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Environmental Impact of Urbanization, Bank Credits, and Energy Use in the UAE—A Tourism-Induced EKC Model

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Abstract: The United Arab Emirates (UAE) has developed rapidly into one of the highest per capita income nations globally. The travel and tourism sector is a central contributor to the Gross Domestic Product (GDP), employment, foreign exchange earnings, and the country's economic diversification strategy. However, the rapid growth of the sector and increase in international tourist arrivals are also major contributors to carbon emissions and long-term environmental challenges. In this context, we employed a tourism-induced Environmental Kuznets Curve (EKC) model for the UAE from 1984 to 2019. The study applied an Autoregressive Distributed Lag (ARDL) model to determine the marginal impact of tourist arrivals and related variables, namely, bank credits to the private sector, urbanization, and energy use, on CO_2 emissions. The Pesaran bounds test indicated redundancy of short run estimates. The long-run coefficients confirmed the EKC hypothesis of inverted U-shape for carbon emissions and per capita income, along with environmental degradation due to tourist arrivals and financial development. Notably, urbanization and energy use highlighted the positive steps taken by the government. Granger causality tests indicated a unidirectional association from GDP, bank credits, and energy consumption to carbon emissions. Importantly, tourist arrivals and urbanization had bidirectional causality with carbon dioxide levels. This study is the first to apply the tourism-induced EKC model to the UAE, and the findings have important implications for policymakers and practitioners. The causality results highlight the need to balance tourism targets and sustainable economic growth through the adoption of 'green' standards. The results also indicate the potential importance of financial sector efforts to boost green investments and implement clean energy-related technologies.

Keywords: climate change; sustainability; trade-offs; EKC; policy; ecological economics

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1. Introduction

Since its formation in 1971, the United Arab Emirates (UAE) has developed rapidly into one of the world's highest per capita income nations. With a focused diversification effort to reduce its dependence on oil and natural gas revenues, the UAE moved towards a free-market economy with minimal restrictions on private-sector activities and capital movements and has transformed its urban landscape, resulting in a high urbanization rate. The development of tourism is a central component of the economic development and diversification strategy of the UAE [1]. According to the World Travel and Tourism Council 2021 [2], travel and tourism contributed to 11.6% of the total UAE Gross Domestic Product (GDP) in 2019 and directly accounted for 11.2% of total employment, a total of 749.2 thousand people. Inbound international arrivals contributed 9.9% of the export revenue in foreign exchange earnings accounting for nearly 39 billion USD.

According to the United Nations World Tourism Organization [3], international tourism has experienced continued expansion since 2010 to become one of the world's largest and fastest-growing economic sectors, driven by rapid urbanization and technological advances in emerging nations. International arrivals and tourism receipts have been growing at an annual 3–5% rate, outpacing the growth of international trade. In 2019, foreign revenues from international tourism around the globe reached USD 1.7 trillion, with the Middle East recording the highest growth in arrivals. Given this rapid growth over the past several decades, it is important to fully understand the environmental impacts of tourism in the UAE, the region's leading tourism center.

The wider relationship between economic growth and the environment has been examined extensively in the scientific literature over the past few decades, and there have been specific attention focused on the environmental impacts and tradeoffs related to tourism development. Environmental degradation due to carbon dioxide emissions (CO_2) has been attributed to burning fossil fuels to generate electricity [4], which is necessary for economic development. While the scientific evidence has highlighted the detrimental effects of CO_2 on the global climate and ecosystems, it is also widely recognized that until there are suitable and scalable alternative sources of energy, CO_2 emissions are a necessary cost of economic development [5]. Tourism is an energy-intensive sector, and the rapid growth and development have also required major investments into other energy-intensive sectors, including transportation, infrastructure, and real estate, all of which contribute to the CO_2 emissions. According to the World Tourism Organization (UNWTO) and the International Transport Forum (ITF) [6], global tourism-related transport is expected to account for 5.3% of all human CO_2 emissions by 2030. Lanzen et al. [7] found that tourism's global carbon footprint has increased four times faster than previous estimates and now accounts for around 8% of global emissions.

