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Abstract

This paper aiming at investigating the impact of renewable combustible and waste on the economic growth and environmental quality for the case of Tunisia using the ARDL bounds testing approach during the period 1971-2018. The results confirm the presence of long-run relationships between the combustible renewables and waste and the aggregate wealth proxy and the ecological proxies, respectively. Furthermore, for the production function model, our empirical results reflect that combustible renewables and waste exerts a significant positive effect on economic growth. For the environmental model, the findings confirm that combustible renewables and waste has a negative effect on environmental quality. From this outlook, the perspectives on the use of renewable energy use in Tunisia seem to be constructive and positive. The transition towards friendly energy sources is the main response to the climate emergency for a green economy in accordance with the Millennium Development Goals (MDGs).The encouragement of sustainable consumption, sustainable goods, and practices will be the main element towards the achievement of the green transition of the structure Tunisian economy as a whole.

Keywords : Renewable combustible and waste ; GDP ; CO_2 ; ARDL Bounds testing ; Tunisia.

1. Introduction

Due to the emergence of the climate emergency as a stylized fact coupled with the thesis of the energy transition towards a green sustainable economy, the diversification of the energy portfolio of the economy and the use of alternatives and friendly energies seems to be challenging scenarios for policymakers in the current millennium (Tiba, 2020). In this context, sustainable waste management seems to be one of the best options for the authorities which offers the possibilities to generate proactive outcomes on the economic and ecological streams (Ng et al., 2014; Brunner and Rechberger, 2015; Cucchiella et al., 2017).

For a long time, economic theory has given rise to several growth models. The phenomenon of economic growth is explained by the capital and labor factors as the main production factors, as the standard model of Solow (1957) stipulates. Nevertheless, some new biophysical business models are based on energy and regard it as the only major production factor, not only relying on energy production, but also, imperative for sustainable economic growth through sufficient production to achieve and sustainable energy supply. They emphasize the role of energy as a tool for economic and social transformation and the role of natural resources. It is for this reason that people have paid attention to incorporating natural resources into theoretical models of economic growth and development as the most controversial subject.

The link between energy use and economic growth constitutes the main topic of several debates and works since the seminal work of Kraft and Kraft (1976). Dogan (2016) and Kocak and Sarkgunesi (2017), among others, supported the view that energy with fossil (e.g. coal, oil, and natural gas) as the main source is the key and vital factor in production. Besides, these conventional energy sources are considered to be the most effective engines of economic growth (Aslan et al., 2014), and are considered to be horizontal contributions to the realization of economic and social development goals of the economy. On the other hand, unlike fossil fuels, fossil fuels are non-renewable and contribute more to increasing the concentration of greenhouse gases, which has aroused environmental concerns. Because of the energy characteristics of fossil fuels, renewable energy is becoming a desirable alternative energy source. Non-renewable energy is considered to be the engine of global warming, climate change, and the biosphere. Since the main reason for increasing air pollution is the use of fossil fuels, many countries are focusing their efforts on replacing this form of energy with cleaner, renewable alternative energy sources that generate enough energy to promote economic growth.

Therefore, this dilemma has led many researchers in energy and environmental economics to explore the relationship between renewable energy consumption and environmental quality in different countries and regions using several econometric methods (see Chiu and Chang, 2009; Apergis et al. 2010; Menyah and Wolde-Rufael, 2010; Tiwari 2011; Menéndez et al. 2014; Jaforullan and King, 2015; Bölük and Mert, 2015; Bilgili et al., 2016; Bento and Moutinho , 2016; Bhattacharya et al., 2017; Sam and Chang, 2018).

Motivated by the rising debates that argued about the main role of waste management and renewable energy resources as the main role in achieving sustainable green economic growth and sound ecological quality, we attempt to assess the main contribution of renewable combustible and wast in the economic growth and environmental quality in the Tunisian economy. Our paper makes a substantial contribution to the existing literature by using renewable combustible and waste as a proxy of renewable energy. To the best of our knowledge, none of the previous studies used this variable to treat this question in the case of Tunisia. For this purpose, we use an augmented production function and environmental equation over the period 1971-2018 through the use of the ARDL bounds testing approach.

The rest of this paper is organized as follows: Section 2 provided a theoretical background. Section 3 portrays the data and material. Section 4 discusses the empirical results. Concludes the paper in Section 5.

2. Theoretical underpinning

Renewable energy is a booming global phenomenon, and its search for resources such as solar, wind, geothermal, biomass, and hydropower has begun to ensure an economic future sustainable. Therefore, the use of this "clean energy" has been greatly increased in the world recently. Internationally, researchers and policymakers have shown great interest in the field of renewable energy. In the latter, this interest develops into a willingness to study the relationship between renewable energy and economic growth, which takes the form of four testable hypotheses, namely: feedback (a two-way causal relationship between energy consumption and economic growth); Conservation (one-way causality from economic growth to energy consumption); growth (one-way causality between renewable energy and economic growth); neutrality (lack of causality between energy consumption and economic growth), and promote economics.

