The dynamic interaction between combustible renewables and waste consumption and international tourism: The case of Tunisia

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ABSTRACT
This paper employs the Autoregressive Distributed Lag (ARDL) bounds methodological approach to investigate the relationship between economic growth, combustible renewables and waste consumption, carbon dioxide (CO_2) emissions and international tourism for the case of Tunisia spanning the period 1990-2010. The results from the Fisher statistic of both the Wald-test and the Johansen test confirm the presence of a long-run relationship among the variables under investigation. The stability of estimated parameters has been tested, while Granger causality tests recommend a short-run unidirectional causality running from economic growth and combustible renewables and waste consumption to CO_2 emissions, a bidirectional causality between economic growth and combustible renewables and waste consumption and unidirectional causality running from economic growth and combustible renewables and waste consumption to international tourism. In the long-run, the error correction terms confirm the presence of bidirectional causality relationships between economic growth, CO_2 emissions, combustible renewables and waste consumption and international tourism. Our long-run estimates show that combustible renewables and waste consumption increases international tourism, and both renewables and waste consumption and international tourism increase CO_2 emissions and output. We recommend that: *(i)* Tunisia should use more combustible renewables and waste energy as this eliminates wastes from especially tourist zones and increases the number of tourist arrivals, leading to economic growth, and *(ii)* a fraction of this economic growth generated by the increase in combustible renewables and waste consumption should be invested in clean renewable energy production (i.e., solar, wind, geothermal) and energy efficiency projects.

Keywords: Combustible renewables and waste; Tourism; Autoregressive distributed lag model; Cointegration; Granger causality; Tunisia.

JEL Classification: C32; O55; Q42; Q43; Q54

1. Introduction

It is well known that the tourism sector is linked to various economic activities and may contribute to the expansion of the green economy on a worldwide basis. However, tourism requires some serious planning and support to be able to affect other economic segments. For example, to build and operate hotels, restaurants and other tourism-related facilities, substantial links with basic infrastructure services, i.e., energy, telecommunications and environmental services, agricultural, manufacturing and construction services, are needed (United Nations Environment Programme, [44]). According to the Agence Foncière Touristique [1], the Tunisian tourism is engaging into the 21st century with a number of assets. The geographic proximity to the main world tourism markets, such as the European Union, as well as a modern, diversified and competitive infrastructure.

Tunisia is currently the first Arab and African destination, and is ranked among the first thirty destinations worldwide. The expansion of the tourism sector in Tunisia represents an economic opening, a choice and a fundamental future requirement. The diversification of tourism in Tunisia must contribute to the sustainability of a number of projects. It must favor the faithfulness of possible clienteles and the creation of innovative services relating to Tourism (Agence Foncière Touristique, [1]).

According to the Central Bank of Tunisia [17], economic growth in the country has displayed a substantial decline from 3.9% in 2012 to 2.3% in 2013. This decline could be explained by a number of drivers, such as the poor performance of the agricultural sector, the non-manufacturing industries' recession and market services' deceleration, particularly in the transportation and the tourism sectors. In 2013, the stoppage of the tourism sector in Tunisia is due to the political instability and to the insecurity climate. In fact, the number of non-resident entries shows a significant increase (5.3%), while this upsurge mostly concerns Maghreb tourists (+14%), while Europeans' entries fell by 2.3%, mainly the French (-22.1%) and the Spanish (-20.1%) tourists. However, the number of tourist-bed nights has shown a decrease by -0.2%, with tourist profits as foreign exchange revenues highlighted a sharp decline (+1.7% only against 30.5% in 2012).

The role tourism plays in the Tunisian's economic expansion seems to be highly important because of its influence on balancing trade deficit and fighting unemployment. Since 1986 the tourism industry has become the second largest foreign currency earner after the textile industry. It displays a strong seasonal instability, leading to the concentration of the demand over a number of months within the same year. It is basically the seaside character of the Tunisian tourism sector that attracts tourists only over the high season. The under-usage of these tourist locates during the off-season has a harmful influence on the financial performances of the sector (Ouerfelli, [33]).

Due to its geographic idiosyncratic characteristics, Tunisia offers important opportunities to encourage the ecological tourism. The country has several national parks and reserves, while the competition of the international tourism requires that the country makes of them a major diversification tourism product. Tunisian government offers eight parks covering 201,752 hectares, and 16 other natural reserves, covering a total area of 16,138 hectares in which special regulations have been enacted to preserve their fauna and flora. These reserves offer opportunities for investors to develop facilities (Agence Foncière Touristique, [1]).

Based on a Cobb-Douglass production function framework, the growth of the GDP is usually measured by the stock of capital and labor force along with technological progress. There is a number of studies that additionally incorporate energy consumption (renewable and/or non-renewable) as a determinant of economic growth and conclude that energy contributes significantly to the increase of the production (Apergis and Payne, [5], [6]; Apergis and Payne, [9]). In addition, the literature shows that the correlation between energy consumption and growth is very robust and any deviations in the share of energy consumption are expected to have a strong impact on the advance of economic activities, while any decrease in the expansion of real GDP is expected to adversely affect energy consumption volatility (Apergis and Payne, [3], [4]; Apergis and Payne, [8]). However, energy consumption is connected to other economic activities, such international trade which is expected to have a positive impact on economic growth (Al-Mulali et al., [2]; Ben Aïssa et al., [12]). In fact, energy consumption is increasing rapidly worldwide. As a result, the demand for energy is growing fast, while total energy consumed for production purposes is very vital for increasing greenhouse (i.e., CO_2) emissions, leading to serious damages of the environmental quality. Moreover, requiring emissions taxes to avoid pollution is not sufficient enough to reduce these damages. In spite of the fundamental innovations and efforts by the international institutions, the share of pollution is continuously growing. Recently, numerous econometric and economic studies have treated the vital role that renewable energy can play in accelerating the industrial and trade profitability. The study developed by Ben Jebli and Ben Youssef [14] concludes that the adoption of environmental friendly renewable energy technology for production purposes is a helpful way to stimulate output and to decrease the level of pollution. Emerging economies, like Tunisia, are particularly encouraged to enlarge their trade relations with developed countries to gain from technology-transfered production, which will contribute to higher levels of renewable energy.

