Environmental Science and Pollution Research
https://doi.org/10.1007/s11356-023-25545-0

RESEARCH ARTICLE

Economic growth, foreign investment, tourism, and electricity production as determinants of environmental quality: empirical evidence from GCC region

Umar Farooq[1] · **Mosab I. Tabash**[2] · **Suhaib Anagreh**[3] · **Mahmoud Al-Rdaydeh**[4] · **Samar Habib**[5]

Received: 10 June 2022 / Accepted: 20 January 2023

Abstract
Each economic factor generates both positive and negative externalities regarding environmental quality. Owing to this, the current study aims to explore the impacts of various economic variables on the environmental quality of the Gulf Cooperation Council (GCC) region. By sampling the 24 years (1996–2019) financial statistics of six GCC region countries, we investigate the impact of economic growth, foreign investment, trade volume, tourism investment and revenue, and electricity production on CO_2 emissions. The empirical analysis is based upon dynamic least square and fully modified ordinary least square model due to the existence of cointegration. Following the results, economic growth, foreign investment, tourism investment, electricity production, and population density have a positive impact, while trade volume and banking development have a negative impact on the volume of CO_2 emissions. The results support the pollution haven hypothesis in the GCC region and have many policies for environmental economists regarding the protection of the natural environment in the long run. In parallel to economic growth, the policy officials from the GCC region should focus on environmental sustainability. They should exert more effort for developing sustainable economic growth policies. The current analysis offers new insights regarding the dynamic role of various economic factors in establishing the CO_2 emission volume in the GCC region.

Keywords CO_2 emissions · Economic growth · Pollution haven hypothesis · GCC region · Tourism

JEL Classification O44 · Q51 · Q56

Introduction

In 2015, the General Assembly of the United Nations argued the famous 17 goals regarding sustainable development. These goals are projected to be accomplished by the year 2030 (UNGA 2015). Considering the importance of these goals, the literature has paid much attention to the exploration of these goals. Among the others, the literature on sustainable economic growth and the impact of various economic factors on environmental sustainability have gained significant attention from researchers (Eyuboglu and Uzar 2020; Huang et al. 2022). For the time being, each country

Responsible Editor: Ilhan Ozturk

✉ Umar Farooq
umerrana246@gmail.com

Mosab I. Tabash
mosab.tabash@aau.ac.ae

Suhaib Anagreh
sanagreh@hct.ac.ae

Mahmoud Al-Rdaydeh
Mahmouda27@gmail.com

Samar Habib
samar.habib@aue.ae

[1] School of Economics and Finance, Xi'an Jiaotong University, Xi'an, Shaanxi, People's Republic of China

[2] College of Business, Al Ain University, Al Ain, United Arab Emirates

[3] Higher Colleges of Technology, Dhabi, United Arab Emirates

[4] Oman College of Management and Technology, Muscat, Oman

[5] American University in the Emirates, Dubai, United Arab Emirates

Published online: 28 January 2023

is concerned about the preservation of natural resources, e.g., a clean environment for its future generation. The intensive increment in multiple environmental issues has created serious threats not only for the health of human beings but also for other creatures in the ocean and air. In case of the GCC, these economies are suffering from intensive climate changes due to their sole dependency on fossil fuels as an energy source (Mahmood 2022). According to statistics provided by The World Bank, the four economies of GCC including Bahrain, Oman, Kuwait, and Qatar are 100% relying on non-renewable energy sources. The ratio in the other two economies is not less than 80%. Meanwhile, these economies are experiencing a major inflow of FDI during the last few decades. Additionally, the GCC region is considered one of the major tourist destinations in the world (Chen et al. 2018; Ozturk et al. 2021). For instance, Saudi Arabia welcomes millions of Muslim pilgrims on Hajj. All these factors substantially impinge upon the climate quality in this region. Therefore, the current study aims to explore the environmental footprints of various economic factors in this region.

In parallel to economic growth, more inflow of FDI, and expansion in other economic activities, it is equally important to develop some policies that ensure the sustainability of the natural environment (Charfeddine and Kahia 2019; Huang et al. 2022). The stimulus behind the staggering focus on environmental sustainability is an extensive increment in environmental issues. The exploration of various economic operations by the economic agents has created a panel of environmental issues, e.g., distortion of the ozone layer, enrichment of harmful gasses in the air, and other health issues. Such environmental degradation shows the incompetency of environmental policies and the exploitation of the natural environment for personal benefits by economic agents. Meanwhile, a country may adopt some policy relaxation in environmental compliance to achieve the various objectives regarding rapid economic growth and encouraging the domestic industrial zones on more production (Odhiambo 2016). However, it becomes necessary to regularize such operations and impose some policy restrictions to undermine environmental degradation. In the real world, China has made double-digit economic growth in the last decade. Parallelly, it has also faced an extensive increment in CO_2 emissions during this era (Chen et al. 2018). This phenomenon exemplifies the direct impact of various economic factors on CO_2 emissions and urges investigation of a similar trend in the GCC region.

From the viewpoint of the above discussion, the current study explores the impact of economic growth, foreign investment, trade volume, tourism investment and revenue, and electricity production on the environmental quality of the GCC region. We select these variables because the GCC region is experiencing a dynamic change in all these mentioned variables like too much tourism, high trade of oil products, consumption of fossil fuel to produce electricity, and high environmental degradation (Table 1). In addition, the GCC region economies are facing the too much environmental issues (as shown in descriptive Tables 2 and 3; the average CO_2 emission is too high, implying the existence of environmental issues), and it is more relevant to explore the relationship of underlying variables in connection with environmental quality specifically in GCC region. The GCC economies are consuming a massive ratio of non-renewable energy in their total energy demands and thus are the haven of pollution. Therefore, we have included these variables in the case of GCC. The empirical analysis is based upon 24 years (1996–2019) statistical scores of six GCC region countries including Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. To test the underlying designed framework, we employ the FMOLS tests due to the existence of cointegration and the nature of data (macro-panel). The statistical results provide a novel understanding of the relevant role of economic growth, foreign investment, tourism investment, electricity production, and population density in CO_2 emissions in this region. Additionally, the current analysis asserts that the trade volume and banking development can mitigate the CO_2 emissions. The empirical results robust the findings of previous literature and suggest the existence of the pollution haven hypothesis in the GCC region.

