	−1.254784	4.055842	150.7037	55.14753	0.509163	2.539715
LVA	953.1103	625.1267	0.585354	3.016912	1542.918	145.7406	1.136979	4.072658
MEX	29225.69	7694.887	0.908046	4.01591	15761.14	1084.71	0.579061	2.20287
NLD	47729.01	50211.95	1.587051	4.798642	3219.287	547.016	−0.449978	2.180842
NOR	7932.852	10030.75	−0.224235	1.502324	12884.95	850.8039	−0.045864	1.905372
NZL	2249.832	1474.858	−0.484819	1.995169	6990.594	1225.95	−0.110437	1.562835
POL	13279.49	5293.24	−0.304	2.415383	7139.166	1731.631	−0.479334	1.554806
PRT	5136.402	2716.215	−0.036192	1.605479	4801.134	621.6936	−0.505279	2.593422
RUS	35892.92	17253.34	0.846885	3.404067	18359.97	657.9242	0.246869	1.612792
SAU	18405.42	11396.02	0.757157	2.152548	6.390583	0.628464	0.038427	2.463245
SVK	2179.134	2130.442	0.155134	1.777155	1247.611	286.8302	−0.31438	1.681882
SVN	693.2406	608.1655	−0.416717	2.41097	1005.617	162.9244	−0.643786	1.873781
SWE	14951.59	10759.51	0.627274	2.503194	16754.17	1524.653	0.015154	1.734854
TUR	14637.69	4449.179	0.266489	1.817328	12326.36	2880.899	0.90078	2.484917
USA	263133.2	110270.2	1.086387	3.274924	132918.9	20287.99	0.032143	1.54293
ZAF	5064.183	2758.211	−0.24089	1.854765	12384.57	253.2994	1.568512	4.24282

Table 2: Results of the granger causality test

Flow of causality	F-statistic	P-value
Renewable energy to FDI inflows	2.49283	0.0841*
FDI inflows to renewable energy	0.85003	0.4282

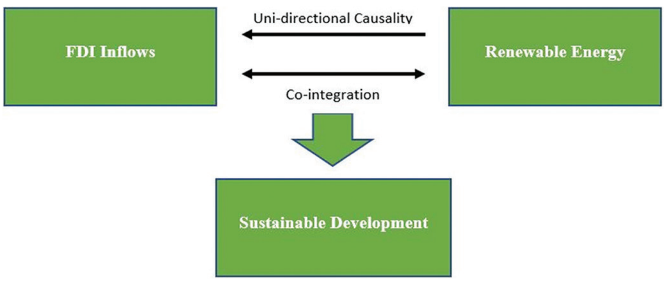
long term in nature. When a business establishing itself in another country, it cannot escape the going concern principle of accounting. A business established contributes to the nation in the long run. The evidence of the long-run relationship of FDI inflows and the

Table 3: Pedroni residual cointegration test

Test	Statistic	Prob.
Panel v-statistic	2.515434	0.0059***
Panel rho-statistic	−5.65661	0***
Panel PP-statistic	−11.2424	0***
Panel ADF-statistic	−6.60382	0***
Group rho-statistic	−1.66576	0.0479**
Group PP-statistic	−13.1057	0***
Group ADF-statistic	−5.16655	0***

***1% level of significance

Figure 1: Model of foreign direct investment inflows, renewable energy and sustainable development



renewable energy consumption is positive for the nations to meet their sustainable development goals in the long-run.

4.4. Model of FDI Inflows, Renewable Energy and Sustainable Development

Figure 1 depicts the constructed model of FDI Inflows, Renewable Energy, and Sustainable Development. We construct this model considering the results of causality and co-integration. The model illustrates the unidirectional causality from renewable energy consumption and FDI inflows. Also, the model demonstrates the co-integration between FDI inflows and renewable energy consumption. A country prioritizing renewable energy consumption may attract FDI inflows. The growing awareness of environmental pollution and degrading climatic conditions due to non-renewable energy sources, pools the companies towards the utilization of renewable energy sources. Although these FDI inflows may not benefit the host country in the short-run, it surely does help in meeting sustainable development goals in the long-run.

5. CONCLUSION

The concern for the use of renewable energy is growing across the globe due to depleting non-renewable sources and various environmental issues. The present study constructed a model of sustainable development by examining the causal relationship between renewable energy and FII inflows and investigated the long-run relationship between the said variables. The study considered the data in annual frequency for the period 2005–2017 of 43 countries and applied panel data analysis. The Granger causality test results revealed unidirectional causality from renewable energy to FDI inflows. This is justified as the countries which prioritize the use of renewable energy resources, attract the FDI inflows resulting in sustainable development. The causality from renewable energy consumption to FDI inflows was also evidenced by Amri (2016).

The Pedroni residual co-integration test results indicated the presence of a long-run relationship between FDI inflows and renewable energy consumption. The results are consistent with Kiliçarslan (2019). The results are justified as the FDI inflows in any country are long term in nature and when a business establishing itself in another country, it cannot escape the going concern principle of accounting. A business established contributes to the nation in the long run. The evidence of the long-run relationship of FDI inflows and the renewable energy consumption is positive for the nations to meet their sustainable development goals in the long run. The study faces the limitation that it considers only 43 countries due to the unavailability of data. The study can be extended by exclusively focussing a particular region to examine the role of FDI inflows and renewable energy consumption in the sustainable development of the region. Consequently, the constructed model will assist the government, non-government organizations, and companies in evaluating the significance of renewable energy and FDI inflows in sustainable development. The results will also assist policy makers while framing and modifying policies relating to sustainable development.

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APPENDIX

Appendix A Appendix Table A1: Results of unit root test

Method	At level	At first difference
	Statistic	Statistic
FDI inflows		
Null: Unit root (assumes common unit root process)		
Levin, Lin and Chu t	0.25291	−17.5084***
Null: Unit root (assumes individual unit root process)		
ADF - Fisher Chi-square	42.6119	334.77***
PP - Fisher Chi-square	41.617	613.217***
Renewable energy		
Null: Unit root (assumes common unit root process)		
Levin, Lin and Chu t	7.16737	−9.24518***
Null: Unit root (assumes individual unit root process)		
ADF - Fisher Chi-square	11.0545	226.185***
PP - Fisher Chi-square	7.88162	361.016***

***Corresponding P-values of the statistic are <0.01 at 1% level of significance. **Probabilities for fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality