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Analyzing the Heterogeneity of Economic Development and Carbon Emissions in the GCC Countries: Based on Panel Quantile Regression Approach

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ABSTRACT

This study explores the effects of energy use, tourism development, financial growth, foreign direct investment on economic growth, and the carbon emissions nexus for GCC countries from 1980 to 2018. GCC nations are currently facing higher demand and use of energy sources, FDI, tourism development, and improving financial sector that represents the major sustainable environmental and economic growth challenges. This study applies a Panel Quantile-Regression model that accepts distributional and unobserved individual heterogeneity. Furthermore, to avoid a response variable bias, some concerned cause variables are heterogeneous across quantiles in our method. The empirical outcomes indicate that the influence of FDI on CO_2 emissions is statistically significant and negative, while tourism growth, energy use and financial growth have an ever-increasing impact on carbon emissions. Likewise, tourism growth decreases economic growth while FDI and energy use have been found to affect economic progress positively. Finally, the research outcomes also support policymakers with significant strategic recommendations.

Keywords: Energy Use, Tourism Growth, Financial Development, CO_2 Emissions, Economic Development, GCC Countries
JEL Classifications: O31, O44, Q56, C32

1. INTRODUCTION

Currently, every country in the world has sustainable development as one of its top priorities or goals. Sustainable growth is indeed an inclusive term that encompasses three interconnected pillars: Social, economic, and ecological sustainability. The environmental damage brought on by rising greenhouse gas emissions, however, is a significant barrier to achieving the sustainable development target. Amongst others, literature about sustainable economic development and the effect of different economic considerations on environmental-sustainability have been gaining considerable attention from the scholars (Huang et al., 2022). The economic size of a country does not only determine the emission of CO_2. Income level alone may not be sufficient; financial growth, foreign direct investment (FDI), and urban population may be additional causes. Thus, researchers sought to integrate output/income or economic growth per se and financial development or other factors to capture the underlying cause of CO_2 emissions. Positive difference in the FD increases footprint with a more noticeable impact over time, while a negative change has a negligible impact, and population density reduces footprint (Ahmad et al., 2018; Ahmed et al., 2021). Financial growth increases CO_2 emissions and environmental degradation (Iorember et al., 2020; Komal and Abbas, 2015; Le and Ozturk, 2020; Shahbaz et al., 2020). Financial development aids industrial expansion, stimulates demand for new infrastructure, and favourable influences energy consumption. Another study found that financial growth reduces damage to the environment while economic development and energy use increase it (Dar and Asif, 2018; Jalil and Feridun, 2011). Financial development may encourage foreign direct investment (Frankel and Romer, 1999),

resulting in increased economic expansion and carbon emissions. FDI is critical for the economic progress of emerging nations that lack enough money for investment. FDI contributes to developing nations' economic development via capital funding and increasing their productivity by transferring sophisticated manufacturing technology, management skills, and know-how necessary to upgrade the economy and promote innovation. FDI improves the CO_2 emissions, in both the shorter and longer terms (Salahuddin et al., 2018). (Salahuddin et al., 2018). The panel fully-modified-least-squares (P-FMOLS) test indicates strong long-term positive connections between financial growth-and urban populations and CO_2-emissions in the world's top ten CO_2 emitting nations (Kayani et al., 2020). With the urban-population growth and resources constrained in ratio to population, poor management of sanitation and sewage systems and rising pollutants from industry are important contributors to increased CO_2-emissions in the urban-areas. This was found to be true in the case of West-Asia and the Middle-East nations (Kihombo et al., 2021). Urbanization may lead to increased energy use, resulting in increased CO_2 emissions (Komal and Abbas, 2015; Mahalik et al., 2017; Prince Nathaniel et al., 2021 and Kayani et al. 2020). The other study by (Charfeddine and Ben Khediri, 2016; Kebede, 2017; Khan, 2023) found that urbanisation improves environmental quality. Economic development is the other factor contributing to CO_2-emissions (Khan et al., 2019; Raggad, 2020; Pachiyappan et al., 2022). For economic expansion is accompanied by the increased CO_2-emissions (Li et al., 2019; Murshed et al., 2021; Manigandan et al., 2023) and is also environmentally unsustainable (Shahbaz et al., 2021).

There have been carried out numerous studies concerning the connection of such variables but were not fully coordinated with complete measures. Different studies have examined various aspects of sustainable environmental and many other factors; however, despite its significance, the connection between sustainable environmental and economic development has not been explored. Therefore, the present analysis contributes to the empirical literature on sustainable environmental and economic development and is related to better explain this issue. According to the authors' knowledge, ever the 1st time this analysis was carried out it is a thorough investigation of the effect of sustainable environmental and economic development on each other based on heterogeneity P-QR. The P-QR is a more effective estimator because it is more robust than panel-regression and it contains more instinctive appeal because it stratified the distributional impacts of the independent factors on dependent factors into various quantile scopes. This research will support policymakers in the GCC nations in implementing precise and reliable policies and rules to oversee an increase in pollution levels. The current research attempts to fill this void in scientific literature. Our study is expected to enrich the available literature on the energy economy in several ways. It will offer comprehensive insight into the impact of tourism growth, financial growth, FDI, and energy use on economic development and CO_2 emission in GCC countries through the following EKC hypotheses:

H_1: To explore how energy use, tourism growth, foreign direct investment, and financial growth of GCC countries respond to CO2 emissions.

H_2: To assess how energy use, tourism growth, foreign direct investment, and financial growth are linked to the economic development of the GCC countries.

