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Article

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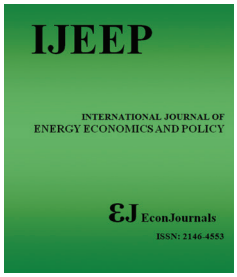

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The Relationship between Electricity Consumption, Price of Oils, and Gross Domestic Product in the Gulf Cooperation Council Countries

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ABSTRACT

The research aimed to evaluate the impact of electricity consumption and oil prices (OP) on the gross domestic product (GDP) of Gulf Cooperation Council (GCC) countries. The oil industry is the backbone of economies in these countries, accounting for a significant portion of GDP. The variations and volatility in petroleum prices significantly affect GCC countries' GDP. Moreover, these countries have also increased the usage of electricity. A substantial increase in the demand for electricity impacts the economic development of GCC countries. The study has considered a quantitative method using secondary data to address the research objective. The data for electricity consumption, energy use (EU), and OP were obtained from the World Development Indicators website from 2010 to 2021. The countries include Bahrain, Oman, Qatar, the United Arab Emirates (UAE), Saudi Arabia, and Kuwait. The data obtained were empirically analyzed using the system-generalized method of moments (GMM) approach as it was identified to be a more robust estimation model controlling for issues such as autocorrelation and endogeneity. The results obtained from the system-GMM indicated that electricity consumption and OP positively impact the GDP of GCC countries. At the same time, EU hurts the GDP. Therefore, the research findings imply that electricity consumption and OP significantly contribute to the growth of the GCC countries.

Keywords: Gross Domestic Product, Electricity Consumption, Energy Use, Gulf Cooperation Council
JEL Classifications: O10, O30, Q32, D80, Q01

1. INTRODUCTION

Electricity consumption, oil prices (OP), and gross domestic product (GDP) are interconnected in many ways. The Gulf Cooperation Council (GCC) countries, which include Bahrain, Qatar, Kuwait, Saudi Arabia, Oman, and the United Arab Emirates (UAE), have seen significant economic development over the years attributed to the region's vast oil reserves (Kubursi, 2015). The oil industry is the backbone of economies in these countries, accounting for a significant portion of GDP. The variations and volatility in petroleum prices significantly affect GCC countries' GDP (Harhara et al., 2015). Moreover, the usage of electricity has also increased in these nations. There has been a significant rise in the usage of electricity demand, which significantly impacts the economic development experienced in these nations. Consumption of electricity is a crucial indicator of economic development as it is directly associated with the consumption patterns of businesses and households. Additionally, the industrial sector accounts for a significant proportion of electricity consumption in GCC states (Osman et al., 2016).

On the other hand, Nusair's (2016) study stated that the association of the GDP with OP is complex. As GCC nations have relied on oil export as a source of revenue for decades, the variations in the price of oils directly impact their GDP. When the price of oils increases, these countries experience increased revenue, which often leads to increased investment and economic growth. GCC countries significantly impacted the low prices of oil from 2014 to 2015, when the price of oils was reduced. The fall in petroleum prices directly influenced these countries' GDP, and they were forced to adopt measures like austerity measures and budget cuts to manage

the impact. In addition, the study by Haque (2021) further stated that the GCC region's availability of oil and current variations in the global price of oils have strengthened the role of energy in a nation's economic modernization and development. Oil is the most frequently transacted commodity worldwide and the most significant energy source, accounting for around 33% of total primary EU.

Moreover, higher global OP increase government income, enabling these nations to grow economically (Haque and Khan, 2019). The GCC nations have seen an increase in energy consumption significantly more than the world average. This is primarily due to rapid population expansion, urbanization, and rising living standards (Alarenan et al., 2019).

Moreover, one of the key concerns related to petroleum prices and their influence on GDP is the volatility of the global oil price directly influencing the economies. GCC is the world's largest gas and oil exporter, and hence, it has significant implications for the country's revenue, government spending, and economic development (Gazdar et al., 2019; Javid et al., 2018). A fall in OP leads to a decline in income that influences investment in infrastructure development, including electricity generation and distribution infrastructure development.

However, many researchers have explored the association between the price of oil, the usage of electricity, and GDP growth in different regions and countries (Nkengfack and Fotio, 2019; Gorus and Aydin, 2019; Taghizadeh-Hesary et al., 2019; Fan and Hao, 2020; Krkošková, 2021; Al-Zuhair and Al-Bazali, 2022; Shahbaz et al., 2020). Findings revealed that an increase in electricity usage increases the GDP growth of GCC countries but also increases the problem of CO_2 emission and volatility in the price of oils that might hurt the economy's performance. Therefore, the main emphasis of this research is to analyze the link between oil price, electricity usage, and GDP growth, specifically in GCC countries, and fill a gap in previous studies. The findings in the current research have been significantly helpful in highlighting the association between GDP and electricity consumption. Further, findings in the current research have also examined the impact of the price of oils on the GDP growth of GCC countries. Hence, it has been believed that the findings revealed in the current research are intensely reliable and suitable for policymakers in GCC countries and other countries that are highly dependent on oil.

