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The Impact of Financial Efficiency and Renewable Energy Consumption on CO_2 Emissions Reduction in GCC Economies: A Panel Data Quantile Regression Approach

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Abstract: As prominent oil producers, the Gulf Cooperation Council (GCC) countries have played a significant role in the global energy market. However, as the world's attention increasingly shifts towards environmental sustainability, understanding the implications of the GCC's economic activities on CO2 emissions becomes indispensable. This research paper investigates the relationship between specific economic indicators and their impact on CO2 emissions in the GCC from 2001 to 2021. The study employs quantile regression, a powerful statistical method that estimates the conditional quantiles of a response variable given a set of predictor variables. The findings reveal several important insights: Financial institution efficiency is significant and negative at a 1% level at the lower (10th) -83537.3 and the higher quantile (90th) -549002.3. The relationship between GDP per capita and CO2 emissions varies across quantiles, highlighting the complexity of the growth-environment nexus. Total patents exhibit a positive and significant relationship with emissions, underscoring the importance of directing innovation towards environmentally sustainable solutions. Renewable energy consumption displays a nuanced relationship with CO2 emissions, with a stronger negative impact observed at higher consumption levels. This underscores the potential of renewable energy to mitigate emissions when integrated at scale. The study's outcomes hold crucial policy implications for the GCC countries as they seek to align economic growth with environmental sustainability. The findings emphasize the importance of fostering financial institution efficiency, promoting green innovation, and expanding renewable energy sources to reduce emissions.

Keywords: financial efficiency; carbon dioxide emissions; GCC's economies; quantile regression; panel data

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1. Introduction

In an era marked by global concerns about environmental sustainability, it becomes increasingly essential to scrutinize the interplay between economic activities and their impact on the environment. The Gulf Cooperation Council (GCC), comprised of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia,

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and the United Arab Emirates, is a crucial player in the global energy landscape. These nations, known for their prolific oil production, have witnessed substantial economic growth over the past few decades. However, industrialization's rapid expansion and reliance on hydrocarbons have raised concerns regarding carbon dioxide (CO2) emissions. This research explores the intricate relationship between various economic indicators and their influence on CO2 emissions within the GCC region.

The GCC countries have experienced remarkable economic growth but at the cost of environmental sustainability. Balancing economic prosperity with environmentally responsible practices is a critical challenge. Yet, considering diverse economic variables within the GCC context, the precise nature of this relationship remains under-explored. This study seeks to address this gap by investigating the connection between key economic indicators and CO2 emissions in the GCC from 2001 to 2021.

The primary objective of this research is to examine the impact of specific economic factors, including financial development, financial institution efficiency, financial market efficiency, GDP per capita, total trade in low carbon technology products as a per cent of GDP, all technologies (total patents), urban population growth (annual %), and renewable energy consumption (% of total final energy consumption) on CO2 emissions in the GCC region.

Understanding this relationship holds substantial importance on several fronts. Firstly, it aids in strategic planning as GCC countries look to diversify their economies beyond oil. Secondly, it encourages regional collaboration among GCC nations to adopt a unified approach towards sustainable development. Lastly, it assists in aligning international commitments to reduce carbon footprints made by many GCC countries with empirical evidence.

The majority of empirical studies in the field of environmental science share two basic flaws. One of these shortcomings is using OLS mean regression models to determine the dependent variable's conditional mean in response to the independent variables [40]. The fact that the distribution of experimental data is heterogeneous is another shortcoming. As a result, OLS might not offer accurate estimations [41]. In order to detect the relationship between CO2, total trade in low carbon technology products as a per cent of GDP, all technologies (total patents), urban population growth (annual %), and renewable energy consumption (% of total final energy consumption), and GDP per capita, this study is the first environmental experiment to apply the QR for multiple percentiles (i.e., 0.05, 0.25, 0.50, 0.75, and 0.95) against the OLS model. QR is a significant and well-established tool for planning and resource management that could provide a meaningful explanation of the environmental relationship.

This research paper is structured as follows: Following this introduction, we delve into the literature review to provide context and insights from prior studies. Next, the data and methodology section illustrates the data sources, variable definitions, and statistical techniques employed. The descriptive statistics and normality tests present an overview of the dataset's characteristics. Subsequently, the Quantile Regression results reveal the findings. Finally, we conclude with some recommendations based on our observations.

2. Literature Review

In this section, we delve into the complex interplay between climate change, economic growth, and the pivotal role of the financial sector in facilitating a transition from nonrenewable to renewable energy sources. The urgency of addressing climate change is universally acknowledged, and this review critically examines the evolution of global economies towards sustainability. Drawing on a comprehensive analysis of several studies, to provide a holistic understanding of the intricate dynamics that intertwine financial sector development with environmental conservation efforts while concurrently fostering economic growth.

2.1. The Nexus between Economic Growth, Financial Sector Development, and Climate Change

Climate change is a pressing issue that has garnered attention worldwide, within developed and developing nations. The fundamental reason lies in the predominant dependency on nonrenewable energy sources across many economic spheres. Consequently, there is a global shift towards renewable resources. The financial sector's capability to channel funds into sustainable energy projects is pivotal in this paradigm shift. A significant gap exists in the literature, where numerous studies have investigated the link between economic growth and CO2 emissions, often overlooking the critical role of financial sector evolution. The intertwined relationship of economic growth, environmental conservation, and renewable energy utilization is an overarching challenge for a prosperous and sustainable global economy.

These studies were bifurcated based on their focus: single-country-specific or multiple-country analyses. No singular hypothesis has emerged as dominant among the reviewed literature, especially in the context of GCC countries. However, the majority underscored the growth or feedback hypotheses, suggesting that GCC energy policies predominantly aim to ensure energy availability for industrial growth and development. Consolidating renewable energy solutions was posited as a strategic move to achieve sustainable development while addressing environmental challenges in the GCC region. Here are some highlighted research findings:

Al-Iriani: Utilized the Pedroni panel cointegration method, examining the nexus between energy consumption and GDP in GCC nations from 1971 to 2002. The study corroborated the conservation hypothesis [2].

Mehrara: Investigated the relationship between per capita energy consumption and GDP across 11 oil-exporting countries. The results endorsed the conservation hypothesis [3].

Squalli: Explored the link between electricity consumption and economic growth within OPEC countries. Findings suggested a bi-directional relationship for Saudi Arabia and Qatar and a one-directional relationship for Kuwait [4].