In this context, Sadorsky (2009) reports that empirical results show that increasing per capita income will increase the consumption of renewable energy in 18 emerging countries. His empirical findings also reported that per capita income increased by 1% and renewable energy consumption increased by 3.5%. For a sample of 27 European countries from 1997 to 2007, Menegaki (2011) studied the interaction between the economy and renewable energy. Their results did not confirm that there is a positive correlation between economic growth and renewable energy consumption, which shows evidence of the neutral hypothesis, which can be explained to some extent by the unequal utilization and insufficient development of renewable energy in these countries. Besides, Tiwari (2011) studied the relationship between renewable energy and real GDP in the case of India, using the structured VAR method. The author found that the increase in renewable energy consumption increased GDP. Arifin and Syahruddin (2011) concluded that adopting energy-saving policies can promote economic growth. The results also confirmed the growth hypothesis for the Indonesian economy. Moreover, Salim and Rafiq (2012) also reported that the consumption of renewable energy leads to increased economic growth. In turn, economic growth will lead to the consumption of renewable energy in six emerging countries (Indonesia, Turkey, the Philippines, India, China, and Brazil). However, Ocal and Aslan (2013) have argued that the consumption of renewable energy has a negative impact on economic growth for the Turkish economy.

In addition, Sebri and Ben-Salha (2014) used a multivariate framework to explore the causal relationship between renewable energy consumption and economic growth in the BRIC countries from 1971 to 2010. The results of this study confirm the long-term relationship between renewable energy consumption and economic growth. Moreover, Lin and Moubarak (2014) confirmed the two-way causal relationship between China's economic growth and renewable energy consumption. Shahbaz et al. (2015) found that renewable energy consumption promoted Pakistan's economic growth. In addition, labor and capital also play an important role in economic growth. Also, Tiba et al. (2015) pointed out that renewable energy contributes to economic performance for the case of high- and middle-economies through the use of a simultaneous equation modeling approach. For G7 countries, Chang et al. (2015) Explore the impact of renewable energy consumption on economic growth. The empirical results confirm the two-way causality between the variables. in the same spirit, Cho et al. (2015) confirmed the two-way causal relationship between renewable energy consumption and economic growth in developing countries. Also, the consumption of renewable energy leads to economic growth in developed countries. Furthermore, Inglesi-Lotz (2016) proved that the consumption of renewable energy has a substantial positive impact on economic growth.

Besides, the findings of Rafindadi and Ozturk (2017) shown that for every 1% increase in renewable energy consumption, economic growth will increase by 0.219%. They pointed out that there is a feedback effect between economic growth and renewable energy consumption. Furthermore, Fotourehchi (2017) proved that the consumption of renewable energy exerts a positive and considerable impact on economic growth. Anwar et al. (2017) have found that renewable energy consumption has a positive and significant impact on economic growth. Their analysis also pointed out that the use of renewable energy has enabled 29 Organization of Islamic Cooperation (OIC) countries to achieve economic growth. In the same path, Bhattacharya et al. (2017) confirm the long-term relationship between renewable energy consumption and economic growth for 38 major consuming countries. Their findings have found that the consumption of renewable energy has a significant positive effect on economic growth. Also, Afonso et al. (2018) pointed out that for all countries with the largest energy use, by focusing on the relationship between economic activities and the consumption of renewable and non-renewable energy, renewable energy will not contribute to economic growth.

Kutan et al. (2018) found that the consumption of renewable energy has a positive and considerable impact on the economic growth of major emerging market economies. They found that there is a neutral effect between the consumption of renewable energy and economic growth. Nevertheless, Lee and Jung (2018) reported that renewable energy consumption has a significant but negative impact on economic growth. They also found that from 1990 to 2012, there was a one-way causal relationship between South Korea's economic growth and renewable energy consumption. While Marinas et al. (2018) showed that renewable energy consumption promoted economic growth. They also found a two-way causal relationship between renewable energy consumption and economic growth in the European Union Member State Group from 1990 to 2014. Finally, Ntanos et al. (2018) showed that from 2007 to 2016, the consumption of renewable energy promoted the economic growth of 25 European economies.

For the ecological stream, Chiu and Chang (2009) studied the impact of renewable energy and economic growth on reducing CO_2 emissions. They found that renewable energy, which accounts for at least 8.39% of the total energy supply, can reduce CO_2 emissions. Besides, Apergis et al (2010) a panel data error correction model was used for a group of 19 developed and developing countries during 1984-2007. They found that there is a positive correlation between carbon dioxide emissions and renewable energy consumption. However, the Granger causality test conducted in the United States by Menyah and Wolde-Rufael (2010) studied the causal relationship between CO_2 emissions, renewable energy consumption, and GDP during 1960-2007. The results indicated there is no causal relationship between renewable energy and carbon dioxide emissions.

Besides, Shafiei and Salim (2013) used the STIRPAT econometric model when analyzing the impact of renewable and non-renewable energy on CO_2 emissions. The empirical results show that non-renewable energy consumption increases CO_2 emissions, while renewable energy consumption reduces emissions. Furthermore, Farhani (2013) conducted a study on 12 groups of the Middle East and North Africa countries covering the period from 1975 to 2008, examining the relationship between economic growth, renewable energy consumption, and CO_2 emissions. The empirical results show that these variables have no causal relationship in the short term, except for the one-way causal relationship from renewable energy consumption to CO_2 emissions. However, in the long run, the results also show a one-way causal relationship from economic growth and carbon dioxide emissions to renewable energy consumption. In the same context, Karplus et al. (2014) studied the impact of China's renewable energy development on CO_2 emissions from 2010 to 2020. They found that after installing large-scale renewable energy, the cumulative CO_2 emissions were reduced by 1.8% compared to the baseline. Hence, Menéndez et al. (2014) used data from 27 European Union countries from 1996 to 2010 to show that renewable energy can help reduce CO_2 emissions.

