Re-examining the Foreign direct investment, Renewable energy consumption and Economic growth nexus: Evidence from a new Bootstrap ARDL test for Cointegration

Ghazouani, tarek

InterVPNC FSJEGJ, University of Jendouba, Tunisia, Bisha Technical College, TVTC, Saudi Arabia

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Re-examining the Foreign direct investment, Renewable energy consumption and economic growth nexus: Evidence from a new bootstrap ARDL test for cointegration

Tarek GHAZOUANI[a,b,*]

[a] InterVPNC & FSJEGJ, University of Jendouba, Tunisia.

[b] Bisha Technical College, TVTC, Saudi Arabia.

E-mail address: ghaztarek@yahoo.com (T.Ghazouani).

Abstract

This study re-examines the long-run relationship among foreign direct investment (FDI), renewable energy consumption (RE) and economic growth (GDP) for 9 Middle East and North Africa (MENA) countries over the period 1990–2015 using a newly developed cointegration test by McNown et al. (2018), the bootstrap autoregressive distributed lag (ARDL) which allows us to generate critical values for ARDL tests that are valid and appropriate for the specific data sets used and allow for endogeneity and feedback that may exist among the variables. In the long run analysis, we found evidence of cointegraion: (i) for Algeria, Armenia, Mauritania, and Tunisia when GDP is the dependant variable; (ii) for Egypt, Iran, Israel, Tunisia and Turkey when FDI is the dependent variable; and (iii) only for Iran, Morocco, and Tunisia when RE is the dependent variable. The short run Granger-causality analysis reveals varied nature of direction of causality between all variables and that is different among countries. This confirms that uniform policy recommendation relating to the causality between these variables may not work for these selected MENA countries.

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

JEL classification: F21, O11, Q43, C15.

[*] Corresponding author.

1. Introduction

Over the past decade, the Middle East and North Africa (MENA) region are faced with the challenges of a growing population, 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.

All these developments have led many countries in the region to revise their energy policy by putting ambitious strategic goals to take advantage of renewable energy. As noted by the International Renewable Energy Agency (Irena), almost every country in the region has a goal of using renewable energies in a proportion of 5 to 15% by the year 2030. This strong growth will positively contribute to reduce CO_2 emissions, which will fall by half, leading to the limitation of global warming to 2 degrees, the threshold chosen at the COP21 in the conference of Paris on climate changes. This is especially important in the MENA region, which is greatly affected by climate change. Renewable energy should also play a fundamental role in boosting countries' economic growth by decreasing the cost of energy use in production, creating jobs, which is essential to ensure ongoing social and economic stability. Finally, the need for energy subsidies will be reduce by the widespread deployment of clean energy and the budget deficits will be improve especially in oil importing countries.

All the benefits mentioned above have led many countries in the region to establish a massive investment plans to enhance renewable energies. The stated objective of these countries is to fully cover their energy consumption over the long term for preserving the environmental framework through wind and solar energy. However, according to the Renewable Global Status Report (2017), investment in the MENA region has increased in some countries. Jordan's investment has increased by reaching USD 1.2 billion and in 2016, Egypt's investment in renewable energies amounted to nearly USD 700 million (IRENA). Similarly, according to a report by the Middle East Solar Industry Association (2017), about 4 GW of photovoltaic power and 1.3 GW of concentrated solar energy are being developed in the MENA region. The UAE and Morocco were amongst the developed countries in renewable energy development in the region, but countries such as Kuwait and Saudi Arabia are accelerating their deployment away from hydrocarbons. Faced with the emergence of renewable energies and the growth of its investments in the MENA countries in order to reach the goals mentioned above, this study aims to research the relationship between economic growth, foreign direct investment (FDI) and renewable energy consumption in nine MENA countries. Several studies regarded the FDI as a driving force behind economic growth and financial development (Maji and

Odoba, 2011; Khan et al., 2014; Aziz and Mishra, 2016). Again, Gohou and Soumaré (2012) consider that FDI constitute to the government a way of dealing the stagnation and to promote the welfare.

The relationship between economic growth, foreign direct investment and renewable energy consumption has been the subject of numerous empirical researches through various econometric methodologies including times-series analyses and panel cointegration and causality tests. Nevertheless, economists do not always arrive at consistent conclusions on this topic. To deal with the drawbacks which appear during studies revolve around the cointegration and causality amongst macroeconomic variables with the small sample properties, researchers have always used the panel analysis. Regarding the macroeconomic series, other research have used the ARDL cointegration test driven by Pesaran et al. (2001) to study the long-run relation between these series. However, recently a group of researchers (McNown et al., 2018; Goh and al., 2017; Cai et al., 2018; and Sam et al., 2019) have observed that many empirical papers can reach inaccurate results when they neglect some key assumption in Pesaran et al. (2001).

This paper re-examine the relationship between economic growth, foreign direct investment and renewable energy consumption offers multiple advantages. Contrary to existing studies which use other approaches to test cointegration which may reveal the presence of long-run relation without establishing which are the "forcing variables" and which are the explained variables in these relations, the first advantage of this study is the use new approach proposed by McNown et al. (2018), known Bootstrap ARDL test, to examine the cointegration among FDI, RE and GDP. To our knowledge this is considered as first study that uses this method to verify the cointegration between these variants. An approach, that gives us to generate critical values for ARDL tests, that are valid and appropriate for the specific data sets used and allow for endogeneity and feedback that may exist among the variables. Secondly, this paper proves that when using the bootstrap ARDL test, we can avoid a failed result of the existence of cointegration or not, if we consider degenerate cases within the ARDL test, unlike the empirical studies that use this method and employing critical values suggested by Pesaran et al. (2001) to test only one of two possible degenerate cases. With the overall F test of the lagged explained and explanatory variables to gauge the evidence of a long run relationship, it is equally necessary to verify the t statistic associated with the coefficient on the lagged explained variable and the F-statistic for the coefficients on the lagged explanatory variables (Goh and McNown, 2015).

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's provided four testable hypotheses about the correlation between energy and growth (Ozturk, 2010 and Payne, 2010). The first, known as *growth hypothesis* which supports a unidirectional causality from energy consumption to economic growth. In such situation, energy is considered one of the principal determinants of production beside labor and the capital, and an increase in the energy consumption may lead to the increase in economic growth. The second hypothesis named *conservation hypothesis* according to which there exists a unidirectional relationship from economic growth to energy consumption. The conservation hypothesis implies that political energy conservation resulting in a reduction of energy consumption does not have a negative impact on real GDP. The third is called *feedback hypothesis* which supports if there is bidirectional causality between economic growth and energy consumption, which proves their mutual relationship so that implementation of sustainable and efficient consumption policies have no negative effect on real GDP. At last, the neutrality hypothesis according to which energy consumption does not influence economic growth. Evidences show the absence total of causal link between energy consumption and growth in either direction. This considers that a change in economic growth will not affect energy consumption, and vice versa. The implication of evidence supporting this hypothesis, like the conservation hypothesis, is that policies that limit energy consumption will not have a negative impact on economic growth (Tugcu and Ozturkand Aslan, 2012).

Many studies have been done supporting each of the hypotheses relating to energy consumption and economic growth. Those studies use three energy proxies to study the relationships between energy consumption and economic growth. Some studies use only the total energy consumption, other use the renewable-energy consumption and there are studies using both the nonrenewable energy and renewable-energy consumption to examine their affect on 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 existing relationship between renewable energy consumption and income. The author used a bivariate panel error correction method for 18 emerging countries from the 1994-2003 periods. The results of its investigation 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.

Apergis and Payne (2011) studied the relationship between renewable energy consumption and economic growth in a panel of six Central American countries for the period from 1980 to 2006 utilizing error correction model and concluded that the feedback hypothesis is valid in the relationship. Contrary, Menegaki (2011) used random effect model and supported the neutrality hypothesis when he examined the causal relationship between economic growth and renewable energy consumption for 27 European countries for 1997–2007 period. Menegaki (2011) suggested that the result may be due to the uneven and the limited exploitation of renewable energy sources in Europe.

Alper and Oguz (2016) examined the causality between economic growth, renewable energy consumption, capital and labor for eight new EU member countries for the period of 1990–2009, by using an asymmetric causality test approach and ARDL approach. They found a positive impact of renewable energy consumption on economic growth among all investigated countries. In their examination, there is no causal link between renewable energy consumption and economic growth for Cyprus, Estonia, Hungary, Poland and Slovenia while a unidirectional causality running from renewable energy consumption to economic growth is present in the Czech Republic. The growth hypothesis is supported only for Bulgaria.

