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Renewable Energy Transition, Trade Openness, and CO_2 Emissions Nexus in the Middle East

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ABSTRACT

Reducing pollutant emissions during the global energy transition from fossil fuels to renewables is a significant endeavor. Nonetheless, a significant portion of the Middle East (ME) economy continues to be based mostly on the extraction and use of fossil fuels, posing a threat to the environment in the area. Thus, the current study examined the impact of income growth, trade openness (TO), and the Renewable Energy Transition (RET) on CO_2 emissions in 12 Middle East nations, from 2000 to 2019. The findings demonstrated that the ME area contains the Environmental Kuznets Curve. RET decreased emissions of CO_2. Therefore, the transition to renewable energy reduced emissions in this ME region. On the other hand, TO enhances CO_2 emissions. For the ME region, TO is concerned with the environment. The research recommends a quick RET to safeguard the environment from CO_2 emissions.

Keywords: Trade Openness; Renewable Energy Transition; CO_2 emissions; Middle East
JEL Classifications: F14, Q20, Q50

1. INTRODUCTION

To reduce pollution emissions in any sector or area, the Renewable Energy Transition (RET) process appears to be essential. Nonetheless, the majority of the economies in the Middle East (ME) still depend on the production and use of fossil fuels. For example, over 30% of oil resources and over 20% of natural gas resources are found in these economies (BP STAT, 2023). Similarly, in terms of fossil fuel output, the Middle East region occupies a prominent position. On the other hand, since 2000, the majority of Middle Eastern economies have worked to switch from fossil fuels to renewable energy sources; nonetheless, fewer than 1% of energy might still come from renewable sources (IRENA, 2021). Furthermore, the area accounts for more than 5% of global pollutant emissions worldwide (Global Carbon Atlas, 2023). A total of US$ 0.765 billion in exports and US$ 0.668 billion in imports in 2020 defined the ME's foreign trade dynamics. According to data from the World Integrated Trade Solution (2023), the region has the main traded commodities with environmental problems. A large amount of trade activity is accounted for by the extensive energy usage. This implies that while imports may potentially raise emissions into the region because of their energy-intensive nature, exports from the ME region may also cause emissions to enter the region (Mahmood et al., 2022a; 2022b).

The topic of whether or not this little percentage of renewable energy helps reduce pollution emissions is raised by the scant progress made in the transition to renewable energy. How strong of a relationship is it to develop future renewable transition plans based on historical experience if this relationship is statistically significant? Hence, this research would help in devising practical policies for the renewable transition of the Middle East and become a source of a practical solution in the region. However, this study also adds empirically to the Middle East's energy literature, as there is a dearth of thorough studies emphasizing the significance of the region's shift to renewable energy sources. Abbasi et al. (2021) in Thailand, Adebayo et al. (2021) in Argentina, Conteh et al. (2021) in South Africa, Ben Jebli et al. (2015) in Africa, Anwar et al. (2021) in Asia, Biswas et al. (2023) in Bangladesh, Erdogan et al. (2020) in OECD countries, Hdom (2019) in South America, Koc and Bulus (2020) in South Korea, and Pata and Caglar (2021) in China are a few previous studies that tested this hypothesis. Nonetheless, there hasn't been much research done on the Middle East in this setting, and this study tries to close this gap in the literature. While some of the research cited has taken the function of trade openness (TO) seriously, others have not. To evaluate the renewable transition hypothesis, the current study additionally takes trade openness into account.

Natural resources are abounding in the ME region, especially reserves of oil and natural gas. Although the mining of these resources has boosted economic growth, worries about their effects on the environment have been raised. The energy industry is a major contributor to the region's emissions, as noted by Abbas et al. (2018). The global energy transition is an important effort to reduce pollution emissions. However, a large number of Middle Eastern economies still primarily rely on fossil fuels, endangering the region's environment. Making the switch to renewable energy might help drastically cut pollution emissions. The goal of this study is to measure how the Middle East's switch to renewable energy has affected environmental emissions. The aim is to obtain a thorough comprehension of the degree to which a transition of this kind can aid in reducing emissions of pollutants. The research also attempts to develop optimal strategies that might facilitate and expedite the region's adoption of RET. The research also acknowledges the contribution that trade liberalization has made to the Middle East's transition to greener energy technologies. Therefore, it needs to be carefully considered how trade openness is affecting this shift. The research's conclusions are highly relevant to policy since they can help direct efforts to move Middle Eastern economies toward a shift to renewable energy sources. By doing this, the area may significantly advance toward accomplishing the Sustainable Development Goals (SDGs), paving the way for a future that is both ecologically benign and sustainable. Therefore, from 2000 to 2019, the current study examined the effects of economic growth, TO, and RET on CO_2 emissions in 12 ME economies.