The tourism and pollution nexus in the Middle East and North Africa region has been the focus of several recent studies, including a panel of North African countries [8], Saudi Arabia [9,10], and Iran [11]. Previous country-level studies have incorporated energy consumption into models examining the relationship between tourism and emissions in Cyprus [12], Singapore [13], and North Africa [14]. Previous studies have also incorporated other key variables relevant to understanding the relationship between tourism and CO_2 emissions in the UAE, including urbanization as a proxy for the real estate sector in China [15], Malaysia [16], and Turkey [17]. Further, the financial sector has been studied in terms of bank credits by Nassani et al. [18] in the BRICS countries, Halkos and Polemis [19] in OECD countries, and Liu et al. [20] in China. In order to fully understand the relationship between tourism and CO_2 emissions in the UAE, the growth of energy use must be considered. Further, the growth of the tourism sector in the UAE has coincided with rapid growth in the urban population, infrastructure, and the real estate sector, as well as the financial sector to provide the investment and credit required.

A tourism-induced Environmental Kuznets Curve (T-EKC) model has been employed for the UAE from 1984 to 2019. The model considers related variables, including bank credits to the private sector, urbanization, and energy use. Bella [21] pointed out that due to specific socio-economic characteristics, environmental studies need to be carried out at country levels. However, prior research on single-country studies have been rare and none focused on the UAE. Past research in the UAE has only looked into the environment—economic growth nexus along with factors like electricity consumption [22] and macroeconomic variables [23]. This would be the first to explore environmental impact of tourist arrivals in the UAE utilizing the T-EKC model and, therefore, would contribute to the existing regional literature.

Sustainability and the reduction of carbon emissions are central to the national development strategies in the UAE, and the rapid growth of the tourism sector has and will continue to pose environmental challenges. Understanding the long-term dynamics between tourism development, carbon emissions, and related variables in the UAE can help guide further development and our findings have relevant implications for policymakers and practitioners.

The next section briefly reviews the literature, and the econometric estimation techniques are presented in Section 3. In Section 4, we provide an account of our data and discuss the results. Section 5 discusses the policy implications, followed by our concluding remarks and scope for further research.

2. Theoretical Framework

2.1. Environmental Kuznets Curve (EKC)

Simon Kuznets [24] suggested that increases in per capita income resulted in income inequality in the initial stages of growth. After a threshold level is reached, it begins to decrease, implying an inverted U-shaped relationship between income per capita and income inequality. Grossman and Krueger [25] adopted the concept in a seminal research paper to postulate the same relationship between economic development and environmental degradation, the Environmental Kuznets Curve (EKC) hypothesis. The EKC hypothesis has been widely adopted and confirmed and provides insights to guide environmental policies. Carbon dioxide (CO_2) emissions are often used as an indicator of pollution and environmental degradation. Other indicators included in the EKC studies include ecological footprint [26,27] and sulfur dioxide [28–31].

Panel data estimates have found contrasting results when testing the EKC hypothesis in country-level studies across the globe. In a matrix of 93 countries, Al-Mulali et al. [26] found support for the EKC hypothesis only for the high and upper-middle-income countries. Similar findings emerged from other studies, including a panel of 16 industrialized countries [32], a panel of provincial-level data in China [33], and a panel of Asian countries [34]. Other notable regional studies of the EKC hypothesis include those by Apergis and Payne [35] for Central American economies; Pao and Tsai [36] for BRIC nations and Galeotti et al. [37] for OECD countries; and Association of Southeast Asian Nations (ASEAN) countries by Chandran and Tang [38] and Adeel-Farooq et al. [39]. Rahman et al. [40] linked carbon emissions to energy consumption in the export sector for a panel of 11 Asian populous countries during the period 1960 to 2014.

In recent years, the focus of research has shifted in favor of sectoral studies to identify the drivers of environmental degradation. The impact of industrial production and energy consumption as explanatory factors of carbon emissions have been studied extensively, but patterns of causality remain unclear. Yoo [41] confirmed a long-term bidirectional causality between electricity consumption and economic growth in Singapore, and similar findings were identified in Tunisia [42] and Turkey [43]. Interestingly, in two studies in very different locations, Shanghai [44] and Austria [45], an inverted N-curve with two turning points was identified, rather than the expected U.

Financial development has also been incorporated into applications of the EKC hypothesis through the role of intermediaries and capital markets. Financial development was found to have a negative relationship with CO_2 emissions in studies on the BRIC countries [46], transitional economies [47], and China [48] and Malaysia [49]. However, Shahbaz et al. [50] confirmed the inverted U relationship for Indonesia, and Al-Mulali and Sab [51] found a positive causal relationship with CO_2 emission in sub-Saharan African countries. No effect was found by Ozturk and Acaravci [52] for Turkey.