Rafindadi an Ozturk (2017) investigates whether the impacts of renewable energy have consolidated the economic growth prospects of Germany for the period 1971–2013. They employed the Clemente-Montanes-Reyes detrended structural break test, the Bayer-Hanck combined cointegration test and the ARDL approach. In addition, the causality analysis was observed using a VECM Granger causality framework. Rafindadi an Ozturk (2017) showed that renewable energy consumption in Germany consolidates the country's economic growth prospects. Their causality analysis revealed the existence of feedback effect between renewable energy consumption and 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 CO2 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; the sign however, differs within the countries and is not significant for the overall panel. 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 using the ARDL approach to cointegration, the Johansen cointegration test and the Gregory–Hansen cointegration test with structural break. He found no causality between renewable electricity consumption and economic growth in Turkey. For the same country, Ocal and Aslan (2013) used the ARDL approach and Toda-Yamamoto causality tests and showed that the impact of renewable energy on growth is negative, but causality reveals the conservation hypothesis. The difference between both studies might be a result of the different variables they used.

Using the ARDL approach to cointegration, Ben-Salha and Sebri (2014) searched the relationship between renewable energy consumption and growth in Tunisia for the period from 1971 to 2010 and found a bidirectional, positive relationship between renewable energy consumption and growth. Ibrahiem (2015) used a similar method to examine the relationship between renewable electricity consumption and economic growth in Egypt for the period from 1980 to 2011 and concluded the validity of the feedback hypothesis; according to which there is a bidirectional causality between economic growth and renewable electricity consumption.

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, proponents of the positive association between FDI inflows and economic growth, in the literature, are attributed to Van Loo (1977), Findally (1978), Romer (1993), Gruben and McLeod (1998), Borensztein et al. (1998) and De Mello (1999). Based on the basic neoclassical growth model of Solow (1956), they underline that FDI enhance growth by exercising a positive impact on the level of capital accumulation through increased investment and by increasing total factor productivity of host countries from technology transfers and spillovers effect. On the other hand, dependency theorists (Caves, 1971 and Hymer, 1976) 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, arguing that FDI is a strategy used by MultiNational Corporations (MNCs) in developed economies to advance monopoly power over local industries (Prebisch, 1968). The MNCs reinforce their competitive advantage over local firm, characterized by low power in terms of marketing and advertisement, by controlling the supply of inputs and earning the benefits of tax incentives in the host country.

With the nature of the association between FDI and economic growth, the causality issue has been the subject of many recent studies. Does FDI cause economic growth or does economic growth is an FDI attractor? Many studies have focused more directly on the causal relationships between FDI and growth. 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. Zhang (2001) concludes that the varied impact of FDI on economic growth is likely to be the outcome of country specific economic structures.

Chowdhury and Mavrotas (2006) tested the causal relationship between the FDI and economic growth using the Toda and Yamamoto approach, in Chile, Malaysia and Thailand for the period from

1969 to 2000.They found that FDI does not Granger-cause GDP in Chile, whereas there is a bidirectional Granger causality between GDP and FDI in Malaysia and Thailand. While Choe (2003) tested the relationship between FDI and growth by using the vector autoregression model in 80 countries for the period from 1997 to 1995 and concluded bidirectional causality between these variables, but the causal impact from FDI to GDP is shown to be weak.

Hanson and Rand (2006) used estimators for heterogeneous panel data to examine the causality between FDI and GDP in a sample of 31 developing countries covering 31 years and showed a Granger causality running for FDI to GDP, while GDP has no long run impact on FDI. According to Hanson and Rand (2006), this finding may be interpreted as evidence in favor of the hypotheses that FDI has an impact on GDP via knowledge transfers and adoption of new technology.

De Mello (1999) looks at causal links from FDI to GDP in 15 OECD and 17 non-OECD countries for the period 1970–1990. His analysis reveals three things: (i) FDI promotes growth when it complements domestic investment; (ii) the long run of FDI on GDP is heterogeneous across countries; (iii) in the non-OECD countries, there is no causality running from FDI to GDP. Like De Mello, Nair-Reichert and Weinhold (2001) emphasize highly heterogenous relationship across counties and find that FDI on average has a significant impact on growth when they used the mixed and random coefficient approach in order to test the impact of FDI on growth in 24 countries over the period 1991-1995.

Recently, Seyoum et al. (2015) used annual balanced panel data to examine the Granger causal link between FDI and economic growth for 23 African countries for the period 1970-2011. Using the recently developed panel econometric techniques, they indicated a two-way Granger causality link between FDI and economic growth and they showed that this causal link is non-homogeneous among individual countries. More specifically, Seyoum et al. (2015) observed unidirectional Granger-causality running from FDI to GDP growth only in three countries that are Egypt, Gabon, and Mauritania, and a causality relationship running from GDP growth to FDI only in Côte D'Ivoire, Kenya, South Africa and Zambia among the 23 investigated countries.

Klai and Zghidi (2017) analyzed the interrelationship between FDI, and economic growth for 15 MENA economies for the period from 1999 to 2012 using 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. Goh and al. (2017) by using the bootstrap ARDL test to cointegration, recently developed by McNown et al. (2018), to examine this long-run relationship concluded the absence of a long-run forcing relation from FDI to GDP in 11 Asian countries for the period 1970-2012. This implies that FDI is not the sole source of economic growth in these countries.

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, for example, the concentration in the secondary sector of a developing country promotes a positive FDI-energy nexus, whereas such concentration in the tertiary sector of a developed country, encourages a negative effect (Salim and al., 2017).

Researches among the link between FDI and energy have concentered on the relationship between financial development and energy demand considering FDI as an important element of financial development (Shahbaz et al., 2013; Khan et al., 2014). Early, 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. Indeed, Using a GMM methodology to analyze the impact of stock market and FDI on energy in 22 emerging economies Sadorsky (2010) finds a positive and statistically significant impact of financial development on energy use but does not find any significant association between FDI and energy use.

Using similar methodology as Sadorsky (2010), Çoban and Topcu (2013) examine the impact of financial development on energy consumption in EU27 countries and found a positive significant effect of FDI on energy consumption. Omri and Kahouli (2014), to avoid aggregation bias, examine the interrelationships among energy consumption, FDI and economic growth using dynamic panel data models in simultaneous-equations for 65 countries from 1990 to 2011 and show a bi-directional causality between FDI and energy consumption in the middle- and low-income countries, but indicate that the emphasis on environmental protection might have deterred energy-intensive FDI in high-income countries.

Salim and al. (2017) used the ARDL bound test approach to examine the relationship between FDI and energy consumption in China over the period from 1982 to 2012. They found stable relationship among these variable in the long run and a 1% increase in FDI leads t a drop in energy consumption by of 0.21%. However, they show a positive relationship between FDI and energy consumption in the short run. Salim and al. (2017) attribute this finding to the overriding of the scale effect and suggest that China should sustain the inward FDI in the tertiary and energy sectors.

We note that the majority of the studies mentioned, addressing 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) utilize 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 depends of sectoral FDI in host country and income group.

Paramati et al. (2016) investigate 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 short run unidirectional causality from the former to the latter.

After presenting the most important studies on the relationship between different interest variables, we turn in the following section to expose our research methodology by describing the ARDL bootstrap test, and to specify the data as well as the sample of our study.

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 model proposed by McNown et al. (2018). Building on the ARDL bounds testing framework of Pesaran et al. (2001), McNown et al. (2018) established that these tests have proper size and reasonable power properties. In order to verify the existence of cointegration or not, they suggested another additional test on the lagged independent variable(s) to complement the existing F and t-test's Pesaran et al. (2001). To distinguish between cases of cointegration and non-cointegrating degenerate cases as defined by Pesaran et al. (2001), it's important to use these three tests (Goh et al., 2017).

In the ARDL bounds test's Pesaran et al., for cointegration two degenerate cases are defined when the coefficients of the error correction terms are jointly significant and yet cointegration does not exist. The first, known as *Degenerate case #1*, occurs when only the lagged dependent variable is significant in the error correction term, whereas, the second, known as *degenerate case #2*, occurs if only the lagged independent variable(s) is (are) significant. There is no-cointegration since an incomplete error correction term does not help to return to equilibrium. The bounds of critical values for degenerate case #2 are presented in Pesaran et al. (2001), but not for degenerate case #1. To rule out degenerate case #1, the integration order for the dependent variable must be *I(1)*. However, according to Perron, (1989) unit root tests are notorious for having low-power. The bootstrap ARDL test examines a significance test on the coefficients of the lagged independent variables to tackle this problem. McNown et al. (2018) conducted Monte Carlo simulations and showed that this new test has reasonable size and power properties.