The importance of current analysis can be categorized into three strands, i.e., theoretically, empirically, and practically. Theoretically, the current study provides the robustness to the existing literature by exploring the impact of various economic factors that were argued by the previous studies on CO_2 emissions in the GCC region. It combines the various strands of literature and offers robust theoretical insights into the GCC region. This study adds a list of variables in a single analysis and explores their dynamic impact on CO_2 emissions in the GCC region. In addition, the undergoing analysis confirms the famous EKC model in the case of GCC nations. Empirically, the current analysis investigates the impact of the most discussed economic factors on CO_2 emissions and provides empirical support for the stratification of the pollution haven hypothesis in this region. The implication of the FMOLS model suggests the persistence of specific relationships of variables in long run. In addition, the current empirical analysis provides robustness by employing the DOLS model and offers unbiased results. Our study supplements the empirical evidence on both the declining and boosting impact of included explanatory variables on CO_2 emissions in the GCC region. Practically, this study suggests direct policies regarding environmental sustainability in this region. Policy officials should focus on sustainable economic progress, introduce some regulations for foreign investors, and develop policies for alternative

Table 1 Variables

Variable	Role	Measurement	References
CO_2 emissions	Dependent	Metric tons/capita	(Charfeddine and Kahia 2019; Gao 2021)
Economic growth	Independent	GDP growth rate	(Ameer and Munir 2020)
Foreign investment	Independent	FDI inflow (% of GDP)	(Luo et al. 2021)
Trade volume	Independent	(Exports + imports) % of GDP	(Shahbaz et al. 2013a, b)
Tourism Investment	Independent	International tourism, expenditures (% of total imports)	(Paramati et al. 2018)
Tourism revenue	Independent	International tourism, receipts (% of total exports)	(Paramati et al. 2018)
Electricity production	Independent	Electricity production from oil, gas, and coal sources (% of total)	(Bakay and Ağbulut 2021)
Population density	Independent	Population density (people per sq. km of land area)	(Rahman and Alam 2021)
Banking development	Independent	Domestic credit to the private sector by banks (% of GDP)	(Acheampong 2019)

Source: previous literature

Table 2 Descriptive results

	Mean	Std. dev	Max	Mini	Skewness	Kurtosis	Observations
CO_2	22.471	0.054	47.699	7.071	0.645	3.108	144
EG	4.397	0.073	26.170	−7.076	1.304	4.949	144
FDI	2.506	0.078	33.566	-3.175	0.353	3.605	144
TDV	106.534	0.158	191.876	56.088	0.901	3.009	144
TRI	12.481	0.064	28.717	2.855	0.604	1.963	144
TRR	5.066	0.138	18.493	0.507	1.400	3.963	144
EPR	96.232	0.081	100.000	67.673	−0.110	5.902	144
POD	299.429	0.091	2104.056	7.226	0.912	4.025	144
DCB	51.343	0.083	105.187	20.792	0.683	2.708	144

Acronym's detail: *CO*$_2$ CO_2 emissions, *EG* economic growth, *FDI* FDI inflow, *TDV* trade volume, *TRI* tourism investment, *TRR* tourism revenue, *EPR* electricity production, *POD* population density, *DCB* domestic credit by banks. Source: own calculation

Table 3 Mean trend across the countries

	Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	U.A.E
CO_2	22.322	24.377	13.133	36.820	14.296	23.875
EG	4.393	3.165	3.224	8.258	3.027	4.314
FDI	5.621	0.408	2.282	2.372	1.996	2.357
TDV	146.707	93.280	102.650	91.913	74.050	130.603
TRI	7.959	22.779	7.189	19.045	8.533	9.378
TRR	11.771	1.374	4.448	5.755	3.445	3.578
EPR	100	100	100	100	77.466	99.929
POD	1397.462	157.387	10.083	130.173	12.109	89.360
DCB	57.822	65.530	45.989	46.122	37.512	55.081

Acronym's detail: *CO*$_2$ CO_2 emissions, *ED* economic growth, *FDI* FDI inflow, *TDV* trade volume, *TRI* tourism investment, *TRR* tourism revenue, *EPR* electricity production, *POD* population density, *DCB* domestic credit by banks. Source: own calculation

energy sources. Specifically, the analysis suggests considering the role of variables as a long-term strategy in managing the environment (the results of FMOLS models suggest the long-term impact). Meanwhile, they should enhance the banking development and trade volume.

The remaining paper is distributed into 5 sections, i.e., the "Literature review" section presents the review of literature, the "Data and methods" section provides data and methodology, and the "Empirical results" section demonstrates the empirical results. In the "Discussion" section, we discuss

the results and conclude the whole study in the "Conclusion and policies" section. The references are offered at the end of the paper.

Literature review

Due to the increment in economic growth and related activities, the sustainability of environmental quality has become the main agenda for policy officials (Shi, et al. 2019). It is eminent that lethal gasses are mandatory to hold the temperature of the earth at some certain level to maintain life. However, huge amounts of such gasses due to man-made operations, e.g., extensive use of fossil fuels and other greenhouse gasses, bring scorching temperatures and global warming which change the global warming system. Some empirical studies in the early 1990s independently examined the connection between per capita income and ecological degradation (Panayotou 1993). Their findings further asserted that ecological degradation and per capita income unveiled an upturned U-shaped curve, identified as the ecological Kuznets curve (EKC). The EG has a direct link with CO_2 emission (CE) in the long orientation (Grossman and Krueger 1995; Mikayilov et al. 2018; Ansari et al. 2020a, b; Mahmood 2022). Over the previous eras, researchers of environment and economics had been examined with the focus on rocketing EG and mitigate on social dilapidation, as a concern lethal gasses from economic growth. This peculiarity has observed numerous empirical studies assumed primarily to scrutinize the link between EG and CE, examine the hypothesis for EKC, and thus create appliances for achieving green growth and sustainable economic progression. The EG does not influence by CE for non-OECD allies, but they acquired statistical outcomes that economic growth indicates an increment in CE (Dinda 2009; Odhiambo 2016). Moreover, there is no significant connection between CE and EG and thereby confirming the impartiality of the hypothesis (Richmond and Kaufmann 2006).

According to the famous EKC model, economic growth has an inverted U-shape relationship with CO_2 emissions. According to recent studies (Liddle 2015; Danish et al. 2017; Ansari et al. 2020a, b; AlKhars et al. 2022), the EKC model has various assumptions, e.g., first economic growth leads to improved environmental degradation as more economic activities necessarily produce more CO_2. However, after a certain level, this direct relationship between economic growth and CO_2 emissions becomes inverted, leading to decreasing trend in CO_2 due to an increment in economic growth. Economies become self-sufficient and purchase modern technology which further reduces the emission of CO_2. Alsamara et al. (2018) have argued that the exponential economic growth allows the country to establish more R & D activities, import modern technology, and give subsidies to their industrial sectors for the adoption of modern technology. All these factors alternatively reduce the emissions of CO_2 and thus exemplify the inverted U-shape relationship between economic growth and CO_2 emissions.

The FDI dynamic encourages economic growth. However, it affects the environment in host economies. Huang et al. (2022) expressed that cross-border inflow tends to raise CO_2 emissions (CE) which exhibits a straight link between FDI and CE. But economic growth and regulatory quality avert this positive link into negative. We observed a growing literature on linking FDI and CE while reviewing prior literature. However, this link has got eminent rank in the discussions of scholars for the last few decades. Numerous studies have inspected the straight impacts of FDI invasions on CO_2 releasing and proposed the pollution haven hypothesis, which advocates that invasion of cross-border investment led to greater CE. Mostly, the advanced regions prefer to choose developing regions for investment portfolios due to minimum stringent regulations which invite higher CE (Mahadevan and Sun 2020; Aller et al. 2021). The amount of CE grows due to the enlargement of FDI-led economic operations (Grimes and Kentor 2003). Grimes and Kentor, (2003) proposed that cross-border invasions significantly upturn CE in less developed regions. Cole et al. (2006) asserted that high corruption perceptions index countries enhance their CE due to lax ecological strategies. Recently, this notion has also been supported by Jianguo et al. (2022).

