Journal of Information Systems Engineering and Management
2026, 11(2s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Nexus between Economic Openness, Money Supply, Environmental Degradation and Economic Growth New Evidence from the MENA Region: A CS-ARDL Analysis

Sonia Mannai[1], Kaouther Amiri[2], Lamia Arfaoui[3], Eman DifAllah Alzahrani [4]
1 Department of Finance and Investment, Faculty of Business Administration, University of Tabuk, P.O. Box 741, Tabuk 71491, Saudi Arabia; s_almanae@ut.edu.sa. ORCID: 0009-0002-5937-0949
2 Higher Institute of Management of Tunis, University of Tunisia, Economics Department, Laboratory of International Economic Integration, Faculty of Economic Sciences and Management of Tunis, University Tunis El Manar, Tunisia, kaoutheramiri1@gmail.com ORCID: 0000-0001-5392-1274
3 Department of Business Administration, College of Business Administration, University of Bisha, Bisha, Saudi Arabia, lalarfawi@ub.edu.sa ORCID: 0000-0001-5392-1274
4 Department of Business Administration, College of Business Administration, University of Bisha, Bisha, Saudi Arabia, ealzahrani@ub.edu.sa ORCID: 0009-0003-3847-1027
***Corresponding Author**: s_almanae@ut.edu.sa.*

ARTICLE INFO

Received: 18 Dec 2024
Revised: 10 Feb 2025
Accepted: 28 Feb 2025

ABSTRACT

This study explores the impact of economic (economic openness, credit, money supply) and environmental indicators (CO_2 emissions) on economic growth in Middle East and North Africa (MENA) countries, considering the challenges posed by climate change. Through a theoretical process of transition to a monetary policy that incorporates these issues, the study examines potential strategies of MENA countries. It analyses empirical approaches to the relationship between climate, productivity, and monetary policy. Empirical results reveal that in the MENA region, CO_2 emissions do not significantly impact long-term growth, mainly due to the high dependence on extractive industries. However, this dynamic could conceal long-term challenges, particularly in economic diversification and energy transition. Moreover, private credit has a negative effect on growth, while the money supply has a significant positive impact. Economic openness spurs growth, but its effects are less pronounced. The results call for prudent credit management and tighter regulation while underscoring the importance of energy transition and diversification-orientated economic policies to ensure long-term sustainable and environmentally sound growth.

Keywords: CO_2 emissions, Economic policy, Money supply, Economic growth, CS-ARDL model.

1. INTRODUCTION

Countries in the Middle East and North Africa (MENA) are facing increasing climate change challenges, which are manifesting alarmingly with the frequent establishment of new temperature records over the past five years (Intergovernmental Panel on Climate Change (IPCC, 2021)[1]. This region experienced a significant increase in average temperatures, exceeding pre-industrial levels by 1.25°C (NASA,2021)[2].

This climate change has profound implications for the MENA economy and financial system. Financial authorities, such as the African Development Bank and local central banks, undertake in-depth assessments to measure the economic impact of climate change through economic resilience testing over five years. These assessments include

[1] https://www.ipcc.ch/report/ar6/wg1/
2 https://climate.nasa.gov/vital-signs/global-temperature/

Journal of Information Systems Engineering and Management
2026, 11(2s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

using diversified scenarios developed in collaboration with international climate partners such as the Network for Greening the Financial System.

The objective of these efforts is to identify the sectors most vulnerable to climate risks and formulate appropriate adaptation strategies (BCEAO, 2023[3]; BIS, 2023[4]). This includes adjustments in economic policies, financial infrastructure, and industrial practices to build resilience to the future impacts of climate change. These strategies aim to protect regional financial stability while promoting sustainable economic development that can withstand growing long-term climate challenges.

The consequences of climate change could disrupt the transmission of monetary policy actions from central banks to financing conditions for households and businesses, thereby affecting consumption and investment, underscoring the importance of proactively anticipating and managing these risks (ECB, 2023[5]; NGFS,2023[6]). Climate change is likely to further restrict the effectiveness of conventional monetary policy, particularly by reducing the equilibrium real interest rate, a key indicator for balancing saving and investment. For example, rising temperatures can undermine labor productivity while increasing morbidity and mortality, thus reducing the potential for economic growth. In these circumstances, policymakers may need to reallocate resources toward climate-adaptation measures, while heightened climate-related uncertainty will increase precautionary saving behavior and weaken incentives to invest. These combined effects can put downward pressure on the equilibrium real interest rate, increasing the risk of hitting the lower bound of the policy rate.