Moreover, it has also been expected that it will help the researchers in future research in the domain of GDP growth, price of oil, and usage of electricity in the GCC context. It will help the policymakers consider OP and CO_2 emissions while using consumption of electricity and evaluating GDP growth. Further, findings in the current research would also help fill the gap in previous bodies of information related to the same research phenomenon.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1. Electricity Consumption and GDP

Energy consumption from all available resources of RES (solar electricity, geothermal electricity, hydroelectric power, wind electricity, biofuels, tidal power, and renewable waste), transportation, and other electricity sectors significantly contribute to economic growth (Fan and Hao, 2020). However, in this regard, various types of research have been conducted globally in the past few decades on several Asian European Union regions, the GCC, and emerging economies, using different empirical models, tools, periods, and methodologies. The findings of research are found to be highly contradicting as some studies demonstrated that usage of electricity and GDP are positively linked with each other (Ozturk and Al-Mulali, 2015; Le, 2016; Gambo et al., 2018; Peng and Wu, 2020; Nkengfack and Fotio, 2019), while others did not (Gorus and Aydin, 2019; Singh and Vashishtha, 2020; Fan and Hao, 2020; Krkošková, 2021).

Likely, Ozturk and Al-Mulali (2015) conducted a study on 58 countries using a causality test. The author found that GDP and usage of electricity are positively linked with each other. This relationship has also been supported by the findings of Gambo et al. (2018). Gambo et al. use an Autoregressive Distributed Lag (ARDL) model and analyze that economic growth and electricity usage in the Nigerian economy are positively linked. Additionally, Le (2016), in their study incorporating electricity usage and GDP growth in Sub-Saharan African (SSA) countries, found a positive relationship in both long and short periods.

Similarly, Peng and Wu (2020) also identified a positive relationship between electricity usage and GDP in both the long and short run. Furthermore, in their study, Nkengfack and Fotio (2019) also investigated the association between electricity usage and GDP in Algeria, South Africa, and Egypt, covering the period from 1971 to 2015. Findings demonstrated a positive relationship between GDP and electricity consumption in both the short and long term in all three countries.

On the contrary, some researchers argued that there is no link between GDP and electricity usage (Gorus and Aydin, 2019; Singh and Vashishtha, 2020; Fan and Hao, 2020; Krkošková, 2021). These conflicts can be due to each country's different periods, regulations, and policies. For example, in their study, Gorus and Aydin (2019) identified no link between electricity consumption and the GDP of Indonesia and Thailand. The author added that people use electricity based on their needs, which is not associated with economic growth. Additionally, Singh and Vashishtha (2020) also examine the link between GDP and electricity usage in India from 1970 to 2015. Findings revealed a link between GDP and electricity usage in the short run. However, in the long run, there is no causality between GDP and electricity usage in India, as an increase in electricity consumption increases the cost of environmental degradation.

Moreover, Fan and Hao (2020) also verified in their study that there is no link between GDP and electricity usage. The authors conducted a study on seven South American countries covering the period from 1975 to 2006, and the findings revealed no association between electricity usage and GDP growth. The author further evaluated a slight directional flow from employment to electricity consumption. Further, a recent study by Krkošková (2021) also examined the long-run association between real GDP and consumption of electricity covering the period from 2005

to 2019, employing causality and co-integration tests. Findings demonstrated that there is an absence of a relationship between real GDP and usage of electricity.

2.2. The Link between Electricity Consumption and GDP in GCC Countries

Further, many researchers have also examined the link between electricity usage and GDP growth in GCC countries. Some researchers argued that there is a bi-directional or unidirectional relationship between GDP and the usage of electricity (Salahuddin et al., 2015; Osman et al., 2016; Akadiri et al., 2019), while others did not (Mahalik et al., 2017; Charfeddine, 2017; Benlaria and Hamad, 2022). For instance, Salahuddin et al. (2015) examined the link between electricity usage and GDP from 1980 to 2012 in GCC countries and demonstrated a direct and significant association between electricity consumption and economy GDP. Similarly, Osman et al. (2016) also investigated the association between economic growth and electricity usage in GCC countries from 1975 to 2012 using the PMG framework. Findings revealed a bi-directional association among variables involved in the study. In another research, Bekhet et al. (2017) examined the link between electricity consumption and GCC countries' economic performance. Bekhet et al. deployed an ARDL model to investigate the link between the variables of interest and found a bidirectional link for all GCC countries except for the UAE.

Moreover, in their study, Salahuddin et al. (2018) also ascertained the link between usage of electricity, foreign direct investment, and GDP growth. The authors relied on the ARDL model to analyze the data from 1980 to 2013 in a case study of Kuwait. Findings revealed that there is a direct association between the consumption of electricity and GDP. Further, it has also been supported by the findings of Akadiri et al. (2019), which claim that there is a positive relationship between GDP and electricity usage in Saudi Arabia.

