

HOW DOES THE STOCK MARKET DEVELOPMENT REACT TO ENERGY CONSUMPTION? EVIDENCE FROM THE ARDL PANEL APPROACH

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ABSTRACT

This article examines the relationship between stock market development and energy consumption in the Gulf Cooperation Council (GCC) countries using panel data from 1971-2021 and ARDL panel and cross-section techniques. The long-term results show that market capitalization has a significant effect on oil consumption. In contrast, the value of shares traded positively and significantly influences the consumption of oil and electricity. Short-term findings indicate that the overall size of the stock market does not significantly affect electricity usage. This suggests that achieving the desired energy-saving goals may require policies that account for the influence of stock market on energy demand, rather than excluding this factor. Given these findings, policymakers in GCC countries should take into account the intricate and various effects that stock market development have on energy consumption. Accordingly, to reduce energy consumption, policies should not solely focus on energy demand and income relationships. Instead, policies should encourage improved corporate governance practices that incentivize companies to reduce their energy consumption to improve their financial performance and increase their share prices. This can be achieved by encouraging companies to invest in energy-efficient technologies and reducing their reliance on energy-intensive projects. Additionally, policymakers should consider regulating the stock market to promote environmentally responsible investments and reduce the financing of energy-intensive projects.

Keywords: Saudi Arabia, development, stock market, energy consumption, ARDL

1. INTRODUCTION

Energy consumption is vital to the national economy, people's livelihoods, and national security. It indicates the wealth of a country and the well-being of its people. In the case of Gulf Coordination Countries (GCC), the fast economic development, the change of lifestyle, the nature of these countries as oil and gas producer countries, and the fossil fuel being provided at a lower cost have led to a high rate of energy consumption in these countries. As shown in Figure (1), the rapid growing of energy consumption in GCC during the period.

Despite its positive effect on economic development and welfare, energy consumption is becoming a challenging phenomenon. Notably, energy growth has exerted high environmental

pressure through CO₂ emission and other pollutants. Although several initiatives have been to develop renewable and clean energy, fossil fuels such as coal and oil are still the primary sources of energy in GCC countries. Additionally, as traditional fossil fuels are non-renewable and will be exhausted in few decades, future energy supply has been a big concern to policymakers. It has become an issue in academic literature.

An extensive body of literature has been established on the leading forces of energy consumption to understand the dynamics consumption, which help provide effective energy policies that could control the relationship between economic growth, energy supply, and environmental protection. It will establish that economic growth is the main determinant of energy consumption. However, the large literature about the association between economic growth and energy usage exhibits different results, which may refer to the different financial development of countries and institutions. The financial system is suggested to affect energy consumption through economic growth channels (Sadorsky 2010). A solid financial system provides effective financing, market liquidity, and risk management, crucial to sustainable economic development. Financial development can lead to a more efficient capital allocation, encouraging businesses to invest in new technologies and equipment. This can increase productivity and economic growth, leading to higher energy demand. Additionally, financial development enables businesses to borrow money, leading to higher energy demand as businesses invest in new projects and expansions. This influence of financial development and its adverse impact on the environment provoked an interest in investigating the dynamic correlation between financial development and energy demand. According to Bakhet et al. (2017), GCC financial systems should consider environmental aspects in their operations.

Despite the eminence role of financial development plays in the energy demand function in the specific case of GCC, research investigating the connection between financial development and energy consumption in this region is still scarce and needs deep analysis. Al-Mulali and Lee (2013) examine the influence of financial development on energy consumption in the GCC using a dynamic OLS panel and find that financial development is a key factor for driving energy consumption in the GCC in the short and long run.

The study is structured into five sections. The second section provides a summary of the literature review. The third section, titled “Methodology,” outlines the presentation of data and model specification. The fourth section presents and discusses the empirical findings. The study concludes with the last section, “Conclusion,” which provides suggestions and recommendations.

2. LITERATURE REVIEW

The correlation between financial market development and energy consumption has received significant attention in academic research in recent years. As the global economy has rapidly developed, energy consumption has also snowballed. Financial development considered as a key factor in driving economic growth in emerging economies, and it is expected to influence energy demand as well (Sadorsky, 2010).

Financial development, outlined the country’s efforts to encourage activities like boosting foreign direct investment (FDI), enhancing banking operations, and expanding stock market activities, can drive economic growth and, in turn, affect energy demand (Sadorsky, 2010). Therefore, financial development is essential since it can improve the efficiency of a country’s financial system. This can lead to more efficient allocation of resources, lower transaction costs, and greater access to financial services for businesses and consumers.

Sadowsky (2011a) argues that financial development can affect energy usages in various ways.

For instance, through facilitating and reducing consumers' borrowing costs, which can lead to boost the demand for energy-intensive goods and services such as cars, houses, refrigerators, air conditioners, and washing machines. Businesses can also benefit from financial development by accessing more financial capital, which can be used to invest in new technologies and equipment that can help them reduce their energy consumption.

Stock market development is essential to financial development because it permits businesses to approach equity financing as an extra source of funding for businesses. Equity financing unlike debt financing because it does not have to be repaid, giving businesses more flexibility in their financial planning. Additionally, stock market activity can aid in diversifying risk for both customers and businesses, thereby offering protection against potential financial losses (Sadorsky 2010). The stock market is frequently seen as a leading indicator of economic activity therefore, any rise in stock market is regarded as a sign of economic growth and prosperity, which can lead to increased consumer and business confidence. This can increase demand for goods and services, including energy-intensive goods.

According to Zhang et al. (2011), stock market has the prospective to attract greater savings by providing individuals and businesses with more investment opportunities. As more people invest their savings in the stock market, the overall pool of available capital increases. This influx of savings can then be transformed into investments in various sectors, stimulating economic growth. As the economy expands, energy consumption is likely to rise as businesses and consumers require more energy to support increased production and consumption activities. Thus, a thriving stock market not only enhances savings but also plays a crucial role in driving investments that lead to higher energy demand. A healthy stock market can also strengthen listed companies' economic strength and efficiency, which can indirectly affect energy consumption.