Moreover, the effects of climate change on inflation should not be underestimated. The IPCC (2021) notes that an increased frequency of extreme events, such as storms, droughts or heat waves, can disrupt agricultural and industrial production, leading to short-term inflationary pressures. Reduced harvests may, for example, lead to higher food prices, while the adjustment or reconstruction costs borne by businesses are likely to be reflected in final prices. These echoes work by Elekdag & Tuuli, (2022), which highlights how climate shocks can make inflation more volatile and less predictable, making it more difficult for monetary policymakers.

Without effective mitigation and adaptation policies, climate disruptions are likely to become more frequent and severe, with lasting impacts on employment, income and household purchasing power. This calls for an in-depth review of the economic policy frameworks. Integrating climate risks into macroeconomic models is becoming imperative to preserve long-term economic stability.

With this in mind, we contribute to the existing literature by analyzing the interactions between climate change, monetary policy and economic growth in MENA countries. Our approach is built around four complementary strands. First, we offer a theoretical reflection on how monetary policy frameworks need to evolve to better respond to the challenges posed by climate change. Next, we review existing empirical approaches that analyze the interactions between climate, productivity, and monetary policy, drawing on contributions from the NGFS (2020)[7] and the work of Krogstrup, (2019). Third, we will develop a suitable empirical methodology for assessing the effects of climate shocks and monetary responses on economic growth. Finally, we use the CS-ARDL model, which provides a fine analysis of the short- and long-term dynamic relationships between the different variables studied. Our objective is to propose concrete ways of adapting economic policies, considering the specific structural, social and environmental characteristics of MENA countries. This work aims to inform thinking about how to achieve resilient, inclusive and sustainable economic growth in the context of growing climate change.

2. LITERATURE REVIEW

It is crucial to examine case studies, economic models, and data analyses to establish empirical validation of the relationships between climate, productivity, and monetary policy. Here is an overview of the relationships identified in these MENA countries' methods and empirical results.

3https://www.bceao.int/fr
4 https://www.bis.org/publ/bcbs/
5 https://www.ecb.europa.eu
6 https://www.ngfs.net
7 https://www.ngfs.net/system/files/import/ngfs/medias/documents/ngfs_guide_scenario_analysis_final.pdf

Journal of Information Systems Engineering and Management
2026, 11(2s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

The shift to a new policy approach in response to climate change can create a range of adaptation challenges needed to mitigate adverse economic impacts (Dées & Weber, 2021). These challenges include the complex adjustments in economic policies, regulations, and technologies needed to meet the ambitious climate targets set by MENA countries and other international agreements.

In MENA, the transition to a low-carbon economy takes place against a complex and diversified economic backdrop (IPCC, 2022). Historically dependent on revenues from the oil and gas industries, these countries face considerable challenges in diversifying their economies while reducing greenhouse-gas emissions. The high upfront costs associated with the transition to renewables and improving energy efficiency represent a major challenge, especially in an economic environment where financial resources may be limited. But this transition also offers significant opportunities. Investments in renewable energy can boost local job creation, encourage technological innovation, and strengthen long-term energy security. By adopting ambitious climate policies, MENA countries can improve their global economic competitiveness, attract foreign investment in sustainable sectors, and strengthen their resilience to the impacts of climate change. Thus, the energy transition represents not only an environmental imperative, but also a strategic opportunity for these nations to turn their climate challenges into engines of sustainable growth and inclusive economic development.

Indeed, monetary policy plays a crucial role in managing the risks associated with climate change by directly influencing economic dynamics and investment decisions. Interest rate decisions, for example, can have a significant impact on companies' choices regarding clean technology and renewable energy. Accommodative monetary policies can encourage investment in these low-carbon sectors, thereby supporting efforts to reduce greenhouse gas emissions and mitigate the effects of climate change.

