Revisiting the Kuznets Curve hypothesis for Tunisia:

Carbon Dioxide vs. Ecological Footprint

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Abstract

The purpose of this study is to examine the validity of the EKC hypothesis for Tunisia for the period from 1965 to 2013 by using the CO2 emissions and the Ecological footprint as proxies for environmental degradation, with the latter being considered in the literature as a more inclusive indicator. The findings of the estimation stipulate an U – shaped curb between CO_2 emissions and real per capita GDP meaning that the EKC hypothesis is not valid for this period in Tunisia. However, when using the EF as a proxy for environmental degradation, the results indicate that the EKC hypothesis is valid for Tunisia. The results have significant policy implications, except for the fact that the use of only the CO2 emissions as a proxy for environmental degradation would provide misleading direction to policymakers. The confirmation of the EKC hypothesis implies that the country's policies should be persistent in aiming to improve overall environmental quality.

Keywords: EKC; Carbon dioxide, ecological footprint; Tunisia

Introduction

Tunisia provides an interesting study case of a developing country with high levels of economic growth and a good position in the global natural resource market. Political uncertainties such as the crisis of 2011 have constraint the economic potential of the country but nevertheless, the country achieved a 1.9% economic growth in 2017 (Kwakwa, et al., 2018). The country also has natural resources such as phosphates, petroleum and iron ore, as well as natural gas and shale resources in its availability. The country has ratified the Kyoto protocol and committed to strategizing towards a reduction of greenhouse gas emissions (GHG) (Farhani, et al., 2014).

Tunisia, thus, as all countries nowadays, struggles with two main challenges: on the one side, promoting economic growth and development and on the other side, climate protection and conservation. The road towards their achievement passes through conflicting policies in many cases. The improvement of economic growth and development in previous decades became self-purpose for many countries, at all costs. Recently, the climate protection has come to the forefront of policies as for both developed and developing countries economic growth has resulted to rises in GHG and thus, rising temperatures. The trade-off is intensified through the years due to growth in industrialization and subsequent increase in energy demand, even more since this demand is met by energy generated by fossil fuels, particularly coal and crude oil.

This challenge explains the higher volume of research recently that examines the dynamics between economic production and environmental quality. The results of the literature have provided inconclusive results and thus, mixed policy recommendations for various countries and regions (Uddin, et al., 2017). The most common framework used to explain the relationship and its interlinkages is the Environmental Kuznets Curve (EKC) hypothesis that states that the relationship between economic development and environmental degradation is portrayed by an inverted U-shape. Grossman and Krueger (1991) firstly described this relationship: at the initial stages of economic growth, with every increase in income per capita leads to higher environmental damage, while after a certain threshold is reached, economic growth is inductive to better environmental conditions. Although some studies (Van Alstine & Neumayer, 2010) have questioned the causes of such a relationship and whether such pattern is automatic or policy induced, theoretically the contributing causes by Grossman and Krueger (1995) are three: the scale, composition and technique effects.

To measure environmental impact, studies have used a variety of indicators which may constitute one of the main reasons for the disagreement in the findings. One type of emissions, that of CO2, is the most widely used indicator although it represents part of the environmental damage (Al-Mulali, et al., 2015; Destek, et al., 2018). Asici and Acar (2016) add that for such a multidimensional issue such as environmental quality, emissions of whatever type on their own are not representing the full concept but only one of its dimensions. A growing literature proposes that the use of the *Ecological Footprint of Consumption (EFC)* is a more comprehensive proxy for the environmental damage that is attributed to humans (Uddin, et al., 2017; Vackar, 2012; Dietz, et al., 2007; Jorgenson, 2003; Wang, et al., 2011; Galli, et al., 2012; Mostafa, 2010). Constanza (2000) also confirms that the EFC should be preferred as it combines a variety of data and information into a single measure. Wackernagel and Rees (1996) first developed the EFC in order to represent the multidimensional concept of the environmental conditions. Lin et al. (2016) explains that EFC is the "sum of six subcomponents (crop-land, grazing land, fishing grounds, forest land, built-up land and carbon footprint)". Bartelmus (2008) also describes it as the anthropogenic pressure on the environment. Charfeddine and Mrabet (2017) state that EF is a more suitable indicator for an EKC analysis because “it can reveal the consequence of human activity in a country on the environment in terms of air, soil and water”. Destek et al. (2018) also explain that environmental degradation cannot be confined to air pollution indicators such as emissions, but needs to take into consideration the degradation of oil, forestry and others. Stern (2014) states the difference in expectations of confirming the EKC hypothesis using CO2 emissions versus EF: emissions may decrease with new technological developments or strict government policies but at the same time, total waste and pollution level increases. The EKC hypothesis, thus, might be confirmed for emissions but not for resource stocks (Destek, Ulucak, & Dogan, 2018). To provide reliable results that will direct policy makers into implementing appropriate policies, emissions as an indicator of environmental degradation should be complemented with other environmental indicators into an inclusive variable.

The purpose of this study is to examine the validity of the EKC hypothesis for Tunisia for the period from 1965 to 2013 by using the CO2 emissions and the Ecological footprint as proxies for environmental degradation. The contribution of this study to the EKC literature is threefold: firstly, it is the first study that aims to examine the EKC hypothesis for Tunisia by proposing the EFC as an indicator for environmental quality; secondly, it contributes to the literature by comparing and contrasting the results of the hypothesis by using *both* the EFC and the CO2 emissions as proxies and providing thus policy recommendations, such as Mrabet and Aslamara (2017); finally, this study examines the hypothesis both in a bivariate but also multivariate framework to account for conditions with regards to population, financial development, exports and urbanization levels.

The next section reviews briefly the empirical literature related to the EKC hypothesis and the indicators used as a proxy of environmental degradation. Section 3 presents the empirical models and data, followed by the discussion of the method and the results in the fourth section and the conclusive remarks in the final section.

Brief literature review

The empirical literature in the recent decades has shown extensive interest in understanding the relationship between environmental degradation and economic development. One of the most prominent theory explaining the relationship is the EKC as discussed in the Introduction: the hypothesis is that the two present a quadratic function (inverted U-shaped) (Dong, et al., 2016; Bimonte & Stabile, 2017). The findings of the literature are inconclusive; fact showing that the confirmation or not of the hypothesis is sensitive to the choice of environmental quality indicator, explanatory/control variables, estimation techniques, region or country and the time period of the investigation (Mrabet & Alsamara, 2017; Kaika & Zervas, 2013).

A number of studies confirmed the validity of the EKC hypothesis using CO2 as an indicator for environmental degradation, such as Chow and Li (2014) for 132 countries, Esteve and Tamarit (2012) for Spain, Hamit-Haggar (2012) for the Canadian industrial sector, Wang (2012) for 98 countries, Saboori et al. (2012) for Malaysia, Acaravci and Ozturk (2010) for EU, Halicioglu (2009) for Turkey, Lean and Smyth (2010) for the Association of Southeast Asian Nations (ASEAN), Ang (2007) for France. Also some studies have taken into account that a major control variable is energy consumption, and using that in a trivariate framework, they confirmed the EKC hypothesis (Yavuz, 2014; Shahbaz, et al., 2012; Pao & Tsai, 2011; Apergis & Payne, 2010).

Among the studies that did not confirm the EKC hypothesis (Llorca and Meunie (2009) for China, Day and Grafton (2003) for Canada, Jebli and Youssef (2015) for Tunisia), some did suggest that the relationship is characterised by a different shape (U-shape, N-shape or monotonic) or specification, for example Liddle and Messinis (2015) confirmed the existence of an inverted V-shaped relationship for some of the countries in the group of 25 OECD countries or a lack of any impact of income per capita to total emissions.

Destek et al. (2018) argue that the most important question to ask in EKC-related studies is which the correct environmental indicator to represent the environmental quality of the case is. In the literature, SO2, N2O, CH4 and other types of emissions were employed to denote the environmental conditions of a country. Chow and Li. (2014) used these three emission types and validated the inverted U-shaped relationship between them and income per capita for the OECD countries. Fodha and Zaghdoud (2010) examined the EKC hypothesis for Tunisia using CO2 and SO2 emissions as indicators of environmental quality. All types of emissions are considered, however, only a part of the overall environmental conditions quality of the countries. Destek et al. (2018) also agree with Stern (2014) that such emissions might be misleading in a sense: "CO2 emissions may really decrease owing to technological innovations or stringent environmental regulations made by governments while aggregate waste and pollution level increases".

Thus, a new strand in the literature prefers the ecological footprint as a more inclusive indicator proxying the environment. Al- Mulali et al. (2015) used the ecological footprint as a proxy to environmental degradation in their study of 93 countries: their findings showed that the EKC hypothesis holds in high-income countries but not in lower income countries. Ozturk et al. (2016) agreed with the results for a larger group of 144 countries. Bagliani et al. (2008), Caviglia-Harris et al. (2009), Wang et al. (2013), and Hervieux and Darne (2015) could not confirm the EKC hypothesis for different panels of countries. Destek et al. (2018), Asici and Acar (2016) and Ulucak and Bilgili (2018) confirmed the EKC hypothesis for the EU countries, 105 countries, and 45 countries respectively. Surely, there is no such things as absolute best proxy, so there are studies that stress the potential risks when using the EF as an environmental degradation proxy: Borucke et al. (2013) point out that the EF captures only biologically productive areas-related resources, for example it excludes soil erosion and fresh-water consumption.

Theoretical framework and Data

To investigate the environmental Kuznets curve for Tunisia, we used annual data over the period from 1965 to 2013. In most studies that test the EKC hypothesis in the literature, CO2 and other atmospheric gases are used to proxy environmental degradation. The argument with using the ecological footprint is that it is a more holistic indicator capturing the degradation on water and land measuring air and water quality, deforestation and soil erosion that was ignored as a result of changing economic development over the years. To this aim, we adopt two indicators to measure environmental pollution for the environmental degradation: the CO_2 emission and the Ecological Footprint.

However, the validity of the environmental Kuznets curve (EKC) hypothesis is complicated and is not limited to the relation between economic growth and environmental degradation (Song, Zheng, & Tong, 2008). Indeed, other explanatory variables are supposed to influence environmental degradation (Akbostanci, Turut-Asik, & Tunc, 2009). In this line, we introduce additional variables selected based on previous studies. Our study follows the work of Charfeddine and Mrabet (2017) and Li et al. (2016) by incorporating urbanization, the work of Ali et al. (2017)

by incorporating financial development. Ganda (2019) confirmed the EKC hypothesis for OECD countries in a panel data application including financial development as a control variable. The study disaggregated the financial development to explore the various impacts depending on the financial development's source. For example, domestic credit to private sector by banks negatively affect emissions. Yazdi and Beygi (2017) find also that financial development is detrimental for the African continent's emissions. Du et al. (2012), Ozturk and Acaravci (2016), Mrabet and Alsamara (2017) and Onafowora and Owoye (2014) incorporate trade in the form of exports or openness in the analysis that we adopt as well. Studies such as Dier et al. (2018) and Yazdi and Shakouri (2018) also suggested that urbanization has an important role in the examination of the EKC hypothesis (with CO2 or EF as the environmental indicator). Also, we added the population growth based on Zoundi (2017). Therefore, our empirical investigation for the EKC involves two panels of specification:

Panel A: without additional explanatory variables.

Model (1): $CO_{2t} = \beta_0 + \beta_1 GDP_t + \beta_2 GDP_t^2 + \varepsilon_t$ Equation 1

Model (2): $EF_t = \beta_0 + \beta_1 GDP_t + \beta_2 GDP_t^2 + \varepsilon_t$ Equation 2

Panel B: with additional explanatory variables.

Model (3): $CO_{2t} = \beta_0 + \beta_1 GDP_t + \beta_2 GDP_t^2 + \beta_3 Pop_t + \beta_4 FD_t + \beta_5 EXP_t + \beta_6 URB_t + \varepsilon_t$ Equation 3

Model (4): $EF_t = \beta_0 + \beta_1 GDP_t + \beta_2 GDP_t^2 + \beta_3 Pop_t + \beta_4 FD_t + \beta_5 EXP_t + \beta_6 URB_t + \varepsilon_t$ Equation 4

CO_2 is carbon dioxide emissions (metric tons per capita), GDP is per capita gross domestic product (constant 2010 US \$), GDP^2 is the square of GDP, EF is the ecological footprint, Pop is annual population growth rate for year (t), FD is the financial development measured by domestic credit to private sector (% of GDP), EXP is the export of goods and services (% of GDP) and URB is urbanization. Table 1 offers a short description of different variables under investigation. All time series data variables are extracted from the World Development Indicators (WDI) database except the ecological footprint collected from the Global Footprint Network. All variables are constructed in naturel logarithm to reduce data's variation.

Table 1: Variable description and Tunisian background

Variable	Description
GDP	GDP represents the real gross domestic product per capita, which is introduced as an indicator of economic development. In fact, increasing GDP needs more inputs consumption which induces more environmental degradation. The Tunisian economy grew at a rate of 4.6 percent in 2008 compared with 6.3 percent for 2007. However, the global financing crisis effects continued to be 5 felt in 2009 when the economy grew by 3.1 percent. Also, when the economy was showing symptoms of recovery and GDP grew by 3.8 percent in 2010. In addition, Tunisia witnessed its first year of negative growth in 1986.
CO_2	The CO2 emissions are an indicator of environmental degradation. In fact, CO2 emissions intensify the problem of global climate change, and consequently global warming. The Greenhouse Gas (GHG) Emissions in Tunisia are increasing over time despite that Tunisia has ratified the Kyoto Protocol in 2003. In fact, Tunisia's GHG emissions change annually 3% in average with a total grew of 73% from 1990-