Mahadevan and Asafu-Adjaye: Focused on the energy-economic growth dynamic in net energy-exporting nations. Their findings resonated with the feedback hypothesis [5].

Hafeez et al. l explores the impact of financial efficiency and environmental innovations on renewable energy consumption and CO2 emissions in highly polluted Asian economies. Using the ARDL-PMG model, it finds that environmental innovations and financial institution efficiency positively influence renewable energy consumption and reduce carbon emissions [45].

Global sentiment on climate change underlines an urgent need to understand and mitigate its impacts. The financial industry emerges as a catalyst in this scenario, offering innovative green financial solutions tailored to environmentally-conscious entities. Consequently, the phrase "testing clean energy investment and financial development as determinants of environmental sustainability" has become a focal point in climate change discourse.

2.2. Recent Empirical Studies

In this subsection, we can outline some recent studies:

Akbulut: Implemented a panel threshold regression model to explore financial strength's influence on carbon emissions among 11 CEE countries from 1995 to 2018. Findings indicated financial depth's dual role in enhancing and mitigating carbon emissions [25].

Mehmood: Analyzed the banking sector's influence on CO2 emissions within the N-11 countries, emphasizing the role of GDP, clean energy, and nonrenewable energy. The study highlighted the ambivalent impact of bank development on environmental sustainability [26].

Cheiu et al.: Probed the effect of financial development on the relationship between OECD RE and CO2 emissions. Their results depicted the dichotomous influence of stock market growth and banking sector evolution on CO2 emissions. [27]

Duc Hong: Evaluated the interconnected roles of trade liberalization, financial evolution, and urbanization. The study unveiled multifaceted causality relationships within the examined parameters. [28].

Anton et al.: Assessed the impact of financial development on renewable energy consumption among 28 EU countries. They discerned a positive correlation between financial development and renewable energy uptake. [29]

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Eregha et al.: Investigated the efficacy of environmental regulations on the ecological footprint within N11 economies. Their findings cast doubt on the effectiveness of current environmental policies. [30]

Amin et al.: Examined a gamut of economic and environmental factors across South and East Asian nations. The study revealed the multifarious impacts of these parameters on CO2 emissions. [31]

Ali et al.: Used advanced econometric techniques to establish long-term links. Their results indicated various positive impacts on green finance, except for inflation. [32]

Zahoor: Delved into the interplay between renewable energy investment, financial growth, and environmental sustainability in China. The study unravelled the inverse relationship between clean energy investment and environmental degradation. [33]

2.3. Research Gap

Despite the substantial research in the world and GCC context, a notable research gap exists. Few studies have deployed quantile regression techniques to analyze the relationship between economic variables and CO2 emissions in GCC countries. This approach is crucial because it allows for a nuanced understanding of how economic factors impact environmental outcomes across different quantiles of CO2 emissions distribution. Additionally, comprehensive studies are scarce that simultaneously consider various economic indicators and their collective influence on CO2 emissions in the GCC.

2.4. Hypothesis

Building on the theoretical framework and insights from existing literature, as well as the empirical results presented above, we propose the following hypotheses for this study:

Hypothesis 1 (H1): An inverted U-shaped relationship exists between per capita GDP (income) and carbon dioxide (CO2) emissions in Gulf Cooperation Council (GCC) countries.

Hypothesis 2 (H2): The turning point (income threshold) at which GCC countries transition from increasing to decreasing CO2 emissions levels will vary among the member states due to their differing economic structures, energy consumption patterns, and policy approaches.

Hypothesis 3 (H3): Factors beyond income, such as energy consumption, urbanization, and technological advancements, significantly influence CO2 emissions in GCC countries.

Hypothesis 4 (H4): Policy interventions, such as investments in renewable energy sources, energy efficiency measures, and environmental regulations, can accelerate the attainment of the turning point in CO2 emissions for GCC countries. The empirical analysis will test these hypotheses rigorously, providing valuable insights into the sustainability of economic growth in the GCC region and the policy pathways toward achieving environmental goals.

3. Data and Methodology

Quantile regression is a statistical method used to estimate the conditional quantiles of a response variable given a set of predictor variables. It was first introduced by Koenker and Bassett in 1978. The authors employed quantile regression with dynamic analysis. Since the models used in this study offer different outcomes for quantile levels and sequence-wise models, they are better than other methods. This technique has the potential to yield more diverse outcomes. Rather than estimating the mean of the studied variables, quantile regression estimates their median. Hence, quantile regression allows for the estimation of different quantiles, such as the median, lower quantiles, or upper quantiles.

The quantile regression methodology involves minimizing a loss function based on the absolute deviations between the observed and predicted quantiles. This approach is robust to outliers and does not assume a specific distributional form for the data. Estimating quantile regression coefficients

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can be done using various algorithms, such as linear programming or iterative reweighted least squares.

Quantile regression has several advantages over OLS regression. It provides a more comprehensive understanding of the relationship between the predictor variables and different parts of the conditional distribution of the response variable. This is particularly useful when the data has heteroscedasticity or the relationship between the variables is not linear [21]. Quantile regression also allows for analyzing distributional changes over time or across different groups. In recent years, quantile regression has gained popularity in various fields, including economics, finance, environmental studies, and healthcare. It has been used to analyze income inequality, asset pricing models, climate change impacts, and healthcare outcomes, among other applications. Quantile regression is a powerful tool providing valuable insights into the relationship between variables across different parts of the conditional distribution [23]. Its flexibility and robustness make it a useful methodology for researchers in various disciplines.

Firstly, quantile regression allows for the estimation of different quantiles of the conditional distribution of the response variable, such as the median; this provides a more comprehensive understanding of the relationship between the predictor variables and different parts of the distribution [1].

Secondly, quantile regression is robust to outliers and does not assume a specific distributional form for the data. This makes it particularly useful when the data has heteroscedasticity or the relationship between the variables is not linear [1].

Thirdly, quantile regression allows for analyzing distributional changes over time or across different groups. It can capture how the relationship between the variables varies at different points in the distribution, providing insights into potential heterogeneity or conditional effects.

Lastly, quantile regression is flexible and can handle non-normal and skewed data, making it suitable for analyzing real-world datasets that may not meet the assumptions of OLS regression. Quantile regression provides a more comprehensive and robust analysis of the relationship between variables, allowing for a deeper understanding of the conditional distribution and potential heterogeneity in the data.