Tourism is the utmost and mounting industry in the world. The swift advancement of the tourism industry and increasing tourism (TR) mobility has backed significantly both developed and developing regions (Ozturk 2016). Eyuboglu and Uzar (2020) asserted that tourism, economic advancement, and energy ingesting affect emissions of CO_2 positively both in short and long orientation. Chen et al. (2018) established the contact between CE and economic advancement in China. They highlighted that tourism advancement positively affects CE and specifically the transportation zone is the fundamental cause of CE. Raza et al. (2017) confirmed the associations of TR with CE in the USA during 1997–2016. The findings' declared TR is a determinant of CE. He et al. (2019) found that the tourism industry's consumptions are lesser than other industries. Dogan et al. (2015) exhibited that tourism shrinks ecological quality by increasing emissions of CO_2. The outcomes regarding the causality strategy represented the occurrence of a unidirectional causative liaison from TR to CE. Moreover, Shakouri et al. (2017) confirmed the interlinks between economic advancement, TR, and CE during 1996–2014 in certain Asia–Pacific economies. They pointed out that tripper invasions directly lead to CE in the long orientation. Azam et al. (2018) investigated the link between TR and CE and specified that tourism positively leads to CO_2 emission. Akadiri et al. (2018) evaluated the link between TR,

economic advancement, and CE during 1995–2014. Their findings suggested that tourism key determinant of CE. Shi et al. (2019) evaluated the interconnection between tripper invasions, TR expenses, and CE from 1995 to 2015. The outcomes indicated that tourism overheads enlarge CE in below-average income economies, while tourism invasions have a direct effect on CE in under an above-average income economy.

Non-renewable energy (NRE) somehow increases CO_2 emissions (CE). Various scholars noticed a direct association of NRE with CO_2 emissions which reveals that high consumption of NRE leads to CO_2 emissions (Awodumi and Adewuyi 2020). Moreover, Jalil and Feridun (2011) explored the long-oriented impact of advancement in the financial sector and energy consumption on ecological degradation in China from 1954 to 2007. Their outcomes exposed that aggregate energy consumption has a direct effect on ecological pollution. Acaravci and Ozturk (2010), Jayanthakumaran et al. (2012), and Ozturk and Acaravci (2013) also recommended a positive link between NRE and CE for India, China, Europe, Indonesia, and Turkey, respectively. Bélaïd and Youssef (2017) and Alola et al. (2019) established that energy consumption is positively associated with ecological pollution. Shahbaz et al. (2013a, b) have declared that trade openness and financial development have a positive link with CO_2 emissions. However, Jalil and Feridun (2011) disclosed a significant positive contribution to mitigating ecological pollution, but they at the same time stated the positive impact of trade openness with CE. Though, this result is consistent with those of Acaravci and Ozturk (2010), Jayanthakumaran et al. (2012), and Ozturk and Acaravci 2013.

More than 50% population of the entire world lives in urban areas and by 2030, this ratio will reach 60%. In some specific states, 70% in Europe is forecasted to be surpassed 80% by 2050. This demographic upsurge in urban areas leads to 80% of energy being consumed in them. The greater population density augments individual energy consumption (Jorgenson and Clark 2010; Zarco-Periñán et al. 2021). In brief, an increase in population density enlarges CO_2 emissions (CE). A mounting of scientific research regarding climate fluctuations' causes and consequences has assured instantaneous and continuous reductions in CO_2 emissions (CE) (Lamb et al. 2014). The interstate quorum on climate disparity (IPCC 2015) 5th valuation report discloses that CO_2 emissions have the main causative of total lethal gas secretion. Growth in population density (PD) in the future few years could affect the consumption of energy and emissions of CO_2 (Hossain 2011; Liddle 2015), which unveils that PD has a direct liaison with CE. India has achieved 2nd most populated country in the world and the world's 3rd leading CO_2 emitter with a portion of 5.98% of aggregate global emissions in 2010 except for the USA and China (WDI, 2015). The emissions of lethal gasses increase with an increment in population which exhibits a positive association between PD and CE (Babu and Kaechele 2015).

Among others, the development and advancement through contemporary approaches in the financial sector led to economic growth (EG). Moreover, financial development (FD) stimulates economic growth (Charfeddine and Kahia 2019). Ozturk and Ullah (2022) recommended a straight link between FD and CO_2 emissions (CE). Presently, FD considers indispensable support for EG because it offers an assortment of funds through savings and enlightens the obligatory information regarding investment operations. The FD plays a mandatory role in observing CE by bringing technological advancement in the energy supply sector for mitigating the degree of CE (Jensen 1996; Shi 2003). This expresses that FD represents real accessibility of financial resources for productive operations and funding networks for ventures by banks and stock markets (Sadorsky 2010). The banking development wanes CO_2 emissions through CSR and eco-friendly strategies. From this viewpoint, environmental dilapidation lessens with financial advancement. In addition, it boosts research and development (R&D) efforts, fascinates FDI, and uninterruptedly upsurges economic operations to inspire ecological quality due to investments in green-associated ventures (Charfeddine et al. 2018; Hayat et al. 2018). FD shrinks the leverage acquiring cost which attracts investment operations and stems the scatterings of lethal gasses by enhancing the efficiency of the energy sector (Tamazian and Rao 2010). Thus, FD may wane the ecological deterioration by boosting industrial operations which obstruct the green atmosphere (Jensen 1996). Their results support a direct association between financial development and CO_2 emissions.

Instead of growing literature highlighting the determinants of CO_2 emissions (Akadiri et al. 2018; Ameer and Munir 2020; Ansari et al. 2020a, b; Huang et al. 2022), the current study adds new thoughts regarding the role of tourism revenue and tourism investment specifically in GCC region that is well known for tourism activities. Additionally, the current analysis robust the empirical outputs of previous literature arranged on other economies of the world even in the GCC region. This study fulfills an instant gap in the literature by exploring the underlying factors in the GCC market.