The autoregressive distributed lag (ARDL) model is a dynamic single-equation error-correction specification. In general, a four-variable ARDL (p,q,r,s) can be written as:

$$y_t = c + \sum_{i=1}^{p} \beta_i y_{t-i} + \sum_{j=0}^{q} \gamma_j x_{t-j} + \sum_{k=0}^{r} \tau_k z_{t-k} + \sum_{l=0}^{s} \theta_l w_{t-l} + \sum_{m=1}^{v} \chi_m D_{t,m} + \varepsilon_t \quad (1)$$

where *i, j, k,l* and *m* are indices of lags: *i = 1, 2, ..., p; j = 0, 1,...., q; k = 0, 1, ..., r; l = 1, 2,..., s; m =1,2,…v; t = 1, 2, ..., T* indicates the time periods; y_t is the dependent variable; x_t, z_t and w_t are the independent variables; $D_{t,m}$ is a dummy variable; β_i are coefficients on the lags of the dependent variable; γ_j, τ_k and θ_l are coefficients on the lags of the independent variables; χ_m is the coefficient of the m^{th} dummy variable; c is the constant term; and ε_t is the i.i.d. disturbance term with a zero mean and a finite variance, σ^2.

Eq. (1) can be re-parameterized and expressed in an error correction representation as follows:

$$\Delta y_t = c + \sum_{i=1}^{p-1} \beta_i' \Delta y_{t-i} + \sum_{j=1}^{q-1} \gamma_j' \Delta x_{t-j} + \sum_{k=1}^{r-1} \tau_k' \Delta z_{t-k} + \sum_{l=0}^{s} \theta'_l w_{t-l} + \sum_{m=1}^{v} \chi_m' D_{t,m} + \quad (2)$$

$$\varphi y_{t-i} + \alpha x_{t-j} + \rho z_{t-k} + \delta w_{t-l} + \mu_t$$

Where β_i', γ_j', τ_k', θ'_l and χ_m' are functions of the original parameters in Eq. (1), and

$\varphi = -(1 - \sum_{i=1}^{p} \beta_i)$; $\alpha = \sum_{j=0}^{q} \gamma_j$; $\rho = \sum_{k=0}^{r} \tau_k$; and $\delta = \sum_{l=0}^{s} \theta_l$

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:

$$\Delta y_t = \hat{c} + \sum_{i=1}^{p-1} \hat{\beta}_i' \Delta y_{t-i} + \sum_{j=1}^{q-1} \hat{\gamma}_j' \Delta x_{t-j} + \sum_{k=1}^{r-1} \hat{\tau}_k' \Delta z_{t-k} + \sum_{l=0}^{s} \hat{\theta}'_l w_{t-l} + \quad (3)$$

$$\hat{\varphi} y_{t-i} + \hat{\alpha} x_{t-j} + \hat{\rho} z_{t-k} + \hat{\delta} w_{t-l} + \mu_t$$

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 test on all error correction terms (denoted as F_1): $H_0 : \varphi = \alpha = \rho = \delta = 0$ against H_1 : any φ, α, ρ, $\delta \neq 0$;
- t test on the lagged dependent variable (denoted as t): $H_0 : \varphi = 0$ against $H_1 : \varphi \neq 0$;
- F test on lagged independent variables (denoted as F_2): $H_0 : \alpha = \rho = \delta = 0$ against H_1 : either α, ρ or $\delta \neq 0$.

Two degenerate cases can arise. Degenerate case #1 occurs when F_1-test and the t-test on the lagged independent variables are significant, but F_2-test on lagged dependent variable is not significant. In this case the joint significance of the error correction terms is due solely to the lag of the dependent variable; the explanatory variables are not part of the long run cointegrating relation. On the other hand, degenerate case #2 occurs when the F_1-test and the F_2-test on the lagged dependent variable are significant, but t-test on the lagged independent variables is not significant. Pesaran et al. (2001) present critical value bounds for the F_1 and the t-tests, but not for the F_2 -test on the lagged independent variables. As demonstrated in Appendix A, Fig. A.1 shows a flowchart of the bootstrap procedure[1] to obtain the critical values for all three tests are generated by McNown et al. (2018).

Goh et al. (2017) argue that the bootstrap ARDL test is appropriate to the specific models and empirical data, regardless of the integration properties of the series. Therefore, one additional advantage of this test is that, it eliminates the possibility of indeterminacy that exists with the bounds test. Since Pesaran et al. (2001) design a test that can be applied to a model with a series of mixed or unknown orders of integration; they could only present the upper and lower bounds for the critical values. The bootstrap procedure produces critical values that are specific to the integration properties of the empirical data at hand, eliminating the possibility of an indeterminate test outcome (McNown et al., 2018). The bootstrap ARDL tests present an additional advantage which that it is appropriate for models with more than one endogenous variable. The imposition of strict exogeneity of the explanatory variables by Pesaran et al. (2001) by developing the critical value bounds presents an unlikely condition for most macroeconomic relations.

After testing for the long-run relationship using the bootstrap ARDL, the standard Granger causality test will be used to determine the direction of the short run causal relationship as follows:

- If no-cointegration is established between y, x, z and w when y is the dependent variable such as in Eq. (1), then the Granger-causality test for x = > y should include the lagged differences on x only; that is, we test whether $\hat{\gamma}'_j = 0$.

[1] For more analysis see McNown et al. (2018)

- If cointegration exists among y, x, z and w, then this means the dependent and the independent variables form a stationary linear combination. As a result, the lagged levels can be treated as *I*(0) (Stock et al., 1990). In this case the Granger causality test for x = > y should include the lagged differences on x and the lagged level of x, i.e. we test whether $\hat{\gamma}_j' = \hat{\alpha} = 0$.

3.2.Model specification and Data description

The prime objective of this paper is to examine the relationship between growth, FDI and renewable energy consumption. The concept of this association will reveal in the framework of the neoclassical Cobb-Douglas production function, whereas the level of the production is explained by the traditional determinants of economic growth, such as capital and labor. According to the importance of energy use in the production, Apergis and Payane (2009, 2010, 2011) include energy renewable consumption as another factor in the production function. Similarly, other studies (Maji and Odoba, 2011; Khan et al., 2014; Aziz and Mishra, 2016) consider that FDI improves economic growth. Consistent with the mentioned studies, among others, on the determinants of economic growth, we consider, specifically, a Cobb–Douglas type production function as follows:

$$Q = e^{\mu} A (FDI)^{\alpha_1} (RE)^{\alpha_2} K^{\alpha_3} N^{\alpha_4} \qquad (4)$$

Where Q refers to the real GDP, A is the total factor productivity, FDI represents the foreign direct investment, RE, is the renewable energy consumption, K is the capital and N is the labor force. The α_1, α_2, α_3 and α_4 represent the output elasticities of foreign direct investment, renewable energy consumption, capital and labor, respectively.

In order to obtain per capita GDP, we divide both sides of Eq. (4) by N. Similarly, we assume that the production function exhibits constant returns to scale. This gives us the following function:

$$\frac{Q}{N} = e^{\mu} A \left(\frac{FDI}{N}\right)^{\alpha_1} \left(\frac{RE}{N}\right)^{\alpha_2} \left(\frac{K}{N}\right)^{\alpha_3} \qquad (5)$$

Then, the logarithmic form of Eq. (5) is such that:

$$Ln\left(\frac{Q}{N}\right) = Ln\,(A) + \alpha_1 Ln\left(\frac{FDI}{N}\right) + \alpha_2 Ln\left(\frac{RE}{N}\right) + \alpha_3 Ln\left(\frac{K}{N}\right) + \mu \qquad (6)$$

Finally, let $\frac{GDP}{N} = \frac{Q}{N}$ and $\alpha_0 = Ln\,(A)$ we get the following specification:

$$ln\_GDP_{i,t} = \alpha_0 + \alpha_1\, ln\_FDI_{i,t} + \alpha_2\, ln\_RE_{i,t} + \alpha_2\, ln\_K_{i,t} + \mu_{i,t} \qquad (7)$$

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. (7) 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.

To study this model, annual data covers the period from 1990 to 2015 are used for Algeria, Armenia Egypt, Iran, Israel, Mauritania, Morocco, Tunisia and Turkey[2]. Economic growth is measured by GDP per capita (constant 2010 US$). For FDI measure, we use as key variable the FDI net inflows (current US$ (BOP)) adjusted by GDP deflator (constant 2010 US$). The gross fixed capital formation (current US$) adjusted by GDP deflator (constant 2010 US$) is used to measure the capital K. Renewable energy consumption data cover electricity generation from geothermal, wind, solar, tide and wave, biomass and waste. The population data are used in order to obtain FDI, capital and renewable energy consumption per capita. GDP, FDI, gross fixed capital formation and population are sourced from *World Development Indicators* and RE consumption, measured in billion kilowatt hours is sourced from the *Energy Information Administration*. All variables are converted into a log form in order to remove heteroscedasticity from the regression model and also to interpret the coefficients as long-term elasticities. Table 1 displays summary statistics of GDP, FDI an RE. It shows that the selected MENA economies have similarities. With the exception of Armenia and Turkey, whose present average growth rates in real GDP per capita more than 2.5 per cent, the rest economies rates have been mostly in the 1 to 2.5 percent range. The highest mean of rates of change in GDP go hand-in-hand with strong FDI growth for all economies except Mauritania (with average growth rate in real GDP equal 0.9% compared to high FDI growth equal 11.3%). The same findings come up when we compare the GDP as well as the FDI with RE. All these observations suggest the non-uniformity of the policies adopted by MENA economies. Similarly, it suggests the difference in causal nature between these variables, which requires a more careful econometric analysis to provide effective recommendations.

