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The Role of Financial Efficiency on Renewable Energy Demand among OPEC Member Countries

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ABSTRACT

In response to the deterioration of environmental quality and weather challenges across the globe, international strategies have prioritized ecological preservation. Contemporary developmental policies often concentrate on greening production systems worldwide. Integrating renewable energy into the global energy composition not only alleviates reliance on fossil fuels but also serves as an adjunct to global non-renewable reserves. The provision of capital for renewable energy projects and technologies is vital for economies. Therefore, the procurement of investment for large-scale projects, especially those related to energy, remains constrained in developing economies due to their special status, underscoring the necessity of selecting proper financing mechanisms. This study aims to investigate the role of financial efficiency on renewable energy demand in OPEC member countries over the period 1995-2021, using panel data analysis. Findings reveal that financial system indicators have a significant negative effect on renewable energy demand, but real interest rates and nominal exchange rates demonstrate a significant positive impact. The negative impact of financial efficiency on renewable energy demand suggests that as financial systems in OPEC member countries increase, their renewable energy demand tends to diminish.

Keywords: Financial Efficiency, Energy Demand, Renewable Energy, OPEC Member Countries.

1.INTRODUCTION

Global research on the association between economic growth and environmental cleanup indicates an interaction between economic prosperity and ecological issues. Consequently, developmental policies today emphasize the greening of global production processes. A principal policy in this field is to inhibit excessive greenhouse gas emissions resulting from fossil fuel combustion. Thus, shifting energy resources from non-renewable to renewable sources is a critical priority (Villavicencio Calzadilla, and Mauger, 2018).

The consumption of renewable energy plays a vital role in suppressing greenhouse gas emission intensity and fostering environmental quality). The 2015 Paris Climate Conference highlighted that elevating renewable energy consumption is essential for maintaining global temperatures below the threshold of critical risk (Rentschler, 2013). In 2015, renewable energy comprised approximately 12.09% of total energy consumption and accounted for 23.26% of electricity generation in OECD countries. These figures were 17.58% and 29.71% for the European Union, 8.71% and 13.22% for the

United States, and 6.29% and 15.98% for Japan, respectively (World Bank, 2020). Data for OPEC members in 2015 show the rate of renewable energy consumption in total consumption to be 0.06% in Algeria, 0% in Bahrain, 0.01% in Saudi Arabia, 0.91% in Iran, 0.8% in Iraq, 0% in Kuwait, 1.97% in Libya, 0% in Qatar, 0.14% in the UAE, and 12.84% in Venezuela (Eckart et al., 2018).

The International Energy Agency (2022) has warned that growing CO_2 emissions because of organized inefficient energy use, pose severe ecological challenges that can only be addressed through coordination between public and private sectors. Accordingly, securing finance for renewable energy projects is significantly important. Absent financial resources or a clear financial strategy, investment projects cannot proceed or will encounter difficulties; hence, an analysis of financial resources is essential prior to any activity. Due to the particular economic status of developing countries, obtaining large-scale project financing, especially in the energy sector, is often challenging, making the choice of a suitable financing approach critically important (Mousavi et al., 2022).

Painuly et al. (2003) maintain that restricted access of developing countries to suitable financing is one of the main barriers to improving energy efficiency. Even though these countries possess considerable potential, they encounter diverse obstacles to financing (e.g. market, financial, and institutional). Accordingly, the role of the financial system is effective not only in expanding investment in renewable energy but also in advancing energy efficiency because the financial efficiency level affects the volume of renewable energy investments and energy efficiency. In fact, financial efficiency covers a set of strategies and mechanisms that can increase efficiency through operational, fiscal, and social mechanisms (Cappers & Goldman, 2010). By developing the financial sector, a country can reduce the cost of investment in renewable installations, thereby incentivizing greater consumption of renewable energy. Financial efficiency causes substantial growth in renewable energy consumption over time. Developing economies often rely on imported inputs, including foreign exchange reserves. This increase in renewable energy consumption preserves foreign exchange reserves, which can then be redirected into financial markets to support further diversification of energy markets.

Moreover, financial efficiency can elevate environmental quality by decreasing CO_2 emissions through environmental innovation and enhanced research and development (Ozturk & Ullah, 2022; Li et al., 2022). Financial efficiency and government development enable firms to adopt environmentally friendly technologies, significantly decreasing CO_2 emissions (Tamazian & Rao, 2010). Financial efficiency also reinforces corporate governance and creates credit incentives that motivate companies to undertake environment-friendly projects, thus reducing CO_2 emissions (Dasgupta et al., 2001). Conversely, financial efficiency may decrease environmental quality through increasing CO_2 emissions due to technological advancement, economic growth, and energy consumption (Acheampong, 2019). in the same way, technological progress and risk diversification contribute to improving financial efficiency, thereby fostering economic growth which, in turn, results in a rise in carbon emissions and energy consumption (Sadorsky, 2011).