2.2. Environmental Kuznets Curve Hypothesis in the Middle East

The rapid economic growth, population growth, and urbanization in many of the countries in the region require that researchers endeavor to understand the environmental implications of this development further. The Middle East has received less attention from researchers employing the EKC hypothesis. However, there have been mixed findings from the studies so far. Jaunky [53] found evidence supporting the EKC hypothesis in Oman, and Al-Rawashdeh et al. [54] found support for Tunisia, Morocco, Turkey, and Jordan. At the MENA regional level, Arouri et al. [55] did not find support for the EKC hypothesis in their panel data, and Ozcan [56] found conflicting results for the individual countries. Ansari et al. [57]'s analysis of the ecological footprint of Gulf Cooperation

Council (GCC) countries between 1991–2017 concluded that energy consumption and globalization increased the region's ecological footprint.

Previous studies in the UAE have suggested that economic development has caused environmental degradation. Several previous studies have provided insights to support this. Shahbaz et al. [22] examined the relationship between economic growth, electricity consumption, urbanization, and carbon emissions from 1975 to 2011. This study was then extended by Charfeddine and Khediri [23] to include macroeconomic factors like GDP and international trade affecting CO_2 emissions from 2000 to 2019. Udemba [58] investigated the EKC hypothesis for UAE in the presence of foreign direct investments, while Basarir and Arman [59] included the Human Development Index.

The EKC hypothesis has been widely supported in studies around the world when considering the relationship between economic development and environmental degradation. The EKC has been utilized to examine the role of specific sectors and specific economic-environmental contexts at regional and country levels. The sophistication and depth of understanding have improved with the adaptations and additions to the EKC hypotheses. From the wide application of the EKC hypothesis, we can make three important observations relevant to this current study. First, the EKC is a valid means for examining the relationship between economic development and environmental degradation. Second, the application of the EKC at the regional and country-level and across different industrial sectors has resulted in varied results. However, this variation suggests that it is important for research to continue deciphering the differences in these different contexts. Finally, given the different dynamics and historical trajectories of the economies at the regional and country levels, it is important to fully consider a range of key indicators to understand the more localized dynamics more precisely.

2.3. Tourism-Induced Environmental Kuznets Curve

Tourism has been explicitly included in the EKC hypothesis for country-specific and panel studies. Country-level studies confirmed that tourism growth contributed to increased carbon dioxide emissions in several countries, including Turkey [60], Cyprus [12], Mauritius [61], and France [21]. Several panel studies have found there to be a positive impact of tourism on carbon emissions, including a panel of 48 top international tourism destinations [62], OECD member countries [63], and Asia—Pacific countries [64]. In contrast, a negative unidirectional effect of tourism development on carbon emissions was found in Singapore [13]. Panel analysis of tourism-related EKC has shown that European Union countries had a statistically significant negative impact on CO_2 emissions [65]. Akadiri et al. [66] had similar results for a panel of 16 tourism island states. Liu et al. [67] concluded that tourism had no significant impact on carbon dioxide emissions in Pakistan from 1980 to 2016.

The non-EKC literature has also considered the relationship between carbon dioxide emissions and tourist arrivals in the context of related economic variables. Solarin [68] explored a long-run relationship between CO_2 emission, tourist arrivals, and other macroeconomic variables in Malaysia and found a positive unidirectional long-run causality. Similar results emerged from Durbarry and Seetanah [61]'s analysis of time series data of Mauritius from 1978 to 2011. Sghaier et al. [69]'s study from 1980 to 2014 indicated that tourist arrivals had a negative impact on CO_2 emissions in Egypt, a positive impact in Tunisia, and no impact in Morocco.

The literature offers no uniform conclusions regarding the impact of tourism on carbon dioxide emissions. Moreover, although there is evidence of EKC hypothesis studies that have looked at panel data to explore tourism's impact, there have only been a few country-level studies on the association between tourism and carbon emissions, none of which have focused specifically on the UAE. Bella [21] asserted that it is important that environmental studies are carried out at the individual country level as each country has specific socio-economic characteristics that should be considered when formulating environmental or tourism policies. The current study contributes to the tourism-related literature for the

UAE, and to the best of our knowledge, this is the first study to explore the environmental impact of tourist arrivals in the UAE utilizing a T-EKC model.

