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The Relationship between Foreign Direct Investment and Renewable Energy Production: Evidence from Brazil, Russia, India, China, South Africa and Turkey

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ABSTRACT

This paper aims to investigate the relationship between foreign direct investment (FDI) and renewable energy production in Brazil, Russia, India, China, South Africa (BRICS) countries and Turkey. For this purpose, the annual data from 1996 to 2015 is examined using with Pedroni co-integration test and panel autoregressive distributed lag test. Test results indicate the existence of long run relationship between renewable energy production and FDIs in BRICS countries and Turkey. Policy makers should adopt appropriate incentive policies to attract FDIs into the renewable energy sector.

Keywords: Foreign Direct Investment, Renewable Energy Production, Panel Autoregressive Distributed Lag Method
JEL Classifications: F21, Q42, C23

1. INTRODUCTION

The energy sector is a strategic area of vital importance in the development policies of countries. In the world, unbalanced geographical distribution of energy resources, scarcity of energy resources, increased energy demand and energy prices have led to gain the importance of renewable energy resources as an alternative to non-renewable energy resources. According to the International Energy Agency, world primary energy demand is expected to increase by 1.8% between 2005 and 2030. This situation reveals the importance of finding a sustainable solution to increasing energy demand (Sadorsky, 2010. p. 2528).

According to the ecological modernization theory, the ecological problems caused by industrialization can be solved by the possibilities brought by new technologies. Renewable energy applications are a successful application of ecological modernization theory to real life. Energy production from renewable sources is expressed as a production that does not consume natural resources, does not destroy nature and does not pollute the environment with its wastes. Increasing energy production from renewable sources can reduce the use of fossil fuels and thus reduce carbon emissions, thus providing solutions to many environmental problems. Renewable technologies reduce both the amount of energy and raw materials required for production processes that provide economic growth and the amount of waste generated from production and consumption processes (Kurucu, 2016. p. 1-7). In this context, in the development of the renewable energy sector to ensure environmental sustainability, foreign direct investments (FDIs) serve as a channel. FDIs are important for developing the energy sector, as it is associated with the transfer of capital, technology and expertise from the home countries to the host countries (Abe et al., 2017. p. 12).

In the literature, the relationship between FDIs and renewable energy has been analyzed in different aspects (such as CO_2 emissions, renewable energy consumption, renewable energy supports, technology expansion, investment motivation and renewable energy generation). However, there is not much study on the effect of FDI on renewable energy production. This study aims to determine whether FDIs have an impact on renewable energy production in Brazil, Russia, India, China, South Africa (BRICS) countries and Turkey and for the period 1996-2015. This study consists of five section. In the second section of the study, a theoretical framework will be given. In the third section, empirical literature will be given. In the fourth section econometric analysis results will be presented. Finally, the results and recommendations will be presented.

2. THEORETICAL FRAMEWORK

Renewable energy sources are important to comply with the binding obligations for reducing CO_2 emissions (such as the Kyoto Protocol) and reduce the dependence on energy imports (especially natural gas and oil imports) (Lavranos, 2015. p. 23). Switching to renewable energy sources will result in a significant reduction of greenhouse gas emissions, but will also require a large investment (Abe et al., 2017. p. 4). Compared to non-renewable energy investments, the high cost of renewable energy investments and the longer return times of these investments have a negative impact on the uncertainty and risk level of investments (Er et al., 2018. p. 181). In order to accelerate the transformation from non-renewable energy sources to renewable energy sources, it is necessary to transfer the technologies correctly and to allocate financial resources appropriately. In this context, direct foreign capital investments become an important source of capital, facilitating the transfer of technology and expertise related to renewable energy to host countries and also increase energy efficiency (Keeley and Matsumoto, 2018. p. 132; Abe et al., 2017. p. 1; Doytch and Narayan, 2016). FDI increases technological capacity and technological spread. The technology spreading through FDI raises the level of technology of the renewable energy industry with new production techniques, ideas and technology.