Bölük and Mert (2015) used the Autoregressive Distributed Lag (ARDL) method to study the potential of renewable energy in reducing the impact of Turkish greenhouse gas emissions. Their results show that in terms of CO_2 emissions, the coefficient of renewable energy power generation is negative in the long term and positive in the short term. Also, Bento and Moutinho (2016) have found the same result. They studied the dynamic causality between Italy’s per capita CO_2 emissions, per capita real GDP, and per capita renewable electricity production from 1960 to 2011. They concluded that, in the short and long term, the production of renewable electricity per capita reduces carbon dioxide emissions per capita. They also pointed out that the production of renewable electricity is a key solution to reduce pollutant emissions over time. From 1977 to 2010, for a group of 17 OECD countries, Bilgili et al. (2016) tested the validity of the EKC hypothesis by using renewable energy as an additional variable in environmental variables. They found that the consumption of renewable energy has a positive effect on reducing carbon emissions. Their findings also indicate that the EKC hypothesis is invalid.

Bhattacharia et al. (2017) from 1991 to 2012, system-based GMM and fully improved OLS technology were used in 85 developed and developing countries. The author found that the consumption of renewable energy has both positive and negative effects. They are of great significance to economic growth and carbon dioxide emissions respectively. Moreover, for the top ten power producers in sub-Saharan Africa, Dogan et al. (2018) shows that the increase in non-renewable energy consumption increases pollution, while renewable energy sources do the opposite. For the Algerian economy, Belaïd and Youssef (2017) studied the relationship between CO2 emissions, renewable and non-renewable energy consumption, and economic growth by using the ARDL co-integration method from 1980 to 2012. Their results show that in the long run, economic growth and non-renewable energy consumption will adversely affect carbon dioxide emissions. The results also show that the consumption of renewable energy can help improve environmental quality. In the same path, Kahia et al. (2017) studied the economic growth and the long-term relationship between renewable energy and non-renewable energy in 11 net oil-importing countries in the Middle East and North Africa from 1980 to 2012. They showed a two-way causal relationship between these selected variables.

Recently, Sam and Chang (2018) used a new structurally destructive ARDL bootstrapping test to study the co-integration and causality of G7 countries. They discovered the feedback effect between clean energy consumption and CO2 emissions in Germany, and the single causality between clean energy consumption and CO2 emissions in the United States. Finally, Chen et al. (2019) studied the relationship between China's carbon dioxide emissions, economic growth, renewable and non-renewable energy production, and foreign trade from 1980 to 2014. Their findings indicate that the increase in non-renewable energy and per capita GDP increases carbon emissions, while the increase in renewable energy reduces carbon emissions. They also found that increased trade openness reduced carbon emissions and rejected the pollution haven hypothesis, which indicated that trade openness increased pollution through the shift of industrial activities from developed countries with less stringent environmental regulations to developing countries.

3. Data and methodology

Following Bakari et al. (2017), Khan et al. (2020), and Chen et al (2019), economic growth and environnmental quality can depend on capital, exports, imports and energy which are applied in the two specifications as follows:

Model 1: $\mathrm{Y} = \mathrm{f(K, CRW, X, M)}$ (1)

Model 2: $\mathrm{CO2} = \mathrm{f(K, CRW, X, M)}$ (2)

where Y is production, K is capital, CRW is combustible renewables and waste, X is exports and M is imports. Using the Cobb– Douglas production function, the model is transformed into a log-linear model.

Model 1: $\mathrm{Ln(Y)_t} = \mathrm{C_t} + \beta_1\mathrm{Ln(K)_t} + \beta_2\mathrm{Ln(CRW)_t} + \beta_3\mathrm{Ln(X)_t} + \beta_4\,\mathrm{Ln(M)_t} + \varepsilon_t$ (3)

Model 2: $\mathrm{Ln(CO2)_t} = \mathrm{C_t} + \beta_1\mathrm{Ln(K)_t} + \beta_2\mathrm{Ln(CRW)_t} + \beta_3\mathrm{Ln(X)_t} + \beta_4\,\mathrm{Ln(M)_t} + \varepsilon_t$ (4)

where Ln is the natural logarithm, C is intercept, βs are the coefficients, t is year, and ε is residuals relaxing the classical Econometric assumptions: no autocorrelation, normally distributed, and homoscedasticity which are tested by the diagnostic tests. The remaining symbols were explained before.

Following Pesaran and Shin (1995), we use an autoregressive distributed lag (ARDL) model to estimate the above log-linear equation. The model is specified in the autoregressive distributed lag (ARDL) framework below.