3. Research Methodology

Grossman and Krueger [25] first demonstrated the relationship between environmental quality and per capita income using the following model:

$$CO_2t = f\,(Y_t, {Y_t}^2) \quad (1)$$

where CO_2 refers to carbon emission, Y is per capita Gross Domestic Product (GDP).

Expanding on the basic model, we introduce the tourism-induced EKC model for the UAE to investigate if international tourism might be a determinant of carbon emission levels along with financial development, urbanization, and energy consumption. Table 1 includes a summary of the study variables and data sources. International tourism has been captured through tourism arrivals (TA); financial development was proxied by the domestic credit to the private sector by banks (F); urbanization was calculated by the growth rate of the urban population (U). Energy use (E) was included in terms of the electric power consumption measured in kilowatt-hours per capita.

Table 1. Variables used in the study.

Variables	Description	Source of Data
Dependent Variable		
CO_2	Yearly data on emissions of CO_2	Emission Database for Global Atmospheric Research (EDGAR)
Independent Variables		
Y	GDP per capita based on US dollars	World Bank database
Y^2	Square of Y	Calculated from Y
TA	International tourism arrivals proxied by inbound visitors into Dubai	United Nations World Tourism Organisation (UNWTO)
F	Financial development proxied by domestic credit to the private sector by banks as a percentage of GDP	World Bank database
U	Urbanization is calculated in terms of the annual growth rate of the urban population	World Bank database
E	Energy use proxied by per capita electricity consumption in kilowatt-hour	International Energy Agency database

The basic EKC model was thus modified as:

$$CO_{2t} = f\,(Y_t, {Y_t}^2, TA_t, F_t, U_t, E_t) \quad (2)$$

This study applied the Autoregressive Distributed Lag (ARDL) approach. The justification of the ARDL model stems from the fact that our time series data might encounter lags in the dependent variable (autoregressive lags) as well as lags of the explanatory variables (distributed lags).

The first step for any time series analysis is the unit root test for stationarity of each time-series data. Granger and Newbold [70] suggested that using non-stationary data for estimation could produce a spurious regression, and therefore, we investigated stationarity properties of the variables by employing the Augmented Dickey-Fuller unit root tests. The appropriate maximum lag length for the variables in the unit root test was based on the Akaike Information Criteria.

Once stationarity was achieved, further tests were performed to determine if there is a cointegrating relationship between the variables to investigate the presence of any long-term equilibrium relationship between test variables. In this paper, the ARDL bound test by Pesaran et al. [71] was used for multivariable cointegration testing since it has certain advantages compared with other cointegration methods [40]. Firstly, traditional cointegration test methods formulated by Johansen [72] and Engle and Granger [73] are suitable only for large sample data. In contrast, ARDL bound test holds for small sample data. Secondly, traditional cointegration tests require that all variables be of the same order, whereas the ARDL bound test can be performed as long as the variables are I(0) or I(1). Thirdly, the ARDL bound test fully solves the autocorrelation and endogeneity of variables. The logarithmic transformation of each series with their first differences were considred for the model, where Δ represents the first differences. The dynamic relationship between GDP, Tourism, Finance, Urbanization, Energy consumption, and CO_2 emissions was then explored in terms of the following equation:

$$\begin{aligned}\Delta lnCO_{2_t} = \alpha_0 \quad & +\alpha_1.\,t + \sum_{i=1}^{p} \alpha_{2i}\Delta lnCO_{2_{t-i}} + \sum_{i=0}^{q1} \alpha_{3i}\Delta lnY_{t-i} \\ & + \sum_{i=0}^{q2} \alpha_{4i}\Delta lnY^2_{t-i} + \sum_{i=0}^{q3} \alpha_{5i}\Delta lnTA_{t-i} + \sum_{i=0}^{q4} \alpha_{6i}\Delta lnF_{t-i} \\ & + \sum_{i=0}^{q5} \alpha_{7i}\Delta lnU_{t-i} + \sum_{i=0}^{q6} \alpha_{8i}\Delta lnE_{t-i} + \alpha_9 lnCO_{2_{t-1}} \\ & + \alpha_{10} lnY_{t-1} + \alpha_{11} lnY^2_{t-i} + \alpha_{12} lnTA_{t-1} + \alpha_{13} lnF_{t-1} \\ & + \alpha_{14} lnU_{t-1} + \alpha_{15} lnE_{t-1} + \mu t \end{aligned} \tag{3}$$