FDI also contributes to the host economy by creating direct and indirect jobs in low-carbon and resource-efficient sectors, also known as green jobs. FDI creates direct employment in the invested sector in the host country FDI creates indirectly new jobs because of knowledge acquisition and general economic activity of foreign firms or increased local spending by employees in FDI projects on renewable energy (Abe et al., 2017. p. 16). Therefore, many countries want to attract more FDI to the renewable energy sector, which is growing steadily worldwide and constitutes 10% of all green space FDI in 2015 (Keeley, 2018. p. 5).

For low-carbon foreign investments, factors that drive a company to invest abroad are the home country market and business conditions, management policies of home country, production costs and business conditions (Hanni et al., 2011. p. 39). On the other hand, the conditions for the host country provide the creation of an environment suitable for FDI in renewable energy sector. A suitable environment for FDI should include the active promotion and targeting of FDI in renewable energy through appropriate marketing techniques and incentives, while reducing bureaucratic barriers (Abe et al., 2017. p. 21). The determinants of FDI in the field of renewable energy in the host country are expressed as the policy framework of the potential host country, market creation policies, economic determinants and promotion and facilitation (Hanni et al., 2011. p. 47).

One of the factors affecting FDI investment decisions in the renewable energy sector is the renewable energy incentives (i) having renewable support policies such as feed-in tariff, renewable energy certificates and renewable portfolio standards, providing guaranteed access to grid, avoiding setting local content requirements, and ii) lowering country-risk and improving the business environment. These incentives are also important to create a suitable environment for FDI, to increase financial return and to minimize investment risk (Keeley and Matsumoto, 2018. p. 133).

3. LITERATURE REVIEW

There are not many studies in the literature dealing with the relationship between renewable energy and FDI. In the current studies, the relationship between renewable energy and FDI has been examined in different aspects. The relationship between FDIs and renewable energy has been investigated within the framework of CO_2 emissions (Mert and Bölük, 2016), renewable energy consumption (Er et al., 2018; Khandker, 2018; Doytch and Narayan, 2016; Ghazouani, 2018), renewable energy supports/incentives (Keeley and Matsumoto, 2018; Keeley and Ikeda, 2017; Wall et al., 2019), technology dissemination (Liu et al., 2016), investment motivation and renewable energy production (Hanni et al., 2011).

Wall et al. (2019) aimed to map FDI flows globally, including the source and destination countries, and made an econometric analysis for 137 OECD and non-OECD countries. According to their study, which policy instruments in the renewable energy sectors such as solar, wind and biomass have investigated more FDIs, Feed in Tariffs is the most important policy instrument in the renewable energy sector that attracts FDI globally. In addition, it has been demonstrated that Financial Measures, such as tax incentives, have a significant and positive impact on renewable energy projects (especially solar energy) by foreign investors, and that carbon taxation and carbon pricing tools affect FDIs.

Er et al. (2018), for the period 1990-2015 in Turkey by using the autoregressive distributed lag (ARDL) method, the entry of FDI and stock market capitalization has estimated the impact on the consumption of renewable energy. In their study, it is concluded that renewable energy consumption is determined by FDI inflows, financial development and research and development expenditures in the long term.

Keeley and Matsumoto (2018) described the determinants of FDI in wind and solar energy in developing economies based on literature review and semi-structured interviews. According to the literature review, the determinants of FDI are classified as institutional environment, macroeconomic environment, natural conditions and renewable energy policies. According to the semi-structured interviews with the experts of multinational companies active in the field of wind and solar energy, 18 factors were selected as important determinants. The opinions of the experts show that renewable energy policies have a strong importance compared to the determinants of traditional FDI (including macroeconomic environment, institutional environment and natural conditions). Among the traditionally discussed determinants, it is suggested that exchange rate stability is one of the most important factors in the positioning of investments in solar and wind energy.

