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Article

Kuznets Environmental Curve: Testing the Relationship between Economic Growth and Environmental Degradation in Qatar as a Case Study

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Abstract: The present study tackles the validity of the occurrence of the Environmental Kuznets Curve (EKC) in the Qatari economy by examining the dependability between economic growth and environmental degradation. The study focuses on analyzing the impact of GDP, population, and energy consumption on CO2 emissions during the period from 2000 to 2022. The results of the study indicate that there is a non-linear relationship between economic growth and emissions, as an inverted U-shaped curve appears. Emissions increase in the early stages of growth due to intensive industrialization and increased energy consumption due to huge capital investments in Qatar. These emissions decrease thanks to the shift to service sectors and the use of clean technologies. Data analysis suggests that population has had an unexpectedly negative impact on emissions, possibly due to sustainable urbanization policies and the use of clean natural gas in electricity generation. However, electric power consumption is associated with increased emissions due to the burning of natural gas.

Keywords: Clean technologies, Environmental investment, Tourism industry, Environmental degradation, Commercial energy, Sustainable urbanization

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1. Introduction

Environmental degradation has become a global challenge that requires concerted local and regional efforts to explore the main causes of this degradation. Possible causes may include excessive consumption of fossil fuels, increased emissions, and unsustainable human activities as a result of the steady economic growth witnessed by global economies. The impact of energy consumption and carbon dioxide emissions on economic growth has become a topic of wide attention at the national and international levels [1]. On the other hand, the issue of environmental degradation and climate change has received great attention from environmentalists, which has made economists and environmentalists more aware of the environmental consequences of economic growth [2]. There has also become a transition point from focusing on simple economic growth to environmentally friendly economic growth. Economic growth affects the quality of the environment through three channels:

1. Volume impact; Increasing production directly affects the environment because increasing output requires more inputs, which means increasing demand for natural resources, including non-renewable resources, as well

as increasing waste products resulting in increased production that affects the environment [3].

2. The impact of installation; In the early stages of development, pollution increases as a result of structural change and the transition from agriculture to more resource-intensive industries, which causes pressure on the environment. Environmental degradation increases, but in the later stages of development, pollution decreases due to another structural transformation from the resource-intensive industrial sector and non-renewable energy to the service sector and light manufacturing industries,so the impact of installation will be positive on the environment [4].
3. The impact of technology and technological progress; It refers to technological improvements that help to use less inputs for each unit produced and rely on clean technologies in production. Increasing the use of clean technology depends on increasing research and development in the environmental field and encouraging environmental investment [5].

In the present study, the attempt is to verify the validity of the hypothesis of the EKC curve in the Qatari economy, which has witnessed a transition from an economy based on pearl fishing to an economy that relies almost entirely on fossil fuels. The great expansion of industrial activities and population leads to an increase in the demand for commercial energy, of which fossil fuels are the main source. This means that this exacerbates the problem of environmental degradation [6], [7]. The heavy reliance on the traditional energy sector to achieve rapid economic growth in Qatar has negative impacts on the environment, which made the state intensify its efforts on climate issues through the conclusion of early international agreements, including the 1996 United Nations Convention on Climate Change, Kyoto 2005 and the Paris Agreement 2016. Preserving the environment for future generations is a strategic goal. This idea is stated in the permanent constitution of the state, which provides for comprehensive and sustainable development. This commitment is clearly reflected in the Qatar National Vision 2030 where the fourth pillar is dedicated to environmental development [8], [9].

The research question of the present study can be formulated as follows: Does the economic growth in the country lead to environmental degradation in its first stage while it turns into environmentally friendly growth in the second stage? The objective of the present study is to investigate the applicability of the Kuznets environmental curve to the Qatari economy. As for the significance of the present study, it focuses on the environmental deterioration, which is very important because it affects life in general and human life in particular. The present study gives way to many studies to be carried out in vital fields.

Section two provides a review of the literature. Section three provides a description of the data and the model. Section four presents the analysis of the data. Section five presents the discussion and remarks.