In the above equation, $\alpha_2, \ldots, \alpha_8$ represent short-term dynamic relationships while $\alpha_9, \ldots, \alpha_{15}$ represent long-term dynamic relationships between the variables. p and qi (i = 1, 2, 3, 4, 5) are the lag periods of the dependent and each explanatory variable, respectively. According to Pesaran et al. [71], the ARDL bound test uses the null hypothesis of F-joint significance test to find the presence of a cointegration relationship. If the calculated statistic is less than the lower bound, the null hypothesis cannot be rejected, and there is no cointegrating relationship between the variables. If the calculated F statistic is greater than the upper bound of the boundary value, the null hypothesis is rejected, indicating the presence of cointegration. The conclusion remains ambiguous if the calculated value is between the lower and upper bound values.

Next, the short-run coefficients were estimated using the Vector Autoregressive (VAR) Model for testing Granger causality between the variables:

$$Y_t = g_0 + a_1.Y_{t-1} + \ldots + a_p.Y_{t-p} + b_1.X_{t-1} + \ldots + b_p.X_{t-p} + u_t \tag{4}$$

$$X_t = h_0 + c_1.X_{t-1} + \ldots + c_p.X_{t-p} + d_1.Y_{t-1} + \ldots + d_p.Y_{t-p} + v_t \tag{5}$$

Equation (4) involves testing H0: $b_1 = b_2 = \ldots = b_p = 0$, against HA: X Granger causes Y while Equation (5) involves testing H0: $d_1 = d_2 = \ldots = d_P = 0$, against HA: Y Granger causes X. In each case, a rejection of the null implies there is Granger causality. The coefficients a_i's and c_i's represent the short-run dynamics between Y_t and X_t. This study estimated the Granger Causality under Vector Autoregression (VAR) framework. Diagnostic tests of the model were also carried out to ensure that all assumptions were satisfied, namely homoscedasticity, dynamic stability of the model, and absence of autocorrelation and autoregressive disturbances.

4. Results and Discussion

4.1. Unit Root Test

The Augmented Dickey-Fuller (ADF) unit root test results for each variable are shown in Table 2. The optimal lags for each variable were determined based on the Akaike Information Criteria. The results for the ADF test indicated that none of our variables were stationary at levels I(0), but all were stationary at their first differences, confirming the I(1) processes. As required by the ARDL bound testing technique developed by Pesaran et al. [71], the ADF unit root testing results confirmed that all variables attained stationarity at I(1), which indicates that the ARDL bound test can be used for investigating the cointegration of the variables. Authors should discuss the results and how they can be interpreted from the perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

Table 2. Results of unit root using augmented Dickey-Fuller test.

	Z(t) for Level	Optimal Lags	Z(t) for First Difference	Optimal Lags
$LnCO_2$	−0.659 (0.8572)	2	−7.533 *** (0.0000)	0
LnY	−1.094 (0.7173)	1	−5.386 *** (0.0000)	3
LnY^2	−1.090 (0.7191)	1	−5.652 *** (0.0000)	0
LnTA	−1.086 (0.7207)	1	−4.313 *** (0.0004)	0
LnF	−0.342 (0.9194)	2	−4.516 *** (0.0002)	1
LnU	−0.783 (0.8240)	4	−3.721 *** (0.0038)	1
LnE	−1.202 (0.6726)	2	−4.265 *** (0.0005)	0

***: denotes significance at 99 percent level of confidence.

4.2. ARDL Model Estimation

Pesaran et al. [71]'s autoregressive distributed lag (ARDL) model was applied to test the presence of cointegration within the variables and estimate the long-run coefficients. Unlike the conventional Johansen system cointegration approach, ARDL adopts one equation, as long as the variables are stationary at first difference or below. The bounds testing procedure based on the F-statistics and t-statistics are presented in Table 3. The Null Hypothesis of no long-run cointegrating relationship between variables is rejected for I(1) processes if the F-statistic is greater than the critical value and the t-statistic is lower than the critical value. Since both these criteria are fulfilled, this confirms the presence of a long-run cointegration relationship between variables.

Table 3. Estimated coefficients using the ARDL model.

