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Military Practices and Experiences and Their Effects on the Environment

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Abstract

International humanitarian law provides the guidelines to meet environmental standards during military operations. Thus, we explore the effect of military spending on CO2 emissions in Saudi Arabia by using data from 1971-2022 and the cointegration technique. Moreover, the effect of fossil fuels on CO2 emissions is also tested along with testing the Environmental Kuznets Curve (EKC) in the model. The EKC is corroborated by the effect of economic progress on CO2 emissions in the long and short runs. Moreover, military spending raises CO2 emissions. A 1% increasing military spending raises 0.0414% of CO2 emissions. Thus, military operations and activities are responsible for environmental problems. The effect of fossil fuels is also positive and a 1% increasing fossil fuels raises 1.0984% of CO2 emissions. The short-run results substantiate the long-run conclusions with different elasticity parameters. The study suggests reducing military spending and operations to protect the environment. Moreover, fossil fuel consumption should also be reduced by shifting energy needs toward clean sources.

Keywords: *International Humanitarian Law, Military Practices and Experiences, CO2 Emissions, Fossil Fuels.*

Introduction

Military practices and experiences could have long-lasting effects on the environment. International Humanitarian Law (IHL) regulates and protects civilians, and reduces misery from armed conflicts. The main focus of IHL is to increase human welfare. Thus, IHL also safeguards the environment from warfare. In 1977, the Geneva Conventions stated to protect the natural environment against military operations (Giuffrida, 2013). This legal provision recognizes that the environment is necessary for human survival and overall well-being. Thus, the environmental impact of military activities is a very important discussion in the literature due to modern weapons for warfare, which could pose a threat to the ecosystem of the world and could also cause global warming due to different gases and chemical releases in military operations.

Saudi Arabia is located at a very important geographical location in the Middle East. Moreover, the country has vast oil and other reserves (Mahmood et al., 2023). Thus, the country is facing geopolitical tensions and global threats as well (Del Sarto and Soler i Lecha, 2024). Thus, countries have to invest in military capabilities for national security, regional influence, and its role in international alliances. For this purpose, the country needs military infrastructure to operate military practices. However, the after-effects of the military practices on the environment cannot be ignored keeping in mind the aspects of defense, environment, and economic development. In addition, Saudi Arabia's military practices and environmental challenges are also looked after by the Vision 2030 agenda, which emphasizes economic diversification and sustainability at the same time (Islam and Ali, 2024). Saudi Arabia's military sector is huge and the government is spending a large budget on the military sector due to its geographic location, oil reserves, and geopolitical relationships (Erdoğan et al., 2022). Moreover, the country has the largest economy in the Arab world and the Gulf Cooperation Council (GCC). Thus, Saudi Arabia has to maintain a strong military presence in the country to serve defensive purposes and for its role in regional conflicts.

Military practices are generally involved in a range of activities from military exercises to weapons testing. For this purpose, defense infrastructure also required land and energy resources to operate military operations and practices (Lawrence et al., 2015). For instance, defense practices include airstrikes, ground operations, and the deployment of military equipment. These operations could have environmental problems in terms of air, land, and water pollution (Fernandez-Lopez et al., 2022). Moreover, operating

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military bases, training exercises, and weapons manufacturing could be responsible for environmental problems, which need attention to reduce the environmental effects of military practices. Military activities would increase environmental effects by magnifying disturbing ecosystems and water resources, which also release many pollutant emissions due to dependence on fossil fuels (Hooks and Smith, 2013). First, we discuss the effects of military operations on the destruction of natural landscapes. The construction of military bases, airstrips, and roads for military operation needs a lot of land, which could reduce land usage for other economic purposes and result in habitat loss, soil erosion, loss of biodiversity, and ecological imbalance (Levy, 1996). Moreover, heavy military machinery like tanks and heavy military vehicles can degrade the land and vegetation. Moreover, military operations could release many solid waste and chemicals into the soil, which could further contribute to land pollution and soil degradation.

