MENA Oil Exporters Need A Renewable Energy Transition Before the Oil Wells Run Dry: A Special Focus on Innovation, Financial Development and Governance

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2023

May 4 - 6,
Cairo Egypt

ECONOMIC RESEARCH FORUM
منتدى البحوث الاقتصادية

ERF 29th Annual Conference

MENA oil exporters need a renewable energy transition before the oil wells run dry: A special focus on innovation, financial development and governance

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Abstract

This paper aims, on the one hand, to examine the dynamic linkage between oil revenues and renewable energy generation in 8 oil-rich MENA countries, namely, Algeria, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates over the period 1996-2020 using the Arellano-Bond difference GMM estimator and, on the other hand, to investigate the impact of innovation, financial development and governance on renewable energy production in these countries. The main findings indicate that oil rents negatively and significantly affect renewable energy production in MENA oil exporters in general and in non-GCC countries in particular. While renewable energy production in GCC countries is positively and significantly affected by oil rents. The results emphasize the importance of innovation in promoting renewable energy generation in MENA oil exporters; the innovation-led renewable energy increases at a greater pace in GCC countries than in their non-Gulf counterparts. Renewable energy production appears also to be positively and significantly affected by financial development in oil-rich MENA countries. Moreover, the results confirm the positive and significant impact of governance on renewable energy generation in oil-abundant MENA countries, and emphasize the effectiveness of the joint impact of governance and oil rents in encouraging renewable energy resource development.

Keywords: Renewable Energy; Innovation; Oil Rents; Financial Development; MENA oil exporters.
JEL Classification Numbers: O16, O30, O53, O55, Q35, Q39, Q42.

1. Introduction

This paper mainly focuses on oil-rich MENA countries that are so much more fortunate than other countries in the region but they still cannot take advantage of the blessings they have. A quick glance at MENA oil-exporting countries conveys that they have not only been blessed with crude oil fortune but also with a range of natural resources such as minerals and tremendous renewable energy resources in the form of solar, wind and geothermal, which could put the region at the forefront of the drive for renewable energy development. Having said that, these countries remain heavily dependent on oil revenues, staying oblivious to the problem of oil depletion and thoroughly underestimating their huge potentials to harvest free, clean, available and inexhaustible renewable energy sources. Such ample sources, if used wisely and efficiently, cannot only meet the oil depletion challenge and energy security objectives but also contribute to shouldering the daunting task of addressing climate change and its unforeseen deleterious consequences (Nematollahi et al., 2016; Marques and Fuinhas, 2011).

Undoubtedly, oil-rich MENA countries have not so far made any serious or meaningful efforts to progressively wean themselves off their dependence on oil export revenues[1], which have provided the incumbent rulers with a means of buying social peace and maintaining stable autocracies. By comparing oil production levels[2] with oil reserves[3], it turns out that MENA oil-exporting countries are highly vulnerable to a large-scale economic distress which may emanate from the inevitability of dwindling oil reserves in the not too distant future, rendering what is already bad infinitely worse. When oil reaches its peak production, oil export levels will definitely take a downward turn whilst domestic energy consumption will relentlessly rise. Unsurprisingly, then, tragic consequences will likely occur, especially since the energy needs that are met almost entirely by non-renewable domestic resources have been stopping or at least delaying investment in the renewable energy sector for decades in a row.

It is worth noting that renewable energy investments appear to be minimal in oil-rich MENA countries[4]. Some GCC countries like the UAE, Saudi Arabia and Qatar have started to invest in advanced renewable energy and are leading the decarbonization of the region. The journey to renewable energy in these countries began by establishing power generation plants and research institutions dedicated to renewable energy, raising resources to invest exclusively in renewable power projects, striding ahead in renewable energy installations, and enhancing

[1] According to OPEC data, the value of oil export revenues in 2020 reached USD 119.36 billion in Saudi Arabia, USD 44.29 billion in Iraq, USD 35.23 billion in Kuwait, USD 32.94 billion in the UAE, USD 13.17 billion in Algeria, and USD 7.66 billion in Iran.

[2] According to OPEC's 2020 data on oil production, Saudi Arabia's output was 9.213 million barrels per day (mb/d), Iraq's output was 3.996 mb/d, the UAE's output was 2.778 mb/d, Kuwait's output was 2.438 mb/d, Iran's output was 1.985 mb/d, Algeria's output was 898.7 thousand b/d, Oman's output was 761.9 thousand b/d, and Qatar's output was 603.1 thousand b/d.

[3] According to OPEC data, proven crude oil reserves at the end of 2020 stood at 261.6 billion barrels (bb) in Saudi Arabia, 208.6 bb in Iran, 145.019 bb in Iraq, 107 bb in the UAE, 101.5 bb in Kuwait, 25.244 bb in Qatar, 12.2 bb in Algeria, and 5.373 bb in Oman.

[4] According to the Arab Petroleum Investments Corporation (APICORP)'s 2021-2025 MENA Energy Investment Outlook, top 10 committed investments in renewable energy are forecast to reach nearly USD 16.9 billion in Iraq, USD 11.3 billion in Saudi Arabia, USD 11 billion in Iran, USD 6.7 billion in the UAE, USD 1.9 billion in Qatar, and USD 0.6 billion in Oman in the 2021-25 period.

infrastructure and equipment for imparting renewable power education. These initiatives, promising though they may look at first, have not yet yielded palpable results. The failure to increase the share of renewables in the energy mix has caused these GCC countries to be lagging behind in the race for alternative energy. In fact, their decision-makers are fearful of switching from the cheapest conventional energy sources such as fossil fuels that are deeply entrenched in the economy to more costly renewable energy sources. A combination of poor innovation[5], low levels of technological readiness and innovation capacities, lack of knowledge, experience and know-how, and a weak system of transferring the results to industry, often conspires to kindle this incessant fear. The situation seems much more terrifyingly worse in the other oil-rich MENA countries as these have not previously made similar efforts and leaps forward in the renewable energy sector. This can be ascribed to the short-sightedness of governments, particularism in seeking short-term benefits, weak innovation capabilities, financial underdevelopment[6], and brittle governance[7].

Most of these countries do not invest sufficiently enough in developing technology and unleashing innovation in order to take the first steps toward gradual transition to clean energy technologies. More often than not, financial underdevelopment constitutes a major obstacle to the development of the renewable energy sector; it increases agency problems and information asymmetries, raises the levels of uncertainty and risk aversion on the part of renewable energy investors, exacerbates the magnitude of the problem of securing adequate funds, and impedes the deployment of new technologies needed to successfully scale up renewable energy (Liu and Hamori, 2020; Kumar et al., 2020; Li et al., 2022).

Other inhibiting factors to the renewable energy transition include the lack of political will and commitment that can fail renewable energy projects at the earliest stages, the careless exploitation of natural resources, and policy-makers' selfish disregard of the public interest. With the continuing and stable flow of oil revenues, policy-makers arrive at the point of putting individual private interests before the public interest that embraces energy sustainability and security, the advancement of energy efficiency and renewable energy supplies, and the reduction of greenhouse gas emissions and increasing carbon sinks that contribute to the global warming and changing climate patterns. Limiting citizens' exposure to air and water pollution has never been at the top of rapacious policy-makers' priority list and has never been urgently necessary in these countries. This is a result of the colossally big role poor governance plays in deterring positive change and delaying the energy transition (Al-Maamary et al., 2017).

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[5] According to the Global Innovation Index 2021 rankings of the performance of 132 economies around the world, the UAE is ranked 33rd with a score of 43, Iran is ranked 60th with a score of 32.9, Saudi Arabia is ranked 66th with a score of 31.8, Qatar is ranked 68th with a score of 31.5, Kuwait is ranked 72nd with a score of 29.9, Oman is ranked 76th with a score of 29.4, and Algeria is ranked 120th with a score of 19.9.

[6] According to the IMF's 2020 financial development index, Algeria scored 0.14, Iran scored 0.47, Kuwait scored 0.37, Oman scored 0.37, Qatar scored 0.53, Saudi Arabia scored 0.45, and the UAE scored 0.46 on a 0–10-point scale.

[7] According to the average of the World Bank's six governance indicators in 2020, governance index is estimated at –0,87 in Algeria, –1,47 in Iran, –1.52 in Iraq, –0.0074 in Kuwait, 0.11 in Oman, 0.48 in Qatar, –0.22 in Saudi Arabia, and 0.64 in the UAE on a scale from –2.5 (bad) to +2.5 (good).