PSS Bounds		**Lower Bound**	**Upper Bound**
F-statistic	3.747	2.45	3.61
t-statistic	−4.707	−2.86	−4.38
Diagnostic Tests		**Test Statistic**	**Probability**
Autoregressive Errors	ARCH LM test	0.442	0.5061
Heteroscedasticity	Breusch Pagan test	0.75	0.3869
Autocorrelation	Breusch Godfrey test	0.289	0.5905
Dynamic Stability	CUSUM test	0.3396	0.9479
ARDL Results Dependent: $lnCO_2$	**Coefficients**	**Test Statistic**	**Probability**
ADJ	−1.076145	−4.71	0.000
SHORT RUN ESTIMATES			
lnY			
D1	−4.710554	−0.87	0.395
LD	0.138863	1.43	0.168
lnY^2			
D1	0.2331778	0.89	0.384
lnT			
D1	−0.2086518	−1.60	0.126
LD	−0.1004792	−0.79	0.437
lnU			
D1	−0.0759302 **	−2.20	0.040
lnE			
D1	0.1293415	0.64	0.529
LONG RUN ESTIMATES			
lnY	16.76206 **	2.55	0.019
lnY^2	−0.80095 **	−2.56	0.019
lnT	0.29974 ***	5.17	0.000
lnF	0.36091 **	−2.81	0.011
lnU	−0.03481 ***	3.95	0.001
lnE	−0.29487 **	−2.12	0.047
R-squared	0.6305		
Log-Likelihood	73.75129		

Note: ** and *** indicate significance at 95% and 99% levels respectively.

Diagnostic checks were performed to check the model for autoregressive conditional heteroscedasticity (ARCH LM test), heteroscedasticity (Breusch-Pagan test), autocorrelation (Breusch-Godfrey test), and the dynamic stability of the model (Cumulative Sum CUSUM test). The test statistics were smaller than their critical values at a 95% level of significance, which rejected all the respective null hypotheses, thus confirming that the dataset fulfilled the assumptions for running the ARDL model.

The speed-of-adjustment coefficient, reported in Table 3, measures how strongly the dependent variable reacts to a deviation from the equilibrium relationship. A positive significant coefficient indicates a divergence, while a negative significant coefficient would indicate convergence and how fast the process reverts back to its long-run relationship when this equilibrium is distorted. The negative coefficient of the speed of adjustment indicates that the model in the present study is convergent to the long run equilibrium. The statistical significance at a 1 percent level with a high coefficient or more than 1 reveals that the disequilibrium or shock in any explanatory variable can be adjusted to the long-run with high speed. As indicated by the Pesaran bounds test, long run cointegration relationships exist between the variables, making the short run estimates redundant. This conforms to our results that the short run estimates were not significant in both the lagged and the first differenced form, and the ARDL technique provides unbiased estimates of the long-run model (Table 3).

The estimated long-run relationships of the ARDL model determined the marginal impact of GDP, tourism, financial development, urbanization, and electricity consumption on CO_2 emissions in the UAE. The results for long-run coefficients are presented in Table 3. All parameters displayed the variables to be statistically significant at 5% and 1% levels. In order to test for evidence of the EKC hypothesis in the UAE, we need to consider the CO_2 emissions with per capita GDP during the time period. The linear term (lnY) coefficient was positive, the quadratic term ($\ln Y^2$) coefficient was negative, and both were statistically significant at the 5% level. The results confirmed the EKC hypothesis that the relation between carbon emissions and per capita income is inverse U-shaped, indicating that GDP per capita over the study period led to degradation of the environment up to a threshold level after which carbon emissions began to decline once the UAE economy achieved a mature level of per capita income. These findings regarding the relationship between carbon emissions and macroeconomic factors corroborated previous studies in the UAE by Shahbaz et al. [22] and Charfeddine and Khediri [23]. However, these studies did not include the effect of tourism while testing the EKC hypothesis for the UAE, a particularly important sector of the UAE economy.

The significant positive coefficients for tourist arrivals have important implications for the tourism sector. Our results indicate that in the UAE, an increase in tourist arrivals has resulted in environmental degradation. This was to be expected based on earlier country-level studies in India [74], Austria [75], Malaysia [68], and Cyprus [12]. However, it is notable that these findings somewhat contradict country-level findings for Singapore, a country to which the UAE is often compared due to similarities in the economic development trajectories. Katircioğlu [13] concluded that in Singapore, tourism growth exerted significant negative effects on climate changes implying successful energy conservation policies in tourism development and that environmental conservation policies are well-balanced with macroeconomic targets in the country. According to Lenzen et al. [7], tourism is highly income-elastic and carbon-intensive, so the supply chain in tourism demand would automatically accelerate carbon emissions. Dubai International Airport is the world's busiest airport in terms of international passenger traffic, and jet fuel combustion is one of the leading contributors to global carbon emissions. Another large source of emissions linked to tourist arrivals includes the operations of hotels, resorts, vacation rentals, restaurants, and shopping malls that rely on high usage of electricity and energy-intensive air conditioning. For example, Ski Dubai is a massive indoor skiing facility that requires extensive refrigeration and snow production and contributes approximately 500 tons of greenhouse gas emissions per year [22].

