# The effects of international tourism, electricity consumption and economic growth on CO2 emissions in North Africa

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# Abstract

This study examines the influence of tourism, economic growth and electricity consumption on carbon dioxide ($CO_2$) emission in the presence of Environmental Kuznets Curve (EKC) model for a panel of four countries of North Africa, namely Morocco, Algeria, Tunisia and Egypt, over the period 1980–2014. Since we find the existence of cross-sectional dependence, we apply the unit root tests of CIPS and CADF, the Westerlund cointegration test as well as the dynamic seemingly unrelated regression (DSUR), and Dumitrescu-Hurlin Granger causality test. The empirical results show that electricity consumption has a positive effect on CO2 emissions. In contrast, tourism has a negative relationship with CO2 emissions, implying improvement in the quality of the environment. The conclusions confirm the hypothesis of the environmental Kuznets curve for the countries in our sample. In addition, the causality test indicates the following results: (i) A one-way causality from real income, electricity consumption and tourism to carbon emissions. (ii) A one-way causality runing from electricity consumption to real income and tourist arrivals. (iii) A two-way causality between real income and tourism development. Based on these empirical results, several policies recommendations are proposed for the four countries of North Africa.


# 1. Introduction

Over the decades, tourism has grown tremendously and has become so diversified that it-is considered as one of the fastest growing economic sectors in the world. From 1950 to 2019, the number of international tourists increased from 25 million to 1.5 billion tourists, an average annual growth rate of 6%. Regionally, North Africa grew by 10%, exceeding the world average. This growth implies the driving role of tourism and its resilience as an economic sector, especially in view of economic crises and socio-political instability. Tourism is the source of significant benefits both socially and economically. Among other things, it has made an important contribution to raising the standard of living by increasing and expanding the range of employment opportunities created in the field of leisure, accommodation, restaurant, transportation and events, as well as becoming, for several Northern African countries, an important source of foreign exchange. In contrast, the tourism sector has suffered environmental damage due to CO2 emissions which are linked to high energy consumption (Gossling, 2002). This sector is responsible for about 8% of total greenhouse gas emissions (Lenzen et al., 2018). In addition, the rapid growth of the tourism industry in North Africa is raising concerns about its negative impact on environment. Unlike many economic sectors, tourism is a major contributor to climate change, and simultaneously it is also vulnerable to its impacts. Thus, the countries of North Africa are particularly vulnerable to climate change. This region features arid and semi-arid climates, as well as tropical coastal areas. It is already the hottest and driest region in Africa and the Intergovernmental Panel on Climate Change (IPCC) forecasts only point to worsening warming. Besides, greenhouse gas emissions in this region have increased quite rapidly, in parallel with their economic development (FEMISE, 2018). This trend could continue or even accelerate in the coming decades. To face these challenges, it seems urgent for the tourism sector in North Africa to design and implement policies to deal with climate change and take appropriate measures to mitigate the negative impacts of tourism on environment.

Furthermore, the countries of North Africa, like many developing countries, are now aiming to achieve strong and sustainable economic growth, taking into consideration several challenges, such as energy and electricity demand growth necessary for economic growth without harming environment. Real GDP per capita and electricity consumption per capita in the four North African countries increased during the period 1980–2014 (see Fig. 1). We can see that real per capita income experienced an average growth of 2.6% Egypt, 0.8% in Algeria, 2.5% in Morocco and 2.2% in Tunisia from 1980 to 2014. Similarly, electricity consumption per capita experienced an average annual growth rate of 4.5% in Egypt, 4.3% in Algeria, 4% in Morocco and 3.8% in Tunisia during the same period. Consequently, CO2 emissions experienced an average annual growth rate of 2.6% in Egypt, 0.2% in Algeria, 2.3% in Morocco and 1.7% in Tunisia during the 1980 period to 2014.

In terms of literature, several research works on the relationship between tourism, economic growth and environmental quality have recently been published. For example, Sharif, Afshan & Nisha (2017) in Pakistan, Raza et al. (2016) in the United States, Shakouri et al. (2017) in Asia-Pacific countries, Danish and Wang (2019) in BRICS countries, Paramati, Koçak et al. (2020) in 10 tourist countries. Eyuboglu & Uzar (2019) for Turkey, Dogan et al. (2015) for OECD countries, Katircioglu et al. (2014) for Cyprus, Solarin (2014) and Jayaraman, Lin, Guat and Ong, (2010) for Malaysia and Sghaier et al. (2019) for Tunisia, Egypt and Morocco. However, the research results are inconclusive for several reasons, including the use of different conventional econometric models and methodologies that do not take into account heterogeneity and cross-sectional dependence, lack of data and correct choice of variables, etc. Moreover, empirical research in this area on the countries of North Africa, notably Morocco, Algeria, Tunisia and Egypt, remains scarce and the estimation method has been limited to the use of the ADRL or FMOLS technique.