Several studies have investigated the factors that influence energy consumption (e.g. Sadorsky 2010; Chang, 2015; Ulusoy and Dimaralay, 2018; Mahmood and Saleem, 2017; Topcu and Payne, 2017; and Çoban and Topcu, 2013) have used data from multiple countries to study energy consumption. Other authors have focused on specific countries; their results have been mixed or contradictory. This is likely due to their different data, which may have been from different time periods or geographical regions.

Ulusoy and Dimaralay (2017) examined the influence of stock market developments on oil demand in OECD member countries from 1996 to 2011. Their findings indicate that income, current prices, stock market size, and liquidity are all essential factors affecting the demand for oil.

Chang (2015) examined the influence of financial development and income on energy consumption in 53 countries from 1999 to 2008. The research revealed a single threshold effect on energy consumption when utilizing private credit, domestic credit, the value of shares traded, and stock market turnover as measures of financial development. In high-income countries, energy consumption tends to increase alongside the growth of credit.

Mahmood and Saleem (2016) They explored the connection between energy demand and financial development using data from 22 emerging economies between 1999 and 2012. Their findings stress the moderating effect of oil prices, revealing that higher oil prices have a negative moderate the relation between energy consumption and financial development.

Sadorsky (2010) examined the effect of financial development on energy consumption. His study used data collected from 22 emerging economies during 1990 until 2006. The study used several financial development indicators and found that financial development when measured using stock market variables have positive influence on the country energy consumption.

Çoban and Topcu (2013) employed the GMM method to investigate the relationship between energy consumption and financial development in EU countries from 1990 to 2011. Their find-

ings indicate that for former members, greater financial development results in increased energy consumption, irrespective of whether it originates from the banking sector or the stock market. In contrast, for new member states, the effect of financial development varies based on the measurement used

Topcu and Payne (2017) assessed the effect of financial development on energy consumption across a panel of 32 developed countries from 1990 to 2014. However, the results show that there is no significant relationship between energy consumption and financial development index.

Zhang et al. (2011) used the grey relational analysis and Granger causality analysis to study the influence of the development of Chinese stock markets on energy consumption. Their empirical results indicate that: The grey relational level between the stock market scale, efficiency, and energy consumption is relatively high, at 0.84 and 0.73, respectively, from 1992 to 2009. The expansion of the stock market in China is emerging as a significant driver of rising energy consumption, although the impact of stock market efficiency remains minimal

Likewise, Xu (2012) conducted a detailed investigation into the relationship between financial development and energy consumption across 29 provinces in China from 1999 to 2009. Utilizing the System Generalized Method of Moments (GMM), the findings reveal a significant positive correlation between financial development and energy consumption, highlighting the interconnectedness of these two factors in the context of China's economic landscape. **Shahbaz et al. (2013)** also measured China production function through mixing financial development and energy consumption by means of ARDL approach to cointegration and VECM Granger causality to examine the long-term and causal relationship between the series. Their results show that financial development positively impacts energy consumption and that financial development causes energy consumption.

Komal and Abbas (2015) used the GMM system estimation technique to analyze the impact of financial development on energy consumption through the economic growth channel in Pakistan from 1972 to 2012. They found that economic growth and urbanization have a positive and significant impact on energy consumption, while energy prices have a significant but negative impact. Financial development also positively and significantly impacts energy consumption through the economic growth channel.

Shahbaz and Lean (2012) investigated the impact of financial development on energy consumption in Tunisia from 1971 to 2008 by applying the energy demand function. They found that financial development increases energy demand by stimulating stock market development and stimulating actual economic activity. The results also show that financial development and energy consumption Granger cause each other.

Islam et al. (2013) employed the Vector Error Correction Model (VECM) to analyze the causal relationships among energy consumption, financial development, economic growth, and population in Malaysia from 1971 to 2008. Their findings indicate that both financial development and economic growth have a positive impact on energy consumption. Notably, they identified bidirectional causality between financial development and long-term energy consumption. In the short term, financial development is found to Granger-cause energy consumption, underscoring the dynamic interplay between these variables in Malaysia's economic framework

Using the panel smooth transition regression model, **Chiu and Lee (2020)** investigated the impact of country risks on the relationship between energy consumption and financial development in 79 countries. They found that the relationship between energy consumption and financial development differs in higher- and lower-risk environments.

Anton and Nucu (2020) found that all three dimensions of financial development (banking sec-

tor, bond market, and capital market) positively impact the share of renewable energy consumption. Their empirical results provide valuable insights into how to deploy capital in the renewable sector to provide cost-competitive options to customers and expand higher value-added services. In the following sections, we will attempt to detect the type of relationship between the stock market development and energy consumption in the case of the GCC group and compare it with the results of subsequent studies.

3. METHODOLOGY

3.1. DATA DESCRIPTION

This analysis is based on panel data covering the Gulf Cooperation Council (GCC) member countries, a regional political and economic union comprising six countries in the Arabian Peninsula: Saudi Arabia, United Arab Emirates, Kuwait, Oman, Qatar, and Bahrain. The GCC was established in 1981 to promote economic, social, and security cooperation among its member countries) over the period 1971-2021 using the ARDL panel technique. This study aims to investigate the correlation between stock market development and energy consumption. a detailed overview of the variables used in the empirical analysis, including their definitions, sources, and dates shown in table 1.

- dependent and the control variables

In this study, oil and electricity consumption were measured in kilograms and used as dependent variables and oil equivalent per capita and kilowatt-hours per capita, respectively. Additionally, we incorporated a several control variables commonly employed in growth literature, including but are not limited to foreign direct investment (FDI) measured by net inflows as a percentage of GDP, as well as factors such as economic growth, income levels, and energy prices. This multifaceted approach allows for a nuanced analysis of the relationships at play

- Stock market development measurement

three key stock market indicators were examined: the turnover ratio, and the total value of shares traded as a percentage of GDP, the market capitalization of listed companies as a percentage of GDP. These financial metrics were chosen to illustrate the deepening of stock markets. Market capitalization serves as a measure of a company's size, and investors frequently rank companies based on this criterion. The turnover ratio is employed to assess liquidity, indicating how easily financial assets can be bought and sold. The total value of shares traded in a country, encompassing both domestic and foreign assets, is known as the stock traded total value (% of GDP), which provides insight into the market's overall size. Additionally, the number of listed companies serves as another indicator of market size, with developed countries typically exhibiting a greater number of listed firms compared to emerging markets. To facilitate analysis, all variables were transformed into natural logarithms.