Although the existing literature on the barriers to renewable energy development in developing countries is rich and diverse [8], to the best of our knowledge, there is still a need for new studies on the impact of heavy reliance on oil revenues, poor innovation performance, lack of financial development, and weak governance on renewable energy development in oil-rich MENA countries. This study seeks to contribute to filling this gap in the existing literature. The contributions of this research are three-fold: First, it examines the dynamic linkage between oil revenues and renewable energy generation in 8 oil-rich MENA countries over the period 1996-2020 using the Arellano-Bond difference GMM estimator. Second, it investigates the impact of innovation, financial development and governance on renewable energy production in these countries. Third, quite unlike the previous research undertakings that our predecessors have carried out, the present study has striven to highlight the major differences among oil-abundant MENA countries by dividing the sample into two groups (GCC and non-GCC countries).

The rest of this paper is structured as follows. Section 2 provides a review of relevant literature and identifies potential research gaps. Section 3 describes the data and econometric methodology. Section 4 presents and discusses the empirical findings. Section 5 concludes and draws some policy implications.

2. Literature Review

2.1. Exploring the link between renewable energy investment and oil revenues

Without a public oversight on the collection, use and management of oil revenues, oil wealth is more of a curse than a blessing for sustainable development, and indeed public monitoring of oil revenue management is entirely absent in governments that neglect economic and social justice, environmental sustainability, and the moral side of environmental exploitation. In most developing oil-producing countries, decision makers predominantly put off the decision of investing in renewable energy until the last possible moment in the hopes that their successors will take the initiative. They do so because they prefer to yield immediate returns rather than generate indirect benefits in the longer term. This behavior is more common when leaders have no intention of seeking re-election (Marques and Fuinhas, 2011). In fact, they basically pay closer attention to the fixed costs obligations that come with major renewable energy investments than to their associated guaranteed advantages and multi-faceted economy-boosting benefits. Risk-averse policymakers are often unwilling to accept a high degree of uncertainty and are reluctant to face the consequences of a sudden and persistent steep drop in oil prices (Shafiullah et al., 2021). Short-sightedness is another factor that can sabotage a good decision regarding renewable energy. The short-sighted decision-making preference leads to procrastination and influences the choice between shifting to a new mix of more sustainable and less environmentally harmful renewable energy resources and ignoring the economic, trade

[8] Shah et al. (2018), Goldemberg et al. (2014), Abban and Hasan (2021), Marques and Fuinhas (2011), Bellakhal et al. (2019), Rasoulinezhad and Saboori (2018), Wang et al. (2021), Ulucak (2021), Alam and Murad (2020), Vural (2021), Khan et al. (2021), Nesta et al. (2014), Altıntaş and Kassouri (2020), Wang and Dong (2021), Le et al. (2020), Ji and Zhang (2019), Kim and Park (2016), Li et al. (2022), Sequeira and Santos (2018), Gatzert and Kosub (2017), Komendantova et al. (2014), and Li and Shao (2021).

and environmental consequences of blind reliance on nonrenewable low-cost fossil fuels (Khan et al., 2017).

Because many MENA oil-exporting countries have failed to diversify their economic base and couldn't find alternate sources of income and wealth, their economies are still hopelessly linked to oil exports (Al-Maamary et al., 2017). The oil industry has changed these countries' social makeup and redrawn their political landscape. It has even formulated the relationships between the public and private sectors in a way contrary to the dictates of economic diversification. The immense oil revenues that flowed to these states for decades in a row proved to be a significant barrier in embarking on large-scale diversification programs. It has, likewise, discouraged investment outside the petroleum sector. On the bright side of seemingly hopeless situations, GCC countries have been able, thanks to impressive oil prices and exports, to enter more technology-intensive industries. The GCC governments now place a great deal of emphasis on the implementation of clean energy plans and the adoption of renewable energy technologies. It is precisely discernible that the UAE, Qatar and Saudi Arabia have placed a tremendous amount of effort and resources into the development of the renewable energy sector, while the remaining GCC countries are not very enthusiastic about renewable energy and are still terrifyingly stuck in the conventional fossil fuel economy. There are of course so many complicating factors that cause the presence of leaders and laggards in the transition to renewables such as political will, political leaders' ambitions that redound to the public's benefit, efficient institutional framework and vibrant local environmental organizations (Atalay et al., 2016). Although the UAE, Qatar and Saudi Arabia achieved limited results in the renewable energy industry, it is noticeable that they want to follow in the footsteps of Norway that is one of the world's leading petroleum exporters and one of Europe's largest producers of renewable energy at the same time. For instance, Norway meets almost all of its domestic electricity demand with solar and wind power (Shah et al., 2018).

There are quite a few studies dealing with the impact of oil revenues on renewable energy investment. These studies include Bellakhal et al's (2019) study on how does oil dependence affect renewable energy investment in 15 MENA countries during the period 1996-2013. Their analysis yielded three key findings. First, oil-generated energy is inversely related to clean energy investments. Second, these countries' energy security continues to rely mainly on traditional sources. Third, heavy dependence on oil revenues thwarts the industrial spirit and reduces incentives for investment in renewable energy. Shah et al's (2018) study is also worth mentioning here, it encompassed Norway, UK and USA during the period 1960-2015. The empirical results indicate that high oil prices are strongly associated with more renewable energy investment in Norway. They elucidated that Norway has been able to effectively harness its oil wealth for renewable energy development. Goldemberg et al (2014) stated that the efficient allocation of oil revenues is of paramount importance for the future of the development and use of renewables in Brazil. Abban and Hasan (2021) examined the impact of oil imports on renewable energy investment in 60 countries during the period 2007-2017 using the system GMM estimator. They found that higher oil prices encourage investment in renewables, motivate electricity producers to invest in renewable energy sources, and induce policy-makers to develop a pilot program for energy efficiency and sustainable technology, whereas the opposite is true for oil exports in developing oil-rich countries. Marques and Fuinhas (2011) found that heavy dependence on non-renewable resources negatively affects renewable energy development in 24 European countries during the period 1990-2006. Rasoulinezhad and Saboori (2018) concluded in their study which targeted 12 member nations of the Commonwealth of Independent States during the period 1992-2015 that the excessive use of non-renewable resources adversely impacts renewable energy investments. Wang et al's (2021) study yielded some interesting and enlightening findings. It was found that the higher the country's dependence on oil revenues, the lower will be the incentives to invest in human capital necessary to unleash clean energy innovations.

2.2. Strengthening innovation: A glimmer of hope for renewable energy development

Technological innovation plays an undeniably crucial role in supporting scaled-up renewable energy and energy efficiency deployment and is critical to the reshaping of energy systems in ways that encourage sustainable development (Frondel et al., 2010; Rahman et al., 2021). Renewable energy technologies provide a roadmap to a cleaner, more secure and more affordable energy future as they may offer lower costs and higher efficiencies. This, in turn, leads to the inescapable fact that only countries that are in the forefront of technological advance have immense chances of becoming major renewable energy exporters (Gielen et al., 2019; Hille et al., 2020).

Most developing countries do not invest adequate resources into broad-based technology development needed by the renewable energy industry. There is considerable concern that insufficient funds are being spent on developing higher capacity, lower cost, more efficient, and more environmentally friendly energy systems. The considerable uncertainty surrounding the future direction of renewable energy policy and regulation in these countries has been repeatedly reported as one of the most important factors hindering any increase in the financial resources allocated to alternative energy projects and related technological innovations (Scherman and Fleischer, 2015). Political stability is another major factor to be considered as well because it brings predictability to renewable energy policy making, thereby helping business groups make smart renewable energy investment decisions, and in contrast, investors take a short-term perspective and underinvest in renewable energy in politically volatile environments (Shafiullah, et al., 2021).

As both the Paris climate agreement and the Sustainable Development Goals acknowledge, there is a need to take the steps to develop actionable projects that will accelerate technological development and enable the faster roll-out of renewables and other cost-effective, efficient and low-emissions technology options. Many European countries are currently taking an active part in several national and European research projects in order to strengthen their national innovation systems, accelerate the energy transition pace, and provide room for the renewables sector to penetrate further. The situation is quite different in most of oil-rich MENA countries that seem adamant in minimally investing in renewable energy technologies in spite of the crucial role they play in fulfilling the main Sustainable Development Goals (IEA, 2020).