However, inappropriate or unaligned monetary policy with climate goals could compound risks by promoting investments in carbon-intensive industries, thereby prolonging dependence on fossil fuels and delaying the transition to a more sustainable economy. Integrating monetary policy into climate risk analysis is therefore essential to promote effective and sustainable management of global environmental impacts. By aligning climate goals with political and economic decisions, governments can play a decisive role in promoting more sustainable and resilient economic practices in the face of the challenges of climate change. Climate change is a growing and multifaceted threat to ecosystems. According to the (IPCC), impacts include rising global temperatures, more frequent extreme weather events and rising sea levels (IPCC, 2023). Accelerated nature degradation exacerbates this crisis by amplifying the effects of climate change, as highlighted by several recent studies on biodiversity loss and its impact on ecosystem services (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) (Seguin, 2022) (Wang & Qi, 2025).

Indeed, high temperatures are likely to reduce labor productivity, leading to higher rates of illness and mortality (Hsiang et al., 2017). According to a World Health Organization study (2021), heatwaves can affect workers' physical and mental health, reducing their effectiveness at work. This underscores the need to redeploy productive resources to finance adjustment measures, even in times of economic uncertainty (IPCC, 2022). On the climate front, rising temperatures could lead people to save more as a precaution, while weakening their incentive to invest in long-term projects((Baker, S. R., Bloom, N., & Davis, S. J., 2016). This can also have an impact on interest rates.

Dell et al. (2012) provide additional insight by demonstrating that countries with higher temperatures tend to have slower economic growth. This is attributed to a decline in labor productivity[8], exacerbated by the effects of climate on the health and well-being of workers. Indeed, temperature increases may reduce people's ability to work efficiently, thereby impacting countries' economic performance.

Empirically, studies using panel data provide valuable insights into the variability of climate impacts across regions and economic contexts. Analyses show that developing countries, often with less robust infrastructure and limited adaptive capacities, are more vulnerable to the effects of heat waves. Moreover, examining transmission

[8] Increased Productivity → GDP Growth

Journal of Information Systems Engineering and Management
2026, 11(2s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

mechanisms such as health, fatigue, and machine efficiency highlights the complex interactions between climate and economic growth. Climate-smart business models, such as those developed by Nordhaus (2013) show how appropriate policies (such as carbon taxes or renewable energy subsidies) can mitigate the negative effects of climate change on productivity. Empirical studies indicate that infrastructure investments (e.g., irrigation systems, coastal protections) improve economies' resilience to climate shocks and help maintain or increase productivity (World Bank, 2020)[9]. Statistical analyses on macroeconomic data have revealed that countries with robust climate policies, such as renewable energy investments, show higher resilience of productivity in the face of climate change (Acemoglu & Restrepo, 2018). This suggests that proactive climate policy actions can play a crucial role in stabilizing economic productivity, particularly in the context of increasing climate change. Finally, empirical evidence confirms that climate change has a significant impact on productivity, while economic policies can mitigate or exacerbate these effects. Therefore, it is essential that governments adopt integrated approaches that combine economic development and environmental sustainability. Such an approach can not only improve resilience to climate challenges but also contribute to long-term sustainable economic growth.

2. EMPIRICAL METHODOLOGY

3.1 Variables definition and data

The period of work from 1990 to 2023 covers MENA countries (Algeria, Bahrain, Iran, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi Arabia, Syria, Tunisia, Yemen, United Arab Emirates). The analysis is based on data from the World Bank, specifically the World Development Indicators (WDI) database. Iraq was excluded due to the lack of data for the variable 'private sector domestic credit', thus reducing the number of countries to 15.

Table1: Variables, measurements and sources of data

Variables	Measurements	Sources
GDP	Annual growth rate of real GDP	WDI
LTRADE	Trade as a percentage of GDP expressed in logarithm	WDI
LCREDIT	domestic credit to the private sector as a percentage of GDP expressed in logarithm	WDI
CO2	CO2 emissions per capita (in metric tons)	WDI
MM	money supply growth in annual percentage	WDI

The analysis of these variables provides a better understanding of how economic and environmental factors have influenced GDP growth in the MENA region over the past decades. The interaction between economic development, trade, private finance, and environmental impact is at the heart of this study. For example, sustained GDP growth can be associated with rising CO2 emissions. However, other factors, such as trade structure or access to private finance, can play a moderating role. Similarly, examining the money supply makes it possible to grasp the impact of monetary policies on economic and environmental dynamics. Deepening these relationships offers critical opportunities for policymakers seeking to reconcile economic growth and environmental sustainability in this rapidly changing region.