2. Materials and Methods

The Environmental Kuznets Curve (EKC) model was employed to explain the relationship between economic growth and environmental degradation. The inverted U EKC curve assumes that environmental degradation rises in the first stage when income is low. After time passes and economic growth increases, environmental degradation decreases after reaching the threshold level (when per capita income reaches $8,000) [10]. This results in an inverted relationship between income, natural resource use and increased emissions. The EKC curve also indicates that economic growth leads to improving the environment in the long term. The EKC curve has been tested in many studies applied to one country or a group of countries that are consistent with the EKC curve hypotheses. The study of [11] correlates economic growth to environmental degradation in Indonesia 1994-2018. In this regard, the study indicates that there is a significant influence of both economic growth and energy consumption on environmental degradation, while income inequality has a negative but not significant impact in the short and long term. In the short term, the level of education has influenced only to a modest extent. However, in the long term, its influence has been considerably profound. Meanwhile, exports have notably contributed to environmental degradation in the short term, yet in the long term, their effect has been mitigated, largely due to Indonesia's reliance on natural resource-based exports. The study of [12] targets measuring the relationship between real GDP and carbon dioxide emissions, renewable and non-renewable energy consumption, tourism development and the workforce in France and Germany 1995-2015. The results of the study indicate that there is an inverse relationship between real GDP and carbon emissions in the long term. Renewable energy significantly reduces carbon emissions while non-renewable energy consumption increases carbon emissions. It is suggested that though tourism development is not very significant for general growth and development, it has much relevance to reduce carbon emission. The state can promote its economic development with the tertiary sector by promoting tourism and reducing dependence on heavy industries that emit high levels of carbon. An advanced tourism industry also creates more jobs and drives the development of related industries such as the catering industry. The study of [13] investigates the relationship between economic growth, energy consumption, and carbon dioxide emissions in the Kingdom of Saudi Arabia 1980-2018 through the use of the multiple linearity test. The study indicates that there is a long-term equilibrium relationship between economic growth, energy consumption, and carbon emissions. It is also indicated that there is a one-way causal relationship between GDP and CO2 emissions in the short term in Saudi Arabia. The study also reveals that there is a two-way causal relationship between carbon emissions and energy consumption and vice versa in the short and long terms. There is also a two-way causal relationship between GDP and energy consumption and vice versa in the short term, which indicates that GDP and energy consumption are interrelated.

There are also some experimental studies that are not consistent with the hypotheses of the EKC curve. The study of [14] is conducted in the United States of America 1960-2014 employing the Joint Integration Model. The results of the study reveal the non-linearity of the relationship between carbon emissions and economic growth. The increase in emissions results from their use as a result of the use of cleaner and less polluting energy. GDP also shows a short-term impact only on emissions. Therefore, there is no conclusive evidence of a long-term relationship between economic development and the inverted form of emissions as indicated by the EKC curve hypothesis. The study of [15] tackles the existence of the EKC curve in Greenland using the distributed deceleration model (ARDL) 1970-2018. The existence of the U-shaped EKC curve instead of the inverted U letter occurs when studying the relationship between carbon dioxide emissions, income, energy consumption, and urbanization. This occurrence is due to the fact that Greenland initially experienced a separation transition during an early stage of development related to the structural conditions of the small subsistence economy, leading to high income and carbon emissions at the same time. The study of [16] tackles the determinants of carbon dioxide emissions in a sample of (35) African countries 1980-2016. The results of the study indicate that economic growth and non-renewable energy consumption are among the most prominent determinants of carbon dioxide emissions. The results indicate that there is a two-way causal relationship between carbon emissions and economic growth. This two-way causal relationship also exists between the consumption of non-renewable energy and economic growth. It is also there between the consumption of non-renewable energy and carbon emissions. The study of [17] also indicates that there is a cubic relationship and an N-shaped pattern between economic growth and the environmental performance index. Therefore, MENA countries should focus on sustainable development to preserve their environmental resources.

1. Data Description and Model Construction

In the empirical analysis, CO2 emissions are used as an indicator of environmental degradation. Independent variables include GDP, percentage of urban population, enrollment rate, and energy consumption. All data are converted from annual frequency to semi-annual frequency using the quadratic matching method. This conversion to semi-annual data makes it possible to test the possibility of structural discontinuities in the long-term relationship between the two variables of the study. These variables are determinants of carbon dioxide emissions in Qatar 2000-2022. The data of the present study are collected from the World Bank Group as in Table (1).