The dynamic interaction between economic growth, combustible renewables and waste consumption, CO_2 emissions and international tourism in Tunisia is the primary goal of our current empirical analysis. The issue has not been previously investigated for the case of the Tunisian economy. The literature survey has mentioned in previous econometric studies that the interdependence between renewable energy consumption and economic growth has been discussed and could be summarized in four hypotheses. The first hypothesis is called the feedback hypothesis and argues that the relationship between the variables is bidirectional (Apergis and Payne, [5], [6], [8], [9]; Pao and Fu, [35]). The second hypothesis suggests that the relationship between the two variables is unidirectional, running from renewable energy consumption to economic growth, the so called the growth hypothesis (Payne, [36]). The third hypothesis is also unidirectional, but this time is running from economic growth to renewable energy consumption, the so called the conservation hypothesis (Menyah and Wolde-Rufael, [31]). Finally, the neutrality hypothesis argues that there is no causal link between economic growth and renewable energy consumption (Ben Aïssa et al., [12]; Menegaki, [30]; Payne, [36]). These hypotheses discuss the direction of causality either in the short- or in the long-run. The econometric studies that investigate the interdependence between growth-energy have revealed that the empirical results vary across studies. Ozturk [32] concludes that there is no consensus on the direction of connection between energy consumption and economic growth. He also confirms that causalities depend on the empirical methodology, the selected period and sample, and the variables included in the empirical model.

International tourism is an additional key variable that may have a significant impact on the productivity growth. Allowing explicitly tourism to enter the production function as a deterministic variable of the output growth has been previously studied in a number of econometric surveys (Belloumi, [11]; Ben Jebli et al., [15]; Choyakh, [18]; Katircioglu, [27], [28]; Katircioglu et al., [29]). For the case of Tunisia, Belloumi [11] investigates the relationship between tourism receipts, the real effective exchange rate and economic growth over the period 1970-2007. The results provide supportive evidence for the presence a cointegrating relationship between economic growth and tourism. Moreover, Granger causality tests suggest that tourism has a positive and unidirectional impact on economic growth. Choyakh [18] develops an econometric model to examine the determinants of the European tourism demand for Tunisia. He applies a cointegration analysis to investigate the long-run association between the number of nights spent by Europeans in Tunisian hotels and a number of leading macroeconomic variables, such as income in the origin countries, relative prices and the volume of tourism investments over the period 1962–2005. His results highlight that the primary determinant of tourism demand turns out to be the income of the tourist-generating countries, while Tunisian tourism is less sensitive to price variations and tourism investments. In other words, the main novelty of this empirical paper is the investigation of the presence or not of any relationship between renewable energy consumption and tourism for a single country, precisely for the case of Tunisia.

Katircioglu [27] investigates the long-run relationship between international tourism and real GDP for the case of Turkey by using bounds tests and the Johansen cointegration approach. His empirical findings document that no long-run equilibrium exists between tourist variables and economic growth. The causal link between tourism, CO_2 emissions, and energy consumption and economic growth has been also examined by Katircioglu [28]. The author investigates the long-run relationship between tourism, energy consumption and environmental degradation (CO_2) in the case of Turkey through two specification models. He suggests that there is a long-run relationship between tourism, energy consumption and CO_2 emissions, while CO_2 emissions converge to a long-run equilibrium through their effect on tourism and energy consumption. Based on his results, he recommends that the extension of tourist activities in Turkey has resulted in the increase in both energy consumption and climate changes. Katircioglu et al. [29] investigate the long-run relationship between international tourism, energy consumption and CO_2 emissions for the case of Cyprus. They conclude that international tourism is in long-run equilibrium with both energy consumption and CO_2 emissions. In addition, they provide evidence conducive to the fact that international tourist arrivals have a positive and statistically significant impact on both energy consumption and CO_2 emissions.

In a very recently paper, the interaction of international tourism with economic growth, renewable energy consumption, CO_2 emissions and trade has been investigated by Ben Jebli et al. [15] for a panel of 22 Central and South American countries over the period 1995-2010. They make use of panel cointegration techniques and Granger causality tests to examine the short- and long-run relationship between the above mentioned variables. They find unidirectional causality running from renewable energy consumption to CO_2 emissions and from renewable energy consumption to trade. Moreover, they support the presence of unidirectional short-run causal link without feedback effects running from economic growth to trade and the number of tourist arrivals, and unidirectional causality running from the number of tourist arrivals to trade. The results from these long-run estimates reveal that both the number of tourist arrivals and renewable energy consumption contribute to the decrease of emissions, while both real GDP and trade contribute to their increase.

To our knowledge, there is not any cross-sectional econometric study on the causal relationship between tourism and combustible renewables and waste consumption. This study investigates the dynamic interactions between real GDP, CO_2 emissions, combustible renewables and waste consumption and international tourism for the case of Tunisia spanning the period 1990-2010 through the ARDL bounds methodological approach along with cointegration and Granger causality tests. The remaining of the study is organized as follows. Section 2 presents the data and the methodology of the empirical analysis. Section 3 discusses the results, while Section 4 provides the conclusions and policy implications.