Model 1:

$$\Delta LnY_t = C_t + \sum_{i_1=1}^{l_1} \alpha_{1i}\,\Delta LnK_{t-i1} + \sum_{i_2=1}^{l_2} \alpha_{2i}\,\Delta LnCRW_{t-i2} + \sum_{i_3=1}^{l_3} \alpha_{3i}\,\Delta LnX_{t-i3} + \sum_{i_4=1}^{l_4} \alpha_{4i}\,\Delta LnM_{t-i4} + \beta_{1j}\Delta LnY_{t-j} + \beta_{2j}\Delta LnK_{t-j} + \beta_{3j}\Delta LnCRW_{t-j} + \beta_{4j}\Delta LnX_{t-j} + \beta_{5j}\Delta LnM_{t-j} + \varepsilon_t$$

(5)

Model 2:

$$\Delta LnCO2_t = C_t + \sum_{i_1=1}^{l_1} \alpha_{1i}\, \Delta LnK_{t-i1} + \sum_{i_2=1}^{l_2} \alpha_{2i}\, \Delta LnCRW_{t-i2} + \sum_{i_3=1}^{l_3} \alpha_{3i}\, \Delta LnX_{t-i3} + \sum_{i_4=1}^{l_4} \alpha_{4i}\, \Delta LnM_{t-i4} + \beta_{1j}\Delta LnCO2_{t-j} + \beta_{2j}\Delta LnK_{t-j} + \beta_{3j}\Delta LnCRW_{t-j} + \beta_{4j}\Delta LnX_{t-j} + \beta_{5j}\Delta LnM_{t-j} + \varepsilon_t \quad (6)$$

where Δ shows the first difference, ‘‘i’’s and ‘‘j’’s are the lags, and ‘‘l’’s are the optimum lags, ‘‘α, β’’s are the coefficients, and the remaining symbols were described previously.

In fact, the ARDL model is superior to other cointegration techniques for the following reasons:

(i) According to Pesaran et al. (2001), this method is more suitable for small sample sizes. However, Johansen's cointegration technique requires a large number of samples to obtain effective results (Ghatak and Siddiki, 2001).

(ii) If variables are used, this method can be used; all I(1), all I(0) or mixed together;

(iii) ARDL model makes it possible to study the causal relationship between long-term and short-term variables Possible;

(iv) The ARDL bound test makes it possible to use different lags for the regression variables, while the VAR cointegration model does not allow mixed delays of variables (Pesaran et al., 2001).

4. Empirical analysis

Before estimating the model, put the variables into two stationarity tests, namely, enhanced Dickey-Fuller (ADF) and Phillips-Perron (PP). The null hypothesis is that the variables have unit roots and non-stationarity. The results in Table 1 show that the first differences of all variables are stable. Integrating the variables in the order of 1 allows us to apply the ARDL model.

<Please Insert Table 1 about Here>

In order to study the co-integration between the variables in the two ARDL models, we applied the Bounds test. For the final analysis, the econometric rules state: (1) If the test value F is not higher than the boundary value I1 at the levels of 1%, 2.5%, 5%, and 10%, it can be said that there is no cointegration between these variables. (2) If the test value F is higher than the boundary value I1 at the levels of 1%, 2.5%, 5%, and 10%, it can be said that there is a cointegration relationship between these variables.

<Please Insert Table 2 about Here>

For Model 1, Table 2 marks that the test value F (17.69046) is more lofty than the bound I1 Bound critical value at 1% level (5.06). Therefore, a cointegration relationship dwells between the variables of the model (1). For Model 2, Table 2 marks that the test value F (4.974850) is more lofty than the bound I1 Bound critical value at 2.5% level (4.49). Therefore, a cointegration relationship dwells between the variables of the model (2).

The results show that for the two models (1 and 2), there is evidence of cointegration between all variables. In this case, all these models can be estimated by the ARDL model to capture causality in the long-term, while the WALD test can detect causality in the short-term.

<Please Insert Table 3 about Here>

The long term equilibrium relationship for model 1 is expressed in the following equation:

$$\mathbf{Ln(Y) = 0.0110 * Ln(CRW) + 0.2199 * Ln(K) + 0.1992 * Ln(X) - 0.2461 * Ln(M) + 0.0167} \quad \mathbf{(7)}$$

Model 1 manifestes the following results. Combustible renewables and waste Ln(CRW) has a positive effect on economic growth Ln(Y); a 1% increase in combustible renewables and waste leads to an increase of 0.0110 % of economic growth. Also according to equation (7) Capital Ln(K) has a positive effect on economic growth Ln(Y); a 1% increase in capital leads to an increase of 0.2119 % of economic growth. In same line of impact, it is seen that Exports Ln(X) has a positive effect on economic growth Ln(Y); a 1% increase in exports leads to an increase of 0.1992% of economic growth. However, Imports Ln(M) has a negative effect on economic growth Ln(Y); a 1% increase in imports leads to a decrease of 0.2461% of economic growth.

Also, the long term equilibrium relationship for model 2 is expressed in the following equation:

$$\mathbf{Ln(CO2) = -0.1558 * Ln(CRW) + 0.0844 * Ln(K) + 0.029 * Ln(X) + 0.2347 * Ln(M) + 0.0028} \quad \mathbf{(8)}$$

Model 2 expresses the following results: Combustible renewables and waste Ln(CRW) has a negative effect on environnemental quality Ln(CO2); a 1% increase in combustible renewables and wase leads to a decrease of 0.1558 % of CO2 emissions. However, Capital Ln(K) has a positive effect on environnemental quality Ln(CO2); a 1% increase in capital leads to an increase of 0.0844 % of CO2 emissions. Besides, Exports

Ln(X) has a positive effect on environnemental quality Ln(CO2); a 1% increase in exports leads to an increase of 0.029% of CO2 emissions. Additionnaly, Imports Ln(M) has a positive effect on environnemental quality Ln(CO2); a 1% increase in imports leads to an increase of 0.2347% of CO2 emissions.