This paper employed quantile regression techniques to analyze the relationship between economic variables and CO_2 emissions in GCC countries. Taking Carbon Dioxide emissions (CO_2) as the dependent variable. The independent variables are listed in the table below. Each independent variable has been selected based on its potential impact on carbon dioxide emissions, supported by literature and empirical studies.

Table 1. Variable and data sources.

Symbol	Variable	Sources
co2	CO2 emissions (kt)	https://databank.worldbank.org/
fi	Financial Institutions Efficiency Index	https://data.imf.org/?sk=f8032e80-b36c-43b1-ac26-493c5b1cd33b
FM	Financial Markets Efficiency Index	https://data.imf.org/?sk=f8032e80-b36c-43b1-ac26-493c5b1cd33b
fd	Financial Development Index	https://data.imf.org/?sk=f8032e80-b36c-43b1-ac26-493c5b1cd33b
GDP	GDP per capita (constant 2015 US$)	https://databank.worldbank.org/
at	All technologies (total patents)	https://stats.oecd.org/Index.aspx?
tr	Total trade in low-carbon technology products as a per cent of GDP	https://stats.oecd.org/Index.aspx?
pop	Urban population growth (annual %)	https://databank.worldbank.org/
ecn2	Renewable energy consumption (% of total final energy consumption)	https://databank.worldbank.org/

Note: own construction.

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Equations illustrate the study variables.

$$E(yit \mid xit,\ \alpha_i) = \beta\ X_{it}^{T} + \alpha_i \quad (1)$$

where yit denotes the logarithm of the number for country yi at year t, xit = $(X_{it,1}^{T}, \ldots, X_{it,p}^{T})^{T}$ is ap ×1vector of independent variables, and ai denotes the (unobserved) county effect, which controls for time-invariant sources of unobserved heterogeneity, such as geography, and formal institutions.

$$QCO2_{it}\ (\tau \mid xit,\ \alpha_i) = \beta 1_{\tau}\, FD_{it} + \beta_{2\tau}\, FI_{it} + \beta_{3\tau}\, FM_{it} + \beta_{4\tau}\, GDP_{it} + \beta_{5\tau} ECN_{it} + \beta_{6\tau} POP_{it} + \beta_{7\tau} TR_{it} + \beta_{8\tau}\, AT_{it} + \alpha_i \quad (2)$$

Here, the authors represent individual countries in the GCC, and t represents time. α_i is the error term and at nine quantiles, namely τ = 0.10, 0.20, 0.30, 0.40, 0.50, 0.60, 0.70, 0.80 and 0.90 The expected relationships between various economic indicators and CO_2 emissions in the GCC (Gulf Cooperation Council) countries from 2001 to 2021to provide a brief analysis of each indicator's potential relationship with CO_2 emissions based on existing literature and empirical findings

$\beta 1 > 0\ or < 0$: Financial development the coefficient is projected to be either negative or positive, indicating that it can lead to more efficient resource allocation and the promotion of green technology and practices. However, it can also increase industrial activity, resulting in increased emissions. [37]

$\beta 2 > 0\ or < 0$: Efficient financial institutions predict the coefficient to be negative or positive, implying that it might promote sustainable initiatives while simultaneously financing carbon-intensive sectors. [38]

$\beta 3 > 0\ or < 0$: Efficient financial markets, the coefficient is expected to be negative or positive and could facilitate funds transfer to cleaner technologies. However, it can also promote industries, increasing emissions depending on market priorities. [39]

$\beta 4 > 0$: A higher per capita GDP coefficient is expected to be positively associated with increased CO_2 emissions; as countries grow wealthier, they initially have increasing emissions due to industrialization. However, after reaching a certain income level, countries might invest more in clean technology and enforce stricter environmental regulations, thus potentially reducing emissions.

$\beta 5 < 0$: Renewable energy consumption (% of total final energy consumption) contributes to reducing CO_2 emissions through efficient energy resource allocation. The coefficient is expected to be negative. This implies that an increase in renewable energy consumption contributes to reducing CO_2 emissions through more efficient energy resource allocation.

$\beta 6 > 0$: The coefficient is expected to be positive for urban population growth (annual %). This suggests that an increase in urban population growth is associated with an increase in CO_2 emissions.

$\beta 7 < 0$: Total trade in low carbon technology If a country imports a higher share of environmental goods, the coefficient is expected to be negative. It suggests a transition towards cleaner technology and practices, potentially lowering emissions.

$\beta 8 < 0$: The coefficient is expected to be negative for all technologies (total patents). This indicates that an increase in total patents, reflecting technological innovation, is associated with a decrease in CO_2 emissions

Originally presented in the seminal study by Koenker and Bassett [1], quantile regression is an expansion of the classic least-squares estimation of the conditional mean to a group of models for various conditional quantile functions. The τ^{th} regression quantile estimate $\hat{\beta}(\tau)$ is the solution to the following minimization problem where t is a parameter (0 < τ< 1) which represents quantile size. According to Bao, Lee, and Saltoglu [43], the primary benefit of quantile regression over ordinary least squares (OLS) analysis is its ability to examine the whole distribution. On the other hand, conditional distributions can only be partially described by conventional OLS regression, which only allows researchers to estimate the conditional mean and conditional median that is located at the center of the distribution. Tukey & Mosteller [42]. Additionally, quantile regression is more forgiving than OLS due to its greater insensitivity to outliers and distributions with heavy tails. In order to construct the regression model, we use penalized panel quantile regression with a fixed effect. The penalized version of the estimator is then solved using the following equation.:

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$$\hat{\beta}(\tau) = arg_{\beta\in R^K}\ \min \sum_{i\in\{i:yi\geq x_i\beta\}}\tau|y_i - x_i\beta| + \sum_{i\in\{i:yi<x_i\beta\}}(1-\tau)|y_i - x_i\beta| \quad (3)$$

where τ is a parameter (0 < τ < 1) that represents quantile size, according to Bao, Lee, and Saltoglu [43], the main advantage of quantile regression over OLS is its ability to analyze the entire distribution. In contrast, traditional OLS regression only allows researchers to approximate the conditional mean and conditional median located in the centre of the distribution, providing only an incomplete description of a conditional distribution. Mosteller and Tukey [42]. Furthermore, quantile regression is more forgiving than OLS because it is relatively insensitive to outliers and distributions with heavy tails. Thus, we employ the penalized panel quantile regression with a fixed effect to build up the regression model and solve the penalized version of the estimator by the following equation.

$$(\hat{\beta}(\tau_K, \lambda),\{\alpha_i(\lambda)\}n_{i=1} = \arg\min \left(\sum_{k=1}^{K}\sum_{t=1}^{T}\sum_{i=1}^{n}\omega_k P_{\tau K}(y_{it} - x_{it}^T\beta(\tau_k) - \alpha_i) + \lambda\sum_{i=1}^{n}|\alpha_i|\right. \quad (4)$$

where $\beta\tau_k$ (u) = u(tk − I(u ≤ 0)) is the standard quantile loss function (Koenker, 2004, 2005) and ω_k is the relative weight given to the kth quantile, which controls for the contribution of the kth quantile to the estimation of the fixed-effects panel data mode.