After discussing the possible effects on land, the environmental effect of military operation can be observed in air pollution due to the use of aircraft, vehicles, and heavy weaponry. For instance, jet fuel, diesel, and other petroleum products for military operations would release CO2 emissions, particulate matter, and other Greenhouse Gases (GHG) emissions into the air (Bem and Bou-Rabee, 2004). This point is particularly important to relate to the Saudi economy, which is using about 99% of energy usage from fossil fuels (Al-Douri et al., 2019). Thus, the military sector can use a significant amount of fossil fuels in its energy-intensive operations, which can contribute to GHG emissions and can affect climate change. Furthermore, weapons testing and explosions would emit many pollutants including GHG emissions, toxic chemicals, and heavy metals (Shukla et al., 2023), which can pollute the country on a large scale. Moreover, military operations could also contribute to water pollution. For instance, military operations would utilize water in military bases and training facilities, which could put pressure on clean scarce water resources. Moreover, fuel, lubricants, and chemicals used in military vehicles and equipment during military activities can pollute water by releasing hazardous materials in water.

Other than the negative expected environmental problems of military operations, the military sector can adopt sustainable practices to avoid environmental problems due to military operations (Smaliukiene, 2018). For instance, the military sector can reduce its reliance on fossil fuels for its energy needs and could find some alternative sustainable energy sources. Renewable sources including biofuels would help reduce emissions (Mahmood et al., 2024a,b). Moreover, the adoption of sustainable practices in the construction and maintenance of defense infrastructure could also reduce environmental problems (Light, 2014). In the same line, Saudi Vision 2030 has targets to reduce environmental problems in the country. Thus, the country has recently invested in a lot of renewable energy projects to reduce fossil fuel consumption in the country and to save the environment from unclean energy usage. Moreover, the country also targeting to reduce dependence on the oil sector and introduce many sustainable practices in the industry and economy. Thus, the same approach can also be utilized for the military sector to reduce the environmental problems of this sector.

The above discussions highlight the expected environmental problems of military operation and also underscore the remedial measures. In this context, the exact effect of military activities on the environment is an empirical question, which has been intensively investigated by the recent literature (Idroes et al., 2024; Uddin et al., 2024; Muhammad et al., 2024; Konuk et al., 2024). However, this testing is missing the Saudi literature and the present study is an effort to fill this literature gap. Thus, the present study utilizes a long dataset from 1971 to 2022 to investigate the effect of the military sector on CO2 emissions in the Saudi economy to provide insightful empirical evidence to float more informed military policies for this economy to avoid environmental problems of military operation in the economy.

Literature Review

The recent literature has intensively investigated the connection between Military Expenditures (ME) and environmental problems. Different studies have been conducted in different geographical regions with both time series and panel approaches. For instance, Wu et al. (2023) utilized wavelet analysis to investigate the EKC in G7 countries from 1970 to 2018 and revealed the causality between ME and environmental pollution. Particularly, causality was observed from military expenditures to pollution in Italy, the UK, and

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the USA. Economic growth was also included as a control variable. This causality was found in Japan and France. Thus, the results suggested that military spending was raising pollution in most G7 economies. Idroes et al. (2024) explored North Africa to analyze the nexus between ME, globalization, Renewable Energy Consumption (REC), and emissions from 1995-2021. The authors found that military spending had an insignificant effect on emissions. However, globalization and REC mitigated CO2 emissions. Nevertheless, manufacturing and tourism increase emissions, and the authors emphasized the sector-specific impacts of economic activities on emissions to reduce environmental problems in the military sector.

