Bölük. G, Çağlar, A. E., Mert, M. / Journal of Yasar University, 2022, 17/66, 415-436

Do Renewable Energy and Foreign Direct Investment Promote Economic Growth in Turkey? An Evidence Through a Nonlinear and Asymmetric Analysis Approach

Yenilenebilir Enerji ve Doğrudan Yabancı Yatırımlar Türkiye'de Ekonomik Büyümeyi Destekliyor Mu? Doğrusal Olmayan ve Asimetrik Bir Analiz Yaklaşımı Aracılığıyla Bir Kanıt

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Abstract: *We aim at examining the asymmetric relationship between foreign direct investment (FDI) and economic growth by adding renewable and non-renewable energy consumption, labor, and capital for Turkey in 1987-2015 period. For this purpose, non-linear ARDL test is employed for the first time to analyze the link amongst the variables in the context of Turkey. Our results confirm that all variables included into model have positive effects on economic growth. For example, while 1 % increase of positive shock in FDI increases economic growth by 0.053 %, 1 % increase in negative shock decreases economic growth around 0.057 % in Turkey in the long-run. Furthermore, since non-renewable energy contributes to economic growth nearly two times higher than renewable energy, Turkish economy is dependent on imported fossil fuels rather than renewable energy sources. Our study highlights the importance of energy efficiency and productivity issues in Turkey. Policy implications of obtained results are presented at the end of the study.*

Keywords: Fdi-Led Growth, Renewable Energy, Non-Linear Ardl, Cusum Test, Growth Hypothesis, Sustainable Economic Growth, Turkey

JEL Classification: D24, Q32, Q43

Öz:Bu çalışmada 1987-2015 döneminde Türkiye için yenilenebilir ve yenilenemez enerji tüketimi, işgücü ve sermayeyi ekleyerek doğrudan yabancı yatırım (DYY) ile ekonomik büyüme arasındaki asimetrik ilişkiyi incelemeyi amaçlıyoruz. Bu amaçla, Türkiye bağlamında değişkenler arasındaki bağlantıyı analiz etmek için ilk kez doğrusal olmayan ARDL testi kullanılmıştır. Sonuçlarımız, modele dahil edilen tüm değişkenlerin ekonomik büyüme ve üzerinde olumlu etkileri olduğunu doğrulamaktadır. Örneğin Türkiye'de uzun dönemde DYY'daki pozitif şokun %1'lik artışı ekonomik büyümeyi %0.053 artırırken,, negatif şoktaki %1'lik artış ekonomiyi %0,057 azaltmaktadır. Ayrıca, yenilenemeyen enerji (fosil yakıtlar), ekonomik büyümeye yenilenebilir enerjiden yaklaşık iki kat daha fazla katkıda bulunduğundan, Türkiye ekonomisi yenilenebilir enerji kaynaklarından ziyade ithal fosil yakıtlara bağımlıdır. Çalışmamız, Türkiye'de enerji verimliliği ve verimlilik konularının önemini vurgulamaktadır. Elde edilen sonuçların politika çıkarımları çalışmanın sonunda sunulmuştur.

Anahtar Sözcükler: Dyy'ye Dayali Büyüme, Yenilenebilir Enerji, Doğrusal Olmayan Ardl, Cusum Testi, Büyüme Hipotezi, Sürdürülebilir Ekonomik Büyüme, Türkiye

JEL Sınıflandırması: D24, Q32, Q43

Makale Geçmişi / Article History

Başvuru Tarihi / Date of Application : 22 Ekim / October 2021

Kabul Tarihi / Acceptance Date : 17 Şubat / February 2022

1. Introduction

Energy sources play key role in economic and social developments which are basic inputs to ensure sustainable development. Worldwide consumption of energy is increasing rapidly as a result of rapid economic development, population growth and industrialization (Ibrahiem, 2015). International Energy Agency (IEA, 2019a) projects that primary energy demand growth rate will be 1.3% per year until 2040 and world energy demand will increase around 12% between 2019-2030 (IEA, 2020). However, increasing energy demand, energy security, upward and unstable prices of fossil fuels and rising Greenhouse Gas Emissions (GHGs) (global changing) cause concerns in the world. These concerns require further efforts to improve efficiency in energy utilization and transition to alternative energy sources like wind, solar, geothermal and biomass. Countries have implemented many incentives for renewable energy (hereafter RNE) and energy efficiency all over the world. Hence the share of renewables more than doubled in global energy mix and it is projected that RNE will spread in significant amounts in the coming years (IEA, 2019b).

Whether energy conservation and stimulation the RNE consumption have affect the output increase has been broadly argued in energy economics literature. Following the pioneering research paper of Kraft and Kraft (1978), a large number of studies have started to examine the causal relationship between energy consumption (hereafter ENCON) and economic growth (hereafter EGR) since the results have important policy implications (Lee & Chang, 2005; Acaravci *et.al*., 2015). In this context, if there is unidirectional causality relationship running from energy utilization to EGR (growth hypothesis), it means that energy conservation policies may negatively affect the EGR. On the contrary, if it has been found no or unidirectional relationship running from EGR to ENCON (neutrality and conservation hypothesis) this means that energy conservation policies may have limited or no impact on EGR. The existence of bidirectional causal relationship between energy utilization level and economic development (feedback hypothesis) shows the interdependence between the two variables (Omri, 2014; Apergis and Daniletiu, 2014). These studies simply have analysed the link between two variables namely EGR and ENCON in a bivariate model, however, recently studies in the energy-growth nexus have been criticized due to omitted-variable bias which comes up when one or more important explanatory variables are ignored. Lean and Smith (2010), for example, argued that ENCON was not the only production factor determining the EGR. As highlighted by the Lutkepohl (1982), no-causality relationship can be found in the bivariate framework due to the relevant omitted variables. In case of omitted variable problem, the results of estimated model can be biased and inconsistent.

