Examining the Foreign Direct Investment, Renewable Energy Consumption, and Economic Growth Nexus in MENA Countries: A Bootstrap ARDL Evidence

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Abstract

This study examines the relationship among foreign direct investment, renewable energy consumption, and economic growth for seven Middle East and North Africa countries over the period 1980–2017 using the bootstrap autoregressive distributed lag test. The long run analysis reveals evidence of cointegration among FDI inflows, renewable energy consumption, and economic growth in all countries except Iran and Turkey, where real GDP is used as the dependent variable. A similar result is observed in economies, with the exception of Mauritania, when FDI inflow is treated as a dependent variable. Whereas, when RE is taken as a dependent variable, cointegration does occur in Algeria, Mauritania, Morocco, and Tunisia. In regards to the direction of causality, the analysis provides varied results among diverse variables for various countries. In this context, this study recommends increasing public awareness and attention in the advantages of renewable energy and clean technologies.

Keywords: FDI; Renewable energy consumption; Economic growth; Bootstrap ARDL; MENA.

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1. Introduction

Over the past decade, the Middle East and North Africa (MENA) regions are faced with the challenges of growing populations, surging demand for electricity, limited investments in new generation capacity, and in certain countries, limited or no supply of indigenous hydrocarbon resources. Really, the demand for energy is rising so rapidly in the MENA regions that even most countries, which have traditionally exported energy in the past, are facing the prospect of becoming energy importers themselves. Such situations may be further aggravated when countries seek to stimulate economic growth by recognizing that it can significantly affect directly energy demand (Siddiqui, 2004; Beldi and Ghazouani, 2024). Indeed, the MENA region ranks second in the world after Asia in terms of energy consumption as shown in Fig. 1. According to the Energy Information Administration, energy use continues to grow rapidly, with about 20 % growth in the region between 2010 and 2016.

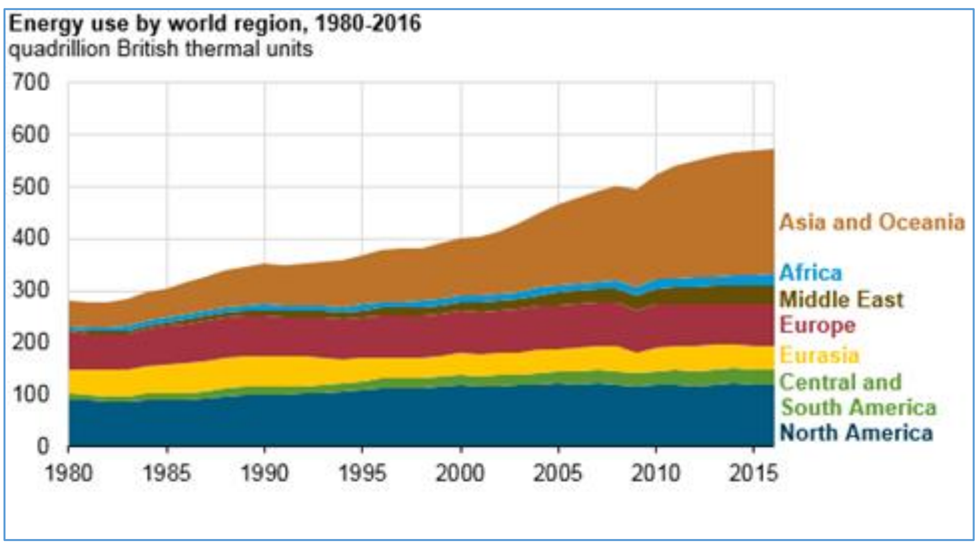

Figure 1. Energy use by world region

Source: U.S. Energy Information Administration, International Energy Statistics.

Additionally, energy demand can be influenced indirectly by other determinants of economic growth, including financial globalization (Ghazouani, 2020). Foreign direct investment (FDI), considered as one of the most relevant aspects of financial globalization (Bajo-Rubio et al., 2010; Ghazouani et al., 2019), has surged spectacularly over the last three decades in the MENA regions. Theoretically, several works have considered FDI as a catalyst for economic growth in the host economy on several levels (Romer, 1993). Consistent with this view is the likelihood that energy use should be positively influenced by raises in FDI inflows across the expansion of the development of the manufacturing and transportation sectors (Sadorsky, 2010; Omri and Kahouli, 2014b; Chaouali et al., 2024).

All these challenges have led many countries in the region to revise their energy policies by setting ambitious strategic goals to take advantage of renewable energy resources. Consequently, many countries have started to establish massive investment plans to enhance renewable energies. As noted by the International Renewable Energy Agency, almost every country in the region has a goal of using renewable energies in a proportion of 5 to 15% by the year 2030. The stated objective of these countries is to fully cover their energy consumption over the long term to preserve the environmental framework through wind and solar energy[1]. Renewable energy should also play a fundamental role in boosting countries' economic growth by decreasing the cost of energy use in production and in creating jobs, which is essential to ensure ongoing social and economic stability (Cai et al., 2011).

Despite that FDI inflows can raise energy demand through the increase of production processes, it’s highlighted that host countries can benefit from FDI through its positive impact on renewable energy development (Fan and Hao, 2020). In fact, FDI inflows can reduce the costs associated with the difficulties of developing renewable sources by providing financing and technical support to the renewable energy industry (Brunnschweiler, 2010). In addition, FDI inflows can lead to technology transfer and technology spillovers that can positively affect the technological advancement of firms in host countries, leading them to adopt high environmental standards (Doytch and Narayan, 2016). Likewise, as mentioned above, that FDI inflows can indirectly influence the demand for non-renewable energy through their impact on economic growth, this is may also be recognized for renewable energy consumption. Thus, it would be interesting to address the long-term as well as short-term dynamic relationship between FDI inflows, renewable energy consumption, and economic growth.

Given its bivariate important role in promoting economic growth as well as preventing further environmental degradation, the study of the causality between the development of renewable energy and economic growth as well as its components such as FDI can provide decision-makers with clear contributions to their policy making, whether economic or environmental. Although there have been many empirical studies focusing

[1] See the summary of the key renewable energy targets and plans in the MENA countries in Aghahosseini et al. (2020).

on the interrelationship between renewable energy use and economic growth, research on the interactions between renewable energy use, FDI inflows, and economic growth is still scarce. Similarly, in reviewing the literature, there were only two studies; Farhani (2013) and Dees and Auktor (2018), that focused solely on the link between renewable energy consumption and economic growth in the MENA region for more than one country. Therefore, we seek to analyze the causal links between FDI inflows, renewable energy consumption, and economic growth for seven selected countries in the region over the period 1980-2017.

For decades, MENA countries have often been sensitive to several shocks, whether they are economic, social, or geopolitical. These shocks can lead to structural breaks in macroeconomic series (Ghazouani et al., 2020). A critical reason for researchers to take these structural breaks into account is to avoid unbiased results and, ultimately, to avoid fallacious recommendations to decision-makers. Taking into account structural break(s), the objective of this study is to add robust results to the empirical literature. For this purpose, we apply the Lee and Strazicich (2003) unit root test who takes into account the presence of structural break(s) in the series to examine the stationarity of the variables. In addition to the fact that our study can be considered a first in examining the link between FDI inflows, renewable energy consumption, and economic growth, it is also believed to be a pioneer in using the augmented ARDL approach by McNown et al. (2018) to test the existence of a possible cointegration between variables in the presence of structural breaks for the MENA region. Finally, in light of the results of the cointegration test, the Granger causality test was designed to analyze the causal directions of the relationships between the variables.

The rest of the study is organized as follows: Section 2 reviews the relevant literature related to the subject. Section 3 gives an overview on econometric specification and methodology, while Section 4 reports and discusses the empirical results. Finally, Section 5 provides conclusion and drawn policy implications.

2. Literature review

2.1. The energy consumption-growth nexus

Since the pioneer study of Kraft and Kraft (1978), various studies have started to examine the relationship between economic growth and energy consumption. Theoretically, it has provided four testable hypotheses about the correlation between energy and growth. The first is known as the *growth hypothesis* which supports a unidirectional causality from energy consumption to economic growth. The second hypothesis is named the *conservation hypothesis* according to which there exists a unidirectional relationship from economic growth to energy consumption. The third is called the *feedback hypothesis* which supports a bidirectional causality between economic growth and energy consumption. Finally, the *neutrality hypothesis* according to which energy consumption does not influences economic growth.

Many studies have been done supporting each of the hypotheses relating to energy consumption and economic growth. As a part of the aim of this study, we present here the literature review which examines the relationship between renewable energy consumption and economic growth. Sadorsky (2009) studied the relationship between renewable energy consumption and income for 18 emerging countries over the 1994-2003 period. The results revealed the presence of unidirectional causality running from economic growth to renewable energy consumption. Panel cointegration estimations show a positive and significant impact of real income on the renewable energy consumption.

Rafindadi and Ozturk (2017) investigated whether the impacts of renewable energy have consolidated the economic growth prospects of Germany for the period 1971–2013. They showed that renewable energy consumption consolidates economic growth prospects. Their causality analysis revealed a feedback effect between renewable energy consumption and economic growth. Ozcana and Ozturk (2019) applied bootstrap panel causality test to analyze the renewable energy consumption-economic growth nexus in 17 emerging countries. They stated that renewable energy demand contributes to Poland's economic growth process, among these emerging economies studied.

