The impact of global renewable energy demand on economic growth – evidence from GCC countries

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Abstract

Purpose – This study aims to examine the relationship between global renewable energy consumption and economic growth in Gulf Cooperation Council (GCC) countries from 2001 to 2019.

Design/methodology/approach – This paper used a panel regression model to study the six GCC countries over the period from 2001 to 2019.

Findings – As expected, the findings indicated a significant and negative relationship between global renewable energy consumption and GCC economic growth. Additionally, there was a positive and significant relationship between GCC economic growth and the control variables, specifically labor, capital, CO_2 emissions and non-renewable energy production.

Practical implications – The results are of great importance to policymakers in GCC oil-exporting countries, as expected growth in renewable energy consumption will lower their economic growth in the future. Hence, they should first diversify their economy and lower their dependence on oil. Second, these countries can invest in solar energy through international joint ventures, especially with North African countries in close proximity to Europe, to become leaders in solar energy production.

Originality/value – How global energy consumption is related to GCC countries' economic growth remains unclear, not only in GCC countries but also in many oil-exporting countries around the world, so future studies are needed. Furthermore, GCC governments will be able to create appropriate policies for the green economy and achieve their objectives if they have a comprehensive understanding of how global growth in renewable energy demand affects GCC economies.

Keywords Gulf Cooperation Council (GCC), Global renewable energy, Non-renewable energy, Economic growth

Paper type Research paper

1. Introduction

The World Bank Group (2022) predicted that the Gulf Cooperation Council (GCC) member states' combined gross domestic product (GDP) would reach US$6tn by 2050 if business as usual were to continue. However, the GDP could potentially increase to almost US$13tn by 2050 if the GCC countries were to adopt a green growth plan that would aid and speed up their economic diversification. Therefore, how will global energy demands affect GCC economies' growth in the absence of green economic growth policies? This question will be of great

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importance to GCC policymakers because if energy demands were to have a negative impact, then there would be an urgent need for GCC countries to make green economy targets the core of any economic growth policy and strategy.

This study focuses primarily on the GCC countries of Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates (UAE), all of which share common socioeconomic and policy challenges (AlKhars, Miah, Qudrat-Ullah, & Kayal, 2020). GCC countries are among the top 14 countries in terms of carbon dioxide (CO_2) emissions per capita [1]. Energy is one of the key drivers of economic growth (Stern and Cleveland, 2004). Moreover, energy plays an essential role in economic growth and is strongly connected to nearly every facet of development (Salim & Alsyouf, 2020). Therefore, these countries are facing global pressure to comply with international agreements based on internal accords to achieve specific climate change and renewable energy penetration targets (Menegaki & Tugcu, 2016). At the international level, climate change has urged many countries, especially developed ones, to look for alternative energy sources that can protect the environment and stop the continuous rise in the global average temperature. Hence, the regulations surrounding economic growth must be framed to diminish their environmental impact, which is one of the great challenges for policymakers (Waheed, Sarwar, & Wei, 2019). However, global carbon dioxide emissions are expected to increase at a 1.8% annual rate in the future (Wang, Yang, & Li, 2023). Thus, an effective strategy to reduce carbon emissions is to substitute fossil energy for renewable energy (Wang, Zhang, & Li, 2023). A rise in the percentage of renewable energy used will also contribute to a reduction in global carbon emissions (Li, Wang, Liu, & Jiang, 2021). Therefore, Zmami and Ben-Salha (2020) suggested that the GCC countries make a commitment to the advancement of renewable energy sources due to the harmful environmental effects associated with the production of fossil fuels.

There is a global trend toward renewable energy. The GCC is heavily dependent on oil, and the shift to renewables is, therefore, likely to be beneficial to the GCC. In the face of these problems, many GCC countries have joined the international community and started to diversify their energy sources by investing in renewable energy. This local and global shift toward renewable energy is expected to reduce the demand for fossil fuels, which will affect the economies of oil-exporting countries, especially GCC countries. Therefore, it will be of great importance for policymakers to study the impact of global growth in renewable energy on GCC oil-based economies.