	2011. The major contributions to air pollution are made by energy generation and transport sectors with 31% and 30%, respectively. Also, the CO_2 emissions represent the major part of the total GHG emissions in Tunisia with 92%.
EF	The EF was introduced by Rees (1992) to evaluate the degradation of the environment produced by human consumption with the regenerative capacity of the biosphere. The ecological footprint in Tunisia depends principally on the standard of living of the population considered. In fact, the Tunisian population puts pressure on its environment, which moves it away, from the sustainability. Consequently, the analysis of behaviours and attitudes attributed to the Tunisian people, on the conduct of ecological footprint, is an important task to detect the main sources of ecological deficit.
Pop	The Pop can have an obvious direct negative impact on the environment. Indeed, more population requires more space to construct houses, more means of transport, more availability of consumer goods, more consumption of fossil fuels, and consequently more pollution of air, land and water. To reduce this negative impact and improve the socio-development, the Tunisian government implemented in 1960 the first family planning program in Africa to reduce population growth. The highest and the smallest increase in Tunisia are recorded in 1983 with 2.92% and in 2003 with 075%, respectively. In overall, the population in Tunisia increased from 4.18 million in 1960 to 11.69 million in 2019.
FD	The financial development (FD) represents an important tool to attract foreign direct investment which able to stimulate the economic growth of the country. However, the FD increases the manufacturing activities and consequently expands the CO_2 emissions. The financial development became the major option of the Tunisian economic since the adopting of the Structural Adjustment Plan in 1986. In this line, many important reforms of the monetary and financial policies was adopted to favorite the financial development as the implementation of new system management of the monetary market in 1987, the liberalization of the banking margin in 1994, the adoption of the universal bank principal in 2011, among others.
EXP	The EXP can have positive or negative effects on the environment. The export quality upgrading is enhanced by countries pledging more capital deepening for knowledge creation and R&D in order to preserve environmental quality.

	Starting in 1990, the Tunisian economy reforms and trade liberalization policies influence positively the exports which represent more than 40% of the GDP from 1990 to 2010. However, after the revolution of 2011, Tunisia observes a situation of political and social instability that affects negatively the exports. In fact, exports fell by almost 5% between 2010 and 2013.
URB	The URB represents a proxy for the level of urbanization, which is calculated by the proportion of urban residents. In literature, the urbanization has an important role in environmental degradation (see Charfeddine and Mrabet (2017) among others). In fact, urban regions are characterized by: a high level of naturel resources consumption, a rapid economic development (industrialization) and an increase of electricity consumption. All of that was positively related to environmental degradation. In 2013, 67.5 percent of Tunisia's total population lived in urban areas and cities.

Table 2 provides some summary statistics of sample data. We report that the EF presents the lowest average while the URB exhibit the highest average. On other hand, the standard deviations show that the URB displays the highest volatility. All the series considered are slightly skewed to the left, as indicated by the small negative values of the skewness. The null hypothesis of normality is rejected for the CO2, the Pop and the Exp at the 10% level, as indicated by the Jarque-Bera test.

Table 2: Descriptive statistics

	CO2	GDP	EF	Pop	FD	EXP	URB
Mean	0.4052	7.7271	0.4042	0.5366	3.9716	3.5805	15.246
Median	0.4893	7.6820	0.4130	0.7794	4.0654	3.6758	15.341
Maximum	0.9553	8.3420	0.8214	1.0561	4.3432	4.0192	15.806
Minimum	-0.6122	7.0091	-0.2155	-0.2731	3.3771	2.9468	14.406
Std. Dev.	0.4201	0.3860	0.2868	0.4149	0.2514	0.2717	0.4415

Skewness	-0.7918	-0.1358	-0.5081	-0.6197	-0.6869	-0.7994	-0.4188
Kurtosis	2.5665	2.2007	2.3018	1.8762	2.4289	2.6462	1.8030
Jarque-Bera	0.0638	0.4831	0.2118	0.0574	0.1043	0.0647	0.1131

Error! Reference source not found. presents the three main variables' trends in their natural logs. It can be seen that GDP, EF and CO2 variables exhibit a linear distinct upward and deterministic trend in pattern with a marginally explosive behavior for the EF.

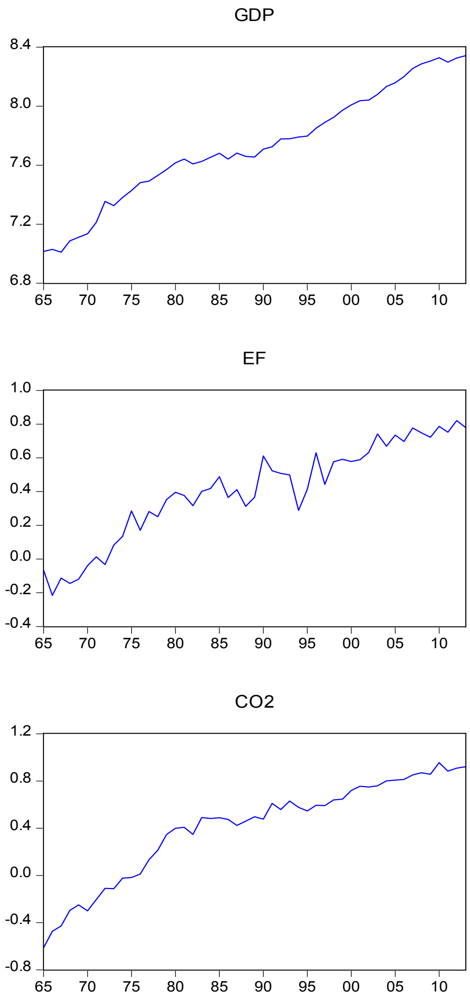

Figure 1: Graphical representation of GDP, EF and CO2 in natural logs

The EKC hypothesis can be verified based on the signs of the coefficients of GDP and GDP^2. That is: (i) if $\beta_1 = \beta_2 = 0$, there is a level relationship (ii) if $\beta_1 < 0$ and $\beta_2 = 0$ there will be a monotonically decrease relationship (iii) if $\beta_1 > 0$ and $\beta_2 = 0$ there will be a monotonically increase relationship (iv) if $\beta_1 > 0$ and $\beta_2 < 0$ there will an inverted U-shape relationship meaning that the EKC hypothesis is valid (v) if $\beta_1 < 0$ and $\beta_2 > 0$ there will an U-shape relationship.

On other hand, (i) if $\beta_3 > 0$ the annual growth of population affect negatively environmental quality (ii) if $\beta_4 > 0$ the FD don't allows easy access to efficient technology (iii) if $\beta_5 > 0$ the increase of exportations (trade openness) degrades environmental quality (iv) if $\beta_6 > 0$ the urbanization helps population to have easy access to energy – efficient technology.

Econometric method and empirical results

In our study, we used the Autoregressive Distributed Lag (ARDL) approach introduced by Pesaran et al. (2001) to test the presence of long – run relationship between variables under investigations. The ARDL approach has some advantages over other cointegration techniques. First, the ARDL approach is able to detect efficiently cointegration relationship for small sample size, while the Johansen's cointegration method is valid for large sample size. Second, the ARDL method allow variables if they are I(0), I(1) or mixture of both I(0) and I(1). However, the application of the Johansen's cointegration approach necessitates the same order of integration for the different variables under investigation. Third, the choices in ARDL's method are more important than the cointegration method of Johansen. In fact, the ARDL approach allows including endogenous, exogenous and dummy variables, which is not possible for the Johansen's method. Furthermore, the ARDL method permits to incorporate different optimal lags for variables, while uniform optimal lags are required for the Johansen's cointegration method.

The ARDL representation of panels A and B can be written as follow:

Panel A: without additional explanatory variables.