The latest research papers, by inserting various additional variables (such as capital and labour) into a multivariate model, have aimed to avoid the possible omitted-variable bias problem (Dogan, 2015). Among the others, one possible important variable impacting on the EGR has been foreign direct investments (FDI) of multinational companies. As many studies have proved (see Li and Liu, 2005; Alfaro *et.al*., 2004; Iamsirarej *et.al*., 2016), FDI is also very important factor for the EGR of hosting countries with well-developed financial market. Like other emerging countries, Turkey desire to enhance of the inflow of FDI to strengthen the domestic savings and to exploit the benefits of these financial capital accumulation as a part of strategy for EGR. Indeed, currency and debt crises in 2018 and Covid-19 pandemic threats to slow the EGR in Turkey. Hence, to evaluate the role of FDI on EGR has gained importance than ever. Moreover, FDI may have also indirect impacts on renewable and/or non-RNE consumption via its influences on EGR (Fan & Hao, 2020). Therefore, the relationship amongst FDI, EGR, renewable and non-RNE utilization should be examined in detail for Turkey.

Despite the weak performance in 2020, Turkey has been rapidly growing country in last decades. As a result of ambitious reforms in many areas such as finance and energy sectors, Turkey's economic and social performances have been impressive since 2000. Turkey was the 13th largest economy in terms of GDP-PPP and 19th largest economy in terms of nominal GDP in the world with a GDP per capita (nominal) of 9,346 USD Dollar in 2019 (IMF, 2019). Moreover, Turkey has relatively high population growth. While population reached 84 million in 2020, the population growth realized around 1.3% in 2019 (TurkStat, 2020). Based on the data of official statistic institute of Turkey in 2019 (TurkStat, 2019) Turkey's population will reach peak in 2040 with 100 million.

As a result of increasing population and EGR, demand for energy in Turkey has grown substantially since the early 1970s. Annual GDP growth and population growth projections indicate that Turkey's energy demand increase will continue in near future. Turkey's electricity demand reached to 304.1 billion KwH with the 6.2% increase in 2018 and electricity demand nearly doubled in last decade (Teias, 2019). Electricity demand is projected to reach 556.3 Twh and 679.8 Twh in the low and high demand scenario, respectively. Electricity demand will increase at around 4.8% in next 20 years (Teias, 2019). As a result of good growth performance and implemented structural reform in last decades, Turkey became 7th most popular FDI attracting country in Europe in 2018. While FDI flow into Turkey had been around 15 billion USD until 2002, Turkey attracted around 209 billion USD FDI over the 2003 and 2018 period (TRIO, 2019). Turkey saw an annual increase of 14% in FDI inflow in 2018 despite a decline around 27% on the global level (KMPG, 2019).

Since Turkey faces with the increasing energy demand, Turkish government targeted to increase the share of renewables in electricity generation (around 30%) by decreasing the share of fossil fuels. As known, since Turkey is a candidate country to European Union and party to Kyoto Protocol, renewables gain importance to fulfil commitments, hence Turkish government have ensured many incentives to stimulate renewable power capacity. At one side, country aims to increase the share of alternative energy sources in final energy use and FDI level in many sectors by implementing tax practices, on the other hand growth projections requires much more energy necessities resulting heavy burden in balance of payment. As known, Turkey's 70% of primary energy consumption is dependent on imported fossil fuels, so benefitting domestic and/or alternative energy sources is important to achieve the sustainable development. Turkey's energy importer position and financial needs brought heavy burden on current account deficit, so FDI became strategic position in Turkish economy's growth process.

There are some studies have analysed the relationship between energy or electricity consumption and EGR in Turkey generally in bivariate models and found inconclusive results (see Altinay and Karagol, 2005; Aktas andYilmaz, 2008; Narayan and Prasad,2008; Acaravci, 2010; Aslan, 2013; Nazlioglu *et.al*., 2014). Few studies empirically have investigated the interaction between RNE and EGR and their results supported the "neutrality hypothesis" for Turkey (see Ocal and Aslan, 2013; Dogan, 2015; Dogan 2016). There are also several studies analysing the causal relationship between FDI and EGR in the country (see Katırcıoglu, 2009; Mucuk and Demirsel.,2009; Merve, 2016; Simsek and Behdioglu 2006; Ekinci, 2011).

When the energy economics literature is analyzed in the context of Turkey, it is seen that there are only three studies investigating the effect of RNE consumption on EGR for the country. Initially, Ocal & Aslan (2013), could not find any relationship from RNE consumption to EGR by using ARDL co-integration and Toda Yamamoto methods. Moreover, Dogan (2015) and Dogan (2016) have used the traditional ARDL and Johansen methods as well as the co-integration method that considers structural breaks. Author did not identify any relationship between RNE or electricity consumption from renewable sources and EGR. In these studies, however, traditional methods have been employed in time series analysis and the effect of FDI inflow has not been discussed so far. As demonstrated by Chowdhury and Mavrotas (2006), FDI is one of the important determinants of EGR. Moreover, since development of RNE projects require large amount of funds and technology, FDI inflow may provide financial and technical support (Fan and Hao, 2020). Therefore, here the question is, between EGR and its determinants (such as EC and FDI) can be an asymmetrical relationship in Turkey?

Unlike current literature, this study considers the possibility of an asymmetrical relationship between EGR and foreign direct investment. Previous studies suggest that EGR will be affected

symmetrically when there is a random shock to foreign direct investments. However, foreign direct investments may increase or decrease in the host country due to political policies, economic crises, and global factors. Some of the investors who continue their investments in that country believe that these shocks are temporary and can continue their investments. On the other hand, investors who do not like risk believe that random shocks are permanent and can withdraw their investments from the host country. Thus, the present growth-FDI literature for Turkey does not consider this situation. Therefore, by incorporating the RNE into the model, this study examines the growth-FDI relationship with the relatively new NARDL approach by using Cobb-Douglas production function. Based on our best knowledge, however, this is the first study, analysing the relationships amongst FDI inflow, renewable and non-RNE and EGR for Turkey. We also include the basic productions means (i.e. capital and labour force) into the growth model to eliminate the omitted variable bias. Therefore, the relationship amongst FDI inflow, EGR, renewable and non-RNE growth has important implications for the suitable energy policy formulation the country.

The rest of the paper is organized as follows. The next section presents a literature review. The third section provides the data source, model structure and econometric procedure. The fourth section gives results of the analysis and last section presents conclusion and important policy implications.