Recently, Rahman and Velayutham (2020) explored the relationship between renewable and non-renewable energy consumption and economic growth for five South Asian countries for the 1990–2014 period. Their study showed positive impacts of renewable energy consumption on economic growth and revealed that there is a unidirectional causality running from latter to the former. Using Arellano-Bond GMM testing approach, Gholizadeh (2020) investigated the relationship between GDP, energy consumption, capital, and labour for 28 EU countries during the period 1990–2014. They found that all of the explanatory variables significantly and positively correlated with economic growth.

In the case of the MENA region, Farhani (2013) used a panel cointegration technique to examine the causal relationship between renewable energy consumption, economic growth, and CO_2 emissions for a group of 12 economies for 1975-2008 period. He finds no causal relationship between renewable energy consumption and GDP in the short run, while GDP growth has an influence on renewable energy consumption in the long run. On a single-country level in the MENA region, Dogan (2015) analyzes the short and long run estimates as well as the causal relationships between economic growth and electricity consumption from renewable sources. He found no causality between renewable electricity consumption and economic growth in Turkey. For the same country, Ocal and Aslan (2013) showed that the impact of renewable energy on growth is negative, but causality reveals the conservation hypothesis.

Using the ARDL approach, Cherni and Jouini (2017) investigated the relationship between renewable energy, CO_2 emissions, and economic growth in Tunisia for the 1990-2015 period and found a bidirectional relationship between renewable energy consumption and growth. Belaïd and Youssef (2017) explored the dynamic causal relationship between renewable and non-renewable electricity consumption, CO_2 emissions, and economic growth for the case of Algeria for the period 1980-2012. Their study revealed a unidirectional causal relationship from GDP to renewable electricity consumption. Kahia et al. (2017) examined the relationship between renewable energy consumption, economic growth, FDI inflows and trade, and CO_2 emissions for a panel of 12 MENA countries for the 1980-2012 period, and their results revealed bidirectional causality among the candidate variables.

2.2 The foreign direct investment-growth nexus

Regarding the link between FDI and economic growth, previous research has failed to establish if there is a positive or negative relationship amongst these variables. On one hand, support for the positive association between FDI inflows and economic growth, in the literature, is attributed to Van Loo (1977), Findlay (1978), Romer (1993), among others. On the other hand, dependency theorists (Caves, 1971) were highly critical of the role of FDI in the economic growth of host countries. They reject the notion that incoming FDI flows to developing countries promote growth.

With the nature of the association between FDI and economic growth, the causality issue has been the subject of many recent studies. Based on an Error Correction Model, Zhang (2001) examined the causality relationship between FDI and GDP for 11 countries in East Asia and Latin America over a period of 30 years. He found that FDI has a positive impact on economic growth more in East Asia than Latin America. A unidirectional causality from GDP to FDI was found in four countries, while only one country exhibited Granger causality from FDI to growth.

Saidi et al. (2018) assessed the link between energy consumption, ICTs, FDI inflows, and economic growth for 13 MENA countries. Their analysis supports the existence of a unidirectional causality running from economic growth to FDI. While Belloumi (2014) indicated that there is no significant Granger causality between FDI to economic growth when he examines the relationship between FDI, trade, and economic growth in Tunisia for the 1970-2008 period.

Kalai and Zghidi (2017) analyzed the interrelationship between FDI and economic growth for 15 MENA economies for the period from 1999 to 2012 using the ARDL bound test approach and the vector error correction model. They found a long-run unidirectional causality running from FDI to economic growth in MENA countries.

Whereas, Omri and Kahouli (2014b), by using the generalized method of moments to study the association between FDI inflows, domestic capital, and economic growth in 13 MENA countries for the 1990-2010 period, revealed bidirectional relationships between FDI inflows and economic growth.

2.3 The foreign direct investment-energy consumption nexus

This nexus is analyzed by many studies. Theoretically, this link can be decomposed into three effects: (i) the increase in energy use brought about by a vibrant economic activity fueled by FDI known as a scale effect; (ii) the technique effect which describes a negative association between FDI and energy consumption that stems from foreign investors, introducing energy efficiency; and (iii) the composition effect which depends on the sectoral distribution of FDI and the level of economic development in the host country.

Research on the link between FDI and energy has concentrated on the relationship between financial development and energy demand, considering FDI as an important element of financial development (Shahbaz et al., 2013). Earlier, Mielnik and Goldemberg (2002) focused on 20 developing countries for the 1970 -1998 period and found a negative FDI-energy consumption nexus. They attribute this finding to the introduction of modern technologies in the developing countries. While, using a GMM methodology to analyze the impact of stock market and FDI on energy in 22 emerging economies, Sadorsky (2010) does not find any significant association between FDI and energy use.

Omri and Kahouli (2014a) examined the interrelationships among energy consumption, FDI, and economic growth using dynamic panel data of 65 countries from 1990 to 2011. This showed a bi-directional causality between FDI and energy consumption in the middle- and low-income countries, but indicated that the emphasis on environmental protection might have deterred energy-intensive FDI in high-income countries. Abdouli and Hammami (2017), exploring the causal relationship among economic growth, FDI inflows, and energy consumption in a panel of 12 Middle East and 5 North African countries over the period 1990-2012, find evidence of unidirectional causality from energy consumption to FDI inflows.

We note that the majority of the studies mentioned, assessing the link between FDI and energy consumption, have largely neglected the effect of renewable energy sources on the FDI–energy nexus. Recently, some studies have emerged which have taken into account the role of renewable energy in FDI. Doytch and Naryan (2016) utilized a Blundell–Bond dynamic panel estimator to examine the relationship between FDI flows and both renewable and non-renewable industrial energies in 74 economies over the period from 1985 to 2012. They found that FDI contributes to the reduction of non-renewable energy consumption (halo effect) and this outcome is depended of sectoral FDI in host country and income group.

Paramati et al. (2016) investigated the impact of FDI inflows on clean energy consumption in 20 emerging countries for the period from 1991 to 2012. They found a significant positive impact of FDI inflows on clean energy consumption in the long run and a unidirectional causality from the former to the latter in short run.

In a quite recent study, Fan and Hao (2020) tested the nexus among renewable energy consumption, FDI inflows, and GDP in 31 Chinese provinces over the 2000-2015 period. They provide a long-term relationship between those variables. In addition, they find that FDI inflows positively affect renewable energy consumption and the granger causality analysis supports the unidirectional causality from the latter to the former.

3. Econometric specification and methodology

3.1. The Bootstrap ARDL test approach

To examine the relationships between GDP, FDI, and renewable energy consumption, this study employs bootstrap test statistics from a dynamic single-equation error correction specification of the autoregressive distributed lag (ARDL) model proposed by McNown et al. (2018). In general, considered as a dynamic single-equation error-correction specification, the ARDL (p,q_1,q_2,q_3) model can be specified as follows:

$$y_t = c + \sum_{i=1}^{p} \beta_i y_{t-i} + \sum_{j=0}^{q_1} \beta_j x_{t-j} + \sum_{k=0}^{q_2} \beta_k z_{t-k} + \sum_{l=0}^{q_3} \beta_l w_{t-l} + \sum_{m=1}^{r} \beta_m D_{t,m} + e_t \quad (1)$$

where *i, j, k,l* and *m* presents the indices of lags: $i = 1, 2, \ldots, p$; $j = 0, 1, \ldots, q_1$; $k = 0, 1, \ldots, q_2$; $l = 1, 2, \ldots, q_3$; $m = 1, 2, \ldots r$; $t = 1, 2, \ldots, T$ stands for time periods; y_t indicates the dependent variable; x_t, z_t and w_t presents the independent variables; $D_{t,m}$ is a dummy variable; β_i are coefficients on the lags of the dependent variable; β_j, β_k and β_l are coefficients on the lags of the independent variables; β_m is the coefficient of the m^{th} dummy variable; c is the constant term; and e_t is an error term with a zero mean and a finite variance, σ^2.

Eq. (1) can be re-parameterized and expressed in an error-correction representation in the following way:

$$\Delta y_t = c + \sum_{i=1}^{p-1} \beta_i' \Delta y_{t-i} + \sum_{j=1}^{q_1-1} \beta_j' \Delta x_{t-j} + \sum_{k=1}^{q_2-1} \beta_k' \Delta z_{t-k} + \sum_{l=0}^{q_3-1} \beta'_l w_{t-l} + \sum_{m=1}^{r} \beta_m' D_{t,m} + \alpha_1 y_{t-i} + \alpha_2 x_{t-j} + \alpha_3 z_{t-k} + \alpha_4 w_{t-l} + \mu_t \quad (2)$$

Where β_i', β_j', β_k', β'_l and $\beta_m'$are functions of the original parameters in Eq. (1), and $\alpha_1 = -(1 - \sum_{i=1}^{p} \beta_i)$; $\alpha_2 = \sum_{j=0}^{q} \beta_j$; $\alpha_3 = \sum_{k=0}^{r} \beta_k$; and $\alpha_4 = \sum_{l=0}^{s} \beta_l$

The derivation of (2) from (1) is the standard renormalization that is used in transforming a vector autoregression in levels in its error correction form.