Solarin et al. (2018) investigated the impact of military expenditure in the USA from 1960-2015 and employing multiple time-series models. The authors found that ME increased emissions. Moreover, non-REC and urbanization also increased emissions. Contrariwise, REC, financial development, and trade mitigated emissions. The authors also used the ecological footprint proxy of environment and military expenditure. Thus, the authors offered policy recommendations to reduce military spending. Uddin et al. (2024) focused on G20 economies from 1980 to 2019 and analyzed military spending's influence on emissions. The authors found that military expenditures raised CO2 emissions, which is realized for policy interventions to regulate military spending in favor of the environment. Smith and Lengefeld (2020) examined 126 economies from 2000-2010 to investigate the nexus between war practices and the environment. The author found that warfare and risk-transfer militarism raised emissions. However, the results were varied between developed and developing nations. Moreover, carbon emissions were fluctuating the economic prosperity and decline. Efayena and Olele (2024) analyzed 35 African economies between 1990 and 2021 through quantile regression and revealed that military expenditures increased CO2 emissions. Moreover, feedback is also reported between emissions and military activities. The authors recommended incorporating environmental sustainability to mitigate these adverse effects of military activities.

Jorgenson and Clark (2016) scrutinized 81 nations between 1990 and 2010 to assess how ME and personnel influence emissions and found that the impact of ME on emissions was found in OECD compared to non-OECD economies. Thus, military activities contributed to environmental change and it was suggested to conduct sustainability research to reduce military impacts on environmental problems. In Pakistan, Muhammad et al. (2024) used a period from 1971-2014 and concluded that military expenditures and financial development raised CO2 emissions. However, democratic regimes helped control environmental degradation. These findings floated a political dimension to suggest governance systems in mediating the environmental impacts of military spending. Bildirici (2018) investigated the nexus between GHG emissions, economic progress, biofuels, and militarization in G7 countries from 1985-2015 and found that both economic progress and militarization raised CO2 emissions. Moreover, economic progress and militarization caused GHG emissions, which also suggested reducing militarization to save environmental degradation.

Asongu and Ndour (2023) examined 40 African countries between 2010 and 2020 and confirmed that military expenditure raised CO2 emissions. However, good governance mitigated these effects, which underscored the importance of strengthening institutions to reduce the environmental problems of military activities. Bildirici (2017a) examined the nexus among CO2 emissions, militarization, and economic progress in the USA from 1960 to 2013 and used the bound test. The study found a positive effect of militarization. A causality was also found from ME to emissions. Thus, militarization and energy usage explained CO2 emissions, which highlighted these factors in accelerating environmental degradation. Li et al. (2023) analyzed the BRICS nations from 1990 to 2021 and examined the effects of institutions, innovations, and trade on emissions. The authors showed that economic progress and trade increased emissions. The EKC was also corroborated and innovations reduced emissions Interestingly, institutional conflicts did not affect emissions.

Samaras et al. (2019) investigated military operations and clean energy nexus. Their research highlighted that the military had advanced energy technologies to enhance energy efficiency by developing renewable energy projects. This shift also included energy systems for military installations and clean fuels for weapons as well. In the study of 15 NATO economies from 1991-2018, Pata et al. (2023) found that energy usage

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and military spending raised emissions. However, technical progress moderated the adverse environmental outcomes of military expenditures, which suggested advancing technology for military operations and activities to offset their environmental damage. However, Financial Market Development (FMD) raised emissions, which could have a bad effect on the nexus between military activities and the environment as well. Bildirici (2017b) evaluated the nexus between emissions, ME, and biofuel in the USA from 1984 to 2015 by using ARDL and found feedback between biofuel and economic progress. The same effects were found between militarization and CO2 emissions. Thus, the authors revealed that militarization and energy usage raised CO2 emissions.

Ben Youssef (2023) examined the USA to explore the nexus between REC, energy trading, military spending, and emissions and found that military expenditures were reducing CO2 emissions due to increasing in REC and declining energy importing. Moreover, arms exporting was raising REC, which again helped reduce emissions. Bildirici (2017c) focused on G7 countries from 1985 to 2015 and examined the effects of militarization on CO2 emissions and found causality from ME to CO2 emissions. Moreover, feedback was observed between economic progress and militarization. The same relationship was found between energy and militarization. Jahanger et al. (2023) analyzed nuclear economies from 1990 to 2018 and indicated the EKC. Thus, it reflected a nonlinear relationship between economic progress and the environment. Moreover, the authors found that ME mitigated the ecological footprint. Thus, nuclear energy and military expenditure should be combined to reduce environmental problems. Ullah et al. (2021) explored the effects of militarization on emissions in Pakistan and India from 1985 to 2018 and found that militarization raised economic progress. A 1% increasing militarization raised 0.818% income in Pakistan and reduced carbon emissions by 1.034%. In India, a 1% increasing militarization raised 3.849% of income and reduced 0.337% of carbon emissions. In a study on the G7 economies between military expenditures and emissions, Konuk et al. (2024) found that FMD and energy usage raised emissions by using data from 1971-2019. Military spending reduced emissions, which suggested that defense-related activities are environmentally friendly in these advanced economies.