2. Literature Review

Since energy sources have vital role in both economy and environment the causal relationship between different kind of ENCON and EGR has been investigated by many studies. These studies can be summarized in four categories. First category simply analysed the role of energy sources on EGR following the pioneering research paper of Kraft and Kraft (1978) who found unidirectional causality running from GDP to ENCON for USA. As mentioned before, in this group of studies, causal relationship between different kind of energy sources and EGR has been tested under the four hypotheses and each of which ensure important implications for policy makers (Ocal and Aslan, 2013). Susana and Ghozali (2017) analyzed the effects of fossil and RNE consumption on EGR in BRICS countries through panel data analysis in the 1995-2014 period and found that consumption of fossil energy (especially coal) stimulated the EGR. While fossil fuel energy resources had positive effects on EGR, interestingly RNE utilization harmed the EGR in these countries. Similarly, Bhattacharya *et.al*. (2016) analyzed the role of RNE utilization in 38 top RNE consuming countries in 1991-2012 period and found conflicting results. They found that while RNE consumption had significant impact on EGR in 23 countries, it had negative impact on output level of 4 countries (India, Ukraine, United States,

and Israel). Using panel ARDL and DOLS methods and dataset of 31 developed countries, Zaghdoudi (2017) examined the interaction between internet usage, RNE, electricity consumption and EGR and found that internet usage and EGR stimulated the electric power consumption. Furuoka (2017) investigated the role of renewable and fossil energy consumption on EGR for Baltic countries and found unidirectional causality running from EGR to renewable electricity consumption. Tatlı (2015) analysed the relationship between total ENCON and EGR by using ARDL bound testing and dataset for Turkey in 1981-2013 period. Author found that EGR was highly dependent on the ENCON in the country. Similarly, Zafar *et.al*. (2019) demonstrated the positive effects of RNE and R&D on EGR for Asia-Pacific Economic Cooperation Countries. Glomsrϕd and Wei (2018) investigated the role of fossil divestments and green bonds on EGR and revealed that green finance stimulates the EGR. Ocal and Aslan (2013) analysed the relationship between RNE consumption, capital, labour and EGR for Turkey over the period of 1990-2010 using ARDL procedure and Toda-Yamamoto causality test. They found that RNE consumption had a negative impact on EGR and there was unidirectional causality running from EGR to RNE. Authors explained the detrimental effect of RNE on output level with the high cost of alternative energy.

Studies in this category focused on different countries, periods, variables (i.e. fossil fuels, renewables and electricity consumption) and applied different econometric methodologies. However, there has been no consensus on the direction of causal relationships between fossil and/or RNE consumption and EGR. Empirical results of energy-growth nexus gives mixed results in terms of four hypothesis (neutrality, conservation, growth and feedback) so the causal relationship between energy sources and EGR remain unsolved issue (See Odhiambo, 2009; Paul and Bhattacharya, 2004; Akinlo, 2008; Mehrara 2007;Apergis and Payne 2009; Apergis and Payne 2010 *etc*.).

Second category analyses the effect of FDI on EGR in different countries and regions. Li and Liu (2005) analysed the role of FDI in EGR for 84 countries using panel data over the 1970-1999 period. Authors proved that FDI directly enlarge EGR by itself and indirectly stimulated the output increase via interaction between FDI and human capital. Alfaro et.al., (2004) analysed the linkage between FDI, financial markets and EGR in 1975-1995 for 71 OECD and non-OECD countries and found that FDI alone played ambiguous role in stimulating the EGR but interaction between FDI and well-developed financial markets contributed to EGR. Bellouni (2014) examined the relationship between FDI, trade openness and EGR in Tunisia by using ARDL bounds testing between 1970 and 2008 and found no evidence supporting the FDI-led growth hypothesis. Using threshold regression model for 91 countries, Azman-Saini et.al., (2010) also found evidence that FDI-led growth could realize under the well-developed

financial market conditions. While many studies analysed the effect of total inward FDI on EGR, by using sectoral data for 12 Asian economies for the 1987-1997 period, Wang (2009) found that only FDI inflow in manufacturing contributed to EGR in hosting countries. Iamsirarej (2016) tested the FDI-led growth hypothesis using a simultaneous system of equations for 124 countries over the 1971-2010 period and found that FDI positively contributed to EGR and vice versa. On the contrary, Alvarado *et.al*, (2017) examined the link between FDI and EGR in 19 Latin American countries and concluded that FDI had no important role on EGR at aggregated form, but it stimulated the growth at regional level. The nexus between FDI and EGR has long debated and revealed mixed results but it is clear that FDI and other factors generally positively affecting the FDI inward stimulate the EGR in hosting countries.

Third category examines the nexus among FDI and ENCON. As known, FDI serves as a catalyst in economies of developing country as a source of investment and promotes energy efficiency and environment friendly energy sources as well. Khander *et.al*. (2018) examined the relationship between FDI and RNE consumption by using VAR model with the data set covering the 1980-2005 period for Bangladesh. Authors found bidirectional causality between FDI and RNE consumption in the long- run. Hagert and Marton (2017) investigated whether FDI influenced the consumption of RNE in middle income countries using panel data and yearly data over the 1990-2010 for 56 developing countries. They found that FDI was negatively correlated with the share of RNE. Doytch and Narayan (2016) analysed the link between FDI and energy demand for 74 countries by using dynamic panel data analysis over the 1985-2012 period and found that FDI seemed bring green energy technology that reduced the use of fossil energy in income groups of countries. Using panel data analysis and data over the 1995-2012 period, Teixeira *et.al*., (2017) examined the relationship between non-RNE sources and FDI. Authors found that a country's endowment of non-RNE sources mattered for FDI attraction when measured by the share of mineral fuel exports in total exports. Using Fourier ADL Yilanci *et.al*. (2019) analyzed the effect of FDI and trade openness on RNE consumption for BRICS countries and found unidirectional causality from FDI to RNE utilization. Similarly, employing spatial panel data analysis for 30 Chinese provinces, Xin-gang *et.al*. (2019) found that FDI can promote the energy intensity convergence and spill over effect.