4. Empirical results and discussion

The ADF by Dickeyand Fuller (1979), the PP by Philips and Perron (1988), and the ZA by Zivot-Andrews (1992) 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, and the most series are integrated on order one. Since the ADRL bound test is based on the assumption that the variables are $I(0)$ or $I(1)$, we proceed with the estimation of all the countries. The approach of the bootstrap ARDL test for the degenerate case #1 also guards against incorrect inferences if the

[2] The sample choice is driven by data availability for the study period. The Iranian data start from 1993.

dependent variable is stationary and therefore not cointegrated with the other two series (Goh et al., 2017).

As described in the previous section, to analyze the long-run relationship interactions among the variables of interest (GDP, FDI, RE), the new bootstrap ARDL tests are used. Table 4 reports the estimates and tests of this technique. Consistent with the acknowledgement that all three variables can be viewed as endogenous and that the bootstrap test permits this type of endogeneity, we renormalize the ARDL equation so that each of the three series is treated 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 price shocks, etc. The optimal lag lengths are determined using the Akaike Information Criterion (AIC). To determine the optimal lag lengths we use the Akaike Information Criterion (AIC). All estimated equations have passed diagnostic tests such as the Ljung-Box Q-test for residual autocorrelation[3]; the Jarque-Bera (JB) test to check normality; the L-M (LM) test for autocorrelation; and the Breusch-Pagan-Godfrey test to check the heteroscedasticity (H) of the residuals (table 3). Furthermore, the stability of long run estimates has been tested by applying the CUSUM and the CUSUMSQ test[4].The estimated results are compared to the critical values at 5% significance level generated from the bootstrap technique presented by McNown et al. (2018), such as F^{*}_{1}, F^{*}_{2} and t^{*}.

The table 4 reports the estimates F_1, F_2, and t and their relatively critical values F^{*}_{1}, F^{*}_{2} and t^{*}at 5% level of Eq. (3).The existence of a long-run relationship in the model is not enough just the significance of the coefficients on the lagged level of all three variables (i.e., the rejection of the hypothesis of the F_1-test ($F_1 > F^{*}_{1}$)). With the significance of this test, the significance of the coefficients on the two lagged levels of the explanatory variables (i.e., $F_2 > F^{*}_{2}$) and also the significance of the coefficient of the lagged level of dependent variable ($t < t^{*}$), the cointegration is established.

Likewise, the only significance of both F_1 and F_2 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 Egypt, and Iran when GDP is the dependent variable, in Israel and Mauritania when RE is dependent variable, and in Morocco when the FDI is the dependent variable. Both equations show significance for F_1 and F_2 but the t statistic on lagged RE and

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

on lagged FDI is not significant. 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, occurred when only the F_1 and t-tests are significant without the F_2-test is significant. For example, it's occurred in Armenia and Egypt when RE is the dependent variable.

In summarizing, to confirm the existence of cointegration, i.e., a long-run relationship with a particular choice of dependent variable in the ARDL model, all three test statistics (F_1, F_2, and t) must be significant. Table 4 shows that cointegration is established in five economies (Algeria, Armenia, Israel, Mauritania, and Tunisia), 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.

Nonetheless, as shown in table 5 and Fig.1, we find short run Granger causality from RE to GDP for all economies except in Armenia, Egypt, and Morocco. 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 labor and the capital, and an increase in the renewable energy consumption may lead to the increase in economic growth in these economies. This evidence is similar to that of Alper and Oguz (2016) in which they found causality running from renewable energy consumption to economic growth in Bulgaria. Similarly, there is evidence for Granger causality running from FDI to GDP for four economies (Algeria, Armenia, Israel, and Tunisia). This differs to the Seyoum et al., (2015)' results who's they found a unidirectional Granger-causality running from FDI to GDP in Egypt, Gabon and Mauritania. This implies that FDI contributes to GDP per capita for these economies which allows as accepting the FDI-led growth hypothesis in these economies in the short run. But the rejection of this assumption is verified for the other countries since they have no causality running from FDI to GDP. This result is consistent with Chowdhury and Mavrotas (2006) who found that FDI does not cause GDP in Chile. Likewise, the FDI-led growth hypothesis rejecting is supported by a few other studies (De Mello, 1999; Mutafoglu, 2012; Mohamed, Singh, and Liew, 2013; Goh et al., 2017).

When FDI is the dependent variable and GDP, RE and K are explanatory variables, the significance of all tests is verified only in six countries (Egypt, Iran, Israel, Mauritania, Tunisia and Turkey) indicating the existence of a long-run relationship between FDI and the explanatory variables for both 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 except Algeria, Egypt, and Morocco, 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. Goh et al. (2017) return this result to the fact that FDI may take place in these economies because its growth prospects have made it more attractive to foreign investors. Also, Herzer et al. (2008) found this direction of causality only in three economies (Indonesia, Ghana and Tunisia)[5] in a sample of 28 developing economies. This is the reverse of the conventional view which suggests that the direction of causality runs from FDI to economic growth by sees FDI as an important driver of economic growth.

Similarly, we find short run Granger causality from RE to FDI (table 5 and Fig.1) for all economies except Algeria and Tunisia which indicate that the RE is an important short-run determinant in promoting the FDI in these countries.

Table 4 showed a long-run relationship only for Iran, Morocco, and Tunisia when RE is the dependent variable. When the RE is used as the dependent variables 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, Israel, Morocco, Tunisia, and Turkey. 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. Evidence that economic growth causes renewable energy consumption, is found in a few studies (Sardosky, 2009; Ocal and Aslan, 2013; Long et al., 2015; Omri et al., 2015; Alper and Oguz, 2016; Mbarek et al., 2017).Similarly, there is an evidence for Granger causality running from FDI to RE for all countries except Egypt and Turkey suggest that the FDI constitute an important short run explanatory variable of renewable energy consumption in these economies.

5. Conclusion and policy implication

This paper has examined the empirical cointegration and the short-run causal relationships among economic growth, foreign direct investment and renewable energy consumption in the case of MENA economies over the period of 1980–2015. There is some thought that encouraging inward FDI constitute a source of finance that enhance economic growth and promote financial development specifically in host countries. On the other hand, many believe that FDI can be a source of innovation

[5] This is consistent with our finding for Tunisia.

that promotes energy efficiency. Around these opinions and according to the view that renewable Energy can play a major role in boosting countries' economic growth, we expect the existence of a long run relationship among these variables and exceptionally when the proxy's variable for economic growth /or financial development is the dependent variable. We have applied a newly developed cointegration test, the bootstrap ARDL, to examine this long-run relationship between FDI, renewable energy consumption, and GDP in MENA economies. An approach, which allows us to generate critical values for ARDL tests that are valid and appropriate for the specific data sets used and allow for endogeneity and feedback that may exist among the variables. Furthermore, we can avoid a failed result of the existence of cointegration or not, if we consider degenerate cases within the ARDL test, unlike the empirical studies that use this method and employing critical values proposed by Pesaran et al. (2001) to test only one of two possible degenerate cases.

Another aspect of this study concerns the demonstration of the occurrence of degenerate cases. Using the ARDL approach to FDI, renewable energy consumption, and GDP in MENA region, we show that the inferences based on the F and t-tests provided by Pesaran et al. (2001) are not sufficient to uncover both degenerate cases. To overcome this deficiency, the two tests of Pesaran et al. are augmented by the test of McNown et al. (2018), the bootstrap test on the significance of the lagged level(s) of the explanatory variable(s). The empirical application of the bootstrap test to FDI, RE consumption and GDP of several MENA economies demonstrate that both degenerate cases can occur in practical applications and that misleading findings can lead if possibility is ignored.

Empirically, when GDP per capita is the dependent variable, we found evidence of cointegtation for five economies (Algeria, Armenia, Israel, Mauritania, and Tunisia), indicating that the foreign direct investment and the renewable energy consumption with the capital are the sole sources of economic growth in these economies, in the long run. Similarly, among these economies, we found evidence of cointegration only in six economies (Egypt, Iran, Israel, Mauritania, Tunisia, and Turkey) when FDI is the dependent variable. This implies that economic growth and benefits experienced by these economies in terms of growth in the use of renewable energy are a vital factor to attract foreign direct investment. Results that can motivate economists and policymakers to encourage countries to become more involve in renewable energy investment. Furthermore, our study finds evidence of cointegration for Iran, Morocco, and Tunisia when RE is the dependent variable. For these economies, GDP and FDI constitute important long run determinant of renewable energy consumption.