The literature reflected that military spending could have different effects on emissions. Like, military expenditures decreased CO2 emissions in some studies. However, most studies found a positive effect on emissions. The relationship is not tested in Saudi Arabia, Thus, we investigate this relationship by using Saudi data from 1971-2022.

Methodology

The paper aims to find the linkages between military practices and their effects on the environment. The military practices and activities are captured by the proxy of military spending as suggested by the recent literature (Wu et al., 2023; Idroes et al., 2024; Uddin et al., 2024; Efayena and Olele, 2024; Asongu and Ndour, 2023; Pata et al., 2023; Ben Youssef, 2023). Moreover, the literature highlighted adding energy variables in the model as the type of energy usage can help in tracing the relationship between the military sector and emissions (Idroes et al., 2024; Ben Youssef, 2023). Solarin et al. (2018) suggested including non-REC energy sources in the model of the military sector as this sector can heavily depend on fossil fuel energy sources. It is particularly important for the Saudi economy as 99% of the energy needs of the economy are served by fossil fuels. In addition, it is also pertinent to consider the effect of economic growth on emissions. Grossman and Krueger (1991) were pioneers in proposing a non-linear relationship (the EKC) between economic progress and environmental degradation. The EKC explains that economic growth at the early stages raises emissions because of industrialization and resource consumption in the economy. However, demand for environmental quality may emerge with higher levels of development, which could help decline in emissions. Thus, this concept forms the inverted U-shaped relationship between economic growth and emissions. Thus, we hypothesize the model as follows:

$$\mathrm{CO}_t = f(\mathrm{Y}_t, Y_t^2, \mathrm{MS}_t, \mathrm{FFC}_t) \qquad (1)$$

In Equation 1, $CO2_t$ represents the natural log of CO2 emissions per capita and data is sourced from Global Carbon Atlas (2024). Y_t is the natural log of Gross Domestic Product (GDP) per capita and Y_t^2 is

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the square of Y_t. It is an indicator of economic prosperity and growth. MS_t refers to the natural log of military spending as a percentage of GDP, which is a proxy for military practices and activities. FFC_t is a natural log of fossil fuel usage as a percentage of GDP, which is a proxy for energy usage in the military sector in Saudi Arabia. Macroeconomic data on these factors, except $CO2_t$, is sourced from the World Bank (2024) dataset. The data is converted into natural logarithms, which allows us to interpret the relationships among variables by reducing skewness and capturing elasticity estimations. This transformation would enhance the statistical suitability of the series, which could also ensure that the percentage changes in the variables can be interpreted.

Before proceeding with further analysis, it is necessary to examine the unit root issues in the variables. Non-stationary series would lead to spurious results if not taken care of its stationary around the stochastic trend. We first perform unit root testing to check for stationarity by using the Ng and Perron (2001) methodology. This method would help enhance power and size properties in detecting unit roots in small sample sizes. Thus, this test could be helpful to determine the stationary of series at levels or differencing. The test statistics are presented in the following way:

$$MZ_a^d = (\left[\frac{y_T^d}{T}\right]^2 - f_0)/2K \quad (2)$$

$$MSB^d = \left[\frac{k}{f_0}\right]^{1/2} \quad (3)$$

$$MZ_t^d = MZ_a^d . MSB^d \quad (4)$$

$$MPT_T^d = [c^2 . K + \frac{1-c}{T}]\frac{Y_T^d}{f_0} \quad (5)$$

The next process of estimation will move to cointegration analysis. The Autoregressive Distributed Lag (ARDL) of Pesaran et al. (2001) is utilized for this purpose. This methodology analyzes both short- and long-run relationships between variables. This technique is equally helpful if the series has a mixed order of integration. Thus, the ARDL is well-suited to handling variables with mixed orders of integration, which is an advantage over traditional cointegration techniques. The ARDL approach also facilitated the modeling of long-term equilibrium relationships with caring short-run adjustments in case of shocks in equilibrium. Moreover, the ARDL model can yield long-run coefficients to measure the equilibrium relationship between variables. In addition, short-run dynamics also capture the speed of adjustment to the equilibrium after any fluctuations in relationships, which would help us to understand the effects of GDP per capita, military expenditures, and fossil fuels on emissions. The estimation process will be started after selecting an appropriate lag structure for each variable. The optimal lag lengths for each variable are selected with the Schwarz Bayesian Criterion (SBC), which also care parsimonious of the model to save the degree of freedom for robust results. The ARDL of the model in Equation 1 is as:

$$\Delta CO2_t = a_0 + a_1 CO2_{t-1} + a_2 Y_{t-1} + a_3 Y_{t-1}^2 + a_4 MS_{t-1} + a_5 FFC_{t-1} + \sum_{i=1}^{n-1} b_{1i} \Delta CO2_{t-i} + \sum_{i=0}^{n-1} b_{2i} \Delta Y_{t-i} + \sum_{i=0}^{n-1} b_{3i} \Delta Y_{t-i}^2 + \sum_{i=0}^{n-1} b_{4i} \Delta MS_{t-i} + \sum_{i=0}^{n-1} b_{5i} \Delta FFC_{t-i} + \Omega_{1t} \quad (6)$$

After calculating the long-run effects, Equation 6 is shifted to changes for short-run analyses, which is modified by adding the error correction term (ECT_{t-1}) in this ARDL framework. This term could capture the speed from short-term deviations to the long-run equilibrium. It also reflects how quickly the system returns to equilibrium after getting shocks. The coefficient of the ECT_{t-1} should be negative to ensure a stable convergence equilibrium. Its larger coefficient could suggest a faster adjustment to equilibrium and vice versa. The following Equation 7 shows the short-run model:

$$\Delta CE_t = b_1 ECT_{t-1} + \sum_{i=1}^{n-1} b_{1i} \Delta CO2_{t-i} + \sum_{i=0}^{n-1} b_{2i} \Delta Y_{t-i} + \sum_{i=0}^{n-1} b_{3i} \Delta Y_{t-i}^2 + \sum_{i=0}^{n-1} b_{4i} \Delta MS_{t-i} + \sum_{i=0}^{n-1} b_{5i} \Delta FFC_{t-i} + \Omega_{2t} \quad (7)$$

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Equation 7 will be regressed to capture the short-run relationships in the model. The parameter of the ECT_{t-1} should be negative to ensure a short-run relationship, which will also show the speed of adjustment to the long-run equilibrium after any deviations. This speed can be expressed in months, which would divert the fluctuation to the long-run path. Lastly, the short-run estimated coefficients will measure the short-run response of the dependent variable.

Results and Discussions

In the estimation procedure, we first estimate descriptive statistics, which shows that the means value of all series is greater than the Standard Deviation (Std. Dev.), which reflects the less dispersion of variables. However, the normality and stationarity of the series is another concern, which is estimated in Table 2.

Table 1. Descriptive Statistics

	$CO2_t$	Y_t	Y_t^2	MS_t	FFC_t
Mean	2.7192	9.2072	85.2114	2.4103	4.6046
Median	2.7003	9.0774	82.3985	2.3833	4.6050
Maximum	3.0577	10.0931	101.8706	2.9447	4.6051
Minimum	2.2819	7.0239	49.3359	1.9782	4.592
Std. Dev.	0.1897	0.6685	11.8458	0.2671	0.0014

Table 2 shows Ng-Perron unit root results. All leveled series are non-stationary except FFC_t, which is stationary. All differenced series are stationary. Thus, the results show a mixed order of integration. We may accept these results for further analysis with the ARDL model, which is efficient in this situation (Pesaran et al., 2001).