To find the best analysis outcomes, we outlined our analyses within P-QR (Abid et al., 2023; Cheng et al., 2020), utilizing a time-varying, the longer-range period from 1980 to 2018, and developed individual patterns for every dependent factor instead of just creating evidence in a statistical manner. The investigation has been using Panel quantile regression (P-QR) provide a more thorough and prosperous contribution to current evidence in order to report the effect of sustainable environmental and economic development through the various quantiles (Yan et. al 2019). The following sections include the remaining part of this paper: Section-2 provides empirical evidence gleaned from the literature; Section-3 addresses the methodologies and data; Section-4 analyses the findings; and Section-5 explores conclusions and policy suggestions.

2. LITERATURE REVIEW

The policymakers, regulators, researchers, and academic community around the globe have understood the enormous significance of mitigating the impacts of global warming and CO_2 emission and the impact that financial growth, FDI, urban population and economic development have on CO_2 emission (Li et al., 2019; Maji et al., 2017; Saidi and Mbarek, 2017; Susanti et al., 2020). The empirical outcomes obtained from the available academic literature can be split into four major groups. The initial group of empirical research shows the effect of financial-growth on CO_2 emission. Qayyum et al. (2021) examine the link between financial growth, renewable-energy use and CO_2 emission. The analysis used the ARDL-model for analysis and found economic expansion. Urbanization and financial growth of the nation negatively affect the environment and result in poor quality environment as they emit a considerable amount of CO_2. In their study, Ibrahim and Vo (2021) obtained similar findings. It was concluded that improved financial development results in increased pollution and greater CO_2 emission. Khoshnevis Yazdi and Ghorchi Beygi (2018) used Granger Causality in the EKC model to examine the connection between financial growth and CO_2 emission on data obtained from 25 African nations for a while 1985-2015. The study's results indicated bisectional causation between financial growth and CO_2 emissions. In another study, Boufateh and Saadaoui (2020) used the Nonlinear ARDL methodology in panel form examining the impact of financial growth shocks on CO_2 in the African countries. The study concluded that the positive financial growth was useful for reducing pollution in the longer term. Nevertheless, the asymmetric outcomes of the study indicated that financial instability results in larger CO_2-emissions in the shorter-run.

The second group of the study consists of empirical papers on the impact of FDI on CO_2-emission. Abid et al. (2021) indicated one-way causal connection between FDI inflows and CO_2-emissions in G8 countries. In another study, Shahbaz et al. (2018) used unit root analysis on French time sequence data during 1955-2016 years to analyze the effect of FDI inflows on CO_2 emission in France and

found that FDI has a beneficial effect on the carbon emission in France and FDI degrades the natural environment. Similar findings were also obtained by Ahmad et al. (2020), Acheampong, 2019; Anser et al., (2020); Nasir et al., (2019; Hamid et al., 2021; 2022) and indicated that FDI deteriorates the environment quality with enhancing CO_2 emission.

In the third group of researches, we take the empirical papers on energy-usage and its impact on CO_2 emission in developed and developing nations. Usman et al. (2020) considered the nexus of energy use, openness of trade (TO) and FDI for the natural atmosphere in 33 upper-middle-income (UMIC) nations operating from 1994 to 2017 and their results considered to improve energy use and FDI environmental catastrophe. Nathaniel et al. (2020) reviewed urbanization, economic growth, trade-openness, renewable energy and eco-footprint connections in case of CIVETS-countries during 1990-2017. The results of the research provide evidence that too and renewable-energy statistically substantially enhances environmental degradation. However, economic development and urbanization statistically significantly increase the environmental deterioration. Yang et al. (2020) emphasized that heavy use of fossil fuels in productive growth lowers environmental standards in 97 global economies.

Similarly, Ulucak, Khan (2020) described a positive connection among renewable-energy sources and ecological standards and proposed that an increase in sustainable energy use has led to enhance the quality environments. Also, Sharif et al. (2020) report that using renewable energies decreases the ecological deterioration in *Turkey*. Also, Alam et al. (2016) and Asongu et al. (2020) studied the dynamic connection between the usage of energy as well as ecological sustainability. The analysis showed that energy use is a significant element of ecological deterioration. Literature also proposed asymmetrical assessments of energy-use and carbon-dioxide-emissions link (Ahmad et al., 2020). Nevertheless, research into the various energy uses has conflicting results in the world literature (Sohail et al., 2022). There are several empirical papers examining the influence of energy-use on increased CO_2-emissions (Jian et al., 2019; Alam et al., 2022; Manigandan et al., 2021; Pachiyappan et al., 2021; Murshed and Alam, 2021).

In the fourth group of studies, we take the empirical papers on economic development and its impact on CO_2 emission. Al-Mulali et al. (2015) used panel data techniques to investigate the effect of economic development and financial growth on CO_2-emissions in European nations from 1990 to 2013. The study concluded that financial growth, urbanization, and economic development increase CO_2-emissions in the longer-run. Li et al. (2021) considered the impact of financial growth and economic development on CO_2 emission in BRICs nations using quantile regression. The results indicated a variation in results among the BRICs nations. Aslan et al. (2021) used the Panel-Vector Autoregression model to examine the link between climate change, FDI, economic development and financial growth in N-11 countries. And the results of the study identified two-way causation between CO_2-emission and economic expansion in selected countries. Kong (2021) used the nonlinear ARDL to concluded that real GDP and energy-consumption feature statistically meaningful and positive effect on CO_2-emissions in the longer-run.