Model (1): $\Delta CO_{2t} = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta CO_{2t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta GDP_{t-i} + \sum_{i=1}^{p} \alpha_{3i} \Delta GDP_{t-i}^{2} +$

$\gamma_1 CO_{2t-1} + \gamma_2 GDP_{t-1} + \gamma_3 GDP_{t-1}^{2} + u_t$ Equation 5

Model (2): $\Delta EF_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta EF_{t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta GDP_{t-i} + \sum_{i=1}^{p} \alpha_{3i} \Delta GDP_{t-i}^{2} +$

$\gamma_1 EF_{t-1} + \gamma_2 GDP_{t-1} + \gamma_3 GDP_{t-1}^{2} + u_t$ Equation 6

Panel B: with additional explanatory variables.

Model (3): $\Delta CO_{2t} = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta CO_{2t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta GDP_{t-i} + \sum_{i=1}^{p} \alpha_{3i} \Delta GDP_{t-i}^{2} +$

$\sum_{i=1}^{p} \alpha_{4i} \Delta Pop_{t-i} + \sum_{i=1}^{p} \alpha_{5i} \Delta FD_{t-i} + \sum_{i=1}^{p} \alpha_{6i} \Delta EXP_{t-i} + \sum_{i=1}^{p} \alpha_{7i} \Delta URB_{t-i} + \gamma_1$
$CO_{2t-1} + \gamma_2 GDP_{t-1} + \gamma_3 GDP_{t-1}^{2} + \gamma_4 Pop_{t-1} + \gamma_5 FD_{t-1} + \gamma_6 EXP_{t-1} + \gamma_7 URB_{t-1}$
$+ u_t$ Equation 7

Model (4): $\Delta EF_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta EF_{t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta GDP_{t-i} + \sum_{i=1}^{p} \alpha_{3i} \Delta GDP_{t-i}^{2} +$

$\sum_{i=1}^{p} \alpha_{4i} \Delta Pop_{t-i} + \sum_{i=1}^{p} \alpha_{5i} \Delta FD_{t-i} + \sum_{i=1}^{p} \alpha_{6i} \Delta EXP_{t-i} + \sum_{i=1}^{p} \alpha_{7i} \Delta URB_{t-i} + \gamma_1$
$EF_{t-1} + \gamma_2 GDP_{t-1} + \gamma_3 GDP_{t-1}^{2} + \gamma_4 Pop_{t-1} + \gamma_5 FD_{t-1} + \gamma_6 EXP_{t-1} + \gamma_7 URB_{t-1}$
$+ u_t$ Equation 8

Where u_t is white noise error term, α_0 is the drift component, α_i $(i > 0)$ are the error correction dynamics and γ_i correspond to the long – run dynamics.

Once the models are estimated, we can execute the ARDL Bounds test to determine the existence of long – run relationship between variables. Indeed, the long – run relationship among variables is tested using the F- statistic which is computed under the null hypothesis of no cointegration (no long – run), i.e., H_0: γ_i=0 against alternative H_1: γ_i≠0 and compared to the bound critical values (Pesaran et al. (2001)). Three cases are possible: first, if the estimated F- statistic is greater than the upper bound critical value, then the null hypothesis of no cointegration is rejected suggesting the presence of long – run relationship between variables. Second, if the estimated F-statistic is smaller than the lower bound critical value, then the null hypothesis of no cointegration is accepted suggesting no long – run relationship between variables. Third, if the estimated F-statistic falls between the lower and the upper bound critical value, then the results of the test are inconclusive.

If the long – run relationship among variables is confirmed by the ARDL Bounds test, then the impact of long –run and short – run coefficients on dependent variable is discussed. The goodness of fit of the ARDL model is test by a number of diagnostic tests on its residuals as the Breusch-Godfrey Serial Correlation LM test, the ARCH and the Breusch–Pagan-Godfrey tests for heteroscedasticity, Ramsey RESET and the Jarque-Bera test. The stability of the ARDL model is tested using the CUSUM and CUSUM of Squares tests.

Unit roots tests

We start our empirical analysis by examining the order of integration for all variables. In this aim, we utilized the two widely used types of unit root tests: the Augmented Dickey and Fuller (ADF) test and the Phillips and Perron (PP) test. They test the null hypothesis of unit root against the alternative of stationarity. The unit root tests are conducted at level and first difference for both intercept and, intercept and trend term cases.

Table 3: Unit root tests results:

ADF test					Conclusion
	Level		First difference		
	Intercept	Intercept and trend	Intercept	Intercept and trend	
CO_2	0.7204	0.1057	0.0000 [a]	0.0000 [a]	I(1)
EF	0.8073	0.0003[a]	0.0000 [a]	-	I(0)/ I(1)
GDP	0.9986	0.9433	0.0000 [a]	0.0000 [a]	I(1)
GDP^2	1.000	09912	0.0001 [a]	0.0000 [a]	I(1)
Pop	0.5859	0.2500	0.0001 [a]	0.0000 [a]	I(1)
FD	0.5545	0.3557	0.0000 [a]	0.0000 [a]	I(1)
EXP	0.3297	0.0745	0.0000 [a]	0.0000 [a]	I(1)
URB	0.7622	0.0041 [a]	0.0000 [a]	-	I(0)/ I(1)
PP test					Conclusion
	Level		First difference		
	Intercept	Intercept and trend	Intercept	Intercept and trend	
CO_2	0.6938	0.1131	0.0000 [a]	0.0000 [a]	I(1)
EF	0.7989	0.0003	0.0001 [a]	-	I(0)/ I(1)
GDP	0.9985	0.9262	0.0000 [a]	0.0000 [a]	I(1)
GDP^2	1.000	0.9866	0.0000 [a]	0.0000 [a]	I(1)
Pop	0.8388	0.5995	0.0000 [a]	0.0000 [a]	I(1)
FD	0.5594	0.2821	0.0000 [a]	0.0000 [a]	I(1)
EXP	0.3790	0.1337	0.0000 [a]	0.0000 [a]	I(1)
URB	0.9347	0.8129	0.0000 [a]	0.0000 [a]	I(1)

Note: ADF and PP denote augmented Dickey-Fuller and Philips-Perron, respectively. Statistical significance at the 1% level is denoted by the superscript [a].

Table 3 reports the results of unit root tests for the variables both in level and in first difference. Based on ADF and PP tests, we found that all variables are I(1), excepting the EF and URB series which are inconclusive between I(0) and I(1). However, these traditional unit root tests do not take into account information about structural break points stemming in the series which able to provide unreliable and biased results. In fact, Baum (2004) forced to use structural break unit root test to investigate unit root properties of the variables. In this line, we apply Zivot and Andrews (1992) structural break unit root test allowing information about the integration order and unknown structural break point in the time series. The Zivot and Andrews test the null hypothesis of unit root break against the alternative hypothesis of stationarity with one-time break point. Table 4 presents the results of Zivot and Andrews test with intercept and trend. Results provide that all variables are stationary at the first difference, excepting EF and URB which are stationary in level. Consequently, none of the variables is I(2). Then, we can move for ARDL bound testing model.