The six GCC countries own almost a fifth of the world's proven gas reserves and close to a third of its proven crude oil reserves (Salim & Alsyouf, 2020). Consequently, more than 21% of the world's oil production comes from GCC countries, which hold 36% of the world's oil reserves (Ozturk & Al-Mulali, 2015). The GCC countries are considered one of the wealthiest regional groupings across the globe (Al-Mulali, Tang, Tan, & Ozturk, 2019). Therefore, the literature on energy economics has increasingly devoted more attention to the association between global renewable energy usage and economic growth (Al-Iriani, 2006).

Energy is considered the pivot on which the wheels of society turn (Stern & Cleveland, 2004). However, the use of energy comes with huge environmental costs due to CO_2 emissions, a greenhouse gas associated with global warming. This phenomenon is the direct result of emissions from energy consumption and production (Bhattacharya, Das, & Datta, 2014). Therefore, among the most important topics in the global warming debate are rising CO_2 levels and their relationship to energy use and economic growth (Waheed *et al.*, 2019). Many countries looking for alternative energy resources have started to diversify their energy economies by shifting toward a green economy or green growth. According to the Organisation for Economic Co-operation and Development (OECD) (2011), "green growth means fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies" (p. 4). Moreover, according to the United Nations Environment Programme (2011), "in a green economy, growth in income and employment should be driven by public and private

investments that reduce carbon emissions and pollution, enhance energy and resource efficiency and prevent the loss of biodiversity and ecosystem services" (p. 9). However, this shift toward a green economy, especially renewable energy, has an economic effect on oil producers, such as GCC countries. Still, many GCC countries have started to believe in the environmental and economic benefits of investing in renewable energy (Elrahmani, Hannun, Eljack, & Kazi, 2021). In fact, the International Renewable Energy Agency (IRENA, 2016) analyzed the GCC region and concluded that there is strong potential for a robust renewable energy market. A transition to a carbon-neutral economy could be facilitated by the gradual implementation of green energy (Alsabbagh & Alnaser, 2022).

Based on the previous arguments, we formulated our research question: Is there any relationship between global renewable energy consumption (GREC) and economic growth in GCC oil-based economies? Based on a review of the literature and data, we expect a negative relationship between GREC and economic growth in the GCC countries. We used a panel regression model for the six GCC countries. Specifically, we examined the relationship between GREC, GCC labor, GCC capital, GCC CO_2, GCC non-renewable energy production (NREP) and economic growth in the GCC countries from 2001 to 2019.

This study is of great importance to both investors and policymakers. For investors, understanding the impact of the global growth in the renewable energy demand on GCC oil-based economies will help them not only to deeply analyze the renewable energy market in the GCC but also to design efficient strategies to enter the market and successfully benefit from it. For policymakers, a gradual and efficient transition toward a green economy depends on the design of the right policies that can foster green growth. According to a renewable market analysis report (IRENA, 2016), the "GCC region can cut its annual water use by 16%, save 400 million barrels of oil, create close to 210,000 jobs and reduce its per capita carbon footprint by 8% in 2030 – all by achieving the renewable energy targets that national and sub-national governments have already put in" (p. 3). Therefore, a clear understanding of how global growth in renewable energy demand affects GCC oil-based economies will help policymakers achieve their green growth targets.

2. Literature review

Most earlier studies looked at the linkages between energy consumption and economic growth, taking energy consumption at the aggregate level, and only a few studies considered this factor at the disaggregate level (Rahman & Velayutham, 2020). Moreover, few studies have assessed CO_2 emissions, energy consumption and GDP growth in the GCC countries (Bekhet, Matar, & Yasmin, 2017).