In fact, the establishment of renewable-energy power plants in many developing countries has been frequently prorogued due to insufficient innovation power, lack of core technology, inadequate R&D investment, weak independent R&D capabilities, fragile institutions and poor governance (Su et al., 2021). It is worthwhile to note that the innovation process depends robustly on the environment in which technological innovations are developed. Renewable energy innovations cannot really take place where exist market structure issues, lack of relevant skills and knowledge, lack of the tacit capability that is needed to exploit external knowledge, shortage of highly qualified personnel for innovation projects, and institutional weaknesses (Negro et al., 2012).

Van de Ven (2017) stated that the costs and risks entailed by introducing an innovation are oppositely linked to the availability of state-of-the-art technology supporting infrastructure. Indeed, innovation requires that large-scale changes are added to the mix; similarly, R&D efforts typically require long time horizons, especially in developing countries that generally face severe difficulties in flexibly adjusting to ever-changing technological advances and remain as mere spectators of fast-evolving technological advances.

It is quite palpable that interest in revealing how innovation affects renewable energy generation has increased rather substantially. Ulucak (2021) examined the impact of innovation proxied by the number of patent applications on renewable energy generation in the United States and China during the period 1980-2016 and found that enhancing innovation is deemed to be the key to achieving a sustainable and cost-effective renewable energy resources.

Alam and Murad (2020) concluded that technological progress measured by the number of patent applications contributes positively to renewable energy development in 25 OECD countries over the period 1970-2012. Vural (2021) demonstrated that technological innovation positively and significantly affects renewable energy production in six Latin American countries during the period 1991-2014. Khan et al. (2021) showed that R&D investment in technological innovations plays a pivotal role in promoting renewable energy generation in 69 Belt and Road Initiative (BRI) countries. Nesta et al (2014) confirmed that clean energy technologies can further diversify the energy supply mix especially in countries with liberalized energy markets.

Alvarez-Herranz et al. (2017) investigated the relationship between government energy R&D spending and renewable energy development in 17 OECD countries over the period 1990-2012. Their results reveal that increasing public spending on energy research, development and innovation gives a substantial boost to renewable energy's share of the total energy mix.

Altıntaş and Kassouri (2020) explored the impact of public energy RD&D budget on renewable energy development in 12 European countries over the period 1985-2016. Their findings suggest that renewable energy is positively related to spending on energy technology innovation. They also reported that the promotion of renewable energy planning paves the way for successful implementation of renewable energy projects and rapid transition to renewable energy technologies in Europe.

2.3. Financial development: A catalysts for renewable energy production

The lack of investment in the renewable energy sector can also be attributed to financial underdevelopment that put renewable energy projects at a financial disadvantage compared to conventional energy projects. Financial markets inefficiencies deter renewable energy project developers and make them more risk-averse and very vulnerable to agency problems and the adverse effects of information asymmetries (Liu and Hamori, 2020; Li et al., 2022). Renewable energy investors face difficulties in securing adequate funds, need access to precise and reliable data, require reliable information and predictable rates of return, and demand a financial environment that provides more accurate price and profit forecasts. Therefore, due to the lack of financial development, renewable energy projects tend to be highly risky and investors will be less interested in renewable energy investments (Kumar et al., 2020).

Greater financial development helps renewable energy investors mobilize necessary funds, but, in contrast, having fewer financial instrument choices can repel renewable energy investors who are likely to face higher funding costs and may incur many losses (Ahmad et al. 2021; Li et al., 2022). Undeveloped equity markets exacerbate liquidity risks and make investors hesitate to engage in long-term risky renewable energy projects, especially when it will be hard for them to sell shares, but the situation is quite different in developed equity markets that help mitigate liquidity risks, make investors feel safe and comfortable investing in such projects, and reassures them that they can easily sell their shares (Kim and Park, 2016).

Financial development provides a suitable environment for large capital-intensive risky renewable energy projects having long payback periods and induces renewable energy producers to expand the output, capacity utilization and scale of their industrial activities. A sound financial system promotes the process of financial deepening and broadening, allows funds to flow more easily to cutting-edge renewable energy technologies, increases clean energy R&D funding, boosts green technology innovation and sustainable, green and eco-friendly technologies, thereby increasing the share of renewable energy in the energy mix (Kim and Park 2016; Wang and Dong, 2021).

Greater financial development can thus contribute to enhancing environmental quality and reducing environmental degradation (Chen et al., 2019). It plays a crucial role in attracting green FDI that may be the best way to draw in domestic investors in this area and develop further linkages with local suppliers and those interested in renewable energy resources (Tamazian and Rao 2010).

Wang and Dong (2021) confirmed the importance of financial development in paving the way for the development of renewable energy sources in the G20 economies over the period 2005-2018. Le et al. (2020) concluded that financial development can potentially boost renewable energy generation.

In their seminal work, Ji and Zhang (2019) underscored the importance of financial development in renewable energy development in China over the period 1992-2013. Their results unambiguously demonstrated that financial development contributes 42.42% of China's renewable energy development. They advised Chinese policy makers to enhance financial development, especially stock market development, and provide financial incentives to renewable energy projects.

Kim and Park (2016) examined whether financial development enhances renewable energy deployment in 30 countries over the period 2000-2013. Their study disclosed that countries with well-developed financial markets witness rapid growth in the renewable energy sector as a result of easier and better access to external sources of finance.

Li et al. (2022) investigated the role played by green financial development in the renewable energy sector in 26 OECD countries over the period 2011-2019. Their findings emphasized that green bonds support renewable energy projects.

2.4. Good governance: A strong foundation for the development of renewable energy sources

Good governance is gaining increasing attention due to its potential to facilitate access to renewable energy technologies and encourage investments in alternative sources of energy (Overland et al., 2019). On the contrary, weak governance is widely regarded as a key barrier to renewable energy development, because it leads to delays or failure in supportive policy implementation. Factors such as rampant corruption, lack of transparency and accountability in government operations, and unnecessarily cumbersome, complicated and often unwritten bureaucratic procedures could stall renewable energy investment. In such predicament, uncertainty and risk aversion ensure that renewable energy investments cannot be made and they inhibit the deployment of renewable energy technologies as well. Large renewable energy-based power generation projects in developing countries plagued by poor governance are more susceptible to long delays because foreign investors insist on transparency, scrutiny and legitimacy (Gonzalez de Asis et al., 2009).

In fact, corruption poses a barrier to the roll-out of renewable energy, especially in countries where the public sector remains the main financier of renewable energy investments. In other words, corruption raises the cost of renewable energy projects through inefficient allocation processes, whereby government contracts and concessions may not be awarded to the most efficient bidders and contractors who refuse to pay bribes, or engage in anti-competitive transactions (Hall, 1999). Komendantova et al (2011) conducted an interesting study and examined perceptions of risks and obstacles among investors in solar projects in North Africa. They found that renewable energy investments in these countries are still beleaguered by several frustrating factors such as widespread corruption, perplexing, annoying, and confusing bureaucratic procedures, the absence of a legal, political and institutional context of long-term confidence, transparency and stability, lack of support from local governments, and inconsistent and unstable regulations. According to investors interviewed by researchers, obtaining permits and licenses to build and operate solar power plants is the phase most affected by corruption and poor governance. In this particular stage, bribes and gifts are exchanged in return for obtaining government contracts. Moreover, there exist expectations to bribe public officials who favor well-connected individuals and companies when awarding public contracts, granting loans, and providing access to information in a manner that was previously unavailable. Respondents highlighted that poor governance induces foreign investors to choose the natural resource sector and extractive industries over renewable energy industries.

Some studies have cast light on the impact of governance on renewable energy development. For example, Sequeira and Santos (2018) identified governance as an important determinant that affects renewable energy generation and revealed that investments in renewable energy and efficient technologies would be prioritized in genuinely democratic countries. Gatzert and Kosub (2017) showed that strengthening governance, particularly regulatory quality, plays a critical role in promoting clean energy investments and shaping the development of a more renewable-based energy future.

Komendantova et al. (2014) emphasized the importance of the rule of law and government effectiveness in laying the groundwork for renewable energy development in North African countries. They stated that poor governance structures and practices, cumbersome bureaucratic procedures, legislative and regulatory barriers, political censorship, and widespread corruption lie behind low renewable energy investments in these countries. They also point out that institutional barriers continue to impede efforts to accelerate energy transition.

Bellakhal et al. (2019) investigated the impact of governance on renewable energy generation in 15 MENA countries over the period 1996-2013. The main findings indicated that fragile institutional frameworks, lack of good policies and bad governance discourage investments in clean energy and energy efficiency and hinder the flow of foreign direct investment into the renewable energy sector in these countries.