Table 4: Zivot–Andrews structural break unit root test:

Variables	Level		First difference		Conclusion
	t-Statistic	Time break	t-Statistic	Time break	
CO_2	-3.7008 (1)	1986	-11.1484^{a} (0)	1982	I(1)
EF	-6.8866^{a} (0)	1986	-	-	I(0)
GDP	-3.6269 (0)	1986	-7.5863^{a} (0)	1996	I(1)
GDP^2	-3.6103 (0)	1993	-7.6013^{a} (0)	2004	I(1)
Pop	-4.1153 (3)	1977	-6.3398^{a} (0)	1982	I(1)
FD	-4.5981 (3)	1981	-6.4083^{a} (4)	1986	I(1)
EXP	-3.9683 (0)	1982	-5.6583^{a} (3)	2004	I(1)
URB	-5.3552^{b} (1)	1977	-	-	I(0)

Note: Statistical significance at the 5% and 1% level are denoted by the superscript ^{b} and ^{a}, respectively.

Next, we implement the Chow forecast test to examine the significance of different structural break points indicated by the Zivot–Andrews structural break unit root test relative to each model. In addition, we follow the suggestion of the referee by incorporating the political change of 2011 as a possible breakpoint.

Table 5: Chow breakpoint test:

Time break	1982	1986	1977	1996	2004	2011
Model 1	0.3507	-	-	-	0.2217	0.8402
Model 2	-	0.3274	-	0.9099	0.9686	0.7371
Model 3	0.1257	0.4890	0.4107	0.3259	0.7986	0.7183
Model 4	0.6556	0.6323	0.6474	0.7931	0.8264	0.5741

Note: Values represents p-values based on F-statistic.

The Chow breakpoint test uses an F-test to determine whether a single regression is more efficient than two separate regressions involving splitting the data into two sub-samples, i.e., a change in parameters between two periods is an indication of structural change. In other words, the null hypothesis that there is no structural break is tested against the alternative that there is a known structural break at time t. Based on table 5; we show that no significant structural break in sample is detected.

ARDL cointegration and estimation

Table 6 provides the ARDL bounds test results that demonstrate clear evidence that there is a long – run relationship among variables for different models under investigation. In fact, the F- statistics are above the upper bounds for all models at 5% significance level, excepting model (1) at 10% significance level.

Table 6: ARDL Bounds test

Models	F-test	95% critical bounds		90% critical bounds	
		Lower bound I(0)	Upper bound I(1)	Lower bound I(0)	Upper bound I(1)
Model (1)	4.3737	3.79	4.85	3.17	4.14
Model (2)	12.822	3.79	4.85	3.17	4.14
Model (3)	6.2712	2.45	3.61	2.12	3.23
Model (4)	4.218	2.45	3.61	2.12	3.23

For the CO_2 representations (model (1) and (3)), long – run results show a significant and negative impact of GDP on CO_2 and a significant and positive impact of squared GDP on CO_2. These results stipulate an U – shaped curb between CO_2 emission and real per capita GDP meaning that the EKC hypothesis is not valid. However, the EF representations (model (2) and (4)) results indicate that the EKC hypothesis is valid for Tunisia. In fact, GDP and squared GDP have a positive and negative impact on EF, respectively. Based on the predicted ecological footprint against the per capita GDP for models 2 and 4, the turning points for per capita income level at which ecological footprint start declining is approximately equal to 2230 (constant 2010 US $) and to 2390 (constant 2010 US $) for models 2 and 4, respectively. This level of per capita income was reached in Tunisia at the beginning of the 90s for both models 2 and 4. More precisely, the level of per capita income was reached in 1990 and 1993 for models 2 and 4, respectively. For both representations (CO_2 and EF), an increase of 1% in financial development increases emissions and EF by 0.02% and 0.013%, respectively. Also, they are nearly unaffected by urbanization.

Table 7: Long and short – run estimates

	Model (1)		Model (2)		Model (3)		Model (4)	
	Coeff.	P.value	Coeff.	P.value	Coeff.	P.value	Coeff.	P.value
Long – run estimates								
GDP	-17.231	0.0025[a]	15.02	0.014[b]	-12.251	0.004 [a]	14.109	0.0211 [b]
GDP^2	1.215	0.0011 [a]	-1.103	0.002 [a]	0.901	0.032 [b]	-1.012	0.001 [a]
Pop					0.2784	0.0015 [a]	-0.339	0.0634 [c]
FD					0.0205	0.0204 [b]	0.0133	0.0468 [b]
EXP					-0.313	0.0903[c]	0.7601	0.0022 [a]
URB					0.003	0.0105 [b]	0.001	0.002 [a]
C	-2.6676	0.0081 [a]	-1.1027	0.4049	-1.0996	0.0001 [a]	-1.1488	0.1959
Short – run estimates								
ΔGDP	-5.331	0.204	-8.016	0.098 [c]	-4.291	0.145	-11.734	0.0055 [a]
ΔGDP^2	0.789	0.433	1.206	0.071 [c]	0.865	0.312	0.791	0.0298 [b]
ΔPop					0.3356	0.0026 [a]	1.3225	0.0006 [a]
ΔFD					0.192	0.461	0.083	0.0612 [c]
ΔEXP					-0.437	0.027 [b]	0.392	0.037 [b]
ΔURB					0.006	0.038 [b]	0.001	0.253
ECT(-1)	-0.3951	0.0003 [a]	-0.454	0.0012 [a]	-0.2052	0.0081 [a]	-0.4347	0.0001 [a]

Note: [c], [b] and [a] indicate statistical significance at the 10%, 5% and 1% levels, respectively.

The error correction model term (ECT) for all models are negative and statistically significant at 1% level. The ECT coefficient is -0.395, -0.454, -0.2052 and -0.435 for model (1) to model (4), respectively. This means that the deviation of variables from short to the long – run equilibrium per one year time span is 39.5%, 45.4%, 20.52% and 43.5% for model (1) to model (4), respectively.

Table 8: Model diagnostic tests results

Tests	Model (1)	Model (2)	Model (3)	Model (4)
Breusch-Godfrey Serial Correlation LM test	0.2 (0.82)	0.299 (0.743)	0.335 (0.718)	1.645 (0.207)
Breusch–Pagan-Godfrey Heteroskedasticity test	0.65 (0.629)	1.423 (0.249)	0.705 (0.734)	0.437 (0.918)
ARCH test	0.125 (0.725)	0.271 (0.605)	0.115 (0.736)	0.741 (0.394)
Ramsey RESET	2.431 (0.127)	0.474 (0.494)	3.0617 (0.09)	2.706 (0.109)
Jarque-Bera test	4.017 (0.134)	5.521 (0.163)	0.828 (0.661)	2.615 (0.27)

Note: P – values in parentheses.

The residual diagnostic tests applied to measure the consistency of our ARDL models are illustrated in Table 8. The Breusch-Godfrey Serial Correlation LM test describes that there no serial correlation. Also, the existence of heteroskedasticity is investigated under Breusch –Pagan-Godfrey and ARCH tests. The F-statistics are insignificant supporting no autoregressive heteroskedasticity. However, the Jarque – Bera normality test show that residuals are normally distributed. The cumulative sum (CUSUM) test and squared – CUSUM test are used to evaluate the stability of coefficients. The CUSUM and CUSUM of squared plots for each model are displayed in figures 1– 4. The graphical representations show that the different models have stable parameters over time both for CO2 and EF.