Renewable energy sources are primary energy sources that can be transformed into secondary energy sources, such as electricity and hydrogen (Salim & Alsyouf, 2020). An increase in energy consumption as a complement to labor and capital during the production process is expected to accelerate economic growth (Shastri, Mohapatra, & Giri, 2020). In GCC countries, energy exports are considered the major source of GDP growth (Al-Iriani, 2006). In particular, there has been rapid growth in the demand for electricity because of, first, an increase in population growth and purchasing power. Second, diversification and industrialization demand electricity as opposed to other forms of energy (Salahuddin & Gow, 2014). Consequently, an increase in the standards of living across the GCC countries has led to an increase in energy consumption per capita. Furthermore, the global economy, industrialization and population expansion are all contributing to an increase in energy demand, particularly, in developing nations (Salim & Alsyouf, 2020).

AlKhars *et al.* (2020) conducted a systematic review of 59 articles on the GCC region and found that the relationship between energy consumption and economic growth could be characterized by four hypotheses. Similarly, following several studies, we reviewed the

literature based on four hypotheses (growth, conservation, feedback and neutrality) that are linked to energy consumption and economic growth (Alabi, Ackah, & Lartey, 2017; Menegaki and Tugcu, 2016; Shastri *et al.*, 2020). First, the *growth hypothesis* supposes a one-directional causality from energy consumption to economic growth. Second, the *conversation hypothesis* emphasizes the causality from economic growth to energy consumption. Third, the *feedback hypothesis* argues that there is bidirectional causality between energy consumption and economic growth. Finally, the *neutrality hypothesis* proposes that there is no causality between energy consumption and economic growth.

There are some conflicting results regarding how energy conservation policies affect economic growth in both developed and developing nations (Al-Iriani, 2006). However, we elected to concentrate on the literature focusing on the GCC region to determine the validity and applicability of the four above hypotheses. First, the four empirical studies provided support for the growth hypothesis. The growth hypothesis assumes that energy consumption predicts economic growth and that energy consumption involves economic growth; therefore, the insufficient provision of energy limits economic growth (Narayan, 2016). Damette and Seghir (2013) used panel econometric techniques to study 12 oil-exporting countries, including two GCC countries (Saudi Arabia and the UAE), from 1990 to 2010. The results of their study found that there is a long-term equilibrium relationship between energy consumption and economic growth. Magazzino (2016) conducted an empirical study of 10 Middle Eastern countries from 1971 to 2006. The results showed that the GCC countries demonstrated a causal relationship from energy consumption to economic growth, which supports the economic growth hypothesis, while the countries in the Middle East (four countries) supported the neutrality hypothesis. Hasanov, Bulut, and Suleymanov (2017) conducted an empirical study of 10 oil-exporting developing Eurasian countries, including the six GCC countries, from 1997 to 2014. The results showed that primary energy consumption had significant effects on the growth relationship, which supports the growth hypothesis, and there was no significant relationship between residential electricity consumption and economic growth, which provides evidence for the neutrality hypothesis. Charfeddine and Kahia (2019) conducted an empirical study of 24 Middle East/North African (MENA) countries, including the six GCC countries, from 1980 to 2015. The results showed that the consumption of renewable energy and financial development had a slight impact on economic growth and CO2 emissions, supporting the growth hypothesis.

Second, the following five empirical studies showed support for the *conservation* hypothesis, which is that economic growth (GDP) affects energy consumption (Narayan, 2016). These studies focused on the GCC countries as one group. Al-Iriani (2006) conducted an empirical study of the six GCC countries as one entity using data from 1971 to 2002, and the results suggested no causality between GDP and energy consumption, meaning the hypothesis that energy consumption is the source of GDP growth was not supported. However, the GCC is less concerned with the issue of energy conservation; therefore, energy abundance in GCC countries has put less pressure on the need for energy conservation than in oil-importing nations (Al-Iriani, 2006). Mehrara (2007) conducted an empirical study of 11 oil-exporting countries, including all countries in the GCC except Qatar, using data from 1971 to 2002, and found a unidirectional relationship from GDP to energy consumption. Salahuddin and Gow (2014) used data from 1980 to 2012 to study the GCC and found a significant association between economic growth and energy consumption in both the short and long term, which supports the conservation hypothesis. Salahuddin, Gow, and Ozturk (2015) conducted a panel data analysis of the GCC countries in the period from 1980 to 2012 and found that economic growth and electricity consumption had a positive long-term relationship with carbon dioxide, which supports the conservation hypothesis. Al-Mulali *et al.* (2019) conducted an empirical study of the six GCC countries using data from 1980 to 2014 and found that the Granger causality test results revealed a short-term unidirectional

link between GDP and electricity consumption. In addition, the association among long-term domestic investment, GDP and electricity consumption was determined to be causative in both directions.