Li and Shao (2021) examined the impact of institutional factors on renewable energy innovation in 34 OECD countries over the period 1990-2018. Their results showed that the enforcement of intellectual property rights contributes to the promotion of technological innovation and to the transfer and dissemination of renewable energy technologies that can further diversify the energy supply mix.

Fatima et al's (2021) findings are also worth addressing here. They confirmed that the quality of governance appears to be the most significant factor influencing renewable energy development.

3. Data and Methodology

3.1. Data description

The empirical analysis is based on annual data covering the period from 1996 to 2020 for 8 MENA oil-exporting countries, namely, Algeria, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. Sample size and time period were determined primarily by data availability. Our model includes the following variables:

- Renewable Energy (RE) as the dependent variable, which is directly represented by renewable energy generation that is measured in Terawatt Hours (TW h), and is based on generation from renewable sources, including wind, geothermal, solar, biomass, waste and other renewable generation. Data are taken from the BP Statistical Review of world energy.

There is a set of explanatory variables which includes:

- Oil Rents (as a percentage of GDP) (OILR); this variable is calculated as the difference between the value of crude oil production at world prices and total costs of production. Data are obtained from the World Development Indicators database.

- Innovation Rate (INV) which is directly represented by the rate of patent applications that is calculated by dividing the number of patent applications in each country by the total number of patent applications in the world. Data are obtained from the WIPO Statistics Database.

- Financial Development (FD) which is proxied by domestic credit to the private sector (% of GDP). Data are obtained from the World Development Indicators database.

- Governance Index (GI) whose values range from −2.50 to +2.50, with a lower value indicating a poor governance; it has been measured as the average of the six World Bank's Worldwide Governance Indicators (WGIs): voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption.

- Political Stability and Absence of Violence Index (PSAV) which measures perceptions of the likelihood of political instability and/or politically motivated violence, including terrorism. Data are taken from the World Bank's Worldwide Governance Indicators (WGI) database.

- Government Effectiveness Index (GE) which captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Data are taken from the World Bank's Worldwide Governance Indicators (WGI) database.

- Control of Corruption Index (CC) which measures the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.

- Human Development Index (HDI) which measures the performance of countries in promoting human capital accumulation. Data are taken from the UNDP database.

- Trade Freedom (TF) which reflects both the openness of an economy to imports of goods and services around the world and the intensity of foreign trade. It is graded on a scale from 0 to 100, where 100 represents the maximum freedom. Data are obtained from Heritage Foundation.

- Gross Domestic Product (GDP) per capita growth which is the annual percentage growth rate of GDP per capita. Data are obtained from the World Development Indicators database.

- Foreign Direct Investment, net inflows (% of GDP) (FDI). Data are obtained from the World Development Indicators database.

3.2. Methodology

This study applies the difference GMM method of Arellano and Bond (1991) to examine the impact of oil revenues, innovation, financial development and governance on renewable energy generation in MENA oil exporters.

The difference GMM method of Arellano and Bond (1991) was chosen because it is one of the most effective econometric methods of addressing endogeneity issues and resolving the problem of autocorrelation. It can also account for the heteroskedasticity of an unknown form. The difference GMM estimator is very well suited for problems related to inconsistent estimators due to variable endogeneity and a relatively short sample period (Arellano and Bond, 1991; Arellano and Bover, 1995; Hansen and West, 2002).

Our empirical model builds on earlier contributions of Shah et al. (2018), Goldemberg et al. (2014), Abban and Hasan (2021), Marques and Fuinhas (2011), Bellakhal et al. (2019), Rasoulinezhad and Saboori (2018), Wang et al. (2021), Ulucak (2021), Alam and Murad (2020), Vural (2021), Khan et al. (2021), Nesta et al. (2014), Altıntaş and Kassouri (2020), Wang and Dong (2021), Le et al. (2020), Ji and Zhang (2019), Kim and Park (2016), Li et al. (2022), Sequeira and Santos (2018), Gatzert and Kosub (2017), Komendantova et al. (2014), and Li and Shao (2021).

Our modified panel data model is as follows:

$$RE_{it} = \alpha_i + \beta_1 RE_{it-1} + \beta_2 OILR_{it} + \beta_3 INV_{it} + \beta_4 X_{it} + \varepsilon_{it} \quad (1)$$

Where the subscripts i and t represent country and time period, respectively. RE is the dependent variable of interest, that is, renewable energy generation. α_i represents unobserved country-specific effects. $OILR$ stands for oil rents. INV stands for innovation rate. X represents the set of other explanatory variables that includes financial development (FD), governance index (GI), human development index (HDI), trade freedom (TF), gross domestic product per capita growth (GDP), foreign direct investment net inflows (FDI), political stability and absence of violence (PSAV), government effectiveness (GE), and control of corruption (CC). ε_{it} is the error term.

The Arellano-Bond difference GMM is a powerful econometric method that can address any potential endogeneity bias by instrumenting the first-differenced right-hand-side variables, which are not strictly exogenous, with suitable lags of their own levels (Arellano and Bond, 1991; Arellano and Bover, 1995; Hansen and West, 2002).

The Arellano-Bond estimation takes the first-difference form of Equation 1.

$$RE_{it} - RE_{it-1} = \lambda_1(RE_{it-1} - RE_{it-2}) + \lambda_2(OILR_{it} - OILR_{it-1}) + \lambda_3(INV_{it} - INV_{it-1}) + \lambda_4(X_{it} - X_{it-1}) + (\varepsilon_{it} - \varepsilon_{it-1}) \quad (2)$$

When Equation 1 is first differenced, potential biases caused by omitted variables and fixed country-specific effects are removed. The Arellano-Bond difference GMM is also able to produce consistent results by solving autocorrelation problems since the first-differenced lagged dependent variable is also instrumented with its past levels. In fact, this method allows controlling for endogeneity of the lagged dependent variable, which occurs due to the correlation between the regressor $(RE_{it-1} - RE_{it-2})$ and the error term $(\varepsilon_{it} - \varepsilon_{it-1})$ (Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell and Bond, 1998).

Instrumenting the regressors by their respective lagged values makes them pre-determined and therefore not correlated with the error term $(\varepsilon_{it} - \varepsilon_{it-1})$ under the assumption that there is no serial correlation in the error term and that the explanatory variables are weakly exogenous. We can check the validity of this assumption using two tests: first, the Sargan and Hansen test of over-identifying restrictions, whose null hypothesis is that instruments are overall exogenous and, thus, valid; a rejection of the null hypothesis implies that the instruments do not satisfy orthogonality conditions required for their employment and, second, the Arellano-Bond test for second-order serial correlation (AR(2)) whose null hypothesis is that there is no serial correlation for the second-order form. Thus, rejecting this null hypothesis implies that the model is misspecified (Arellano and Bond, 1991; Arellano and Bover, 1995; Blundell and Bond, 1998).

4. Results and Discussion

Table 01. Descriptive Statistics

Variables	Mean	Maximum	Minimum	Std. Dev.	Observations
RE	0.138405	5.559121	0.000000	0.525047	200
OILR	30.76643	66.56408	9.221253	12.73319	183
INV	0.046431	1.112352	0.000000	0.140259	200
FD	33.90383	138.8578	-2.170658	24.27592	180
GI	-0.303977	0.724268	-1.895952	0.732006	176
HDI	0.754202	0.890000	0.560000	0.077501	188
TF	67.77700	87.00000	39.60000	15.06178	200
FDI	1.354870	8.496352	-4.541592	2.117538	199
GDP	0.462111	49.48028	-38.41823	7.067043	195
PSAV	-0.266904	1.223623	-3.180798	1.141009	176
GE	-0.066341	1.509267	-2.088645	0.770511	176
CC	-0.034788	1.567186	-1.602183	0.794430	176