To determine the causal relationship between combustible renewable energy and waste, economic growth and environmental quality in Tunisia, we used the Wald test included in the ARDL model. In fact, due to the existence of a causal relationship from the independent variable to the dependent variable, the probability of econometric rules including Wald test must be less than 5%.

<Please Insert Table 4 about Here>

Table 4 presents results of causality in the short run. In the case of the estimation of Model 1, results indicate that exports Ln(X), imports Ln(M) and capital Ln(K) cause economic growth Ln(Y) in the short run. However, combustible renewables and waste Ln(CRW) have no effect on economic growth Ln(Y) in the short run. In the other hand, results of Model 2 denote that only combustible renewables and waste Ln(CRW) cause economic growth Ln(Y) in the short run.

In order to confirm the consistency and efficiency of the model, diagnostic tests were performed, and the results are reported in Table 5. All the remaining diagnostic tests are smart and think that our three models {Model(1) and Model(2)} are qualified and well processed (Breusch-Godfrey serial correlation LM test and heteroscedasticity test are both better than 5%) .

<Please Insert Table 5 about Here>

We follow Pesaran and Pesaran (1997) to test the stability of long-term coefficients and short-term dynamics by using the cumulative sum of recursive residuals (CUSUM) and the recursive residual sum of squares (CUSUMSQ). . The stability of the model is also confirmed by the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUM square) in Figures 1, 2, 3 and 4. The blue lines of CUSUM and CUSUMSQ are both within the critical range and are significant at 5%, which means that the model is very stable during the sampling period.

<Please Insert Fig 1 about Here>

<Please Insert Fig 2 about Here>

5. Conclusion

Spurred by the emerging contests about sustainable waste management and renewable energy resources as fundamental elements aiming at establishing green economic growth and sound ecological quality, our paper addressed the impact of renewable combustible and waste in the economic growth and environmental quality for the Tunisian economy by adopting an augmented production function and environmental equation over the period through the use of the ARDL bounds testing approach.

Our highlights confirm the presence of long-run relationships between the combustible renewables and waste and the aggregate wealth proxy and the ecological proxies, respectively. Furthermore, for the production function model, our empirical results reflect that combustible renewables and waste exerts a significant positive effect on economic growth. Indeed, due to the weak share of alternative energy in the Tunisian global mix, the impact of combustible renewables and waste seems to be marginal and without real importance on the economic stream. For the environmental model, our results confirm that combustible renewables and waste has a negative effect on environmental quality. Indeed, the perspectives on the use of renewable energy use in Tunisia are constructive. Furthermore, the Tunisian authorities are invited to encourage the use of friendly energy sources by the producers to prevent the environment and biodiversity with a sustainable economic path. The Tunisian economy needs more incentive the producers to adopt the use of green technologies in their production process towards the green economy in accordance with the Millennium Development Goals (MDGs). As a fundamental step, the Tunisian authorities need to strengthen the environmental standards and investing more in the institutional tools to reward or penalize the emitters. May also, the set of ecological taxes and taxing the primitive energy source to raise the price for the producer could be a reliable tool of the government short-run mechanism. For the long-term policies, the encouragement of sustainable consumption, sustainable goods, and practices will be the main element towards the achievement of the green transition of the structure Tunisian economy as a whole.