Model (1)

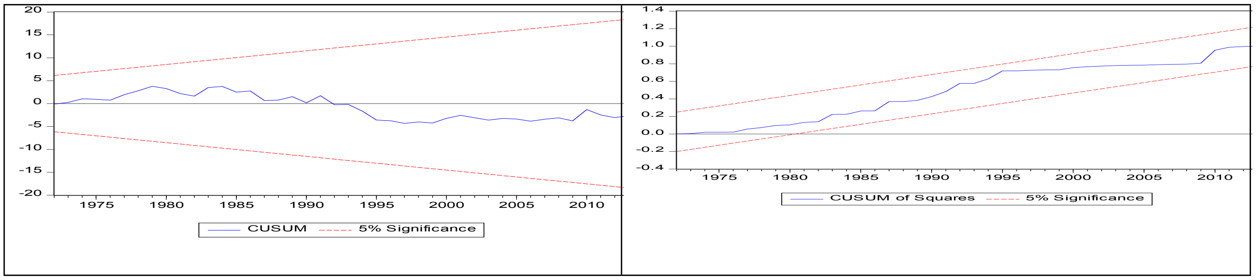

Fig 1: Plots of cumulative sum and sum of squares of recursive residuals for model (1).

Model (2)

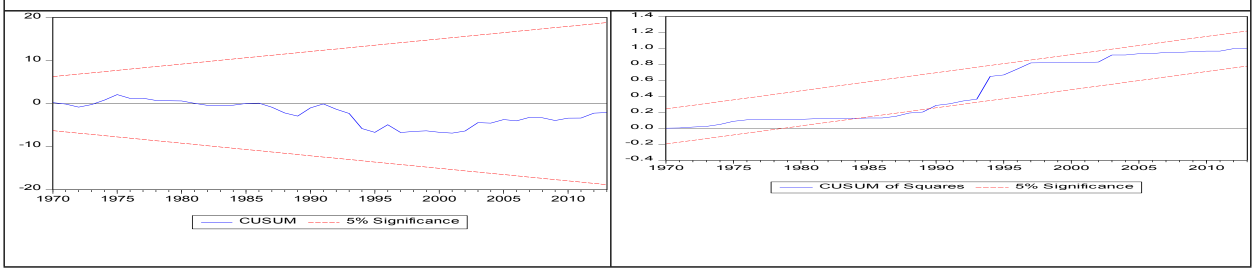

Fig 2: Plots of cumulative sum and sum of squares of recursive residuals for model (2).

Model (3)

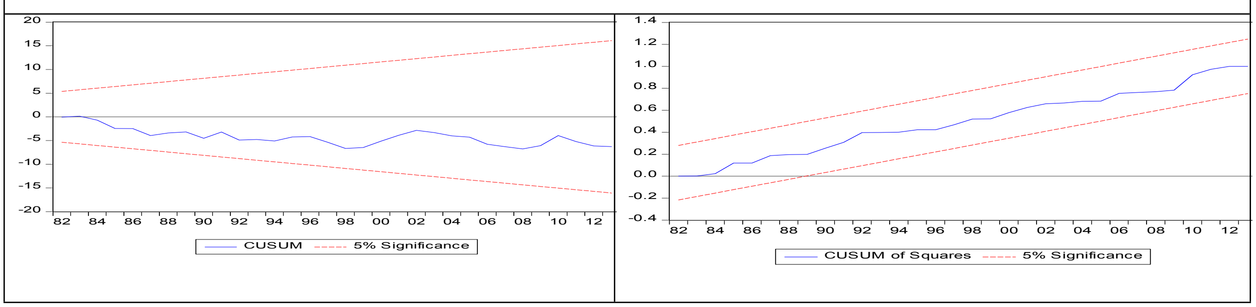

Fig 3: Plots of cumulative sum and sum of squares of recursive residuals for model (3).

Model (4)

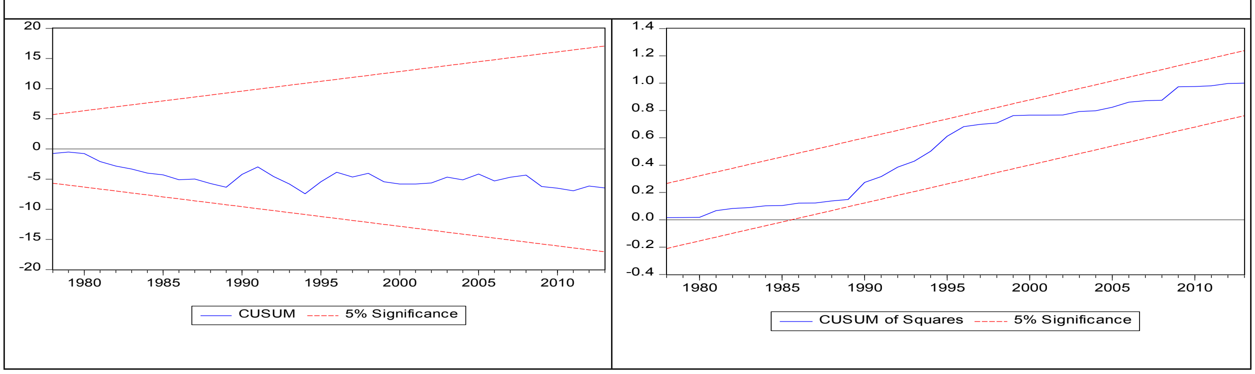

Fig 4: Plots of cumulative sum and sum of squares of recursive residuals for model (4).

Also, the VAR Granger causality results are added in Table 9 to analyze the causal relationships of the different variables with the CO2 and the EF. These results can be summarized as follows: [1] causality running from real GDP per capita, GDP2, population, and exportations to CO2 emissions per capita and [2] causality running from per CO2 emissions capita, GDP2, population, and urbanization to ecological footprint.

Table 9: VAR Granger causality

	CO_2	EF
GDP	0.0269	0.0372
GDP^2	0.0768	0.0809
Pop	0.0498	0.0516
FD	0.9759	0.1425
EXP	0.0215	0.6308
URB	0.2841	0.0387

Note: Statistical significance at the 5% and 1% level are denoted by the superscript [b] and [a], respectively.

Conclusion and Policy implications

This paper's purpose was to investigate whether the EKC hypothesis is confirmed for the case of Tunisia. To do so, we employed the ARDL methodology as proposed by Pesaran et al. (2001) with annual data for the period 1965 to 2013 controlling for a variety of variables such as financial development, population growth, exports and urbanization. The modelling exercise included two indicators as proxies for environmental degradation: the CO2 emissions level and the ecological footprint. The first one is the most commonly used indicator in the literature while the second one is considered by many studies recently as a more comprehensive indicator.

The findings of the estimation stipulate an U – shaped curb between CO_2 emissions and real per capita GDP meaning that the EKC hypothesis is not valid for this period in Tunisia. However, when using the EF as a proxy for environmental degradation, the results indicate that the EKC hypothesis is valid for Tunisia. The results showed that for the models with CO2 emissions the EKC hypothesis cannot be confirmed, agreeing with studies such as Lise (2006), Akbostanci (2009) and Acaravci and Ozturk (2010). For the models with EF, the EKC hypothesis was found valid, in accordance with Acaravci and Ozturk (2010), Shahbaz et al. (2013) and Halicioglu (2009). The combination of the results (no EKC for CO2 and EKC for EF) is consistent with Mrabet and Alsamara (2017) for Qatar. All in all, the results agree with the literature that focuses on countries that are of similar economic development and environmental profiling as Tunisia.