The model

$$GDP_{i,t} = \beta_1 LCREDIT_{i,t} + \beta_2 LTRADE_{i,t} + \beta_3 CO2_{i,t} + \beta_4 MM_{i,t} + \varepsilon_{i,t} \quad (1)$$

3.2 The theoretical approach

[9] https://www.worldbank.org/en/topic/climatechange

Journal of Information Systems Engineering and Management
2026, 11(2s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

This study uses an advanced econometric model, the Distributed Autoregressive Transversely Increased Delay Model (CS-ARDL), to address the challenges of analyzing complex economic data in the MENA region. This model is particularly well suited to deal with three major problems often encountered in panel analyses: slope heterogeneity, endogeneity, and cross-sectional dependence.

Cross-cutting dependency: MENA countries are not independent of each other, and events or policies in one country can have an impact on others. This can lead to a correlation between countries. CS-ARDL allows this cross-sectional dependency to be modeled to avoid biased results.

Heterogeneity of slopes: This phenomenon refers to the variability in the relationships between independent and dependent variables across countries. In other words, how economic factors influence economic growth may differ from country to country, even within the same region. The CS-ARDL model makes it possible to consider this heterogeneity in the estimation of the parameters to obtain more precise and reliable results.

Endogeneity: This is the problem where some explanatory variables can be correlated with the model error, leading to estimates' biases. For example, there could be a reciprocal relationship between economic openness and the rate of GDP growth. CS-ARDL incorporates methods to address this problem by considering causal relationships between variables.

3.3 Framework for empirical analysis

Analysis begins with preliminary tests to identify the specifics of the data.

- Test of Pesaran (2015): This test is used to detect the presence of cross-sectional dependencies in the data. This means that if one country observes economic variation, it could affect other countries similarly. This should be considered to avoid errors in estimating the relationships between variables.
- Test of Hashem Pesaran & Yamagata (2008): This test is then used to consider the heterogeneity of economic relations between countries. It checks whether the estimated coefficients are homogeneous across countries, which is essential for panel models like this.

  The test equations for SH test are given as:

$$\check{\Delta}_{SH} = (N)^{\frac{1}{2}} (2k)^{\frac{-1}{2}} \left(\frac{1}{N}\ \bar{S} - k\right) \quad (2)$$

$$\check{\Delta}_{ASH} = (N)^{\frac{1}{2}} \left(\frac{2k\,(T-k-1)}{T+1}\right)^{\frac{-1}{2}} \left(\frac{1}{N}\ \check{S} - 2k\right) \quad (3)$$

- Stationarity tests: Before estimating the cointegration relationships, verifying that the variables studied are not subject to non-stationary trends that could distort the results is necessary. The CIPS test (Im et al., 2003) and the adjusted Dickey-Fuller test for panel data (CADF) are used to test the stationarity of variables in each country.

$$\Delta y_{i,t} = \varphi_i + \varphi_i Z_{i,t-1} + \varphi_i \bar{y}_{t-1} + \sum_{l=0}^{p} \varphi_{il} \Delta\bar{y}_{t-l} + \sum_{l=1}^{p} \varphi_{il} \Delta y_{i,t-l} + u_{it} \quad (4)$$

The test statistics is given as:

$$\widehat{CIPS} = N^{-1} \sum_{i=1}^{n} CDF_i \quad (5)$$

- Panel cointegration test of Westerlund (2007): After the stationarity tests have been carried out, this test is used to check whether there are long-term relationships between the variables. For example, it can be used to determine whether a change in the money supply or economic openness has a lasting impact on economic growth or whether these effects are transitory.

The Westerlund test utilizes the following statistics:

Journal of Information Systems Engineering and Management
2026, 11(2s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

$$G_t = \frac{1}{N}\sum_{j=1}^{N}\frac{\dot{\alpha}_j}{SE(\dot{\alpha}_j)} \quad (6)$$

$$G_\alpha = \frac{1}{N}\sum_{j=1}^{N}\frac{T\dot{\alpha}_j}{\dot{\alpha}_j(1)} \quad (7)$$

$$P_T = \frac{\dot{\alpha}}{SE\,(\dot{\alpha})} \quad (8)$$

$$P_\alpha = T\dot{\alpha} \quad (9)$$

Moreover, CS-ARDL estimates the dynamic effects of independent variables on the dependent variable. The CS-ARDL's equation is:

$$GDP_{it} = \alpha_0 + \sum_{j=1}^{P}\gamma_{it}\ GDP_{i,t-j} + \sum_{j=0}^{P}\dot{\alpha}_{it}\ x_{t-j} + \sum_{j=0}^{3} v_{it}\ \bar{Z}_{t-j} + u_{it} \quad (10)$$

$$\text{where } \bar{Z}_{it} = (\Delta\overline{GDP}_{it}, \bar{X}_{it}) \text{ and } X_{it} = (LCREDIT_{it}, LTRADE_{it}, CO2_{it}, MM_{it})$$