2. Data and methodology

Annual data are used for the empirical analysis over the period 1990-2010 and include real GDP per capita (measured at constant 2005 US$), CO_2 emissions per capita (metric tons), renewable energy consumption per capita, defined as combustible renewables and waste consumption (metric tons of oil equivalent), and international tourism measured by the number of tourists arrivals in Tunisia. Real GDP per capita, CO_2 emissions per capita and combustible renewables and waste consumption per capita are obtained from the World Bank [45], while international tourism data are obtained from the National Institute for Statistics of Tunisia [32]. All variables are used after natural logarithmic transformations.

To test the presence of a long-run dynamic relationship between time series has been examined using various cointegration techniques. One of them is the ARDL bounds approach, recommended by Pesaran and Pesaran [37], Pesaran and Smith [40], Pesaran and Shin [38], and Pesaran et al. [39]. The methodology involves several econometric advantages over alternative cointegration methodologie: *i)* it examines the long-run dynamic relationship among time series without explicitly examining whether regressors are purely integrated of order zero I(0), order one I(1), or fractionally integrated (Pesaran and Pesaran, [37]), *ii)* Pesaran and Shin [38] suggest that the ARDL approach integrates the short- and long-run data information in the same model, and *iii)* the use of the ARDL approach provides better results even in small samples over the alternative approaches by Engle and Granger [20], Johansen and Juselius [26], and the fully modified OLS procedures by Phillips and Hansen [41] (Haug, [24]). The ARDL presentation of each variable is given by the following expressions:

$$\Delta y_t = \theta + \sum_{i=1}^{p}\theta_{1i}\Delta y_{t-i} + \sum_{i=1}^{p}\theta_{2i}\Delta e_{t-i} + \sum_{i=1}^{p}\theta_{3i}\Delta re_{t-i} + \sum_{i=1}^{p}\theta_{4i}\Delta trs_{t-i} + \theta_5 y_{t-1} + \theta_6 e_{t-1} + \theta_7 re_{t-1} + \theta_8 trs_{t-1} + \pi_{1t} \quad (1)$$

$$\Delta e_t = \alpha + \sum_{i=1}^{p}\alpha_{1i}\Delta y_{t-i} + \sum_{i=1}^{p}\alpha_{2i}\Delta e_{t-i} + \sum_{i=1}^{p}\alpha_{3i}\Delta re_{t-i} + \sum_{i=1}^{p}\alpha_{4i}\Delta trs_{t-i} + \alpha_5 y_{t-1} + \alpha_6 e_{t-1} + \alpha_7 re_{t-1} + \alpha_8 trs_{t-1} + \pi_{2t} \quad (2)$$

$$\Delta re_t = \beta + \sum_{i=1}^{p}\beta_{1i}\Delta y_{t-i} + \sum_{i=1}^{p}\beta_{2i}\Delta e_{t-i} + \sum_{i=1}^{p}\beta_{3i}\Delta re_{t-i} + \sum_{i=1}^{p}\beta_{4i}\Delta trs_{t-i} + \beta_5 y_{t-1} + \beta_6 e_{t-1} + \beta_7 re_{t-1} + \beta_8 trs_{t-1} + \pi_{3t} \quad (3)$$

$$\Delta trs_t = \delta + \sum_{i=1}^{p}\delta_{1i}\Delta y_{t-i} + \sum_{i=1}^{p}\delta_{2i}\Delta e_{t-i} + \sum_{i=1}^{p}\delta_{3i}\Delta re_{t-i} + \sum_{i=1}^{p}\delta_{4i}\Delta trs_{t-i} + \delta_5 y_{t-1} + \delta_6 e_{t-1} + \delta_7 re_{t-1} + \delta_8 trs_{t-1} + \pi_{4t} \quad (4)$$

where Δ and π denote first differences and the error terms, respectively. p denotes the number of lags corresponding to the first difference of the lagged variables.

Based on the Wald-test, the presence of a long-run association between series is tested through the joint significance of estimated lagged coefficients. We start by determining the number of the optimal lag length through both the Akaike Information Criterion (AIC) and the Schwarz Information Criterion (SIC). Then, the significance of Fisher-statistics of the Wald test is measured to check out for cointegration among the variables. In this stage, two terminal critical values provided by Pesaran et al. [39] are considered to be used vis-à-vis the computed values. The test investigates the validity of the null hypothesis of no cointegration against the alternative of a long-run relationship. The first terminal critical value assumes that all variables are I(0) and corresponds to the lower critical bound value, whereas the second terminal assumes that all variables are I(1) and corresponds to the upper bound value. Three assumptions are possible to interpret Fisher-statistic value: if the computed F-statistic exceeds the upper critical value, then we reject the null hypothesis of no cointegration. If the computed Fisher-statistic falls behind the lower critical value, then we cannot reject the null hypothesis of no cointegration among the variables. Finally, if the calculated value falls within the lower and upper critical values, then the result is inconclusive. To assess the robustness of the estimated models, a number of diagnostic tests is computed on the serial correlation, the residual heteroskedasticity, and normality tests. Finally, the cumulative sum (CUSUM) and the cumulative sum of the square (CUSUMSQ) methodologies (Brown et al., [16]) are used to evaluate the stability of the long-run estimations. Based on the significance of the error correction model corresponding to the long-run specification, the stability of the long-run estimations is tested graphically. Ensuring the stability of these estimations indicates that there is no break point detected in the selected period for the Tunisian economy. Haliciolgu [20] argues that the tests recommended by Brown et al. [16] are more powerful over other stability tests, such as Hansen's [22] and Hansen and Johansen's [23], because they require that the variables must be integrated of order one, while they do not incorporate short-run estimations in the relevant model.