Therefore, this study focuses on the impact of tourism development, electricity consumption, and economic growth on CO2 emissions in North African countries. Our objective is to contribute to enriching the existing literature in various ways: first, this article differs from that of previous work by highlighting the impact of electricity consumption rather than energy consumption as a variable control, due to its use in all sectors of activity including the tourism sector and its demand higher than the overall energy demand. Second, that the size of the time series data assessment is relatively moderate (T = 34), the application of the panel data approach in this study improved the power of statistical tests, so, we may obtain more robust estimation results. For this reason, we use several econometric methods such as unit root and cointegration tests as well as the dynamic seemingly unrelated regression (DSUR) estimator which takes into account the cross-sectional dependence in the model to produce consistent and reliable results. Finally, we conducted a causal analysis, using Dumitrescu and Hurlin test, which is more appropriate for heterogeneous panel data in order to study the dynamics between tourism, electricity consumption, economic growth and carbon emissions in the context of North African countries. Thus, the implications of this study would give decision-makers a deeper insight into the development of global and sectoral policies.

This study is organized as follows: Sect. 2 provides a comprehensive literature review; Sect. 3 presents the selected data, model, and used methodology ; Sect. 4 discusses the empirical results; and Sect. 5 concludes with the conclusions and policy implications.

# 2. Literature Review

In the literature, the economic impacts of the tourism industry and the relationship between economic growth and the quality of the environment have been the subject of several research studies. However, many empirical studies have provided controversial results regarding the link between tourism development, energy consumption, environmental quality and economic growth. Therefore, we will briefly analyze the results of previous studies under two lines of research.

2.1 Tourism and economic growth

Theoretically, international tourism is a source of long-term growth through several channels. In a more traditional sense, it has been argued that tourism brings in foreign currency, which can be used to import the capital goods needed to produce goods and services, thereby contributing to economic growth (Nowak, Sahli, and Cortés-Jiménez, 2007).

On the other hand, international tourism contributed to increasing income in several ways. First, it increases efficiency by rising competition between international tourist destinations (Zemla, 2014), secondly by facilitating the exploitation of economies of scale in local businesses (Jenkins, 1982), third , it makes it possible to boost the competitiveness of tourism companies from tourism clusters (Novelli, Schmitz and Spencer, 2006).

In terms of empirical literature, the link between international tourism and long-term growth has been the subject of numerous econometric studies since the early 2000s. The results of these studies show that it is difficult to establish a robust relationship between international tourism and growth.

2.2 Tourism, energy / electricity consumption, economic growth and CO2 emissions

Tourism development can have consequences on the degradation of environment, through the construction of hotels, tourist facilities and infrastructure, movement of tourists and additional energy consumption, reduction natural and agricultural areas. Conversely, environmental degradation could lead to a decline in tourism growth (Organization for Economic Co-operation and Development, 1980).

Empirically, the dynamic relationship between CO2 emissions, tourism development and economic growth are also controversial. For example, Sharif, Afshan & Nisha (2017) examined the effect of economic growth, tourist arrivals on CO2 emissions in Pakistan during the period 1972 to 2013 using cointegration techniques. The results of the analysis confirm the long-term relationship between tourism and CO2 emission. Raza et al. (2016) analyzed the influence of tourism development on environmental



discrete wavelet transform (MODWT). The study revealed that tourism development has a positive influence on CO2 emissions in the short, medium and long term. Shakouri et al. (2017) examined the impact of tourism and economic growth on CO2 emissions in selected Asia-Pacific countries for the period 1995–2013. Their results show that tourist arrivals have positive effects on CO2 emission levels. Danish and Wang (2019) explored the relationship between tourism, economic growth and CO2 emissions, in the context of the BRICS economies during the period 1995 to 2014, using econometric tests at heterogeneity and cross-sectional dependence. The results of the analysis show that the tourism sector encourages economic growth but degrades the quality of environment. In addition, they prove the EKC hypothesis in BRICS countries, according to which the relationship between environmental quality and per capita income can have the shape of an inverted “U”, means that there may be a break in the positive relationship between the degradation of environmental quality and per capita income from a threshold level of the latter, called the turning point, from which the relationship becomes negative. Paramati, Alam, and Chen (2016) studied the relationship between tourism revenues, economic growth and CO2 emissions in developed and developing economies for the period 1995-2012. The econometric results indicate that tourism receipts have a positive effect on CO2 emissions. They also show the magnitude of the impact of tourism revenues on economic growth, and CO2 emissions vary widely between developed and developing countries. Koçak et al. (2020) has examined the relationship between tourism development and CO2 emissions in the top 10 tourist destination countries for the period 1995-2014. The results show that tourist arrivals have an increasing effect on CO2 emissions, while tourism receipts have a reduced effect on CO2 emissions.