The nexus between carbon emissions and tourism-growth is being widely reported in the existing literature. A significant positive link among CO_2-emission and tourism-growth has been concluded in Turkey by Rico et al. (2019) and Katircioglu (2014). In a further investigate, Kocak et al. (2020), used panel data approach from the period 1995-2014, utilizing urbanization, carbon emissions, tourism growth, energy intensity and economic development variables, considered the most frequently visited tourist country in the world. Their research adamant that the total number of tourists arriving improves CO_2 emission. Furthermore, Ruiz-Guerra et al. (2019) have a negative connection between tourism growth on environmental degradation in Barcelona. Likewise, Zhang et al. (2019), under the outcomes of ARDL, ecological deterioration negatively affects Thailand's tourism growth. Zhang and Zhang (2018) determined that the shorter-term impact of tourism development is more effective about the negative impact than the longer-term. As discussed earlier, we now conclude that tourism growth, financial growth, and energy use significantly impact CO_2 emission, whereas FDI and energy use significantly affects economic growth. The existing literature is divided over the impact and postulates that it has both negative and positive impacts on CO_2-emission. Furthermore, we find significant cause to examine the impact of these variables on CO_2 emission and economic development in GCC nations.

3. DATA AND METHODOLOGY

3.1. Data

The current research explores the interconnected effects of CO_2-emissions and economic development in a panel of GCC countries (Oman-Kuwait-Bahrain-Saudi Arabia-UAE-Qatar). Data about the variables were gathered from the "WDI," the runs from year 1980 to 2018. The variables included in this study were economic development ("real GDP per capita constant USD at 2005 prices") and CO_2-emission calculated in conditions of metric-tons-per-capita, which are obtained to be the primary-greenhouse emissions accountable for global-warming in earlier research. The research paper's key variables are economic development and CO_2 emission as a dependent variable. In contrast, energy use (EU), tourism growth (TG), FDI, and financial development (FD) are used as independent variable. The variable's definition is depicted in the Table 1.

3.2. Model

In the current study, our objective is to explore the impacts of independent factors on CO_2 emission and economic development

Table 1: Variable definitions

Variables	Definition	Web-source
GDP	"Economic Growth (real GDP per capita constant USD at 2005 prices)"	WDI (World-Development-Indicator)
CO_2	"Carbon-Dioxide Emissions (Metric Tons Per Capita)"	
EU	Energy use	
FD	Financial development	
TG	Tourism growth	
FDI	Foreign direct investment	

(dependent variables) in GCC countries. The model describing the determining factors of carbon-emissions and economic development can be presented as follows:

$CO_2 = f(EU, FD, TG, FDI)$

$GDP = f(EU, FD, TG, FDI)$

(*EU*, *FD*, *TG*, and *FDI*) denote energy use, financial growth, tourism growth, and foreign-direct investment, respectively.

The econometric time series model is currently specified in the following terms:

$$CO_{2it} = \alpha_i + \beta_1 EU_{it} + \beta_2 FD_{it} + \beta_3 FG_{it} + \beta_4 FDI_{it} + \mu_{it} \quad (1)$$

Model – I

$$GDP_{it} = \alpha_i + \beta_1 EU_{it} + \beta_2 FD_{it} + \beta_3 TG_{it} + \beta_4 FDI_{it} + \mu_{it} \quad (2)$$

Model – II

Where i and t represent the GCC nations and year, respectively, β1, β2, β3…. β4 have represented the estimated parameters, and μ_{it} denotes the error term. Models (1) and (2) take all variables and convert them into their natural logarithmic form, allowing the interpretation of estimated parameters in terms of their elasticities.

3.2.1. Panel-Quantile regressions

This study explores the effects of energy use, tourism development, financial growth, foreign direct investment on sustainable environmental and economic development nexus for GCC countries from 1980 to 2018. P-QR method used extensively economic methodologies in theoretical recent papers (Khan et al., 2020; Wang et al., 2019). QR is an alternative regression line model. Standard linear-regression estimates only the conditional-mean of the dependent factor; contrarily, the QR model with panel data estimates the quantile of the dependent variable and takes into account unobserved heterogeneity and heterogeneous covariate effects. A technique suggested by Koenker and Bassett (1978) overcoming the deficiencies of the ordinary least-squares. The conventional approach is only beneficial in detecting moderate effect as conditional expectation on sustainable environmental and economic development parameters by affecting factors, presuming that most studies use ordinary least-squares to explore sustainable environmental and economic development phenomena (Xu et al., 2017). According to Arshad et al. (2018), quantile regression is appropriate for research when parameters' effects differ across conditional-quantiles and reveals the regression factor for the based upon the quartile.

The econometric theory of using panel data with quantile regression is supported by the work of the scholars Canay (2011), and Galvao (2011). Consequently, we applied this methodology. The panel data's mathematical form is provided below,

$$y_i = x_i^{'}\beta_\theta + \omega_{\theta j} \quad 0<\theta<1 \quad (3)$$

$$PQR_\theta(y_i/x_i) = x_i\beta^\theta$$

Where $PQR_\theta(y_i/x_i)$ demonstrates the y_i quantile of all the economic development and environmentally friendly variables, x_i is the vector of explanatory variables; β_θ has a conditional quantile distribution of zero and is a random error term that satisfies the homoscedasticity. $PQR_\theta(y_i/x_i)$ denotes θ^{th} quantile of the sustainable environmental and economic development variables and β_θ denotes the θ^{th} quantile-regression estimator, and the following equation illustrates the solution;

$$\min \sum_{y_{i\geq x_i'\beta}} \theta/y_i - x_i\beta \Big/ + \sum_{y_{i\geq x_i'\beta}} (1-0)/y_i - y_i - x_i\beta \quad (4)$$