3. Results and discussion

The analysis starts by testing the stationarity proprieties of the time series under investigation. To this end, the empirical analysis of the Zivot-Andrews [46] endogenously determined break unit root test is used to explore the integration order of each variable. The Zivot-Andrews [46] test is more powerful than the traditional unit root tests, i.e. the ADF (Dickey and Fuller, [19]) and the Phillips-Perron test (Phillips and Perron, [42])[1]. Testing the stationarity order of variables using these unit root tests does not give sign about any structural changes across time. However, the use of Zivot-Andrews may catch information about the integration order and structural break properties and may help policy makers in expressing comprehensive economic policy (Shahbaz et al., [43]). The null hypothesis of a unit root with breaks exposes that the series is non-stationary, while the alternative hypothesis specifies that the variable is stationary with one-time break point.

Table 1
Zivot-Andrews unit root tests

Variables	Levels		1st differences	
	t-statitic	Time break	t-statitic	Time break
y	-5.418456 (1)	1996	-5.178057 (0)**	1995
e	-5.693173 (0)***	1994	-10.27862 (0)***	1995
re	-5.592607 (1)**	2007	-3.131303 (0)	1995
trs	-3.897892 (4)	2001	-5.048655 (1)*	2003

***, **; *, indicate statistical significance at 1%, 5%, and 10%, respectively. Lag order is shown in parentheses.

Table 1 reports the results from the the Zivot-Andrews test with structural breaks and indicates that the variables are either integrated of order zero I(0) or of order one I(1)[2]. Thus, all variables are integrated after first differences, except that for renewable energy consumption, which is found to be stationary in levels, but non-stationary after first differences.

[1] According to the ADF and PP unit root tests, the results indicate that all variables are non-stationary at their levels, but stationary after their first differences. These tests are available upon request.
[2] The ARDL bounds approach requires that all series are whether integrated of order zero, I(0), or of order one, I(1), or are fractionally integrated (I(0)/I(1)). However, we cannot proceed if one or more time series are integrated of order two, I(2), or beyond.

Table 2
ARDL bounds tests to cointegration

Estimated model	Bounds testing to cointegration		F-statistics	Prob (F.stat)
	optimal lag length			
F(y/e,re,trs)	1,1,1,0		6.592184	0.0073***
F(e/y,re,trs)	2,2,2,2		5.311934	0.0479**
F(re/y,e,trs)	1,1,1,0		11.67185	0.0009***
F(trs/y,e,re)	2,2,2,2		12.76252	0.0151**
Critical values	Lower bounds I(0)			Upper bounds I(1)
1%	4.310			5.544
5%	3.100			4.088
10%	2.592			3.454
	Diagnostic tests			
	LM-test	ARCH test	Normality test	
F(y/e,re,trs)	0.5856	0.4982	0.8185	
F(e/y,re,trs)	0.4066	0.1708	0.8026	
F(re/y,e,trs)	0.7230	0.1584	0.2478	
F(trs/y,e,re)	0.3133	0.9888	0.5528	

***, **, indicate statistical significance at 1% and 5% , respectively. Critical values are provided by Pesaran et al. [39]. LM-test, ARCH test and normality test refer to the Breusch-Godfrey Serial Correlation test, the heteroskedasticity test and the Jarque-Bera normality test, respectively.

In this stage, the order of integration of the analysis variables has been tested which allows us to provide evidence for the presence of long-run cointegration among the variables by using the ARDL approach to cointegration test in two steps. The first step involves the inspection of the maximum number of lags for the vector autoregressive (VAR) model[3]. In the second step, we estimate the ARDL equation using the Ordinary Least Square (OLS). Then, we test the joint significance of the long-run lagged coefficients by using the Wald test, which is based on the Fisher-statistics (Pesaran et al., [39]).

It is known that the AIC is more powerful than the other criteria for small samples. To this end, we chose this criterion to get the number of adequate lags. By minimizing the AIC value, we discover that the maximum number of lags is set to 2. Table 2 reports the results of the ARDL bounds test to cointegration for each model. The F-statistics exceed the upper value and confirm that there is evidence of a long-run relationship across the variables under study. With respect to Equations 1 and 3, the F-statistics are statistically significant at the 1% level, when real GDP and combustible renewables and waste consumption are the dependent variables, respectively. The ARDL bounds suggest a maximum number of lag 1. With respect to Equations 2 and 4, the F-statistics are statistically significant at 5%, when CO_2 emissions and international tourism are the dependent variables, respectively. Thus, for all equations, there is evidence in favor of the presence of cointegration between the variables. Moreover, diagnostic tests (i.e., LM, ARCH and normality tests) confirm the validity of our results.

[3] The number of lags is obtained from the unrestricted VAR by means of some selection criteria such as Log likelihood (LogL), Log likelihood ratio (LR), final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SIC), and Hannan-Quinn information criterion (HQ).

Table 3
Johansen cointegration test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	5% Critical Value	Prob.
None *	87.3018	64.4032	47.85613	0.0007
At most 1	65.9389	25.1928	29.79707	0.1547
At most 2	21.5568	4.72947	15.49471	0.8368
At most 3	6.1050	0.11635	3.841466	0.7330

* indicate statistical significance at 1%.

In order to confirm the result obtained from the ARDL bounds approach, we also apply the Johansen-Juselius [26] cointegration test. The results are reported in Table 3 and suggest that there is evidence of long-run cointegration among variables.