The short run Granger-causality analysis reveals that the bidirectional relations between GDP and FDI apply in Armenia, Israel, and Tunisia. Unidirectional causality from FDI to GDP works only in Algeria and a Granger causality running from GDP to FDI were founded in Iran, Mauritania, and Turkey. However, for Egypt and Morocco, there is no causality between FDI and GDP which confirms

Granger-neutrality. The varied nature of the direction of causality confirms that uniform policy recommendation relating to FDI and growth may not work in these MENA countries. More specifically, we document that FDI can stimulate economic growth in some MENA economies. On the other hand, economic growth can also promote FDI given that some local advantages might be favored by the government policies. In order to enhance the economic performance, the policy makers in these economies should continue supporting FDI by discovering their own advantages and providing better investment environments for foreign firms.

When it comes to the nexus of FDI and renewable Energy, our study found varied nature of the direction of causality. Using Granger-causality, it has been observed unidirectional short run causality for Armenia, Egypt, Morocco and Turkey from renewable energy to foreign direct investment and reverse causality (i.e., from foreign direct investment to renewable energy) only for Algeria. Only in case of Armenia, Israel and Tunisia a bidirectional causal relationship exists. The short-run impact and the presence of the long-run dependence of FDI on renewable energy; and vice versa for some MENA economies, implicates two principal things: on one hand that strategy implemented to push the use of renewable energy will have a positive effect on foreign direct investment; on another hand, the positive impact on foreign direct investment from the utilization of renewable energy further speeds up the progress of the renewable energy sector. As pointed out by Amri (2016), policy makers should give importance still for renewable energy resources development since it has a vital role to attract foreign direct investment.

Concerning the short run causality between economic growth and renewable energy consumption our finding supported: (i) feedback hypothesis for three economies that are Israel, Tunisia, and Turkey; (ii) growth hypothesis for Algeria and Iran; (iii) conservation hypothesis for Egypt and Morocco; and (iv) neutrality hypothesis for Armenia and Mauritania.

The interrelationship among economic growth and renewable energy consumption emphasize that this type of energy source is important for economic growth and at the same time, economic growth encourages the use of more renewable energy source. The causality found provides an avenue to continue the use of government policies that enhance the development of the renewable energy sector (Apergis and Danuletu, 2014). While the non-presence of causality in Mauritania, encourages policymakers to support more in the use of renewable energy. Again, given the natural characteristics of the Middle East and North Africa region, the expansion of the renewable energy sector may serve as an impetus for the modernization of the energy sector in meeting sustainability objectives specified by policy makers (Kaygusuz, 2007). As pointed out by Apergis and Danuletiu (2014), generating resource needs for R&D in renewable energy technologies and corresponding infrastructure, require economic growth in order to facilitate expansion of the renewable energy sector. Furthermore, policy makers should encourage private investment in this area, provide adequate infrastructure for networks, and facilitate access to the vast areas needed to implement projects.

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Table 1. Summary of statistics.

Economies	Algeria				Armenia				Egypt			
Variables	GDP	FDI	RE	K	GDP	FDI	RE	K	GDP	FDI	RE	K
Mean	0.011	-0.102	0.010	0.029	0.031	0.109	-0.050	0.0007	0.021	0.028	-0.007	-0.005
Median	0.017	0.000	-0.018	0.036	0.067	-0.288	-0.050	0.056	0.021	0.079	-0.003	0.009
Maximum	0.056	2.994	1.779	0.267	0.137	11.318	13.466	0.561	0.051	5.135	0.212	0.194
Minimum	-0.043	-6.054	-1.399	-0.141	-0.523	-9.584	-13.272	-1.035	-0.012	-6.184	-0.192	-0.203
Std. Dev.	0.023	1.464	0.737	0.103	0.136	5.486	5.377	0.322	0.017	1.751	0.098	0.104
Skewness	-0.617	-2.408	0.464	0.135	-2.902	0.120	0.108	-1.338	0.000	-0.810	0.437	0.069
Kurtosis	3.433	12.766	2.835	2.494	12.108	2.878	6.240	5.695	2.395	10.066	3.240	2.091

Economies	Iran				Israel				Mauritania			
Variables	GDP	FDI	RE	K	GDP	FDI	RE	K	GDP	FDI	RE	K
Mean	0.016	0.034	0.015	0.005	0.017	0.124	0.212	0.015	0.009	0.113	0.068	0.053
Median	0.013	-0.018	0.007	-0.009	0.017	0.124	-0.017	0.003	0.016	0.098	0.010	0.051
Maximum	0.099	2.148	0.442	0.287	0.052	1.049	1.574	0.235	0.144	17.329	0.663	1.173
Minimum	-0.090	-2.614	-1.255	-0.161	-0.023	-1.522	-0.487	-0.072	-0.071	-16.603	-0.099	-0.814
Std. Dev.	0.039	0.842	0.343	0.097	0.019	0.604	0.465	0.065	0.043	6.500	0.179	0.387
Skewness	-0.303	-0.555	-2.017	0.964	-0.401	-0.721	1.147	1.344	0.808	-0.276	2.155	0.462
Kurtosis	3.683	7.193	8.612	4.482	2.600	3.516	4.487	5.943	4.908	6.398	6.849	4.922

Economies	Morocco				Tunisia				Turkey			
Variables	GDP	FDI	RE	k	GDP	FDI	RE	K	GDP	FDI	RE	K
Mean	0.024	0.092	0.034	0.029	0.025	0.075	0.062	0.017	0.028	0.077	0.031	0.039
Median	0.029	0.052	-0.011	0.018	0.027	0.018	0.000	0.033	0.043	0.138	0.025	0.070
Maximum	0.102	3.001	1.189	0.120	0.054	1.482	1.067	0.176	0.090	1.194	0.426	0.276
Minimum	-0.070	-1.764	-0.822	-0.054	-0.030	-1.178	-0.704	-0.148	-0.076	-1.796	-0.295	-0.286
Std. Dev.	0.038	0.981	0.457	0.052	0.020	0.681	0.462	0.066	0.047	0.696	0.197	0.141
Skewness	-0.469	1.145	0.493	0.191	-0.644	0.422	0.291	-0.319	-1.048	-0.883	0.355	-0.790
Kurtosis	3.470	5.546	3.400	2.104	3.419	2.581	3.064	3.938	2.949	4.057	2.397	3.006

Note: The descriptive statistics are based on the differences of the logarithms of each variable.

Table 2. Unit root test results

Economies	Algeria				Armenia				Egypt			
Var./tests	ADF	PP	ZA	BY	ADF	PP	ZV	BY	ADF	PP	ZA	BY
Ln_GDP	0.723	-0.876	-5.639*	2002	-0.658	-0.290	-8.355*	2009	-1.286	-0.345	-6.421*	2006
Δln_GDP	-3.281**	-3.238**	-5.177**	1995	-3.053**	-2.841	-9.301*	2009	-3.318**	-3.078**	-4.555	2011
	(0.027)	(0.030)			(0.044)	(0.067)			(0.026)	(0.041)		
Ln_FDI	-1.359	-1.359	-1.094	1996	-3.422**	-3.563**	-4.292	2000	-3.767*	-3.765*	-5.151**	2011
					(0.019)	(0.014)			(0.009)	(0.009)		
Δln_FDI	-5.227*	-5.089*	-3.561**	2010	-7.555*	-7.555*	-5.158**	2000	-7.143*	-8.124*	-7.116*	2008
	(0.000)	(0.000)			(0.000)	(0.000)			(0.000)	(0.000)		
Ln_RE	-3.353**	-3.429**	-4.705	2003	-5.593*	-5.686*	-4.573	1998	-2.152	-2.107	-3.454	1995
	(0.029)	(0.019)			(0.000)	(0.000)						
Δln_RE	-7.078*	-8.403*	-7.838*	2003	-7.158*	-19.32*	-7.279*	2004	-6.544*	-6.544*	-7.136*	2002
	(0.000)	(0.000)			(0.000)	(0.000)			(0.000)	(0.000)		
Ln_K	0.796	1.063	-3.045	1996	-1.374	-1.302	-5.370*	2011	-2.310	-1.985	-3.782	2011
Δln_K	-3.932*	-3.864*	-5.825*	2010	-4.914*	-3.191**	-5.993*	2009	-3.517**	-3.519**	-6.322*	2004
	(0.006)	(0.007)			(0.000)	(0.031)			(0.016)	(0.016)		