Eq. (2) will be estimated with a constant term in the unconditional model as:

$$\Delta y_t = \hat{c} + \sum_{i=1}^{p-1} \hat{\beta}_i' \Delta y_{t-i} + \sum_{j=1}^{q_1-1} \hat{\beta}_j' \Delta x_{t-j} + \sum_{k=1}^{q_2-1} \beta_k' \Delta z_{t-k} + \sum_{l=0}^{q_3-1} \hat{\beta}'_l w_{t-l} + \widehat{\alpha_1} y_{t-i} + \widehat{\alpha_2} x_{t-j} + \widehat{\alpha_3} z_{t-k} + \widehat{\alpha_4} w_{t-l} + \mu_t \quad (3)$$

McNown et al. (2018) propose a cointegration among y_t, x_t, z_t and $w_t$that requires rejection of all three of the following null hypotheses:

- F_1-test on all error correction terms: H_0: $\alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = 0$ against H_1 : any $\alpha_1, \alpha_2, \alpha_3, \alpha_4 \neq 0$;
- F_2-test on lagged independent variables: H_0: $\alpha_2 = \alpha_3 = \alpha_4 = 0$ against H_1 : either $\alpha_2, \alpha_3, \alpha_4 \neq 0$.
- t-test on the lagged dependent variable: H_0 : $\alpha_1 = 0$ against H_1 : $\alpha_1 \neq 0$;

Two degenerate cases can arise. On one hand, degenerate case #1 occurs if the F_1-test and the t-test are significant, but F_2-test is not significant. On the other hand, degenerate case #2 occurs when the F_1-test and the F_2-test are significant, but the t-test is not significant[2].

[2] For further explanation see McNown et al. (2018)

After testing for the long-run relationship using the bootstrap ARDL, the standard Granger causality test will be used to assess the causality among the variables.

3.2 Model specification and Data

The prime objective of this paper is to examine the relationship between economic growth, FDI, and renewable energy consumption. Following the existing literature (Ghazouani, 2024; Rafindadi and Ozturk, 2017; among others), we consider, the following empirical specification:

$$ln\_GDP_{i,t} = \alpha_0 + \alpha_1\ ln\_FDI_{i,t} + \alpha_2\ ln\_RE_{i,t} + \alpha_2\ ln\_K_{i,t} + \mu_{i,t} \qquad (4)$$

Where $ln\_GDP_{i,t}$, $ln\_FDI_{i,t}$, $ln\_RE_{i,t}$,*and* $ln\_K_{i,t}$ are GDP, FDI, renewable energy consumption and capital per capita in logarithmic form, respectively. i and t refer to the country and the time, respectively. Eq. (4) is a renormalization of the four error correction terms in Eq. (3), which (y or $ln\_GDP_{i,t}$) is expressed in terms of the other three variables (x or $ln\_FDI_{i,t}$, z or $ln\_RE_{i,t}$ and w or $ln\_K_{i,t}$) and an error term $\varepsilon_{i,t}$ that represent deviations from the long run relationship. The parameters α_1, α_2, α_3 and α_4 represent the output elasticities of FDI, RE and K, respectively.

To study this model, annual data covering the period from 1980 to 2017 are used for Algeria, Egypt, Iran, Mauritania, Morocco, Tunisia and Turkey. Annual data on real GDP per capita, FDI inflows, gross fixed capital formation[3], and population are sourced from World Bank (2020), and RE consumption is sourced from the U.S. Energy Information Administration (2020).

Table 1 displays the compounded annual growth rates of GDP, FDI, and RE between 1980 and 2017. It shows that all countries had positive growth rates in all considered variables over the study period. Among the countries, Tunisia recorded the highest growth rate in renewable energy consumption with 8.96%, followed by Algeria and Mauritania with 8.15% and 7.50%, respectively. At the same time, these countries are also posting significant annual GDP growth rates of around 4%. With the exception of Egypt, the annual growth rates of energy consumption converge with those of real GDP in other countries. Roughly, observations indicate that for most of these economies, renewable energy consumption is increasing at about the same rate as GDP (5.33% compared to

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[3] This used to measure the capital (K)

4.38%). The annual growth rates of FDI inflows range from 2.41% for Algeria to 15.96% for Turkey. They evolve more than the GDP and renewable energy consumption in the economies with the exception of Algeria, Tunisia and Mauritania.

Table 1

Compound annual growth rates of the variables (percent), 1980-17

	GDP	FDI	RE	K
Algeria	4.15	2.41	8.15	2.79
Egypt	4.63	5.17	1.45	4.86
Iran	2.96	10.24	2.70	1.43
Mauritania	2.67	6.11	7.50	5.52
Morocco	4.82	8.96	3.04	4.44
Tunisia	3.61	2.82	8.96	2.71
Turkey	7.83	15.91	5.50	6.28
Total	4.38	7.38	5.33	4.00

Note: the compound annual growth rates are obtained using non-logarithmic data.

4. Empirical results and discussion

Before beginning the study of the cointegration tests between the variables, it is necessary to first of all analyze their stationarity in order to choose the appropriate cointegration method. The ADF by Dickey and Fuller (1979) and the PP by Philips and Perron (1988), unit root tests, are applied to examine the stationarity of each time series. The results of the stationarity tests in table 2 show that a few series are stationary in levels (I(0)), and that most series are integrated on order one ($I(1)$). However, these results may mislead the choice of method for the cointegration study between variables because of the low power of these traditional tests to study series with structural breaks. For this reason, we apply the LS unit root test by Lee and Strazicich (2003), which has great power in studying the stationarity of the variables in the presence of structural breaks.

Table 2

ADF and PP Unit root tests

Country	Algeriaa		Egypt		Iran		Mauritania	
	ADF	PP	ADF	PP	ADF	PP	ADF	PP
LnGDP	-0.401	-0.652	-1.054	-1.698	-0.517	-0.595	-2.365	-2.244
ΔLnGDP	-5.832*	-5.926*	-3.038**	-3.644*	-5.636*	-5.657*	-5.943*	-5.943*
LnFDI	-2.852***	-2.849	-2.048	-4.470*	-1.736	-1.412	-2.516	-2.461
ΔLnFDI	-6.517*	-12.248*	-8.704*	-13.108*	-8.063*	-11.128*	-7.618*	-8.472*
LnRE	3.082	-2.647	-2.511	-2.617	-2.662	-2.620	1.041	1.041
ΔLnRE	-4.758*	-7.139*	-6.811*	-7.149*	-5.716*	-8.128*	-5.571*	-5.589*
LnK	-2.497	-1.063	-1.106	-2.270	-1.598	-1.598	-2.022	-3.307**
ΔLnK	-3.163*	-5.998*	-5.993*	-4.038**	-5.283*	-5.258	-4.234*	-4.173**

Country	Morocco		Tunisia		Turkey	
	ADF	PP	ADF	PP	ADF	PP
LnGDP	-0.637	-2.252	0.174	0.147	-0.092	-0.027
ΔLnGDP	-12.835*	-11.723*	-5.851*	-5.869*	-4.657*	-6.547*
LnFDI	-3.029	-3.397***	-2.439	-2.410	-2.494	-2.589
ΔLnFDI	-8.631*	-8.631*	-8.358*	-9.225*	-7.855*	-13.702*
LnRE	-1.884	-2.076	-1.491	-1.392	-1.510	-1.186
ΔLnRE	-5.060*	-7.796*	-7.105*	-8.277*	-7.710*	9.173*
LnK	-2.713***	-0.084	-0.750	-1.062	-0.247	0.010
ΔLnK	-4.557*	-4.557*	-4.170*	-4.173*	-6.624*	-7.140*

Notes: *, **, and ***indicate the significance at the 1% , 5%, and 10% levels respectively.

Table 3 summarizes the results of this test. For all variables, the null hypothesis that they have a unit root is rejected in their first differences when taking into account the presence of two structural breaks in the series. This leads us to conclude that the variables are integrated in order 1 for all countries. In summary, all these results lead us to estimate the ARDL bound test for all countries as this approach is based on the assumption that the variables are *I(0)* or *I(1)*.