The short- and long-run dynamic causal links between the variables are established using the Engle and Granger [20] procedure in two steps. The examination, first, estimates the long-run coefficients, and secondly, we estimate the coefficients related to the short-run adjustment. The vector error correction model (VECM) of Granger causality between economic growth, CO_2 emissions, combustible renewables and waste consumption and international tourism is described as follows:

$$\Delta y_t = \lambda_0 + \sum_{i=1}^{p} \lambda_{1i} \Delta y_{t-i} + \sum_{i=1}^{p} \lambda_{2i} \Delta e_{t-i} + \sum_{i=1}^{p} \lambda_{3i} re_{t-i} + \sum_{i=1}^{p} \lambda_{4i} \Delta trs_{t-i} + \alpha_1 ECT_{t-1} + \eta_{1t} \quad (5)$$

$$\Delta e_t = \lambda_0 + \sum_{i=1}^{p} \lambda_{1i} \Delta y_{t-i} + \sum_{i=1}^{p} \lambda_{2i} \Delta e_{t-i} + \sum_{i=1}^{p} \lambda_{3i} re_{t-i} + \sum_{i=1}^{p} \lambda_{4i} \Delta trs_{t-i} + \alpha_2 ECT_{t-1} + \eta_{2t} \quad (6)$$

$$\Delta re_t = \lambda_0 + \sum_{i=1}^{p} \lambda_{1i} \Delta y_{t-i} + \sum_{i=1}^{p} \lambda_{2i} \Delta e_{t-i} + \sum_{i=1}^{p} \lambda_{3i} re_{t-i} + \sum_{i=1}^{p} \lambda_{4i} \Delta trs_{t-i} + \alpha_3 ECT_{t-1} + \eta_{3t} \quad (7)$$

$$\Delta trs_t = \lambda_0 + \sum_{i=1}^{p} \lambda_{1i} \Delta y_{t-i} + \sum_{i=1}^{p} \lambda_{2i} \Delta e_{t-i} + \sum_{i=1}^{p} \lambda_{3i} re_{t-i} + \sum_{i=1}^{p} \lambda_{4i} \Delta trs_{t-i} + \alpha_4 ECT_{t-1} + \eta_{4t} \quad (8)$$

where Δ denotes first differences, p represents the number of lags, and α indicates the speed of adjustment coefficients, η_t denotes the standard error term, and ECT_{t-1} is the lagged error term generated from the long-run equation. The significance of the lagged *ECT* corresponding to each equation is measured by the student t-statistics for the long-run adjustment. The short-run causality is measured using the Fisher statistics by the pair of variables (i.e., the pairwise Granger causality test).

Table 4
Granger causality tests

	Short-run				Long-run
Variables	*Δy*	*Δe*	*Δre*	*Δtrs*	ECT
Δy	-	1.99082	8.94188	0.94962	-0.615230
		(0.1734)	(0.0031)***	(0.4105)	[-4.03385]***
Δe	5.73979	-	9.15613	1.37320	-0.538928
	(0.0151)**		(0.0029)***	(0.2854)	[-3.02816]***
Δre	10.2523	1.20557	-	2.17919	-0.231290
	(0.0018)***	(0.3288)		(0.1500)	[-1.73874]*
Δtrs	4.48279	0.69783	3.57323	-	-0.090516
	(0.0313)**	(0.5142)	(0.0557)**		[-2.48194]***

***, **, * indicate statistical significance at 1%, 5% and 10%, respectively. P-values are in parentheses, while t-statistics are in brackets.

Granger causality test results are reported in Table 4. In the short-run, pairwise Granger causality tests reveal the presence of *i)* bidirectional causality between combustible renewables and waste consumption per capita and real GDP per capita, *ii)* unidirectional causality running from real GDP per capita and combustible renewables and waste consumption per capita to CO_2 emissions per capita, and *iii)* unidirectional causality running from real GDP per capita and combustible renewables and waste consumption per capita to international tourism. In the long-run, all the lagged error correction terms, corresponding to Equations (5)-(8), are statistically significant, which confirms that a bidirectional long-run relationship is established between economic growth, CO_2 emissions, combustible renewables and waste consumption and international tourism.

With respect to Equation (5), the short- and long-run relationship between combustible renewables and waste consumption and economic growth is shown to be bidirectional for the benefit of Tunisian economic. This result supports the feedback hypothesis and is in accordance with those provided by Apergis and Payne [5] for a panel of OECD countries, Apergis and Payne [6] for the case of Eurasia, Apergis and Payne [8] for Central America and Apergis and Payne [9] for a panel of 80 countries; However, they are opposite to those found by Menegaki [30] for the case of 27 European countries, i.e. she finds no causal link between these two variables. Our findings document that the consumption of combustible renewables and waste energy is expected to affect the expansion of Tunisian economic activities, while economic growth in that region is expected to affect the use of combustible renewables and waste energy in both the short- and the long-run. In the same equation, we have a unidirectional short-run causality running from output to the number of tourist arrivals, while bidirectional causality is supported in the long-run. These results are different from those provided by Belloumi [11] who argues that there is a long-run unidirectional relationship running from real international tourist receipts to GDP. This difference in results may be explained by the fact that we use the number of international tourist arrivals as a variable explaining tourism, while Belloumi [11] uses real international tourist receipts as a variable explaining tourism in Tunisia.