Table 1. Results of order of integration according to ADF test and PP test

UNIT ROOT TEST RESULTS TABLE (ADF)							
	At Level						
		Ln (Y)	***Ln (CO2)***	***Ln (CRW)***	***Ln (K)***	***Ln (X)***	***Ln (M)***
With Constant	t-Statistic	-1.6330	-2.5634	-0.3913	-1.9895	-1.5578	-2.0988
	Prob.	0.4581	0.1079	0.9020	0.2903	0.4959	0.2461
With Constant & Trend	t-Statistic	-2.3524	-2.9352	-2.2934	-3.0205	-2.0805	-2.5316
	Prob.	0.3987	0.1613	0.4291	0.1379	0.5429	0.3123
Without Constant & Trend	t-Statistic	5.5317	1.9038	-2.7895	3.0579	4.3225	3.7946
	Prob.	1.0000	0.9851	0.0063***	0.9992	1.0000	0.9999
	At First Difference						
		Ln (Y)	***Ln (CO2)***	***Ln (CRW)***	***Ln (K)***	***Ln (X)***	***Ln (M)***
With Constant	t-Statistic	-9.3290	-8.7753	-8.9020	-4.8597	-7.0989	-6.1478
	Prob.	0.0000***	0.0000***	0.0000***	0.0002***	0.0000***	0.0000***
With Constant & Trend	t-Statistic	-9.2166	-9.2265	-8.8029	-4.8805	-7.1212	-6.2325
	Prob.	0.0000***	0.0000***	0.0000***	0.0014***	0.0000***	0.0000***
Without Constant & Trend	t-Statistic	-2.2515	-6.9934	-7.5772	-4.3804	-5.4598	-5.1093
	Prob.	0.0250**	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***
UNIT ROOT TEST RESULTS TABLE (PP)							
	At Level						
		Ln (Y)	***Ln (CO2)***	***Ln (CRW)***	***Ln (K)***	***Ln (X)***	***Ln (M)***
With Constant	t-Statistic	-1.6906	-2.7649	-0.6246	-1.8655	-1.5753	-2.0110
	Prob.	0.4293	0.0711*	0.8551	0.3453	0.4871	0.2813
With Constant & Trend	t-Statistic	-2.5024	-2.9013	-2.2407	-2.7584	-2.3439	-2.7045
	Prob.	0.3257	0.1714	0.4568	0.2194	0.4031	0.2396
Without Constant & Trend	t-Statistic	5.7580	1.3755	-3.1893	2.4320	4.3225	3.2989
	Prob.	1.0000	0.9557	0.0020***	0.9958	1.0000	0.9996
	At First Difference						
		Ln (Y)	***Ln (CO2)***	***Ln (CRW)***	***Ln (K)***	***Ln (X)***	***Ln (M)***
With Constant	t-Statistic	-8.9101	-8.6127	-8.9020	-4.8844	-7.0989	-6.1520
	Prob.	0.0000***	0.0000***	0.0000***	0.0002***	0.0000***	0.0000***
With Constant & Trend	t-Statistic	-8.8167	-9.2265	-8.8029	-4.9093	-7.1212	-6.2387
	Prob.	0.0000***	0.0000***	0.0000***	0.0013***	0.0000***	0.0000***
Without Constant & Trend	t-Statistic	-6.0475	-7.0893	-7.5304	-4.3326	-5.5898	-5.1778
	Prob.	0.0000***	0.0000***	0.0000***	0.0001***	0.0000***	0.0000***
***; ** and * denote significances at 1%; 5% and 10% levels respectively							

Source: Authors' calculations using Eviews 10 software

Table 2. Bound test cointegration results

ARDL Bounds Test: Model 1		
Test Statistic	Value	k
F-statistic	17.69046	4
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06
ARDL Bounds Test: Model 2		
Test Statistic	Value	k
F-statistic	4.974850	4
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06
*******,***; ** and * denote significances at 1%; 2.5%; 5% and 10% levels respectively***		

Source: Authors' calculations using Eviews 10 software

Table 3. Results of ARDL estimation in the long run

ARDL Cointegrating And Long Run Form				
Dependent Variable: Ln(Y)				
Selected Model: ARDL(1, 1, 0, 0, 0)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Ln (CRW, 2)	-0.041109	0.040095	-1.025279	0.3115
Ln (K, 2)	0.230113	0.052083	4.418184	0.0001
Ln (X, 2)	0.208425	0.067361	3.094142	0.0036
Ln (M, 2)	-0.257519	0.077305	-3.331212	0.0019
CointEq(-1)	-1.046430	0.104035	-10.058405	0.0000
$\mathrm{Ln(Y)} = 0.0110 * \mathrm{Ln(CRW)} + 0.2199 * \mathrm{Ln(K)} + 0.1992 * \mathrm{Ln(X)} - 0.2461 * \mathrm{Ln(M)} + 0.0167$				
ARDL Cointegrating And Long Run Form				
Dependent Variable: Ln(CO2)				
Selected Model: ARDL(2, 2, 2, 2, 2)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
Ln(CO2(-1), 2)	-0.251742	0.157920	-1.594113	0.1214
Ln(CRW, 2)	-0.293866	0.103009	-2.852828	0.0078
Ln(CRW(-1), 2)	-0.238320	0.107930	-2.208091	0.0350
Ln(K, 2)	0.240360	0.165852	1.449241	0.1576
Ln(K(-1), 2)	-0.183181	0.128058	-1.430459	0.1629
Ln(X, 2)	0.210665	0.168880	1.247421	0.2219
Ln(X(-1), 2)	0.359191	0.175580	2.045740	0.0496
Ln(M, 2)	-0.241155	0.206815	-1.166042	0.2528
Ln(M(-1), 2)	-0.375469	0.198958	-1.887183	0.0688
CointEq(-1)	-1.168843	0.252417	-4.630595	0.0001
$\mathrm{Ln(CO2)} = -0.1558 * \mathrm{Ln(CRW)} + 0.0844 * \mathrm{Ln(K)} + 0.029 * \mathrm{Ln(X)} + 0.2347 * \mathrm{Ln(M)} + 0.0028$				
***; ** and * indicate significance at 1%, 5% and 10%, respectively				

Source: Authors' calculations using Eviews 10 software

Table 4. Results of ARDL estimation in the short run

WALD Test/Short run in ARDL Model			
Model 1. Dependent Variable: Ln (Y)			
	Value	df	Probability
Ln(CRW)	1.904000	(2, 39)	0.1626
Ln(K)	4.418184	39	0.0001
Ln(X)	3.094142	39	0.0036
Ln(M)	-3.331212	39	0.0019
Model 2. Dependent Variable: Ln (CO2)			
	Value	df	Probability
Ln(CRW)	4.160420	(3, 30)	0.0141
Ln(K)	2.221461	(3, 30)	0.1061
Ln(X)	2.091494	(3, 30)	0.1223
Ln(M)	1.632338	(3, 30)	0.2027
***; ** and * indicate significance at 1%, 5% and 10%, respectively			