Table 2: Test for weak cross-sectional dependence (Test of Pesaran (2015))

Variables	Test statistics	P-values
GDP	11.18561	0.000
CO2	12.81713	0.000
LCREDIT	18.43816	0.000
LTRADE	13.79749	0.000
MM	9.626032	0.000

Null hypothesis (H0): There is no cross-sectional dependence; errors are independent between the different cross-sectional areas.

Alternative hypothesis (H1): There is a cross-sectional dependence errors are correlated between cross-sectional areas.

The results of the Pesaran cross-sectional dependency test (Table 2) indicate a significant correlation between cross-sectional unit errors (for MENA countries). Indeed, the p-value associated with the test statistic is extremely low (0.0000), well below the significance threshold of 0.05. This leads to rejecting the null hypothesis of the absence of transverse dependence. This low p-value suggests that there is significant cross-country dependency, meaning that the errors of different countries are correlated.

Table 3: Slope homogeneity test (Test of Hashem Pesaran & Yamagata (2008))

Slope Homogeneity Tests	Δstatistic	P-value
Δtest	10.337	0.000
Δadjtest	11.717	0.000

The results of Table 3 show that the associated p-value is below the significance threshold, which leads to the rejection of the null hypothesis. This indicates that the coefficients are heterogeneous and that long-term relationships vary from variable to variable. Therefore, the rejection of the null hypothesis suggests that the impact of these variables on CO2 emissions is not uniform across countries. Each country could have a specific relationship with CO2 emissions, depending on its economic and institutional characteristics.
In this context, the CS-ARDL model effectively corrects the problem of slope heterogeneity and cross-sectional dependence by allowing for the modeling of long-term and dynamic relationships specific to each cross-sectional unit while considering the correlation between the units.

Journal of Information Systems Engineering and Management
2026, 11(2s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

- Panel Unit Root Tests

Two stationarity tests on panel data are applied: the Cross-Sectionally Augmented IPS (CIPS) test and the Cross-Sectionally Augmented Dickey-Fuller (CADF) test. The CIPS test is an extension of the IPS test for panel data, which makes it possible to consider the cross-sectional dependencies between the different sections of the panel. The CADF test, meanwhile, adapts the Dickey-Fuller test for panel data by incorporating cross-sectional effects, to improve the examination of stationarity in a cross-sectional and temporal data framework. The purpose of these tests is to verify whether the panel data sets are stationary, considering possible interactions between the panel units. Table 4 (above) summarizes the results of these tests. It is observed that the variables LCREDIT and CO2 become stationary after a transformation to a first difference. This means that these variables are integrated in order one, i.e. I(1), according to the different models tested: the one with a constant and a trend, the one with a constant only, and the one without a constant or a trend. On the other hand, the variables MM, LTRADE, and GDP are integrated of zero order, that is I(0).

Table 4: CIPS and CADF unit root test results

Cross-Sectionally Augmented IPS (CIPS) Test	Level		First difference		Order
	with trend	without trend	With trend	without trend	
GDP	0.0000	0.0000*	0.0000	0.0000	I(0)
CO2	0.9808	0.1326	0.000*	0.0000	I(1)
LCREDIT	0.8841	0.0095	0.0000	0.0000	I(1)
LTRADE.	0.0327	0.0137	0.0000	0.0000	I(0)
MM	0.0000	0.0000	0.0000	0.0000	I(0)
Cross-Sectionally Augmented Dicky-Fuller (CADF) Test					
GDP	0.0929	0.0000	0.0051	0.0000	I(0)
CO2	0.3752	0.0056	0.0000	0.0000	I(1)
LCREDIT	1.0000	0.0000	0.0000	0.0000	I(1)
LTRADE.	0.0929	0.0051	0.0000	0.0000	I(0)
MM	0.0177	0.0001	0.0000	0.0000	I(0)

The statistical significance level is represented as follows: *p < 0.01

Table 5: Results of cointegration analysis.