The results have significant policy implications, except for the fact that the use of only the CO2 emissions as a proxy for environmental degradation would provide misleading direction to policymakers. The confirmation of the EKC hypothesis implies that the country's policies should be persistent in aiming to improve overall environmental quality.

Programmes such as the national Solar Energy plan that was initiated in 2009 will be crucial in the development of a cleaner energy sector, a positive contributor to the country's economic development. Additionally, having established a U-shape of the relationship of CO2 emissions and economic development, it is apparent that policies that promote economic growth and development will lead to intensification of the emission levels in the future, after a certain threshold. Government policies should aim at implementing policies and promote technologies that will aim at changing the relationship between growth and emissions – promote a less automatic and more policy-induced trend where in the future emissions will decrease with higher economic development.

Furthermore, the water and land quality as well as the rest of the sub-indicators that comprise the ecological footprint of the country are of paramount important and should not be neglected, due to the global agreements focusing primarily on the air quality and atmospheric gases and their concentrations. To do so, though, concerted efforts need to be directed in all these aspects of the natural environment and the land use by the economy overall to maximize the interactions between economic development and ecological footprint.

References

Acaravci, A., & Ozturk, I. (2010). On the relationship between energy consumption, CO2 emissions and economic growth in Europe. *Energy Policy, 35*(12), 5412-5420.

Akbostanci, E., Turut-Asik, S., & Tunc, G. (2009). The relationship between income and environment in Turkey: is there an environmental Kuznets curve? *Energy Policy, 37*(3), 861-867.

Ali, W., Abdullah, A., & Azam, M. (2017). Re-visiting the Environmental Kuznets Curve hypothesis for Malaysia: fresh evidence from ARDL bounds testing approach. *Renewable and Sustainable Energy Reviews, 77*, 990-1000.

Al-Mulali, U., Weng-Wai, C., Sheau-Ting, L., & Mohammed, A. (2015). Investigating the environmental Kuznets curve (EKC) hypothesis by utilizing the ecological footprint as an indicator of environmental degradation . *Ecological Indicators, 48*, 315-323.

Ang, J. (2007). CO2 emissions, energy consumption and output in France. *Energy Policy, 35*(10), 4772-4778.

Apergis, N., & Payne, J. (2010). Renewable energy consumption and economic growth: evidence from a panel of OECD countries. *Energy Policy, 38*, 656-660.

Asici, A., & Acar, S. (2016). Does income growth relocate ecological footprint? *Ecological Indicators, 61*, 707-714.

Bagliani, M., Bravo, G., & Dalmazzone, S. (2008). A consumption-based approach to environmental Kuznets curves using the ecological footprint indicator. *Ecological Economics, 65*(3), 650-661.

Bartelmus, P. (2008). *Quantitative eco-nomics: how sustainable are our economies?* . Amsterdam, Netherlands: Springer.

Baum, C. F. (2004). Are view of Stata 8.1 and its time series capabilities. *International Journal of Forecasting, 20*, 151-161.

Bimonte, S., & Stabile, A. (2017). Land consumption and income in Italy: a case of inverted EKC. . *Ecological Economics, 131*, 36-43.

Borucke, M., Moore, D., Cranston, G., Gracey, K., Iha, K., Larson, J., . . . Galli, A. (2013). Accounting for demand and supply of the Biosphere's regenerative capacity: the National Footprint Accounts' underlying methodology and framework. *Ecological indicators, 24*, 518-533.

Caviglia-Harris, J., Chambers, D., & Kahn, J. (2009). Taking the "U" out of Kuznets. A comprehensive analysis of the EKC and environmental degradation. *Ecological Economics, 68*(4), 1149-1159.

Charfeddine, L., & Mrabet, Z. (2017). The impact of economic development and social-political factors on ecological footprint: A panel data analysis for 15 MENA countries. *Renewable and Sustainable Energy Reviews, 76*, 138-154.

Chow, G., & Li, J. (2014). Environmental Kuznets curve: conclusive econometric evidence for CO2. *Pacific Economic Review, 19*(1), 1-7.

Costanza, R. (2000). The dynamics of the ecological footprint concept. *Ecological Economics, 32*, 341-345.

Dai, D., Liu, H., & Wu, J. (2018). Urbanization, energy use, and CO2 emissions: A provinvial level analysis of Chna. *Energy Sources, Part B: Economics, Planning, and Policy , 13*(4), 205-210.

Day, K., & Grafton, R. (2003). Growth and the environment in Canada: an empirial analysis. *Canadian Journal of Agricultural Economics, 51*, 197-216.

Destek, M. A., Ulucak, R., & Dogan , E. (2018). Analyzing the environmental Kuznets Curve for the EU countries: the role of ecological footprint. *Environmental Science and Pollution Research, 25*, 29387-29396.

Destek, M., Ulucak, R., & Dogan, E. (2018). Analyzing the environmental Kuznets curve for the EU countries: the role of ecological footprint. *Envronmental Science and Pollution Research, 25*, 29387-29396.

Dietz, T., Rosa, E., & York, R. (2007). Driving the human ecological footprint. *Frontiers on ecological environment, 5*, 13-18.

Dong, B., Wang, F., & Guo , Y. (2016). The global EKCs. *International review of Economic Finance, 43*, 210-221.

Esteve, V., & Tamarit, C. (2012). Threshold cointegration and nonlinear adjustment between CO2 and income: the environmental Kuznets curve in Spain, 1857-2007. *Energy Economics, 34*, 2148-2156.

Farhani, S., Chaibi, A., & Rault, C. (2014). CO2 emissions, output, energy consumption, and trade in Tunisia. *Economic Modelling, 38*, 428-434.

Fodha, M., & Zaghoud, O. (2010). Economic growth and pollutant emissions in Tunisia: an empirical analysis of the environmental Kuznets curve. *Energy Policy, 38*, 1150-1156.

Galli, A., Wiedmann, T., Ercin, E., Knoblauch, D., Ewing, B., & Giljum, S. (2012). Intergrating ecological, carbon and water footprint int a "Footprint Family" of indicators: defintion and role in tracking human pressure on the planet. *Ecological Indicators, 16*, 100-112.

Ganda, F. (2019). The environmental impacts of financial development in OECD countries: A panel GMM approach. *Environmental Science and Pollution Research , 26*(7), 6758-6772.

Grossman , G., & Krueger, A. (1995). Economic growth and the environment. *Quarterly Journal of Economics, 110*(2), 353-377.

Grossman, G., & Krueger, A. (1991). Environmental impacts of a North American Free Trade Agreement. Washington DC.: National Bureau of Economic Research (NBER). Working paper No 3914.

Halicioglu, F. (2009). An econometric study of CO2 emissions, energy consumption, income and foreign trade in Turkey. *Energy Policy, 37*(3), 1156-1164.

Hamit-Haggar, M. (2012). Greenhouse gas emissions, energy consumption and economic growth: a panel cointegration analysis from Canadian industrial sector perspective. *Energy Economics, 2148-2156*, 34.