Table 3

LS unit root test

Country	Variable	Y^{B}_{1}	Y^{B}_{2}	T-statistic	*L*
Algeria	LnGDP	1990	2009	-1.153	1
	ΔLnGDP	1991	2007	-7.855*	1
	LnFDI	1990	1993	-3.047	0
	ΔLnFDI	1993	2001	-8.162*	0
	LnRE	1996	2004	-2.015	1
	ΔLnRE	1990	1999	-6.614*	1
	LnK	1986	1990	-2.005	2
	ΔLnK	1990	2004	-7.755*	1
Egypt	LnGDP	1983	1990	-3.400	1
	ΔLnGDP	1989	2000	-7.427*	4
	LnFDI	2002	2010	-5.573	1
	ΔLnFDI	1991	2011	-8.395*	0
	LnRE	1985	1999	-5.237	0
	ΔLnRE	1985	1991	-6.818**	1
	LnK	1990	1992	-3.864	3
	ΔLnK	1991	2009	-5.358*	0
Iran	LnGDP	1992	2001	-1.701	4
	ΔLnGDP	1991	2006	-4.496*	5
	LnFDI	1989	2001	-2.697	5
	ΔLnFDI	1988	1998	-5.692*	0
	LnRE	1991	2008	-5.453	1
	ΔLnRE	2002	2008	-9.031*	7
	LnK	1990	1995	-2.085	3
	ΔLnK	1988	1994	-6.747**	6
Mauritania	LnGDP	1995	2004	-4.478	2
	ΔLnGDP	1994	2006	-5.627*	0
Morocco	LnGDP	1991	2000	-4.068	4
	ΔLnGDP	2004	2009	-7.797**	1
	LnFDI	1998	2002	-4.025	2
	ΔLnFDI	1990	1992	-8.495*	0
	LnRE	1996	2010	-5.071	2
	ΔLnRE	1989	1993	-8.303*	1
	LnK	1992	2005	-5.190	4
	ΔLnK	2008	-	-8.216*	6
Tunisia	LnGDP	1990	2006	-4.610	0
	ΔLnGDP	1998	2011	-7.735*	0
	LnFDI	1990	2013	-5.411	4
	ΔLnFDI	1989	1994	-8.579*	0
	LnRE	1986	2013	-4.736	1
	ΔLnRE	1985	2011	-7.530*	0
	LnK	1990	2012	-4.837	2
	ΔLnK	1989	-	-6.726**	3
Turkey	LnGDP	1992	2005	-4.357	2
	ΔLnGDP	1994	2009	-8.853*	7
	LnFDI	1992	2008	-3.754	0
	ΔLnFDI	1988	1995	-4.766**	0
	LnRE	1993	1999	-4.197	2
	ΔLnRE	1989	-	-7.807*	0
	LnK	1998	2003	-3.954	1
	ΔLnK	1993	2009	-6.249*	0

	LnFDI	1990	1998	-3.859	0
	ΔLnFDI	1991	-	-6.798*	0
	LnRE	1986	2008	-3.370	2
	ΔLnRE	1986	2006	-6.452**	0
	LnK	1988	2007	-3.624	1
	ΔLnK	1994	2005	-5.367*	6

Notes: * and ** indicates the statistical significance at the 1 and 5% levels respectively. $Y^B{}_1$ and $Y^B{}_2$ are the times of structural break. *L* is the optimal lag.

As described in the previous section, to analyze the long-run relationship interactions among GDP, FDI, and RE, the new bootstrap ARDL tests are used. Table 4 reports the estimates and tests of this technique. In keeping with the recognition that all three variables can be considered endogenous and that the bootstrap test allows this kind of endogeneity, we renormalize the ARDL equation in order to treat each of the three series as the dependent variable. Each country's equation presents their dummy variables which is added to capture shocks as the data show unexpected peaks and drops: as an example, the sudden stop of FDI, the financial crisis, the oil shocks, etc. The optimal lag lengths are determined using the Akaike