4. Results and Analysis

Descriptive Statistics

Descriptive Statistics summarize the central tendency, dispersion, and shape of a dataset's distribution, presented in the table below.

Table 2. Descriptive Statistics.

stats	CO2	FD	GDP	FI	FM	AT	TR	ECN2	POP
Mean	134507.7	0.432779	33441.54	0.614043	0.372024	60.11748	1.403897	0.00186	4.305412
Median	79189.9	0.432155	23671.85	0.676653	0.240786	6.60625	1.317068	3.71E-05	3.13081
Maximum	565190	0.58593	73493.3	0.780721	1	758.08	3.282995	0.076731	19.61203
Minimum	15876.5	0.264384	15512.7	0.285995	0.011617	0.33	0.022589	-0.002029	-2.605206
Std. Dev.	145738.1	0.074635	16637.95	0.13143	0.30993	145.7936	0.691809	0.009169	4.048381
Skewness	1.770123	-0.174216	0.854789	-0.954099	0.609715	3.565122	0.743584	6.870983	1.664043
Kurtosis	5.034254	2.489945	2.35958	2.746825	2.030884	15.35824	3.061748	51.40331	6.509573

Source: Authors' calculation.

In the given dataset, the mean CO_2 emission is approximately 134507.7 kt, characterized by a pronounced rightward skewness and elevated kurtosis, signaling the preponderance of lower values with a spread of higher values. The Financial Institutions Efficiency Index exhibits a leftward skewness, suggesting a prevalence of higher values with a mean of 0.614. The Financial Markets Efficiency Index possesses a mild rightward skewness with a mean of 0.372, and the GDP per capita has a slightly rightward skewness with an average of 33441.54. Remarkably, the variables 'Total Patents' and 'Renewable Energy Consumption' display extremely high rightward skewness and kurtosis, highlighting numerous extreme values.

The results from normality tests, predominantly relying on assessments of skewness and kurtosis, unveil that most variables diverge from normal distributions, with p-values below the 0.05

threshold. Specifically, the variables, including CO2, fi, fm, GDP, at, tr, pop, and ecn2, display substantial deviations from normality in their distributions, entailing potential implications for subsequent analyses utilizing methods premised on the assumption of normality.

The detailed results of Levin, Lin, and Chu t*, Breitung t-stat, Im, Pesaran, and Shin W-stat, and ADF - Fisher Chi-square tests are shown in Table 3 to demonstrate that every factor in our model has an I(0) or I(1) process, indicating that every series is stationary at its levels or the first difference. The authors use the previously stated panel unit root test results to see if there is a long-term relationship across the variable. Recent econometrics research has introduced generation unit root tests to control the issue of cross-sectional dependence throughout panel units. [44,45]

Table 3. Panel unit root tests.

Variables	Level				First difference			
	Levin, Lin & Chu t*	Breitung t-stat	Im, Pesaran and Shin W-stat	ADF - Fisher Chi-square	Levin, Lin & Chu t*	Breitung t-stat	Im, Pesaran and Shin W-stat	ADF - Fisher Chi-square
Co2	3.73633 (0.9999)	-4.06574 (0.0000)	4.81104 (1.0000)	0.32347 (1.0000)	-3.98180 (0.0000)	1.27221 (0.8984)	-2.25793 (0.0120)	33.5467 (0.0008)
Fi	-0.73930 (0.2299)	-2.34471 (0.0095)	-0.63224 (0.2636)	12.4197 (0.4126)	-10.2963 (0.0000)	-6.97417 (0.0000)	-9.01634 (0.0000)	78.2641 (0.0000)
Fd	2.98683 (0.9986)	-1.36721 (0.0858)	1.07577 (0.8590)	5.58413 (0.9356)	-7.56227 (0.0000)	-7.10773 (0.0000)	-8.38458 (0.0000)	70.4906 (0.0000)
Fm	0.82168 (0.7944)	1.48981 (0.9319)	1.02558 (0.8475)	7.84030 (0.7975)	-8.96396 (0.0000)	-6.94931 (0.0000)	-7.35313 (0.0000)	64.4648 (0.0000)
Gdp	1.76007 (0.9608)	1.37743 (0.9158)	2.06426 (0.9805)	3.63452 (0.9892)	-3.13688 (0.0009)	-2.64493 (0.0041)	-1.94244 (0.0260)	22.1369 (0.0360)
Tr	0.68659 (0.7538)	-0.50047 (0.3084)	0.82309 (0.7948)	31.9863 (0.0014)	-11.0984 (0.0000)	-6.25717 (0.0000)	-10.4500 (0.0000)	88.2078 (0.0000)
At	0.13102 (0.5521)	-1.85462 (0.0318)	0.43554 (0.6684)	7.77865 (0.8022)	1.43240 (0.9240)	-2.31317 (0.0104)	-0.89739 (0.1848)	91.8424 (0.0000)
Pop	2.42895 (0.9924)	3.48707 (0.9998)	3.12790 (0.9991)	1.77678 (0.9997)	-3.32578 (0.0004)	-3.98072 (0.0000)	-1.79895 (0.0360)	20.4973 (0.0582)
ecn2	4.44772 (1.0000)	6.16539 (1.0000)	6.05401 (1.0000)	0.77962 (1.0000)	-3.82540 (0.0001)	0.58076 (0.7193)	-2.03838	28.7479 (0.0043)

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							(0.0208)	

Note: standard errors are in parenthesis. ***p < 0.001, **p < 0.05, *p < 0.1.