Khandker (2018) used the Johansen co-integration test and the Granger causality test in his study, which aimed to reveal the relationship between FDI and renewable energy consumption in Bangladesh for the period 1980-2015. Khandker (2018) reveals that there is a bi-directional causality between FDI and renewable energy consumption.

Ghazouani (2018) examined the long-term relationship between FDI, renewable energy consumption and economic growth using the ARDL method for the 9 MENA countries for the 1990-2015 periods. The results shown that the benefits of economic growth and growth in the use of renewable energy are a crucial factor for attracting FDIs in Egypt, Iran, Israel, Mauritania, Tunisia, and Turkey. In addition, in the study, it was stated that GDP and FDI are determinants of renewable energy consumption in Iran, Morocco and Tunisia.

Salahuddin et al. (2018) examined the empirical effects of economic growth, electricity consumption, FDI, and financial development on carbon dioxide (CO_2) emissions in Kuwait using time series data for the period 1980-2013. Findings indicate that economic growth, electricity consumption, and FDI stimulate CO_2 emissions in both the short and long run. The VECM Granger causality analysis revealed that FDI, economic growth, and electricity consumption strongly Granger-cause CO_2 emissions.

Keeley and Ikeda (2017) examined the effectiveness of renewable support policies in attracting FDIs in wind energy using exploratory factor analysis (EFA) and structural equation modeling (SEM) for the period 2008-2014 and in 10 developing countries. They emphasized the importance of analyzing the FDI determinants that focus on a particular sector rather than looking at general FDIs in order to better understand the factors affecting investments.

Bhattacharya et al. (2016) investigate the effects of renewable energy consumption on the economic growth of major renewable energy consuming countries in the world. Using the Renewable Energy Country Attractiveness Index developed by the Ernst and Young Global Limited, they choose 38 top renewable energy consuming countries to explain the growth process between 1991 and 2012. With panel estimation techniques, our findings establish cross-sectional dependence and heterogeneity across the countries. They confirmed the evidence of long-run dynamics between economic growth, and traditional and energy-related inputs. Findings from long-run output elasticities indicate that renewable energy consumption has a significant positive impact on the economic output for 57% of our selected countries.

Liu et al. (2016) examined the effects of the spread of renewable energy technology, which is connected to FDIs, for the period of 2005-2011 on the performance of China's energy industry using factor analysis, data envelope analysis and also panel data regression model (for 30 different provinces). They concluded that the spread of renewable energy technology, which occurs depending on FDI, has a positive effect on China's energy sector performance. Moreover, it has been found that the effects of technology spread appear more in economically and technologically advanced regions.

Doytch and Narayan (2016) examined the effect of FDI inflows (by separating into mining, manufacturing, total services and financial services components) on renewable and non-renewable industrial energy resources by using dynamic panel estimator in the period of 1985-2012 for 74 countries. The results show that FDI reduces non-renewable energy-based energy consumption and increases renewable energy-based energy consumption.

Ozturk and Acaravci (2016) examine the long-run and causal relationship issues between economic growth, carbon emissions, energy consumption, foreign trade ratio, and employment ratio in Cyprus and Malta by using ARDL bounds testing approach of cointegration and error-correction-based Granger causality models. Empirical results over the period 1980-2006 suggest an evidence of a long-run relationship between the variables at 5% significance level only in Malta. Thus, Granger causality models are estimated only for Malta. Results for the existence and direction of Granger causality show that the causality runs from carbon emissions, energy consumption, foreign trade ratio, and employment ratio to economic growth but not vice versa in Malta.

Mert' and Bölük (2016) examined the effects of FDIs and renewable energy consumption on carbon dioxide emissions by using an unbalanced panel data. The results support the halo hypothesis, which expresses that FDI brings clean technology and improves environmental standards, and also shows that renewable energy consumption reduces carbon emissions.