Information Criterion. All estimated equations have passed diagnostic tests[4] (i.e. the residual autocorrelation, the normality, the serial autocorrelation, and the heteroscedasticity tests). In addition, the CUSUM and the CUSUMSQ are applied to examine the stability of long run estimates (Fig. 2). Based on the critical values generated from the bootstrap technique proposed by McNown et al. (2018), we can conclude whether or not there is cointegration between the variables by comparing the empirical estimation results to these critical values (F_1^*, F_2^* and t^*) at the 5% significance level.

[4] These results are not reported for the sake of space but are available from the author upon request.

<table>
<tr><th colspan="2">Country
Equations</th><th>Algeria</th><th>Egypt</th><th>Iran</th><th>Mauritania</th></tr>
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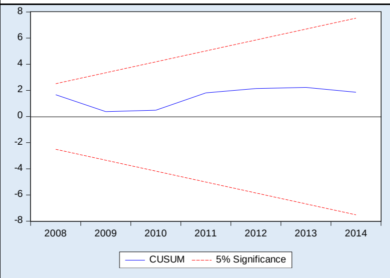
<td>
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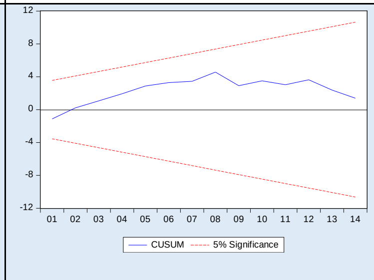
<td>
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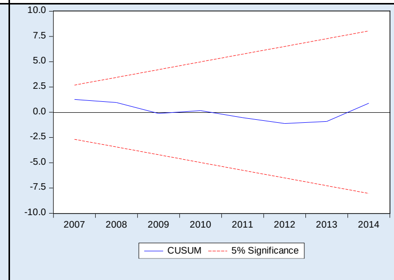
<td>
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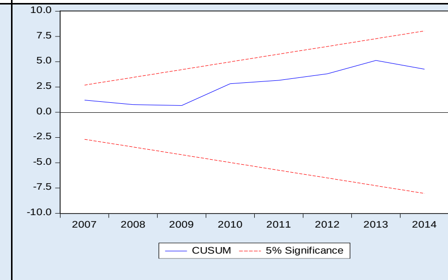
<td>
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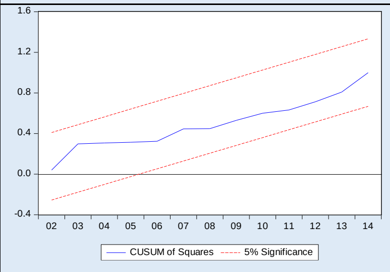
<td>
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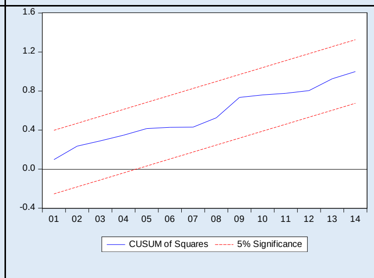
<td>
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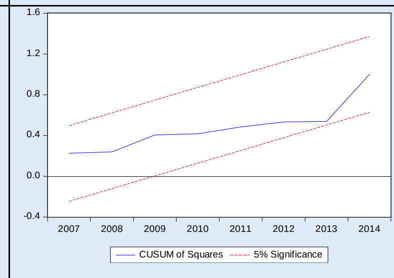
<td>
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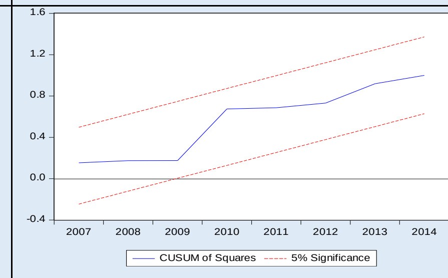
<td>
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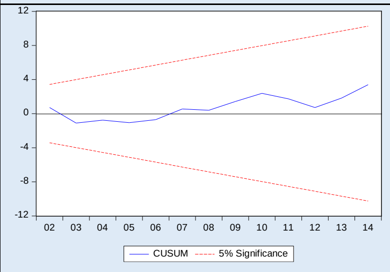
<td>
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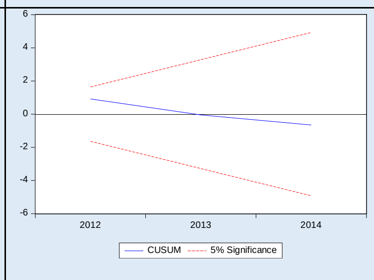
<td>
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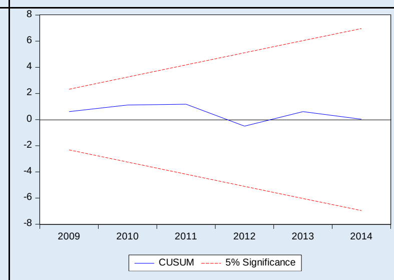
<td>
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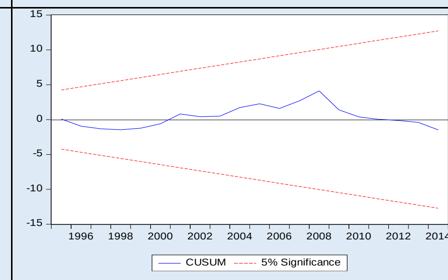
<td>
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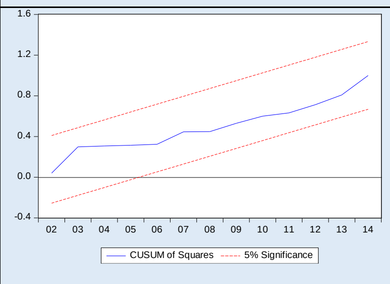
<td>
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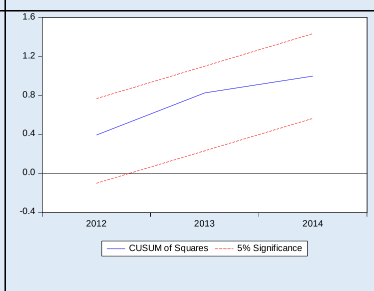
<td>
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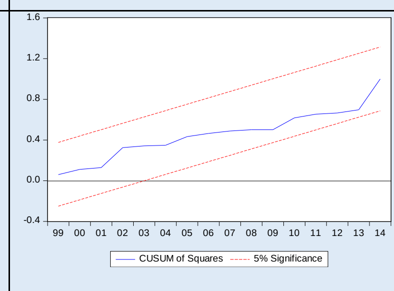
<td>
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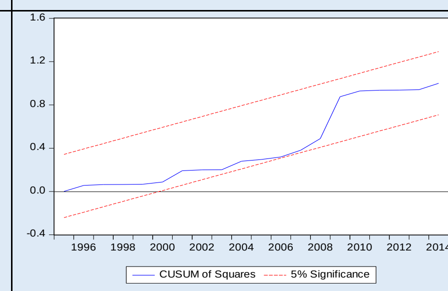
<td>
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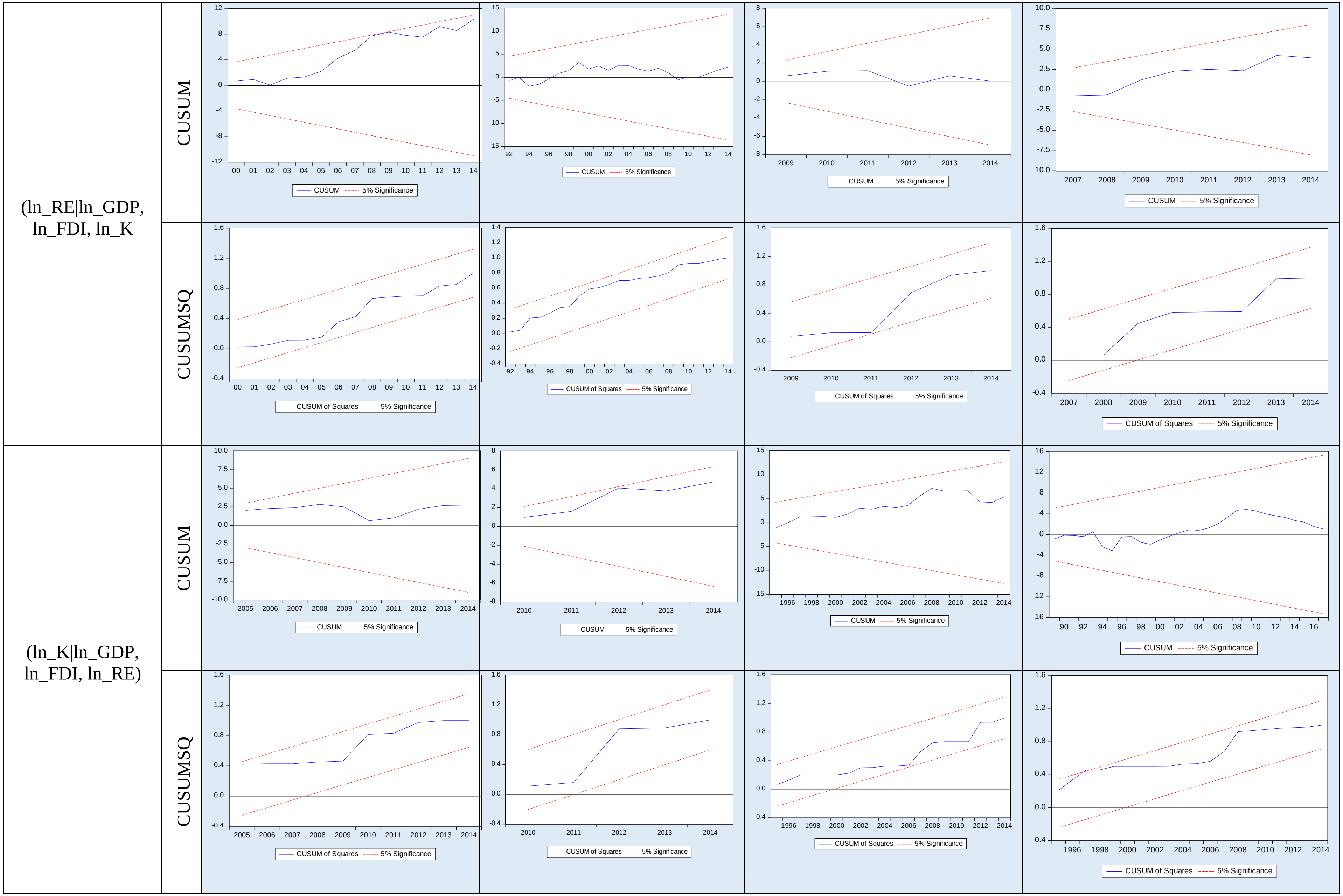