The authors performed dynamic analysis on collected data using nine models in different periods. Table 4 shows the findings for the year. Standard deviations are given in parentheses. Model 1 to 6 indicates a significant negative effect on the GDP per capita, and All technologies (total patent) on CO_2 with -.2515758** and -54.66656***, respectively. The result may be attributed to the high-income level of GCC countries which may enable them to increase investment in clean technologies, enforce stricter environmental regulations, and reduce emissions. Other variables regarding technologies have negative effect demonstrating that an increment on them reflect innovative development is related with a diminish in CO_2 outflows. On the other side, models 1 to 9 indicated an expected significant positive impact of urban population growth on CO_2 emissions with a value of coefficient 361.7188. CO_2 is shown to have a considerable and detrimental impact on GCC countries' investment. The following models in diverse time zones showed an insignificant but positive relationship between FD, FM, ECN2, and CO_2 implying that financial institutions and market efficiency environment need more progress to reduce CO_2 emissions. In different models concerning periods, different beta values are shown in the case of FI. This means that if GCC countries want to reduce their CO_2 emissions, they must invest more in renewable energy projects. The economic indicator, GDP per capita also exerted a negative pressure on CO_2 emissions with a -.2515758*** beta value in model 1. Following this, the authors examined the data through the quantile regression technique and examined the impact of Fd, Fi, Fm, GDP, at, tr, pop, and ecn2 on CO_2 in GCC countries.

Table 4. Renewable energy and CO2 relationship.

Variable	**M-1**	**M-2**	**M-3**	**M-4**	**M-5**	**M-6**	**M-7**	**M-8**	**M-9**
period	**2021-2020**	**2020-2019**	**2019-2018**	**2018-2017**	**2017-2016**	**2016-2015**	**2015-2014**	**2014-2013**	**2013-2012**
Fi	**-1702.121 (7524.118)**	**1092.601 (7905.362)**	**-854.3858 (9325.619)**	**506.3395 (10684.5)**	**980.3714 (12397.37)**	**8223.686 (14392.32)**	**14013.52 (16559.74)**	**19411.11 (17816.25)**	**-22282.43 (19389.39)**
Fd	**29007.87 (18493.67)**	**24213.11 (19351.37)**	**24649.48 (21012.08)**	**15685.95 (23921.19)**	**20049.24 (27537.05)**	**5992.077 (31752.06)**	**-4935.701 (35844.46)**	**-13976.4 (38349.44)**	**3544.443 (041549.47)**
Fm	**899.6757 (4570.033)**	**572.3488 (4950.002)**	**2184.765 (5379.091)**	**6122.058 (5795.661)**	**3512.103 (6590.809)**	**7464.449 (7437.67)**	**9921.395 (8428.047)**	**14345.19 (9034.014)**	**14031.75 (9970.689)**
Gdp	**-.2515758** (.1032343)**	**-.2211375** (.1101319)**	**-.2451776** (.1175154)**	**-.2540144** (.1230287)**	**-.2167689 (-.2167689)**	**-.1713489 (.1362349)**	**-.1618858 (1418558)**	**-.1650761 (.1420702)**	**-.247454 (.1593102)**
Tr	**-1239.236**	**-1374.116**	**-1564.843**	**-1404.534**	**-1338.478**	**-2488.661**	**-2659.711**	**-2961.522**	**-3405.381**

	(1235.452)	(1295.465)	(1373.09)	(1470.246)	(1575.444)	(1609.569)	(1730.392)	(1894.782)	(2082.315)
At	-54.66656*** (9.194927)	-53.51432*** (11.34117)	-64.37327*** (14.502)	-83.85143*** (16.65998)	-73.13967*** (20.25201)	-89.80826*** (22.61398)	-100.169*** (25.2357)	-131.269*** (27.13217)	-106.5161*** (30.77096)
Pop	361.7188** (152.6018)	368.0806** (161.7725)	403.8418** (174.9024)	408.8782** (0.646)	366.0271** (196.675)	395.4598** (199.1936)	400.5054** (224.0622)	285.4512 (262.3137)	437.2312 (333.5236)
ecn2	2567.129 (6428.038)	2403.447 (6705.235)	2443.179 (7066.791)	325.0101 (7319.28)	3459.337 (8019.85)	6656.735 (8092.902)	6543.821 (8453.006)	9076.003 (8485.313)	10601.04 (9062.235)
0bs.	126	120	114	108	102	96	90	84	78

Note: This table shows the beta coefficients and standard error in parenthesis. ***p <0.001, **p <0.05, *p <0.1.

Quantile Regression

Certainly, in the quantile regression analysis for the given dataset, the influence of several independent variables on CO2 emissions is investigated across different quantiles, which provides a more comprehensive understanding of their relationships than standard linear regression models. Below is an elaboration on the quantile regression analysis, focusing on each independent variable.

The quantile regression model was specified considering the various quantiles, ranging from 0.10 to 0.90, and the potential impact of each independent variable on carbon dioxide emissions was analyzed at these specified quantiles (Table 5).

Table 5. Quantile regression.

	co2	co2	co2	co2	co2	co2	co2	co2	co2
	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
Fi	-83537.3 (0.027)	-358232.6 (0.000)	-443214.9 (0.000)	-486985.89 (0.000)	-516025.3 (0.000)	-563621.7 (0.000)	-572810.8 (0.000)	-478746.6 (0.000)	-549002.3 (0.000)
Fd	-87153.89 (0.187)	-197111 (0.172)	-116505 (0.404)	-55075.87 (0.596)	-30645.2 (0.771)	-33379.6 (0.767)	74308.56 (0.542)	102151.2 (0.356)	-93298.7 (0.534)
Fm	77642.75 (0.000)	107923.4 (0.001)	120278.2 (0.000)	104810.7 (0.000)	97727.15 (0.000)	84795.45 (0.001)	56327.45 (0.047)	68475.65 (0.008)	76673.69 (0.028)
Gdp	-.55983 (0.029)	-1.14338 (0.041)	-1.34533 (0.014)	-1.64755 (0.000)	-1.36072 (0.001)	-1.04476 (0.018)	-1.07388 (0.024)	-.917857 (0.033)	-.0077746 (0.989)
Tr	3116.676 (0.572)	7919.605 (0.66)	8693.199 (0.456)	1859.903 (0.830)	-557.288 (0.950)	-7109.72 (0.452)	-20458.8 (0.047)	-17246.5 (0.064)	-16393.4 (0.193)
At	628.4973	510.4718	471.8405	451.273 (0.000)	426.6955	467.2045	476.6955	631.5421	612.0191

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	(0.000)	(0.000)	(0.000)		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Pop	2135.022 (0.007)	1420.594 (0.407)	454.5198 (0.784)	566.5764 (0.646)	-365.927 (0.770)	-1094.23 (0.415)	-717.229 (0.621)	-1867.74 (0.157)	-1704.15 (0.340)
ecn2	1397177 (0.000)	940622.4 (0.245)	565664.2 (0.470)	651639.4 (0.265)	354910 (0.549)	71639.37 (0.910)	53860.52 (0.937)	-216598 (0.727)	-660405 (0.433)
0bs.	132	132	132	132	132	132	132	132	132
R-squared	0.4749	0.5081	0.5737	0.6166	0.6549	0.6934	0.7441	0.7843	0.8200

standard errors are in parenthesis. ***p < 0.001, **p < 0.05, *p < 0.1.