Data and methods

Data, sample, and variables

The current empirical analysis is based upon the balanced panel data of 6 GCC region countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates). The sampling period is from 1996 to 2019. The statistical

information of under-consideration variables was extracted from the WDI (world development indicators) (Bank 2022), The World Bank. The impetus behind the selection of the GCC region is an extensive exploration of non-renewable energy that is causing numerous environmental issues (Almulali and Tang 2013). Similarly, the selection of span is based upon data availability and consistent change in underlying economic situations, e.g., economic growth, FDI inflow, and energy dependency, during this era. The current study responds to the research question of how various economic factors including economic growth, foreign investment, trade volume, tourism investment and revenue, and electricity production influence the environmental quality in the GCC region. In addition, the existing empirical analysis considers other variables, e.g., population density and banking development, as control variables. To assess the environmental quality, we use the proxy of CO_2 emissions which is a metric ton per capita emission of CO_2. This proxy illustrates the net exhaust of CO_2 into the air by main CO_2 emitters. It further shows the impact of other economic operations on environmental quality. A range of studies has specified a similar measurement of CO_2 emissions (Charfeddine and Kahia 2019). Economic growth, foreign investment, trade volume, tourism investment, tourism revenue, and electricity production serve as explanatory variables.

For measurement, we use the annual % GDP growth for economic growth, FDI inflow for foreign investment, and a sum of exports and imports for the measurement of trade volume. Similarly, expenditures on the facilitation of tourism activities and the development of tourist points were used as a proxy for tourism investment. Tourism revenue is a net receipt of income from tourism and scaled as % of total exports. Electricity production was proxied by the production of electricity from the primary sources of energy in this region, i.e., non-renewable energy sources including coal, gas, and oil. For the measurement of control variables, the people resided per square kilometer area of land were used as a proxy of population density, and the proxy variable for banking development is the volume of domestic credit (% of GDP) extended by private sector banks. The measurement of these variables is based upon the WDI, The World Bank. Additionally, some recent studies have also recommended a similar measurement of these variables (Ameer and Munir 2020; Gao 2021; Farooq 2022). Table 1 presents a brief description of the variables. Figure 1 shows the theoretical framework of the study.

Equations

To present the designed model for the current study, we develop the following equation.

$$\begin{aligned} CO2_{it} = {} & \beta_{\circ} + \alpha_1 EG_{it} + \alpha_2 SEG_{it} + \alpha_2 FDI_{it} \\ & + \alpha_3 TDV_{it} + \alpha_4 TRI_{it} + \alpha_5 TRR_{it} \\ & + \alpha_6 EPR_{it} + \gamma_1 POD_{it} + \gamma_2 DCB_{it} \\ & + \mu_i + \omega_t + \varepsilon_{it} \end{aligned} \tag{1}$$

In Eq. (1), CO_2 is a vector of CO_2 emissions, EG is economic growth, SEG is the square of economic growth to check the EKC model, FDI is FDI inflow, TDV is trade volume, TRI is tourism investment, TRR is tourism revenue, and EPR shows the electricity production. Similarly, POD is an acronym for population density, and DCB shows the banking development. Other symbols, e.g., $\beta_{\circ}$ is a constant, showing the intercept, while α and γ are the coefficients of explanatory variables. Similarly, μ_i is for country, and ω_t is an indication of time effect. The subscripts i, t represent the variation of countries and time, respectively, while ε_{it} denotes the residual term.

Estimation technique

As the analysis contains many macroeconomic variables, therefore it is necessary to check the stationarity of the data. However, before estimating the unit root test, it is also necessary to check the cross-section dependence. For this purpose, we employ the famous Breusch-Pagan LM, Pesaran scaled LM, and Pesaran CD tests and report the results in Table 8 of the Appendix. The significant statistical values accept the alternative hypothesis, i.e., there exists the issue of cross-section dependence. In this situation, we estimate the stationarity by utilizing the second-generation unit root test. The current study employs second-generation unit root testing named cross-section Im-Pesaran-Shin (CIPS) (Pesaran 2007) and cross-sectional augmented Dickey-Fuller (CADF) tests to unveil the stationarity status. The statistical analysis shown in Table 3 demonstrates the stationarity of most variables at first difference I (1) instead of level I (0). This non-stationary status of variables at a level 1 further motivates to check the integration among the variables. We test the long-run cointegration among the variables by employing the Johansen cointegration test proposed by Johansen (1988) and selecting the Kao residual cointegration. This test produces more reliable results as it can detect cointegration even when there is more than one explanatory variable. Additionally, it tests all the series in the long run and produces unbiased analysis (Ozturk et al. 2021). The significant p-values ($p \leq 0.05$) of the Kao residual test affirm the alternative hypothesis, i.e., there exists cointegration among the variables.

Owing to the existence of cointegration, the current analysis mainly considers the fully modified ordinary

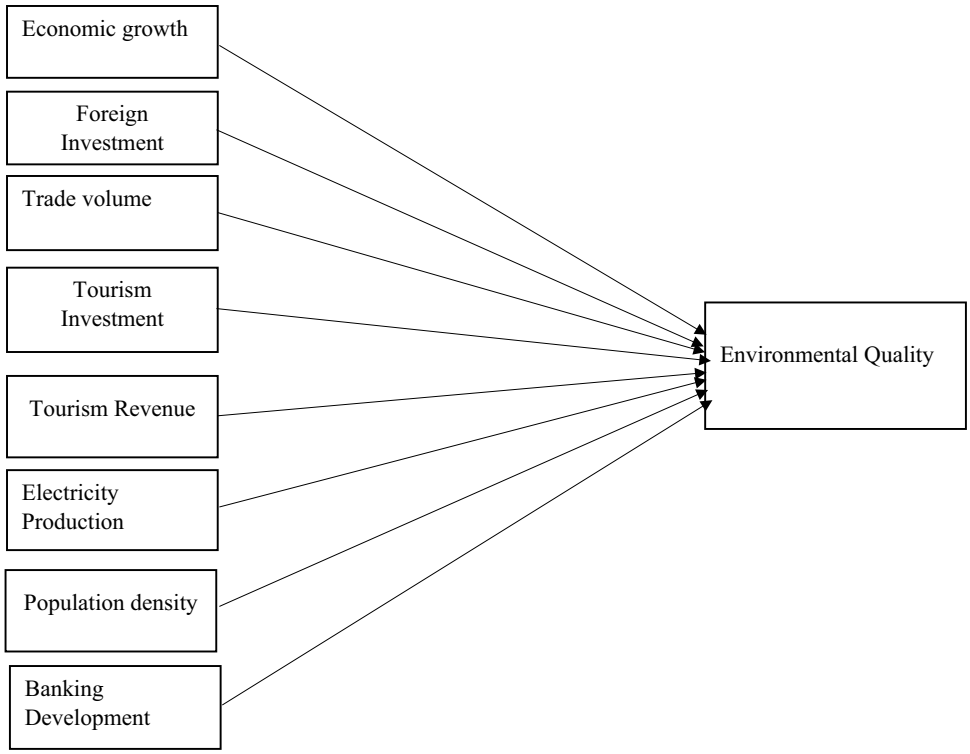

Fig. 1 Theoretical framework

least square (FMOLS) tests to investigate the regression among the variables. FMOLS model was first formulated by Phillips and Hansen (1990) to estimate the coefficients in the long run. Additionally, this model is more appropriate for macro-panel analysis (N < T) and can resolve the potential issue of endogeneity observed in explanatory variables. FMOLS model is effective to eliminate the successive problem of high correlations and overlapping of the error terms. All these assumptions support the implication of the FMOLS test in the current case. In addition to FMOLS, the current analysis utilizes the DOLS model for robustness. The contemporary literature has also utilized both models to investigate regression analysis (Ozturk et al. 2021; Farooq 2022).