Other studies have also provided additional information, in particular on energy consumption in the modeling of the determinants of CO2 emissions. Indeed, the positive impact of energy consumption on CO2 emissions has been shown in the following cases: Eyuboglu & Uzar (2019) for Turkey, Dogan et al. (2015) for the countries of the Organisation for Economic Co-operation and Development (OECD) and Katircioglu et al. (2014) for Cyprus. However, other studies have proved that the impact of energy consumption on CO2 emissions is not significant, in particular: Solarin (2014) and Jayaraman, Lin, Guat and Ong, (2010) for Malaysia.

On the other hand, the results of the research are not uniform, which emerges from the contradictory conclusions of Katricioglu (2014) and Bella (2018). For example, Katricioglu (2014) found a negative impact of tourist arrivals on CO2 emissions in Singapore, while Bella (2018) noticed that there is a long-term negative relationship between tourism growth and polluting emissions for the case of France.

Finally, few studies in the literature have assessed the relationship between tourism, economic growth, energy or electricity consumption and CO2 emissions within the scope of the case study region, especially the North Africa. Sghaier et al. (2019) examined the influence of tourism development and energy consumption on economic growth and CO2 emissions in Tunisia, Egypt and Morocco, for the period 1980-2014, using an ARDL model. The results obtained are also attenuated, they consider that the growth of tourism has a negative effect on the quality of environment in Egypt while it has a positive effect in Tunisia and neutral in Morocco. The study support for the existence of an inverted U-shaped [illegible] Morocco and Egypt, while for Tunisia, this relationship is U-shaped. Gao et al. (2019) studied the relationship between CO2 emissions, energy consumption, economic growth and tourism receipts using cointegration tests on panel data from 18 Mediterranean countries over the period 1995-2010. The study revealed that tourism has a negative and significant impact on CO2 emissions in the southern Mediterranean region.

The empirical evidence for North Africa countries makes it clear that there is a lack of consensus among researchers on the relationship between the variables studied. In addition, studies on the impact of tourism development on the quality of the environment in North Africa remain low and the estimation method has been limited to ADRL and FMOLS. Therefore, this article considers it important to study the EKC and TLG assumptions in North African countries using the DSUR estimator which takes into account both heterogeneity and cross-sectional dependence, that is not the case for the DOLS and FMOLS estimator. Likewise, this method is particularly suitable when the time dimension is greater than the cross sectional data.

Moreover, unlike previous studies, this one uses electricity consumption in the study of the dynamic relationship between tourism, growth and environmental quality. Indeed, unlike other types of energy, electricity consumption is used in all sectors of activity (Ferguson et al, 2000; Shaari et al., 2017; Rahman, 2020). Given that the tourism sector is transversal, this study contributes to the existing literature by including electricity consumption in the analysis of the link between tourist arrivals, economic growth and CO2 emissions.

## 3. Methodological Framework

# 3.1 Model specification and data source

In order to study the impact of tourism and electricity consumption on the quality of the environment, the theoretical framework adopted is that of the environmental Kuznets curve (EKC). Therefore, the functional form for the conceptualization of the EKC is inspired by the pioneering study of Grossman and Krueger (1991) and more recently the studies of Katircioglu (2014) and Gao et al. (2019), who integrated the development of tourism into the conventional EKC model. Therefore, the following model can be suggested in the present study:<

$$CO2_{it} = \beta_0 + \beta_1 GDP_{it} + \beta_2 GDP^2{}_{it} + \beta_3 TO_{it} + \beta_4 ELECT_{it} \qquad (1)$$

The $\beta$ coefficients reflect the relevance of the independent variables to carbon emissions as a dependent variable ($CO2_{it}$). Indeed, equation 1 tests the non-linear link between economic growth ($GDP_{it}$) and carbon emissions per capita ($CO2_{it}$). Additional explanatory variables are integrated, such as tourist arrivals ($TO_{it}$) and electricity consumption ($ELECT_{it}$). εit is the error term, which is normally distributed with mean zero and constant variance. The sub-index i designates country i, and t designates the time dimension.