On the contrary, Hamrita and Mekdam (2016), while analyzing the impact of electricity consumption on GDP growth, contradict the findings. The authors deployed a bootstrap model on a dataset for GCC countries from 2000 to 2011. Findings demonstrated that there is no association between GDP and the usage of electricity in Kuwait, Saudi Arabia, and Oman. However, UAE and Bahrain demonstrated a positive association between GDP growth and usage of electricity. Additionally, Magazzino (2016), in their research, also examines the link between electricity and GDP in GCC countries between the period of 1960–2013. Findings show that there is no link between the usage of electricity and GDP in Saudi Arabia and Bahrain. In the case of Qatar, Oman, and Kuwait, Granger causes GDP growth. Moreover, in their study, Mahalik et al. (2017) also investigated the interlink between electricity consumption and GDP in Saudi Arabia from 1971 to 2011. They used both ARDL and the co-integration model and revealed that there is no association between the usage of electricity and GDP. Further, Charfeddine (2017) also examines the impact of electricity usage on GDP in Qatar using Hatemi-J's and Gregory and Hansen's techniques. The author found no bi-directional or unidirectional causality in Qatar's GDP growth and electricity usage from 1970 to 2016. However, in previous studies, most of the studies have indicated that there is a causal association between GDP and the usage of electricity (Salahuddin et al., 2015; Ozturk and Al-Mulali, 2015; Osman et al., 2016; Le, 2016; Gambo et al., 2018; Bekhet et al., 2017; Salahuddin et al., 2018; Akadiri et al., 2019; Peng and Wu, 2020; Nkengfack and Fotio, 2019). Therefore, based on the findings in the current research, the following hypothesis has been developed to assess the association between electricity consumption and GDP in GCC countries.

- H1a: There is a casual association between GDP growth and consumption of electricity in GCC countries
- H0a: There is no causal association between GDP growth and consumption of electricity in GCC countries

2.3. The Relationship between the Price of Oil and GDP

The price of oil movement also played an integral part in electricity usage and GDP growth. Likely, as per the research of Dudley (2018) and IEA (2019), oil is one of the most significant sources of electricity worldwide. It provides approximately 33% of electricity consumption. However, in prior studies, minimal studies have investigated the link between the movement in the price of oils and GDP, specifically in the case of the GCC countries. While those exist are found to be mixed, as some researchers suggested that variation in price of oil has direct link with economic growth (Taghizadeh-Hesary et al., 2019; Alarenan et al., 2019; Al-Zuhair and Al-Bazali, 2022), while others did not (Caporale et al., 2019; Gorus and Aydin, 2019; Nkengfack and Fotio, 2019). For instance, Timilsina (2015) investigated the association between OP and the economic growth of 25 countries. The author found a positive and robust association between GDP growth and volatility in the price of oils in developing countries, as their manufacturing system depends on oil supply.

Additionally, Sarwar et al. (2017) also examined the association between GDP growth, usage of electricity, and price of oils using a panel dataset of 210 countries. Findings revealed that there is a direct association in all variables of interest. Similarly, in their study, Howarth et al. (2017) indicated that oil price is directly associated with GDP growth in GCC countries. The author further evaluated that most of the country's GDP relies on oil and gas production. Moreover, Haque and Khan (2019), in their research, indicated that an increase in the price of oil helps the government in GCC countries to raise their revenue and expand their economic activities, which positively contributes to economic growth.

Further, in another research, while examining the association between the price of oil and GDP, it was revealed that the movement in the price of oils has a different effect for countries that import oil and different for countries that export oil (Al-Badi and Al-Mubarak, 2019). The author further evaluated that an increase in price hurt importing countries, and the same price increase positively contributed to oil exporting countries. Similarly, it has also been supported by the findings of Taghizadeh-Hesary et al. (2019), who claim that a higher price for oils tends to decrease the usage of electricity and influence GDP growth. The author further evaluated that if countries are the net purchaser of oil, then OP negatively influence GDP growth. On the other hand, if countries are net oil producers, then OP increase revenue and positively influence GDP growth.

Furthermore, this is especially true in the case study of GCC countries, which are found to have abundant oil reserves (Vohra, 2017).

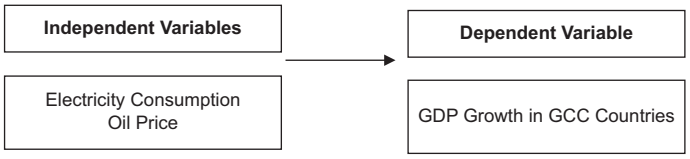
Furthermore, Alarenan et al. (2019), while examining the influence of the price of oils on GDP growth in the GCC countries, found that increasing prices helps the public sector expand their economic activities. The author further evaluated that increased economic activities positively contributed to infrastructural development, a rising standard of living, expansion in the petrochemicals sector, and heavy industry, which positively contributed to GDP growth. It has also been evident with the findings of Al-Zuhair and Al-Bazali (2022), who claim that OP decreased during the 1997–1998 crisis and the outbreak of COVID-19, which significantly declined the GDP of Kuwait. The author further evaluated that the same trend has been observed in other GCC countries.

On the contrary, in their study, Kriskkumar and Naseem (2019) emphasized GDP per capita and changes in the price of oils using a panel system-generalized method of moments (GMM) model for GCC countries between 1985 and 2014. Findings revealed that the price of oil does not directly influence economic growth. Moreover, it has also been supported by the findings of Caporale et al. (2019), which claim that an increase in the price of oils negatively influences GDP growth. The author further evaluated that oil is a necessary input in production, which tends to increase input costs, negatively influencing economic output. Similarly, Gorus and Aydin (2019) argued that the movement in the price of oils is inversely associated with GDP growth. The author further evaluated that an increase in the price of oil leads to a contraction in sectors that are highly dependent on their production process.