Empirical results

Descriptive analysis

Table 2 presents the overall descriptive analysis for the variables of the study, while Table 3 demonstrates the mean trends of main variables across the under-analysis countries. Concentrating on the statistics shown in Table 3, Qatar has the highest CO_2 emission value of 36.820, illustrating the worst environmental quality in Qatar. Comparably, the economic growth in Qatar is 8.258 which is the highest compared to other companion countries. Bahrain is experiencing the highest FDI inflow of 5.621% of its total GDP. As likely to FDI, Bahrain also has the highest volume of trade 146.707. However, Kuwait is making the highest tourism investment of 22.779, while the highest tourism revenue is earned by Bahrain which is 11.771% of its total exports. In most GCC region countries (Bahrain, Kuwait, Oman, and Qatar), non-renewable energy sources are the only sources for producing electricity. The highest population density value is 157.387 which is owned by Kuwait. Lastly, the highest banking sector development score is 65.530 which is earned by Kuwait.

Correlation analysis

Table 4 is presenting the correlation statistics among the variables. Most correlation statistics are less than 0.70, rejecting the existence of a multicollinearity issue. Excluding TDV, column 2 shows that all variables have positive correlation statistics with CO_2, implying the direct correlation between CO_2 emissions and other variables of the study.

Panel regression results

Before analyzing the regression, we test the stationarity of variables by employing the unit root testing and report the results in Table 5. The statistical outcomes imply that most variables show the stationarity status at level 1, claiming to investigate the cointegration in the long run. To identify the cointegration, we explore the Johnsen cointegration test and choose the Kao residual test (analysis is shown in Table 6). The significant probability value of this test rejects the null hypothesis, i.e., no cointegration exists.

Table 4 Correlation results

	CO_2	EG	FDI	TDV	TRI	TRR	EPR	POD	DCB
CO_2	1.000								
EG	0.418	1.000							
FDI	0.063	0.188	1.000						
TDV	−0.008	−0.011	0.381	1.000					
TRI	0.550	0.099	−0.262	−0.284	1.000				
TRR	0.038	−0.075	0.183	0.313	−0.226	1.000			
EPR	0.412	0.138	0.063	0.466	0.268	0.182	1.000		
POD	0.035	−0.014	0.240	0.606	−0.181	0.632	0.235	1.000	
DCB	0.016	−0.312	−0.106	0.429	0.296	0.232	0.323	0.309	1.000

Acronym's detail: *CO_2* CO_2 emissions, *EG* economic growth, *FDI* FDI inflow, *TDV* trade volume, *TRI* tourism investment, *TRR* tourism revenue, *EPR* electricity production, *POD* population density, *DCB* domestic credit by banks. Source: own calculation

The existence of cointegration tests signifies the implication of the FMOLS test for testing Eq. (1). As the analysis is shown in Table 7, economic growth has a significant coefficient value of 1.104, illustrating that a one-unit increase in economic growth can enhance CO_2 emissions by 1.104%. The coefficient value of the foreign investment is 1.494, implying the positive contribution of foreign investment to CO_2 emissions. Nonetheless, trade volume has a negative coefficient value of −0.584, indicating that trade volume can reduce environmental degradation. Tourism investment has a positive significant adherence, while tourism revenue has an insignificant association with CO_2 emissions. Other factors, e.g., electricity production and population density, positively contribute, while banking development negatively contributes to the CO_2 emissions volume in the GCC region.

Discussion

The current analysis probes the influence of various macroeconomic factors on the environmental quality of GCC region countries. For empirical assessment, we employ the DOLS and FMOLS tests and mentioned the results in Table 7. As the coefficient values prevail, the economic growth has a direct impact on CO_2 emissions, signifying the deteriorating role of economic growth in environmental quality. For quick economic growth, the different activities, e.g., production and consumption of pollution-intensive products, are performed at a massive level. This factor causes environmental degradation. Additionally, the propagation of economic growth requires the massive production of various products by industrial units and hence causes environmental degradation (Ameer and Munir 2020). The overall economic growth reflects the consistent increment in net domestic products that enhance the exhaust of CO_2 emissions. Contrarily, the square of economic growth asserts the negative impact on CO_2 emissions, stating the validation of the famous EKC model in this region. After a certain period, more economic prosperity allows the policy officials to extend the subsidies to industries for exploration of environmental protection activities and thus substantially reduce environmental degradation. Supporting this, the study of Ozturk et al. (2021) inferred similar results in the GCC region. FDI

Table 5 Second-generation unit root testing

	CIPS		CADF	
Variables	At level	1st-differ	At level	1st-differ
CO_2 emissions	−2.068***	–	−1.026	−2.661***
Economic growth	−3.231***	–	−1.961**	–
FDI inflow	−2.999***	–	−3.995***	–
Trade volume	−4.982***	–	−0.335	−6.199***
Tourism investment	−4.061***	–	−0.994	−6.420***
Tourism revenue	−0.719	3.141***	−2.492***	–
Electricity production	−1.112	–2.880***	−4.910***	–
Population density	−4.637***	–	−6.420***	–
Banking development	−5.546***	–	2.545***	–

(−1) shows that most variables are stationary at level 1. Source: self-estimation

Table 6 Cointegration diagnostic

Kao residual cointegration test		
Test name	*t*-statistics	Probability
ADF	−1.993	0.023
Residual variance	1.794	–
HAC variance	1.947	–

The significant value of ADF rejects Ho, i.e., no cointegration. Source: self-estimation

inflow positively influences the volume of CO_2 emissions, corroborating the underlying assumptions of the pollution haven hypothesis in this region. This theory claims that the inflow of foreign investment boosts the production of such particles that impede environmental quality. The exploration of foreign investment enhances the pace of industrial establishments, and extensive economic activities, disregarding the environmental sustainability of foreign investors (Farooq 2022). Foreign investors are interested in enhancing the profit volume by leaps and bounds and mostly ignore environmental sustainability due to the occurrence of extra costs for compliance with environmental protection. Additionally, they also enjoy the relaxation in environmental regulations by local governments and hence undermine the activities regarding the preservation of the natural environment (Luo et al. 2021). All these factors substantially lead to environmental degradation.