The following seven empirical studies provide support for the *feedback* hypothesis, which assumes a bidirectional relationship between energy consumption and economic growth (Narayan, 2016). An empirical study on six Middle Eastern countries, including three GCC member countries (Kuwait, Oman and Saudi Arabia), for the period from 1974 to 2002 was conducted by Narayan and Smyth (2009). The study found that the six countries as a group had a 1% rise in exports. Consequently, a 1% increase in GDP resulted in a 0.95% increase in electricity consumption. Moreover, they found statistically significant feedback effects between these variables. Omri (2013) conducted a panel data analysis of 14 MENA countries, including the six GCC countries, over the period from 1990 to 2011. The results showed that energy consumption and economic growth were causally related in both directions, validating the feedback hypothesis. Al-Mulali and Lee (2013) utilized the panel data methodology covering the period from 1980 to 2009 and found that the Granger causality results show a bidirectional positive relationship between energy consumption and GDP, which further supports the feedback hypothesis. Ozturk and Al-Mulali (2015) conducted a panel study of the GCC countries from 1980 to 2012 and found that long-term GDP growth was positively predicted by natural gas energy consumption. Moreover, the results from the Granger test exposed the bidirectional causality between natural gas energy consumption and GDP growth, which confirms the feedback hypothesis. Osman, Gachino, and Hoque (2016) investigated the relationship between electricity consumption and economic growth in the GCC countries using annual panel data from 1975 to 2012. They found an equilibrium relationship between these variables, thus also supporting the feedback hypothesis since the results showed a bidirectional causality between economic growth and electricity consumption. Charfeddine and Mrabet (2017) conducted a study on 15 MENA countries, including the six GCC countries, between 1975 and 2007. A short-run bidirectional causality among real GDP, energy use and ecological factors was found. Al-Mulali and Sab (2018) conducted a panel analysis of the Middle East, including the six GCC countries, from 1990 to 2008. Their results demonstrated a long-term connection among CO_2 emissions, electricity use and economic growth. Furthermore, there was a long- and short-term Granger causal relationship between CO_2 emissions, electricity use and economic development.

The *neutrality* hypothesis assumes that there is no causality between energy consumption and economic growth (Narayan, 2016). Meanwhile, we did not find any support for the neutrality hypothesis in the panel data, as the six GCC countries analyze GCC as one group) in selected studies in our study. However, we found support for the hypothesis when the analysis took place at the national level, meaning the following studies showed some evidence to support the hypothesis. Solarin and Ozturk (2016) conducted an empirical study on 12 OPEC member countries, including 4 GCC countries, from 1980 to 2012. They found a causal relationship between natural gas consumption and economic growth among OPEC members as a group, which supports the feedback hypothesis. For individual countries, specifically the four GCC countries studied, the results provided evidence supporting the growth hypothesis in both Kuwait and Saudi Arabia, the conservation hypothesis in the UAE and the neutrality hypothesis in Qatar. Al-Iriani and Trabelsi (2016) utilized GCC annual data from 1980 to 2011 to test the causality between GDP and energy consumption. The findings varied for different GCC countries.