Sbia et al. (2014) investigated the relationship between FDI, clean energy, openness, carbon emissions and economic growth by using ARDL boundary test and VECM Granger causality test in United Arab Emirates the period 1975Q1-2011Q4. Empirical findings show that FDI, trade openness and carbon emissions decline energy demand and economic growth and clean energy have positive impact on energy consumption. In addition, the results of Granger causality test show that there is a bi-directional causality relationship between direct foreign investment and green energy.

Hanni et al. (2011) made an analysis of FDI in renewable electricity generation and the manufacture of related equipment. In their study, FDI in the production of renewable electricity and the production of related equipment has been expressed to increase significantly in the period of 2003-2010. According to their findings, governments that want to target FDIs should pay particular attention to the motivation of the investors they target and the state of local energy policies. There are three motivations for FDI, namely market-seeking, resource seeking and efficiency-seeking. Among them, market-seeking motivation is the most appropriate motivation for the growth of investments in renewable energy sources in countries.

4. ECONOMETRIC ANALYSIS

BRICS countries have an important place in FDI flows. In 2018, the share of BRICS countries in FDI inflows is 19% and FDI amount is 266 billion dollars. According to the UNTACD (2018) report, Turkey 2007-2015 period, most investment areas among West Asian countries. However, in 2017, FDI inflows were realized as 11 billion dollars (UNCTAD, 2018). With the economic performance of the show in recent years, Turkey has approached quite the economic level of the BRICS countries. Thus, in this study, the relationship between renewable energy production and FDI inflows has been tried to be determined with the data of the period of 1996-2015 for BRICS countries and Turkey. Electricity production from renewable sources (excluding hydroelectric, % of total) is used as an indicator of renewable energy production. Other variables used are FDI, net inflows (% of GDP) and trade openness (% of GDP). The variables are taken from World Development Indicators.

All the variables in the model were used by taking logarithms. In this study, the model used in order to examine the relationship between renewable energy production, FDI and trade openness is presented in equation (1).

$$LRENP_{it}=\alpha_{0i}+\beta_1 LFDI_{it}+\beta_2 LTRADE_{it}+\varepsilon_{it} \quad (1)$$

Where *LRENP* is the logarithm of renewable energy production for country *i* in the period *t*; *LFDI* is the logarithm of FDI inflows for country *i* in *t* period; *LTRADE* is the logarithm of the trade gap for the *i* country, α is constant term, β is slope coefficients of the model and ε_{it} is error term.

In this respect, firstly, Levin, Lin and Chu (LLC), Im, Pesaran and Shin (IPS), ADF - Fisher and PP - Fisher unit root tests were applied to the variables used in panel data analysis. Pesaran et al. (1997), Peseran et al. (2004) proposed an ARDL approach for co-integration analysis in SEM. The ARDL co-integration approach involves two steps to estimate a long-term relationship. The first step is to examine the existence of a long-term relationship between all variables. The second step is to estimate the long-term coefficients according to the results of the ARDL model if there is a long-term relationship (co-integration) between the variables (Bildirici, 2014. p. 721).

In the study, the existence of long-term relationship between the variables was investigated by the co-integration test of Pedroni (1999). Then, according to the maximum Akaike information criterion (AIC), the optimum ARDL model was determined. The long-term and short run coefficients were reached with the panel ARDL estimator.

4.1. Panel Unit Root Tests

As in time series models, panel data models also need to primarily perform unit root analysis. As the number of observations increases, it is accepted that panel unit root tests are statistically more powerful than time series unit root tests (Güven and Mert, 2016. p. 140). In this study, LLC, IPS, ADF - Fisher, PP - Fisher unit root tests were used. LLC considers that individual unit root tests (for each section) have limited explanatory power. Therefore, individual residues are standardized in order to apply the test of unit residues at the full panel level (common unit root). In the IPS test, individual unit root tests are applied to time series for each unit without combining the data. IPS test statistics are obtained by averaging the obtained statistics (Im et al., 2003. p. 53). The Fisher ADF test is based on combining unit root test statistics for each nonparametric horizontal section (Güven and Mert, 2016. p. 140). Table 1 shows the unit root test results for the series of FDI, renewable energy generation and trade openness.