Trade volume has a negative coefficient, indicating the favorable impacts of trade volume on environmental quality. Unlike common literature findings (Ansari et al. 2020a, b; Essandoh et al. 2020), this inverse relationship between trade volume and CO_2 emissions can be explained as a higher trade volume allows for the transformation of modern technology and hence reduces the CO_2 emissions. Trade volume also reflects the trade liberalization, incurring the bi-directional sharing of modern production systems and favorable competition (Sbai et al. 2014). Both factors lead to reduce environmental degradation. This inverse relationship between trade volume and CO_2 emissions stands with the theoretical description of the pollution halo hypothesis. Tourism investment which is an expansion and modification of tourists points positively contributes to CO_2 emissions. The development of tourist points attracts more tourists and hence more economic activities incurred in this region which eventually led to extensive emissions of CO_2. The empirical results of the studies conducted by Koçak et al. (2020) and Ravinthirakumaran and Ravinthirakumaran (2022) aligned with such results. Nonetheless, tourism revenue does not impact CO_2 emissions in the GCC region.

Continuing the discussion, the production of electricity from non-renewable sources of energy has positive adherence to CO_2 emissions. GCC region is mostly relying on oil, gas, and oil to produce electricity. The combustion of such energy sources substantially enhances the emissions of smoke and other particles that cause environmental degradation. In addition to electricity, the sole dependency of industrial units and the transportation sector on non-renewable energy is continuously reinforcing the degradation of the natural environment in this region. The direct impact of electricity production from non-renewable energy sources on CO_2 emissions provides robustness to the empirical findings of Shafiei and Salim (2014) and Zmami and Ben-Salha (2020). Explaining the

Table 7 Regression analysis

	Dependent variable = CO_2 emissions			
	DOLS		FMOLS	
	Coefficient	Probability	Coefficient	Probability
Economic growth	0.106***	0.000	1.104***	0.009
Sq. economic growth	−0.076***	0.000	−0.112***	0.005
FDI inflow	0.108**	0.081	1.494**	0.064
Trade volume	−0.118*	0.100	−0.584***	0.004
Tourism investment	0.121*	0.109	0.573*	0.090
Tourism revenue	−0.180***	0.000	−1.113	0.253
Electricity production	0.179**	0.051	0.248***	0.044
Population density	0.110***	0.001	0.274*	0.109
Banking development	−0.112***	0.040	−0.304**	0.089
Adjusted R-squared	0.341		0.327	
S.E of regression	0.051		0.053	
Long-run variance	43.212		45.343	

*** denotes significance at 1%, ** represents the significance at 5%, and * at 10% level. Source: own calculation

effect of control variables, both population density and banking development have a positive correlation with CO_2 emissions. The region with more population density necessarily experiences outstanding economic activities, e.g., consumption of industrial goods. This factor enhances the emissions of CO_2 in this region. Additionally, higher population density reflects the more burden on natural resources, e.g., water, air, and other consumable goods, which eventually results in impeding the level of such resources and hence causes more emissions of CO_2 (Zmami and Ben-Salha 2020). Lastly, the negative association of banking development with CO_2 emissions claims that the development of the financial sector can enhance the pace of technological development and thus significantly reduces environmental degradation. The development status of the banking sector allows the industrial sectors to adopt modern production systems, import updated technology, and low-cost financing for eliminating the operations causing high environmental deterioration. In coalition, all these factors reduce the emissions of CO_2. A list of studies has asserted the similar role of banking development in mitigating environmental deterioration (Shahbaz et al. 2013a, b; Charfeddine and Kahia 2019; Lv and Li 2021).

Conclusion and policies

The current analysis is an attempt to explore the effect of various economic factors including economic growth, foreign investment, trade volume, tourism revenue and investment, and electricity production on environmental quality in the GCC region. To estimate the regression, we mainly use the FMOLS tests and check the effect of economic factors in the long run. The statistical results imply that economic growth, foreign investment, tourism investment, electricity production, and population density damage environmental quality. The adverse impact of foreign investment on environmental quality confirms the pollution haven hypothesis in this region. Economic growth induces CO_2 emissions due to increments in economic activities. Similarly, foreign investment makes the domestic market a pollution haven by exploration of more industrial units and disregarding environmental sustainability. Tourism investment enhances the economic activities in the region, resulting in excessive consumption of goods which further produces more CO_2. The positive impact of the production of electricity from fossil fuels can be regarded as it creates numerous negative externalities in the form of smoke and combustion of pollution-intensive sources. Similarly, population density deteriorates the environmental quality by inducing more pressure on natural resources. Nonetheless, the empirical analysis argued the negative impact of trade volume and banking development on CO_2 emissions in GCC region countries. Both factors can mitigate the volume of CO_2 by boosting the knowledge transformation and availability of funds to explore pollution mitigation activities. Concluding, economic growth, FDI, tourism investment, electricity production, and population density have a positive correlation, while trade volume, tourism revenue, and banking development have a negative correlation with CO_2 emissions.

From the underlying relationship of various economic factors with CO_2 emissions, the following policies can be recommended. In parallel to economic growth, the policy officials from the GCC region should focus on environmental sustainability. They should exert more effort for developing sustainable economic growth policies. The empirical findings vow that foreign investment enhances CO_2 emissions; therefore, policy officials should introduce some regulations, e.g., green productivity, and environmental tax for foreign investors to reduce the volume of CO_2 emissions. It is further recommended to policy economists in the GCC region that they should enhance the trade volume and development of the banking sector. Both factors can mitigate the CO_2 emissions. More specifically, energy economists in the GCC region should immediately develop policies that transform the energy dependency from non-renewable to renewable energy sources. It looks that the extensive combustion of fossil fuels is a primary source of environmental degradation in this region as most economies are producing 100% energy from such sources (follow statistics in Table 3). Specifically, it can be viewed that Qatar has the highest average CO_2 emissions followed by Kuwait, UAE, Bahrain, Saudi Arabia, and Oman in order (from Table 3). Thus, it is recommended to the Qatar government to immediately start such initiatives, e.g., the transformation from non-renewable to renewable sources, and the development of the financial sector to mitigate environmental degradation. Similar policies are recommended to other nations of the GCC region. Moreover, the GCC leaders should consider the role of those variables that have a negative impact on CO_2 emissions, e.g., banking development and tourism revenue, as a long-run strategy because the analysis held in long run. The integration of the banking sector with green environmental assumptions can bring more positive outcomes regarding environmental sustainability.

The current study has a limitation as it considers all GCC economies in a panel and check underlying relationships together. Each country might have a separate trend. Despite this limitation, the empirical analysis extends the existing literature and provides multiple policies. Future studies can be arranged by following the assumptions of the famous environmental Kuznets curve (EKC) hypothesis in this region.

Appendix

Table 8 Cross-section dependence test

Test name	Statistics	*df*	Prob
Breusch-Pagan LM	41.694	15	0.000
Pesaran scaled LM	3.778	–	0.000
Pesaran CD	− 1.522	–	0.128

Source: self-estimation. Note: the significant *p*-values reject the null hypothesis, i.e., no cross-section dependence

Author contribution Umar Farooq: conceptualization, data curation, and writing—original draft preparation

Mosab I. Tabash: supervision, reviewing and editing, and methodology

Suhaib Anagreh: methodology, data handling, language, and spelling check

Mahmoud Al-Rdaydeh: literature review, proofreading, and discussion on results

Samar Habib: conclusion, policy implications, and comments handling

Data availability Data that were used in the formal analysis do not require any formal consent and can be provided on demand..