The fourth category combines the previous categories and investigates the relationship amongst EGR, FDI and ENCON in a multivariate model structure. Since former literature mostly used the bivariate model, these studies were most likely suffered from the omitted variable bias. Alam (2013) analysed the potential causality and comparative relationships among electric power consumption, FDI and EGR for India and Pakistan by using VECM

method in 1950-2008 period. Author found that electric power consumption and FDI stimulated the EGR in the long- run. Moreover, FDI and EGR induced the electric power consumption in Pakistan in the long- run. Acaravci *et.al*., (2015) analysed the causal relationship between electricity consumption per capita, GDP per capita, trade openness and FDI per capita by using ARDL method in 1974-2013 period. Authors found unidirectional relationship running from electricity consumption to GDP per capita (growth hypothesis) in Turkey. Tang *et.al*., (2016) analysed the relationship between ENCON and EGR by using neo-classical Solow growth framework over the 1971-2011 period in multivariate framework (adding FDI as an explanatory variable) and found that ENCON, FDI and capital stock had positive effects on EGR in Vietnam. Findings also supported the unidirectional causality running from ENCON to EGR in the mentioned country. Khatun and Ahamad (2015) analysed the interrelationships amongst the FDI, energy sector and EGR in Bangladesh over the period 1972 and 2010. Authors found unidirectional short-run causal relationship running from FDI to energy usage and energy utilization to EGR. Using dynamic panel data analysis, Saidi *et.al*., (2018) analysed the relationship among ENCON, information and communication technology (ICT), FDI and EGR in 13 MENA countries. Authors found that there was a bidirectional causality between ENCON and EGR (feedback hypothesis) and a unidirectional causality running from EGR to FDI. Omri and Kahouli (2014) analyzed the effects of ENCON and FDI on EGR using global dynamic panel data and dataset covering the 1990-2011 period for 65 countries. Authors found a bidirectional relationship between FDI and GDP in all group of countries (developed, developing and middle-income countries). While there was bidirectional relationship between GDP and ENCON in both high-income and middle-income countries, ENCON was a Granger cause of GDP in low-income countries. Moreover, FDI inflow was found to have a statistically significant effect on EGR and ENCON. Amri (2016) analysed the relationship amongst ENCON (renewable and non-RNE), FDI inflow and EGR in both developed and developing 75 countries by using dataset covering 1990-2010 period. Author found bidirectional relationship among renewable and non-RNE consumption and EGR and FDI and output. Moreover, it had been found a bidirectional linkage between RNE consumption and FDI in developed countries. In this context, an increase of FDI contributed to enhancing RNE by 0.29%. Mohamed and Mamat (2016) analysed the interrelationships amongst the FDI, EGR, ENCON and exports by using the dataset over the period 1990-2004 and ARDL bound testing for Yemen. Authors found negative relationships between FDI, GDP and export but positive relationship between FDI and ENCON by using ARDL approach and dataset over the period 1990-2012. Dogan (2015) analysed the relationships amongst EGR, electricity consumption from renewable and non-renewable sources in a multivariate model for Turkey. Author found that 1% increase in

electricity consumption from non-RNE sources stimulated the EGR by 0.22% however electricity consumption from renewables had no stimulating effects on EGR in Turkey. Dogan (2016) analysed the linkages among EGR, renewable and non-RNE consumption by using ARDL approach in 1988-2012 period for Turkey. Author found that RNE consumption had no significant effect on EGR. Using ARDL bound testing Ibrahiem (2015) analysed the link between renewable electricity consumption, FDI and EGR for Egypt over the period 1980 and 2011. Author found that electricity consumption and FDI contributed to EGR. Moreover, author found a unidirectional causality running from FDI to EGR and a bidirectional causality between renewable electricity consumption and EGR. Solarin and Shahbaz (2015) analysed the relationship among natural gas consumption, FDI and EGR by using ARDL bound testing for Malaysia over the period 1971-2012 and they found that natural gas consumption, FDI, capital formation and trade openness had positively effects on EGR in Malaysia. Kazar and Kazar (2014) analysed the linkages among renewable electricity generation, Human Development Index (HDI) and development by using panel analysis for two sub-periods (1980-2010 and 2005-2010). Authors found that a bidirectional relationship between EGR and renewable electricity production, but this causal relationship changed in sub-periods due to HDI variable. Similarly, Lin &Benjamin (2019) panel dynamic OLS model for MINT countries, demonstrated that FDI is positively linked with the EGR and ENCON and FDI inflow. Fan and Hao (2020) analysed the relationship amongst RNE consumption, FDI and GDP in 31 provinces in China for the period of 2000-2015 period by using VECM and Granger causality test. Authors found FDI couldn't significantly cause RNE consumption change in the short-run however a modest slowdown in gross domestic product growth and targeted FDI generated a significant boost in RNE in China in the long-run. Moreover, it had been highlighted that GDP and RNE growth rate were positively affected by FDI in China.

The relationship between electricity consumption, FDI and EGR has recently started to be debated in energy economics literature. Generally, the impact of ENCON and FDI on EGR has been separately analysed in the literature. However, as highlighted by the empirical studies, FDI is linked to EGR and ENCON as well. Since the question of whether RNE consumption and FDI inflow cause EGR or FDI inflow stimulates the renewable or fossil energy utilization are unresolved issue, current paper may be considered as a complementary study of the available literature.

3. Modelling, Data, and Econometric Method

3.*1. Model*

The motivation behind the current paper is to investigate whether there is asymmetrical relationship between EGR and FDI using a production function wherein the level of output is

explained by capital, labour, renewable and non-RNE consumption and FDI. Following the research paper of Amri (2016), Amri and Kahouli (2014) and Dogan (2015), we employ the Cobb-Douglas production function which is widely used in the energy-growth literature. Cobb-Douglas specification assumes constant returns to scale; however, it allows us to change magnitude of inputs response to changes in prices of production factors. Modelling the EGR for Turkey is under the data availability limitations.