The lag lengths used in the unit root tests were determined according to the Schwarz information criterion. LLC, IPS, ADF - Fisher, PP - Fisher approaches were used to ensure consistency through comparison and verification of results. As shown in Table 1, when the probability values according to LLC, IPS, ADF and PP unit root tests are examined, FDI variable I (0), RENP (electricity production from renewable sources) and trade (trade openness) variables are the first difference I (1) is stationary. None of the variables are second difference stationary.

4.2. Pedroni Cointegration Test

To evaluate the long-term relationship between the analyzed variables, the Pedroni co-integration test was used, which uses the Engle Granger procedure applied to the residues of the regression. Pedroni co-integration test allows dynamic and fixed effects between the sections of the panel to be different. It also allows the co-integration vector to be different under the alternative hypothesis (Pedroni, 1999. p. 655). Pedroni (1999; 2004) categorizes seven statistics, four of which belong to the panel (panel v, panel rho, panel PP and panel ADF) and three of which belong to the group (group rho, group PP VE group ADF). In this method, H_0 hypothesis states that there is no long term relationship between variables. The hypothesis H_1 also suggests the existence of long-term relationships. In order to deny the H_0 hypothesis, Panel-v statistic should have a large positive value or the other six statistics should have negative small values (Pedroni, 1999. p. 668; Pedroni, 2004. p. 607-615).

As a result of the Pedroni co-integration test as shown in Table 2, the results of the panel v-statistic, panel rho test and group rho test results were not statistically significant. But the other four tests (panel PP-statistic, panel ADF-statistic, group PP-statistic, group ADF-statistic) are statistically significant. This result shows that there is a co-integration relationship between variables. Thus, the hypothesis H_0, which states that there is no co-integration relationship between the variables, is rejected. Accordingly, there is a long-term relationship between the variables included in the analysis.

4.3. Measuring the Strength of the Model Selection Criteria

According to the criterion which recommends 16 different Panel ARDL models using the AIC, the model with the lowest AIC value should be selected (Lee and Ghosh, 2009. p. 95). In this case, as shown in Figure 1, the ARDL (4, 4, 4) model is chosen as the optimum Panel ARDL model because it give the lowest value of the Akaike Criterion (−1.543132).