The positive long-run effect of financial development on pollution implies that the domestic credit provided to the private sector has been used in energy-intensive projects which might have been less environment-friendly. Our results were similar to previous studies on China [76], India [77], and Europe [26]. In terms of bank credits, financial development in the UAE helped to augment private investments, which enhanced economic growth while also contributing to increased carbon emissions through higher energy use. Bank credits also increase access to consumer loans, enabling consumers to purchase energy-intensive devices like automobiles, air conditioners, and other electronic appliances, thereby augmenting carbon emissions.

Growth in the urban population in the UAE had significant negative coefficients in the long run, which confirm the positive steps taken by the Government to conserve the environment along with its drive towards urban development. These findings contradict those by Shahbaz et al. [22], who found a positive relationship between urbanization and CO_2 emissions in the UAE. However, our findings align with a more recent study in the UAE by Charfeddine and Khediri [23]. The findings suggest that the UAE may have passed a threshold level of urbanization [78], and sustainability has been central to the recent planning and growth of the cities. The urbanization rate in the UAE has been one of the highest globally, but the government has been conscious of its environmental consequences. The Abu Dhabi Urban Planning Council developed the Estidama framework in 2008 to address sustainable urban development, followed by the launch of Abu Dhabi's green building rating system, the Pearl Rating System (PRS). Since September 2010, the PRS has been integrated into the building permit process where all new buildings must meet the Pearl requirements. The Dubai Municipality also launched its Green Building Regulations and Specifications in 2011 as mandatory requirements for new constructions, in line with its goal to create a smart and sustainable city. The urbanization drive also saw major sustainable initiatives by the Road and Transportation Authority (RTA) in the last decade, where taxi fleets were converted to hybrid cabs to reduce carbon emissions and slash fuel consumption; public buses were modified to use low-sulfur diesel; and traffic lights were converted to halogen bulbs using LED power-saving technology. Further, our findings are supported by previous studies that suggest that urbanization has a negative impact on carbon emissions in countries where a greater percentage share of the GDP is derived from the service industries, such as tourism [79].

The significant and negative effect of energy use on pollution indicates that there were improvements in favor of environmentally friendly sources, which helped to mitigate greenhouse gases. The findings echo those by Shahbaz et al. [22]. Although the country is well endowed with hydrocarbon resources, it diversifies its supply options. In its drive toward renewable resources of "clean energy," UAE has undertaken major initiatives that include a solar-energy park by Dubai Electricity and Water Authority and the establishment of Masdar city with its fully integrated eco-friendly energy systems using solar panels and wind towers. In 2010, the UAE Cabinet approved the Green and Sustainable Building standards to be applied across the country, which will reduce carbon emissions by around 30 percent by 2030. In 2014, DEWA launched Shams Dubai, which allows customers to install solar PV panels on their rooftops to generate electricity from solar power. In 2015, the emirates of Sharjah and Ajman created Conservation Departments with a target to conserve electricity, water, and gas and achieve affordable and clean energy through their Concentrated Solar Power (CPS) projects.

4.3. Granger Causality Test

After examining the long-run relationship between the variables, we used the Granger causality test in a Vector Autoregressive framework to determine the causality between the variables. As we found cointegration among the variables, we may expect uni- or bi-directional causality between the series. We examined the causal relationships between carbon emissions and the dependent variables (Table 4), which confirmed unidirectional causality between GDP, GDP2, bank credits, and electricity consumption to CO_2 emissions.

The findings indicated that UAE's economic growth, financial development, and energy use positively impacted CO_2 emissions, while the change in CO_2 emissions did not affect these factors. Notably, the Granger causality showed that there was bi-directional causality between tourist arrivals and growth in urban population to CO_2. Therefore, increases in tourism and urbanization resulted in environmental degradation, but, at the same time, the efforts to mitigate CO_2 emissions also had a positive impact on promoting development in these sectors.

Table 4. Granger Causality Wald test statistics (only significant statistics).