Model	Gt	Ga	Pt	Pa
GDP = f(CO2,LTRADE,LCREDIT,MM)	-4,217	-19,335	-24,019	-27,23
Z-value	0.000*	0.000*	0.000*	0.000*

*Means significance at 1%.

Table 5 presents the results of a Westerlund cointegration test. The values of the statistics (Gt, Ga, Pt, Pa) are all negative, suggesting a strong cointegration relationship between the data series analyzed. The negative and relatively low Z-values indicate that the results are far from the null hypothesis, which reinforces the idea that the non-cointegration hypothesis can be rejected. And the p-values of 0.000 for all the statistics, well below the threshold of 0.05, make it possible to reject the null hypothesis of the absence of cointegration with high statistical confidence. The results show that variables are co-integrated, meaning they share a long-term relationship and evolve on a common trajectory.

Journal of Information Systems Engineering and Management
2026, 11(2s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

3.4 Estimating short- and long-term dynamics

Once long-term relationships are identified, the CS-ARDL model can be used to estimate short-term and long-term dynamics. The short-term analysis captures the immediate effects of certain variables on economic growth. In contrast, the long-term analysis assesses the sustained impacts of variables such as money supply, CO2 emissions, private credit, or renewable energy on economic growth in the region.

The CS-ARDL model can capture delayed effects on growth from economic and environmental policies, such as the effects of renewable-energy investments or the gradual impacts of economic openness. It also provides a robust approach to studying the complex interactions between these variables over extended periods.

This study goes beyond conventional analyses by integrating advanced econometric techniques to study the determinants of economic growth in the MENA region. It is distinguished by providing a thorough understanding of the respective roles of the money supply, economic openness, private sector credit, and CO2 emissions on both short- and long-term economic growth.

In addition, the study addresses complex methodological issues such as cross-dependence and heterogeneity of countries, providing reliable results for economic and environmental policy formulation in the MENA region. These findings have practical implications, including for policymakers, who can use the insights gained from this analysis to improve resource management and economic policies, including on energy transition, financial regulation, and the promotion of sustainable growth.

Table 6: CS-ARDL's estimates: Long-term analysis

	Long Run Equation			
Variable	Coefficient	Std. Error	t-Statistic	P-value
CO2	0,189840	0,134259	1,413,992	0,1583
LCREDIT	-2.081100***	0,660934	-3,148,725	0.0018
LINTER	2,217,285*	1,248,740	1,775,618	0,0767
MM	0.122990***	0.033079	3,718,031	0.0002

*** p<0.01, ** p<0.05, * p<0.1

Analysis of the long-term regression results for MENA countries reveals several relationships between economic variables and economic growth rates. For CO2, the positive coefficient (0.189840) suggests a relationship between CO2 emissions and the dependent variable. However, this relationship is not statistically significant, as the p-value of 0.1583 is above the threshold of 0.05. This indicates that in this model, CO2 emissions do not significantly directly affect long-term economic growth in MENA countries. This result can be explained by the economic structure of the countries in this region, largely dependent on extractive industries and fossil fuels, where emissions increase with economic growth in certain phases of development. However, this lack of significance could also result from the particularities of the data and the absence of robust environmental policies in some MENA countries. Consider Algeria, where the economy heavily depends on extractive industries, especially oil and gas. As the main oil producer and exporter, Algeria faces relatively high CO2 emissions due to its energy sector, which is mainly based on fossil fuels. In the short term, this dependence on fossil fuels can lead to increased CO2 emissions alongside economic growth, as oil and gas extraction is a key driver of the national economy. However, the absence of robust environmental policies, such as serious initiatives to promote renewable energies or cleaner technologies, can limit the positive effect of economic growth on reducing CO2 emissions (Al-Mulali et al., 2015). In the Algerian context, economic growth fueled by hydrocarbon exports has often been correlated with increases in CO2 emissions. However, the relationship between these two variables has not always been statistically significant in economic analyses, partly due to the slow adoption of environmental reforms and the continued dependence on natural resource extraction. This may explain the lack of significance in some studies of the MENA region, where countries such as Algeria do not have sufficiently ambitious environmental policies to reverse this dynamic. For example, other studies indicate that the impact of CO2 emissions on economic growth may follow an environmental

Journal of Information Systems Engineering and Management
2026, 11(2s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Kuznets curve model, in which CO2 emissions increase in the short term with economic growth, but this relationship reverses as clean technologies and environmental reforms are adopted Jalil & Mahmud (2009) and Ozturk (2010). The results of this study may not yet capture this inversion, given the specific characteristics of the region.