2. LITERATURE REVIEW

Six nations were the subject of a comprehensive analysis carried out by Azam et al. (2022) that covered the years 1975–2018. According to their findings, variables that contributed to higher CO_2 emissions were urban population development, industrialization, increased trade, and higher energy usage. It's interesting to note that the study found a moderating effect on emissions from higher income levels. India from 1980 to 2018 was examined by Jiao et al. (2021). According to the study, higher exports and innovations were associated with higher CO_2 emissions, whereas lower exports and rising oil prices were associated with lower emissions. Data from G7 countries was examined by Sharif et al. (2022). Their results made it clear that financial incentives, trade, and green breakthroughs were linked to lower CO_2 emissions. Saqib et al. (2022) examined seven of the world's largest economies, focusing on the years 1990–2020. Their research showed that the reduction of the ecological footprint was mostly dependent on innovation and renewable energy consumption (REC). South Asian nations were examined by Tariq et al. (2022) between 1981 and 2018. According to their research, greenhouse gas (GHG) emissions rose due to exports, economic growth, and overall trade. On the other hand, elements that have been linked to a decrease in GHG emissions include sophisticated industrial technology, imports, and the adoption of green energy. Ahmed et al. (2019) examined eight economies. According to their analysis, increasing exports were linked to higher CO_2 emissions. These revelations highlight the complex interplay of trade, economic variables, and emissions, underscoring the necessity for sophisticated approaches to environmental problems.

Anser et al. (2020) found that TO raised GHG and CO_2 emissions during their 1975–2018 examination in Saudi Arabia. Notably, it was linked to the export of metals and ores. Furthermore, higher CO_2 and GHG emissions were associated with higher power use and advances in financial market development (FMD). Growth in the economy was positively correlated with CO_2 emissions, and the value added by industry led to an increase in it. Analogously, Andriamahery and Qamruzzaman (2022) investigated the effects of overall trade and energy innovation in Tunisia and Morocco from 1980 to 2018. Their research showed a bidirectional relationship, meaning that energy innovation and overall trade both influenced and were influenced by environmental quality. Moreover, their results verified that the Environmental Kuznets Curve (EKC) existed in both nations. Pham et al. (2020) determined the existence of EKC after investigating the dynamics of environmental quality in emerging nations. Furthermore, their study revealed a complex relationship in which merchandised imports showed a declining trend in CO_2 emissions while merchandised exports showed a rising tendency. Rana and Sharma (2019) looked at causal relationships in India between 1982 and 2013, identifying the EKC.

Numerous research studies have emphasized the inverse connection between trade and emissions. An analysis of Pakistan's emissions dynamics from 1970 to 2018, for example, by Ahmad et al. (2022), showed that a drop in CO_2 emissions was correlated with both a positive trade balance and a favorable exchange rate. Nonetheless, a rise in overall production was associated with increased emissions, highlighting the complex interactions between economic and environmental issues. Forslid et al. (2018) discovered that exports contributed to production volumes and reduced emission intensity. This shows that trade helped to generate cleaner output, which in turn helped to improve the environment. After focusing on China, Li et al. (2022) found that trade reduced emissions. The study also showed that medium- and high-technology green items contributed significantly to the decrease in emissions, highlighting the significance of technological developments in supporting environmentally responsible trading practices. According to Jebli et al. (2016), which examined the emissions landscape in OECD nations, non-REC was linked to higher emissions. A decrease in CO_2 emissions has been associated with the use and trading of renewable energy.