This study examines, in a balanced panel framework, the impact of income, electricity consumption and tourism activity on the quality of the environment in the context of the countries of North Africa, particularly: Morocco, Algeria, Tunisia and Egypt during the period 1980–2014.

Carbon dioxide emissions were in metric tons per capita. Real income per capita is used as a measure of economic performance (GDP in USD), tourist arrivals as a measure of tourism activity and electricity consumption per capita (kWh per capita).

All data was taken from the World Development Indicators (WDI) database, with the exception of tourist arrivals which was taken from the Compendium of Tourism Statistics of the World Tourism Organization. All variables are expressed as natural logarithms.

## 3.2 Methodological approach

The estimation process is divided into five stages. The first step of the procedure consists in analyzing the cross-sectional dependence between the variables. The second step studies the levels of integration of the variables with the tests of unit roots CIPS and CADF of Pesaran (2007) which takes into account the cross-sectional dependence. In the third step examines the structure of long-term relationship between variables using the Westerlund cointegration test (2007). In the fourth step, in order to estimate the long term impact of the independent variables on carbon emissions, cointegration regression (FMOLS, DOLS, DSUR) is used. Finally, the last step of the process concerns the use of the Granger causality test in panel data introduced by Dumitrescu and Hurlin (2011).

*Cross-sectional independence tests*

When estimating panel data, dependency is an important issue and ignoring it can lead to biased and inconsistent estimates (O'Connell, 1998). Given that N is small with respect to the time dimension T, this study applies two tests in order to verify the cross-sectional dependence: the Breusch-Pagan LM test developed by Breusch and Pagan (1980) and the Pesaran scaled LM test (2004) .

The Breusch-Pagan LM test can be calculated as follows:

$$M = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} T_{ij}\hat{\rho}_{ij}^{2} \rightarrow x^{2}\frac{N(N-1)}{2}$$

2

where are the correlation coefficients obtained from the model residuals as described above. The asymptotic distribution is obtained for fixed as for all, and follows from an assumption of normality on the errors.

In addition, Pesaran (2004) provides a standardized version of the LM test. This test can be calculated as follows:

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$$LM_s = \sqrt{\frac{1}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} (T_{ij}\hat{\rho}_{ij}^2 - 1) \rightarrow N(0,1) \quad (3)$$

*Panel unit root tests*

As a second step in the empirical study, we will perform unit root tests for the panel data to determine the level of integration of all selected variables. More precisely, we use the second generation unit root tests, in particular the CADF and CIPS tests developed by Pesaran (2007) which take into account the cross-sectional dependence of the observations and the heterogeneity of the parameters.

The Dickey-Fuller Sectional Augmented Statistics (CADF) can be expressed as:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \delta_i \bar{y}_{t-1} + \sum_{j=0}^{\rho} \theta_{ij} \Delta \bar{y}_{t-j} + \sum_{j=1}^{\rho} \mu_{ij} \Delta y_{i,t-j} + e_{it} \quad (4)$$

With $y_t$ is the mean at time T of all N countries. After running the CADF and CIPS test statistics can be obtained as follows:

$$CIPS = N^{-1} \sum_{i=1}^{N} t_i(N,T) \quad (5)$$

With $t_i(N,T)$ is the statistic t in the CADF regression defined by Eq.5.

*Panel cointegration test*

Then, the panel cointegration test advanced by Westerlund (2007) is used to identify the existence of cointegration relationships among the selected variables. This test solves the problem of cross-sectional dependence.

*Long-run estimates: FMOLS, DOLS, DSUR*

After checking for stationarity and cointegration between the variables, we use three econometric methods to estimate the long-run coefficients of equation 1. We used the cointegration regressions developed by Pedroni (2001), in particular least squares Fully Modified Ordinary (FMOLS) and Dynamic Ordinary Least Squares (DOLS) Estimators. These two methods are widely used in the literature due to their help in eliminating endogeneity issues among regressors and autocorrelation (Danish et al., 2020; Dogan and Seker, 2016, Wang et al. (2020) , we used the dynamic seemingly unrelated regression (DSUR) technique developed by Mark et al. (2005) which is robust to both cross-sectional dependence and heterogeneity issues. Likewise, another advantage of this technique lies in its ability to produce very well behaved estimates with all the usual desirable properties in the where the sample size (N) is significantly smaller than the time dimension (T) (Mark et al., 2005).