Hervieux, M., & Darne, O. (2015). Environmental Kuznets curve and ecological footprint: a time series analysis. *Economic Bulletin, 35*(1), 814-826.

Jebli, M., & Youssef, S. (2015). The environmental Kuznets curve, economic growth, renewable and non-renewable energy and trade in Tunisia. *Renewable and Sustainable Energy reviews, 47*, 173-185.

Jorgenson, A. (2003). Consumption and environmental degradation: a cross-national analysis of the ecological footprint. *Social Problems , 50*, 374-394.

Kaika, D., & Zervas, E. (2013). The environmental Kuznets curve (EKC) theory - Part A: Concept, causes and the CO2 emissions case. *Energy Policy, 62*, 1391-1402.

Kwakwa, P., Alhassan, H., & Aboagye, S. (2018). Environmental Kuznets Curve hypothesis in a financial development and nature resource extraction context: evidence from Tunisia. *Quantitative Finance and Economics, 2*(4), 981-1000.

Lean, H., & Smyth, R. (2010). CO2 emissions, electricity consumption and output in ASEAN. *Applied Energy, 87*, 1858-1864.

Li, T., Wang, Y., & Zhao, D. (2016). Environmental Kuznets curve in China: new evidence from dynamic panel analysis. *Energy Policy , 91*, 138-147.

Liddle, B., & Messinis, G. (2015). Revisitng carbon Kuznets curves with endogenous breaks modeling: evidene of decoupling and saturation (but few inverted-us) for individual OECD countries. *Economic modelling, 49*, 278-285.

Lin, D., Hanscom, L., Martindill, J., Borucke, M., Cohen, L., Galli, A., . . . Wackernagel, M. (2016). *Working guidebook to the National Footprint Accounts* (2016 Edition ed.). Oakland: Global Footprint Network.

Lise, W. (2006). Decomposition of CO2 emissions over 1980-2003 in Turrkey. *Energy Policy, 34*(14), 1841-1852.

Llorca, M., & Meunie, A. (2009). SO2 emissions and the environmental Kuznets curve: the case of Chinese provinces. *Journal of Chinese Economic and Business Studies , 7*, 1-16.

Mostafa, M. (2010). Clustering the ecological footprint of nations using Kohonen's self-organizing maps. *. Expetise in System Applications , 37*, 2747-2755.

Mrabet, Z., & Alsamara, M. (2017). Testing the Kuznets Curve hypothesis for Qatar: A comparison between carbon dioxide and ecological footprint. *Renewable and Sustainable Energy Reviews, 70*, 1366-1375.

Onafowora, O., & Owoye, O. (2014). Bounds testing approach to analysis of the environmental Kuznets curve hypothesis. *Energy Economics, 44*, 47-62.

Ozturk, I., & Acaravci, A. (2016). Energy consumption, CO2 emissions, economic growth, and foreign trade relationship in Cyprus and Malta. *Energy Sources, Part B: Economics, Planning, and Policy , 11*(4), 321-327.

Ozturk, I., Al-mulali, U., & Saboori, B. (2016). Investigating the environmental Kuznets curve hypothesis: the role of tourism and ecological footprint. *Environmental sciences and pollution research, 23*(2), 1916-1928.

Pao, H.-T., & Tsai, C.-M. (2011). Modelling and forecasting the CO2 emissions, energy consumption, and economic growth in Brazil. *Energy, 36*, 2450-2458.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships . *Journal of Applied Econometrics, 16*, 289-326.

Rees, W. E. (1992). Ecological footprints and appropriated carrying capacity: what urban economics leaves out. *Environmental Urbanization, 4*, 121-130.

Saboori, B., Sulaiman, J., & Mohd, S. (2012). Economic growth and CO2 emissions in Malaysia: a cointegration analysis of the environmental Kuznets curve. *Energy Policy , 51*, 184-191.

Shahbaz, M., Hye, Q., Tiwari, A., & Leitao, N. (2013). Economic growth, enegy consumption, financial development, international trade and CO2 emissions in Indonesia. *Renewable and Sustainable Energy Reviews, 25*, 109-121.

Shahbaz, M., Lean, H., & Shabbir, M. (2012). Environmental Kuznets Curve hypothesis in Pakistan: cointegration and Granger causality. *Renewable and Sustainable Energy Reviews, 16*, 2947-2953.

Song, T., Zheng, T., & Tong, L. (2008). An empirical test of the Environmental Kuznets curve in China: A panel cointegration approach. *China Economic Review, 19*, 381-392.

Stern , D. (2014). THe Environmental Kuznets curve: a primer . CCEP Working paper 1404.

Stern , D. I. (2014). The Environmental Kuznets Curve: a primer. CCEP Working apaepr 1404.

Uddin, G., Salahuddin, M., Alam, K., & Gow, J. (2017). Ecological footprint and real income: Panel data evidence from the 27 highest emitting countries. *Ecological Indicators, 77*, 166-175.

Ulucak, R., & Bilgili, F. (2018). A reinvestigation of EKC model by ecological footprint measurement for high, middle and low income countries. *Journal of Cleaner Production, 188*, 144-157.

Vackar, D. (2012). Ecological footprint, environmental performance and biodiversity: a cross-national comparison. *Ecological Indicators, 16*, 40-46.

Van Alstine, J., & Neumayer, E. (2010). The environmental Kuznets curve in Gallagher. In K. P. (Ed.), *Handbook on Trade and the Environment* (pp. 49-59). Cheltenham, UK: Edward Elgar.

Wackernagel, M., & Rees, W. (1996). *Our ecological footprint: Reducing Human Impact on Earth.* Gabriola Island: New Society Publishers.

Wang, K. (2012). Modeling the nonlinear relationship between CO2 emissions from oil and economic growth. *Economic modelling, 29*(5), 1537-1547.

Wang, S., Zhou, D., Zhou, P., & Wang, Q. (2011). CO2 emissions, energy consumption and economic growth in China: a panel data analyses. *Energy Policy, 39*(9), 4870-4875.

Wang, Y., Kang, L., Wu, X., & Xiao, Y. (2013). Estimating the environmental Kuznets curve for ecological footprint at the global levle: a spatial econometric approach. *Ecological Indicators, 34*, 15-21.

Yavuz, N. (2014). CO2 emission, energy consumption and economic growth for Turkey: evidence from a cointegration test with a structural break. *Energy Sources Part B: Economic Planning and Policy, 9*(3), 229-235.

Yazdi, S. K., & Beygi, E. G. (2017). The dynamic impact of renewable energy consumption and financial developent on CO2 emissions: for selected African countries. *Energy Sources, Part B: Economics, Planning, and Policy , 13*(1), 13-20.

Yazdi, S. K., & Shakouri, B. (2018). The effect of renewable energy and urbanization on CO2 emissions: A panel data. *Energy Sources, Part B: Economics, Planning, and Policy , 13*(2), 121-127.

Zivot, E., & Andrews, D. (1992). Further Evidence of great cash, the oil price shock and the unit root hypothesis. *Journal of Buisness and Economic Statistics, 10*, 251-270.

Zoundi, Z. (2017). CO2 emissions, renewable energy and the Environmental Kuznets Curve: a panel cointegration approach. *Renewable and Sustainable Energy Reviews, 72*, 1067-1075.