Using structural breaks in their model, Shahbaz et al. (2019a) looked into the USA and found the EKC. Interestingly, they discovered that trade openness was connected with lower CO_2 emissions and that foreign direct investment (FDI) was linked to higher emissions. Ren et al. (2014) examined China and found that FDI and trade surpluses led to an increase in CO_2 emissions. Above a certain point, however, industrial income showed the opposite impact, resulting in a decrease in emissions. Muhammad et al. (2020) discovered the EKC in 65 countries. Their research showed that exports mitigated CO_2 emissions, but FDI was associated with higher emissions. Banerjee and Murshed (2020) examined the economies of the BRICS, finding that FDI had a different effect in the BRICS, increasing emissions while decreasing emissions in the G7. According to Wang et al.'s (2023) analysis of 14 European economies between 1995 and 2020, REC and innovations were linked to a smaller ecological footprint. However, there was a correlation found between an increase in ecological footprint and characteristics including FMD, non-REC, and FDI. In a similar vein, Saqib (2022) looked at 18 developed nations between 1990 and 2019 and found that the adoption of REC and positive shocks to technological innovation reduced emissions. When taken as a whole, these studies highlight the environmental effects of FDI and TO. Evidence for the positive environmental effects of FDI is also found in the literature. As an illustration, Aslan et al. (2022) studied oil importers and exporters. According to their findings, there was a correlation between greater income levels and higher CO_2 emissions. On the other hand, trade had the reverse effect, raising emissions in countries that export oil, while FDI played a mitigating function, resulting in a drop in emissions in countries that buy oil. Ghorbal et al. (2022) found that FDI reduced emissions. They did, however, point out the complex link between various economic forces and environmental results. Horobet et al. (2021) confirmed that FDI, imports, and exports were linked to lower CO_2 emissions by expanding their research to 24 EU countries. Investigating the impact of trade between Africa and China on carbon emissions, Tawiah et al. (2021) found a correlation between rising carbon emissions and African exports to China. This linkage highlights the necessity for sophisticated approaches to managing environmental issues that are linked to international economic activity.

Mahmood (2020) carried out a study that covered 21 economies and revealed the EKC phenomenon. In this context, it was found that while FMD tended to raise emissions, FDI emerged as a contributor to emissions reduction. Liu and Wei (2022) examined the details of thirty provinces. Their results showed that variables like income, FDI outflows, and export structure led to a decrease in emissions through the effect of increased energy efficiency while also enhancing emissions through the scale effect. Furthermore, it was shown that FDI outflows could lower CO_2 emissions, especially in energy-intensive industries. In their analysis, Haug and Ucal (2019) found that there was no discernible effect on emissions from rising exports, falling imports, or FDI. Moreover, there was no change in CO_2 intensity as a result of these economic activities. It was determined that urbanization and FMD were causing CO_2 intensity to rise. Together, these studies highlight the complex interactions that influence environmental consequences between trade, income, FDI, and other economic variables. The differences in context between different industries and areas highlight the necessity for customized strategies to address environmental issues related to economic activity.

In their study, Farhani et al. (2014) looked at ten countries in the Middle East and North Africa (MENA), offering empirical evidence in favor of the EKC. Furthermore, they emphasized how trade and the rule of law have favorably shaped the EKC and improved environmental outcomes. During 1990–2015, Shahbaz et al. (2019b) found that FDI and income accelerated emissions. Interestingly, their results showed that biomass energy mitigated emissions, offering a complex picture of the variables affecting environmental results in the area. Bardi and Hfaiedh (2021) confirmed the existence of the EKC theory. Additionally, their research demonstrated a causal link, indicating that FDI influenced higher emissions and bolstered the Pollution Haven Hypothesis (PHH). After carefully examining the 14 MENA nations between 1987 and 2019, Saqib (2021) highlighted the complex interactions that shape the region's energy dynamics. Zhuang et al. (2023) expanded the focus to encompass MENA economies as well as BRI nations, and they confirmed that FDI reduced emissions across the board for the BRI sample. Regional differences in the environmental consequences of FDI were highlighted by the MENA regional analysis, which found that FDI had an influence that increased emissions. After studying the MENA from 2002 to 2019, Tahir et al. (2022) concluded that trade contributed to a decrease in emissions. Nonetheless, their results showed that terrorism had a negative impact and increased CO_2 emissions. All of these studies highlight the intricate and regionally unique dynamics of FDI, trade, and other factors affecting environmental consequences.