Table 1. Variables and Data Codes

Variables	Codes	Measurement Unit
Carbon Dioxide Emissions	CO2	Kilowatt
Grose Domestic Product	GDP	USD for 2015
Square Total Grose Domestic Product	GDP^2	GDP^2
Population	P	1000 people
Consumption of Electricity	CE	Kilowatt/Hour

The mathematical form of the model is determined based on the variables mentioned in Table (1). The mathematical form is the main starting point in constructing the standard model.

$CO2=F(GDP,GDP^2,P, CE,)$ …… (1)

Equation (1) is rewritten in logarithmic form as follows:

$LogCO2 = B0 + B1 \log(GDP) + B2 \log(GDP2) + B3 \log(P) + B4 \log(CE) + \varepsilon$ …..(2)

The equation is written in logarithmic form so that the parameters are interpreted as elasticities and multiple linear multiples are eliminated, to give more accurate results [18], [19]. The error limit, which refers to external factors that are not addressed in the study but they contribute to environmental degradation, is also included in the model.

3. Results

4.1 Descriptive Statistics

Descriptive statistics is a set of methods used to describe the variables employed to study the relationship between carbon dioxide emissions and between each of Qatar's GDP, population, and electricity consumption 2000-2022.

Table (2) Descriptive Statistics

Variable	OBS	MEAN	STD. DEV.	MIN	MAX
LOGCO2	42	3.643613	0.136199	3.449384	3.864030
LOGGDP	42	11.02491	0.108247	10.85060	11.20495
LOGGDP2	42	121.5600	2.387222	117.7355	125.5509
LOGP	42	14.21444	0.527211	13.37846	14.84771
LOGCE	42	10.20333	0.510281	9.298809	10.75754

Source; Results of Eviews13.

The table provides an overview of some of the descriptive statistics of the variables employed to study the relationship between carbon emissions, GDP, GDP2, population, and consumption of electricity in Qatar 2000-2022. The data set does not contain any strange patterns and the data is relatively stable and shows limited diversity.

4.2 Testing the Unit Root

Unit root tests help determine the order of integration of time series variables. They help determine whether the time series is stable at level or difference, in order to avoid the pseudo-regression problem experienced by time series. This provides basic information for the subsequent application of the ARDL boundary test [20]. Table (3) shows the results of the unit root test.

Table (3) Unit Root Test

Variable	Level	1st difference
	ADF	ADF
LOGCO2	-4.171312*	….
LOGGDP	-1.560760	-3.612189*
LOGGDP2	-1.554636	-3.588846**
LOGP	-2.159163	-3.263703**
LOGCE	-1.608695	-7.971355*

*Indicates significant at 1% level.**Indicates significant at 5% level.***Indicates significant at 10% level.

Source; Results of Eviews13.

The results of Table (3) show that CO2 emissions (the dependent variable) are stable at level. The results also indicate that GDP, GDP2, population, and consumption of electricity are stable at difference. This justifies using ARDAL to validate long-term relationships and identify links between variables [21].

4.3 Testing Joint Integration

After testing the stability of the time series of all study variables by conducting the unit root test, the transition to joint integration and the long-term equilibrium relationship is carried out by testing the limits according to the following hypotheses:

*The Null Hypothesis; It states that there is no long-term equilibrium relationship between the variables of the study, that is:

$H_0: \beta_1 = \beta_2 = 0$

*The Alternative Hypothesis; It states that there is a long-term equilibrium relationship between the variables of the study, that is:

$H\beta_{1:1}\beta_{2\ 0}$

The results of Table (4) show that the calculated (F) test value of 8.962396 is greater than the critical values of the minimum I (0) and the maximum (1) Iat different significant levels. Therefore, the alternative hypothesis, which states that there is a long-term equilibrium relationship (co-integration) between the study variables, is accepted.

Table (4) Joint integration results using boundary testing

F – Statistics	**Value**	**Significant**	**I (0)**	**I (1)**
	8.962396	10%	2.460	3.460
		5%	2.947	4.088
		1%	4.093	5.532

Source; Results of Eviews13.