This paper analyzes the interrelationship between stock market development and energy consumption using annual data from 1971-2021. To find this relationship type, we have used the ARDL panel, which stands for the "Autoregressive Distributed Lag Panel" model. The model was first proposed by Pesaran et al. (1999) as a panel data extension of the autoregressive distributed lag (ARDL) model developed by Pesaran and Shin (1998) for time series data. The ARDL panel model allows for estimating the long-run equilibrium relationships among variables in panel data while accommodating the possibility of short-run dynamics and cross-sectional dependence. The ARDL panel model has three advantages over other panel data models. First, it is flexible because it can accommodate stationary and non-stationary variables, essential when working with panel data that may have a mix of these variables. Second, the model can manage cross-sectional dependence, which can arise when the individual units' errors are

correlated. Third, the model is relatively easy to estimate, requiring only two steps, and the estimation procedure is well-established and widely available.

In the first step of empirical analyses, we started by giving definitions and sources of variables indicated in Table 1 following:

Table 1. Definitions and data sources

Energy consumption		
Indicators	Measures	Sources
Ln(oil consumption): LnOC	Natural logarithm of energy consumption (kg of oil equivalent per capita)	WDI, 2023
Ln(electricity consumption): LnEC	Natural logarithm of electricity consumption (kWh per capita)	WDI, 2023
Stock market development		
Indicators	Measures	Sources
Ln(market capitalization): LnMC	This indicator refers to the size of the company. It is a natural logarithm of the market capitalization of listed companies (% of GDP).	WDI, 2023
Ln(turnover ratio): LnTr	The logarithm of traded stocks, domestic equity turnover ratio (%), and turnover ratio are mainly used to assess liquidity.	WDI, 2023
Ln(total value traded on the exchange): LnVTE	The natural logarithm of the total value of traded shares (% of GDP) measures the liquidity of the stock market.	WDI, 2023
Ln(foreign direct investment): LnFDI	Natural logarithm of foreign direct investment, net inflows (% of GDP).	WDI, 2023
Ln(income): LnI	Natural logarithm of income (GDP per capita is measured in constant 2005 US dollars)	WDI, 2023
Ln(energy prices): LnEP	logarithmic of energy price	WDI, 2023
Ln(economic growth): LnGDP	Logarithmic of economic growth GDP (constant 2010 US\$)	WDI, 2023

Source: WDI: World Development Indicators; 2023.

All descriptive statistics of different variables are indicated in Table 2. The results describe the distribution characteristics of various economic indicators in the GCC group throughout 1971-2021. The skewness and kurtosis values are reported for each variable, which provides information on the shape of the distribution and the presence of outliers or extreme values. The distribution of oil consumption is slightly skewed to the right, indicating more values on the lower end of the range. The distribution of electricity consumption is slightly skewed to the left, indicating more values on the higher end of the range. The market capitalization of listed companies, the traded stocks, and the domestic equity turnover ratio are skewed to the right, with many more values on the higher end of the range. The value of traded shares as a percentage of GDP and foreign direct investment net inflows as a percentage of GDP is also skewed to the right. These variables have kurtosis values greater than 3, indicating heavy-tailed distributions with many outliers or extreme values.

The distribution of income (GDP per capita in constant 2005 US dollars) is also skewed to the right but with a moderately heavy-tailed distribution (kurtosis value greater than 3). This suggests some variation in income over time, but not as much as some of the other variables. The crude oil prices in Saudi Arabia have a positive skewness, indicating more values on the higher end of the range. The kurtosis value is greater than 3, indicating a heavy-tailed distribution

with some extreme values. This suggests some periods of extreme price volatility in crude oil prices in the GCC group. Finally, the GDP growth in Saudi Arabia is skewed to the right with a moderately heavy-tailed distribution (kurtosis value greater than 2). This suggests moderate but steady growth in the GCC group over the past 50 years, with some periods of high growth.

Table 2. Descriptive statistics

Variables Indicators	OC	EC	MC	Tr	VTB	FDI	I	EP	GDP
Mean	6,391.28	9,096.38	75.25%	43.79%	48.60%	2.94%	20967.46	39.67	3.9%
Median	5,996.94	9,325.29	65.25%	38.36%	37.65%	2.04%	16920.77	35.49	3.9%
Maximum	9,578.69	15,835.54	219.51%	223.91%	211.38%	13.49%	54624.43	116.68	22.6%
Minimum	2,979.81	1,267.84	16.59%	5.19%	2.10%	-8.53%	5852.19	13.76	-3.7%
Std. Dev.	1,518.06	2,534.59	43.14%	41.51%	45.34%	3.09%	10683.78	22.19	5.7%
Skewness	0.7646	-0.7635	1.5412	1.7651	1.6524	0.8124	0.6775	0.96	0.64
Kurtosis	2.9818	2.5904	3.4428	5.3182	4.4191	3.0803	2.4337	3.59	2.85
Observations	51	51	51	51	51	51	51	51	51

Source: Author's calculation

The main objective of our research paper is to investigate the factors that influence and the nature of the relationship between OC, EC, MC, Tr, BTB, FDI, I, EP, and GDP in the GCC group economies during the 1971-2021 periods. The present study presents the following equation to examine the connection between these variables,

$$LnY(t) = \alpha_0 + LnX(t) + \varepsilon(t) \quad (1)$$

Our current research focuses on investigating the relationship between OC, EC, MC, Tr, VTE, FDI, I, EP, and GDP in a single multivariate framework. Therefore, our econometric model is formulated as follows:

$$OC_{it} = \beta_0 + \beta_1 MC_{it} + \beta_2 VTB_{it} + \beta_3 GDP_{it} + \beta_4 EP_{it} + \beta_5 Tr_{it} + \beta_6 I_{it} + \varepsilon_{it} \quad (2)$$

This section presents the model's specification used to consider the discrete nature of the variable to be explained (Energy consumption) and the spatial interactions observed at the data level. This is a spatial panel model (see [LeSage, J., and K. Pace, 2009](#)).