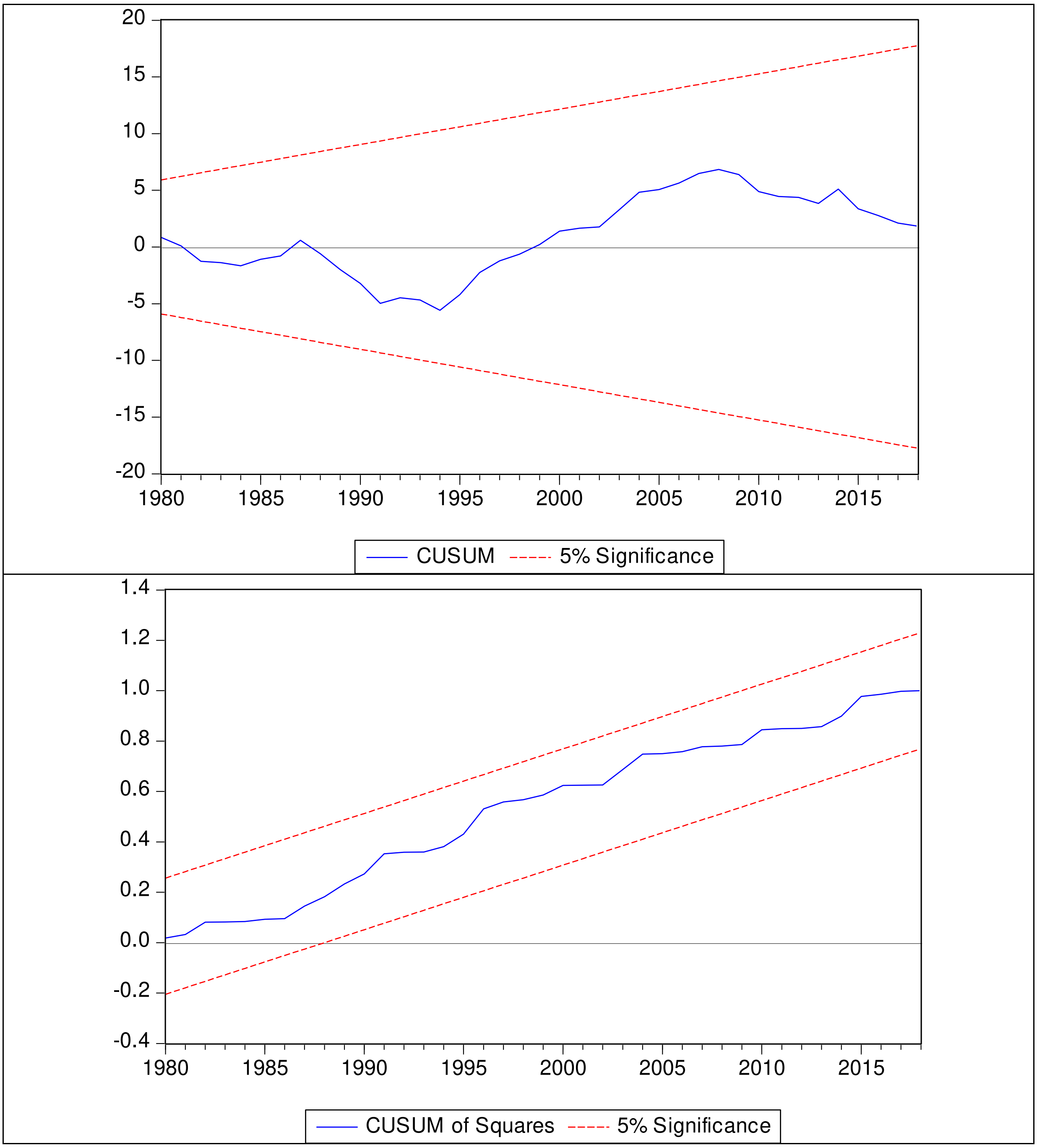
Source: Authors' calculations using Eviews 10 software

Table 5. Diagnostics tests

Diagnostics Tests of Model 1			
Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	1.192835	Prob. F(6,39)	0.3304
Obs*R-squared	7.132664	Prob. Chi-Square(6)	0.3088
Scaled explained SS	5.047082	Prob. Chi-Square(6)	0.5378
Heteroskedasticity Test: Harvey			
F-statistic	1.774181	Prob. F(6,39)	0.1299
Obs*R-squared	9.863493	Prob. Chi-Square(6)	0.1305
Scaled explained SS	10.41809	Prob. Chi-Square(6)	0.1081
Heteroskedasticity Test: Glejser			
F-statistic	1.388135	Prob. F(6,39)	0.2438
Obs*R-squared	8.094968	Prob. Chi-Square(6)	0.2312
Scaled explained SS	6.803040	Prob. Chi-Square(6)	0.3394
Heteroskedasticity Test: ARCH			
F-statistic	0.112141	Prob. F(1,43)	0.7393
Obs*R-squared	0.117052	Prob. Chi-Square(1)	0.7323
Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	1.409275	Prob. F(2,37)	0.2571
Obs*R-squared	3.256104	Prob. Chi-Square(2)	0.1963
Diagnostics Tests of Model 2			
Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.879721	Prob. F(14,30)	0.5865
Obs*R-squared	13.09724	Prob. Chi-Square(14)	0.5189
Scaled explained SS	4.060747	Prob. Chi-Square(14)	0.9951
Heteroskedasticity Test: Harvey			
F-statistic	1.344313	Prob. F(14,30)	0.2404
Obs*R-squared	17.34761	Prob. Chi-Square(14)	0.2381
Scaled explained SS	15.75170	Prob. Chi-Square(14)	0.3288
Heteroskedasticity Test: Glejser			
F-statistic	1.150545	Prob. F(14,30)	0.3590
Obs*R-squared	15.72068	Prob. Chi-Square(14)	0.3307
Scaled explained SS	9.807041	Prob. Chi-Square(14)	0.7762
Heteroskedasticity Test: ARCH			
F-statistic	3.101626	Prob. F(1,42)	0.0855
Obs*R-squared	3.025867	Prob. Chi-Square(1)	0.0819
Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.746103	Prob. F(2,28)	0.4834
Obs*R-squared	2.276849	Prob. Chi-Square(2)	0.3203