It is crucial to mention that we found some mixed results when it comes to individual countries, as evidenced by the next four studies reviewed. The feedback hypothesis was confirmed for Qatar and Saudi Arabia. The conservation hypothesis was confirmed for Bahrain and Kuwait. The growth hypothesis was confirmed for Oman. Finally, the neutrality hypothesis was confirmed for the UAE. Ozturk (2017) conducted an empirical study of

11 MENA countries, including 4 GCC countries, from 1971 to 2011. The causality tests showed that there was no causal relationship between energy consumption and real GDP in Bahrain; however, there was a one-way relationship between real GDP and energy consumption in Saudi Arabia. Furthermore, there was a bidirectional causality between Oman and the UAE. Bekhet *et al.* (2017) empirically analyzed six countries in the GCC from 1980 to 2011. The results revealed unidirectional causality running from CO_2 to energy consumption in Saudi Arabia, the UAE and Qatar, while Oman and Kuwait exhibited a bidirectional causal relationship. Finally, in Oman, a unidirectional relationship runs from financial development to CO_2.

It is evident that there are mixed results across the GCC countries, especially when it comes to the individual country level. Although previous research has found some indication of a link between energy (electricity) consumption and economic growth in the GCC nations, the conclusions are undoubtedly contentious (Al-Mulali *et al.*, 2019). Therefore, this study contributes to the literature by examining the relationship between renewable energy consumption and economic growth in oil countries in the GCC.

Table 1 summarizes the studies' concerns in relation to the four hypotheses (growth, conservation, feedback and neutrality) as they pertain to the GCC countries. The contents demonstrate that there is no consensus in the findings, thus highlighting the need for the current study. The reason behind the inconsistent results may be the different methodologies, datasets and countries.

3. Research methodology

Our study examined the relationship between GREC, GCC labor, GCC capital, GCC CO_2, GCC NREP and economic growth in GCC countries from 2001 to 2019.

Data on renewable energy consumption at the world level were taken from Our World in Data (https://ourworldindata.org). Data on total labor force per capita, gross capital formation per capita (US$), CO_2 emissions (metric tons per capita) and GDP per capita (US$) were obtained from the World Bank (https://data.worldbank.org). Finally, GCC NREP (electricity generation [GWh] per capita) was taken from https://irena.org.

The methodology used was based on an econometric approach that took into account both the time series and cross-sectional aspects of the data. Additionally, the control variables were chosen based on the literature review that supported the significance of the model's strength, taking care to avoid omitted variable bias. Consequently, we studied the impact of

Table 1.
Summary of the papers that supported the different hypotheses

Growth hypothesis	Conservation hypothesis	Feedback hypothesis	Neutrality hypothesis
Damette and Seghir (2013)	Al-Iriani (2006)	Narayan and Smyth (2009)	Solarin and Ozturk (2016)
Magazzino (2016)	Mehrara (2007)	Omri (2013)	Al-Iriani and Trabelsi (2016)
Hasanov *et al.* (2017)	Salahuddin and Gow (2014)	Al-Mulali and Lee (2013)	Ozturk (2017)
Charfeddine and Kahia (2019)	Al-Mulali *et al.* (2019)	Ozturk and Al-Mulali (2015)	Bekhet *et al.* (2017)
		Osman *et al.* (2016)	
		Charfeddine and Mrabet (2017)	
		Al-Mulali and Sab (2018)	

Source(s): Authors work

GREC, labor, capital, CO_2 and non-renewable energy consumption on GCC economic growth (GDP). Thus, panel regression analysis was used to estimate the study variables. The panel regression equation is expressed as follows:

$$\log(GDP_{it}) = constant + \log(GREC_t) + \log(L_{it}) + \log(K_{it}) + \log(CO2_{it}) + \log(NREP)_{it}$$

In the above equation,

i denotes the GCC country; t denotes the time period; GDP, which is an established measure of economic output for every country, is denoted at the country level; GREC denotes the use of renewable energy around the world at time t; L denotes the labor force; K denotes the gross fixed capital formation measured in U.S. dollars; and NREP denotes the production of non-renewable energy at t.

4. Results

4.1 Descriptive statistics

The GDP ranged between 9.045 and 11.351 for the six GCC countries. All details related to GREC, GCC labor, GCC capital, GCC CO_2 and GCC NREP can be found in Table 2.