The Cobb-Douglas production function is as follows:

$$Y_t = f(K_t, L_t, RE_t, NRE_t, FDI_t) \quad (1).$$

In Eq. 1, $\boldsymbol{Y_t}$ indicates EGR, $\boldsymbol{K_t, L_t, RE_t, NRE_t}$ and $\boldsymbol{FDI_t}$ represent capital, labour, renewable, non-RNE consumption and foreign direct investment, respectively. This study presents a new proposal to the EGR-FDI literature. It is well known that FDI in developing countries is one of the triggers of EGR. Developing countries do not have sufficient resources to reach their EGR targets. Thus, some of the resources for EGR can be provided through FDI. As a result, most developing countries are dependent on FDI. However, the impact of FDI on EGR may not be symmetrical. To give an example, when a random shock occurs in the host country, some companies believe that this shock is temporary and continue their investments in the host country. On the contrary, some companies believe that the impact of the shock is permanent and withdraw their investments from the host country. Non-linearity emerged as a new methodology and argued that changes in explanatory variables can create different reactions in dependent variable. Thus, in the face of a random shock, FDI may have different reactions on EGR. In other words, contrary to the existing literature, the effect of FDI on EGR is analysed asymmetrically with the help of Cobb-Douglas production function:

$$\boldsymbol{Y_t = f(K_t, L_t, RE_t, NRE_t, FDI_t^+, FDI_t^-)} \quad (2).$$

where $\boldsymbol{FDI_t^+}$ and $\boldsymbol{FDI_t^-}$ show positive and negative changes in the vector of foreign direct investment.

3.2. Data

The empirical analysis uses annual data for Turkey over the period of 1987-2015 and time interval is determined by data availability. The source of data is World Development Indicators of World Bank. For multivariate analysis, the dependent variable is EGR and represented by "Y" (real GDP per capita based on 2010 US$), while the independent variables are RNE consumption per capita (measured in kilotons of oil equivalent), non-RNE consumption per capita (measured in kilotons of oil equivalent), labour (labour force, total)capital (gross capital formation, constant 2010 US$) and foreign direct investment (net inflows, % of GDP). We have converted all variables into logarithm form to obtain growth rate of variables in the empirical model.

3.3.Method

ARDL approach is frequently used in determining short- and long-term relationships between variables. The ARDL bound test developed by Peseran *et al*., (2001) offers researchers many advantages. The most important of these is the relief of the unit root properties of the variables. In this context, as long as the variables are not *I (2)*, short- and long-term relationships between the variables can be determined. Granger and Yoon (2002) argued that in the event of a possible asymmetric relationship between the analysed variables, the co-integration tests that deal with the relationship between the variables symmetrically caused the assumptions to collapse. Based on this approach, Shin et al. (2014) introduced the nonlinear autoregressive distributed lag (NARLD) test to the literature. Following the Cobb-Douglas production function, the nonlinear co-integrating regression is defined as follows:

$$\boldsymbol{lnY_t = \vartheta_0 + \vartheta_1 lnK_t + \vartheta_2 lnL_t + \vartheta_3 lnRE_t + \vartheta_4 lnNRE_t + \vartheta_5^{+} FDI_t^{+} + \vartheta_6^{-} FDI_t^{-} + \varepsilon_t} \quad (3).$$

where $\boldsymbol{\vartheta_5^{+}}$ and $\boldsymbol{\vartheta_5^{-}}$ are long-run parameters of kx1 vector of regressors $\boldsymbol{FDI_t}$, decomposed as:

$$\boldsymbol{FDI_t = FDI_0 + FDI_t^{+} + FDI_t^{-}} \quad (4).$$

where, $\boldsymbol{FDI_t^{+}(FDI_t^{-})}$ is expressed as partial sums of positive (negative) change in $\boldsymbol{FDI_t}$:

$$\boldsymbol{FDI_t^{+} = \sum_{h=1}^{t} \Delta FDI_h^{+} = \sum_{h=1}^{t} \mathbf{max}(\Delta FDI_h, 0)} \text{and} \boldsymbol{FDI_t^{-} = \sum_{h=1}^{t} \Delta FDI_h^{-}}$$
$$\boldsymbol{= \sum_{h=1}^{t} \mathbf{min}(\Delta FDI_h, 0)} \quad (5).$$

By acting with Shin et al. (2014) strategy, Eq.3 is fitted to the ARDL equation:

$$\boldsymbol{\Delta lnY_t = \gamma_0 + \delta_1 lnY_{t-1} + \delta_2 lnK_{t-1} + \delta_3 lnL_{t-1} + \delta_4 lnRE_{t-1} + \delta_5 lnNRE_{t-1} +}$$
$$\boldsymbol{\delta_6^{+} FDI_{t-i}^{+} + \delta_7^{-} FDI_{t-i}^{-} + \sum_{i=1}^{b} \beta_i \Delta lnY_{t-i} + \sum_{i=1}^{j} \alpha_i \Delta lnK_{t-i} + \sum_{i=1}^{k} \omega_i \Delta lnL_{t-i} +}$$
$$\boldsymbol{\sum_{i=1}^{e} \tau_i \Delta lnRE_{t-i} + \sum_{i=1}^{m} \pi_i \Delta lnNRE_{t-i} + \sum_{i=0}^{r} (\lambda_i^{+} \Delta FDI_{t-i}^{+} + \lambda_i^{-} \Delta FDI_{t-i}^{-}) + \upsilon_t} \quad (6).$$

where b, j, k, e, m, r indicates lag order. Furthermore,$\boldsymbol{\delta_6^{+} = -\delta_1/\vartheta_5^{+}}$and $\boldsymbol{\delta_7^{-} = -\delta_1/\vartheta_6^{-}}$. The asymmetric error correction model for obtaining short-term relationships between variables is as follows:

$$\boldsymbol{\Delta lnY_t = \sum_{i=1}^{h} H_i \Delta lnY_{t-i} + \sum_{i=1}^{t} A_i \Delta lnK_{t-i} + \sum_{i=1}^{c} T_i \Delta lnL_{t-i} + \sum_{i=1}^{s} I_i \Delta lnRE_{t-i} +}$$
$$\boldsymbol{\sum_{i=1}^{u} C_i \Delta lnNRE_{t-i} + \sum_{i=1}^{n} (E_i^{+} \Delta FDI_{t-i}^{+} + E_i^{-} \Delta FDI_{t-i}^{-}) + \xi_i ECT_{t-i} + \eta_t} \quad (7).$$

The first stage of the NARDL procedure is the same as the ARDL method. That is, the Eq.6 is estimated by the OLS method and the joint null ($\boldsymbol{H_0}: \boldsymbol{\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6^+ = \delta_7^- = 0}$)hypothesis test is applied. In the second stage, Wald F-test is performed to obtain short-run ($\boldsymbol{\lambda^+ = \lambda^-}$) and long-run ($\boldsymbol{\delta_6^+ = \delta_7^-}$) asymmetries in the relationship. At the last stage, positive and negative asymmetric cumulative dynamic multiplier effects are obtained as follow: $\boldsymbol{m_h^+ = \sum_{v=0}^{h} \frac{\partial Y_{t+v}}{\partial FDI_{t-1}^+}}$and $\boldsymbol{m_h^- = \sum_{v=0}^{h} \frac{\partial Y_{t+v}}{\partial FDI_{t-1}^-}}$, h=1,2, …

(8).