4.4. Analysis of Long-Term Relationships

The results of Table (5) indicate that there is a statistically significant relationship between GDP (LOGGDP) and carbon dioxide emissions in Qatar. This indicates that an increase in GDP by 1% leads to a decrease in emissions by (103.3785-)units. The negative relationship indicates that economic growth may lead to environmental improvements at certain levels of development, which represents the first part of the Kuznets environmental curve (EKC). As a wave and non-linear relationship emerged between GDP2 (LOGGDP2) and carbon emissions (CO2), the positive relationship suggests that emissions begin to increase as the economy grows beyond a certain tipping point of the second part of the environmental Kuznets curve (EKC). The inverted U shape of the curve also confirms this idea. While there has been an unexpected inverse relationship between population (LOGP) and carbon emissions, sustainable urbanization policies may show an impact, or population increase is associated with more efficient use of resources or a shift towards lower carbon consumption. The reason is also due to the fact that Qatar is the second largest natural gas producing country in the world and ranks third in the world after Russia and Iran in the proven natural gas reserves, which are used in the operation of power plants because it is environmentally friendly [22]. Consumption of electricity (LOGCE)has also shown a positive relationship with carbon emissions despite the use of natural gas in electricity generation. It turns out that burning natural gas in the process of generating electric power leads to an increase in harmful emissions to the environment. It is worth mentioning that Qatar and countries with a desert climate suffer from water scarcity, and rely almost entirely on desalination of seawater through large desalination plants that consume huge amounts of energy [23]. Reports also indicate an increase in electricity consumption from 8.0 billion kilowatt-hours in 2000 to 32.7 billion kilowatt-hours in 2012 [24].

Table (5) Estimating Long-Term Coefficients according to ARDL

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGGDP	-103.3785	40.84607	-2.530928	0.0163
LOGGDP2	4.670904	1.841273	2.536780	0.0161
LOGP	-0.780233	0.083496	-9.344567	0.0000
LOGCE	0.659310	0.139542	4.724822	0.0000
C	-4.223588	3.912916	-1.079397	0.2854

Source ; Results of Eviews13.

4.5. Analysis of Short-Term Relationships

The results of Table (6) show that the relationship between the independent and dependent variable of carbon dioxide emissions in the short term is statistically significant at a level of significance of less than (0.05%), which confirms that there is the Kuznets environmental curve in the form of (U) inverted shape in the Qatari economy. On the one hand, the ECM error correction rate (-1) shows a negative signal, which indicates that any deviation in the short-term equilibrium between the variables will be adjusted and corrected by the equivalent of 0.501315 to restore it to long-term equilibrium after a year.

Table (6) Representing Error Correction Using ARDL

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGGDP	-51.82525	12.08703	-4.287673	0.0003
LOGGDP2	2.341598	0.543886	4.305312	0.0003
LOGP	-0.231407	0.060054	-3.853349	0.0007
LOGCE	0.225363	0.037104	6.073778	0.0000
ECM (-1)	-0.501315	0.132530	-3.782670	0.0011

Source; Results of Eviews13.

4.6.Diagnoctic Teses

Diagnostic Tests are employed to evaluate the adequacy of models and validate basic statistical hypotheses. These tests help to ensure that the obtained results are correct and reliable in the analysis. The following tests are conducted:

4.6.1. Variance Proof Test

The heterogeneity of variance test is one of the statistical tests used to verify the heterogeneity of variance in errors hypothesis. The homogeneity of variance means that the variance of errors is constant across all levels of independent variables. If the variance is not constant, the model suffers from heteroscedasticity, which may adversely affect the validity of statistical conclusions. The results of the heteroscedasticity test are shown in Table (7).

Table (7) Variance Stability Test

test	Value	Prob.
F- statistics	0.680711	0.7817
Obs* R Squared	12.97756	0.6744

Source; Results of Eviews13.

The results of Table (7) indicate that all probability values (p-values) are greater than (5%). This means that the null hypothesis, which states that there is a constant variation in the remaining errors, cannot be rejected. The results also indicate that the variation in errors does not depend on independent variables or expected values, but on external factors that are not included in the model.

4.6.2 Estimated Model Stability Test

The stability of the estimated model is confirmed and there is no structural change in the estimated data, which leads to the inconsistency of the short-term parameters with the long-term parameters through the CUSUM. CUSUM Square tests are as in Figures (1&2).