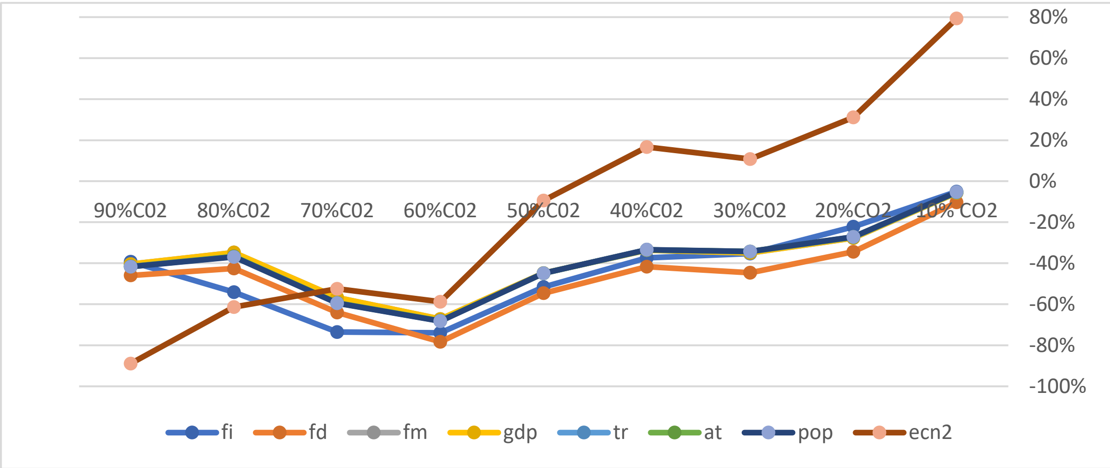

Figure 1. Results of Quantile Regression.

Across all quantiles, an increase in the Financial Institutions Efficiency Index is consistently associated with decreased CO2 emissions. This negative relationship is significant, suggesting that as the efficiency of financial institutions increases, CO2 emissions tend to decrease, a significant and negative relationship with CO2 emissions across all quantiles. These results indicate that the effect is statistically significant and negative at a 1% level at the lower (10th) -83537.3 and the higher quantile (90th) -549002.3. This could be attributed to more efficient financial institutions fostering investments in cleaner technologies or enforcing stricter environmental standards.

Conversely, the Financial Markets Efficiency Index shows a significant and positive relationship with CO2 emissions across all quantiles; these results indicate that the effect is statistically significant and positive at a 1% level at the lower (10th) 77642.75 and the higher quantile (90th) -549002.3. This suggests that as the efficiency of financial markets increases, CO2 emissions tend 76673.69 to rise. This may imply that more efficient financial markets, while fostering economic activity, may also lead to higher emissions without corresponding environmental regulations.

The relationship between GDP per capita and CO2 emissions varies across the quantiles. A decrease in CO2 emissions is observed in most quantiles with increased GDP per capita, signifying a possibility of cleaner production processes or higher environmental consciousness in higher-income economies. However, there is a slight and insignificant increase in CO2 emissions at the 0.90 quantile. This could suggest that increased consumption and production may offset the benefits of cleaner technologies or environmental consciousness beyond a certain income level. Total patents directly and significantly correlate with CO2 emissions across all quantiles. These results indicate that the effect is statistically significant and positive at a 1% level at the lower (10th) 628.4973 and the higher quantile (90th) 612.0191. This can imply that the regions with a higher number of patents, possibly

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indicating higher innovation and industrial activity, tend to have higher CO2 emissions. It is crucial to understand the nature of these patents to determine whether they are related to cleaner technologies or industries with high emissions. The variable representing Renewable Energy Consumption portrays a nuanced relationship with CO2 emissions. It has positive coefficients at lower quantiles, switching to negative at higher quantiles. This can imply that an increase in renewable energy consumption does not significantly decrease CO2 emissions at lower levels of renewable energy consumption. However, at higher levels, it does have a substantial impact in reducing emissions. The variables 'Total trade in low carbon technology products as a per cent of GDP' (tr), 'Urban Population Growth'(pop), and 'Financial development' (FI) show inconsistent relationships with CO2 emissions across different quantiles.

To visualize the results of a quantile regression by plotting a series of line graphs, each line representing a different quantile (0.10, 0.20, 0.30, etc.) for each independent variable (fi, fd, fm, etc.). Each independent variable will have a graph showing how its relationship with CO2 emissions varies across the different quantiles. Connecting these points, the coefficient of financial institutions' efficiency index "fi" changes across different quantiles, reflecting the varying impact of "fi" on CO2 emissions across the distribution of the dependent variable.

This test refers to a process in statistical analysis where the researcher checks the reliability and validity of their results under different conditions, assumptions, or parameters. This can involve altering the dataset, using different statistical models, or changing key variables to see if the results remain true. Robustness testing is crucial in research to ensure that the findings are not just specific to a particular set of circumstances but can be generalized to a broader context. Probit and Tobit regression tests (see Table 6). Both tests indicated that the same significant results had been found in the case of dynamic analysis and quantile regression.

Table 6. Testing the robustness.

	Tobit	Probit
Fd	29998.35 (0.007)	2.240671 (0.024)
Fi	23746.12 (0.000)	1.575652 (0.000)
Fm	10874.26 (0.000)	.5193258 (0.000)
Gdp	.1935762 (0.774)	.00000974 (0.883)
At	2052.171 (0.000)	.0018809 (0.000)
Tr	2090.038 (0.488)	.1788664 (0.935)
ecn2	5798047 (0.110)	11.78696 (0.280)
Pop	317.3253 (0.255)	.0246225 (0.156)

standard errors are in parenthesis. ***$p < 0.001$, **$p < 0.05$, *$p < 0.1$.