Further, this negative association has also been supported by the findings of Nkengfack and Fotio (2019). The authors conducted a study on economic growth, price of oil, and CO_2 emission for Egypt, Algeria, and South Africa, covering a period of 1971–2015. Findings revealed that increased CO_2 emission negatively influences the price of oils and GDP growth. However, in many studies, it has been found that there is a direct link between GDP and the price of oils, especially in GCC Countries (Vohra, 2017; Haque and Khan, 2019; Al-Badi and Al-Mubarak, 2019; Taghizadeh-Hesary et al., 2019; Alarenan et al., 2019; Al-Zuhair and Al-Bazali, 2022). Therefore, the following hypotheses have been developed based on the studies above.

- H1b: There is a direct association between GDP growth and OP in GCC countries.
- H0b: There is no direct association between GDP growth and OP in GCC countries.

2.4. Conceptual Framework



3. DATA AND EMPIRICAL METHODOLOGY

This study has analyzed the association between the GCC countries' GDP, OP, and electricity consumption. Researchers collected the data for the analysis of four variables: GDP per capita, electric power consumption (EC), EU, and OP. The data was gathered from the World Development Indicator (WDI) database for six GCC countries from 2010 to 2021. The countries include Bahrain, Oman, Qatar, the UAE, Saudi Arabia, and Kuwait. The four measurements include EC, GDP per capita, EU, and OP. From the literature findings, it is inferred that there is a significant relationship between energy consumption, oil price movements, and variations in GDP (Haque, 2021; Mahmood et al., 2022).

Accordingly, this research study has evaluated the impact of electricity consumption and OP on GDP. Notably, the research has included the static regression model (Pooled ordinary least square regression along with other panel data models such as Fixed Effect Model [FEM] and Random Effect Model [REM]). It also comprised the dynamic panel models (system-GMM). These models are used for energy consumption and to analyze the association of the associated variables. The empirical multivariate model used by the study is stated as follows:

$$\Delta GDP_{it} = \beta_1 EC_{it} + \beta_2 EU_{it} + \beta_3 OP_{it} + \mu_i + \varepsilon_{it} \quad \text{(Eq 1)}$$

Where:
ΔGDP_{it} = The real GDP for country i at time t.
ΔEC_{it} = The energy consumption for country i at time t.
ΔEU_{it} = The EU for country i at time t.
ΔOP_{it} = The OP for country i at time t.
μ_i = Country fixed effects.
ε_{it} = The error term.

Primarily, the study has used preliminary tests, including the static model, for estimating the above-stated equation. It is found that the model has produced biased and inconsistent results since the zero-conditional mean error falls short of the combined error term (Barros et al., 2022; Baum, 2001). Subsequently, the Hausman test is employed to make a differentiation between the two-panel data models (FEM and REM). The findings of the Hausman test show that the random effect model might deliver biased and inconsistent ordinary least squares (OLS) estimates. Therefore, the fixed effect model was finalized as the P value is more than significance level, thereby rejecting the null hypothesis (Huang et al., 2019; Drukker, 2003). Primarily, the estimates have observed the occurrence of autocorrelation and error of heteroskedasticity. Thus, the presence of autocorrelation and heteroskedasticity error have made the static panel estimate biased. As the static model estimates were inconsistent, the study employed dynamic approaches, including the system GMM model. Within the presence of endogeneity, the static model provides inconsistent and biased estimates of the parameters (Zaid et al., 2020).

It is observed that the dynamic models are efficiently used as empirical models for economic growth. This is because the variables in these models are simultaneously ascertained with the dependent variable and are not exogenous (Khan et al., 2022). Specifically, the model's dependent variable is impacted by its past values (as illustrated in the equation below). As the parameters' estimates had the problem of heteroskedasticity of the unknown type, the study employed the system GMM approach. Specifically, this model uses the orthogonality conditions to allow the efficient

estimation within the presence of heteroskedasticity of unknown form (Niyogi et al., 2022). The system GMM estimator is preferred over the difference GMM as the instruments within the level model are likely to provide better estimates for the endogenous variables (Bakhsh et al., 2021). In addition, the model also provides the estimates after first differencing the data to remove the fixed effects and deal with the endogeneity issues. Accordingly, the model accounting for economic growth precisely of a one-period lagged value has been articulated as follows:

$$\Delta GDP_{it} = \beta_1 \Delta GDP_{it-1} + \beta_2 \Delta EC_{it} + \beta_3 \Delta EU_{it} + \beta_4 \Delta OP_{it} + \mu_i + \varepsilon_{it} \quad \text{(Eq 2)}$$

where:

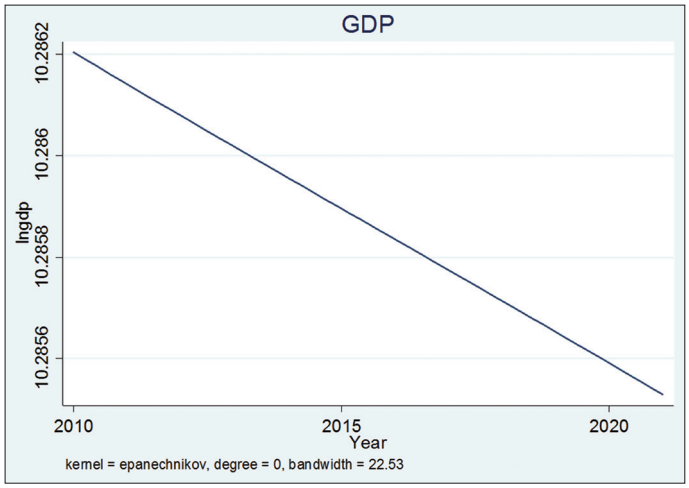
ΔGDP_{it} = The first difference of the log of real GDP for country i at time t.
ΔGDP_{it-1} = The lag of the first difference of the log of real GDP.
ΔEC_{it} = The first difference of the log of energy consumption for country i at time t.
ΔEU_{it} = The first difference of the log of EU for country i at time t.
ΔOP_{it} = The first difference of the log of OP for country i at time t.