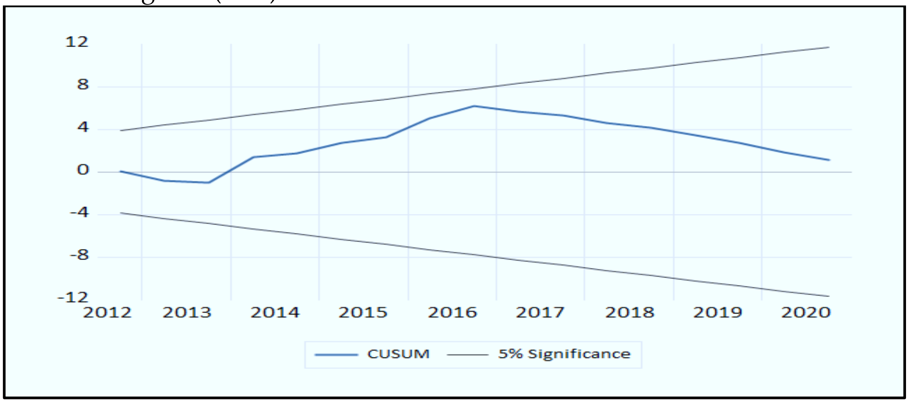

Figure 1. Plot of CUSUM Test

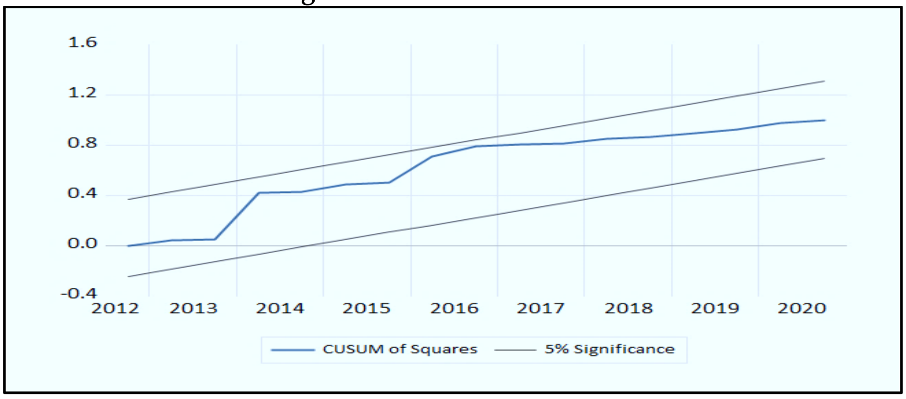

Figure 2. The plot of CUSUM Squares Test

It is clear from Figures (1&2) that the cumulative total of the residues as well as the cumulative total of the squares of the residues is a line located within the critical limits, which indicates that the long-term and short-term parameters are stable and the values are within the critical limits of level of significance of (5%).

4. Discussion

Achieving sustainable development in Qatar requires integrated efforts that strike a balance between economic growth and reducing environmental degradation. Qatar shall focus on achieving sustainable economic development by gradually reducing carbon emissions and reducing environmental degradation. Recent studies show that Qatar is witnessing a second turning point within the inverse U-shaped relationship between economic growth and environmental degradation. This point indicates a rise in environmental degradation in the first and last stages of economic growth and a decrease in the middle stage. Therefore, Qatar should avoid falling into this trap in the last stage, while continuing to support the Kuznets Environmental Curve (EKC) hypothesis by following environmental policies of promoting energy efficiency, supporting environmental investment, and using environmental regulations such as taxes and subsidies, as well as raising community awareness of the role of renewable energy in preserving the environment and human health.

5. Conclusion

In conclusion, achieving sustainable development in Qatar necessitates a strategic balance between economic growth and environmental preservation. The observed inverse U-shaped relationship in the Environmental Kuznets Curve (EKC) suggests that Qatar must proactively implement policies to mitigate environmental degradation, particularly in the later stages of economic growth. By prioritizing energy efficiency, promoting environmental investments, enforcing regulations such as taxes and subsidies, and enhancing public awareness of renewable energy benefits, Qatar can sustain economic progress while minimizing its ecological footprint. This approach will not only support the EKC hypothesis but also ensure long-term environmental sustainability and public health, positioning Qatar as a model for sustainable economic development.

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