When θ has a range of values in quantile regression, the researcher might use this to estimate various parameter values for the problem being studied. The panel quantile regression models developed for exploring the impact of energy use, financial growth, tourism growth, and FDI on economic growth and carbon emissions, and achieve the best outcomes, this analysis selected various quantile representatives (0.1^{th}, 0.2^{th}, 0.3^{th}, 0.4^{th}, 0.5^{th}, 0.6^{th}, 0.7^{th}, 0.8^{th}, 0.9^{th} quantiles). Thus, we can get regression analysis outcomes for all quantile viewpoints (Xu and Lin, 2020). Despite its benefits, QR does not take unobserved heterogeneity in the underlying nations into account. To solve the problem, we examined the conditional and unobserved individual heterogeneity using a fixed-effects panel quantile. The following can be used to represent the fixed effect panel quantile regression:

$$PQR_\theta\left(y_i/\sigma_i x_i\right) = \sigma_i + x_i^{'}\left(y_i\right) \quad (5)$$

Koenker (2004) advised that unobservable fixed-effects be taken into consideration as parameters that must be evaluated in conjunction with covariate-effects for various quartiles. The parameter estimate is computed using the formula below:

$$\min_{(\sigma,\gamma)} \sum_{\kappa=1}^{\kappa}\sum_{t=1}^{\tau}\sum_{i=1}^{N} \omega_\kappa \gamma\tau_k \left(y_{it} - \sigma_i - x_{it}^{\tau}\beta\left(\tau_k\right)\right) + \delta\sum_{i}^{N}|\sigma_i| \quad (6)$$

In the present analysis δ is set to 1 ($\delta = 1$) (Damette and Delacote, 2012). The conditional-quantile function for the δ quantile is shown in the equation below;

$$PQR_{y_{it}}(\tau/\sigma_i,\vartheta_t,x_{it}) = \sigma_i + \vartheta_t + \beta_{1\tau}EU_{it} + \beta_{2\tau}FD_{it} + \beta_{3\tau}TG_{it} + \beta_{4\tau}FDI_{it} \quad (7)$$

$$PQR_{y_{jt}}(\tau/\sigma_i,\vartheta_t,x_{it}) = \sigma_i + \vartheta_t + \beta_{1\tau}EU_{it} + \beta_{2\tau}FD_{it} + \beta_{3\tau}TG_{it} + \beta_{4\tau}FDI_{it} \quad (8)$$

y_{it} and y_{jt} denotes dependent factors of sustainable environmental and economic development. Regions were indexed and denoted as *i and for the time t.* To deal with the panel, unit-root tests were utilized to verify whether factors were stationary and slope heterogeneity by implementing the econometric approach stated above; this research employs panel quantile regression to achieve robust parameter estimation. The econometric framework employed in the current study is detailed in Figure 1.

3.2.2. Econometric methodology

Appropriate approaches must be used on the data in order to produce the best unbiased outcomes. According to Kapetanios et al. (2011), Cross-Sectional Dependence (C-SD) problems into the panel data frequently lead to inaccurate estimates by skewing the data. Due to the potential for misleading results, we performed Pesaran's (2005) cross-section dependence test to determine whether the dataset has any CD concerns. Following is a representation of the C-SD equation;

$$C-SD=\sqrt{\frac{2}{N-1}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\tau_{ij}P_{ij}^{2}\right)\rightarrow n^{'}N\left(0,1\right) \tag{9}$$

τ and N denotes the time and individual dimension and P_{ij}^{2} indicate the correlation coefficient, which presumes that the variance is constant and the mean value is zero.

To prevent biassed results in the presence of CD problems, it is crucial to use second-generation unit root tests. The analysis employed the Phillips Perron (PP), Augmented Dickey Fuller (ADF), and Levine-Lin-Chu (LLC) tests. After verifying stationary properties of the variables, the study then used Westerlund's (2007) cointegration test to evaluate whether the error correction terms in the panel model are equal to zero. The cointegration test is stated in the following mathematical form;

$$\sigma_i\left(\tau\right)\Delta y_{1i}=\vartheta_{1i}+\vartheta_{2i}t+\sigma_i\left(y_{it-1}-\beta_i^{'}x_{it-1}+\delta_i\left(\tau\right)^{'\ell it}+\varepsilon_{it}\right) \tag{10}$$

The test stats are illustrated by the following.

$$G_\theta=\frac{1}{N}\sum_{i=1}^{N}\frac{\sigma_i^{'}}{SE\left(\sigma_i^{'}\right)},\ \mathrm{G}_\rho=\frac{1}{N}\sum_{i=1}^{N}\frac{\tau\ \sigma_i^{'}}{\sigma_i^{'}\left(1\right)},\text{ and}$$

$$P_\beta=\frac{\sigma^{'}}{SE\left(\sigma^{'}\right)},P_\theta=\frac{P_a}{\tau}$$

G_θ and G_ρ in the equations above reflect group mean estimates, whereas P_β and P_θ a stand for panel estimates.

We applied the causality test developed by Dumitrescu and Hurlin (2012) during the final estimation phase. This method efficiently produces the best results for heterogeneous longitudinal-data by testing the null-hypothesis that there is no causal connection among variables. The test's statistical form can be expressed as follows;

$$\mathbb{Z}_{t,t}=\sigma_i+\sum_{i=1}^{\eta}\beta_i^{j}\mathbb{Z}_{t,t}+\sum_{i=1}^{P}\chi_i^{j}\tau_{i,t-j} \tag{11}$$

j and β^{j} stands for the lag length, and autoregression's parameters.