*Dumitrescu-Hurlin panel causality analysis*

Finally, the last step consists in studying the causal interactions between the studied variables, using the



ain reasons: first, it allows to take into account the individual heterogeneity in causal relation and cross-sectional dependence, then it can be applied flexibly when $N > T$ and $N < T$

# 4. Empirical Results And Analysis

Interpretation of empirical results begins with descriptive statistics which strengthens our understanding of the characteristics of the sample by providing information on the mean, median, maximum and minimum deviation, standard deviation, Skewness and Kurtosis measurements as well as the Jarque-Bera test of normality. This is presented in Table 1. All the variables show positive averages and a wide dispersion of their averages with the exception of CO2 emissions per capita. Indeed, CO2 emissions per capita is on average 2,012 with a standard deviation of 0.794 in the four countries of the North African region, compared to real GDP per capita (M = 2667.289, SD = 980.9489), consumption electricity (M = 757.252, SD = 358.071) and tourist arrivals (M = 3878045, SD = 2982230). Furthermore, the skewness indicator shows that all the considered variables are positively biased, which means that the distribution is skewed to the right. Regarding the results of kurtosis, the distribution of electricity consumption is approximately mesokurtic (kurtosis value about 3) while carbon emissions and per capita income are platykurtic (kurtosis values below normal value). Only tourist arrivals among all variables had their kurtosis greater than the normal value suggesting that the curve of this distribution is leptokurtotic. Since the values of Skewness and kurtosis did not satisfy the conditions for normality, we affirm that the series are not normally distributed. This is confirmed by the Jarque-Bera test which provides solid proof that the hypothesis of normality of the series studied is rejected.

**Table 1. Descriptive statistics of variables**

| | | | | |
|---|---|---|---|---|
| **Mean** | 2.012293 | 757.2524 | 2667.289 | 3878045 |
| **Median** | 1.804986 | 680.5568 | 2463.304 | 3008000 |
| **Maximum** | 3.735803 | 1685.819 | 4702.170 | 14051000 |
| **Minimum** | 0.774235 | 236.8683 | 1102.308 | 520000 |
| **Std. Dev.** | 0.794681 | 358.0717 | 980.9489 | 2982230 |
| **Skewness** | 0.383809 | 0.854325 | 0.366070 | 1.137344 |
| **Kurtosis** | 2.062747 | 2.963473 | 1.930095 | 3.610012 |
| **Jarque-Bera** | 8.561469 | 17.03813 | 9.804241 | 32.35352 |
| **Probability** | 0.013832 | 0.000200 | 0.007431 | 0.000000 |

We continue the empirical interpretation by examining the correlation matrix of the variables. This is presented in Table 2. The results of the correlation analysis show that the CO2 per Capita correlates positively with electricity consumption and real GDP per capita and negatively with tourist arrivals. A positive and statistically significant correlation is observed between tourist arrivals and electricity consumption. While the negative correlation observed between tourist arrivals and real income per capita is not significant.

**Table 2. Correlation Matrix**

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| | | | |
|---|---|---|---|
| 1.000000 | | | |
| ----- | | | |
| 0.584646 | 1.000000 | | |
| 0.0000 | ----- | | |
| 0.869040 | 0.491161 | 1.000000 | |
| 0.0000 | 0.0000 | ----- | |
| -0.136628 | 0.609879 | -0.017839 | 1.000000 |
| 0.1075 | 0.0000 | 0.8343 | ----- |

In order to test for multicollinearity among the independent variables (electricity consumption, per capita income and tourist arrivals), the tolerance and the variance inflation factor (VIF) for each variable is calculated. The results presented in Table 3 show that there is no multicollinearity problem since the tolerance values are not less than 0.2 and the VIF values are much less than 5. This therefore implies that all the independent variables can be kept for econometric analysis.

**Table 3. Test of multicolnearity**

| Variable | VIF | Tolerance |
|---|---|---|
| | 2.67 | 0.374701 |
| | 1.66 | 0.600693 |
| | 2.02 | 0.494117 |

We also apply the homogeneity tests of Pesaran and Yamagata (2008). Based on the results presented in Table 4, we reject the null hypothesis of homogeneity in favor of the alternative hypothesis of heterogeneity. Which consequently implies the existence of heterogeneity in the panel data analyzed. Therefore heterogeneous panel data methods should be adopted.

**Table 4. Pesaran-Yamagata's homogeneity test**

| Test | statistic | p-value |
|---|---|---|
| **Delta** | 9.003 | 0.000 |
| **adj.** | 9.774 | 0.000 |

In addition to the homogeneity test, we also apply cross-sectional dependence tests including the Breusch-Pagan LM test (1980), the Pesaran scaled LM test (2004) and the Pesaran CD test (2004). Table 5 clearly indicates a significant cross-sectional dependence for the countries of the sample considered (because the p-value associated with the CD statistic is much lower than the threshold of 1%, which implies the rejection of the H0 hypothesis).