It could be observed that within this setting, the variable contains the existing lags of strict exogenous regressors (Eq 2). Accordingly, the system GMM model delivers more efficient and consistent outcomes since it employs two simultaneous equations (Eq 1 and Eq 2). Specifically, the model has connected the Eq 2 estimator with the Eq 1 estimator, thereby evaluating the dynamic system-GMM model.

3.1. Graphical Assessment

Figure 1 displays the comparison of GDP growth across all the six selected GCC countries. Specifically, the study employed a kernel-weighted local polynomial regression model to produce this figure. As discussed earlier, GDP per capita is selected for 10 years (2010–2021). It is observed from Figure 1 that all the selected GCC countries have confronted a steady decline in their GDP per capita. The main reason behind the declining growth in the GCC economies is the tighter fiscal policy and lower level of oil production (World Bank Group, 2021).The individual graphical representation of the GDP per capita of the selected GCC countries is presented.For the GCC member countries, as depicted in Figure 2, an examination of GDP per capita trends reveals various dynamics. Notably, Saudi Arabia's GDP per capita has displayed fluctuations over the observed period, with a distinct and sustained decline in 2019 attributed to the impact of the COVID-19 pandemic. Nevertheless, it is noteworthy that the country has recently rejuvenated and elevated its growth trajectory.

Figure 1: Gross domestic product per capita of the selected Gulf Cooperation Council countries



Similarly, Figure 2 illustrates Bahrain's GDP per capita, showing a consistent and positive upward trend over the past decade. However, a sharp downturn in the years 2019–2020 is indicative of the adverse effects of the COVID-19 pandemic.

Turning our attention to the data presented in Figure 2 concerning the UAE, it becomes evident that GDP per capita has followed a consistent and upward trajectory throughout the entire time frame. Nonetheless, there is a slight decline from 2019 to 2020, coinciding with the global pandemic.

In the context of Figure 2, Kuwait's GDP per capita is portrayed as having experienced a continuous decline over the past 10 years.

Furthermore, Figure 2 illustrates Qatar's GDP per capita, revealing a consistent and stable growth pattern in GDP over the observed duration. It is worth noting that the country experienced a modest increase in economic growth in 2021.

Finally, the data in Figure 2 indicates that Qatar's GDP per capita has demonstrated a sustained yet decreasing trend over time. However, there is evidence of a subtle increase in the growth rate in 2021, suggesting a potential shift in the country's economic landscape.

3.2. Descriptive Statistics

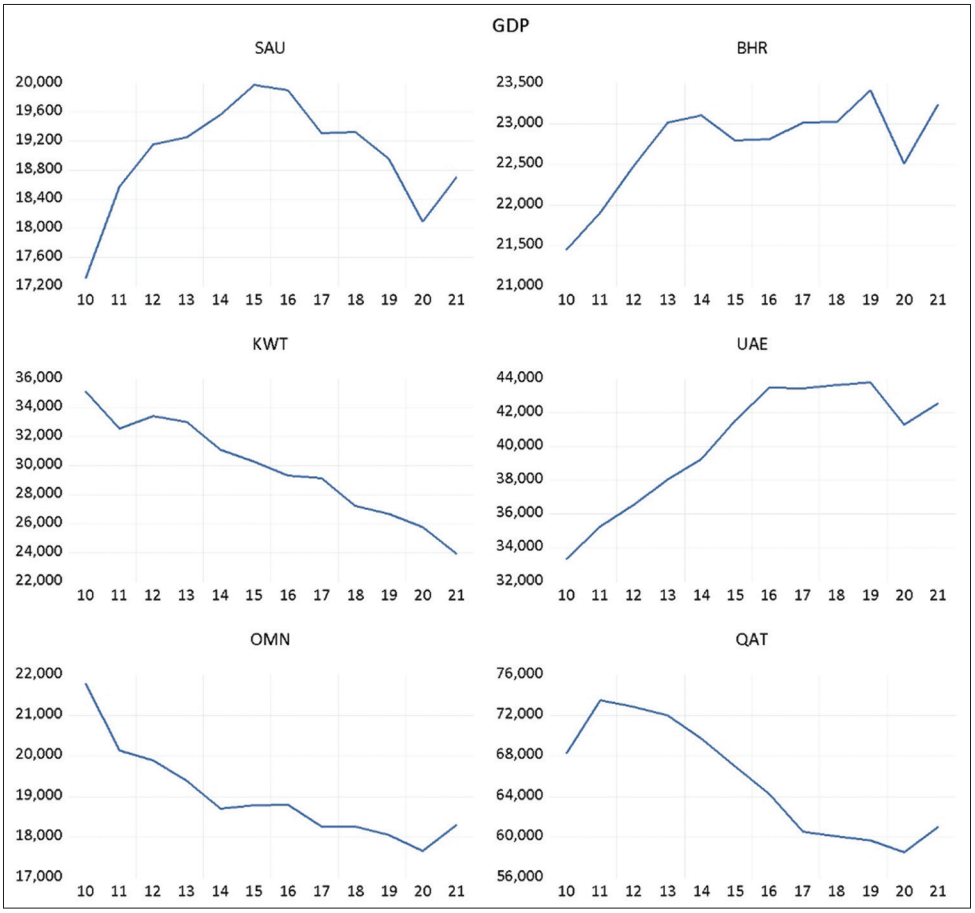
Table 1 and Figure 3 show shows the descriptive statistics of the study variables, including GDP, electricity consumption, EU, and OP. The table indicated that GDP has a mean value of 32720.1, reflecting that GCC countries' average GDP per capita is US$32720.1 with a standard deviation of US$16829.45, reflecting a higher deviation in the values. The electricity consumption mean in the GCC countries is 12560.89 kWh per capita, deviating above or below by 5241.057. Hence, it reflects a higher spread in electricity consumption in GCC countries. The EU has a mean value of 10000.4 kg in the GCC countries, deviating above or below by 4475.733. The value of EU is also highly deviated from its average in the GCC countries. The OP indicated a mean value of $73 in GCC countries with a deviation of $24.774. It shows that the OP also deviate highly in these countries. Hence, it is shown from the descriptive statistics that