The final model mentioned above is transformed into a log-linear functional form and expressed as follows:

$$LnOC_{it} = \beta_0 + \beta_1 LnMC_{it} + \beta_2 LnVTE_{it} + \beta_3 LnGDP_{it} + \beta_4 LnEP_{it} + \beta_5 LnTr_{it} + \beta_6 LnI_{it} + \varepsilon_{it} \quad (3)$$

$$LnEC_{it} = \beta_0 + \beta_1 LnMC_{it} + \beta_2 LnTr_{it} + \beta_3 LnFDI_{it} + \beta_4 LnI_{it} + \beta_5 LnEP_{it} + \beta_6 LnVTE_{it} + \varepsilon_{it} \quad (4)$$

Where LnOC is the natural log of oil consumption. LnMC corresponds to the natural log of electricity consumption. LnVTE is the natural log of value traded on the exchange. LnGDP relates to the natural log of growth economic product. LnEP measures the natural log of energy prices. LnTr is the natural log of turnover ratio. LnI is the natural log of income. β represents the fixed country effect. t is the time (yearly data spanning from 1971 to 2021). ε denotes the error term.

3. 2. MODEL SPECIFICATION

According to [Johansen \(1995\)](#) a long-term relationship normally materializes between variables with the same integration order. Nevertheless, [Pesaran and Shin \(1999\)](#) proposed even with different integration order ARDL panel can also be using with different integration orders (e.g. I(0), I(1)) or both at the same time.

Mean Group (MG)

The mean group (MG) estimator, presented by [Pesaran and Smith \(1995\)](#), provide estimation of regression, coefficients, and unweighted averages separately for each of the studied countries. This does not impose any restrictions on the coefficients, meaning they can vary and be heterogeneous in both the long and short term. However, the MG estimator is only consistent and valid if the large enough for testing time series dimension.

Pooled Mean Group (PMG)

The pooled mean group (PMG) estimator, proposed by [Pesaran and Shin \(1999\)](#), allows the short-term coefficients, including the intercept, the adjustment speed of long-term equilibrium values, and the error variances, to vary across countries, while the long-term slope coefficients are constrained to be equal across countries.

This approach is particularly valuable when there is reason to believe that the long-term equilibrium relationship among the variables is consistent across countries, or at least among a part of them. However, the short-term adjustments are permitted to vary by country due to the differing effects of vulnerability to financial crises, exposure to external shocks, stabilization policies, monetary policy, and various other factors. This flexibility allows for a more nuanced understanding of how these influences manifest in different contexts. The proposed estimated model and ARDL (p,q) will be as follows:

$$EC_{it} = \sum_{j=1}^p \delta_i EC_{i,t-j} + \sum_{j=0}^q \beta'_{ij} X_{i,t-j} + \varphi_i + e_{it} \quad (5)$$

Où X is the vector of explanatory variables. Reparametrizing the model 2, it transforms in:

$$\Delta EC_{i,t} = \theta_i (EC_{i,t-j} - \beta'_{ij} X_{i,t-j}) + \sum_{j=1}^{p-1} \gamma_j^i \Delta EC_{i,t-j} + \sum_{j=0}^{q-1} \delta_j^i \Delta X_{i,t-j} + u_i + e_{it} \quad (6)$$

The model estimated has the form of an ARDL (p,q) model 2:

$$OC_{it} = \sum_{j=1}^p \delta_i OC_{i,t-j} + \sum_{j=0}^q \beta'_{ij} X_{i,t-j} + \varphi_i + e_{it} \quad (7)$$

Où X is the vector of explanatory variables. Reparametrizing the model 2, it transforms in:

$$\Delta OC_{i,t} = \theta_i (OC_{i,t-j} - \beta'_{ij} X_{i,t-j}) + \sum_{j=1}^{p-1} \gamma_j^i \Delta OC_{i,t-j} + \sum_{j=0}^{q-1} \delta_j^i \Delta X_{i,t-j} + u_i + e_{it} \quad (8)$$

Where:

The vectors of interest are the explanatory variable β_i , which quantify the long-run impact on the share of energy consumption, while θ represents the influence of the error correction mechanism. The remaining parameters φ_i correspond to the short-run coefficients. The disturbances are independently distributed across time and units, characterized by a zero mean and constant variance within each ε_{it} unit. This framework allows for a comprehensive analysis of both the long-term and short-term dynamics affecting energy consumption

The model in Equation 1 allows for the parameters to vary across countries. [Pesaran and Smith \(1995\)](#) and [Pesaran et al. \(1999\)](#) exhibited that this can be steadily estimated using the mean group (MG) estimator. This estimates the parameters for each country and then averages them across the countries. Contrariwise, when t if the long-run coefficients are the similar through countries, pooled mean group (PMG) estimator will be used for providing more efficient estimation. This will permit the short-run coefficients to differ from country to country, nonetheless it will restrict variation of the long-run coefficients between countries. However, in order to

use these methods, the model variables should be measured using mixture of integrated order 1 (I(1)) and integrated order 0 (I(0)). Additionally, the variables must be cointegrated for the model to be interpreted as an error correction mechanism.

4. EMPIRICAL RESULTS AND DISCUSSIONS

In unit root panel tests, it is essential to consider whether the cross-sectional components that structure the panel are independent. The first generation of unit root tests assumes that the cross-sectional units are independent, while the second generation considers the possibility of cross-sectional dependence. Therefore, it is essential to run cross-sectional dependence tests first and then run the unit root tests. Pesaran's (2004) test was used in this study to test for cross-sectional dependence. This test is a second-generation test that is robust to the presence of cross-sectional dependence.