Figure 2 (continued)

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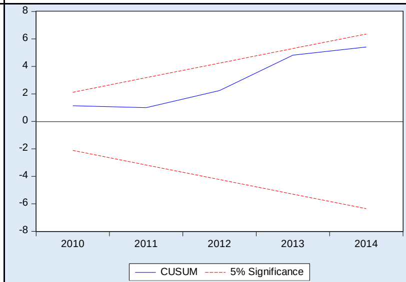
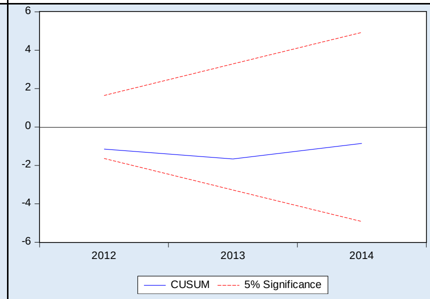
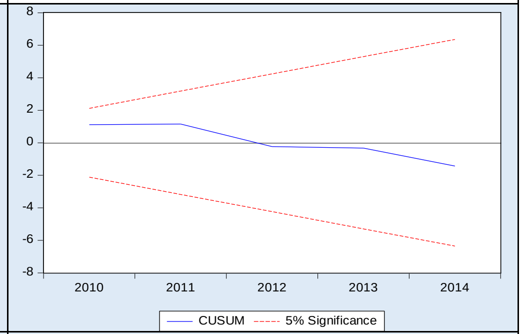
<tr><td rowspan="2">(ln_GDP|ln_FDI, ln_RE, ln_K)</td><td>CUSUM</td><td>
</td><td>
</td><td>
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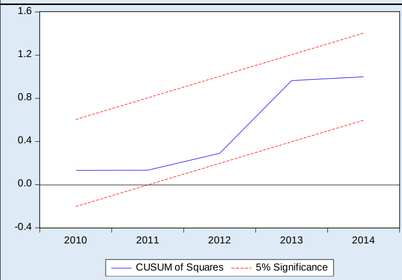
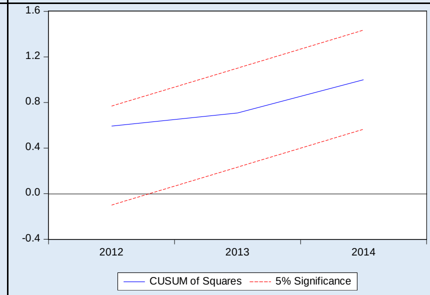
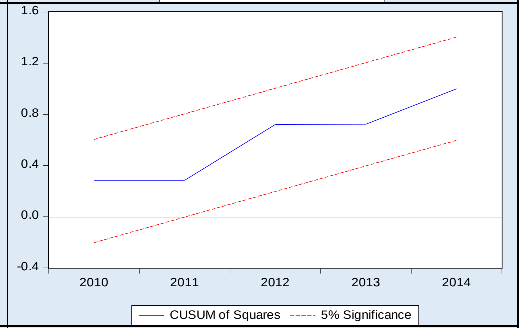
<tr><td>CUSUMSQ</td><td>
</td><td>
</td><td>
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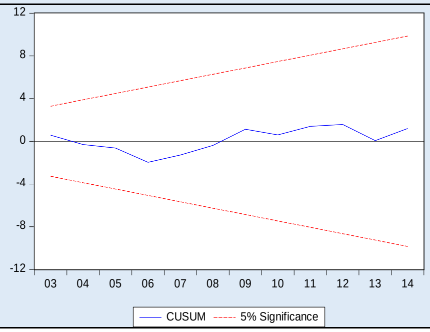
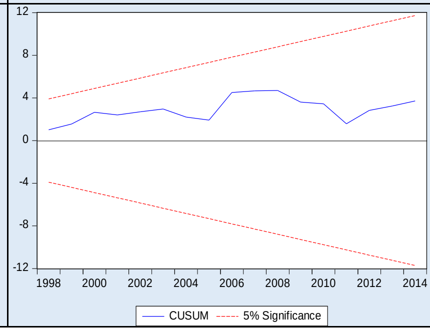
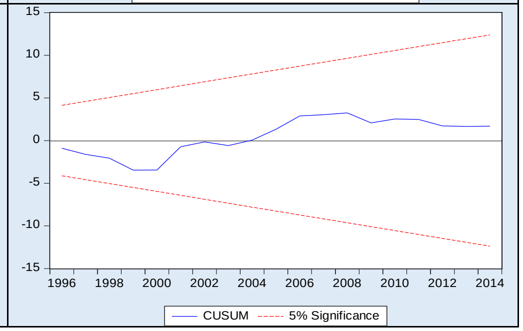
<tr><td>(ln_FDI|ln_GDP, ln_RE,ln_K)</td><td>CUSUM</td><td>
</td><td>
</td><td>
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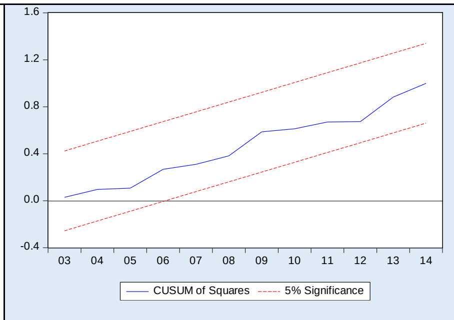
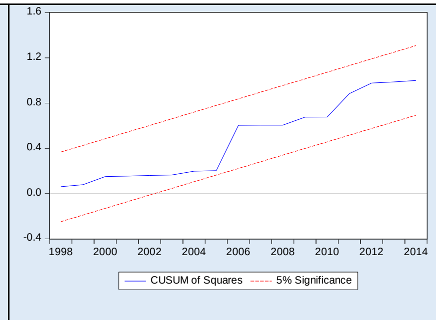
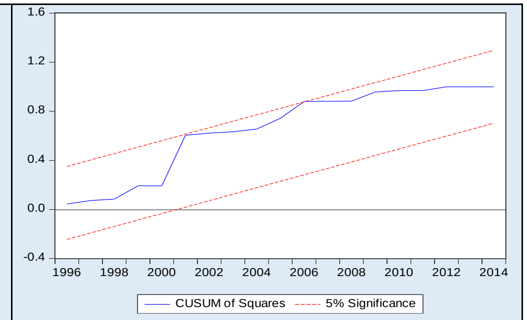
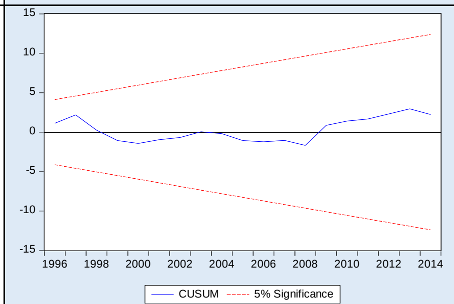
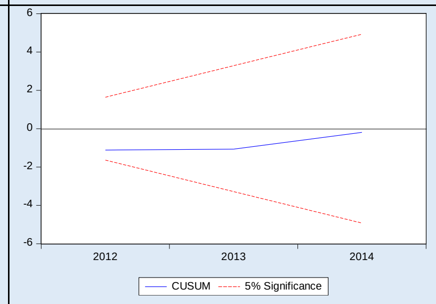
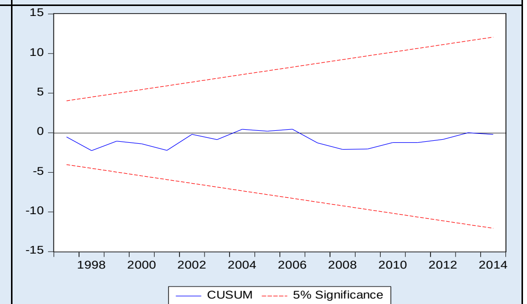
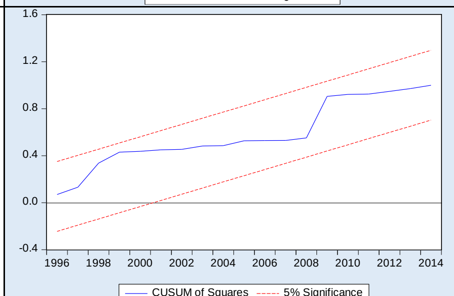
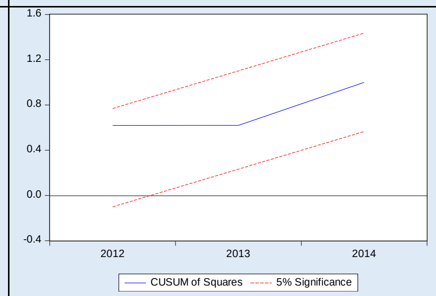
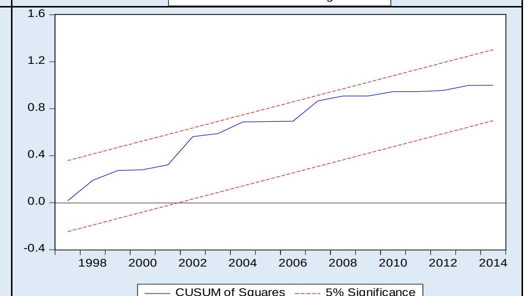
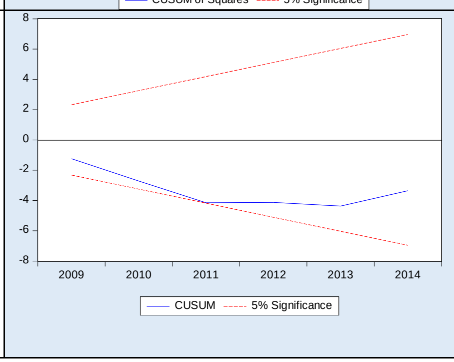
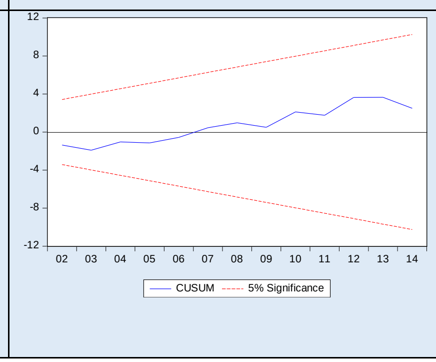
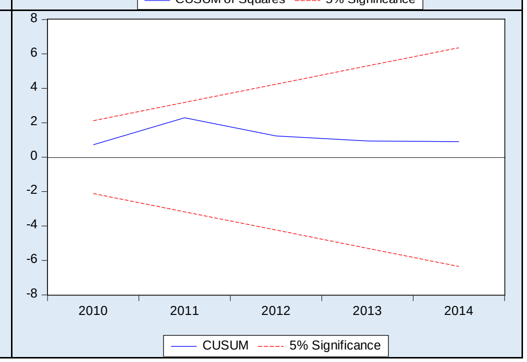
<tr><td></td><td>CUSUMSQ</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">(ln_RE|ln_GDP, ln_FDI, ln_K</td><td>CUSUM</td><td></td><td></td><td></td></tr>
<tr><td>CUSUMSQ</td><td></td><td></td><td></td></tr>
<tr><td>(ln_K|ln_GDP, ln_FDI, ln_RE)</td><td>CUSUM</td><td></td><td></td><td></td></tr>
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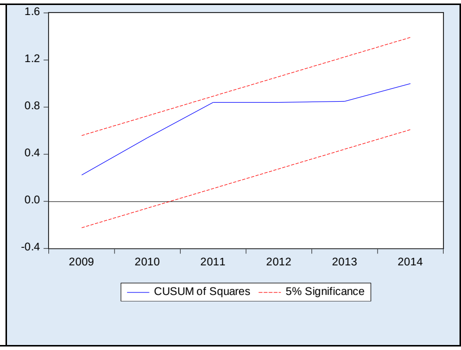
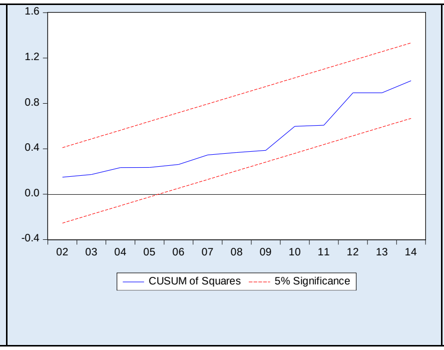
CUSUMSQ