4.2 Normality test

To test the normality assumption, the Jarque–Bera normality test was used (1.061 $\chi^2 = 0.588$; Jarque–Bera test for H0: normality). The Jarque–Bera statistic did not reject the normal distribution hypothesis. Because the p-value was greater than 5%, there was no reason to reject the null hypothesis; consequently, we failed to reject the null hypothesis. Therefore, the residual was normally distributed (Table 3).

4.3 Cross-sectional dependence test results

Due to a series of unavoidable situations, such as the formation of common socioeconomic policies and political issues, the need to examine the cross-sectional dependence in the panel data cannot be overstated. Results obtained without taking into account the effect of cross-sectional interdependency, if it exists, can be misleading (Adekoya, Oliyide, & Fasanya, 2022). Therefore, we conducted Pesaran's (2004) test for cross-sectional independence, and the result was 8.010 ($p < 0.001$). Moreover, the average absolute value of the off-diagonal elements was 0.684. Since the p-value was less than 5%, we concluded that there was cross-sectional dependence in our panel data (Table 3).

Variable	Obs	Mean	Std. Dev.	Min	Max
GREC	95	0.846	0.03	0.817	0.905
GCC Labor	114	13.18	0.25	12.64	13.54
GCC Capital	114	22.65	0.69	21.1	24.22
GCC CO^2	114	3.078	0.34	2.484	3.931
GCC NRE Production	103	9.29	0.4	8.353	9.906
GCC GDP	114	10.21	0.57	9.045	11.35

Note(s): GCC: Gulf Cooperation Council, GREC: Global-Renewal Energy Consumption, NREP: Non-Renewal Energy Production, GDP: Gross Domestic Product
Source(s): Authors work

Table 2.
Descriptive statistics

Test	Results	Decision
Normality test	p-value = 0.5883 > 5%	Fail to reject Normality
Multicollinearity test	VIF mean = 4.39 < 5	No multicollinearity
Modified Wald test for groupwise heteroskedasticity. in fixed effect regression model	p-value = 0.0004 < 5%	There is heteroskedasticity
Wooldridge test for autocorrelation in panel data	p-value = 0.0025 < 5%	There is serial correlation
Pesaran's test of cross-sectional independence	p-value = 0.0000 < 5%	There is cross sectional dependence
Hausman Test	p-value = 0.0055 < 5%	Fixed effect is chosen

Table 3.
Assumptions check

Source(s): Authors work

4.4 Multicollinearity test

We used the multicollinearity test to ensure that the independent variables were not highly correlated. The variance inflation factor (VIF) revealed a mean below 5 (Table 3). The VIF should be smaller than 5, 8 or 10 to ensure no multicollinearity issues (Kalnins, 2018).

4.5 Fixed versus random effect regression

The Hausman test was used to determine which panel data model to utilize and whether to use the fixed effects or random effects method. The results of the Hausman specification test yielded a p-value of 0.0055, which is less than 5%. Therefore, the recommendation was to apply a fixed-effect model.

We also used the modified Wald test to determine groupwise heteroskedasticity in the fixed effect regression model, and we concluded that there was heteroskedasticity, since the p-value was 0.0004, which is less than 5% (Table 3).

Given our results in Table 3, we created a fixed effect model with Driscoll and Kraay standard errors that account for heteroskedasticity, autocorrelation and cross-sectional dependence (Hoechle, 2007). The results of this estimation are presented in Table 4.

Table 4 shows some interesting results that are of great importance to GCC countries. A 1% increase in GREC lowers GCC GDP per capita growth by 1.9% on average, which has a negative impact on employment and job creation, and hence, on aggregate demand in these countries. One can explain this by the fact that a global trend toward renewable energy consumption will lower the demand for oil and gas, and thus negatively affect the economies of oil-exporting countries, especially those that are highly oil-dependent. Therefore, for these countries to benefit from the global trend in renewable energy consumption, they should