4. EMPIRICAL RESULTS

Table 2 summarizes the specifics of the descriptive-statistics on every variable. According to the analysis, the skewness outcomes are different from zero, which explains why the factors are asymmetric. The positively kurtosis-coefficients exhibit the fatter tail of indicators. There is no evidence of negative kurtosis, which depicts the thinner tail. There is no normal distribution of the mean and median, the values that elaborate the series, based on the minimum and maximum values. The normally distributed for all the variables, except in financial development, has been strongly rejected by the Jarque-Bera-test, demonstrating that unconditional distribution is not normal. This study uses panel quantile regression, which was supported by the heterogeneous effects of the descriptive statistics outcome. In general, the investigated variables demonstrated useful insights in the beginning that led to a thorough investigation to verify the effectiveness of mitigation strategies. The correlation between outcomes in the same table indicates the strength of the nexus between the study variables under analysis.

The findings of the cross-sectional dependence are indicated in Table 3. The null hypothesis of no cross-sectional dependence is rejected based on Pesaran's probabilities from 2005, which suggests using a second-generation unit root test to assess and correct data properties.

4.1. Panel Unit-Root Tests

Before we begin to conduct an empirical study, it is essential that we perform the panel-unit-root tests, such as the non-stationary data could cause variations of regression in the outcomes. Therefore, we carry out three different panel-unit-root statistics to verify the stationery of the six variables used in our sample. To accomplish this, we used three various panel stationarity tests, such as Phillips Perron (PP), Augmented Dickey Fuller (ADF), and Levine-Lin-Chu (LLC) tests. The results of the panel stationarity statistics are also denominated in Table 4, which shows that selected factors cannot reject a null-hypothesis at levels. The tests demonstrate that the whole variables are I(1) stationary.

The outcomes of the panel co-integration analysis as shown in Table 5. The panel (P_β, P_ρ) and group statistics (G_θ, G_ρ) findings demonstrate that the null hypothesis of no cointegration is rejected at the 1% significance level and confirms that Co2 emission and economic growth have longer-term equilibrium with the levels of energy usage, financial growth, tourism growth, and foreign direct investment.

4.2. Regression Results and Discussion

As an outcome of the preliminary analysis, the effects of energy usage, financial growth, tourism growth, FDI on economic development, and CO_2 emission are estimated by panel QR analysis. Two method conditions have been developed in order to get the disaggregated effects of EU, FD, TG, and FDI. Method 1 studies the validity of EKC assumptions for energy use, financial growth, tourism growth, and FDI in economic growth. Model 2, conversely, examines the validity of the EKC nexus for levels of energy use, financial growth, tourism growth, and FDI in CO_2 emission.

Table 6 suggests the outcomes of the PQR assessment on the impact of energy use, financial growth, tourism growth, FDI on economic development, and CO_2 emission in panel of GCC nations. The

Table 2: Descriptive analysis and correlation matrix

Variables	Co2	RGDP	FD	TG	FDI	EU
Mean	22.03861	285652.8781	0.378097	7156171.569	1.901966	44.12513
Median	21.72044	123828.3672	0.384836	4609000	0.801865	20.4355
Std. Dev	9.632486	371742.7954	0.102327	6482023.512	3.633677	65.44471
Minimum	4.445465	17636.66406	0.162935	0.420934089	−13.6049	0.896
Maximum	58.5744	1649509.25	0.585395	1.226247357	33.56602	355.6105
Kurtosis	0.389883	3.54987437	-0.98736	1095000	26.97155	9.248426
Skewness	0.534315	2.004286725	-0.07971	25282000	3.448193	2.902609
Jarque-Bera	5.2456***	2.5778***	4.9521	6.0914***	8.0923***	2.9524**
Correlation						
Co2	1					
RGDP	−0.27965	1				
FD	0.330071	0.075484	1			
TG	−0.07535	0.753687	0.065671	1		
FDI	0.027281	−0.02291	0.18834	0.1842	1	
EC	−0.23149	0.935996	0.232163	0.768349	−0.00211	1

Authors compilation; **and ***refers to the significance level at 5% and 1%. EU: Energy use, FD: Financial development, TG: Tourism growth, FDI: Foreign direct investment

Table 3: Results of cross-sectional dependence test

Variables	CD-statistics
FD	83.284***
TG	68.321***
FDI	6.567***
EC	46.451***

Authors compilation; ***refers to the significance value at 1%. EU: Energy use, FD: Financial development, TG: Tourism growth, FDI: Foreign direct investment

outcomes are introduced for percentile (0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, and 0.9) percentiles-distribution of every explanatory factor. The outcomes of each pattern suggest that several variables for all two endogenous factors were heterogeneous.

The evaluated coefficient of financial growth is statistically significant at a 1% level across each quantile (except 0.3% and 0.9%), and the sign is positive, showing that financial development rises CO_2 emissions. Our conclusions are consistent with the findings of Zhang and Cheng (2009), that have also concluded that financial growth substantially enhances CO_2 emission from China, whereas (Boutabba, 2014) obtained this outcome for India. Jiang and Ma 2019 and Jian et al. 2019 also established that the statistically significant financial growth raises the CO_2 emission that has enforced our research outcomes. Considering this article, outcomes negate the outcome of Xiong et al. (2017) study that expresses FD reduces the emission in higher advanced regions, but the emission rises in low advanced regions. Nevertheless, Kim and Park (2016) used thirty nations and analyzed that financial development reduces the CO_2-emission.