Note: Std dev. indicates standard deviation

Table 01 presents the summary statistics for the variables included in the empirical study, covering 8 oil-rich MENA countries (Algeria, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates) over the period 1996-2020. As can be readily seen from Table 01, renewable energy (RE) has a maximum value of 5.56 TWh which belongs to the UAE and an average of 0.14 TWh which indicates that despite the abundance of renewable energy resources, these MENA oil exporters remain highly dependent on non-renewable energy sources. Oil rents (OILR) has an average of 30.77 percent and a maximum value of 66.56 percent, confirming the great dependence of most oil-abundant MENA countries on export earnings from oil which is subject to depletion. Innovation rate (INV) has an average of 0.046 and a maximum value of 1.11 that belongs to Iran, reflecting that most oil-rich MENA countries are lagging behind in the innovation race. Financial development (FD) has an average value of 33.9 percent and a maximum value of 138.86 percent that belongs to Qatar, the descriptive statistics of this variable show that the private sector is not crowded out of the domestic credit in GCC countries. Governance index (GI) has a maximum value of 0.72 that belongs to Qatar and a minimum value of -1.89 that belongs to Iraq, highlighting the wide difference in governance performance between GCC and non-GCC countries. Human development index (HDI) has an average value of 0.75, a maximum value of 0.89 that belongs to the UAE, and a minimum value of 0.56 that belongs to Iraq, indicating a major deterioration in human capital in war-scarred countries. Trade freedom (TF) has a maximum value of 87 that belongs to Oman, and a minimum value of 39.6 that belongs to Iraq; in fact, security challenges, layers of nontariff barriers and institutional shortcomings continue to impede the dynamic flows of trade in non-GCC countries. Foreign direct investment (FDI) has an average of 1.35 percent and a maximum value of 8.50 percent that belongs to Saudi Arabia, reflecting that GCC countries outperform their oil-rich non-Gulf counterparts in terms of attracting foreign direct investment. Political stability and absence of violence index (PSAV) has an average of -0.27 and a maximum value of 1.22 that belongs to Qatar, indicating that GCC countries continue to enjoy remarkable political stability as compared with conflict-ridden countries in the region. Government effectiveness index (GE) has an average of -0.07 and a maximum value of 1.51 that belongs to the UAE; GCC countries have a wide lead over the rest of oil-rich MENA countries in terms of government effectiveness. Control of corruption index (CC) has an average of -0.03 and a maximum value of 1.57 that belongs to Qatar; the lack of control of corruption has placed non-GCC oil producers at a distinct disadvantage relative to their Gulf counterparts.

Table 02. Regression Results for 8 MENA Oil Exporters

Regressors	**(a)**	**(b)**	**(c)**
	Dependent Variable: RE		
	MENA Oil Exporters	**GCC Countries**	**Non-GCC Countries**
RE_{t-1}	2.769988	3.147665	1.073505
	(0.0001) ***	(0.0000) ***	(0.0000) ***
OILR	-0.001134	0.047119	-0.012751
	(0.0011) ***	(0.0816) *	(0.0545) *
INV	0.046890	5.137200	0.166966
	(0.0023) ***	(0.0000) ***	(0.0117) **
GI	0.323553	3.811568	0.631623
	(0.0000) ***	(0.0000) ***	(0.0001) ***
GI*OILR	0.008720	0.085915	0.009017
	(0.0000) ***	(0.0000) ***	(0.0190) **
AR (2) (p-value)	0.9903	0.4741	0.5222
Hansen Test	0.064865	0.001090	0.224564
[p-value]	[0.798966]	[0.973662]	[0.635584]
No of instruments	6	4	2
No of countries	8	5	3
No of observations	134	80	40

***p < 0.1; **p < 0.05; ***p < 0.01**

Table 02 presents the Arellano-Bond difference GMM results. As shown in columns (a) and (c), oil rents (OILR) negatively and significantly affect renewable energy production in MENA oil exporters in general and in non-GCC countries in particular, confirming what have been reported by Bellakhal et al (2019), Abban and Hasan (2021), Marques and Fuinhas (2011), Rasoulinezhad and Saboori (2018), and Wang et al. (2021); high oil revenues reinforce rent-seeking behavior and discourage investment in renewables, and thus thwart the implementation and operation of renewable energy projects in non-GCC countries. While according to the regression results reported in column (b), oil rents (OILR) positively and significantly affect renewable energy production in GCC countries at the 10% level of significance, confirming what have been reported by Goldemberg et al. (2014) and Shah et al. (2018); the governments of GCC countries, particularly the UAE, Qatar, and Saudi Arabia, have effectively harnessed a portion of oil revenues for paving the way for the development of renewable energy sources, and have laid plans for many investments in the clean energy sector.

Columns (a), (b) and (c) reveal that innovation rate (INV) exhibits a statistically significant positive effect on renewable energy generation in the three groups of countries. This result is consistent with that of Ulucak (2021), Alam and Murad (2020), Khan et al. (2021), and Vural (2021); it is worthwhile to note that according to the regression results reported in these three columns, the absolute value of the coefficient of INV is higher in GCC countries than in non-GCC countries; an increase of 1% in innovation rate (INV) leads to an increase of 5.14% in renewable energy generation in GCC countries, while an increase of 1% in INV can generate only a 0.17% increase in non-GCC countries' renewable energy generation; the reason why innovation-led renewable energy increases at a greater pace in GCC countries than in their non-Gulf counterparts is the former countries' atmosphere which induces innovation and creativity, enables improving the quality and quantity of research and development activities, and maximizes the benefits derived from available human resources, while non-GCC countries invest less in R&D activities and generate less innovation output, and thus fail to promote renewable energy technologies.

As shown in columns (a), (b) and (c), governance index (GI) positively and significantly affects renewable energy generation in the three groups of countries at the 1% level of significance. This result is consistent with that of Sequeira and Santos (2018), Gatzert and Kosub (2017), Komendantova et al. (2014), and Bellakhal et al. (2019); without good governance, the necessary investments in renewable energy may not take place; the quite interesting result is that the coefficient of GI in GCC countries (3.81) appears to be higher than that in non-GCC countries (0.63); in other words, an increase of 1% in governance index (GI) leads to an increase of 3.81% in renewable energy generation in GCC countries, while an increase of 1% in governance index (GI) leads to an increase of 0.63% in renewable energy generation in non-GCC countries, and this can be explained by the fact that GCC countries score consistently higher in good governance than non-GCC countries[9] which in turn lag considerably behind. GCC countries have made important progress in improving governance that facilitates investments in renewable energy, while poor governance in non-GCC countries leads to a misallocation of resources and acts as an active barrier to an attractive operating environment for renewable energy development. As long as such misallocation and inefficiencies continue, large renewable energy projects will remain future hopes, and not present realities.

According to the regression results reported in columns (a), (b) and (c), the multiplicative interaction term between governance index and oil rents (GI*OILR) carries the expected positive sign and is statistically significant, implying that the combined effect of good governance and oil rents appears to be of paramount importance in encouraging renewable energy resource development; good governance helps dispel the negative effects of oil revenues and renders them an important funding source for renewable energy projects by reducing resource misallocation, curbing corrupt practices, enhancing government accountability, encouraging greater public participation, and prioritizing human capital development. The coefficient of the multiplicative interaction term (GI*OILR) in GCC countries (0.086) appears to be higher than that in non-GCC countries (0.009) owing to the significant governance gap between these two groups of countries.

The Sargan-Hansen test of over-identifying restrictions and the Arellano-Bond test of second-order serial correlation AR (2) were conducted in order to assess the validity of instruments in GMM first-difference estimates shown in Table 02. The results show that null hypotheses

[9] According to the average of the World Bank's six governance indicators in 2020, governance index is estimated at –0,87 in Algeria, –1,47 in Iran, –1.52 in Iraq, –0.0074 in Kuwait, 0.11 in Oman, 0.48 in Qatar, –0.22 in Saudi Arabia, and 0.64 in the UAE on a scale from –2.5 (weakest) to +2.5 (strongest).

cannot be rejected in the three models. This indicates that the instruments are valid and the results of our estimates are consistent and credible.