Cross-sectional dependence: Pesaran Tests 2004 (CD)

The Pesaran (CD) 2004 test is a statistical test used for cross-sectional dependence in panel data. The test is based on the following statistics:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left(\sum_{i=1}^{N-1} \sum_{j=i+1}^N \rho_{ij} \right)$$

Where N is the number of cross-sectional units, T is the number of periods, and ρ_{ij} is the sample estimate of the pairwise correlation coefficient of the residuals. The null hypothesis for this test is that there is no cross-sectional dependence between the residuals.

Table 3. Cross-sectional dependence Results Pesaran (2004) CD

Variables	CD-test	P-value	Decisions
LnOC	6.982	0.000***	Dependence
LnEC	1.670	0.095*	Dependence
LnMC	20.336	0.000***	Dependence
LnI	17.436	0.000***	Dependence
LnTr	14.971	0.000***	Dependence
lnVTE	41.220	0.000***	Dependence
lnGDP	48.103	0.000***	Dependence
LnEP	46.957	0.000***	Dependence
FDI	5.378	0.000***	Dependence

Source: Author's calculation, NB: * and *** refer to significance at the 10% and 1% threshold, respectively

The table shows that the null hypothesis of no cross-sectional dependence is rejected at the 1% significance level for all the variables considered. This means there is cross-sectional dependence in the variables across the countries considered. In other words, a shock on one GCC capital market can affect the other GCC capital markets.

Therefore, the evidence from the Pesaran test (2004) shows that the first-generation unit root tests are not applicable. As a result, we apply the second-generation Pesaran unit root test (2003), which assumes cross-sectional dependence, to identify the order of integration of the variables.

Unit root test: Pesaran (2003)

Pesaran (2003) recommended a testing for the dependencies between cross-sectional units. The analysis is based on the mean of the individual t-statistics of the augmented Dickey-Fuller (ADF) test for each cross-sectional unit in the panel. He considered an augmented DF model in the cross-sectional dimension, also known as the CADF model. This model is written in the

absence of autocorrelation of terms as follows:

$$\Delta_{Y_{it}} = \alpha_i + \rho_i Y_{i,t-1} + C_i \bar{Y}_{t-1} + W_t \Delta \bar{Y}_t + \theta_{it}$$

Table 4. Unit root test results (Pesaran 2003)

Variables	Level		First difference		Integra- tion order
	Constant and no Trend	Constant and Trend	Constant no Trend	Constant and Trend	
LnOC	2.864 (0.998)	0.623 (0.733)	-5.013 (0.000)***	-2.07 (0.006) ***	I(1)
LnEC	1.308 (0.904)	0.610 (0.729)	-4.014 (0.000)***	-2.409(0.002) ***	I(1)
LnMC	-0.437 (0.331)	0.248 (0.598)	-3.681(0.000)***	-1.423(0.077) *	I(1)
LnI	-0.067 (0.437)	-0.165 (0.434)	-4.289 (0.000)***	-2.551(0.005) ***	I(1)
LnTr	-0.314 (0.377)	-2.58(0.005)***	-7.069 (0.000)***	-5.638(0.000) ***	I(1)
lnVTE	-0.568 (0.285)	-0.451(0.326)	-3.251 (0.001)***	-1.585(0.057) *	I(1)
lnGDP	-2.74 (0.003)***	-2.233(0.013)**	-4.511 (0.000)***	-1.329(0.092) *	I(0)
LnEP	-3.10 (0.001)***	-2.45(0.007)***	-5.328 (0.000)***	-2.325(0.010) ***	I(0)
FDI	-2.43 (0.007)***	-1.795 (0.036)**	-7.786 (0.000)***	-6.520(0.000) ***	I(0)

Source: Author's calculation; Notes ***, **, and * show significance at the 1%, 5%, and 10% levels, respectively.

As shown in Table 2, the results of the unit root analysis indicate that some variables are stationary in level including (ln_ener, ln_mc, ln_st, ln_tr, and ln_rev), while others are stationary in the first difference (ln_gdp, ln_enerp, and fdi). This is known as a mixed order of integration. As a result, we use the ARDL panel approach, a more robust approach to cointegration testing in the presence of a mixed order of integration. Several advantages characterize the ARDL panel approach. It allows us to estimate different variables with different orders of stationarity, as in our case in Table 2. We also found that our data have mixed order of integration, with some variables being integrated of order 0 (I(0)) and others being integrated of order 1 (I(1)). Additionally, the ARDL panel approach allows us to estimate short-run and long-run relationships between the variables and error correction coefficients.

Results of PMG and MG Estimators

To identify the impact of the variable of interest, an error correction model based on the ARDL (p,q) model with autoregressive distributed lag was used. The PMG model was chosen over other error correction models, such as the MG estimator because it allows short-run coefficients to vary across countries.

Table 5. Estimation Results of Models 1 and 2

Models Variables	Model 1: Electricity consumption as the dependent variable		Model 2: Oil consumption as the dependent variable	
	PMG	MG	PMG	MG
	Long-run coefficients (LR)			
LnMC	0.0831(3.47) ***	-0.0423 (-0.63)	0.1672 (4.80) ***	0.0962 (2.18) **
LnVTE	0.8154 (6.81) ***	0.9056 (1.86) *	0.7597 (6.54) ***	1.1661 (1.09)
LnGDP	0.1219 (4.03) ***	-0.0484 (-0.63)	-0.0636 (-1.47)	-0.2504 (-1.02)
LnEP	-0.1563(-6.04) ***	-0.0707 (-1.54)	-0.094(-4.45) ***	-0.0245(-0.48)
FDI	-0.0417(-4.36) ***	0.0077 (0.70)	0.0095 (1.55)	-0.0142(-0.58)
Short-run coefficients (SR)				
Error-correction coefficient (ec)	-0.1362(-2.61) ***	-0.960(-7.4) ***	-0.179(-4.61) ***	-0.8630(-6.13) ***
LnMC	0.0021(0.43)	0.0022 (0.12)	-0.0059(-0.95)	-0.0392 (-1.45)
LnVTE	0.5383(2.45) **	0.1280 (0.34)	0.1547(0.65)	-0.0591(0.10)
LnGDP	-0.0696(-1.20)	-0.1076 (-0.73)	0.0030(0.04)	-0.2634 (-1.20)
LnEP	0.0354(2.10) **	0.056(2.05) **	-0.0000(-0.00)	0.0506 (2.07) **
FDI	0.0048(2.05) **	0.0045(1.20)	0.0007(0.35)	0.0034 (0.89)
Constant	-0.452 (-2.56) ***	3.686 (0.90)	0.274 (4.54) ***	-2.531 (-0.43)
Tests de Hausman	(MG PMG) =3.41 (0.6371)		(MG PMG) =0.44 (0.9941)	