According to Equation (6), short-run Granger causality test results reveal evidence in favor of unidirectional causal links running from both combustible renewables and waste consumption and real GDP to CO_2 emissions without feedback, while there is no short-run causality relationship between CO_2 emissions and tourism. The finding of unidirectional short-run causality running from combustible renewables and waste consumption to CO_2 emissions indicates that the level of combustible renewables and waste consumption is directly linked to changes of pollution. This type of causality is not consistent to the findings by Menyah and Wolde-Rufael [31] for the United States and Apergis et al. [10]. One may think about the environmental situation of the region by the implementation of serious decisions to improve the air and water quality. In the long-run, the relationship between combustible renewables and waste consumption and CO_2 emissions is bidirectional, indicating that changes in the use of combustible renewables and waste are expected to affect CO_2 emissions, while any variations in the degree of CO_2 emissions are expected to affect the consumption of combustible renewables energy in Tunisia. Consequently, the Tunisian government should encourage industrial firms to adopt new and clean technologies by adopting renewable energy methodologies for production purposes. This could be a good strategy to reduce emissions as well as energy dependence.

The Granger causality results reveal unidirectional short-run causality running from economic growth to CO_2 emissions without feedback at the 5% significance level. These findings are consistent with those of Jalil and Mahmud [25] for China and Ben Jebli and Ben Youssef [13] for Tunisia. In the long-run, the bidirectional causality relationship between CO_2 emissions and economic growth is also established. Thus, pollution changes are in a strong correlation with the expansion of economic activities in Tunisia, implying that changes in real GDP may increase or decrease CO_2 emissions and vice-versa. In the light of causality results, the use of renewable energy seems to be a key driver in expanding the Tunisian economy. Furthermore, the adoption of clean technology through renewable energy may ends up to a better ecological environment and promote the number of tourists arrived from developing countries to Tunisia. Indeed, more wastes treated and recycled into energy can lead to a better environment, particularly, in touristic zones where there is high concentration of hotels' activities visited by tourists with high consumption (e.g. they are on holidays, they all are within the 'all inclusive' formula usually applied in Tunisia, or simply because food consumption is less expensive than in their countries). Since there is legislation in Tunisia unabling to transport wastes in long distances for treatment, treating these wastes is costly unless this is done by recycling them into energy use. A recent and important example is the island of Djerba which is one of the most important tourist regions in Tunisia. Indeed, this region faces the problem of waste treatment since almost three years, and this has had already a negative impact on the reputation of the island as well as on the number of tourist arrivals. The Tunisian government should encourage investors to promote the ecological tourism, providing an extra boost to the tourism market. This could be a good strategy to support simultaneously growth and employment rates.

With respect to Equation (4), unidirectional short-run causality running from economic growth to international tourism without feedback is statistically significant at the 5% of significance level. In the long-run, there is bidirectional causality relationship between economic growth and international tourism, which is online with those provided by Ben Jebli et al. [15] for a panel of Central and South American countries. In the same equation, short-run Granger causality results suggest unidirectional causality running from combustible renewables and waste consumption to international tourism at the 5% significance level. With respect to Equations (3) and (4), the error correction terms are negative and statistically significant, implying the presence of bidirectional causal links between combustible renewables and waste consumption and international tourism. This result is similar to those by Ben Jebli et al. [15] in the long-run, while they are in constrast to their short-run findings, which reveal no causality between international tourism and renewable energy consumption.

Table 5
Short- and long-run estimates

	Dependent variable: *y*	*e*	*re*	*trs*	*C*
	ARDL estimates	-0.623229	1.347663	0.273883	18.47536
	p-value	0.0000***	0.0000***	0.0000***	0.0000***
	Dependent variable: *e*	*y*	*re*	*trs*	*C*
	ARDL estimates	-1.604546	2.162388	0.439458	29.64457
	p-value	0.0000***	0.0000***	0.0000***	0.0000***
Long-run Estimates	Dependent variable: *re*	*y*	*e*	*trs*	*C*
	ARDL estimates	0.742025	0.462452	-0.203228	-13.70918
	p-value	0.0000***	0.0000***	0.0000***	0.0000***
	Dependent variable: *trs*	*y*	*e*	*re*	*C*
	ARDL estimates	-3.651197	-2.275533	4.920584	-67.45718
	p-value	0.0000***	0.0000***	0.0000***	0.0000***
	Dependent variable: *d(y)*	*d(e)*	*d(re)*	*d(trs)*	*C*
		0.176205	-1.174406	-0.111117	0.065149
	p-value	0.0102**	0.0187**	0.0541*	0.0000***
	Dependent variable: *d(e)*	*d(y)*	*d(re)*	*d(trs)*	*C*
		0.925946	-2.116512	-0.100285	0.049278
Short-run Estimates	p-value	0.0049***	0.0233**	0.3466	0.0727*
	Dependent variable: *d(re)*	*d(y)*	*d(e)*	*d(trs)*	*C*
		-0.192938	0.003178	0.013005	0.003430
	p-value	0.0823*	0.9411	0.7230	0.7137
	Dependent variable: *d(trs)*	*d(y)*	*d(e)*	*d(re)*	*C*
		1.273428	0.200404	1.486996	-0.038360
	p-value	0.1052	0.5119	0.5059	0.5632

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

In this last step, the analysis investigates the long- and short-run estimated parameters associated with each model. Table 5 deals with the long-run impact of CO_2 emissions, combustible renewables and waste consumption and international tourism on economic growth.

The results document that both combustible renewables and waste consumption and international tourism affect positively economic growth, while CO_2 emissions affect negatively economic growth at the 1% significance level. In other words, in the long-run a 1% increase in the consumption of combustible renewables and waste increases economic growth by 1.34%, while any increase in the number of tourist arrivals also increases the level of real GDP in Tunisia by 0.27%. However, any increase in the level of CO_2 emissions decreases economic growth by 0.62%.