Due to the modest share of renewables in OPEC member states and their high potential, they must invest in renewable-energy infrastructure on a scale that effectively decreases CO_2 emissions. In this regard, financial framework efficiency capable of supporting the renewable energy demand is essential due to the high costs of

renewable energy projects (Ji & Zhang, 2019). An efficient financial system simplifies and economizes access to financial resources for investment in renewable energy projects (Fangmin & Jun, 2011). Given the importance of this issue, this study examines the role of financial efficiency on renewable energy demand among OPEC member countries.

2- Literature Review

Naeimi et al. (2023) applied the Autoregressive Distributed Lag (ARDL) approach in EViews to assess the effect of financial development, economic growth, industrialization, and urbanization on Iran's energy consumption between 1991 and 2021. Their empirical results demonstrate that industrialization and urbanization increase energy use in the long run but financial development and economic growth decrease energy use. Accordingly, in line with Iran's energy consumption reduction policies, it is necessary to establish a robust and advanced financial system capable of attracting investors, revitalizing the stock market, and enhancing the efficiency of economic operations. At the same time, sustainable economic growth can generate increased demand for financial services, thereby leading to the development of the financial sector. Therefore, effective strategies to attain sustained economic growth will contribute to lowering national energy consumption. Despite the fact that industrialization and urbanization increase energy use in Iran, focusing on and promoting these fields are vital as they are fundamental pillars of economic progress and must never be excluded from the development process.

Baseri et al. (2019) analyzed the financial effects of expanding renewable energy on economic growth in Iran. In the estimation model of this research over the period from 1991 to 2016 based on an autoregressive distributed lag (ARDL) approach, there was a significant and positive correlation between hydroelectric energy, as an indicator of renewable energy, and economic growth. One of the key advantages of hydroelectric energy is its environmental compatibility. In most countries worldwide, hydroelectric energy has been expanding in terms of investment and the growth of clean energy, with many policy initiatives now focusing on this field. Government financial support plays a vital role in expanding investments in these types of energy to achieve sustainable development goals.

Moradpour Oladi and Ebrahimi (2012) studied the relationship between financial market development and energy demand in Iran over the period from 1980 to 2007. The objective of their research was to explore the relationship between the development of the financial market and energy demand in the Iranian economy, using the autoregressive distributed lag (ARDL) model over the period of 1980 to 2007. The results indicated a positive and statistically significant relationship between financial market development and energy demand both in the long and short term. The elasticity of the financial development index in the long term exceeded 1, indicating the high impact of financial development on increasing energy demand in the long term.

Elmonshid et al. (2024) investigated the effects of financial efficiency and renewable energy consumption on reducing CO_2 emissions in the economies of the Gulf Cooperation Council (GCC) through a panel data quantile regression approach. To this end, they assessed the relationship between specific economic indicators and their effects on CO_2 emissions in these countries over the period from 2001 to 2021. The research highlighted several key findings: Financial institution efficiency was significant and negative at the 1 percent level in the lower quantiles (10, -83537.3) and upper quantiles (90, -549,002.3). The relationship between per capita GDP and CO_2 emissions varied across the

quantiles, indicating the complexity of the growth-environment association. Patent registration demonstrated a positive and significant relationship with emissions, emphasizing the need to direct innovations toward environmentally friendly solutions but renewable energy consumption showed a negative relationship with CO_2 emissions, which emphasizes the potential of renewable energy to mitigate greenhouse gas emissions. These findings emphasize the importance of improving financial institution efficiency, promoting green innovation, and expanding renewable energy resources to reduce CO_2 emissions.

Al-Sagr (2023) examined the role of financial efficiency on renewable energy investment, using empirical data from advanced and emerging economies. The economic consequences of environmental pollution worldwide highlight the importance of renewable energy sources, which as the main causes help economies to combat global warming. An efficient financial structure can provide the necessary budget for renewable energy projects at a reasonable cost. The study analyzed whether the effect of financial efficiency on renewable energy investment was symmetric or asymmetric over the period from 1996 to 2020, using a nonlinear ARDL-PMG model. The results from the symmetric model demonstrated that increasing financial efficiency was beneficial for promoting renewable energy investment in the long term. On the other hand, the asymmetric model revealed that higher financial efficiency supported renewable energy investment, while lower efficiency reduced it. However, the effects varied between emerging and developed economies. The study suggested that public-private financial partnerships should be encouraged to foster investment in renewable energy resources.

Hafeez et al. (2022) conducted a study titled "Financial Efficiency and Its Impact on Renewable Energy Demand and CO_2 Emissions: Do Eco-Innovations Matter for Highly Polluted Asian Economies?" This study aimed to investigate the effect of environmental innovations and financial efficiency on CO_2 emissions and renewable energy consumption in highly polluted Asian economies, such as China, India, Russia, and Japan. The empirical analysis was based on the ARDL-PMG model. The findings showed that environmental innovations facilitate renewable energy consumption and contribute to the reduction of CO_2 emissions. Conversely, financial development estimates in both renewable energy and CO_2 emission models were insignificant. However, the estimates for financial institution efficiency and financial market were positive and significant in both renewable energy and CO_2 emission models. In fact, financial institutions and improved financial market efficiency enhanced renewable energy consumption and reduced CO2 emissions.