Table 1: Descriptive statistics

Variable	Obs	Mean	SD	Min	Max
GDP	72	32720.1	16829.45	17311.74	73493.27
Electricity consumption	72	12560.89	5241.057	3483.303	21230.08
Energy use	72	10000.4	4475.733	3537.305	21420.63
Oil prices	72	73.698	24.774	40.76	109.45

GDP: Gross domestic product, SD: Standard deviation

Figure 2: The individual gross domestic product per capita of the selected Gulf Cooperation Council countries



the variables used in this study show higher deviation from the mean, indicating higher spread.

3.3. Correlation Analysis

Table 2 below shows the correlation analysis among the variables. The purpose of using correlation analysis is to provide a preliminary analysis of the association between the variables. It shows the strength of the relationship between each variable. It shows that the GDP and electricity consumption are moderately and significantly related to each other based on the correlation coefficient of 0.4964. Furthermore, GDP and EU have a strong and significant relationship based on the correlation coefficient 0.7738. In addition, the OP and GDP have shown a weak and insignificant relationship based on a coefficient value of 0.0311. Electricity consumption and EU are strongly related based on the value of 0.8239. OP and electricity consumption are found to be weakly correlated with each other, with a coefficient of −0.0214. OP and EU are also weakly correlated based on the value of 0.0065. Therefore, it is shown that electricity consumption and EU have a significant relationship with GDP and are also correlated.

4. RESULTS

The econometric analysis aimed to investigate the association among GDP, OP, and electricity consumption in the GCC countries using panel data from 2010 to 2021. Three estimation models were employed: Pool-OLS, FEM, and REM.

Table 2: Correlation analysis

	[1]	[2]	[3]	[4]
[1] GDP	1			
[2] Electricity consumption	0.4964*	1		
[3] Energy use	0.7738*	0.8239*	1	
[4] Oil prices	0.0311	−0.0214	0.0065	1

Table 3 presents the outcomes of static panel estimations aiming to explore the relationship between GDP and three key independent variables—EC, EU, and OP—within the GCC countries. These estimations employ three distinct modeling approaches: Pool-OLS, Fixed Effects Model, and Random Effects Model.

In interpreting the table, the coefficients for each variable reveal the strength and direction of their associations with GDP:

4.1. For EC

- Pool-OLS: −1.301496**
- Fixed Effects Model: −0.712220
- Random Effects Model: −0.620705.

4.2. For EU

- Pool-OLS: 4.182801**
- Fixed Effects Model: 0.103357
- Random Effects Model: 0.650815.