Table 1: Unit root test results

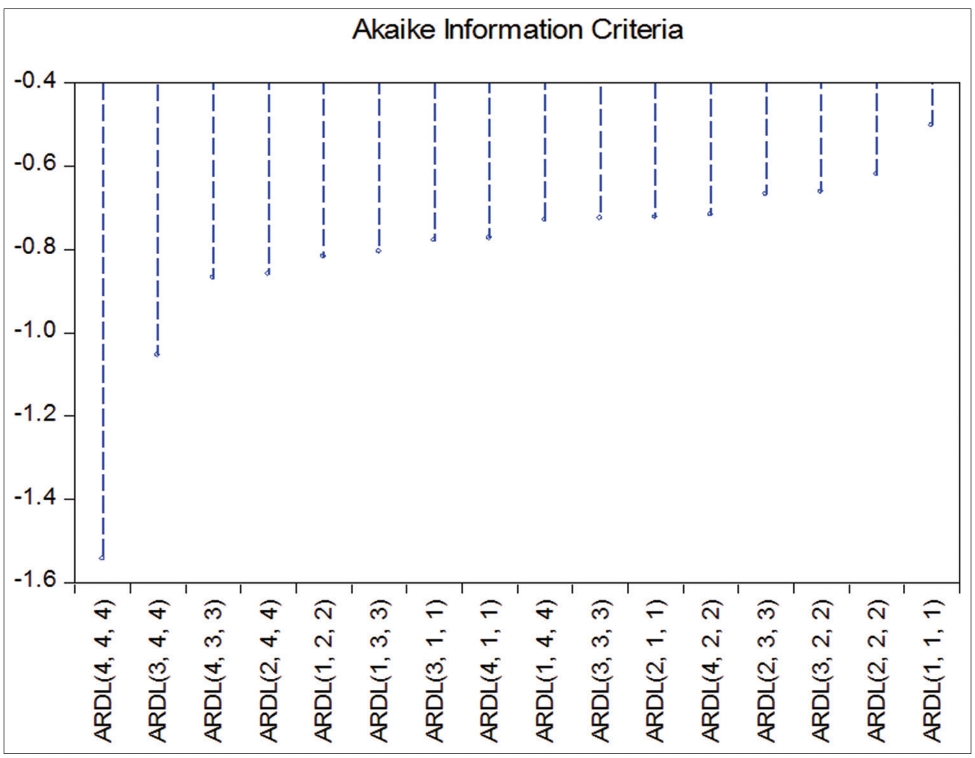
Variable		Level (Ind. intercept)		First difference (Ind. intercept)		Order of integration
		Statistic	Prob.	Statistic	Prob.	
FDI	Levin, Lin and Chu t*	−2.11716	0.0171	−9.97497	0.0000	I (0)
	Im, Pesaran and Shin W-stat	−2.29159	0.0110	−9.02760	0.0000	I (0)
	ADF - Fisher Chi-square	26.1844	0.0101	82.4961	0.0000	I (0)
	PP - Fisher Chi-square	27.0433	0.0076	328.904	0.0000	I (0)
RENP	Levin, Lin and Chu t*	1.23442	0.8915	−3.39255	0.0003	I (1)
	Im, Pesaran and Shin W-stat	3.98336	1.0000	−3.27153	0.0005	I (1)
	ADF - Fisher Chi-square	3.03555	0.9953	31.0517	0.0019	I (1)
	PP - Fisher Chi-square	7.38829	0.8309	37.3977	0.0002	I (1)
TRADE	Levin, Lin and Chu t*	−2.49512	0.0063	−5.18280	0.0000	I (1)
	Im, Pesaran and Shin W-stat	−1.40839	0.0795	−5.55109	0.0000	I (1)
	ADF - Fisher Chi-square	16.9174	0.1527	51.0400	0.0000	I (1)
	PP - Fisher Chi-square	15.3877	0.2209	65.3178	0.0000	I (1)

Table 2: Pedroni co-integration test results

Test	Statistic	Prob.	Weighted statistic	Prob.
Panel v-statistic	−0.677023	0.7508	−0.935030	0.8251
Panel rho-statistic	−0.976442	0.1644	−2.256893	0.0120
Panel PP-statistic	−2.273721	0.0115**	−4.209036	0.0000
Panel ADF-statistic	−1.455562	0.0728*	−2.022598	0.0216
Group rho-statistic	−0.965927	0.1670		
Group PP-statistic	−3.724795	0.0001***		
Group ADF-statistic	−1.371810	0.0851*		

***, ** and *respectively denote statistical significance at 1%, 5% and 10% confidence levels

Figure 1: Model selection criteria



4.4. Panel ARDL Analysis

ARDL analysis has a number of advantages compared to other cointegration methods. The first of these advantages is that the ARDL approach can be applied regardless of the integrated degrees, such as I (0) and I (1). Second, the ARDL test does not require a comprehensive set of data and can also be applied to a small set of observations. Thirdly, in the ARDL approach, the optimal lag length levels of the variables at different levels can be taken into account, while in other conventional tests this is not the case. Finally, although long-term relationships in traditional co-integration techniques can only be calculated with the help of system equations, ARDL approach can be applied to single-equation systems (Ozturk and Acaravci, 2010. p. 1939).