Economies	Iran				Israel				Mauritania			
Var./tests	ADF	PP	ZA	BY	ADF	PP	ZV	BY	ADF	PP	ZA	BY
Ln_GDP	-1.005	-1.013	-4.054	2012	-1.378	-1.360	-3.471	2002	-0.452	-0.512	-4.476	2006
Δln_GDP	-3.679**	-3.742**	-4.815	2002	-4.216*	-4.221*	-5.359*	2004	-4.459*	-4.441*	-5.023**	2008
	(0.012)	(0.011)			(0.003)	(0.003)			(0.001)	(0.002)		
Ln_FDI	-1.252	-1.385	-5.16**	2000	-2.655	-2.809	-4.363	2009	-5.016*	5.033*	-11.13**	2011
									(0.000)	(0.000)		
Δln_FDI	-5.968*	-5.645*	-7.398*	2003	-4.979*	-7.421*	-5.427*	2001	-8.948*	-24.37*	-13.04**	2010
	(0.000)	(0.000)			(0.000)	(0.000)			(0.000)	(0.000)		
Ln_RE	-2.273	-2.273	-3.414	2008	-0.713	-0.807	-3.537	2010	2.463	3.855	-0.975	2009
Δln_RE	-4.351*	-4.349*	-4.810	2001	-4.205*	-4.179*	-6.473*	2008	-5.253*	-5.253*	-7.230*	2009
	(0.002)	(0.002)			(0.003)	(0.003)			(0.000)	(0.000)		
Ln_K	-1.737	-1.650	-3.390	2008	-2.179	-3.516**	-3.459	2001	-1.298	-1.298	-4.204	1996
						(0.016)						
Δln_K	-4.182*	-4.182*	-6.757*	2007	-3.631*	-5.273*	-4.929*	2004	-6.601*	-6.902*	-7.313*	2006
	(0.004)	(0.004)			(0.001)	(0.000)			(0.000)	(0.000)		

Economies Var./tests	Morocco				Tunisia				Turkey			
	ADF	PP	ZA	BY	ADF	PP	ZV	BY	ADF	PP	ZA	BY
Ln_GDP	1.482	0.776	-5.560^{*}	2006	-1.229	-1.204	-3.024	2011	0.540	0.605	-3.555	1999
Δln_GDP	-10.07^{*}	-9.292^{*}	-5.449^{*}	2002	-4.084^{*}	-4.092^{*}	-5.518^{*}	1996	-4.948^{*}	-4.948^{*}	-5.317^{**}	2003
	(0.000)	(0.000)			(0.004)	(0.004)			(0.000)	(0.000)		
Ln_FDI	-1.550	-1.401	-5.913^{*}	2003	-3.616^{**}	-3.609^{**}	-4.900	2011	-1.699	-1.643	-3.549	2009
					(0.012)	(0.013)						
Δln_FDI	-6.533^{*}	-6.528^{*}	-8.170^{*}	2000	-7.024^{*}	-7.170^{*}	-5.393^{*}	2010	-4.580^{*}	-6.719^{*}	-5.343^{*}	2006
	(0.000)	(0.000)			(0.000)	(0.000)			(0.001)	(0.000)		
Ln_RE	-2.064	-2.098	-5.182^{**}	2009	-1.671	-1.671	-3.669	2009	-2.013	-1.870	-3.998	2000
Δln_RE	-5.494^{*}	-5.786^{*}	-7.310^{*}	1999	-5.476^{*}	-5.607^{*}	-5.877^{*}	2006	-5.881^{*}	-5.873^{*}	-6.211^{*}	2009
	(0.000)	(0.000)			(0.000)	(0.000)			(0.000)	(0.000)		
Ln_K	-0.577	-0.233	-3.538	2004	-1.771	-1.771	-2.990	2011	-0.504	-0.504	-3.411	1999
Δln_K	-2.951	-2.923	-5.122^{**}	2009	-4.071^{*}	-4.087^{*}	-4.089	2010	-5.099^{*}	-5.099^{*}	-5.624^{*}	2003
	(0.054)	(0.057)			(0.004)	(0.000)			(0.000)	(0.000)		

Notes: Values in (.) are p-value. *and **and *** symbolize statistical significance at the 1% and 5% levels respectively. The t-statistic of ZV test are compared to critical value of this test at 1% and 5% levels which equal to -5.34 and -4.93 respectively. BY is the Breack point Year for the ZV test.

Table 3. Results from the diagnostic error tests

Economies Eq./tests	Algeria			Armenia			Egypt		
	JB	LM	H	JB	LM	H	JB	LM	H
Eq_GDP	0.253	0.353	0.971	0.375	0.381	0.934	0.446	0.770	0.932
	(0.881)	(0.364)	(0.412)	(0.828)	(0.442)	(0.434)	(0.799)	(0.259)	(0.431)
Eq_FDI	0.727	0.761	0.839	0.546	0.386	0.880	2.015	0.776	0.871
	(0.477)	(0.172)	(0.480)	(0.760)	(0.689)	(0.463)	(0.364)	(0.213)	(0.469)
Eq_RE	0.006	1.092	0.450	0.661	0.033	0.371	2.788	0.535	1.051
	(0.996)	(0.116)	(0.781)	(0.718)	(0.926)	(0.860)	(0.247)	(0.360)	(0.376)
Eq_K	1.914	0.082	0.808	0.316	0.136	0.726	0.894	0.292	0.827
	(0.383)	(0.813)	0.505	(0.853)	(0.757)	(0.564)	(0.653)	(0.630)	(0.488)
Conclusion	ND	No SC	No H	ND	No SC	No H	ND	No SC	No H

Economies Eq./tests	Iran			Israel			Mauritania		
	JB	LM	H	JB	LM	H	JB	LM	H
Eq_GDP	1.552	0.005	0.187	1.494	0.903	1.221	0.458	0.710	0.698
	(0.460)	(0.983)	(0.968)	(0.473)	(0.185)	(0.310)	(0.795)	(0.321)	(0.580)
Eq_FDI	0.570	0.148	0.183	0.661	0.642	1.070	1.563	0.689	830
	(0.751)	(0.666)	(0.970)	(0.718)	(0.253)	(0.369)	(0.457)	(0.305)	(0.493)
Eq_RE	0.701	1.721	1.248	0.304	0.753	0.433	0.243	1.129	1.362
	(0.704)	(0.493)	(0.305)	(0.858)	(0.236)	(0.798)	(0.885)	(0.140)	(0.264)
Eq_K	0.213	0.554	0.487	1.645	0.828	1.425	2.958	1.249	1.628
	(0.898)	(0.210)	(0.711)	(0.439)	(0.209)	(0.251)	(0.227)	(0.150)	(0.195)
Conclusion	ND	No SC	No H	ND	No SC	No H	ND	No SC	No H

Economies Eq./tests	Morocco			Tunisia			Turkey		
	JB	LM	H	JB	LM	H	JB	LM	H
Eq_GDP	2.732	0.273	1.688	0.629	0.640	1.608	2.405	0.066	1.677
	(0.255)	(0.606)	(0.185)	(0.729)	(0.330)	(0.200)	(0.300)	(0.800)	(0.199)
Eq_FDI	0.802	0.054	1.027	0.887	0.620	0.938	0.613	0.960	1.303
	(0.669)	(0.901)	(0.385)	(0.641)	(0.213)	(0.431)	(0.735)	(0.156)	(0.286)
Eq_RE	0.979	0.057	1.080	0.686	1.165	1.013	1.069	0.172	1.080
	(0.612)	(0.814)	(0.372)	(0.709)	(0.174)	(0.390)	(0.585)	(0.665)	(0.365)
Eq_K	1.883	0.644	1.109	1.027	0.064	0.314	0.879	0.443	1.683
	(0.389)	(0.236)	(0.356)	(0.598)	(0.875)	(0.903)	(0.644)	(0.242)	(0.243)
Conclusion	ND	No SC	No H	ND	No SC	No H	ND	No SC	No H

Notes: Values in (.) are p-value that are compared with the 10% level of significance. ND, No SC, and No H indicate normally distribution, no serial correlation and no heteroscedasticity, respectively.