Al-Mulali and Sheau-Ting (2014) found that TO increased emissions during their analysis of the MENA economies from 1990–2011. Abdouli and Hammami (2017) found that increased TO and FDI were linked to higher emissions. In their analysis of the MENA from 1990 to 2011, Omri et al. (2015) established a link between TO and CO_2 emissions. Awan et al. (2020) looked at the MENA region and found that FMD caused environmental deterioration. When Bilal et al. (2022) expanded their analysis to include the years 1991–2019, they found a different pattern in which a decrease in CO_2 emissions was associated with globalization. After examining the MENA region from 1970 to 2017, Ekwueme and Zoaka (2020) found that increased TO led to higher CO_2 emissions. The MENA region's complicated interplay between economic activities, globalization, and environmental impacts is highlighted by these diverse studies. Time-related variables and context-specific elements are important in determining the various environmental effects reported in various research studies.

The literature made clear how crucial TO and REC are to CO_2 emissions. In the ME region, there hasn't been any testing done on how TO and RET affect CO_2 emissions. The current study addresses this problem to provide empirical support.

3. METHODOLOGY

The way that trade openness and RET interact has a big impact on how much pollution is produced in a given area. Furthermore, economic expansion might increase pollution emissions and energy demand (Mahmood et al., 2023a, 2023b), especially if renewable energy sources aren't included in the energy mix. As a result, the current analysis makes the following assumptions about a complete CO_2 emissions model that includes TO, RET, and economic growth:

$$LCO_{2it} = f\,(LGDPC_{it}, LGDPC_{it}^{2}, LRET_{it}, LTO_{it}) \quad (1)$$

LCO_{2it} is the logarithm of CO_2 emissions per capita. $LGDPC_{it}$ is the logarithm of Gross Domestic Product (GDP) per capita in US dollars and $LGDPC_{it}^2$ is the square of $LGDPC_{it}$. $LRET_{it}$ is the logarithm of REC percentage of total energy usage. LTO_{it} is the logarithm of the total trade percentage of GDP. All data is taken from 12 ME economies from 2000 to 2019 and sourced from the World Bank (2023).

IPS, LLS, and ADF are the three tests that are utilized for unit root. These, which are supplied by Im et al. (2003), Levin et al. (2022), and Maddala and Wu (1999), confirm the robustness of one another. Cointegration would then be applied using Kao's (1999) technique. We also use the Maddala and Wu (1999) approach to evaluate the robustness. By examining the cointegration vectors using the following aggregating equations, we may be able to confirm the cointegration.

$$y = -2\sum_{i=1}^{N} ln(probability_i) \quad (2)$$

After using the aforementioned equation to test cointegration, Pedroni's (2004) test can be used to confirm robustness by using the following statistics:

$$T^2 N^{1.5} Z_{\hat{v} N,T} \quad T^2 N^{1.5} \sum_{i=1}^{N}\sum_{t=1}^{T} 1/\hat{L}_{11i}^{2}\hat{e}_{i,t\ 1}^{2})\ ^{1} \quad (3)$$

$$TN^{0.5} Z_{\hat{\ } N,T\ 1} = T^2 N^{0.5}\left(\sum_{i=1}^{N}\sum_{t=1}^{T} \frac{}{\hat{L}_{11i}^{2}\hat{e}_{i,t\ 1}} \hat{e}_{i\ t} - \hat{\ }_i\right)$$

$$(\sum_{i=1}^{N}\sum_{t=1}^{T} 1/\hat{L}_{11i}^{2}\hat{e}_{i,t\ 1}^{2})\ ^{1} \quad (4)$$

$$Z_{t\,N,T} = \left(\sum_{i=1}^{N}\sum_{t=1}^{T} 1/\hat{L}_{11i}^{2}\hat{e}_{i,t-1}\Delta\hat{e}_{i,t} - \hat{\lambda}_i\right)(\tilde{\sigma}_{N,T}^{2}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{L}_{11i}^{-2}\hat{e}_{i,t-1}^{2})^{-0.5} \quad (5)$$