The results obtained in favor of heterogeneity and cross-sectional dependence between the countries of North Africa, the subject of this study, require the application of second-generation panel unit root tests which take into account the cross-sectional dependence. Therefore we used the unit root test of Pesaran (2007) CIPS and CADF. The results of the unit root tests are shown in Table 6.

**Table 5. Test for Cross-Sectional Dependence**

| Variables | Breusch-Pagan LM | | Pesaran scaled LM | | Pesaran CD | |
|---|---|---|---|---|---|---|
| | Statistic | *p*-Value | Statistic | *p*-Value | Statistic | *p*-Value |
| | 109.5292 | 0.0000 | 29.88632 | 0.0000 | 9.451378 | 0.0000 |
| | 203.0404 | 0.0000 | 56.88066 | 0.0000 | 14.24869 | 0.0000 |
| | 152.5271 | 0.0000 | 42.29872 | 0.0000 | 12.18215 | 0.0000 |
| | 139.3259 | 0.0000 | 38.48786 | 0.0000 | 12.26799 | 0.0000 |

CADF and CIPS unit root test results indicate that not all variables are stationary in level and stationary in first differences. Since the variables are all integrated of order one I (1), their linear combination must follow a stationary process I (0). Panel unit root tests were extended to study panel cointegration tests, in order to examine the existence of a long-term relationship between variables.

**Table 6. Result of CADF and CIPS panel unit root test**

| Variable | CADF | | CIPS | |
|---|---|---|---|---|
| | **At level** | **First difference** | **At level** | **First difference** |
| | 0.414 | -5.377*** | -0.280 | -5.377*** |
| | 2.059 | -4.103*** | 2.977 | -4.996*** |
| | 1.190 | -1.733** | 1.129 | -2.140** |
| | -0.077 | -3.756*** | -0.077 | -4.876*** |

We used Westerlund (2007) to test whether the variables are cointegrated. This is a test made up of four other tests namely: Gt, Ga, Pt and Pa. The first two tests are called group means tests and the alternative hypothesis is that at least one case has cointegrated variables. The last two tests are called Panel tests, and in this case, the alternative hypothesis is that the panel, considered as a whole, is cointegrated. The results presented in Table 7 indicate that the hypothesis of non-cointegration is rejected for the case of the Gt and Pt tests, with a significance rate of 1%, and for the case of the Ga and Pa tests, with a rate of significance of 10%. In the light of these results, we conclude that the studied variables are cointegrated.

**Table 7. Westerlund (2007) Panel Cointegration Test**

| Statistic | Value | Z-value | P-value |
|---|---|---|---|
| Gt | -4.136 | -4.038 | 0.000 |
| Ga | -15.674 | -1.338 | 0.090 |
| Pt | -6.845 | -2.842 | 0.002 |
| Pa | -12.122 | -1.422 | 0.077 |

This study also applies the FMOLS and DOLS methods, the DSUR method in order to display a precise and robust estimate of the long-term coefficients associated with economic growth, electricity consumption and the tourism sector with carbon emissions. We showed first mention that all the estimated coefficients are statistically significant at the 1%, 5% or 10% level. Besides, the signs of the coefficients of the variables are the same for the three estimators even if their magnitude varies slightly between the estimators. The elasticity of carbon emissions to economic growth is positive and ranges from 5.07−6.5%, implying that the increase in real income leads to a sharp increase in emissions in the countries of the North Africa. Economic growth is a cause of CO2 emissions. Moreover, the negative coefficient of real income squared confirms the hypothesis of the environmental Kuznets curve. The inverted U behavior of the EKC corresponds to the coefficients β1 > 0 and β2 < 0. Our results support the findings of Grossman and Krueger (1991) and Danish and Wang (2019) as well as Dogan et al. (2019) who estimated the evidence supporting an inverted U-shaped relationship according to the EKC framework. However, our conclusions are not consistent with the results estimated by Ozturk et al. (2015) and Azam et al. (2018).