Table 03. Regression Results for 8 MENA Oil Exporters

Regressors	(a)	(b)	(c)	(d)	(e)	(f)
	Dependent Variable: RE					
	MENA Oil Exporters	GCC Countries	Non-GCC Countries	MENA Oil Exporters	GCC Countries	Non-GCC Countries
RE $_{t-1}$	1.854293 (0.0000) ***	0.447905 (0.0009) ***	0.852361 (0.0000) ***	1.482169 (0.0000) ***	1.180401 (0.0000) ***	1.042728 (0.0000) ***
FD	0.004899 (0.0000) ***	0.010109 (0.0000) ***	0.001246 (0.0020) ***			
HDI	0.745529 (0.0000) ***	1.042463 (0.0000) ***	0.198731 (0.0000) ***			
TF	0.004621 (0.0000) ***	0.011206 (0.0000) ***	0.001146 (0.0000) ***			
FDI	0.028356 (0.0000) ***	0.099508 (0.0000) ***	0.014070 (0.0000) ***			
GDP	0.034501 (0.0000) ***	0.030028 (0.0000) ***	0.002148 (0.0000) ***			
PSAV				0.154701 (0.0000) ***	0.272067 (0.0193) **	0.195109 (0.0000) ***
GE				0.568309 (0.0000) ***	1.818275 (0.0000) ***	0.190575 (0.0000) ***
CC				0.772396 (0.0000) ***	1.586190 (0.0000) ***	0.159780 (0.0000) ***
AR (2) (p-value)	0.6987	0.7684	0.7324	0.6614	0.3428	0.5376
Hansen Test [p-value]	0.231279 [0.630577]	0.730401 [0.392753]	0.012526 [0.910889]	0.161244 [0.983589]	0.264168 [0.607271]	0.951335 [0.813025]
No of instruments	7	4	2	7	4	2
No of countries	8	5	3	8	5	3
No of observations	148	94	50	148	94	50

***p < 0.1; **p < 0.05; ***p < 0.01**

As shown in columns (a), (b) and (c), financial development (FD) is positively and significantly linked to renewable energy generation at the 1% level of significance in the three groups of countries, which is in line with the findings of Khan et al. (2021) and Shahbaz et al. (2021); financial development plays a crucial role in boosting renewable energy investments that require high start-up funds, more certainty, greater information symmetry, and low risk levels. The coefficient of FD in GCC countries (0.01) appears to be higher than that in non-GCC countries (0.0012). GCC countries' financial sector development has been quite rapid and can provide necessary funds for transition to renewable energy, while the lack of financial development constitutes a stumbling block to the development of renewable energy sources in non-GCC countries.

According to the regression results reported in columns (a), (b) and (c), human development index (HDI) positively and significantly affects renewable energy generation in the three groups of countries at the 1% level of significance. This result is consistent with that of Zhou and Li (2022) and Hashemizadeh and Ju (2021); the improvement of human capital enables more technological progress and catalyzes industrial upgrading and thus increases the production of attractive low-cost renewables and triggers renewable energy development. The absolute value of the coefficient of HDI is higher in GCC countries than in non-GCC countries; an increase of 1% in human capital development (HDI) leads to an increase of 1.04% in renewable energy generation in GCC countries, while an increase of 1% in HDI can generate a 0.2% increase in non-GCC countries' renewable energy production, and this can be explained by the fact that GCC countries have, however, achieved better results than non-GCC countries in terms of investment in human capital which, in turn, is a key ingredient in strategies to promote renewable energy technologies.

As shown in columns (a), (b) and (c), trade freedom (TF) exhibits a statistically significant positive effect on renewable energy generation at the 1% level of significance in the three groups of countries, confirming what have been reported by Bellakhal et al. (2019), Altıntaş and Kassouri (2020), and Li and Shao (2021); more trade freedom prompts technological diffusion and is associated with an increase in renewable energy generation; high trade barriers, in contrast, reduce opportunities for getting familiar with cutting-edge renewable energy technologies through trade channels. The coefficient of TF in GCC countries (0.01) appears to be higher than that in non-GCC countries (0.001); trade freedom allows GCC countries to have a technological contact with the outside world and boost renewables.

Columns (a), (b) and (c) reveal that foreign direct investment (FDI) has a significant positive impact on renewable energy production at the 1% level of significance in the three groups of countries, confirming the findings of Doytch and Narayan (2016), Khandker et al. (2018), and Ergun et al. (2019); foreign direct investment is a paramount source of foreign technology and knowledge inflow and is an important channel through which investors invest in host countries' renewable energy sources. The coefficient of FDI in GCC countries (0.1) appears to be higher than that in non-GCC countries (0.014). GCC countries have a solid foundation for attracting FDI inflows that can potentially enhance technology transfer and generate technological spillovers necessary to set up renewable energy-based power generation projects.

Columns (a), (b) and (c) indicate that renewable energy production is positively and significantly affected by GDP per capita growth at the 1% level of significance in the three groups of countries, which is in line with the findings of Pfeiffer and Mulder (2013), Aguirre and Ibikunle (2014), and Abban and Hasan (2021); higher GDP per capita indicates a greater capacity to invest in renewable energy production; it also reflects the availability of wealth to cope with renewable energy costs and motivate renewable energy deployment. The coefficient of GDP in GCC countries (0.03) appears to be higher than that in non-GCC countries (0.002). Renewable energy production increases by 0.03% when GDP per capita is increased by 1% in GCC countries. While a 1% increase in GDP per capita growth is found to increase renewable energy production by 0.002% in non-GCC countries. Higher GDP in GCC countries can promote renewable energy development by providing financial resources needed to fund capital-intensive renewable energy projects.

Columns (d), (e) and (f) show that political stability and absence of violence index (PSAV) has a significant positive impact on renewable energy production in the three groups of countries, confirming the findings of Bellakhal et al. (2019); an increase in political stability is necessarily consistent with increased investment in renewables. The coefficient of PSAV in GCC countries (0.27) appears to be higher than that in non-GCC countries (0.19). A 1% increase in PSAV is found to increase renewable energy generation by 0.27% and 0.19% in GCC and non-GCC countries, respectively. Political stability is a fundamental component of any long-term renewable energy strategy and is an essential prerequisite for market certainty which, in turn, is strongly related to both the continuity of renewable energy investment projects and the production price of renewable energy. GCC States have a long tradition of promoting political stability when compared with non-GCC countries.

Columns (d), (e) and (f) demonstrate that renewable energy production appears to be positively and significantly affected by government effectiveness (GE) at the 1% level of significance in the three groups of countries, confirming what have been reported by Komendantova et al. (2014) and Bellakhal et al. (2019); government effectiveness is an important factor affecting renewable energy investors' preferences because it directly reflects the quality of policy formulation and implementation, and the degree to which governments commit to their policies and reforms. The coefficient of GE in GCC countries (1.82) appears to be higher than that in non-GCC countries (0.19); an increase of 1% in GE leads to an increase of 1.82% in renewable energy generation in GCC countries, while an increase of 1% in GE can generate a 0.19% increase in non-GCC countries' renewable energy production, and this can be explained by the fact that most GCC governments have made recognizable and remarkable progress toward improving their government effectiveness[10], regulating their economies, and committing to the implementation of relatively important policies, areas where non-GCC countries fall short of requirements.

Columns (d), (e) and (f) indicate that control of corruption (CC) exhibits a statistically significant positive effect on renewable energy generation at the 1% level of significance in the three groups of countries. This result is consistent with that of Lopez and Mitra (2000) and Bellakhal et al. (2019); a better control of corruption leaves adequate financial resources to fund investment in renewable energy sources, lowers the cost of doing business, boosts confidence in government institutions, and creates environments that are attractive for renewable energy investors. The coefficient of CC in GCC countries (1.59) appears to be higher than that in non-GCC countries (0.16); A 1% increase in CC would increase renewable energy production by 1.59% and 0.16% in GCC and non-GCC countries, respectively; this can be explained by the fact that most GCC countries have made consistent strides in combating corruption[11] and in strengthening their anti-corruption mechanisms, and this sends a strong signal to foreign investors engaged in renewable energy projects about convergence to international standards. In non-GCC countries, oil rents have fueled corruption and helped policy makers retain power, get ancillary professional and material benefits and indulge in rent-seeking behavior at the expense of the long-term public interest that mandates the development of non-emitting renewable energy projects.

[10] According to the 2020 Worldwide Governance Indicators (WGI), government effectiveness was estimated at –0.54 in Algeria, –1.48 in Iran, –1.28 in Iraq, –0.16 in Kuwait, 0.14 in Oman, 0.9 in Qatar, 0.14 in Saudi Arabia, and 1.32 in the UAE. (Estimates range from –2.5 (weakest) to +2.5 (strongest)).

[11] According to the 2020 Worldwide Governance Indicators (WGI), control of corruption was estimated at –0.65 in Algeria, –1.48 in Iran, –1.32 in Iraq, –0.07 in Kuwait, 0.23 in Oman, 0.78 in Qatar, 0.27 in Saudi Arabia, and 1.11 in the UAE. (Estimates range from –2.5 (weakest) to +2.5 (strongest)).

As indicated in all columns (a), (b), (c), (d), (e) and (f), Hansen J-statistics are insignificant and therefore the instruments are valid; all models also pass the Arellano–Bond test for second-order serial correlation. This indicates that the instruments are indeed reliable and the results of our estimates are consistent and credible.

5. Conclusion

The findings of the present study demonstrate that oil rents exert a negative and significant effect on renewable energy production in oil-rich MENA countries in general and in non-GCC countries in particular; large oil windfalls induce rent-seeking behavior and delay renewable energy investments, and thus frustrate the development of renewable energy resources in non-GCC countries. On the contrary, oil rents exhibit a statistically significant positive impact on renewable energy production in GCC countries; it is worthwhile to note that governments of the UAE, Qatar, and Saudi Arabia, invest a share of oil revenues in renewable energy sources that will yield future benefits and encourage initiatives to develop the clean energy sector.