Source: Author's calculation

Table 6. Estimation Results of Models 3 and 4

Models Variables	Model 3: Electricity consumption as the dependent variable		Model 4: Oil consumption as the dependent variable	
	PMG	MG	PMG	MG
	Long-run (LR)			
LnMC	-0.0027 (-0.26)	0.0249 (1.03)	0.1401(7.30) ***	0.1295(1.26)
LnVTE	0.9254 (13.40) ***	0.2605 (0.75)	0.9042(12.33) ***	-2.3828 (-0.86)
LnGDP	0.0933 (4.03) ***	0.0416 (0.59)	-0.1018 (-4.66) ***	0.5993(0.97)
LnEP	-0.0988 (-7.32) ***	-0.0796 (-1.51)	-0.0327 (-1.95) *	-0.1157(-1.80) *
FDI	0.0057 (1.69) *	-0.0009(-0.09)	0.0001 (0.02)	0.0146(0.39)
Short run (SR)				
Coefficients de correction d'erreur (ec)	-1.9184 (-2.29) ***	-0.7355(-4.09) ***	-0.1527 (-3.01) ***	-0.8031 (-7.73) ***
	0.0069 (1.69) *	0.0019 (0.17)	-0.0010 (-0.14)	.0033 (0.28)
	0.4948 (2.58) ***	0.3579 (0.88)	0.2291(0.75)	-0.0594 (-0.15)
	-0.0873 (-1.13)	-0.0576 (-0.61)	-0.0283 (-0.21)	-0.0046 (-0.04)
	0.0348 (2.20) **	0.0464 (1.97) **	-0.0144 (-0.35)	0.0305 (1.66) *
	0.0006 (0.46)	0.0078 (1.54)	0.0019(0.93)	0.0058 (1.22)
Constante	-0.6505 (-2.16) **	2.8777 (0.78)	0.2268 (3.10) ***	3.8943 (1.57)
Tests de Hausman	(MG PMG) =0.59 (0.9884)		(MG PMG) =5.22 (0.3896)	

Source: Author's calculation

Table 7. Estimation Results of Models 5 and 6

Models Variables	Model 5: Electricity consumption as the dependent variable		Model 6: Oil consumption as the dependent variable	
	PMG	MG	PMG	MG
Long-run (LR)				
LnMC	-0.0067 (-0.59)	-0.0889 (-0.93)	-0.0208(-1.02)	0.0518 (1.16)
LnVTE	1.0133 (16.11) ***	0.3869 (1.04)	0.4264 (3.85) ***	0.6164 (1.31)
LnGDP	0.0579 (2.93) ***	0.0634 (1.02)	0.0641 (1.39)	-0.1889(-0.97)
LnEP	-0.0828 (-7.37) ***	-0.0791(-1.44)	-0.0926(-5.64) ***	-0.0378(-0.89)
FDI	0.0063(1.75) *	-0.0240(-1.17)	0.0363(6.53) ***	-0.0050(-0.25)
Short run (SR)				
Coefficients de correction d'erreur (ec)	-0.2308 (-2.70) ***	-1.141 (4.95) ***	-0.1928 (-3.16) ***	-1.0602 (-4.87) ***
LnMC	-0.0024 (-0.35)	-0.0241(-1.24)	0.0078 (0.69)	-.00119 (-0.42)
LnVTE	0.6291 (3.12) ***	-0.1883(-0.47)	0.3248 (1.24)	-0.1458 (-0.28)
LnGDP	-0.0901(-1.23)	0.0420(0.41)	-0.0167 (-0.18)	-0.0087 (-0.08)
LnEP	0.0278 (1.88) *	0.0876(2.98) ***	-0.0057 (-0.17)	0.0746 (2.33) **
FDI	0.0011(0.86)	0.0064(0.79)	-0.0017 (-0.62)	0.0043 (0.53)
constant	-0.7463(-2.52) **	5.7412 (1.96) **	0.3475 (3.00) ***	8.338 (1.56)
Tests de Hausman	(MG PMG) =0.69 (0.9834)		(MG PMG) =0.69 (0.9835)	

Source: Author's calculation

Tables 5, 6, and 7 display the estimates for both the pooled mean group (PMG) and mean group (MG) methodologies, accompanied by the Hausman test to assess their efficiency and consistency. Before delving into the analysis of the variable coefficients, it is important to highlight that the estimated coefficient for the error correction mechanism (ECT) is consistently significant and negative across all cases. This indicates that the system adjusts to deviations from long-run equilibrium at a rate proportional to the magnitude of the disequilibrium. The results reveal that the error correction coefficient is negative and significant at the 1% level for models (1) through (6), reinforcing the validity of the error correction model. This finding confirms the existence of a statistically significant long-term relationship between the dependent and independent variables.

The results from the pooled mean group (PMG) estimation, recognized as the more efficient estimator compared to the mean group (MG) estimator, reveal that the long-term coefficients for stock market development indicators are significantly higher than the short-term parameters. This suggests that the influence of these indicators on energy consumption is more substantial in the long run than in the short run, highlighting the enduring effects of stock market development on energy consumption patterns.