Declarations

Ethical approval I, Umar Farooq, hereby confirmed that the paper is solely submitted to this journal and not under the publication process in any other journal.

Consent to participate In this research, no human being/animals is/are involved in direct research or observation. The analysis is purely based upon secondary data available on different data sites.

Consent for publication We hereby grant the consent and acknowledge that the paper should be sent for peer review or any other publication process required by the journal.

Competing interests The authors declare no competing interests.

References

Acaravci A, Ozturk I (2010) On the relationship between energy consumption, CO2 emissions and economic growth in Europe. Energy 35(12). https://doi.org/10.1016/j.energy.2010.07.009

Acheampong AO (2019) Modelling for insight: does financial development improve environmental quality? Energy Econ 83(September):156–179

Akadiri SS, Lasisi TT, Uzuner G, Akadiri AC (2018) Examining the causal impacts of tourism, globalization, economic growth and carbon emissions in tourism island territories: bootstrap panel Granger causality analysis. Curr Issue Tour: 1–15

AlKhars MA, Alwahaishi S, Fallatah MR, Kayal A (2022) A literature review of the environmental Kuznets curve in GCC for 2010–2020. Environ Sustain Indic 14. https://doi.org/10.1016/j.indic.2022.100181

Aller C, Ductor L, Grechyna D (2021) Robust determinants of CO2 emissions. Energy Econ 96(1). https://doi.org/10.1016/j.eneco.2021.105154

Al-mulali U, Tang CF (2013) Investigating the validity of pollution haven hypothesis in the gulf cooperation council (GCC) countries. Energy Policy 60:813–819

Alola AA, Bekun FV, Sarkodie SA (2019) Dynamic impact of trade policy, economic growth, fertility rate, renewable and non-renewable energy consumption on ecological footprint in Europe. Sci Total Environ 685(1):702–709

Alsamara M, Mrabet Z, Saleh AS, Anwar S (2018) The environmental Kuznets curve relationship: a case study of the Gulf Cooperation Council region. Environ Sci Pollut Res 25(33):33183–33195

Ameer A, Munir K (2020) Nonlinear effect of FDI, economic growth, and industrialization on environmental quality: evidence from Pakistan. Manag Environ Qual 31(1):223–234

Ansari MA, Ahmad MR, Siddique S, Mansoor K (2020a) An environment Kuznets curve for ecological footprint: evidence from GCC countries. Carbon Manage 11(4):355–368

Ansari MA, Haider S, Khan NA (2020b) Does trade openness affects global carbon dioxide emissions: evidence from the top CO2 emitters. Manag Environ Qual 31(1):32–53

Awodumi OB, Adewuyi AO (2020) The role of non-renewable energy consumption in economic growth and carbon emission: evidence from oil producing economies in Africa. Energy Strat Rev 27(1). https://doi.org/10.1016/j.esr.2019.100434

Azam M, Alam MM, Hafeez MH (2018) Effect of tourism on environmental pollution: further evidence from Malaysia, Singapore and Thailand. J Clean Prod 190(1):330–338

Babu TA, Kaechele H (2015) Dichotomy in carbon dioxide emissions–the case of India. Clim Dev 7(2):165–174

Bakay MS, Ağbulut Ü (2021) Electricity production based forecasting of greenhouse gas emissions in Turkey with deep learning, support vector machine and artificial neural network algorithms. J Clean Prod 285. https://doi.org/10.1016/j.jclepro.2020.125324

Bank TW (2022) World development indicators 2022, DC Washington: World Bank

Bélaïd F, Youssef M (2017) Environmental degradation, renewable and non-renewable electricity consumption, and economic growth: assessing the evidence from Algeria. Energy Policy 102(1):277–287

Charfeddine L, Kahia M (2019) Impact of renewable energy consumption and financial development on CO2 emissions and economic growth in the MENA region: a panel vector autoregressive (PVAR) analysis. Renew Energy 139(August):198–213

Charfeddine L, Al-Malk AY, Korbi K (2018) Is it possible to improve environmental quality without reducing economic growth: evidence from the Qatar economy. Renew Sustain Energy Rev 82(1):25–39

Chen L, Thapa B, Yan W (2018) The relationship between tourism, carbon dioxide emissions, and economic growth in the Yangtze River Delta, China. Sustainability 10(1):1–20

Cole MA, Elliott RJR, Fredriksson PG (2006) Endogenous pollution havens: does FDI influence environmental regulations? Scand J Econ 108(1):157–178

Danish, Zhang B, Wang B, Wang Z (2017) Role of renewable energy and non-renewable energy consumption on EKC: evidence from Pakistan. J Clean Prod 156(855):864

Dinda S (2009) Climate change and human insecurity. Int J Glob Environ 9(1):103–109

Dogan E, Seker F, Bulbul S (2015) Investigating the impacts of energy consumption, real GDP, tourism and trade on CO2 emissions by accounting for cross-sectional dependence: a panel study of OECD countries. Curr Issue Tour 20(16):1–19

Essandoh OK, Islam M, Kakinaka M (2020) Linking international trade and foreign direct investment to CO2 emissions: any differences between developed and developing countries? Sci Total Environ 712. https://doi.org/10.1016/j.scitotenv.2019.136437