Furthermore, the co-efficient of tourism growth is also a highly positive sign and statistically significant across all quantiles (except 0.6-0.8%) at a 5% level, showing that tourism growth raises CO_2 emissions. The existing study outcomes are similar to the outcomes of Wei and Ullah (2022), who have found that tourism development positively affects CO_2-emission while inconsistent with these of Chishti et al. (2020) and Lawal et al. (2018), which declares that rise in tourism growth improves CO_2-emission. In a similar study, Zhang et al., 2021) and Sharif et al. (2020) found the impact of tourism growth and energy utilization on environmental-degradation in Tunisia, applying a panel dataset obtained from 1995 to 2010. This indicates that tourism growth reduces CO_2 emissions in the longer term.

The outcomes of FDI on our outcomes is obviously heterogeneous, where are the evaluated co-efficient of FDI is statistically insignificant and negative at quantile (Lower 0.1-0.3% and upper 0.7-0.9%), which is inadequate to provide for the Pollution-Haven-Hypothesis (PHH) in the GCC nations. Especially at lower quantiles like 0.4^{th}, 0.5^{th}, and 0.6^{th}, the affect of FDI on CO_2 emission is negatively and statistically-significant at 1%. The association between FDI and carbon dioxide supports the halo hypothesis, which states that companies from the developed investing countries help reduce the emissions in the host country by relying primarily on green technology in their production. The current research outcomes are similar to Atici (2012), which have no impact of FDI on environmental degradation. Accordingly, this analysis demonstrates that the PHH is generally present in both Low and High OECD nations. This seems to contradict Shahbaz et al. (2015) and Omri et al. (2014) that found FDI appears to have a significant and positive effect on the CO_2-emission in panel studies (suggesting that it may lead to pollution havens through FDI). Similarly, Zhu et al. (2016) have investigated identical outcomes in moderate CO_2-emissions and high-CO_2-emission nations that support the hypothesis of pollution haloes.

Finally, the co-efficient of energy usage is highly-significant, and its effect on CO_2 emission is positive except for 0.9% of all quantiles, which indicates that growth in energy use rises CO_2 emission in the GCC panel. The recent research outcomes are related to the consequences of Usman et al. (2021) and Yang et al. (2021), which found that the usage of energy increase carbon dioxide emissions. The graphical evaluation outcomes of each regressor on CO_2 emissions are represented in Figure 2.

According to Table 7, the coefficient of financial growth is statistically insignificant in all quantiles, which indicates that financial growth has no influence on economic growth in the GCC kingdoms. Additionally, the co-efficient of tourism growth is also extremely negative and statistically significant in each quantile, indicating that tourism growth also negatively affects economic growth in GCC countries.

Table 4: The outcomes of panel unit-root tests

Tests/variables	CO_2	RGDP	FD	TG	FDI	EU
LLC						
Levels	−2.7981	−1.3523	−4.7849**	−0.5281	−6.1594***	−1.5305
First order	−18.8507***	−11.2056***	−15.0925***	−9.6959***	−23.7452***	−13.8498***
ADF						
Levels	−2.9849	−2.2272	−3.6189**	−1.0097	−4.3936***	−2.3085
First order	−9.4367***	−12.8753***	−7.1846***	−6.2314***	−16.9237***	−8.4612***
PP						
Levels	−16.818	−8.9848	−37.234***	−3.3715	−55.151***	−10.135
First order	−23.6513***	−19.5947***	−57.9834***	−15.3467***	−67.3768***	−32.3456***

Authors compilation; **and *** represent the statistical significance levels at 5% and 1%, respectively

Table 5: Outcomes of Westerlund test

Test type	Statistics-1	P-value	Statistics-2	P-value	Decision
G_θ	−7.321	0.000	−8.563	0.000	Cointegration
G_ρ	−9.632		−10.341		Cointegration
P_β	−12.034		−6.852		Cointegration
P_θ	−18.335		−5.863		Cointegration

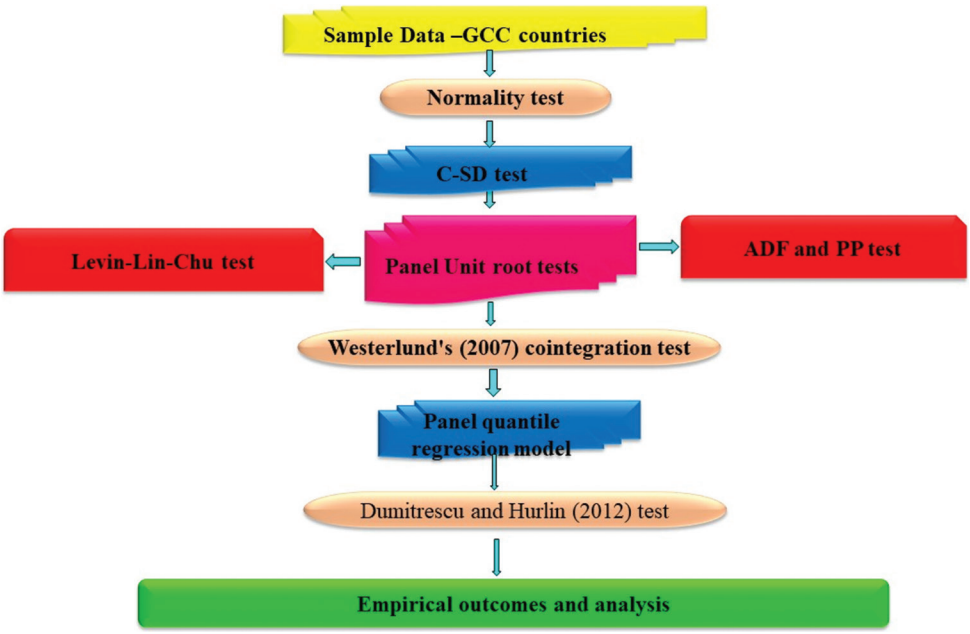
Authors compilation; significance at 1% level