	LnCO$_2$	**LnY**	**LnY^2**	**LnT**	**LnF**	**LnU**	**LnE**
LnCO$_2$		23.705 ***	23.653 ***	23.912 ***	18.142 ***	27.415 ***	7.996 **
LnY							
LnY^2							
LnT	14.654 ***				17.215 ***		11.454 ***
LnF							
LnU	14.101 ***	10.548 ***	10.316 ***	12.844 ***	8.248 **		5.2946 *
LnE							

Note: *, ** and *** indicate significance at 90%, 95%, and 99% levels respectively.

5. Conclusions and Implications

This paper empirically investigated the tourism-induced EKC hypothesis and the long-term equilibrium relationship and causality between tourism development and carbon dioxide emissions in the UAE. The study results will be of interest to scholars and policymakers since the UAE is one of the most dynamic nations globally, characterized by diverse energy resources, high-level urbanization, a rapidly developing tourist industry, and the airport with the highest number of international passenger arrivals.

This study is the first in UAE to investigate the interaction between tourism development and carbon emissions using the theoretical EKC framework. Our results confirmed a long-term positive relationship between tourism development, carbon emissions, per capita GDP, and financial development. The findings suggest that the UAE needs to strengthen its financial sector by developing bonds and securities to boost green investments and provide opportunities to implement clean energy-related technologies. There is also a need to create incentives for industries to adopt environment-friendly technologies. The Granger causality tests showed unidirectional causality from GDP, bank credits, and energy consumption to carbon emissions, while bidirectional causality between tourist arrivals and urbanization to carbon dioxide levels. Urbanization and energy use resulted in declines in carbon emission levels, highlighting the successful diversification efforts of the UAE government. Green urbanization has been adopted across the UAE in a major way that has reduced carbon emissions with its clean, intelligent transport systems and environmentally sustainable construction.

Our findings highlight the need to balance tourism targets and sustainable economic growth. Although renewable and sustainable environment objectives have been at the core of the UAE, the adoption of 'green' standards should continue to be implemented across its various tourism projects, keeping in mind the goals of continuing to increase the number of arrivals to the country and resulting increase in footfall at each of its destinations. It is essential to promote effective investments to promote tourism and economic growth by emphasizing the role of renewable sources of energy, especially solar sources. To this end, the Mohammed bin Rashid Al Maktoum Solar Park has started operations to become the largest single-site solar park globally and is expected to generate 5000 MW by 2030. UAE might need to enforce stricter environmental laws and introduce green taxes on pollution, especially at the popular tourist destination sites, as was implemented in many European countries such as Finland, Norway, and Ireland. As emphasized in the UN Climate Change

Agreement signed at COP 21 in Paris, the commitment to sustainability aims to raise awareness about environmental preservation through avenues like eco-tourism.

In a concerted effort to control the steep rise in the country's carbon footprint, the UAE Supreme Council of Energy set a strategy to reduce carbon emissions by 11 million tonnes of carbon dioxide. The Dubai Department of Tourism and Commerce Marketing has also laid out a set of sustainability guidelines that hotels must comply with, along with mandatory monthly carbon emissions reporting, starting July 2021. The UAE government has recently launched several eco-tourism initiatives centered on conserving nature and raising awareness about the country's nature reserves and protected areas. With the UAE hosting the World Expo between October 2021 and March 2022, the country showcased some of the innovations and efforts towards sourcing clean energy, water conservation, effective waste management, and sustainable building materials. The Sustainability Pavilion of the Expo showcased innovative environmental solutions.

The UAE is aware of the ecological consequences of its tourism targets and has already undertaken major future investments by implementing the Clean Development Mechanism (CDM) projects. The UAE Energy Plan 2050 has been formulated to reduce carbon dioxide emissions by 70 percent from the power sector, resulting in potential savings worth up to AED 700 billion. The country also formulated its sustainability goals to make UAE a global hub of Renewable Energy Research and Development and aims to invest AED 600 billion by 2050 to ensure sustainable growth for the country. The UAE Centennial Plan 2071 offers a clear long-term roadmap for each emirate to derive 75 percent of energy from clean sources. The findings of this study highlight the challenges facing the UAE in balancing the environmental impacts and its continued robust and ambitious economic development plan. The findings also indicate that the equally ambitious initiatives to ensure this balance may already have had some impact on mitigating the long-term environmental degradation, particularly in the context of the tourism industry.

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