It should be noted that, if $\boldsymbol{h \rightarrow \infty}$, $\boldsymbol{m_h^+ \rightarrow \vartheta_5^+ \; and \; \vartheta_6^-}$.

4. Results and Discussions

Descriptive statistics for the variables analysed over the period 1987-2015 such as mean, median, standard deviation, minimum and maximum values can be seen in Table 1. Minimum real GDP per capita based on 2010US$ is 6,308.832, maximum value is 13,853.097 and mean value of GDP is 8.958.572 for Turkey. The mean, minimum and maximum values of gross capital formation of Turkey are 2,185.972, 1,147.807 and 3,795.133 respectively. The mean value of total labour force is calculated to be 0.348 in Table 1. Moreover, while minimum foreign direct investments are 841.064, maximum is 37,456.796 and mean value is 11,174.164 (See Table 1). One can say that non-RNE consumption is higher than RNE consumption in Turkey since the mean value of non-RNE consumption is 104,487.014 while the mean value of RNE consumption is 9,544.052 for the data period analysed.

Table 1. Descriptive statistics of EGR and selected variables

Variable	Mean	Median	Maximum	Minimum	Std. Dev.
Y	8,958.572	8,237.599	13,853.097	6,308.832	2,215.912
K	2,185.972	1,888.896	3,795.133	1,147.807	851.889
L	0.348	0.349	0.379	0.323	0.015
RE	9,544.052	9,688.547	15,444.098	3,736.980	3,492.897
NRE	104,487.014	98,064.126	143,409.493	69,980.417	23,882.983
FDI	11,174.164	3,903.887	37,456.796	841.064	10,952.308

We performed ADF unit root test by Dickey and Fuller (1982) to analyze unit root in the series and performed the unit root test with structural break by Zivot and Andrews (1992) as well. The results of unit root tests for the levels of the series are given in Table 2. We found that the first differences of all series were stationary according to the results of all tests we had performed, and we didn't represent these results to conserve space.

Table 2. Unit root test results

Variable	ADF test at level		ZA test at level	
	Constant	Constant and trend	Constant	Constant and trend
LnY	0.594 (0.986)	-2.083 (0.532)	-3.397 [1999]	-4.019 [2001]
LnK	-0.987 (0.743)	-3.644** (0.043)	-4.818** [2004]	-4.741 [2004]
LnL	-2.236 (0.199)	-1.100 (0.907)	-2.544 [2010]	-3.243 [2006]
LnRE	3.027 (0.999)	0.496 (0.998)	-2.239 [2011]	-1.970 [2003]
LnNRE	-0.541 (0.868)	-3.344* (0.079)	-4.001 [2006]	-4.079 [2006]
LnFDI	-1.879 (0.336)	-3.112 (0.122)	-5.509*** [2005]	-5.728*** [2005]

Notes: ***, ** and * stand for significance at 1%, 5% and 10% levels, respectively. Constant and constant and trend critical values for ZA unit root test at 1%, 5% and 10% are −5.34, −4.80, −4.58 and-5.57, -5.08, -4.82, respectively. The *P*-values for the ADF test are shown in () and the break time for ZA test are indicate in [].

As seen in Table 2, the series Y is nonstationary at level according to all tests. The first differences of the series Y are stationary, and we conclude that the series Y is *I (1)*. Based on the models with constant, the series K has a unit root according to ADF test while it is stationary at .05 level according to ZA test with structural break date 2004. This result indicated that there was a significant structural break in 2004 on the series gross capital formation in Turkey. Based on the models with constant and trend, the series K is stationary at .05 level according to ADF test. From these analyses, one can say that the series K is *I(0)*.The series labor force and RNE consumption are nonstationary at level according to all test results but they are stationary at the first differences so, the series L and RE are *I(1)*. The series non-RNE consumption is stationary at .10 level according to ADF test with the model constant and trend, but it is nonstationary based on all other test results. Because of that the non-RNE consumption is stationary at the first differences, the series NRE is *I (1)*. The series foreign direct investments are nonstationary according to ADF test, but it is stationary at .01 level according to ZA test with the structural break in 2005. We concluded that the series FDI is *I (0)*. We investigated that the series gross capital formation and the foreign direct investments have significant structural breaks in the years 2004 and 2005. These structural breaks could be explained by the new capital inflows to the country and the positive movements on Turkish economy after the economic crises in 2001.

NARDL methodology is appropriate for estimating our model since the series analyzed are mixture of *I (0)* and *I (1)* according to unit root test results given in Table 2. NARDL estimation results can be seen in Table 3. The maximum lag value has been taken as 2 and the model with appropriate lag values has been selected among the 1458 different model estimations according to AIC statistic thus, we have estimated NARDL (1,2,2,0,0,0,2) model. As seen in the table, the

series are co-integrated according to NARDL bound test (F=16.313 is higher than upper bounds for all significant levels).

Table 3. Short- and long-run NARDL results

Short-run estimates		
Variable	Coefficient	*P*-value
ΔLnK	0.231***	0.000
$\Delta LnK(-1)$	0.051***	0.000
ΔLnL	0.336***	0.000
$\Delta LnL(-1)$	-0.297***	0.000
$\Delta LnFDI^-$	0.001	0.757
$\Delta LnFDI^-(-1)$	0.025***	0.000
$ECT(-1)$	-0.312***	0.000
Long-run estimates		
LnK	0.099	0.203
LnL	1.803***	0.000
LnRE	0.283**	0.010
LnNRE	0.640***	0.000
$LnFDI^+$	0.053***	0.009
$LnFDI^-$	-0.057*	0.094
Asymmetry Wald test	$W_{LR} = 8.159[P = 0.013]$	
NARDL bound test	F-stat=16.313	
	at %10 [LB=1.75] [UB=2.87]	
	at %5 [LB=2.04] [UB=3.24]	
	at %1 [LB=2.66] [UB=4.05]	

***, ** and * stand for significance at 1%, 5% and 10% levels, respectively.
LB: Lower bound, UB: Upper bound.

We performed Breusch-Pagan-Godfrey and White tests to test heteroscedasticity; Jarque-Bera test to test normality; Breusch-Godfrey LM test to test serial correlation and Ramsey Reset test to test model specification error. According to all these diagnostic tests, the estimated model provided all conditions as seen in Table 4 (all *P*-values>.10). In addition to these diagnostics, we obtained CUSUM and CUSUMSQ graphs to test model stability. As seen in Fig. 1 and 2, that the statistics are between the confidence bounds indicates stability of the coefficients.