Eyuboglu K, Uzar U (2020) The impact of tourism on CO2 emission in Turkey. Curr Issue Tour 23(13):1631–1645
Farooq U (2022) Foreign direct investment, foreign aid, and CO2 emissions in Asian economies: does governance matter? Environ Sci Pollut Res 29(5):7532–7547
Gao C et al (2021) Decoupling of provincial energy-related CO2 emissions from economic growth in China and its convergence from 1995 to 2017. J Clean Prod. https://doi.org/10.1016/j.jclepro.2021.126627
Grimes P, Kentor J (2003) Exporting the greenhouse: foreign capital penetration and CO? Emissions 1980 1996. J World-Syst Res 9(1):261–275
Grossman GM, Krueger AB (1995) Economic growth and the environment. Q J Econ 110(2):353–377
Hayat F, Pirzada MDS, Khan AA (2018) The validation of Granger causality through formulation and use of finance-growth-energy indexes. Renew Sustain Energy Rev 81(1):1859–1867
He J, Liu H, Salvo A (2019) Severe air pollution and labor productivity: evidence from industrial towns in China. Am Econ J: Appl Econ 11(1):173–201
Hossain MS (2011) Panel estimation for CO2 emissions, energy consumption, economic growth, trade openness and urbanization of newly industrialized countries. Energy Policy 39(11):6991–6999
Huang Y et al (2022) The impacts of FDI inflows on carbon emissions: economic development and regulatory quality as moderators. Front Energy Res 9(1):1–11
IPCC (2015) Intergovernmental panel on climate change: the fifth assessment report. Gevena: https://www.ipcc.ch/report/ar5/syr/
Jalil A, Feridun M (2011) The impact of growth, energy and financial development on the environment in China: a cointegration analysis. Energy Econ 33(2). https://doi.org/10.1016/j.eneco.2010.10.003
Jayanthakumaran K, Verma R, Liu Y (2012) CO2 emissions, energy consumption, trade and income: a comparative analysis of China and India. Energy Policy 42(1). https://doi.org/10.1016/j.enpol.2011.12.010
Jensen AL (1996) Beverton and Holt life history invariants result from optimal trade off of reproduction and surviva. Can J Fish Aquat Sci 53(1):820–822
Jianguo D, Ali K, Alnori F, Ullah S (2022) The nexus of financial development, technological innovation, institutional quality, and environmental quality: evidence from OECD economies. Environ Sci Pollut Res. https://doi.org/10.1007/s11356-022-19763-1
Johansen S (1988) Statistical analysis of co-integrating vectors. J Econ Dyn Control 12(2–3):231–254
Jorgenson AK, Clark B (2010) Assessing the temporal stability of the population/environment relationship in comparative perspective: a cross-national panel study of carbon dioxide emissions, 1960–2005. Popul Environ 32(1):27–41
Koçak E, Ulucak R, Ulucak ZŞ (2020) The impact of tourism developments on CO2 emissions: an advanced panel data estimation. Tour Manag Perspect 33. https://doi.org/10.1016/j.tmp.2019.100611
Lamb WF et al (2014) Transitions in pathways of human development and carbon emissions. Environ Res Lett 9(1):1–10
Liddle B (2015) What are the carbon emissions elasticities for income and population? Bridging STIRPAT and EKC via robust heterogeneous panel estimates. Glob Environ Chang 31(1):62–73
Luo Y, Salman M, Lu Z (2021) Heterogeneous impacts of environmental regulations and foreign direct investment on green innovation across different regions in China. Sci Total Environ 759:1–11
Lv Z, Li S (2021) How financial development affects CO2 emissions: a spatial econometric analysis. J Environ Manag 277. https://doi.org/10.1016/j.jenvman.2020.111397
Mahadevan R, Sun Y (2020) Effects of foreign direct investment on carbon emissions: evidence from China and its belt and road countries. J Environ Manag 276(1). https://doi.org/10.1016/j.jenvman.2020.111321
Mahmood H (2022) The spatial analyses of consumption-based CO2 emissions, exports, imports, and FDI nexus in GCC countries. Environ Sci Pollut Res. https://doi.org/10.1007/s11356-022-19303-x
Mikayilov JI, Galeotti M, Hasanov FJ (2018) The impact of economic growth on CO2 emissions in Azerbaijan. J Clean Prod 197(1):1558–1572
Odhiambo NM (2016) Coal consumption and economic growth in South Africa. Energy Environ 27(1):215–226
Ozturk I (2016) The relationships among tourism development, energy demand, and growth factors in developed and developing countries. Int J Sust Dev World 23(2):122–131
Ozturk I, Acaravci A (2013) The long-run and causal analysis of energy, growth, openness and financial development on carbon emissions in Turkey. Energy Econ 36(1):262–267
Ozturk I, Ullah S (2022) Does digital financial inclusion matter for economic growth and environmental sustainability in OBRI economies? An empirical analysis. Resour Conserv Recycl 185. https://doi.org/10.1016/j.resconrec.2022.106489
Ozturk I, Aslan A, Altinoz B (2021) Investigating the nexus between CO2 emissions, economic growth, energy consumption and pilgrimage tourism in Saudi Arabia. Economic Research-Ekonomska Istraživanja: 1–16. https://doi.org/10.1080/1331677X.2021.1985577
Panayotou T (1993) Empirical tests and policy analysis of environmental degradation at different stages of economic development. International Labour Organization, Geneva. p 1–42
Paramati SR, Alam MS, Lau CKM (2018) The effect of tourism investment on tourism development and CO2 emissions: empirical evidence from the EU nations. J Sustain Tour 26(9):1587–1607
Pesaran HM (2007) A simple panel unit root test in the presence of cross-section dependence. J Appl Economet 22(2):265–312
Phillips PC, Hansen BE (1990) Statistical inference in instrumental variable regression with I(1) processes. Rev Econ Stud 57(1):99–125
Rahman MM, Alam K (2021) Clean energy, population density, urbanization and environmental pollution nexus: evidence from Bangladesh. Renew Energy 172(July):1063–1072
Ravinthirakumaran K, Ravinthirakumaran N (2022) Examining the relationship between tourism and CO2 emissions: evidence from APEC region. Anatolia. https://doi.org/10.1080/13032917.2021.2021430.
Raza SA, Sharif A, Wong WK, Karim MZA (2017) Tourism development and environmental degradation in the United States: evidence from wavelet-based analysis. Curr Issue Tour 20(16):1768–1790
Richmond AK, Kaufmann RK (2006) Is there a turning point in the relationship between income and energy use and/or carbon emissions? Ecol Econ 56(1):176–189
Sadorsky P (2010) The impact of financial development on energy consumption in emerging economies. Energy Policy 38(1):2528–2535
Sbai R, Shahbaz M, Hamdi H (2014) A contribution of foreign direct investment, clean energy, trade openness, carbon emissions and economic growth to energy demand in UAE. Econ Model 36(C):191–197
Shafiei S, Salim RA (2014) Non-renewable and renewable energy consumption and CO2 emissions in OECD countries: a comparative analysis. Energy Policy 66(March):547–556
Shahbaz M, Hye QMA, Tiwari AK, Leitão NC (2013a) Economic growth, energy consumption, financial development, international trade and CO2 emissions in Indonesia. Renew Sustain Energy Rev 25(September):109–121
Shahbaz M, Tiwari AK, Nasir M (2013b) The effects of financial development, economic growth, coal consumption and trade

openness on CO2 emissions in South Africa. Energy Policy 61(1):1452–1459
Shakouri B, Yazdi SK, Ghorchebigi E (2017) Does tourism development promote CO2 emissions? Anatolia 28(3):444–452
Shi A (2003) The impact of population pressure on global carbon dioxide emissions, 1975–1996: evidence from pooled cross-country data. Ecol Econ 44(1):29–42
Shi H et al (2019) Global difference in the relationships between tourism, economic growth, CO2 emissions, and primary energy consumption. Curr Issue Tour 23(9):1–16
Tamazian A, Rao BB (2010) Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies. Energy Econ 32(1):137–145
United-Nations-General-Assembly-(UNGA) (2015) Sustainable development goals, New York
Zarco-Periñán PJ, Zarco-Soto IM, Zarco-Soto EJ (2021) Influence of population density on CO2 emissions eliminating the influence of climate. Atmosphere 12(19): https://doi.org/10.3390/atmos12091193
Zmami M, Ben-Salha O (2020) An empirical analysis of the determinants of CO2 emissions in GCC countries. Int J Sust Dev World 27(5):469–480