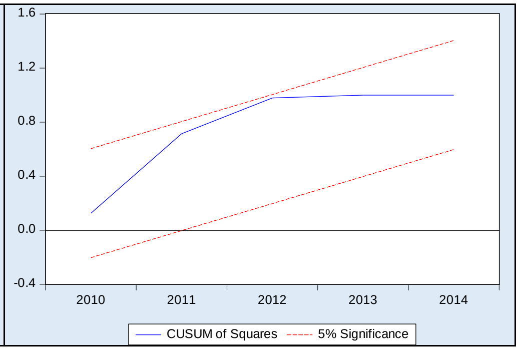


Figure *2*: CUSUM and CUSUM of squares tests

Table 4

BARDL test analysis

	Dependent variable | Independent variables	Lag-Specification	F_1	F_1^*	F_2	F_2^*	t	t^*	Dummy Variables	Co-integration Status
Algeria	(ln_GDP|ln_FDI, ln_RE, ln_K)	(4,4,3,0)	7.990	4.069	9.984	4.347	-4.158	-2.578	D91, D07	**Cointegration**
	(ln_FDI|ln_GDP, ln_RE,ln_K)	(0,0,1,4)	10.184	4.856	7.272	4.518	-6.136	-3.072	D93,D01	**Cointegration**
	(ln_RE|ln_GDP, ln_FDI, ln_K)	(0,4,1,3)	5.497	3.763	6.595	3.857	-3.117	-2.720	D90,D99	**Cointegration**
	(ln_K|ln_GDP, ln_FDI, ln_RE)	(1,1,0,1)	2.923	3.772	3.354	3.466	-2.036	-2.682	D90, D04	No-cointegration
Egypt	(ln_GDP|ln_FDI, ln_RE, ln_K)	(0,0,4,2)	6.871	2.894	8.854	3.123	3.193	-1.775	D00	**Cointegration**
	(ln_FDI|ln_GDP, ln_RE,ln_K)	(0,1,4,0)	19.874	4.061	5.367	4.394	-8.042	-2.826	D91,D11	**Cointegration**
	(ln_RE|ln_GDP, ln_FDI, ln_K)	(0,1,0,0)	5.030	4.313	2.071	3.684	-3.739	-3.270	D85,D91	Degenerate #1
	(ln_K|ln_GDP, ln_FDI, ln_RE)	(2,2,0,0)	4.484	3.813	5.150	3.276	-3.616	-2.818	D98, D09	**Cointegration**
Iran	(ln_GDP|ln_FDI, ln_RE, ln_K)	(4,1,3,0)	10.163	4.288	13.520	4.315	-2.182	-2.452	D91, D06	Degenerate #2
	(ln_FDI|ln_GDP, ln_RE,ln_K)	(1,3,1,2)	4.719	4.081	4.702	3.861	-2.745	-2.630	D88,D98	**Cointegration**
	(ln_RE|ln_GDP, ln_FDI, ln_K)	(0,1,0,3)	5.219	3.506	6.787	3.392	-2.072	-2.646	D02, D08	Degenerate #2
	(ln_K|ln_GDP, ln_FDI, ln_RE)	(1,1,2,0)	5.622	3.916	4.541	3.302	-0.520	-2.740	D88, D94	Degenerate #1
Mauritania	(ln_GDP|ln_FDI, ln_RE, ln_K)	(3,3,3,2)	13.785	3.973	13.761	3.814	-6.619	-2.166	D94, D06	**Cointegration**
	(ln_FDI|ln_GDP, ln_RE,ln_K)	(0,3,0,2)	4.488	4.216	4.386	4.561	-4.291	-3.330	D91	Degenerate#1
	(ln_RE|ln_GDP, ln_FDI, ln_K)	(0,2,0,1)	6.490	4.025	8.407	3.531	-2.901	-2.590	D86, D06	**Cointegration**
	(ln_K|ln_GDP, ln_FDI, ln_RE)	(1,1,0,0)	6.721	3.980	3.405	3.671	-4.849	-2.561	D94	Degenerate #1
Morocco	(ln_GDP|ln_FDI, ln_RE, ln_K)	(2,1,2,4)	9.656	3.505	12.540	3.789	-2.954	-1.829	D04,D09	**Cointegration**
	(ln_FDI|ln_GDP, ln_RE,ln_K)	(3,3,4,1)	7.746	3.952	5.441	4.179	-4.979	-2.055	D90,D92	**Cointegration**
	(ln_RE|ln_GDP, ln_FDI, ln_K)	(1,1,0,3)	5.402	3.670	4.860	3.163	-4.072	-1.980	D89, D93	**Cointegration**
	(ln_K|ln_GDP, ln_FDI, ln_RE)	(3,4,0,4)	4.436	3.339	3.722	3.644	-0.879	-1.763	D08	Degenerate #2

Tunisia	(ln_GDP|ln_FDI, ln_RE, ln_K)	(3,0,3,4)	3.627	3.279	3.990	3.574	3.261	-1.954	D98,D11	**Cointegration**
	(ln_FDI|ln_GDP, ln_RE,ln_K)	(0,2,2,3)	7.991	3.703	5.143	3.671	-4.950	-2.722	D89, D94	**Cointegration**
	(ln_RE|ln_GDP, ln_FDI, ln_K)	(0,0,1,1)	10.308	4.362	12.493	3.257	-5.787	-3.075	D85, D11	**Cointegration**
	(ln_K|ln_GDP, ln_FDI, ln_RE)	(3,4,1,3)	14.338	3.700	19.097	3.453	-4.089	-2.171	D89	**Cointegration**
Turkey	(ln_GDP|ln_FDI, ln_RE, ln_K)	(0,1,2,0)	3.489	3.189	4.632	3.424	-2.047	-2.445	D94, D09	Degenerate #2
	(ln_FDI|ln_GDP, ln_RE,ln_K)	(0,3,0,1)	5.564	3.836	4.460	3.792	-3.183	-2.861	D88, D95	**Cointegration**
	(ln_RE|ln_GDP, ln_FDI, ln_K)	(0,0,4,2)	4.786	3.740	3.342	3.736	-2.723	-2.845	D89	Degenerate #1
	(ln_K|ln_GDP, ln_FDI, ln_RE)	(3,4,0,0)	5.166	3.574	5.652	3.854	-1.480	-2.320	D93,D09	Degenerate #2

***Note**:* - F_1 is statistic *for the coefficients* of the lagged dependent variable *[y(-1), x(-1), z(-1) and w(-1)];*
F_2 is statistic *for the coefficients* of the lagged independent variable *[y(-1), x(-1), z(-1) and w(-1)];* -
t is statistic *for the coefficients* of the lagged dependent variable *[y(-1), x(-1), z(-1) and w(-1)];* -
D## indicates the dummy year (for example, D92 and D08 for the year 1992 and 2008, respectively that are obtained from -
LS unit root test;
are the bootstrapped critical values.F_1^*, F_2^* *and* t^* -

Test statistics (F_1, F_2, and t) and their relatively critical values at 5% level are summarized in Table 4. The existence of a long-term relationship in the model is not limited to the significance of the coefficients at the lagged level of the three variables. The presence of cointegration is supported by the significance of this test, the significance of the coefficients on the three lagged levels of the explanatory variables (i.e., $F_2 > F^*_2$), and also by the significance of the coefficient on the lagged level of the dependent variable ($t < t^*$).

However, the significance of both F_1 and F_2-tests alone is not sufficient to establish the existence of the long-run relationship among variables without the significance of the coefficient on the lagged level of the dependent variable. This case is appeared in Turkey and Iran when GDP is the dependent variable and in Iran when RE is the dependent variable. These two cases presented the example of degenerate case #2. In addition to these two cases mentioned above, another case may arise. Known as degenerate case #1, it has occurred only with the significance of the F_1 and t-tests. For example, it occurred in Egypt and Turkey when RE is the dependent variable and in Mauritania when the FDI is the dependent variable.

In summarizing, to confirm the existence of cointegration, all three test statistics (F_1, F_2, and t) must be significant. Table 4 shows that cointegration is established in all economies except Iran and Turkey, where all the tests are significant at the 5% level, when the GDP is the dependent variable and FDI, RE, and K are the independent variables. This implies that either FDI, RE, or K is an important long run determinant of GDP per capita in these economies. This result is surprising if we compare it with previous studies in terms of the existence of integration between these variables when GDP is the dependent variable. However, the evidence of the non-existence of a long-term relationship between these variables may be due to the failure to take into account the effects of structural breaks. In this sense, our result, supported by the ARDL Bootstrap test, avoids spurious evidence concerning the relationship between these variables.

For the causality analysis, as shown in Table 5 and Fig.3, we find short run Granger causality from RE to GDP for all economies except Turkey. This result reveals the growth hypothesis, according to which the renewable energy contributes to GDP per capita for these economies in the short run. In this situation, renewable energy is considered one of the main factors of production alongside labour and capital, and an increase in renewable energy consumption may lead to the increase in economic growth in these economies. This evidence is similar to some studies, such as Ben Mbarek et al. (2018) for Tunisia; Ibrahiem (2015) for Egypt; and Dees and Auktor (2018) for Morocco. However, it differs to those studies of Dogan (2015) for Turkey and Farhani (2013) for the selected MENA countries, which supported the neutrality hypothesis.

Similarly, there is evidence for Granger causality running from FDI to GDP for all economies. Same result was founded by Kalai and Zghidi (2017) for all the selected MENA countries. This implies that FDI contributes to GDP per capita for these economies which allows for accepting the FDI-led growth hypothesis in these economies in the short run.