Table 4. Diagnostic test results

Test	F-stat	*P*-value	Diagnostic Check
Heteroskedasticity test: Breusch-Pagan-Godfrey	0.655	0.769	√
Heteroskedasticity test: White	0.625	0.793	√
Normality test: Jarque-Bera	3.949	0.138	√
Serial Correlation test: Breusch-Godfrey LM	1.977	0.181	√
Specification test: Ramsey Reset	1.104	0.314	√
Stability			
Cusum			√
Cusum of Squares			√

In Table 3, long-run asymmetry Wald test result for the series FDI is given. Test statistic is obtained as 8.159 and *P*=0.013. This result implies that the null of symmetric relationship between the foreign direct investments and EGR is rejected. Any positive or negative shock to the foreign direct investments in Turkey will impact on EGR asymmetrically in the long- run. In Fig. 3, asymmetry effects of FDI on EGR go on for about 10 years since asymmetry line in the figure is increasing and becoming stable after for about 10 years. This result from the Fig. 3 supports to asymmetric relationship between the series FDI and EGR in the long- run. Estimated these long-run coefficients of the series FDI can be seen in Table 3. The coefficient of the positive cumulative shocks of the series foreign direct investments is positive and significant (coef. = 0.053 and *P*=0.009<.01). The positive improvements in the foreign direct investments will lead to an increase in EGR in long-run. In other words, 1% increase of positive shocks in the foreign direct investments in Turkey increases EGR by .053% in long-run. The coefficient of the negative cumulative shocks of the series foreign direct investments is negative and significant (coef.=-0.057 and *P*=0.094<.10). The negative improvements in the foreign direct investments will lead to a decrease in EGR in long-run. That is to say, 1 % increase of negative shocks in the foreign direct investments in Turkey decreases EGR by .057% in long-run. The impacts of positive shocks of FDI on the growth (coef. = 0.053) is higher than the impact of the negative shocks of FDI (coef. =-0.057) and this can be also seen in Fig. 3. As seen in this figure, the positive multiplier line for FDI is above the negative multiplier line for FDI within for about 10 years. All these results of the impacts of the positive and the negative shocks of the foreign direct investments on EGR supports FDI-led growth hypothesis for Turkey in long-run.

Except the coefficient of the gross capital formation, all the other estimated coefficients are positive and statistically significant in long-run as seen in Table 3. Accordingly, 1% increase in labor force will lead to an increase in EGR by 1.803% in long-run. One can see that the impact of ENCON on EGR is positive and significant in long-run. Decomposing the ENCON as renewable and non-renewable; non-RNE consumption effects EGR positively for about two times rather than RNE consumption since the estimated coefficient of non-RNE consumption is 0.640 while the estimated coefficient of RNE consumption is 0.283 in long-run equation. From these results, one can say that output level of Turkey depends on fossil fuel energy sources more than RNE sources to improve itself in long-run.

Short-run estimation results can also be seen in Table 3. The estimated coefficient of the error correction term is negative and significant as expected (coef. = -0.312, *P*<.01). This means that 31% of the deviations from short-run will be adjusted within the first year and system will reach to long-run equilibrium within for about 3 years. Furthermore, short-run impact of gross capital formation on EGR is positive and significant as seen in the results of short-run

estimation. However, short-run effects of the variables L and FDI^- is not clear from the results since the signs of the of the variable L and its one–lag values are different and also the variable FDI^- has insignificant effects on the EGR while its one-lag values have negative and significant effects on the EGR in short-run.

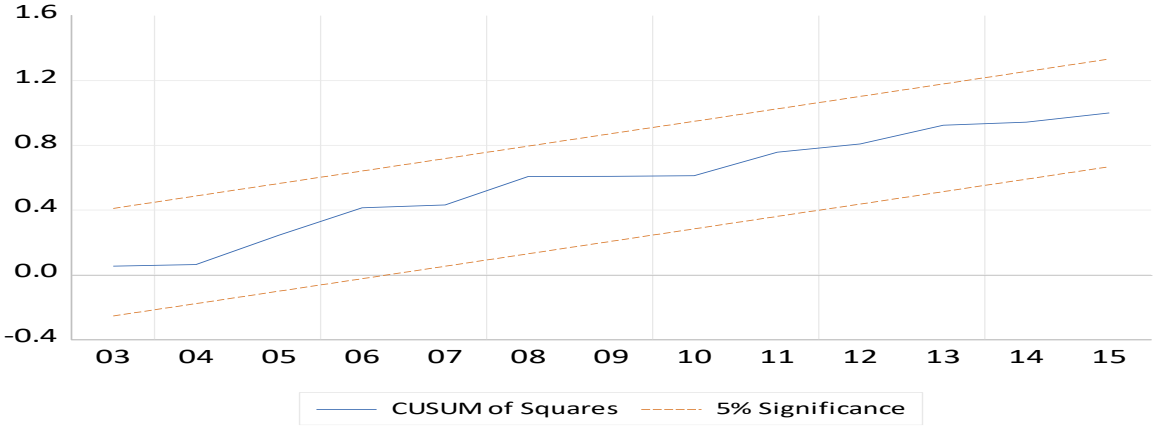

Figure 1. Graph of CUSUMSQ.