Table 6: Panel quantile regression results for GCC countries (Model-I)

Dep. variable (CO_2)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
lFD	1.786***	1.545***	1.111*	1.331***	1.272***	1.507***	1.156***	1.163***	0.703*
	(0.303)	(0.361)	(0.428)	(0.356)	(0.333)	(0.268)	(0.243)	(0.283)	(0.320)
ITG	0.141**	0.116**	0.155**	0.079**	0.038**	-0.007	-0.058	-0.071	-0.146**
	(0.047)	(0.057)	(0.07)	(0.070)	(0.066)	(0.055)	(0.052)	(0.054)	(0.052)
lFDI	−0.021	−0.012	−0.044	−0.064***	−0.064***	−0.054***	−0.034	−0.027	−0.025
	(0.018)	(0.026)	(0.029)	(0.028)	(0.025)	(0.021)	(0.023)	(0.021)	(0.021)
lEU	0.178***	0.144***	0.179***	0.155***	0.155***	0.140***	0.099*	0.110*	0.012
	(0.032)	(0.035)	(0.042)	(0.040)	(0.038)	(0.037)	(0.042)	(0.054)	(0.057)
Intercept	2.701***	2.839**	2.096	3.426**	4.073***	4.965***	5.369***	5.657***	6.133***
	(0.772)	(0.929)	(1.187)	(1.130)	(1.105)	(0.894)	(0.769)	(0.636)	(0.554)

Authors compilation; ***,**and * refers to the significance level at 1%, 5% and 10%

Figure 1: Flowchart of the analysis process



FDI and energy use are also extremely statistically significant, mainly in the whole quantiles, whereas the sign is positive, which shows that they significantly influence economic growth. Its additional illustrates that an improves in FDI and energy-use improves economic development. FDI is positive and insignificant except for the 0.1%, 0.8%, and 0.9% quantiles, which indicates

Table 7: Panel quantile regression outcomes for GCC countries (model-II)

Dep. variable (RGDP)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
lFD	0.014	0.079	0.113	0.177	0.410	0.300	0.126	−0.024	−0.026
	0.256	0.268	0.280	0.335	0.362	0.397	0.448	0.392	0.240
lTG	−0.394***	−0.418***	−0.496***	−0.520***	−0.494***	−0.469***	−0.380**	−0.322**	−0.305***
	0.053	0.066	0.0767	0.074	0.0744	0.085	0.115	0.118	0.070
lFDI	0.031	0.038*	0.058*	0.062*	0.067*	0.087**	0.094*	0.024	0.010
	0.018	0.018	0.024	0.025	0.029	0.032	0.040	0.051	0.043
lEU	1.374***	1.386***	1.418***	1.435***	1.360***	1.332***	1.252***	1.154***	1.144***
	0.037	0.038	0.0423	0.063	0.070	0.078	0.099	0.091	0.043
Intercept	12.854***	13.281***	14.433***	14.826***	15.012***	14.708***	13.605***	13.146***	12.955**
	0.797	1.067	1.2505	1.163	0.987	1.054	1.397	1.528	0.995

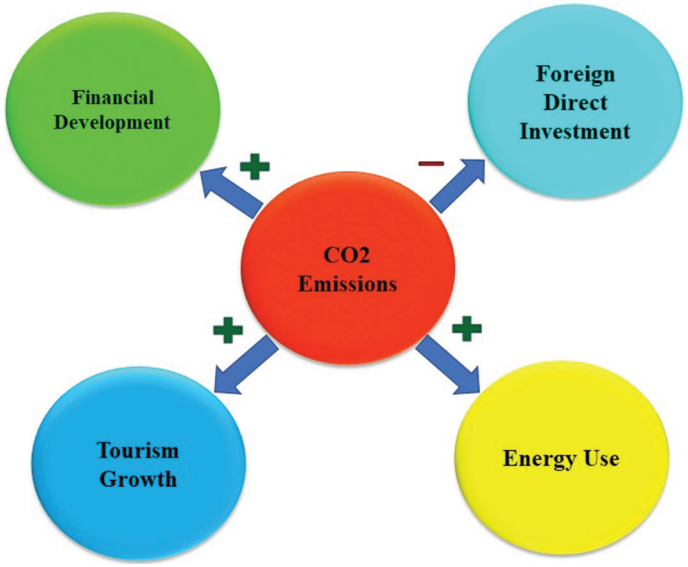
Authors compilation; ***, ** and * refers to the significance values at the 1%, 5% and 10% level

Table 8: Dumitrescu and Hurlin's causality test

Variables	W-statistics	Z-statistics	P-value
CO_2-FD	7.0377	6.1699	0.00068
CO_2-TG	6.435	5.672	0.0145
CO_2-FDI	4.530	3.0986	0.1092
CO_2-EC	5.4216	4.1905	0.0002
CO_2-RGDP	5.9928	4.8901	0.0001
RGDP-FD	5.7911	4.6431	0.1436
RGDP-TG	7.894	6.467	0.02134
RGDP-FDI	10.985	11.004	0.0003
RGDP-EC	5.922	4.8035	0.00001
RGDP-Co2	3.0615	1.302	0.1936