Köksal et al. (2021) investigated the role of financial efficiency in renewable energy demand: Evidence from OECD countries. This study examined 36 OECD member countries, using a wide range of financial system proxies between 1990 and 2017. The results indicated that financial system proxies generally had a weak relationship with renewable energy demand in OECD countries. Even though the financial development proxy coefficient was significant for renewable energy demand, the coefficients for financial efficiency were insignificant.

3- Research Methodology

This study used a panel data method to examine the effect of financial efficiency on renewable energy consumption in OPEC member countries. The research variables included renewable energy demand (RED), nominal exchange rate (NER), trade volume (T), real interest rate (RIR), and financial efficiency (FS), which were defined based on the variables from Koksal et al. (2021).

Financial efficiency was derived from the World Bank reports and is a composition of variables, namely FD (the overall financial development), FI (financial institutions), FM (financial markets), FMA (financial market access), FME (financial market efficiency), and FMD (financial market depth). The time frame of this study was from 1995 to 2021 according to the data availability, while the geographical frame included the OPEC member countries, namely the Republic of Congo, Gabon, Iran, Kuwait, Libya, Nigeria, Algeria, and Venezuela. Prior to estimating the model, and to avoid the possibility of spurious regression, the stationarity of the variables was first assessed using the Levin, Lin, and Chu (LLC) test. Table 1 presents the results.

Table (1): Stationarity Results of Model Variables

Variable	Levin,Lin & chu		Levin,Lin & chu	
	Statistic	**Prob**	**Statistic**	**Prob**
LNRED	-0.33984	0.3670	-5.99296	0.000
LNNER	-1.29566	0.0975	-5.09142	0.000
LNRIR	-2.88578	.0020	-	-
LNT	-0.07936	0.4684	-6.62357	0.000
MFs	0.13701	0.5545	-6.34451	0.000

Source: Research Findings

The results indicate that LnRER, lnRED, LnT, and MFs are stationary at the first degree, while RIR is stationary at the zero degree.

Given that the variables in the model are a combination of stationarity at both the zero and first degrees, it is necessary to apply the Kao cointegration test. Table 2 presents the findings of the Kao test.

Table (2): Kao Cointegration

ADF	t-statistic	prob
	-0.525152	0.2997

Source: Research Findings

The results from the test suggest that no cointegration exists among the variables in the model.

After confirming the absence of cointegration, the F-Limer test is used to determine whether the model is a pooled or panel model. Table 3 presents the results of the Limer test

Table (3): Results of the Effects of the Limer Test

Effect Test	Statistic	d.f	Prob
F	576.244140	(7, 203)	0.0000
Chi-square	653.242258	7	0.0000

Source: Research Findings

The results suggest that the data are panel. The next step includes conducting the Hausman test to determine the existence of random or fixed effects. Table 4 presents the results.

Table (4): Hausman Model Estimation

Chi2	Prob > Chi2
3.863098	0.4249

Source: Research Finding

The findings from the above table indicate the presence of random effects in the model. After confirming the existence of random effects, the panel data model is estimated with random effects. Table 5 presents the results.

Table (5): Model Estimation Using Random Effects Method

Variable	COEFFICIENT	STD.ERR	t	p> | t |
MFs	4.200012-	.815313	5.151408-	0.0
LNT	0.073591	0.142077	0.517967	0.6050
LNRIR	0.328090	0.068596	4.783688	0.000
LNNER	0.204131	0.041884	4.873688	0.000
C	0.659881	1.068877	0.617359	0.5377

Source: Research Findings

The estimated results from the random effects model show a significant negative effect of financial efficiency and a significant positive effect of the real interest rate (RIR) and the nominal exchange rate (NER) on renewable energy demand (RED). In addition, trade volume does not significantly affect renewable energy demand. The significant negative relationship between financial efficiency and renewable energy demand suggests that as financial efficiency increases in OPEC countries, the renewable energy demand tends to decrease.

A heteroscedasticity test is conducted to verify the model's findings. The results are reported in Table 6.

Table (6): Heterogeneity of Variance Test

Value	Prob
8.209381	0.4133

Source: Research Findings

The findings from the table above indicate the absence of heteroscedasticity in the model, thereby ensuring the reliability of the results.

4- Discussion and Conclusion

This research investigates the role of financial efficiency on renewable energy demand in OPEC member countries through the use of panel data methods. The study period was from 1995 to 2021 and its geographical scope includes OPEC member countries: the Republic of Congo, Gabon, Iran, Kuwait, Libya, Nigeria, Algeria, and Venezuela. The research results reveal a significant negative effect of financial efficiency on renewable energy demand and a significant positive effect of nominal interest rates and real interest rates on renewable energy demand. The significant negative effect of financial efficiency on renewable energy demand in OPEC countries suggests that as financial efficiency increases in these countries, the renewable energy demand decreases. This finding may be attributed to the fact that OPEC countries are major consumers of fossil fuels, and their economic prosperity due to higher economic efficiency attracts investment into the fossil fuel energy sector.

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