The findings indicate that a 1% increase in stock market size, as measured by the market capitalization of listed companies (% of GDP), leads to an increase in electricity and oil consumption by 0.083 and 0.167, respectively, in the long term. However, in the short run, market capitalization does not have a statistically significant effect on energy consumption. Regarding stock market liquidity, the results demonstrate that the stock traded total value (% of GDP) has

a positive and significant impact on oil consumption in the long term (see Table 6). Specifically, a 1% increase in the stock traded total value (% of GDP) results in an increase in oil consumption by 0.1405. Conversely, the stock traded total value does not significantly affect electricity consumption.

In the short run, the stock traded total value increases electricity consumption with a slight coefficient. An increase of this indicator by 1% increases electricity consumption by 0.0069. The impact of stock market development on energy consumption in the GCC during the COVID-19 pandemic has been contradictory. On the one hand, the pandemic has caused a significant decline in oil prices, which has led to a decrease in energy consumption as countries have cut back on production and consumption. On the other hand, stock markets in the GCC have seen an uptick in activity as investors look for opportunities to capitalize on the current market conditions. This increased activity has increased energy consumption as investors seek to maximize profits. In general, ascertaining the precise influence of stock market growth on energy usage in the GCC throughout the COVID-19 pandemic proves challenging.

Nonetheless, changes in oil prices and stock market performance have led to fluctuations in energy consumption, with both increasing and decreasing trends noted. Table 7 presents the results for the turnover ratio, an additional indicator for assessing stock market liquidity. These findings indicate that the turnover ratio does not significantly affect electricity or oil consumption, either in the long term or the short term. These results are consistent with those of [Ulusoy and Demiralay \(2017\)](#), who found that the turnover ratio does not influence energy consumption in OECD member countries. This contrasts with the findings of [Chang \(2015\)](#), who identified a negative and significant relationship between the turnover ratio and energy consumption in advanced economies, while observing a positive and significant impact in emerging and developing countries.

Regarding the control variables, our findings indicate that economic growth ($\ln\_gdp$) has a significant impact on electricity consumption in the long term, but it does not have a significant effect on oil consumption in the long run. Nevertheless, in the short term, economic growth does not influence energy consumption in terms of oil and electricity. Income exhibits a positive and statistically significant influence on electricity consumption in both the long and short terms. Conversely, income demonstrates a positive and significant impact on oil consumption solely in the long run. These findings highlight that variations in per capita income have a more pronounced effect on GCC countries' electricity demand than oil demand, a pattern akin to the observations made by [Ulusoy and Demiralay \(2017\)](#) for OECD member nations.

Our results regarding energy prices reveal that they negatively influence electricity consumption in the long term, aligning with economic theory, which posits that demand decreases as prices rise. Conversely, in the short term, the energy price positively impacts electricity consumption. However, oil consumption remains unaffected by changes in energy prices, both in the long and short term.

Much of the literature have highlighted the significant consequences of per capita income and exact energy prices on estimating the energy demand. For example, research by [Belke et al. \(2011\)](#), [Bernstein and Madlener \(2015\)](#), and [Destek \(2018\)](#) has shown a positive association between real income and energy consumption, while energy prices tend to exert a negative influence on energy usage. The findings generally indicate that foreign direct investment (FDI) inflows do not have a significant impact on energy consumption. Additionally, [Lee \(2013\)](#) provided evidence that does not convincingly establish a clear connection between FDI and the adoption of clean energy practices.

[Sadorsky \(2010\)](#) demonstrated the way stock market influence energy demand. The first, la-

belled as “wealth effect” in the short term, which involves increased stock market activity as an initial indicator of future economic prospects. This increase in stock market activity encourages customer and industry confidence, leading to a rise in energy demand.

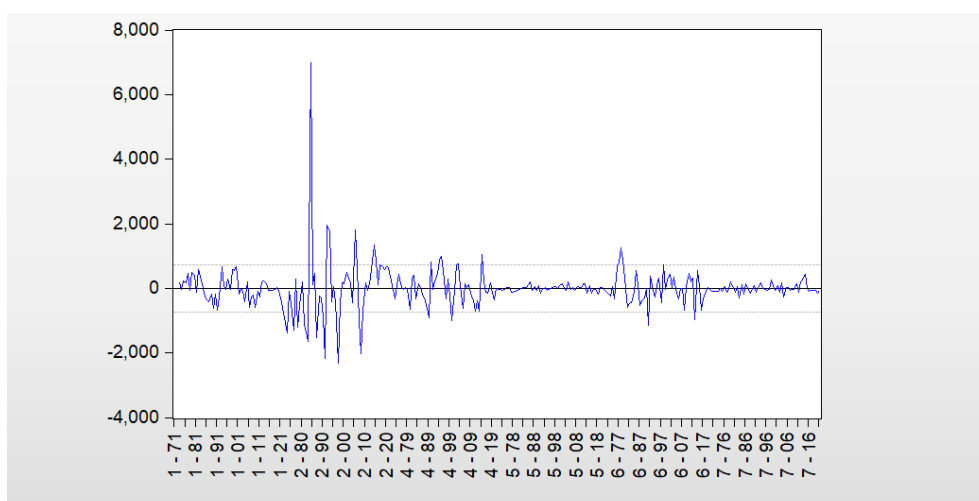
The second theoretical effect is known as the “efficiency effect” or the investment channel, which facilitates companies in accessing equity financing as a source of funds. The growth of stock markets enhances diversification and liquidity, expanding the pool of funds available for investment in higher-yield, higher-risk projects. Consequently, as stock market development increases the availability of funds for investment initiatives, it is anticipated that this development will lead to more significant investment, economic growth, and, subsequently, an increase in energy demand.

The findings of the current research have shown some support to the existence of these two effects. Precisely, in GCC countries, stock market size measured by market capitalization, shows a significantly positive long-term influence on electricity consumption at the 1% level. Regarding oil demand, the long-term test results showed that both stock market’s size and liquidity have significant a positive influence on oil consumption at the 1% threshold. In the short term, stock market liquidity increases electricity consumption. As observed in our study, the positive impact of stock market development on energy consumption aligns with prior research in this field. For instance, [Hasnaoui \(2014\)](#) conducted a Principal Component Analysis (PCA) and identified a significant effect of stock market development on energy consumption in OECD countries, providing further support for this relationship.