This study confirms the crucial role innovation plays in boosting renewable energy generation in oil-rich MENA countries; the main results reveal that the innovation-led renewable energy increases at a greater pace in GCC countries than in their non-Gulf counterparts due to the former countries' environment that encourages innovation and creative thinking, increases the quality and quantity of R&D activities, and takes full advantage of investments in human capital, while non-GCC countries invest comparatively less in R&D and show low innovation performance, and hence cannot adopt renewable energy technologies.

The results reveal that financial development positively and significantly affects renewable energy generation in MENA oil exporters. Furthermore, the findings also show that governance appears to positively and significantly affect renewable energy production in the three groups of countries, and confirm the effectiveness of the joint impact of governance and oil rents in promoting renewable energy. Good governance helps remove, reduce, or counter the adverse effects of oil rents and turns them into an effective funding source to scale up renewable energy investments by minimizing resource misallocation, reducing incentives and opportunities for corruption, promoting transparency and accountability, encouraging more active public participation, and emphasizing human capital development.

The most substantial contribution of the paper is undoubtedly to reveal the major differences among oil-abundant MENA countries, particularly between GCC countries and their non-Gulf counterparts. It turns out that GCC countries are keen on promoting alternative energy resources and have announced high-profile renewable energy projects in recent years, while non-GCC countries have taken comparatively little action to diversify their energy mix so far. Clearly, there is still much more to be done, however, in making firm and determined efforts to address the issues at stake and prevent them from becoming fundamental barriers to renewable energy development, especially in non-GCC countries.

Crucial policy implications can be drawn from these findings:

• Oil-rich MENA governments must demonstrate their commitment to renewable energy development by allocating a higher percentage of oil revenues to establish a budget entirely devoted to support and promote research and innovation efforts in the clean renewable energy. Policy makers should consider a constructive attitude towards facilitating renewable energy projects and providing financial incentives for R&D investments in renewable energy technologies through tax credits and low-interest loans.

• There is an urgent need to induce universities, research institutes and R&D centers to develop scientific and technical research projects in renewable energy technologies, train renewable energy researchers and engineers, provide financial incentives for renewable energy-related patent holders, and make sure these inventions are actually put into practice and not on the shelf.

• The challenges facing MENA oil exporters signal a need for skilled and highly qualified human resources in high-tech renewable energy industries. This can be fulfilled by increasing the number of scientists, engineers, professionals and technicians working in different fields of renewable energy research, development and implementation.

• Policies to foster the development of high-technology innovations need to consider governance issues. Particular attention should be paid to reinforcing governance, strengthening institutional capacity, improving the legal framework for intellectual property protection, ensuring more effective and predictable law enforcement, and enhancing transparency and accountability.

• The fight against corruption must continue with the greatest possible support. Transparency should pervade every aspect of the decision-making process and resource allocation as it enables processes and decisions to be monitored and reviewed, and helps ensure that corrupt practices are detected and prosecuted and decision-makers are held accountable for the ramifications of their decisions. Oil-rich MENA governments must step up their efforts to implement open data initiatives and facilitate stakeholder access to, and use of, public information and data concerning policies, initiatives, salaries, budget allocations and spending. This, in turn, ensures that a robust system of checks and balances is in place.

• The removal of trade barriers facilitates a more rapid transfer of renewable energy technologies. Therefore, these governments should take decisive steps to liberalize trade, promote the integration of renewable energy markets within the MENA region and with other leading countries in renewable energy production, and unlock greater scale economies in renewable energy industries.

• Financial development is of roughly equal importance in promoting renewable energy technologies and energy efficiency. Efforts must therefore be directed to creating a financial environment that is conducive to investment in renewables, improving the range of financial services, widening access to finance, developing financial intermediation, streamlining the costs of financial resources, taking preemptive actions to ensure financial market stability, and advancing financial sector reforms aimed at restoring confidence.

• An attractive investment environment to encourage alternative energy source development is desperately needed in MENA oil exporters. Measures to relax investment restrictions, simplify the procedures for issuing investment licenses, remove unnecessary burdens and bureaucratic blockages, and provide a regulatory framework that contains guarantees to attract foreign investors and address their specific concerns, must be implemented for the sake of clean and sustainable energy development in MENA oil-exporting countries.

• These actions should be coupled with the maintenance and restoration of political stability which has a large bearing on whether or not foreign investors will be enticed to invest in renewable energy projects.

Despite the fact that this paper has filled a gap in the existing research on oil revenues, innovation, financial development, governance and renewable energy production in oil-rich countries, it has certain limitations that provide inspiration for further research. First, this paper mainly focused on MENA oil-exporting countries whose economies remain extremely reliant on oil. Future research may include and shed light on MENA oil-importing countries like Egypt, Jordan, Lebanon, Morocco, and Tunisia. Second, this study explored the differences between GCC countries and their non-GCC counterparts whereas future studies can explore whether cooperation between GCC and non-GCC countries can lead to better performance in innovation and renewable energy generation. Third, the present study depends on macro-level data while future follow-up research and economic analysis can provide further insight into the contribution of public and private companies to supporting and reinforcing renewable energy innovation using micro-level data from surveys.

References

Abban, A. R., & Hasan, M. Z., 2021. Revisiting the determinants of renewable energy investment-New evidence from political and government ideology. *Energy Policy*, *151*, 112184.

Aguirre, M., & Ibikunle, G., 2014. Determinants of renewable energy growth: A global sample analysis. *Energy policy*, *69*, 374-384.

Ahmad, M., Işık, C., Jabeen, G., Ali, T., Ozturk, I., & Atchike, D. W., 2021. Heterogeneous links among urban concentration, non-renewable energy use intensity, economic development, and environmental emissions across regional development levels. *Science of The Total Environment*, *765*, 144527.

Alam, M. M., & Murad, M. W., 2020. The impacts of economic growth, trade openness and technological progress on renewable energy use in organization for economic co-operation and development countries. *Renewable Energy*, *145*, 382-390.

Al-Maamary, H. M., Kazem, H. A., & Chaichan, M. T., 2017. The impact of oil price fluctuations on common renewable energies in GCC countries. *Renewable and Sustainable Energy Reviews*, *75*, 989-1007.

Altıntaş, H., & Kassouri, Y., 2020. The impact of energy technology innovations on cleaner energy supply and carbon footprints in Europe: a linear versus nonlinear approach. *Journal of Cleaner Production*, *276*, 124140.

Alvarez-Herranz, A., Balsalobre-Lorente, D., Shahbaz, M., & Cantos, J. M., 2017. Energy innovation and renewable energy consumption in the correction of air pollution levels. *Energy policy*, *105*, 386-397.

Arellano, M., & Bond, S., 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The review of economic studies*, *58*(2), 277-297.

Arellano, M., & Bover, O., 1995. Another look at the instrumental variable estimation of error components models. *Journal of econometrics*, *68*(1), 29-51.

Atalay, Y., Biermann, F., & Kalfagianni, A., 2016. Adoption of renewable energy technologies in oil-rich countries: Explaining policy variation in the Gulf Cooperation Council states. *Renewable Energy*, *85*, 206-214.

Bellakhal, R., Kheder, S. B., & Haffoudhi, H., 2019. Governance and renewable energy investment in MENA countries: How does trade matter?. *Energy Economics*, *84*, 104541.