Table 3: Panel ARDL short run and long run estimates

Variables	Coefficient	Standard error	t-Statistic	Prob.*
Long run equation				
LTRADE	2.098754	0.213976	9.808356	***0.0000
LFDI	−0.147363	0.085183	−1.729964	*0.0913
Short run equation				
COINTEQ01	−0.292409	0.163471	−1.788756	*0.0812
D (LREP(−1))	0.276335	0.256714	1.076434	0.2882
D (LREP(−2))	−0.015802	0.179303	−0.088133	0.9302
D (LREP(−3))	0.336789	0.142666	2.360677	**0.0232
D (LTRADE)	−1.201164	0.360682	−3.330258	****0.0019
D (LTRADE(−1))	−0.651559	0.301190	−2.163283	**0.0366
D (LTRADE(−2))	−0.641238	0.532984	−1.203108	0.2360
D (LTRADE(−3))	−0.101452	0.386049	−0.262795	0.7941
D (LFDI)	0.191164	0.191101	1.000325	0.3232
D (LFDI(−1))	0.167574	0.107539	1.558265	0.1270
D (LFDI(−2))	0.128556	0.099464	1.292485	0.2036
D (LFDI(−3))	0.072274	0.093058	0.776656	0.4419
C	−2.883557	1.705469	−1.690771	*0.0987

***, ** and *represents 1%, 5%, and 10% significant level respectively. ARDL: Autoregressive distributed lag

Table 3 shows the short and long-term estimate results for the ARDL (4, 4, 4) model. According to the long-term estimate results, FDI inflows affect the renewable energy production negatively and statistically significant at 10% significance level. The 1% increase in FDIs reduces renewable energy production by 0.147363%. However, in the short run equation, FDIs do not have a significant impact on renewable energy production. Trade openness variable has a positive and statistically significant effect on renewable energy production. The 1% increase in trade openness increases renewable energy production by 2.098754%. According to the results of the short-term equation, a period-delayed value of the commercial openness variable has a negative and statistically significant effect on renewable energy production. Short-term results show that there is a positive and statistically significant relationship between the three-period delay of renewable energy production and itself.

The error correction term (cointeq01), which shows how quickly the variables approach the equilibrium, must have a negative sign and a statistically significant coefficient (Bildirici, 2014. p. 722). In ARDL (4, 4, 4) model, error correction term is negative and significant and thus 29% of errors are eliminated in long term. This means that there is a long-term equilibrium relationship between variables. It also confirms the appropriateness of the model and the existence of cointegration (Kutu and Ngalawa, 2016. p. 16).

5. CONCLUSION

Non-renewable energy sources are not sustainable due to both environmental pollution and lack of resources. Implementation of energy production and consumption activities in a sustainable and ecological is the application of ecological modernization theories to modern life (Kurucu, 2016. p. 16). BRICS countries and in Turkey, there is a wide variety of renewable energy sources. In BRICS countries, the renewable energy sector is developing rapidly. Renewable energy sources, such as wind energy, solar energy and hydroelectricity, are widely available in BRICS countries. However, a source of finance is needed to generate energy from these sources. The financing requirement of energy production from renewable sources can be met through FDI. However, due to the high-risk features of the renewable energy industry, most investors do not want to invest in this area (Zeng et al. 2017. p. 869-870).

In this study, the effect of FDI on renewable energy production was investigated by Panel ARDL analysis for the period 2007-2015 in BRICS countries and Turkey. As a result, the FDI inflows have been found to have a negative effect on the production of renewable energy. In other words, the increase in FDI inflows reduces energy production from renewable energy sources. This result may be an indication that FDIs are not directed towards the renewable energy sector. In order to channel FDIs from non-renewable energy sources to the renewable energy sector and to attract investments on this sector, policy makers should identify appropriate incentive policies.

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