Figure 3: Overview of study variable descriptive statistics

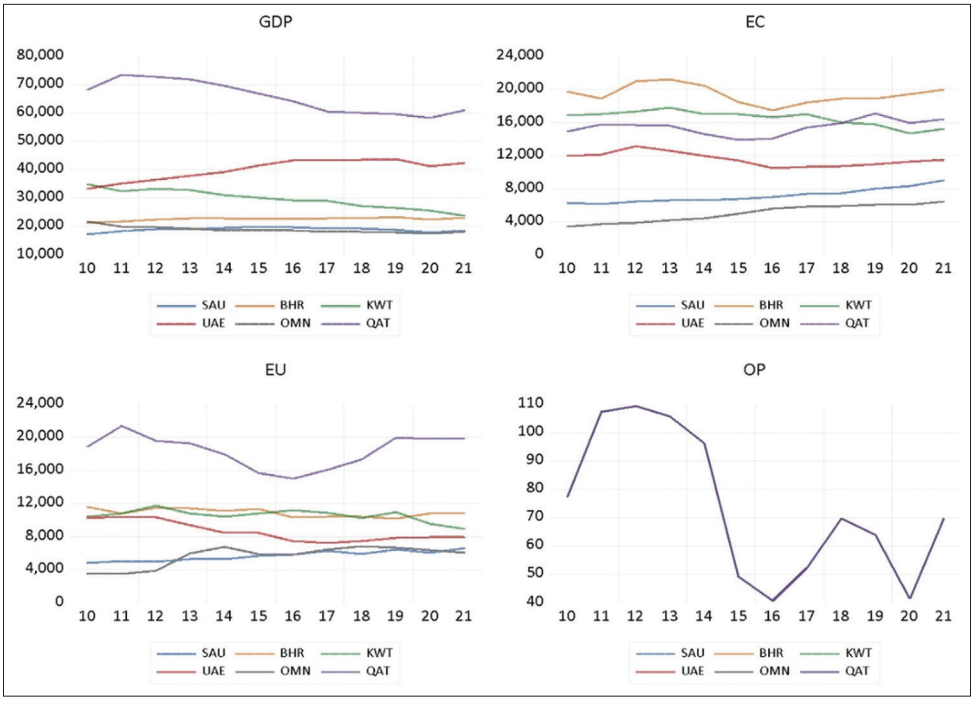


Table 3: Results of the static panel estimations

Variable	Pool-OLS	Fixed effects model	Random effects model
	Coefficient	Coefficient	Coefficient
Electric power consumption (EC)	−1.301496**	−0.712220	−0.620705
Energy use (EU)	4.182801**	0.103357	0.650815
Oil prices (OP)	−4.112772	32.553022**	26.540428*
Constant (C)	7541.452**	38233.50**	32052.30**
R-squared	0.789917	0.970959	0.070526
Adjusted R-squared	0.780649	0.967271	0.029520
F-statistic	85.22716	263.2920	1.719884
Prob (F-statistic)	0.000000	0.000000	0.171110
Durbin-Watson stat	0.162911	0.252585	0.166928

**Significant at 5%, *Significant at 10%. OLS: Ordinary least squares

4.3. For OP

- Pool-OLS: −4.112772
- Fixed Effects Model: 32.553022**
- Random Effects Model: 26.540428*.

Additionally, the constant terms (C) in each model represent the expected GDP value when all independent variables are zero:

- Pool-OLS: 7541.452**
- Fixed Effects Model: 38233.50**
- Random Effects Model: 32052.30**.

The goodness-of-fit measures, R-squared and adjusted R-squared, reflect how well the models explain GDP variation:

- Pool-OLS: R-squared = 0.789917, Adjusted R-squared = 0.780649
- Fixed Effects Model: R-squared = 0.970959, Adjusted R-squared = 0.967271
- Random Effects Model: R-squared = 0.070526, Adjusted R-squared = 0.029520.

Furthermore, the F-statistic and its associated probability (Prob(F-statistic)) evaluate the overall significance of the models:

- Pool-OLS: F-statistic = 85.22716, Prob(F-statistic) = 0.000000 (highly significant)
- Fixed Effects Model: F-statistic = 263.2920, Prob(F-statistic) = 0.000000 (highly significant)
- Random Effects Model: F-statistic = 1.719884, Prob(F-statistic) = 0.171110 (less significant).

The Durbin-Watson statistics identify potential autocorrelation in the models' residuals:

- Pool-OLS: 0.162911 (positive autocorrelation)
- Fixed Effects Model: 0.252585 (positive autocorrelation)
- Random Effects Model: 0.166928 (positive autocorrelation).

The Pool-OLS model revealed a negative relationship between EC and GDP, indicating that a 1-unit increase in EC is associated with a decrease of 1.301496 units in GDP. On the other hand, EU exhibited a positive association with GDP, with a 1-unit increase in EU corresponding to an average increase of 4.182801 units in GDP. However, the coefficient for OP was not statistically significant, suggesting no strong association between OP and GDP.

When incorporating fixed effects to account for country-specific effects, the FEM results indicated a negative relationship between EC and GDP, implying that a 1-unit increase in EC is associated with a decrease of 0.712220 units in GDP. EU is positively associated with GDP, with a 1-unit increase corresponding to an average increase of 0.103357 units. Notably, the coefficient for OP became statistically significant in the FEM, indicating a positive association between OP and GDP.

Further analysis using the REM model, which considered cross-section and idiosyncratic random effects, showed mixed results.

While the coefficients for EC and EU remained consistent with the FEM, the coefficient for OP was no longer statistically significant. When accounting for the random effects, this suggests a weaker association between OP and GDP.

Table 3 shows the Hausman test results, crucial to choosing the best panel data model for this investigation. The main goal of this test is to determine whether the Cross-Section Random Effects model or the Correlated Random Effects model is superior at estimating variable relationships.

Hausman test results reject the null hypothesis, which states the random effects model's consistency and efficiency. This rejection is underpinned by a highly significant chi-squared statistic of 21.599715, complemented by an exceedingly small P value of 0.0001.

Consequently, dismissing the null hypothesis leads to a clear implication: the fixed effects model (Correlated Random Effects) is the more appropriate choice for conducting the analysis. This preference for the fixed effects model stems from its ability to accommodate individual-specific effects that may notably influence relationships among the variables of interest.

Furthermore, the Hausman test results validate the correlation between the fixed effects in the FEM and the independent variables, thus affirming the superiority of the FEM over the REM in capturing the country-specific effects within the context of this study.

These findings contribute significantly to the broader understanding of the GCC countries' intricate relationships among GDP, OP, and electricity consumption. Specifically, the analysis underscores the importance of considering country-specific effects when exploring these associations. The positive correlation between EU and GDP suggests that increased energy consumption can contribute to economic growth within the GCC countries. Additionally, the positive relationship between OP and GDP in the Fixed Effects Model suggests that oil price fluctuations can substantially impact economic performance in the region. This nuanced understanding enhances our grasp of the dynamics driving economic growth in the GCC countries and underscores the significance of tailored, country-specific analyses.