Table 5

Granger-causality analysis

		Dependent variable			
		$ln\_GDP_{t-1}, \Delta ln\_GDP_t$	$ln\_FDI_{t-1}, \Delta ln\_FDI_t$	$ln\_RE_{t-1}, \Delta ln\_RE_t$	$ln\_K_{t-1}, \Delta ln\_K_t$
		F or t statistic [p-value]			
Algeria	Δln_GDP_t	-	2.276*** [0.069]	5.609* [0.008]	4.404*[0.000]
	Δln_FDI_t	37.660* [0.000]	-	5.388** [0.014]	6.343*[0.001]
	Δln_RE_t	1.293 [0.318]	8.218* [0.003]	-	2.045 [0.139]
	Δln_K_t	**5.379** [0.026]**	-	**2.321** [0.029]**	-
Egypt	Δln_GDP_t	-	4.115* [0.000]	2.324*** [0.085]	11.436*[0.000]
	Δln_FDI_t	3.763** [0.043]	-	4.428*[0.007]	0.522 [0.479]
	Δln_RE_t	**2.700** [0.012]**	-	-	-
	Δln_K_t	3.566** [0.031]	1.115 [0.277]	0.820 [0.421]	-
Iran	Δln_GDP_t	-	**10.195* [0.006]**	**6.033* [0.006]**	-
	Δln_FDI_t	6.114* [0.003]	-	5.560** [0.013]	6.422* [0.034]
	Δln_RE_t	**2.995*** [0.098]**	-	-	**3.511** [0.000]**
	Δln_K_t	**4.789* [0.000]**	**6.883* [0.005]**	-	-
Mauritania	Δln_GDP_t	-	5.355* [0. 009]	8.743* [0. 001]	6.420* [0.006]
	Δln_FDI_t	**4.470** [0.014]**	-	-	**4.048** [0. 033]**
	Δln_RE_t	3.369** [0.036]	3.114* [0.005]	-	5.705** [0.010]
	Δln_K_t	**3.710*** [0. 065]**	-	-	-
Morocco	Δln_GDP_t	-	3.580*** [0.055]	6.859* [0.004]	5.225* [0.006]
	Δln_FDI_t	2.605*** [0.089]	-	5.538* [0.007]	5.660** [0.018]
	Δln_RE_t	7.950* [0.003]	0.002 [0.961]	-	-
	Δln_K_t	**4.888** [0.012]**	-	**4.562** [0.016]**	-
Tunisia	Δln_GDP_t	-	2.322** [0.037]	3.320** [0.044]	3.827** [0.023]
	Δln_FDI_t	5.444* [0.008]	-	1.680 [0.208]	2.151*** [0.071]
	Δln_RE_t	2.552** [0.017	8.805* [0.001]	-	9.791* [0.000]
	Δln_K_t	13.907* [0.000]	2.129 [0.158]	6.686* [0.003]	-
Turkey	Δln_GDP_t	-	**4.100*** [0.055]**	**1.919 [0.170]**	-
	Δln_FDI_t	4.059** [0.014]	-	-	6.844* [0.005]
	Δln_RE_t	-	**3.353** [0.032]**	-	**1.574 [0.234]**
	Δln_K_t	**7.041* [0.001]**	-	-	-

Notes: [.] are refers to the p-value. Bold value represents the non-existence of co-integration. *, **, and *** indicate the significance at the 1% , 5%, and 10% levels respectively.

When FDI is the dependent variable and GDP, RE, and K are explanatory variables, the significance of all tests is verified in all countries except Mauritania, indicating the existence of a long-run relationship between FDI and the explanatory variables for these economies. This suggests that either GDP or RE or K does not determine FDI of these economies in the long run. The short run Granger causality tests indicate that GDP causes FDI in all economies, which implies that strong economic growth leads to high FDI inflows. This result is consistent with the findings of Goh et al. (2017) which show only five of eleven Asian economies exhibiting unidirectional short-run causality from GDP to FDI. This is the reverse of the conventional view which suggests that the direction of causality runs from FDI to economic growth but sees FDI as an important driver of economic growth. Therefore, based on the overall results on the causality between economic growth and FDI inflows, we would conclude that there is a two-way causality between these variables that corroborates those of Omri and Kahouli (2014b) and Kahia et al. (2017) for MENA countries.

Similarly, we find short run Granger causality from RE to FDI (table 5 and Fig.3) for all economies except Mauritania, Tunisia, and Turkey, which indicates that RE is an important short-run determinant in promoting the FDI in these countries. This indicates that any strategy aimed to reduce renewable energyy consumption (i.e., a renewable energy conservation policy) will stop FDI inflows.

Table 4 showed a long-run relationship only for Algeria, Mauritania, Morocco, and Tunisia when RE is the dependent variable. When RE is used as the dependent variable and GDP, FDI, and K are explanatory variables in these economies, all the three test statistics (F_1, F_2, and t) are significant in 5% level significance. This implies that either GDP or FDI or K is an important long run determinant of renewable energy consumption in these four economies. The short run Granger causality was found from GDP to RE for, Egypt, Iran, Mauritania, Morocco, and Tunisia. This suggests that political energy conservation resulting in a reduction of renewable energy consumption does not have a negative impact on GDP per capita in these six economies. Similarly, there is evidence for Granger causality running from FDI to RE for four countries (Algeria, Mauritania, Tunisia, and Turkey), suggesting that FDI constitutes an important short run explanatory variable of renewable energy consumption in these economies. This implies that any change in FDI flows will affect the consumption of renewable energy in these countries.

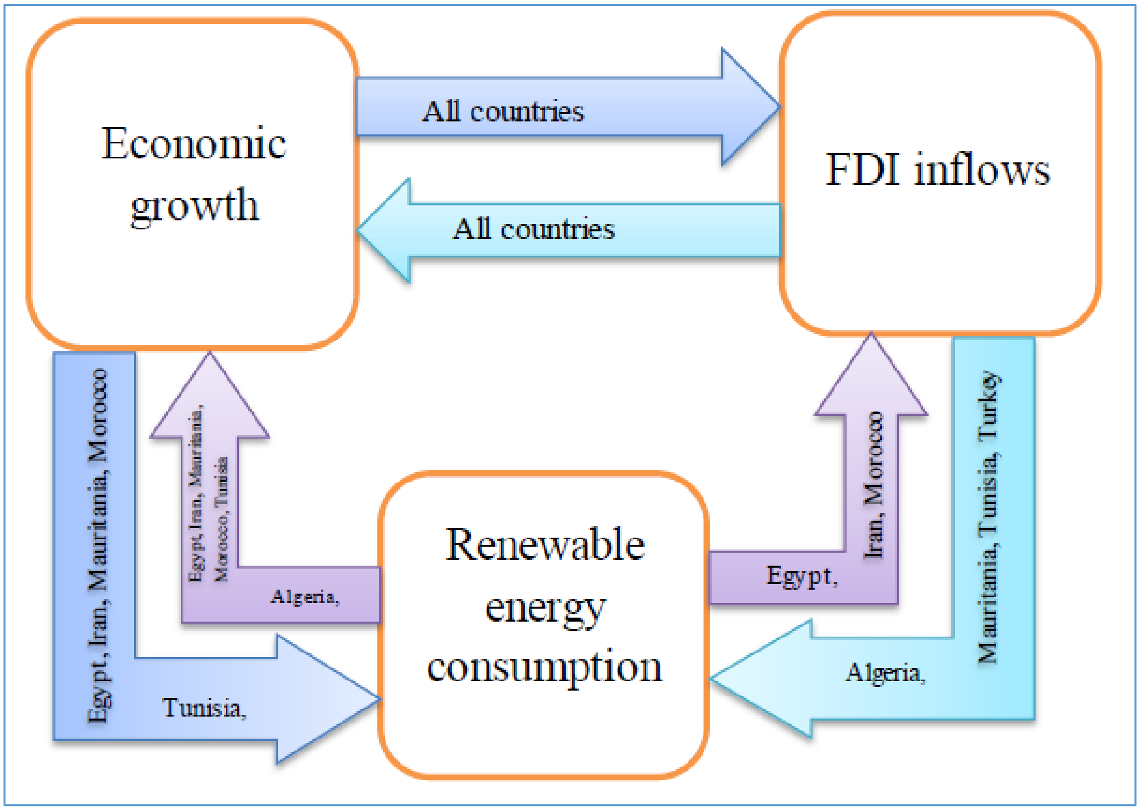


Figure 3. Granger Causality direction

5. Conclusion and policy implication

This paper examined the empirical cointegration and short-run causal relationships among economic growth, foreign direct investment (FDI), and renewable energy consumption in MENA economies from 1980 to 2017. Our analysis using the bootstrap ARDL cointegration test revealed significant findings. When GDP per capita is the dependent variable, we found cointegration for all economies except Iran and Turkey, indicating that FDI and renewable energy consumption are key long-term factors of economic growth in these regions. When FDI is the dependent variable, cointegration is present for all countries except Mauritania, suggesting that economic growth and renewable energy usage are vital in attracting FDI. For renewable energy consumption as the dependent variable, cointegration exists in Algeria, Mauritania, Morocco, and Tunisia, highlighting that GDP and FDI significantly determine long-term renewable energy consumption.

The short-run Granger-causality analysis shows a bidirectional relationship between GDP and FDI in all selected MENA countries, indicating that FDI stimulates economic growth and vice versa. The FDI and renewable energy nexus revealed varied causal directions: a bidirectional relationship in Algeria, Mauritania, and Tunisia, a unidirectional relationship from renewable energy to FDI in Egypt, Iran, and Morocco, and a unidirectional causality from FDI to renewable energy in Turkey. For the causality between economic growth and renewable energy consumption, a feedback hypothesis is supported in Egypt, Iran, Mauritania, Morocco, and Tunisia, while Algeria supports the growth hypothesis, and Turkey supports the neutral hypothesis.

These findings imply several policy recommendations. Policymakers should encourage FDI inflows by creating favourable investment environments, recognizing the mutual reinforcement between FDI and economic growth. Strategies promoting renewable energy usage will positively impact FDI, and vice versa, thus accelerating the development of the renewable energy sector. MENA countries should also focus on guiding and attracting foreign investment in renewable energy. Lastly, the interrelationship between economic growth and renewable energy consumption underscores the importance of renewable energy for economic development and vice versa. Policymakers should continue to support renewable energy sector development, facilitate private investment, and provide necessary infrastructure to meet sustainability goals.

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