Authors compilation; W- and Z-statistics are shown. EU: Energy use, FD: Financial development, TG: Tourism growth, FDI: Foreign direct investment

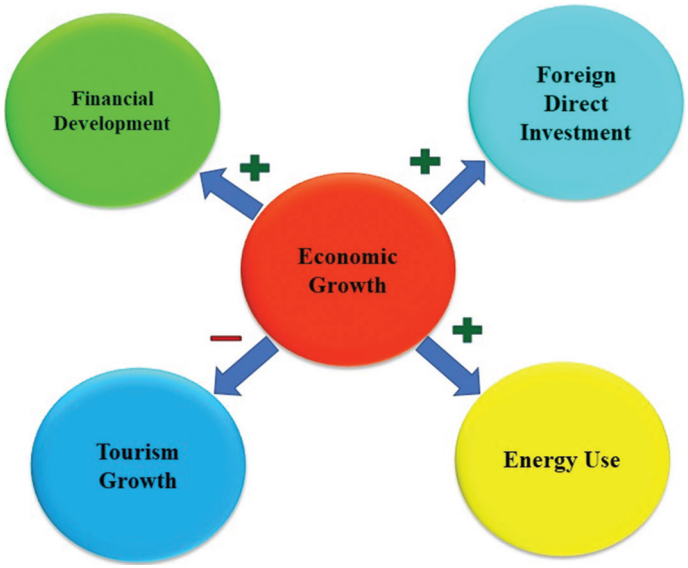
Figure 2: Outcomes of the connection between the evaluates variables



that FDI positively impacts economic expansion in the middle. The graphical evaluation outcomes of each regressor on economic growth are represented in Figure 3.

Table 8 Dumitrescu and Hurlin (2012) proposed a panel causality test that aimed to identify cause and effect variables in a panel dataset. This test was developed to overcome the limitations of traditional correlation analysis, which cannot establish the direction of causality between variables or determine if a causal relationship exists. The test validates that cause-and-effect variables can be causally correlated in both directions. The

Figure 3: Outcomes of the nexus between the evaluated variables



bidirectional causality has been observed between Co2 emissions and financial development, energy use, and causality between economic growth, foreign direct investment, and energy use. Moreover, unidirectional causality is traced from Co2 emissions to tourism growth and causal between economic growth to tourism growth. For the remaining variables, FD and FDI are found to be the cause of Co2 emissions and economic growth in GCC countries. The given findings are illustrated in the following table.

5. CONCLUSION AND POLICY IMPLICATION

The current analysis is an attempt to investigate the effect of energy use, tourism development, financial growth, and foreign direct investment on CO_2 emissions and economic growth during the period from 1980 to 2018 in the case of GCC countries. To achieve this aim, we applied advanced techniques of Panel Quantile Regression. The research assumed advanced econometrics analysis techniques of second-generation panel methods such as the panel unit-root test, Westerlund cointegration test, and the Dumitrescu-Hurlin Granger causality test has been used to identify the causal links among the variables. The Panel Quantile Regression outcomes show that foreign direct investment negatively and statistically significantly affects CO_2 emission, while financial growth, tourism growth, and energy use increasingly impact CO_2

emission. Likewise, tourism growth is negatively and statistically significantly related to economic development, while FDI and energy use have been found to influence economic development positively. Finally, there is an unimportant correlation between financial growth and economic progress. Additionally, the Dumitrescu Hurlin panel causality test revealed that a bidirectional causality has been observed between Co2 emissions and financial development, energy use, and causality between economic growth, foreign direct investment, and energy use. Moreover, unidirectional causality is traced from Co2 emissions to tourism growth and causal between economic growth to tourism growth. Conversely, there is no causal connection between financial development to Co2 emissions and economic growth to foreign direct investment.

The current research outcomes have significant policy implications for GCC countries to promote cleaner technology by enhancing renewable energy use, which can significantly improve environmental quality. Energy is major essential for poverty reduction and a country's development. Additionally, the GCC government should create effective and efficient environmental regulations to ensure economic growth and promote the import of cleaner technology for carbon emission reduction. As a result, GCC nations must explore the role of renewable energy, which can significantly contribute to CO_2 emission reduction, by modifying their present energy strategies to encourage using renewable energies and other energy-efficient technology.

The outcomes also propose that financial growth is a significant factor in CO_2 emission. GCC countries should concentrate on improving their financial systems to provide better incentives for clean energy generation projects as well as research and development activities that will aid in the establishment of a clean environment. Our outcomes show that the increasing tourism growth increases the ecological deterioration in selected GCC countries. Moreover, GCC countries should focus on sustainable tourism development that minimizes negative environmental impacts. Encourage the adoption of eco-friendly practices in hotels, resorts, and tourist attractions. Promote cultural heritage preservation, biodiversity conservation, and responsible tourism practices. However, policymakers should also consider potential challenges and risks associated with foreign direct investment, such as ensuring compliance with environmental regulations, monitoring the environmental impact of industries, and promoting responsible business practices. It is essential to strike a balance between attracting FDI and protecting the environment to achieve sustainable and inclusive growth in the GCC countries. These policy implications aim to guide GCC countries toward a more sustainable and diversified economy, while also addressing environmental concerns and fostering long-term economic growth. Our research is limited to exploring the variable. Further research should be concerned with both developed and developing areas and may involve additional variables to clarify this connection.

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