GCCGDP	Drisc/Kraay Fixed effect	Fixed effect	Random effect	Pooled regression
GREC	−4.178** (1.634)	−4.178** (1.283)	−1.935** (0.924)	−1.935** (0.924)
GCC CO^2	0.307 (0.283)	0.307 (0.228)	0.357** (0.149)	0.357** (0.149)
GCC Capital	0.399*** (0.078)	0.399*** (0.081)	0.406*** (0.055)	0.406*** (0.055)
GCC Labour	−0.371 (0.357)	−0.371 (0.381)	0.307*** (0.107)	0.307*** (0.107)
GCC NREP	0.338 (0.410)	0.338 (0.315)	0.308*** (0.083)	0.308*** (0.083)
Cons	5.526 (3.342)	5.526 (4.590)	−5.344*** (1.846)	−5.344*** (1.846)

Note(s): Standard Errors are between parentheses and also *** means significance at 1%, ** significance at 5%

GCC: Gulf Cooperation Council, GREC: Global-Renewal Energy Consumption, NREP: Non-Renewal Energy Production, GDP: Gross Domestic Product

Table 4.
Estimation results

Source(s): Authors work

become leaders in this market, since they are sun-abundant countries. Therefore, solar energy investment and exportation should be an inevitable first step. Furthermore, they should capture worldwide interest in hydrogen energy.

5. Discussion

Our study raised the following research question: Is there a relationship between global renewable consumption and economic growth in the GCC countries?

Our econometrics analysis revealed that GREC has a significant effect on the GDP of GCC countries, which is consistent with previous studies (Charfeddine & Kahia, 2019; Damette & Seghir, 2013; Hasanov *et al.*, 2017; Magazzino, 2016). Moreover, the results are consistent with a panel study of five South Asian countries from 1990 to 2014, which found that renewable and non-renewable energy consumption had positive impacts on economic growth (Rahman & Velayutham, 2020). The negative relationship between global renewable energy consumption and economic growth in GCC countries can be explained by the fact that the economies of GCC countries are reliant on non-renewable energy. According to Chen, Pinar, and Stengos (2020), the relative cost of using renewable energy compared to fossil fuels may be higher in countries that do not have green economies, and as a result, the consumption of renewable energy or growth in the consumption of renewable energy may not have a significant impact or may even have a negative impact on these countries' economic growth. These results reflect those of empirical analyses of Russia from 1990 to 2015, which found that oil prices negatively affected renewable energy consumption (Karacan, Mukhtarov, Barış, İşleyen, & Yardımcı, 2021).

Furthermore, labor and capital play a crucial role in affecting GDP for any country and are considered key contributions to GCC countries' economic growth (AlKhars *et al.*, 2020). Specifically, our regression results showed that capital and labor have a positive effect on GDP. These results reflect those of a recent study by Sarwar (2022), which confirmed using both long-and short-run estimations that the coefficients of capital are positive. Specifically, the long-run estimations demonstrated that capital and economic growth were significantly and positively linked in the majority of the models (Sarwar, 2022).

This study takes as its point of departure its specific focus on the influence of global renewable energy usage on the economies of the GCC countries. Our findings differ from Dogan's (2016) study in the Turkish context, which found that renewable energy consumption had no influence on economic growth, whereas non-renewable energy consumption had a considerable beneficial effect. The effects of renewable energy determinants may differ from country to country, depending on the level of democratization (Chen, Pinar, & Stengos, 2021).

The empirical findings of this study offer policymakers better knowledge of the energy consumption–economic growth nexus, allowing them to create more effective energy policies in GCC countries. In addition, it is recommended that the government provide capital assistance to small firms so that they can take advantage of innovations and participate in economic development (Sarwar, 2022). Finally, to reduce CO_2 emissions, GCC countries should implement more significant energy conservation programs and explore strict environmental and energy legislation. As has been demonstrated, switching to renewable energy sources and pivoting away from fossil fuels is key to an effective strategy for reducing carbon emissions (Wang *et al.*, 2023).

For example, the energy crisis in 2022 prompted various governments worldwide to increase their investments in research and development and alter their policies to encourage alternative energy possibilities, such as renewable energy (Aldabbas & Oberholzer, 2023). Therefore, clean energy research and investment should be an integral component of the process of reducing emissions and identifying alternate sources of energy for a pollution-free environment (Saqib, 2021). Furthermore, the exploitation of natural resource rents can lead to an increase in environmental pressure (Wang, Wang, & Li, 2022).