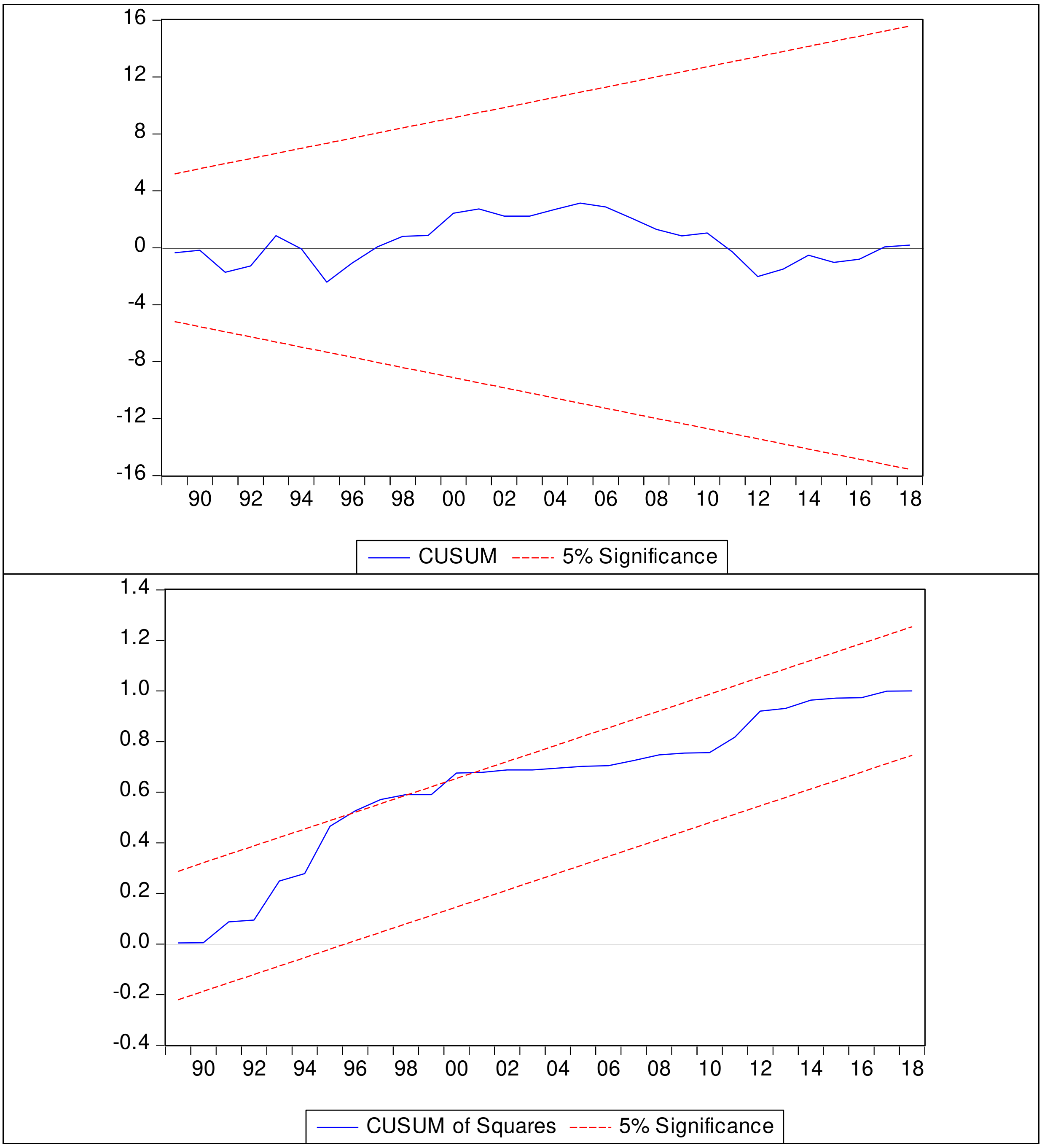
Source: Authors' calculations using Eviews 10 software

Fig 1. Stability of Model 1



Source: Authors' calculations using Eviews 10 software

Fig 2. Stability of Model 2



Source: Authors' calculations using Eviews 10 software

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