$$Z_{t\,N,T}^{*} = \left(\sum_{i=1}^{N}\sum_{t=1}^{T}\frac{1}{\hat{L}_{11i}^{2}\hat{e}_{i,\,t-1}^{*}}\Delta\hat{e}_{i,t}^{*}\right)(\tilde{s}_{N,T}^{*2}\sum_{i=1}^{N}\sum_{t=1}^{T} 1/\hat{L}_{11i}^{2}\hat{e}_{i,t-1}^{*2})^{-0.5} \quad (6)$$

$$TN^{0.5}\tilde{Z}_{\hat{\rho}N,T-1} = T.N^{-0.5}\left(\sum_{t=1}^{T}\hat{e}_{i,t-1}\ddot{A}\hat{e}_{i,t} - \hat{\lambda}_i\right)(\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{e}_{i,t-1}^{2})^{-1} \quad (7)$$

$$N^{-0.5}\tilde{Z}_{t\,N,T} = N^{0.5}\left(\sum_{t=1}^{T}\hat{e}_{i,t-1}\ddot{A}\hat{e}_{i,t} - \hat{\lambda}_i\right)^{-1}\sum_{i=1}^{N}\left(\hat{\sigma}_i^{2}\sum_{t=1}^{T}\hat{e}_{i,t-1}^{2}\right)^{-1} \quad (8)$$

$$N^{-0.5}\tilde{Z}_{t\,N,T}^{*} = N^{0.5}\left(\sum_{t=1}^{T}\hat{e}_{i,\,t-1}^{*}\ddot{A}\hat{e}_{i,\,t}^{*}\right)^{-1}\sum_{i=1}^{N}\left(\sum_{t=1}^{T}\hat{s}_i^{*2}\hat{e}_{i,t-1}^{*2}\right)^{-0.5} \quad (9)$$

The aforementioned equations would imply cointegration when taking heterogeneous country effects into account. Next, we use the Pesaran et al. (1999) technique to determine how our model's variables affect emissions of carbon dioxide. This approach was selected because it uses a Pooled Mean Group (PMG) and yields reliable findings in a mixed integration order.

$$\Delta z_{it} = \alpha_i + \sum_{j=1}^{p-1}\gamma_j\Delta z_{i,t-1} + \sum_{j=0}^{q-1}\beta_j\Delta w_{i,t-1} + \mu_1 z_{i,t-1} + \mu_2 w_{i,t-1} + e_{1it} \quad (10)$$

$$\Delta z_{it} = \alpha_i + \sum_{j=1}^{p-1}\gamma_j\Delta z_{i,t-1} + \sum_{j=0}^{q-1}\beta_j\Delta w_{i,t-1} + \varphi_j u_{i,t-1} + e_{2it} \quad (11)$$

Equations 11 and 12 assess the impacts in the short and long terms. Then, using the FMOLS of Pedroni (2000) and DOLS of Kao and Chiang (2000), the robustness of PMG would be evaluated as follows:

$$\hat{\beta}_{FMOLS} = \left(\sum_{n=1}^{N}\left(\sum_{t=1}^{T}(w_{it} - \overline{w}_i)\,\hat{z}_{it}^{+} + T\hat{\Delta}_{\varepsilon\mu}^{+}\right)\right)/\left(\sum_{i=1}^{N}\sum_{t=1}^{T}(w_{it} - \overline{w}_i)'\right) \quad (12)$$

$$\hat{\beta}_{DOLS} = \left(\sum_{t=1}^{T} z_{it}\hat{z}_{it}^{+}\right).\sum_{i=t}^{N} 1/\sum_{t=1}^{T} z_{it}z_{it}' \quad (13)$$

The above equations eliminate a lot of econometric issues to get reliable findings.

4. DATA ANALYSES

Table 1 shows that LTO_{it} is stationary at the level. Moreover, most of the experiments that have been run show that every differenced variable is stationary. As a result, all of these results point to the dataset's mixed integration order being correct.