5. Conclusion

The Gulf Cooperation Council (GCC) nations have contributed significantly to the global energy market as major oil producers. But with the focus of the globe turning more and more toward environmental sustainability, it is imperative to comprehend how the GCC's economic activities affect CO2 emissions. This study comprehensively analyses the relationship between various economic factors and CO2 emissions in the GCC region using quantile regression. This approach allows for a nuanced understanding of how these relationships vary across different levels of CO2 emissions. The empirical findings indicated that FI is a significant negative predictor with 549002.3 beta values in model .09. Thus, green energy channels can be improved by raising a consistent relationship between financial institutions' efficiency and CO2 emissions, suggesting that efficient financial institutions can contribute to reducing emissions by fostering investments in cleaner technologies respectively, policymakers should encourage financial institutions to provide capital and credit at reasonable costs to deploy renewable energy projects and promote green activities, this finding also accepts the H2.

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However, FM has a significant positive relationship with CO_2, with a beta value of 76673.69, a positive correlation highlighting the potential environmental cost of increased economic activities facilitated by efficient financial markets

A variable relationship between GDP per capita and CO_2 emissions indicates the complex interplay between economic growth and environmental impact.

A direct and significant relationship between technological innovation (measured through patents) and CO_2 emissions, emphasizing the need for green innovations. There is a nuanced relationship between renewable energy consumption and CO_2 emissions, with its impact varying across different emissions levels.

All these results appear to be robust to the estimation approach and are consistent with prior literature such as (e.g., Al-Iriani, M. (2006); Mahadevan et al., J. (2007), Hafeez et al. l(2022))

6. Recommendations

Promoting Financial Institutions' Efficiency: Policymakers should encourage financial institutions to invest in cleaner technologies and enforce stricter environmental standards. This can be achieved through policy incentives and regulatory frameworks that prioritize sustainable investments.

Balancing Financial Market Efficiency and Environmental Regulations: While efficient financial markets are crucial for economic growth, it is important to counterbalance this with stringent environmental regulations to mitigate the associated increase in CO_2 emissions.

Fostering Sustainable Economic Growth: Efforts should be made to ensure that economic growth, especially in higher-income GCC economies, is accompanied by sustainable practices and technologies to limit the increase in CO_2 emissions.

Innovation and Green Technology: There is a need for a strategic shift in innovation towards green and sustainable solutions. Governments and private sectors should invest in research and development of low-carbon technologies and incentivize patents in environmentally friendly technologies.

Renewable Energy Development: Given the complex relationship between renewable energy consumption and CO_2 emissions, GCC countries should invest more in renewable energy infrastructure, particularly at levels that can significantly impact emission reductions.

Further Research and Policy Implementation: Ongoing research into the specific dynamics of the energy-growth relationship in the GCC countries is crucial. Policymakers should use these insights to implement balanced strategies that promote energy efficiency, economic growth, and environmental sustainability.

Regional Collaboration and Knowledge Sharing: GCC countries should collaborate in sharing best practices, technological advancements, and policy experiences to collectively address environmental challenges and achieve sustainable development goals.

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References

1. Koenker, R., & Bassett, G. (1978). Regression quantiles. Econometrica: Journal of the Econometric Society, 46(1), 33-50.
2. Al-Iriani, M. (2006). Energy-GDP relationship revisited: an example from GCC countries using panel causality. Energy Policy, 34(17), 3342-3350.
3. Mehrara, M. (2007). Energy consumption and economic growth: the case of oil exporting countries. Energy Policy, 35(5), 2939-2945.

 doi:10.20944/preprints202405.0997.v1

4. Squalli, J. (2007). Electricity consumption and economic growth: bounds and causality analyses of OPEC members. Energy Economics, 29(6), 1192-1205.
5. Mahadevan, R., & Asafu-Adjaye, J. (2007). Energy consumption, economic growth and prices: a panel VECM reassessment for developed and developing countries. Energy Policy, 35(4), 2481-2490.
6. Al-Mulali, U., Ozturk, I., & Lean, H. H. (2015). Economic growth, urbanization, trade openness, financial development, and renewable energy influence European pollution. Natural Hazards, 79(1), 621-644.
7. Hamdi, H., Sbia, R., & Shahbaz, M. (2014). The nexus between electricity consumption and economic growth in Bahrain. Economic Modelling, 38, 227-237.
8. Salahuddin, M., Gow, J., & Ozturk, I. (2015). Is the long-run relationship between economic growth, electricity consumption, carbon dioxide emissions and financial development in Gulf Cooperation Council Countries robust? Renewable and Sustainable Energy Reviews, 51, 317-326.
9. Dogan, E., Taskin, D., & Alharthi, M. (2021). The relationship between energy consumption and economic growth in the GCC countries: A systematic review. Environmental Science and Pollution Research, 28(30), 38901-38908.
10. Eller, S. L., & Medlock, K. B. (2007). Energy demand and economic development: relationships and implications. USAEE Houston Conference.
11. Nathaniel, S., Nwanya, S. C., Ohale, C. O., & Igwe, R. (2020). Energy consumption, renewable energy, and environmental degradation in MENA countries: Evidence from simultaneous equation model. Energy Reports, 6, 276-285.
12. Magazzino, C., & Cerulli, G. (2019). Renewable energy consumption and economic growth nexus in MENA countries: A bootstrap rolling window approach. Energy Policy, 126, 295-302.
13. Gulf Cooperation Council (GCC) Secretariat-General. (2021). GCC Statistical Center. Retrieved from https://www.gccstat.org/en/
14. World Bank. (2021). World Bank Data. Retrieved from https://databank.worldbank.org/
15. International Monetary Fund (IMF). (2021). IMF Data. Retrieved from https://data.imf.org/?sk=f8032e80-b36c-43b1-ac26-493c5b1cd33b
16. Organization for Economic Cooperation and Development (OECD). (2021). OECD Data. Retrieved from https://stats.oecd.org/Index.aspx?
17. Line, T.(2021).Quantile Regression in R. Retrieved from https://data.library.virginia.edu/getting-started-with-quantile-regression-in-r/
18. Koenker, R. (2021). Quantreg: Quantile Regression. Retrieved from https://cran.r-project.org/web/packages/quantreg/index.html
19. StataCorp. (2021). Stata Statistical Software: Release 17. College Station, TX: StataCorp LLC.
20. R Core Team. (2021). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. Retrieved from https://www.R-project.org/
21. Uribe, J. M., & Guillen, M. (2020). Quantile regression for cross-sectional and time series data: Applications in energy markets using R. Cham, Switzerland: Springer International Publishing.
22. Wickham, H. (2016). ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York. Retrieved from https://ggplot2.tidyverse.org/k
23. Huang, Q., Zhang, H., Chen, J., & He, M. J. J. B. B. (2017). Quantile regression models and their applications: a review. Journal of Biometrics & Biostatistics, 8(3), 1-6.
24. AlKhars, Mohammed, Fazlul Miah, Hassan Qudrat-Ullah, and Aymen Kayal. 2020. "A Systematic Review of the Relationship Between Energy Consumption and Economic Growth in GCC Countries" *Sustainability* 12, no. 9: 3845. https://doi.org/10.3390/su12093845.
25. AKBULUT, "Could Financial Deepening Be the Solution to the Carbon Emission Problem? Empirical Evidence from CEE Countries," Transylvanian Review of Administrative Sciences, vol.2023, no.69, pp.5-24, 2023.10.8.
26. Mehmood, U. Environmental sustainability through renewable energy and banking sector development: policy implications for N-11 countries. *Environ Sci Pollut Res* **30**, 22296–22304 (2023). https://doi.org/10.1007/s11356-022-23738-7.
27. Chiu, Y.-B.; Zhang, W. Moderating Effect of Financial Development on the Relationship between Renewable Energy and Carbon Emissions. *Energies* **2023**, *16*, 1467. https://doi.org/10.3390/en16031467.
28. Duc Hong Vo, Chi Minh Ho & Anh The Vo (2023) Trade openness, financial development, and urbanization in the renewable energy-growth-environment nexus, Energy Sources, Part B: Economics, Planning, and Policy, 18:1, DOI: 10.1080/15567249.2023.2240784.
29. Anton, S. G., and A. E. A. Nucu. 2020. The effect of financial development on renewable energy consumption: a panel data approach. *Renewable Energy*. 147:330–38. doi: 10.1016/j.renene.2019.09.005.
30. Eregha, P. B., Nathaniel, S. P., & Vo, X. V. (2023). Economic growth, environmental regulations, energy use, and ecological footprint linkage in the Next-11 countries: Implications for environmental sustainability. *Energy & Environment*, *34*(5), 1327–1347. https://doi.org/10.1177/0958305X221084293.