5. DISCUSSION

Electricity consumption's role in developing nations' economic development is undeniably profound. It serves as a cornerstone for production and manufacturing activities, and the absence of reliable electricity infrastructure can have detrimental effects, destabilizing both micro and macroeconomic levels. Consequently, energy consumption remains a pivotal component of economic growth. This research study has delved into the impact of three key independent variables, namely energy consumption, energy usage, and OP, on the overall growth dynamics of the GCC economies.

Table 4: Haussman test

Correlated random Effects-Hausman test			
Test cross-section random effects			
Test summary	**Chi-square statistic**	**Chi-Square d.f.**	**Prob.**
Cross-section random	21.599715	3	0.0001

Our observations align with the work of Sarwar et al. (2017), who explored a similar nexus. Their analysis revealed a bidirectional association among OP, electricity consumption, population, fixed capital formation, and GDP in a comprehensive panel of OECD countries. Moreover, their study underscored that economies heavily reliant on non-renewable energy sources such as coal and oil for electricity generation tended to negatively impact economic growth. In our specific context, we have found a substantial and positive influence of energy consumption, contributing approximately 43%, on GDP growth.

The findings resonate with Sadraoui et al. (2019), who also observed a significant and positive correlation between energy consumption and economic growth in the Middle East and North Africa (MENA) region. This correlation stems from the ability of energy consumption to enhance productivity and efficiency in the countries studied. Deonanan and Ramkissoon (2018) reached a similar conclusion, highlighting the significant association between energy consumption and inclusive economic development in 13 small island states in the Caribbean.

Furthermore, our research has revealed a noteworthy negative impact, approximately 14%, of energy usage on GDP growth. This outcome aligns with the work of Zhe et al. (2021), who demonstrated the significant influence of renewable energy usage on financial development and economic growth.

Regarding OP, we have identified a substantial and positive impact of approximately 27% on GDP growth in the GCC countries. This observation reinforces the notion that OP serve as highly predictive indicators for the per capita GDP of GCC nations. Abdelsalam (2020) similarly noted that fluctuations and volatility in OP can significantly affect economic growth, particularly in the MENA region.

Akinsola and Odhiambo (2020) analyzed the influence of OP on GDP per capita or growth rates in SSA countries. They found no significant impact of OP on the short-term growth rate but did identify a significant influence over the long run. Odhiambo (2020) further emphasized the significant impact of OP on economic growth. However, the extent of this impact varied across countries and during different periods of oil price volatility.

In summary, our discussion underscores a robust and significant association between energy consumption, energy usage, OP, and the per capita GDP of the selected GCC countries. These findings contribute substantially to our understanding of the intricate economic dynamics within the region, highlighting the pivotal role of these factors in shaping economic growth trajectories.

6. CONCLUSION

In conclusion, the comprehensive analysis presented here demonstrates a robust and significant association between energy consumption, energy usage, OP, and GDP per capita in the selected

GCC countries. These findings underscore the critical importance of sustainable energy practices and informed economic policies in driving economic growth in the region.

7. RECOMMENDATION

The study aimed to evaluate the relationship between electricity consumption, OP, and GDP. It has evaluated the impact of electricity consumption and OP on the GDP of GCC countries. The study has considered a quantitative method using secondary data to address the research objective. The data for electricity consumption, EU, and OP were obtained from the WDI website throughout 2010–2021. The data obtained were empirically analyzed using the system-GMM approach as it was identified to be a more robust estimation model controlling for issues such as autocorrelation and endogeneity. The results obtained from the system-GMM indicated that electricity consumption and OP positively impact the GDP of GCC countries. At the same time, EU has a negative impact on the GDP. Therefore, the research findings imply that electricity consumption and OP significantly contribute to the growth of the GCC countries.

The findings have important policy implications indicating that the significant increase in the consumption of electricity and OP can enhance the GDP of the GCC countries. The reason that OP are identified to have a positive impact is well established as these countries are highly reliant on the oil reserves as their revenues. Hence, it is contributing to their GDP growth. Electricity consumption has also been positively impacted as the economies are highly reliant on the use of electricity, and industrial development is also relying on this factor. Hence, policymakers must work on these factors and develop appropriate policies on using and generating electricity to increase GDP growth. Hence, the research findings are significant for the policymakers of GCC countries in this respect.

This research study has focused on the association between the GDP, OP, and energy consumption within the GCC countries from 2010 to 2020. Therefore, it is limited to the analysis of only the past 10 years. For future directions, the study must focus on the economies with a large data set of several years. In addition, the data must be broken down into different sets to scrutinize and treat distinctly to obtain more consistent and reliable results. Furthermore, the analysis of the subgroups must be premised upon the highly developed, developing, and underdeveloped economies. Specifically, the periods of oil crises must be thoroughly and distinctly analyzed to investigate the structural shifts within the association of the variables. The study is also limited to the panel analysis of six countries. However, it can include more countries to enrich the findings in the future.

Another direction for the impending research includes including electricity prices, as it is observed to directly impact the earnings of business organizations, industrial growth, and economic indicators. Accordingly, future studies can replace OP with electricity prices. Finally, the study can focus on including more variables, such as urbanization and trade, that substantially impact the GDP per capita of the economies.

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