When CO_2 emissions are the dependent variable, the impact of economic growth is statistically negative at the 1% of significance level. However, both combustible renewables and waste consumption and international tourism contribute to the increase of CO_2 emissions and their impact is statistically significant at the 1% level. A 1% increase in both combustible renewables and waste consumption and international tourism leads to an increase of economic growth by 2.16% and 0.43%, respectively.

The impact of international tourism on combustible renewables and waste consumption is statistically negative at the 1% of significance level. It implies that a 1% increase in the number of tourist arrivals to Tunisia decreases combustible renewables and waste consumption. The impact of both economic growth and CO_2 emissions on combustible renewables and waste consumption is positive and statistically significant at the 1% of significance level. A 1% increase in real GDP and CO_2 emissions increases combustible renewables and waste consumption by 0.74% and 0.46%, respectively.

Interestingly, when international tourism is the dependent variable, the long-run estimates of combustible renewables and waste consumption are positive and statistically significant at the 1% level. A 1% increase in combustible renewables and waste consumption increases the number of tourist arrivals by 4.92%. However, both real GDP and CO_2 emissions affect negatively international tourism at the 1% significance level. A 1% increase in the level of real GDP and CO_2 emissions decreases the number of tourists by 3.65% and 2.27%, respectively. The validity of the estimated coefficients has been also tested. Diagnostic tests on the R-square, heteroskedasticity, serial correlation and normality statistics confirm the good fit of the estimated model[4]. The stability of the short- and long-run estimates is established graphically using the CUSUM and CUSUMSQ statistical tests. The results are displayed in Figures 1-4.

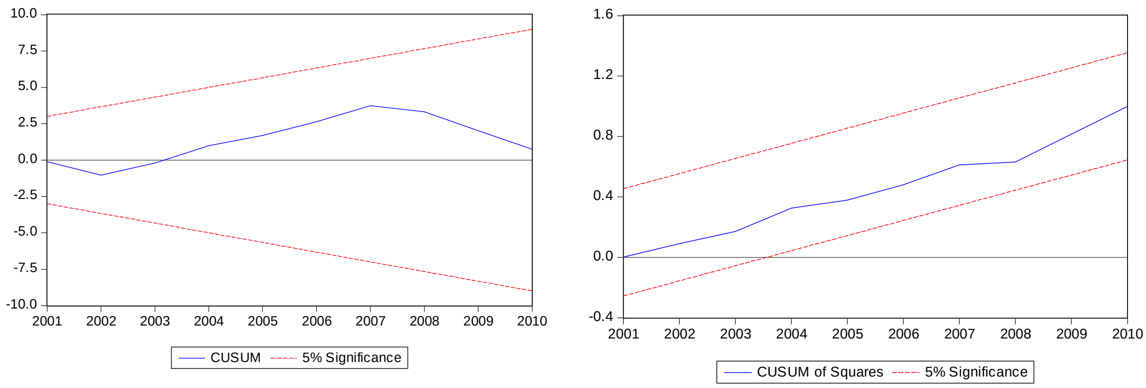

Fig 1. CUM and CUSUMSQ plots for per capita real GDP

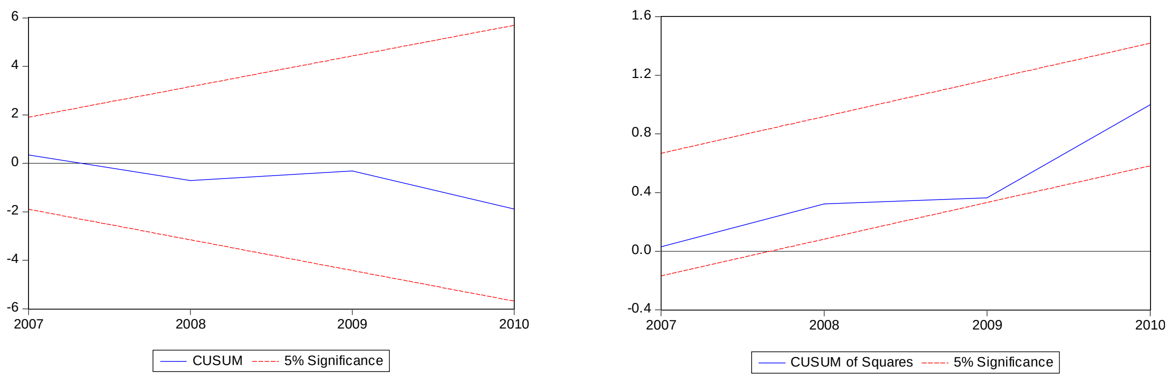

Fig 2. CUM and CUSUMSQ plots for per CO_2 emissions

[4] The diagnostic tests (R-square, heteroskedasticity, serial correlation and normality) are available upon request.