The findings of the tests carried out to evaluate long-term relationships, are shown in Table 2. While Kao's test supports a long-term relationship in the model. On the other hand, 5 cointegrating vectors are found in Fisher-Johansen's test. Furthermore, cointegration is supported by Pedroni's test, which yields confirmation in 1 of the 4 weighted statistics. Moreover, Table 3 illustrates that the coefficients of ECT_{t-1} are constantly negative. The models' cointegration is validated by this alignment with the anticipated negative sign. We can move forward with both long- and short-term analyses with confidence with this strong cointegration evidence.

In Table 3, the EKC hypothesis is thoroughly examined and shown to be validated over the long term for all predicted regressions. This conclusion suggests that there is a point at which environmental deterioration starts to diminish as

Table 1: Unit root tests

Series	IPS		LLC		Fisher-ADF	
	C	C & T	C	C & T	C	C & T
Level						
LCO_{2it}	0.6012	−1.1252	−0.5964	−0.2541	10.2571	16.3541
	(0.7052)	(0.1354)	(0.2755)	(0.1252)	(0.5241)	(0.2301)
$LGDPC_{it}$	−1.5641	1.5241	−0.8954	0.5631	16.3541	5.6241
	(0.1352)	(0.8965)	(0.2045)	(0.5964)	(0.2014)	(0.9125)
$LGDPC_{it}^2$	−1.1524	−1.8654	−1.8641	−2.2041	26.5241	27.5241
	(0.2054)	(0.0452)	(0.0354)	(0.0102)	(0.0000)	(0.0000)
$LRET_{it}$	−0.8657	−1.7521	−1.8745	−2.0412	24.5621	24.025
	(0.2641)	(0.0652)	(0.0364)	(0.0197)	(0.0012)	(0.0201)
LTO_{it}	−4.5212	−5.3241	−6.3541	−10.2541	29.3541	30.2541
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
First Difference						
LCO_{2it}	−7.5214	−6.3541	−5.4125	−3.1254	32.415	34.5218
	(0.0000)	(0.0000)	(0.0000)	(0.0010)	(0.0000)	(0.0000)
$LGDPC_{it}$	−7.9654	−7.5241	−8.8541	−9.6251	40.2541	43.2542
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$LGDPC_{it}^2$	−8.6741	−7.0145	−7.5874	−5.0241	45.5241	46.3541
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$LRET_{it}$	−8.9654	−9.6521	−5.9641	−4.9258	56.3542	58.9674
	(0.000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
LTO_{it}	−9.6312	−9.6847	−7.5974	−9.8547	31.5241	35.5218
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Table 2: Cointegration results

Statistics	Test	P-value	Weighed test	P-value
Pedroni test				
V	−1.7608	0.9609	−1.4097	0.9207
Rho	1.0842	0.8609	1.5305	0.9370
PP	−1.5294	0.0631	−0.4392	0.3303
ADF	2.2051	0.9863	0.8679	0.8073
Grouped-rho	2.8820	0.9980		
Grouped-PP	−0.4269	0.3347		
Grouped-ADF	0.6981	0.7574		
Kao test				
Stat	−2.6208	0.0044		
Variance				
Fisher-Johansen test				
Vectors	Trace Stats		Max-Eigen Stats	
0	365.8	0.0000	229.5	0.0000
1	192.6	0.0000	111.4	0.0000
2	102.4	0.0000	56.57	0.0000
3	67.21	0.0000	47.44	0.0005
4	59.53	0.0000	59.53	0.0000