### Table 8. Long-Run Estimation Results

| **Dependent Variable** | **FMOLS** | | **DOLS** | | **DSUR** | |
|---|---|---|---|---|---|---|
| **Regressors** | Coefficient | *p*-Value | Coefficient | *p*-Value | Coefficient | *p*-Value |
| | 6.51305 | 0.0000 | 5.07050 | 0.0052 | 6.23814 | 0.000 |
| | -0.30515 | 0.0000 | -0.28736 | 0.0107 | -0.36196 | 0.000 |
| | -0.06819 | 0.0931 | -0.11572 | 0.0454 | -0.29813 | 0.000 |
| | 0.13687 | 0.0000 | 0.33749 | 0.0000 | 0.57523 | 0.000 |

Likewise, the elasticity of carbon emissions with respect to electricity consumption is significantly positive. Indeed, a 1% increase in electricity consumption per capita, ceteris paribus, increases carbon dioxide emissions per capita by 0.57%. This result suggests that increasing electricity consumption leads to environmental degradation. The conclusion are similar to those of other studies, notably by Rahman (2020) and Kasman and Duman (2015). Unlike electricity consumption, the elasticity associated with tourist arrivals is positive and statistically significant. These studies imply that the tourism sector is not an environmental pollution problem in the sample countries. Moreover, a 1% increase in tourist arrivals, ceteris paribus, reduces carbon emissions by 0.29%. This result is consistent with that of Katircioglu (2014) and Gao et al. (2019). It appears that operators of the tourism industry are encouraging responsible consumption by using renewable energy resources. This study also uses the Dumitrescu and Hurlin causality test to reveal the relationship between CO2 emissions, electricity consumption, economic growth and tourism development for the sample countries. The results of the Dumitrescu and Hurlin causality test are reported in Table 9. We have sufficient evidence to conclude that there is a one-way Granger causality ranging from real income, electricity consumption and tourism to emissions of carbon. Also, there is a one-way causality from electricity consumption to real income and tourist arrivals. This assumption assumes that electricity consumption plays a primary role both directly and indirectly in the production process. Under these conditions, the energy policy implemented influences the level of production and tourist attendance. Finally, we have observed a two-way causality between real income and tourism development. Both influence each other. This observation implies that tourism and economic policies will have to be implemented jointly.

### Table 9. Dumitrescu and Hurlin: Heterogeneous Panel Causality Tests

| Null Hypothesis: | W-Stat. | Zbar-Stat. | *p*-Value |
| --- | --- | --- | --- |
| does not homogeneously cause | 5.43926 | 2.82444*** | 0.0047 |
| does not homogeneously cause | 1.65143 | -0.43193 | 0.6658 |
| does not homogeneously cause | 4.65067 | 2.14649** | 0.0318 |
| does not homogeneously cause | 2.78396 | 0.54171 | 0.5880 |
| does not homogeneously cause | 5.62460 | 2.98377*** | 0.0028 |
| does not homogeneously cause | 2.57095 | 0.35858 | 0.7199 |
| does not homogeneously cause | 2.67152 | 0.44504 | 0.6563 |
| does not homogeneously cause | 8.36394 | 5.33876*** | 9.E-08 |
| does not homogeneously cause | 2.29991 | 0.12557 | 0.9001 |
| does not homogeneously cause | 6.45599 | 3.69851*** | 0.0002 |
| does not homogeneously cause | 6.54817 | 3.77775*** | 0.0002 |
| does not homogeneously cause | 5.42976 | 2.81627*** | 0.0049 |

# 5. Conclusion And Policy Implications

The main objective of this study is to analyze the influence of tourism and electricity consumption on CO2 emissions in the presence of the EKC model in four countries of North Africa, namely Morocco, Algeria, Tunisia and Egypt, over the period 1980–2014, using estimation techniques several suitable econometric methods such as the unit root tests of CIPS and CADF, the Westerlund cointegration test as well as the estimate of dynamic seemingly unrelated regression (DSUR) which takes into account the cross-sectional dependence and heterogeneity of the countries in the sample. Finally, we carried out a causality analysis using the test of Dumitrescu and Hurlin (2012), to verify the causal relationship in the case of data with cross-sectional dependence. The results of the unit root tests in CADF and CIPS panels show that the series studied become stationary at their first differences. Westerland's (2007) panel data cointegration test indicates the presence of a long-term relationship between the variables. The results of the FMOLS, DOLS and DSUR estimates prove that electricity consumption has a positive relationship with long-term carbon dioxide emissions. In addition, our results show that tourist attendance has a negative relationship with carbon emissions in the countries of North Africa (Morocco, Algeria, Tunisia and Egypt). Our results also indicate that economic growth and GDP squared have a positive and negative effect, respectively, confirming the environmental Kuznets curve hypothesis for the countries in our sample. Furthermore, the Granger causality test shows the following results: (i) A one-way causality ranging from real income, electricity consumption and tourism to carbon emissions. (ii) A one-way causality going from electricity consumption to real income and tourist arrivals. (iii) A two-way causality between real income and tourism development we have then drawn several implications from the analysis of these empirical results. First, the results confirm the inverted U behavior of the EKC for the four North African countries. Public authorities in these countries must promote technological progress for the benefit of economic growth and sustainable development. So, the perverse impact of electricity consumption on environment suggests an energy transition by turning to renewable energies. Therefore, it is necessary to put in place a certain number of measures aiming at ensuring the sustainable financing and at a lower financial cost of the energy transition, by mobilizing existing financial tools and developing new ones. Tax and regulatory measures should also be considered to ensure the energy transition, and to be used as