Table 2. Ng-Perron Test Results

Variables	MZa	MZt	MSB	MPT
$CO2_t$	-3.7343	-1.2243	0.3279	6.6199
Y_t	-3.2079	-1.2266	0.3824	27.5258
Y_t^2	-3.4419	-1.2795	0.3718	25.8778
MS_t	-7.9005	-1.9857	0.2513	11.5390
FFC_t	-18.4018**	-3.0289**	0.1646**	4.9783**
$\Delta CO2_t$	-23.8273***	-3.4513***	0.1448**	3.8260***
ΔY_t	-21.6822**	-3.2879**	0.1516**	4.2313**
ΔY_t^2	-21.9281**	-3.3017**	0.1506**	4.2133**
ΔMS_t	-23.8552***	-3.4204**	0.1434**	4.0188***
ΔFFC_t	-22.6209**	-3.3631**	0.1487**	4.0284**

Note: *** and ** are presenting stationarity at a 1% and 5% significance level.

Table 3 shows cointegration results based on the Bound test after the lag length assortment by SBC. The estimated F-value=4.7883 is more than the critical value, which corroborates the cointegration in the model. Thus, we may claim that the proposed model has a long-run relationship between hypothesized variables and that all variables follow a stable path in the long run. In addition, the p-values of diagnostic tests are more than 0.1, which validates the good econometric health of the estimated model.

Table 3. Cointegration Test

Dependent	F-statistic	Hetero	Serial corr.	Normality	Function
$\Delta CO2_t$	4.7833	0.8134(0.5952)	0.4092(0.6672)	0.5876(0.7454)	1.1015(0.2776)
At	1%	5%	10%		

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Bound-statistic	3.845-5.150	2.823-3.872	2.372-3.320		

Note: () contains p-values.

Table 4 posits the long-run results. The positive and negative of Y_t and Y_t^2 corroborate the inverted U-shaped effects of economic progress on CO2 emissions, which substantiate the EKC in the Saudi economy. This relationship exposes that this economy has environmental degradation initially by the increasing GDP per capita. However, after reaching a certain level of GDP per capita, the trend gets reversed and economic progress has environmental improvements at later stages of development. This result may be claimed due to increasing industrial activity and resultant higher levels of pollution due to increasing energy consumption. This shows an economic target of industrialization, which can result in higher emissions. However, the further increasing GDP per capita may recall the need for a clean environment to support higher living standards, which increases environmental awareness and tight environmental regulations, which help improve environmental quality.

Table 4. Long Run Estimates

Variables	Parameter	Standard error	t-value	p-value
Y_t	2.7415	1.4476	1.8938	0.0649
Y_t^2	-0.1606	0.0792	-2.0279	0.0488
MS_t	0.0414	0.0095	4.3578	0.0000
FFC_t	1.0984	0.2833	3.8770	0.0000
Intercept	-32.0947	11.7773	-2.7251	0.0163

The coefficient of MS_t is positive. Thus, increasing military spending has increased Saudi emissions. Along the same line, the recent literature has found a positive effect of ME on emissions (Uddin et al., 2024; Efayena and Olele, 2024; Muhammad et al., 2024; Asongu and Ndour, 2023). A 1% increasing military spending could lead to a 0.0414% increase in emissions, which reflects that military operations and activities need energy for vehicles, aircraft, and ships. This energy usage can increase CO2 emissions because fossil fuels are mostly used for military energy needs. Moreover, military infrastructure like the production and maintenance of military equipment also needs energy, which can release CO2 emissions. Because, the manufacturing and operational activities of the military equipment are energy- and carbon-intensive, which results in CO2 emissions. In addition, military operations like training exercises and logistics also require energy inputs, which contribute to CO2 emissions. This discussion leads us to the need for fossil fuels in the model. The coefficient of FFC_t is positive. A 1% increasing fossil fuels could lead to a 1.0984% increase in CO2 emissions. Thus, fossil fuel usage is accelerating CO2 emissions. Fossil fuels are polluting oriented. For instance, the use of coal, oil, and natural gas are carbon-intensive energy sources. The burning of these fossil fuels releases carbon, which interacts with oxygen in the atmosphere to form CO2 emissions.