Table 4. Long-run analysis

Country	Dependant variable∣ Independent variable	Lag Specifi-cation	F_1	F_1^*	F_2	F_2^*	t	t^*	Dummy Variables	Cointegration Status
Algeria	(lnGDP∣lnFDI, lnRE, lnK)	(2,1,0,2)	12.490	4.624	13.932	4.626	-2.952	-2.873	D95,D01,D04	**Cointegration**
	(lnFDI∣lnGDP, lnRE,lnK)	(0,2,2,0)	1.063	3.496	1.211	3.636	-1.189	-2.147	D96,D98,D01	No-cointegration
	(lnRE∣lnGDP, lnFDI, lnK)	(2,2,0,0)	7.670	5.567	2.382	4.342	-3.112	-3.366	D00,D02,D05	No-cointegration
	(lnK∣lnGDP, lnFDI, lnRE)	(1,1,0,0)	12.778	4.126	15.642	3.978	-6.232	-2.691	D98,D00,D05,D09, D13	**Cointegration**
Armenia	(lnGDP∣lnFDI, lnRE, lnK)	(1,1,0,1)	5.254	3.598	6.752	3.763	3.745	-2.254	D95,D07,D09	**Cointegration**
	(lnFDI∣lnGDP, lnRE,lnK)	(0,1,1,1)	4.087	4.520	3.569	4.040	-2.540	-3.003	D01, ,D05,D06, D11	No-cointegration
	(lnRE∣lnGDP, lnFDI, lnK)	(0,0,1,1)	519.64	4.286	3.389	4.394	-40.21	-2.416	D98,D01,D02,D08	Degenerate #1
	(lnK∣lnGDP, lnFDI, lnRE)	(1,0,1,0)	13.646	4.870	10.960	4.636	-5.660	-3.164	D95,D05,D07	**Cointegration**
Egypt	(lnGDP∣lnFDI, lnRE, lnK)	(0,0,0,2)	22.416	3.208	20.340	3.354	-0.123	-1.883	D06, D08	Degenerate #2
	(lnFDI∣lnGDP, lnRE,lnK)	(1,0,1,0)	26.154	4.191	15.155	4.559	-7.041	-2.906	D04,D05,D06,D11	**Cointegration**
	(lnRE∣lnGDP, lnFDI, lnK)	(0,1,0,0)	17.757	4.373	3.312	4.745	-7.801	-3.100	D99,D01,D07, D09	Degenerate #1
	(lnK∣lnGDP, lnFDI, lnRE)	(1,0,0,0)	2.892	5.024	0.545	5.168	-2.887	-3.727	D10	No-cointegration
Iran	(lnGDP∣lnFDI, lnRE, lnK)	(1,0,1,0)	11.378	3.732	14.711	3.765	1.507	-2.101	D01,D07,D11,D12	Degenerate #2
	(lnFDI∣lnGDP, lnRE,lnK)	(1,0,1,1)	24.704	3.719	26.456	3.854	3.649	-1.859	D99,D00, ,D02, D13	**Cointegration**
	(lnRE∣lnGDP, lnFDI, lnK)	(0,0,1,1)	12.873	4.231	16.846	4.135	-5.274	-2.721	D98,D04,D08	**Cointegration**
	(lnK∣lnGDP, lnFDI, lnRE)	(0,1,1,1)	41.951	8.131	23.111	6.832	-8.718	-4.4.13	D97,D02,D04,D10	**Cointegration**
Israel	(lnGDP∣lnFDI, lnRE, lnK)	(1,0,1,0)	9.604	3.582	10.605	3.788	-5.836	-2.144	D01, D10,D11	**Cointegration**
	(lnFDI∣lnGDP, lnRE,lnK)	(1,1,0,1)	9.747	3.940	5.543	4.382	-4.736	-2.399	D99,D00,D06	**Cointegration**
	(lnRE∣lnGDP, lnFDI, lnK)	(0,1,1,0)	6.138	4.711	6.854	4.256	-0.380	-3.243	D98,D05,D09	Degenerate #2
	(lnK∣lnGDP, lnFDI, lnRE)	(0,1,0,1)	4.308	4.208	3.966	3.678	-3.329	-2.935	D01,D02,D10	**Cointegration**
Mauritania	(lnGDP∣lnFDI, lnRE, lnK)	(0,0,0,1)	10.481	4.612	13.750	4.708	-3.911	-3.271	D97,D99	**Cointegration**
	(lnFDI∣lnGDP, lnRE,lnK)	(1,0,0,0)	26.228	5.761	34.971	5.204	-5.965	-2.938	D93,D95,D10	**Cointegration**
	(lnRE∣lnGDP, lnFDI, lnK)	(0,0,1,1)	22.644	3.916	16.260	3.824	-0.749	-2.459	D01,D03,D09	Degenerate #2
	(lnK∣lnGDP, lnFDI, lnRE)	(0,0,2,0)	2.293	4.106	2.671	3.623	-2.451	-2.775	D94	No-cointegration
Morocco	(lnGDP∣lnFDI, lnRE, lnK)	(1,0,0,0)	1.347	3.094	1.358	3.232	0.902	-1.929	D93, D95,D00	No-cointegration
	(lnFDI∣lnGDP, lnRE,lnK)	(2,2,0,0)	6.180	3.896	8.214	4.071	-1.269	-2.742	D99,D00,D03	Degenerate #2
	(lnRE∣lnGDP, lnFDI, lnK)	(1,1,0,1)	38.695	6.205	37.887	6.314	-10.54	-3.427	D02,D04,D08,D11, D13	**Cointegration**
	(lnK∣lnGDP, lnFDI, lnRE)	(1,1,0,0)	2.417	3.750	2.931	3.901	-1.728	-2.500	D02,D07,D09,D13	No-cointegration
Tunisia	(lnGDP∣lnFDI, lnRE, lnK)	(1,0,10)	26.432	2.995	32.395	3.219	8.166	-1.885	D00, D04	**Cointegration**
	(lnFDI∣lnGDP, lnRE,lnK)	(1,1,0,1)	12.490	3.572	5.476	3.770	-4.421	-1.854	D92,D99,D06,D11, D12	**Cointegration**
	(lnRE∣lnGDP, lnFDI, lnK)	(0,0,1,0)	7.323	4.754	9.055	4.594	-5.118	-3.231	D04, D14	**Cointegration**
	(lnK∣lnGDP, lnFDI, lnRE)	(1,1,0,1)	25.221	5.026	28.399	3.559	-9.547	-2.811	D98,D04	**Cointegration**
Turkey	(lnGDP∣lnFDI, lnRE, lnK)	(0,0,2,1)	1.539	3.371	1.765	3.493	-0.911	-2.011	D94,D99	No-cointegration
	(lnFDI∣lnGDP, lnRE,lnK)	(1,1,0,1)	21.881	4.436	23.600	4.793	-8.915	-2.390	D04,D05,D09	**Cointegration**
	(lnRE∣lnGDP, lnFDI, lnK)	(0,2,0,2)	2.022	3.598	2.327	3.965	-1.117	-2.181	D99, D08	No-cointegration
	(lnK∣lnGDP, lnFDI, lnRE)	(1,0,2,2)	25.404	6.017	32.579	6.473	-7.607	-3.640	D93,D99,D01	**Cointegration**

*Note: F1 is the F statistic for the coefficients of y(-1), x(-1), z(-1) and w(-1); F2 is the F statistic for the coefficients of x(-1), z(-1) and w(-1); t denotes the t statistic for the coefficient of y(-1). D## refers to the dummy of that year. Example, D93 indicates a dummy variable for the year 1993 and D11 for the year 2011. Notations with an asterisk, *, symbolize significance at 5%, based on critical values generated from the bootstrap method suggested by McNown et al. (2018).*

Table 5. Granger-causality analysis

Country	Dependant 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	-	15.281* [0.001]	23.343* [0.000]	8.333* [0.005]
	Δln_FDI_t	**1.780 [0.218]**	**-**	**1.636 [0.242]**	**- [ ]**
	Δln_RE_t	**2.303 [0.146]**	**3.282*** [0.097]**	-	**- [ ]**
	Δln_K_t	20.381* [0.000]	- [ ]	- [ ]	-
Armenia	Δln_GDP_t	-	7.525* [0.007]	- [ ]	14.889* [0.000]
	Δln_FDI_t	**3.228*** [0.099]**	-	**-4.894* [0.000]**	9.164** [0.011]
	Δln_RE_t	**- [ ]**	**-3.845* [0.002]**	-	**-4.552* [0.000]**
	Δln_K_t	4.465* [0.000]	19.287* [0.000]	-1.504 [0.156]	-
Egypt	Δln_GDP_t	-	**- [ ]**	**- [ ]**	**69.338* [0.000]**
	Δln_FDI_t	1.610 [0.133]	-	13.969* [0.000]	- [ ]
	Δln_RE_t	**3.669* [0.002]**	**- [ ]**	-	**- [ ]**
	Δln_K_t	**- [ ]**	**- [ ]**	**- [ ]**	-
Iran	Δln_GDP_t	-	**- [ ]**	**3.833* [0.004]**	- [ ]
	Δln_FDI_t	4.974* [0.000]	-	46.157* [0.000]	21.769* [0.000]
	Δln_RE_t	0.112 [0.912]	20.213* [0.000]	-	6.561** [0.015]
	Δln_K_t	34.891* [0.000]	36.470* [0.000]	18.357* [0.001]	-
Israel	Δln_GDP_t	-	5.097* [0.000]	20.624* [0.000]	-0.234 [0.818]
	Δln_FDI_t	10.265* [0.003]	**-**	-2.445** [0.0325]	6.653** [0.012]
	Δln_RE_t	**3.307* [0.006]**	**-3.088* [0.009]**	-	**- [ ]**
	Δln_K_t	11.649* [0.001]	1.574 [0.1414]	7.036* [0.009]	-
Mauritania	Δln_GDP_t	-	0.341 [0.737]	0.032 [0.974]	26.686* [0.000]
	Δln_FDI_t	2.208** [0.044]	-	-8.973* [0.000]	3.672* [0.002]
	Δln_RE_t	**- [ ]**	**10.140* [0.000]**	-	**2.251** [0.042]**
	Δln_K_t	**- [ ]**	**1.637 [0.229]**	**- [ ]**	-
Morocco	Δln_GDP_t	-	**- [ ]**	**- [ ]**	**- [ ]**
	Δln_FDI_t	**- [ ]**	-	**-5.086* [0.000]**	**- [ ]**
	Δln_RE_t	17.775* [0.001]	-5.139* [0.000]	-	-0.623 [0.550]
	Δln_K_t	**-4.896* [0.000]**	**- [ ]**	**2.116*** [0.057]**	-
Tunisia	Δln_GDP_t	-	5.172* [0.000]	7.570* [0.005]	94.610* [0.000]
	Δln_FDI_t	6.856** [0.013]	-	-1.457 [0.175]	8.066* [0.008]
	Δln_RE_t	2.285** [0.037]	7.152* [0.006]	-	1.847*** [0.084]
	Δln_K_t	42.107* [0.000]	-3.321* [0.005]	17.201* [0.000]	-
Turkey	Δln_GDP_t	-	**- [ ]**	**11.374* [0.001]**	**-3.390* [0.003]**
	Δln_FDI_t	21.436* [0.000]	-	-2.520** [0.026]	5.238** [0.032]
	Δln_RE_t	**5.927** [0.017]**	**- [ ]**	-	**9.648* [0.003]**
	Δln_K_t	3.742* [0.005]	19.320* [0.000]	43.331* [0.000]	-