In the context of European Union (EU) countries, the research conducted by [Çoban and Topçu \(2013\)](#) reveals that stock market developments do not significantly impact energy consumption overall. However, their study suggests a noteworthy influence of stock market developments on energy consumption, specifically in the older member countries of the EU. This nuanced finding highlights the variability in the relationship between stock market developments and energy consumption across different regions and subsets of countries.

The results have also suggested that energy demand in the economies of GCC member countries is significantly influenced by the stock market growing development. Assumed the expectation for further growth in the stock markets development in these countries, it is essential to consider this additional rise in energy demand associated with increased financial development when modeling energy demand in GCC countries. This insight underscores the need to incorporate the evolving role of financial markets in energy consumption forecasts for GCC nations.

Figure 1. Growing of energy consumption in GCC



Source: Author's calculation

This study aims to investigate the relationship between stock market development and energy consumption in the Gulf Cooperation Council (GCC) countries. To this end, an autoregressive distributed lag (ARDL) panel approach was employed. The results showed that there is a positive and statistically significant relationship between stock market development and energy consumption in the GCC countries. The results also indicated that energy consumption positively affects stock market development in the short run, while it has a negative effect in the long run. Furthermore, the results revealed that energy consumption has a more significant impact on stock market development in Bahrain, Kuwait, Oman, Qatar, and Saudi Arabia than in the United Arab Emirates. These findings suggest that policymakers should consider energy conservation policies to promote sustainable economic growth and financial stability in GCC countries.

Limitations and suggestion for future researcher

Here are some recommendations for future research based on the findings of the study: Firstly, future research could expand its geographic scope by investigating the impact of stock market development on energy consumption beyond the Gulf Cooperation Council (GCC) to achieve a more comprehensive understanding. Furthermore, exploring how stock market development influences energy consumption within specific sectors, such as manufacturing and transportation, could present valuable opportunities for further investigation. Utilizing advanced methodologies, including machine learning, may also provide deeper insights into the relationship between stock market development and energy consumption. (Škuflić and Bašić, 2024; Mazina et al. 2024; Laradi etl al., 2024; Lutfi et al., 2022; Almaiah et al., 2023; Alrawad et al., 2023)

5. CONCLUSION

In recent years, several studies have attempted to measure the influence of financial development, on county energy consumption. However, limited research has focused on the connection between stock market development, which is a crucial facet of financial development, and energy consumption. Accordingly, in this research we aimed at addressing the existing gaps in the existing literature through utilizing ARDL panel methods for dynamic panels to inspect the impact of stock market development on energy consumption. Doing so contributes to a more comprehensive understanding of the relationship between financial market development and energy consumption dynamics. The empirical analysis in this study was conducted using a sample comprising seven GCC member countries, spanning the time frame from 1971 to 2021. To assess the dependency among GCC countries, the Pesaran 2004 cross-sectional dependency test was employed. The findings from this test indicate the presence of cross-sectional dependence across all variables.

This study took a comprehensive approach to account for the cross-sectional dependence and the differing integration orders ($I(0)$ and $I(1)$) identified in the tests. This approach included applying a second-generation test that considers transversal dependence to test for the variables' stationarity. As a result of these tests, it was determined that the integration order varies, with some variables being integrated of order $I(0)$ and others of order $I(1)$.

The study employed the ARDL panel model to analyse the long and short-term relationships between the variables, particularly in mixed integration orders. Two estimators, namely PMG and MG, were utilized to assess these relationships. This methodological choice enables a more nuanced understanding of the dynamics and interplay between the variables, considering both short-term and long-term effects, and ensures the reliability and accuracy of the empirical analysis in the study. Our estimates indicate that the size of the stock market, measured by market capitalization as a percentage of GDP, positively and significantly impacts electricity consump-

tion. In contrast, liquidity—assessed through the stock traded total value (% of GDP) and the turnover ratio—does not significantly influence electricity consumption in the long term.

For oil consumption, market capitalization significantly affects demand in the long term, while market liquidity, as measured by the stock traded total value, also has a positive and significant impact. However, in the short term, the size of the stock market does not significantly affect electricity consumption, whereas liquidity (the value of shares traded) shows a positive influence. Overall, neither the size nor the liquidity of the stock market significantly impacts oil consumption.

The results obtained in this study support the hypothesis that stock market development exerts a positive and significant influence on energy consumption. These findings have important implications for energy policy and planning. Specifically, energy-saving policies that solely rely on energy demand and income connections may undervalue energy demand if the role of stock market development is not reflected. Therefore, policies of energy conservation that neglect the influence of stock market development have on energy demand might need to be revised to achieve the desired energy conservation objectives. Energy policymakers need to recognize and incorporate the impact of stock market development when formulating effective energy-saving strategies. This holistic approach can lead to more accurate and comprehensive energy policy decisions, better aligned with the complex dynamics of energy consumption in the studied context. The impact of stock market development on energy consumption in the Gulf Cooperation Council (GCC) countries is complex and multifaceted. On the one hand, stock markets can provide an essential source of capital for energy-related investments, leading to increased energy consumption. On the other hand, stock markets can also provide incentives for companies to reduce their energy consumption in order to improve their financial performance and increase their share prices.

Regarding direct impacts, increased stock market development has been linked to higher energy consumption levels in GCC countries. This is because stock markets provide access to capital that can be used for investments in energy-intensive projects such as oil and gas exploration and production. Additionally, increased access to capital through stock markets can lead to more efficient use of existing resources, resulting in higher energy consumption levels.

In indirect impacts, increased stock market development has been linked to improved corporate governance practices that encourage companies to reduce their energy consumption to improve their financial performance and increase their share prices. Investors are increasingly taking environmental factors into account when making investment decisions, and companies that are seen as being more environmentally responsible tend to have higher share prices. Additionally, improved corporate governance practices have been linked with improved efficiency in using existing resources, which can also lead to lower energy consumption levels.

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