Table 4. Short Run Estimates

Variables	Parameter	Standard error	t-value	p-value
$\Delta CO2_{t-1}$	0.5587	0.1290	4.3311	0.0001
ΔY_t	1.5317	0.7573	2.0226	0.0500
ΔY_t^2	-0.0897	0.0417	-2.1503	0.0378
ΔMS_t	0.0231	0.0061	3.4952	0.0000
ΔFFC_t	1.6419	0.4234	3.8776	0.0000
ECT_{t-1}	-0.5587	0.1104	-5.0606	0.0000

Table 4 presents short-run estimates. The parameter of ECT_{t-1} is -0.5587, which is negative. The speed of convergence is 0.5587% in a year. So, any short-run fluctuations could be adjusted to the long-run path in less than 2 years. The parameter of $\Delta CO2_{t-1}$ is positive. Thus, increasing CO2 emissions in one year could also increase CO2 emissions in the next year by 0.5587%. Moreover, the positive and negative of ΔY_t and ΔY_t^2 substantiate the EKC. In addition, the coefficient of MS_t is 0.0231. A 1% increasing military spending could lead to a 0.0231% increase in CO2 emissions. This result reflects that military operations and activities have environmental problems. The coefficient of FFC_t is 1.6419 and a 1% increase in fossil fuels raises a 1.6419% increase in emissions. Thus, fossil fuel usage is accelerating CO2 emissions.

Conclusion

Military practices can affect the environment. Thus, we test this effect on pollution in Saudi Arabia by using data from 1971-2022 and the ARDL framework. Moreover, the EKC is also tested and the effect of fossil fuels is examined. The long-run results substantiate the EKC in the Saudi economy. This presence of EKC discloses that the Saudi economy has environmental degradation by increasing with GDP per capita at earlier stages, which exposes a positive relationship. Nevertheless, the relationship gets negative after reaching a certain level of GDP per capita at later stages of development. Moreover, the effect of military spending is positive and a 1% increasing military spending raises 0.0414% of CO2 emissions. Thus, military operations and activities including the use of military vehicles, aircraft, and ships are using unclean energy, which is responsible for CO2 emissions. In addition, military infrastructure and its maintenance also need energy, which is increasing CO2 emissions. Thus, the manufacturing and operational activities of military equipment are pollution-oriented activities. The effect of fossil fuels on emissions is positive and a 1% increasing fossil fuels raises 1.0984% of CO2 emissions. Thus, fossil fuel usage in the Saudi economy is raising CO2 emissions. The short-run conclusions are also the same as long-run results with slightly different elasticity parameters. Thus, military spending and fossil fuel usage also enhance environmental problems in the short run.

The results suggest reducing military spending to reduce its effect on CO2 emission to protect the environment. For this purpose, the military sector should monitor and report the level of CO2 emissions in military activities. So, the regulations should be traced to reduce the emissions. Moreover, the concepts of REC and energy efficiency should be promoted in military equipment and infrastructure to protect the environment from unclean energy usage in this sector. For instance, biofuels, electric vehicles, and renewable energy should be encouraged in military operations and fuel efficiency should be increased for military vehicles, ships, and aircraft. The private contractors and companies to produce military equipment should be provided financial incentives to generate cleaner technologies for military equipment production. Fossil fuels also contribute to CO2 emissions in the Saudi economy. The economy should find alternative clean technologies to meet the overall energy needs of the economy and also for the military sector. For this purpose, renewable energy projects should be financed and supported by government policies. Thus, the private sector should have financial incentives for REC and the installation of renewable energy plants.

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