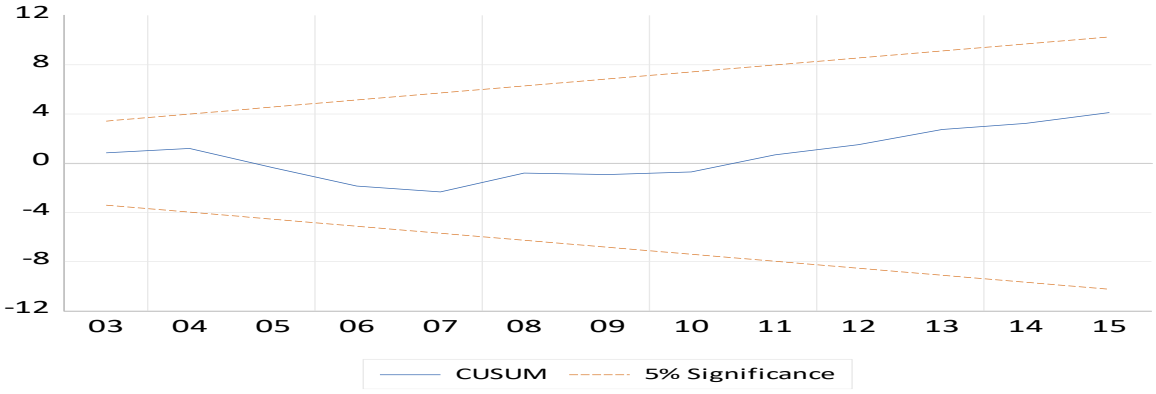

Figure 2. Graph of CUSUM

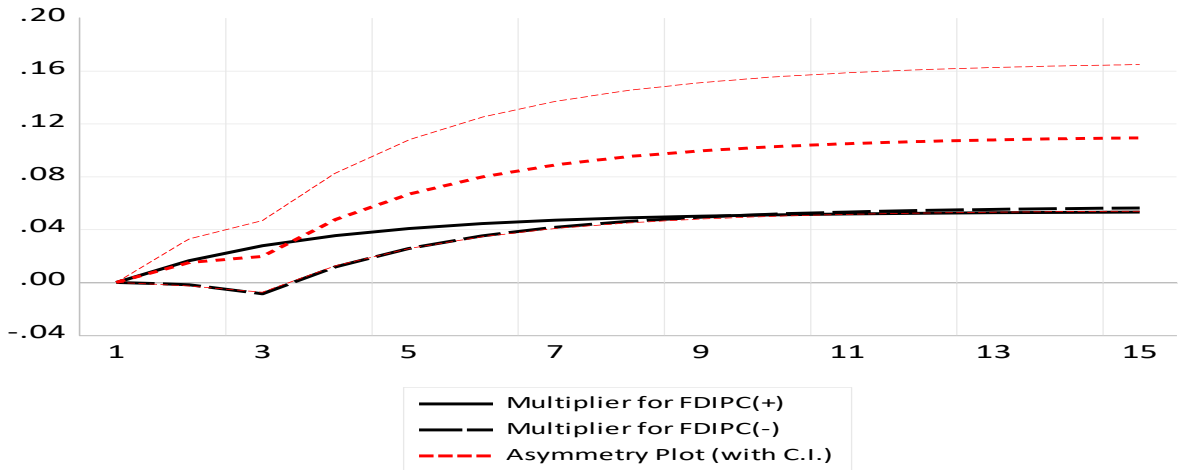

Figure 3**.** Cumulative effect of FDI on EGR

5. Conclusion

This paper examined the neo-classical production function by incorporating FDI, renewable and non-RNE consumption as potential determinants of EGR in the objective of sustainable development for Turkey over the 1987-2015 period. Since the previous studies used estimation

techniques without asymmetric aspect, we applied NARLD approach for the first time to investigate the long-run relationships amongst the variables, namely EGR, RNE, non-RNE consumption and FDI inflow. Furthermore, based on the Cobb-Douglas production function, our estimated parameters of ENCON and FDI, using logarithmic form, indicates the key role of FDI inflow and ENCON on EGR.

Several conclusions can be emerged from the current study. Based on the long-run asymmetry Wald test, the null of symmetric relationship between the foreign direct investment and EGR is rejected. Since we found asymmetric relationship between FDI and EGR, any positive and negative shocks to FDI in Turkey will affect EGR asymmetrically in the long- run (at least 10 years). Accordingly, any 1% increase of positive shocks to FDI inflow will increase the EGR by 0.053% in the country in the long- run. Conversely, any 1% increase of negative shocks in FDI inflow decreases the Turkish EGR around 0.57% in the long- run. If the magnitude of effect is compared, the impact of the positive shocks of FDI is higher than the impact of negative shocks on the EGR in the country.

We found that labour force, renewable and non-RNE positively contribute to output level in the long run. Although the contribution of capital formation on EGR seems ambiguous in the long run, it enhances the output level in the short run. Any 1% increase in labour force increases the output level by 1.803% in the long run. Since non-RNE sources increases EGR nearly two times higher than RNE sources, EGR rate of Turkish economy dependent on fossil fuels rather than RNE sources. However, since Turkey meets energy need through imported energy sources from other countries, fostering non-RNE utilization will deteriorate the current account deficit. Increasing emphasis on RNE in economic activities can retard output expansion; however, the utilization of RNE sources must be increased due to energy supply security and environmental concerns. This aggravating effect can be compensated by increasing overall factor productivity and energy efficiency in the country. Moreover, since R&D activities may foster the deployment of RNE and stimulate the FDI inflow, government should financially support the research activities. These economic and environmental interactions and complementarities may support Turkey to achieve its sustainable development goals.

Moreover, since FDI-led growth has been proven by our empirical findings, it can be projected that FDI inflow will boost the economy in the long-run. Although Turkey has implemented a series of reforms for FDI, such as Investment Support Promotion Agency (ISPAT), there are some problems remaining for the attraction of FDI. In this respect, Turkish government should ensure the stability of Turkish Lira and high digit inflation. Moreover, extra improvements in tax payments, infrastructure (such transportation, ports, airports, energy *etc*.), human capital (skilled workforce) would stimulate FDI inflow in Turkey. FDI can foster EGR

by increasing energy efficiency and local firms may benefit from the spill over effect of green FDI as well.

The further studies are needed to investigate the productivity and energy efficiency issues in this area and the factors affecting the FDI inflow in the country. Indeed, FDI can increase energy efficiency and improve technology development in both energy and other sectors in the Turkish economy.

Funding information:

This study was supported by Akdeniz University, Scientific Research Projects Coordination Unit in Turkey (Project Number:SBG-2019-5112).

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