However, it must be noted that oil exporters have no incentive to switch to renewable energy production and consumption. As oil-dependent economies (Deniz, 2019), when will the GCC countries transform their economies and pivot toward renewable energy? Deniz (2019) stated some critical points from the exporter countries' perspective: first, transformation to renewables is costly; second, it could be argued that these economies will have no incentive to increase their renewable energy resources until their oil reserves decline; and finally, a political change may be imposed at the national or international level. However, this contradicts the World Bank report (2022) on GCC economies shifting toward a green economy, which found that by 2050, the GCC countries' combined GDP would reach US$6tn if business as usual were to continue. Yet, GDP could potentially increase to almost US$13tn by 2050 if the GCC countries were to adopt a green growth plan that would aid and speed up their economic diversification.

6. Conclusion, limitations and future studies

The relationship between global energy consumption and GCC countries' economic growth has been inadequately studied, not only in the GCC but also in many oil-exporting countries around the world. GCC governments will be able to develop suitable green economy policies and achieve their goals if they were to have a thorough grasp of how global increases in the demand for renewable energy affect GCC oil-based economies. This study further argued that the GCC countries should first diversify their economies and reduce their reliance on oil. Additionally, these countries should engage in solar energy production through international joint ventures, particularly with North African countries close to Europe, to become solar energy production leaders.

Energy is crucial for any economy, whether it is part of an oil-exporting or an oil-importing country. Its consumption comes with huge environmental costs that necessitate the move toward clean energy, which could mean a loss for oil-exporting countries, such as the GCC countries, but the question is, will pivoting away from fossil fuels really be a loss? Perhaps a cost–benefit analysis will reveal that these countries will actually benefit rather than lose out. This study can help policymakers understand how the global surge toward renewable energy will affect GCC economies. Specifically, we studied the relationship between GREC and economic growth in GCC countries from 2001 to 2019. The results were as expected; there was a negative relationship because an increase in GREC will lower the demand for non-renewable energy and hence negatively affect the economic growth of oil-exporting countries.

Policymakers will benefit from our study in many ways. First, it confirmed that the growth in demand for global renewable energy puts downward pressure on GCC countries' economic growth; hence, a defendable adverse policy is necessary to offset the negative effect of economic growth. We argue that what could be better than becoming a leading producer of renewable energy, such as solar power? GCC countries have a great opportunity to become major players in the global renewable energy market through international joint ventures with North African countries in close proximity to Europe. This would allow the benefits of pivoting away from fossil fuels to outweigh their costs in response to the global demand for clean energy. Second, the study sheds light on the importance of moving toward a green economy despite the negative effect on economic growth. Furthermore, solar power is an abundant resource in GCC countries. However, this study revealed other new questions, such as the extent to which each of these countries' economic growth is affected by global energy demand. This is an important question for future studies that can provide more insight for GCC policymakers. Finally, a scientific foundation for developing renewable energy, improving the energy infrastructure and achieving the goal of low-cost energy transformation will provide many lessons for renewable energy development in many countries (Wang & Wang, 2020).

Like most studies, ours faced limitations. Specifically, long-time series data for each country were limited. Furthermore, we cannot generalize our findings based on the limitations of our sample size. Additionally, GCC renewable energy consumption was not included in our model due to limitations in the data. Future studies could include these variables based on the availability of data, which will provide new insights for our model. However, renewable energy consumption is still limited, despite an upward trend, in many countries due to its comparatively high costs and technological limitations, whereas the use of non-renewable energy has been growing rapidly because it is comparatively inexpensive and easy to use (Nguyen & Kakinaka, 2019). Despite these findings, shifting toward a green economy has enormous long-term benefits that outweigh the heavy cost of initial investment, as stated in the World Bank report (2022).

Note

1. https://www.irena.org/-/media/Files/IRENA/Agency/Factsheet/Renewable-Energy-in-the-Gulf.pdf

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