g in energy transition skills. Finally, considering that tourism improves the quality of environment, policy makers in these countries should encourage the tourism sector as a lever for sustainable development and a means to increase energy efficiency.

# Declarations

### Declaration of competing interest

The author declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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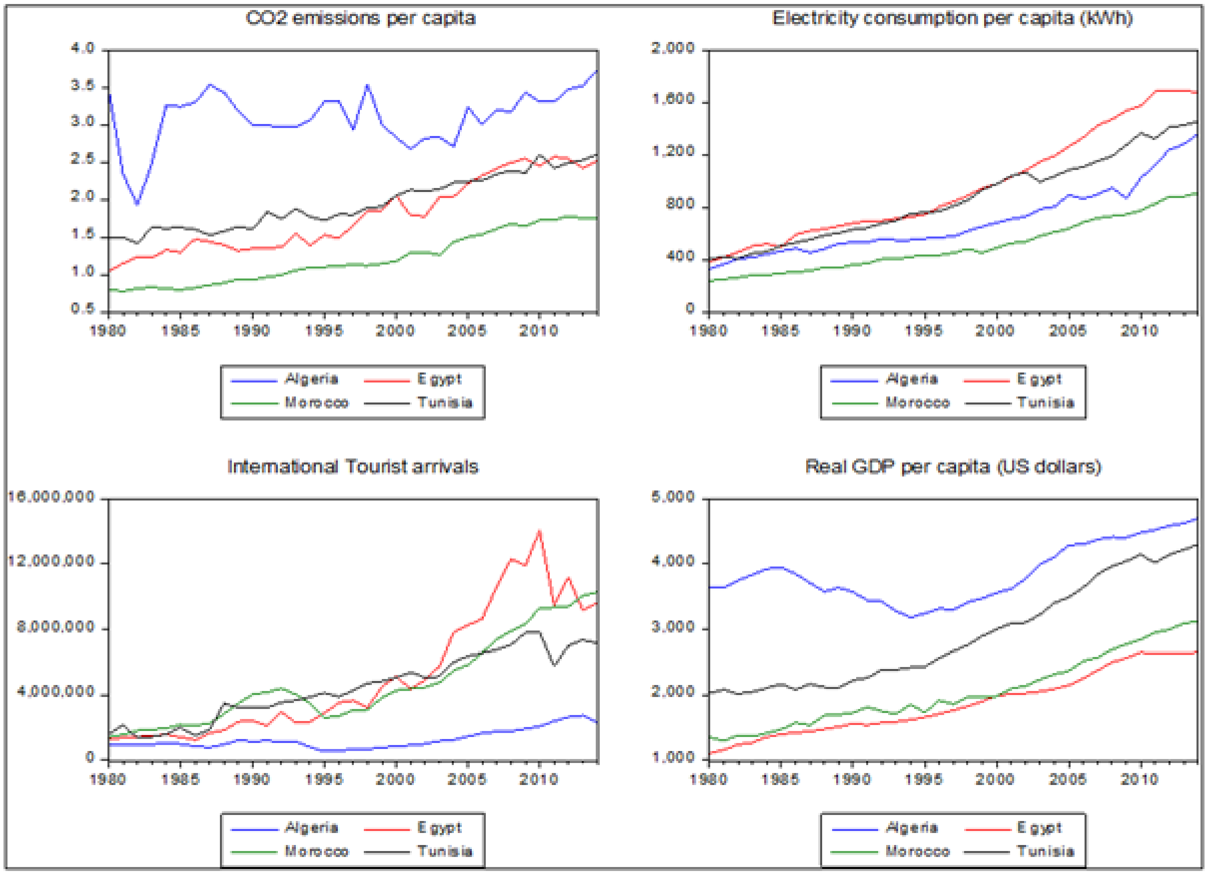
# Figures




## Figure 1

Trends in carbon emission per capita, electricity consumption per capita, international tourist arrivals, and real GDP per capita in North Africa countries from 1980 to 2014

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