Notes: Values in [.] are p-value. No bold value refers to the case of cointegration and its causality test involved its lagged level and differenced variables. Those values in bold refers to the case of no-cointegration and its causality test involved only lagged differenced variables. *, **and *** symbolize statistical significance at the 1%, 5% and 10% levels respectively.

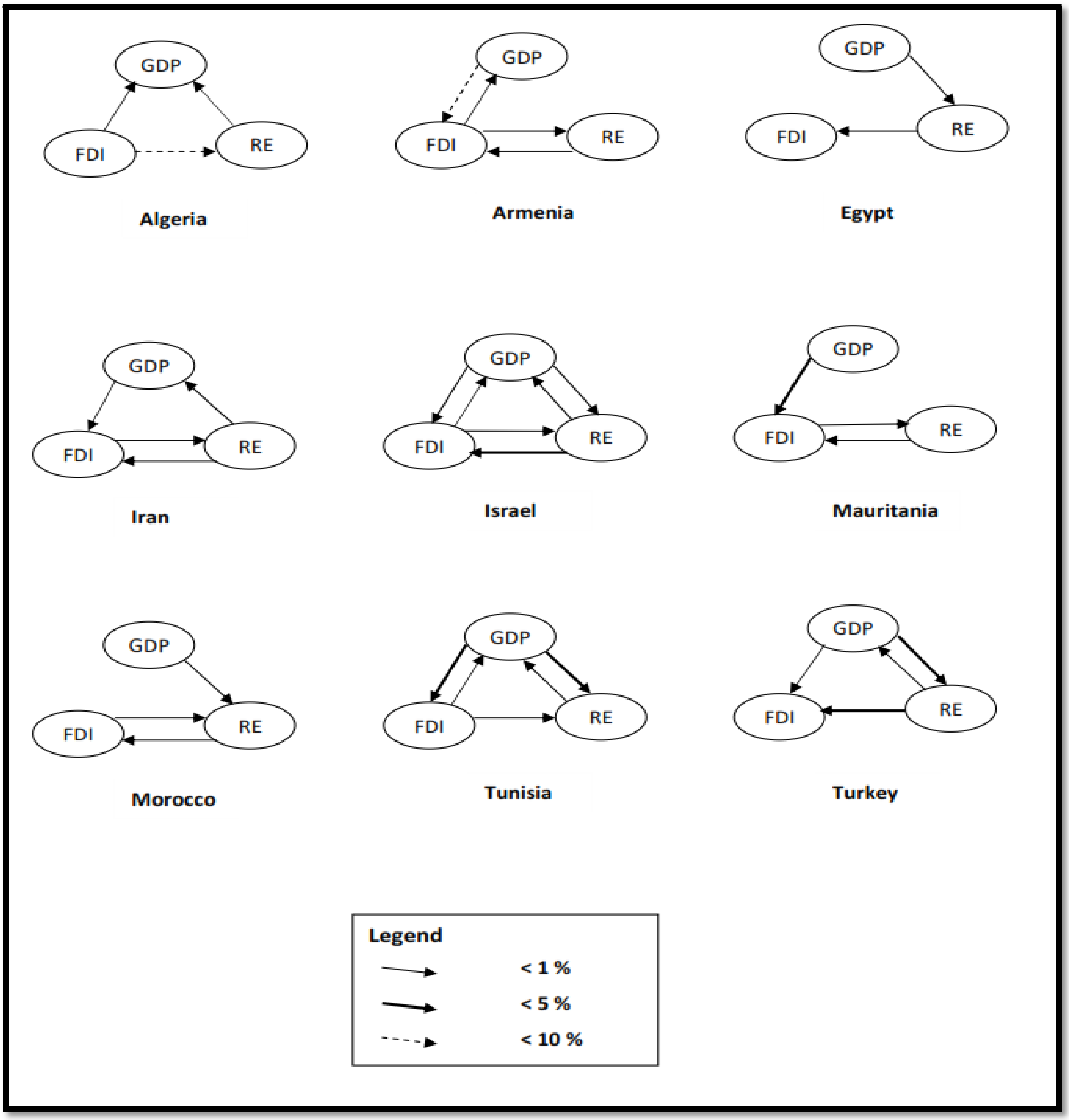

Fig. 1. Granger-Causality relationship

Appendix A

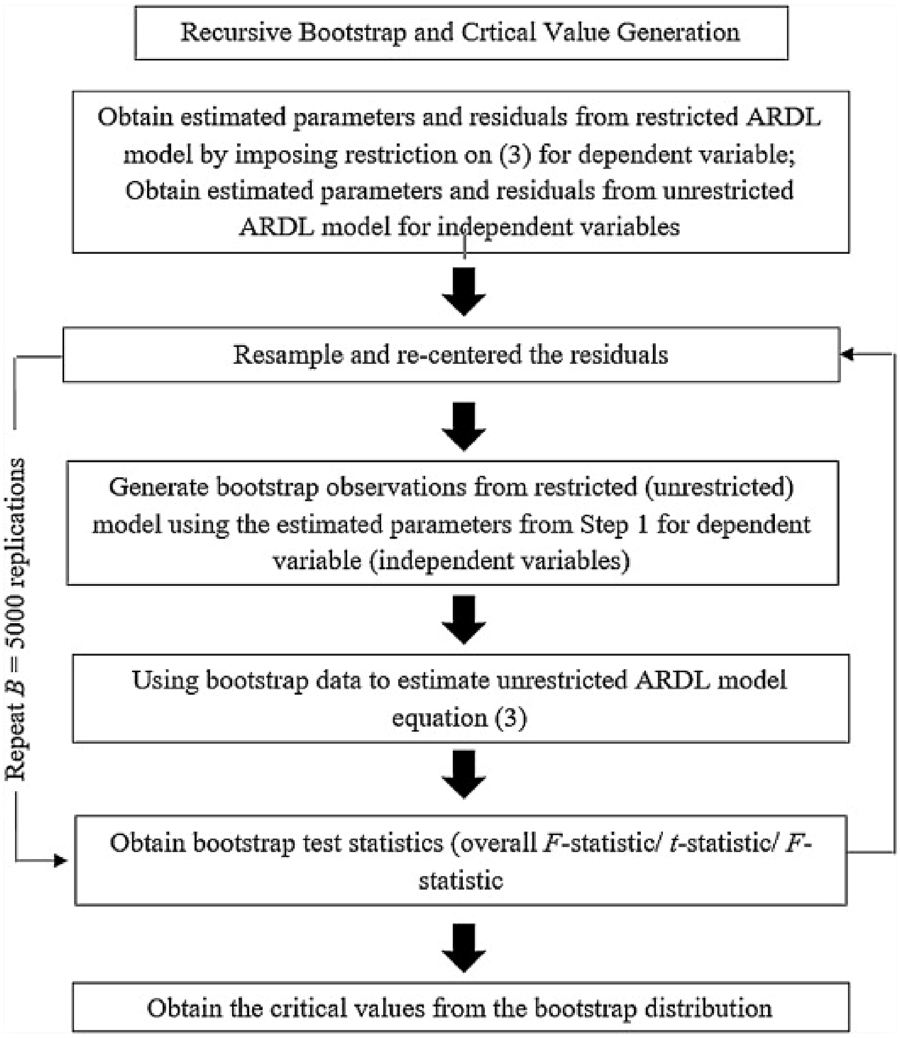

Fig. A.1. Flowchart of bootstrapping (Goh et al., 2017).