Blundell, R., & Bond, S., 1998. Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics*, *87*(1), 115-143.
Chen, S., Saud, S., Bano, S., & Haseeb, A., 2019. The nexus between financial development, globalization, and environmental degradation: Fresh evidence from Central and Eastern European Countries. *Environmental Science and Pollution Research*, *26*(24), 24733-24747.
Doytch, N., & Narayan, S., 2016. Does FDI influence renewable energy consumption? An analysis of sectoral FDI impact on renewable and non-renewable industrial energy consumption. *Energy Economics*, *54*, 291-301.
Ergun, S. J., Owusu, P. A., & Rivas, M. F., 2019. Determinants of renewable energy consumption in Africa. *Environmental Science and Pollution Research*, *26*(15), 15390-15405.
Fatima, N., Li, Y., Ahmad, M., Jabeen, G., & Li, X., 2021. Factors influencing renewable energy generation development: a way to environmental sustainability. *Environmental Science and Pollution Research*, *28*(37), 51714-51732.
Frondel, M., Ritter, N., Schmidt, C. M., & Vance, C., 2010. Economic impacts from the promotion of renewable energy technologies: The German experience. *Energy Policy*, *38*(8), 4048-4056.
Gatzert, N., & Kosub, T., 2017. Determinants of policy risks of renewable energy investments. *International journal of energy sector management*. 11, 28-45.
Gielen, D., Boshell, F., Saygin, D., Bazilian, M. D., Wagner, N., & Gorini, R., 2019. The role of renewable energy in the global energy transformation. *Energy Strategy Reviews*, *24*, 38-50.
Goldemberg, J., Schaeffer, R., Szklo, A., & Lucchesi, R., 2014. Oil and natural gas prospects in South America: Can the petroleum industry pave the way for renewables in Brazil?. *Energy policy*, *64*, 58-70.
Gonzalez de Asis, M., O'Leary, D., Ljung, P., & Butterworth, J., 2009. Improving Transparency, Integrity, and Accountability in Water Supply and Sanitation: Action, Learning, Experiences. Washington, D.C.: World Bank.
Hall, D., 1999. Privatisation, multinationals, and corruption. *Development in Practice*, *9*(5), 539-556.
Hansen, B. E., & West, K. D., 2002. Generalized method of moments and macroeconomics. *Journal of Business & Economic Statistics*, *20*(4), 460-469.
Hashemizadeh, A., & Ju, Y., 2021. Optimizing renewable energy portfolios with a human development approach by fuzzy interval goal programming. *Sustainable Cities and Society*, *75*, 103396.
Hille, E., Althammer, W., & Diederich, H., 2020. Environmental regulation and innovation in renewable energy technologies: Does the policy instrument matter?. *Technological Forecasting and Social Change*, *153*, 119921.
IEA, 2020. Energy Technology RD&D Statistics Overview. Paris: International Energy Agency.
Ji, Q., & Zhang, D., 2019. How much does financial development contribute to renewable energy growth and upgrading of energy structure in China?. *Energy Policy*, *128*, 114-124.
Khan, A., Chenggang, Y., Hussain, J., & Kui, Z., 2021. Impact of technological innovation, financial development and foreign direct investment on renewable energy, non-renewable energy and the environment in belt & Road Initiative countries. *Renewable Energy*, *171*, 479-491.
Khan, M. I., Yasmeen, T., Shakoor, A., Khan, N. B., & Muhammad, R., 2017. 2014 oil plunge: Causes and impacts on renewable energy. *Renewable and Sustainable Energy Reviews*, *68*, 609-622.
Khandker, L. L., Amin, S. B., & Khan, F., 2018. Renewable energy consumption and foreign direct investment: Reports from Bangladesh. *Journal of Accounting, Finance and Economics*, *8*(3), 72-87.
Kim, J., & Park, K., 2016. Financial development and deployment of renewable energy technologies. *Energy Economics*, *59*, 238-250.
Komendantova, N., Patt, A., & Williges, K., 2011. Solar power investment in North Africa: Reducing perceived risks. *Renewable and Sustainable Energy Reviews*, *15*(9), 4829-4835.
Komendantova, N., Pfenninger, S., & Patt, A., 2014. Governance barriers to renewable energy in North Africa. *The International Spectator*, *49*(2), 50-65.
Kumar, S., Kaur, T., Upadhyay, S., Sharma, V., & Vatsal, D., 2020. Optimal sizing of stand alone hybrid renewable energy system with load shifting. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 1-20.
Le, T. H., Nguyen, C. P., & Park, D., 2020. Financing renewable energy development: Insights from 55 countries. *Energy Research & Social Science*, *68*, 101537.

Li, N., Pei, X., Huang, Y., Qiao, J., Zhang, Y., & Jamali, R. H., 2022. Impact of financial inclusion and green bond financing for renewable energy mix: implications for financial development in OECD economies. *Environmental Science and Pollution Research*, *29*(17), 25544-25555.

Li, S., & Shao, Q., 2021. Exploring the determinants of renewable energy innovation considering the institutional factors: A negative binomial analysis. *Technology in Society*, *67*, 101680.

Liu, T., & Hamori, S., 2020. Spillovers to renewable energy stocks in the US and Europe: are they different?. *Energies*, *13*(12), 3162.

Lopez, R., & Mitra, S., 2000. Corruption, pollution, and the Kuznets environment curve. *Journal of Environmental Economics and Management*, *40*(2), 137-150.

Marques, A. C., & Fuinhas, J. A., 2011. Drivers promoting renewable energy: A dynamic panel approach. *Renewable and sustainable energy reviews*, *15*(3), 1601-1608.

Negro, S. O., Alkemade, F., & Hekkert, M. P., 2012. Why does renewable energy diffuse so slowly? A review of innovation system problems. *Renewable and sustainable energy reviews*, *16*(6), 3836-3846.

Nematollahi, O., Hoghooghi, H., Rasti, M., & Sedaghat, A., 2016. Energy demands and renewable energy resources in the Middle East. *Renewable and Sustainable Energy Reviews*, *54*, 1172-1181.

Nesta, L., Vona, F., & Nicolli, F., 2014. Environmental policies, competition and innovation in renewable energy. *Journal of Environmental Economics and Management*, *67*(3), 396-411.

Overland, I., Bazilian, M., Uulu, T. I., Vakulchuk, R., & Westphal, K., 2019. The GeGaLo index: Geopolitical gains and losses after energy transition. *Energy Strategy Reviews*, *26*, 100406.

Pfeiffer, B., & Mulder, P., 2013. Explaining the diffusion of renewable energy technology in developing countries. *Energy Economics*, *40*, 285–296.

Rahman, A., Dargusch, P., & Wadley, D., 2021. The political economy of oil supply in Indonesia and the implications for renewable energy development. *Renewable and Sustainable Energy Reviews*, *144*, 111027.

Rasoulinezhad, E., & Saboori, B., 2018. Panel estimation for renewable and non-renewable energy consumption, economic growth, CO2 emissions, the composite trade intensity, and financial openness of the commonwealth of independent states. *Environmental Science and Pollution Research*, *25*(18), 17354-17370.

Scherman, W. S., & Fleischer, J. J., 2015. The environmental protection agency and the clean power plan: A paradigm shift in energy regulation away from energy regulators. *Energy LJ*, *36*, 355.

Sequeira, T. N., & Santos, M. S., 2018. Renewable energy and politics: A systematic review and new evidence. *Journal of Cleaner Production*, *192*, 553-568.

Shafiullah, M., Miah, M. D., Alam, M. S., & Atif, M., 2021. Does economic policy uncertainty affect renewable energy consumption?. *Renewable Energy*, *179*, 1500-1521.

Shah, I. H., Hiles, C., & Morley, B., 2018. How do oil prices, macroeconomic factors and policies affect the market for renewable energy?. *Applied energy*, *215*, 87-97.

Shahbaz, M., Topcu, B. A., Sarıgül, S. S., & Vo, X. V., 2021. The effect of financial development on renewable energy demand: The case of developing countries. *Renewable Energy*, *178*, 1370-1380.

Su, C. W., Umar, M., & Khan, Z., 2021. Does fiscal decentralization and eco-innovation promote renewable energy consumption? Analyzing the role of political risk. *Science of The Total Environment*, *751*, 142220.

Tamazian, A., & Rao, B. B., 2010. Do economic, financial and institutional developments matter for environmental degradation? Evidence from transitional economies. *Energy economics*, *32*(1), 137-145.

Ulucak, R., 2021. Renewable energy, technological innovation and the environment: a novel dynamic auto-regressive distributive lag simulation. *Renewable and Sustainable Energy Reviews*, *150*, 111433.

Van de Ven, A. H., 2017. The innovation journey: you can't control it, but you can learn to maneuver it. *Innovation*, *19*(1), 39-42.

Vural, G., 2021. Analyzing the impacts of economic growth, pollution, technological innovation and trade on renewable energy production in selected Latin American countries. *Renewable Energy*, *171*, 210-216.

Wang, Q., & Dong, Z., 2021. Does financial development promote renewable energy? Evidence of G20 economies. *Environmental Science and Pollution Research*, *28*(45), 64461-64474.
Wang, R., Tan, J., & Yao, S., 2021. Are natural resources a blessing or a curse for economic development? The importance of energy innovations. *Resources Policy*, *72*, 102042.
Zhou, A., & Li, J., 2022. How do trade liberalization and human capital affect renewable energy consumption? Evidence from the panel threshold model. *Renewable Energy*, *184*, 332-342.