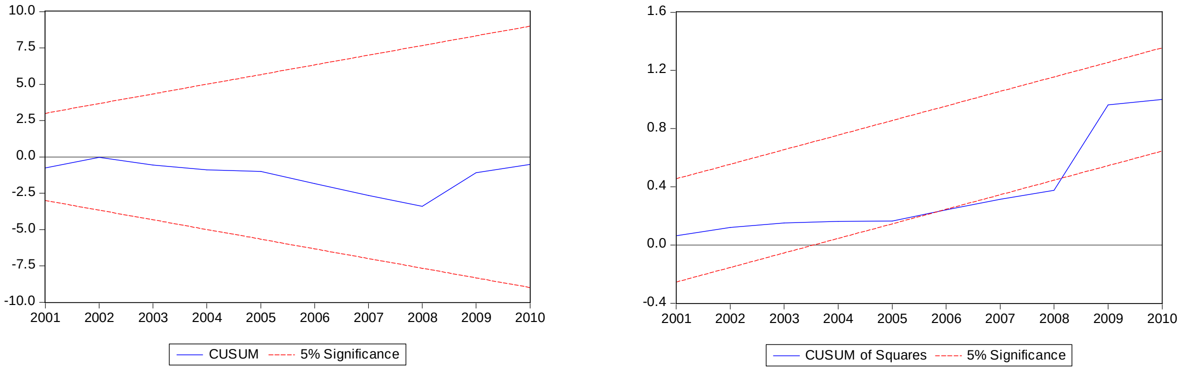

Fig 3. CUM and CUSUMSQ plots for per capita combustible renewables and waste consumption

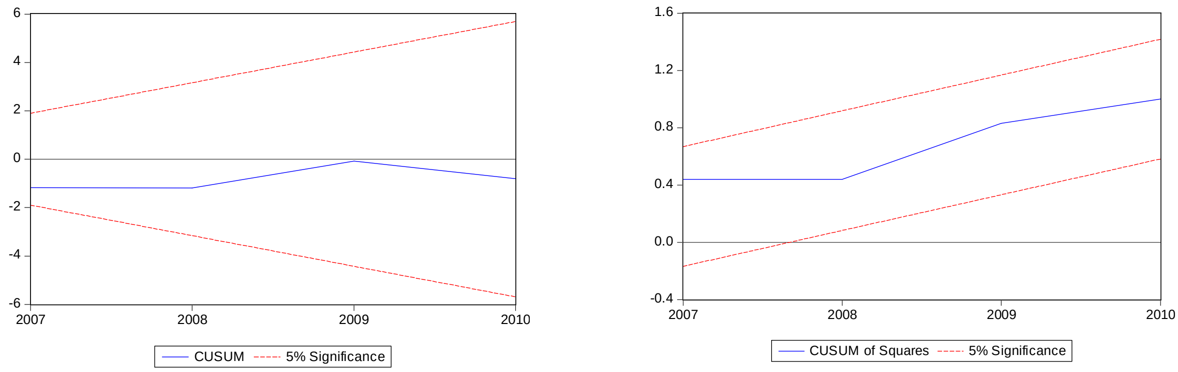

Fig 4. CUM and CUSUMSQ plots for per capita international tourism

According to the stability tests plots, all statistics illustrations demonstrate that the short- and long-run estimates are well within the 5% critical bounds for the case where real GDP, CO_2 emissions and international tourism are the dependent variables. The CUSUMSQ test in Figure 3 shows that the statistic does not remain inside the corridor when combustible renewables and waste is the dependent variable, implying that the estimated coefficients are unstable. According to the plots of Figure 3, the parameters' instability is around the time period 2005-2008. Finally, we make use of the Chow forecasting test to examine the break points effects.

Table 6
Chow forecast tests

Test predictions for observations from 2005 to 2010		
	Value	Probability
F-statistic	3.436444	0.1262
Likelihood ratio	34.52700	0.0000***

*** indicates statistical significance at the 1% level.

Table 6 reports the result of the Chow forecasting test, which confirms that there are no significant structural break points in the model.

4. Conclusions and policy implications

By using the ARDL bounds methodological approach for cointegration, the short- and long-run dynamic relationships between per capita economic growth, per capita CO_2

emissions, per capita combustible renewables and waste consumption and the number of tourist arrivals for the Tunisian economy have been established spanning the period 1990-2010. The Wald test (Fisher statistic) and the Johansen-Juselius cointegration test highlighted the presence of long-run association among these variables.

Short-run Granger causality tests recommended a bidirectional causality between economic growth and combustible renewables and waste consumption, a unidirectional causality running from economic growth and combustible renewable and waste consumption to CO_2 emissions, and a unidirectional causality running from economic growth and combustible renewables and waste consumption to international tourism. In the long-run, the error correction terms confirmed the presence of bidirectional causality between economic growth, CO_2 emissions, combustible renewable and waste consumption and international tourism.

Moreover, our long-run estimates showed that increasing combustible renewables and waste consumption led to greater numbers of tourist arrivals. This can be attributed to the wastes eliminated, especially, in tourist zones, when the former are treated and transformed in energy. In addition, increasing the number of tourist arrivals and combustible renewables and waste consumption increased CO_2 emissions. This can be attributed to the increase in food consumption, energy for transport, cooling, heating, and to the fact that transforming wastes into energy, generates higher CO_2 emissions.

Interestingly, our long-run estimates also showed that increasing the number of tourist arrivals or increasing combustible renewables and waste consumption increased GDP, while the increase in GDP reduced CO_2 emissions. Indeed, more tourist arrivals imply more foreign currency for the country which can be used to import industrial goods, necessary for higher levels of production, leading to increased levels of output. More combustible renewables and waste consumption also increased output. Finally, the increase in GDP pushes Tunisians to demand a better environment quality and this reduced CO_2 emissions.

Given the above estimates, our policy recommendations go as follows: *(i)* Tunisia should use more combustible renewables and waste energy as this eliminates wastes from especially tourist zones and increases the number of tourist arrivals, leading to higher economic growth, and *(ii)* a fraction of this economic growth generated by the increase in combustible renewables and waste consumption should be invested in clean renewable energy production (i.e., solar, wind, geothermal) and energy efficiency projects as this may reduce CO_2 emissions generated by the increase in both tourist arrivals and combustible renewables and waste consumption.

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