 doi:10.20944/preprints202405.0997.v1

31. Amin, N., Song, H. The role of renewable, nonrenewable energy consumption, trade, economic growth, and urbanization in achieving carbon neutrality: A comparative study for South and East Asian countries. *Environ Sci Pollut Res* **30**, 12798–12812 (2023). https://doi.org/10.1007/s11356-022-22973-2.
32. Ali M, Seraj M, Türüç F, Tursoy T, Raza A (2023): Do banking sector development, economic growth, and clean energy consumption scale up green finance investment for a sustainable environment in South Asia: evidence for newly developed RALS cointegration. Environ Sci Pollut Res Int. 30(25):67891-67906. doi: 10.1007/s11356-023-27023-z. PMID: 37118398.
33. Zahoor Z, Khan I, Hou F (2022). Clean energy investment and financial development as determinants of environment and sustainable economic growth: evidence from China. Environ Sci Pollut Res Int. 29(11):16006-16016. doi: 10.1007/s11356-021-16832-9. PMID: 34636020.
34. Koenker, R. (2004). Quantile regression for longitudinal data. Journal of Multivariate Analysis, 91(1), 74-89.
35. Graham, B. S., Hahn, J., Poirier, A., & Powell, J. L. (2016). Quantile regression with panel data. Econometrica, 84(3), 961-993.
36. Candy, I. A. (2011). A simple approach to quantile regression for panel data. The Econometrics Journal, 14(3), 368-386.
37. Zhang, Y.J. (2011). The impact of financial development on carbon emissions: An empirical analysis in China. Energy Policy, 39(4), 2197-2203
38. Tamazian, A., & Rao, B. B. (2010). Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies. Energy Economics, 32(1), 137-145.
39. Sadorsky, P. (2010). The impact of financial development on energy consumption in emerging economies. Energy Policy, 38(5), 2528-2535.
40. Isa, Z., Alsayed, A. R., & Kun, S. S. (2015). Review paper on economic growth-aggregate energy consumption nexus. International Journal of Energy Economics and Policy, 5(2).
41. Zaidi, I., Ahmed, R. M. A., & Siok, K. S. (2017). The relationship between economic growth, energy consumption and Co2 emission is examined using inverse function regression. Applied Ecology and Environmental Research, 15(1), 473–484
42. Mosteller, F., & Tukey, J. W. (1977). Data analysis and regression: A second course in statistics. Reading, MA: Addison-Wesley
43. Bao, Y., Lee, T. H., & Saltoglu, B. (2006). Evaluating the predictive performance of value-at-risk models in emerging markets: A reality check. Journal of Forecasting, 25(2), 101–128.
44. Elmonshid, L. B. E. F., Yousif, G. M. A., Sarabdeen, M., & Bilal, A. O. A. (2022). Financial inclusion and economic growth in Saudi Arabia: An empirical analysis. International Journal of Economics and Finance Studies, 14(1), 218-238.
45. Moon, H. R., & Perron, B. (2004). Testing for a unit root in panels with dynamic factors. Journal of Econometrics, 122(1), 81-126.
46. Pesaran, M. H. (2007). A simple panel unit root test in the presence of cross-section dependence. Journal of Applied Econometrics, 22(2), 265-312.
47. Sarabdeen, M., ELmonshid, L. B. E., Afroz, R., Kijas, A. M., & Adam, S. U. (2000). Estimating household's marginal benefit for air quality improvement options using choice experimental design: evidence from Klang Valley, Malaysia. Malaysia Journal of Critical, 7, 1988-1998.
48. Hafeez, M., Rehman, S. U., Faisal, C. N., Yang, J., Ullah, S., Kaium, M. A., & Malik, M. Y. (2022). Financial efficiency and its impact on renewable energy demand and CO2 emissions: Do eco-innovations matter for highly polluted Asian economies? Sustainability, 14(17), 10950.