Table 3: Regression Tests

Variable	Coefficient	S.E.	t-value	p-value
FMOLS				
$LGDPC_{it}$	3.6119	0.6243	5.7853	0.0000
$LGDPC_{it}^2$	−0.1528	0.0362	−4.2155	0.0000
$LRET_{it}$	−0.0206	0.0182	−1.1290	0.2603
LTO_{it}	0.0006	0.0009	0.6773	0.4990
DOLS				
$LGDPC_{it}$	1.7108	0.6070	2.8184	0.0058
$LGDPC_{it}^2$	−0.0336	0.0368	−0.9120	0.3640
$LRET_{it}$	−0.0478	0.0083	−5.7636	0.0000
LTO_{it}	0.0025	0.0011	2.3938	0.0186
PMG-Long Run				
$LGDPC_{it}$	2.7778	0.7060	3.9300	0.0000
$LGDPC_{it}^2$	−0.1441	0.0465	−3.1101	0.0020
$LRET_{it}$	−0.0235	0.01331	−1.7602	0.0780
LTO_{it}	0.0122	0.0017	7.0101	0.0000
PMG-Short Run				
$LGDPC_{it}$	−2.7119	14.5724	−0.1902	0.8520
$LGDPC_{it}^2$	0.1114	0.7245	0.1501	0.8780
$LRET_{it}$	0.1639	0.2206	0.7409	0.4580
LTO_{it}	−0.0003	0.0009	−0.3706	0.7140
ECT_{t-1}	−0.1562	0.0649	−2.4102	0.0160

economies improve, which has important implications. An important finding from the investigation is how the shift to renewable energy affects CO_2 emissions. The analysis emphasizes a less positive effect linked to trade openness. The results imply that higher CO_2 emissions are associated with greater trade openness. The intricate connection between trade and environmental effects highlights how crucial it is to take globalization and international trade's environmental effects into account. It encourages a more thorough investigation into the nature of these emissions, taking into account elements like transportation, energy sources connected to increased trade activity, and industry processes. The shift to RET is a good way to cut CO_2 emissions, but trade openness has drawbacks that must be resolved to guarantee that environmental preservation and economic growth coexist together. The negative effect of ECT_{t-1} also confirms the short-term connection. The short-term impacts, however, are insignificant.

The long-term confirmation of the EKC hypothesis offers important new perspectives on the dynamic relationship between environmental effect and income. The shift to renewable energy has been beneficial, highlighting how technologies may help create more sustainability. To alleviate the environmental effects of expanding global trade, however, smart measures and careful analysis are required. Policymakers and researchers can use these findings as a solid basis to build focused initiatives that promote sustainable growth while reducing environmental impact.

5. CONCLUSIONS

The world needs to switch to RET to reduce pollution emissions and promote environmental sustainability. However, a significant portion of the Middle East's economy is still firmly rooted in the exploitation and burning of fossil fuels, which poses a significant obstacle to environmental preservation in the area. In light of this, this paper conducts a thorough analysis of the effects of income, TO, and the RET on CO_2 emissions across 12 Middle Eastern countries, covering the years from 2000 to 2019. The discovery of the EKC in the ME area is the main outcome of this study. According to the EKC, which is a theoretical framework that postulates income levels and environmental degradation, the environmental impact gets worse when economies grow initially, but after a certain point, economic development starts to help the environment. This finding emphasizes how intricately environmental preservation and income interact in the ME region. The RET is shown to be beneficial for the environment. According to the study, switching to RET is connected with a measurable decrease in CO_2 emissions. This research demonstrates how RET has the potential to make a substantial contribution to environmental preservation and is in line with the worldwide conversation about switching to cleaner and more sustainable energy sources. The story of TO and CO_2 emissions in the Middle East is more complex. The findings suggest a positive relationship between emissions and TO. It implies that trading activities may be organized in a way that has comparatively more ecological problems within the framework of the ME region. Nevertheless, more research is necessary to identify the precise mechanisms underlying the complex link between trade openness and environmental effects.

In summary, this study adds an important new understanding to the intricate interactions between ecological consequences and trade. However, together with the benefits of the RET, the discovery of the EKC highlights the region's potential for an environmentally benign and sustainable future. The paradoxical association with trade openness highlights the need for more research and subtle policy interventions to strike a balance between environmental preservation and trade in the ME region. These results provide a strong basis on which policymakers, industry stakeholders, and researchers can work together to design and put into practice policies that promote sustainable development. The study recommends a swift and comprehensive RET in the ME region as a vital tactic to reduce emissions in light of these findings. The beneficial effects of RET are highlighted when compared to the ME region's ongoing reliance on fossil fuels, underscoring the pressing need for radical changes that would bring economic prosperity and environmental stewardship into harmony.

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