For LCREDIT (the credit log granted by the private sector), the negative (-2.081100) and significant coefficient (p-value = 0.0018) indicate that an increase in private credit is associated with a reduction in the dependent variable. This suggests that the rapid expansion of private credit in MENA countries could lead to financial imbalances, banking crises, or misallocation of resources, thus holding back long-term economic growth. This is also reflected in studies of emerging economies, where high private credit exposure can lead to economic instability (Jordà et al., 2013). For LINTER (the log of economic opening), the positive coefficient (2.217285) shows that economic opening favors long-term growth in the MENA region. The impact of the economic opening is extensively studied in the literature, and several studies suggest that MENA countries, through their integration into the global economy and access to international markets, can benefit from a flow of foreign investment, modern technology and best business practices (Frankel & Romer, 1999). However, the p-value of 0.0767, although close to 0.05, remains slightly above the usual materiality threshold, indicating that this effect is only marginally significant at a 90% confidence level. This underscores that while openness is beneficial, it can depend on local economic structures, trade policies, and institutions in MENA countries.

Finally, for MM (the money supply), the positive coefficient (0.122990) and highly significant (p-value = 0.0002) suggest that the increase in the money supply favors economic growth in the region. Such a relationship is consistent with monetarist principles, which stipulate that increasing the money supply boosts aggregate demand and can foster economic growth, particularly in developing economies where access to credit and liquidity is limited (Friedman & Schwartz, 2008). However, excessive money supply expansion can lead to inflationary pressures, which requires prudent management of monetary policies to avoid jeopardizing long-term economic stability.

Table 7: CS-ARDL's estimates: Short-term analysis

	Short Run Equation			
	Coefficient	Std. Error	t-Statistic	*P-value*
COINTEQ01	-0.815104***	0.070554	-11.55289	0.0000
D(CO2)	5.553553***	2.059371	2.696723	0.0073
D(LCREDIT)	-8.621068**	3.997188	-2.156783	0.0317
D(LINTER)	2.683800	2.700456	0.993832	0.3210
D(MM)	-0.010927	0.019529	-0.559536	0.5762
C	-1.575286***	0.595219	-2.646564	0.0085

*** p<0.01, ** p<0.05, * p<0.1

Analysis of the short-term model results shows important relationships between economic variables in the MENA region. First, the cointegration variable (COINTEQ01) displays a negative and significant coefficient, indicating that the model follows a process of adjustment towards long-term equilibrium after any short-term disturbance. This adjustment relationship is typical of cointegration models, where short-term imbalances tend to correct over time, particularly in economic contexts subject to external shocks (Narayan, 2005).

For CO2 (D(CO2)) emissions, the coefficient is positive and significant, suggesting that an increase in CO2 emissions is associated with increased economic growth in the short term. This can be explained by many MENA

countries' dependence on extractive industries and fossil fuels, the expansion and investment of which generates both emissions and increased economic output in the short term. Research, such as Maalej & Cabagnols, (2020) and Osobajo et al. (2020), confirm that this relationship is typical in countries highly dependent on natural resources such as oil and gas. However, this relationship can also indicate a long-term challenge to economic and environmental sustainability, as highlighted Almasria et al. (2024), which highlight the importance of transitioning to greener energy sources in these countries.

On the other hand, private credit (D(LCREDIT)) is negative and significant, suggesting that credit expansion in the MENA region could have adverse short-term effects on economic growth. This observation is consistent with recent studies on credit regulation, such as that of Mahrous et al. (2020), which show that excessive levels of private credit can lead to macroeconomic imbalances and financial crises, especially in fragile economies where financial institutions are not sufficiently robust. The results also suggest that MENA countries, facing business cycles and liquidity crises, need to reassess their credit policies to avoid crowding out other sectors of the economy.

On the other hand, economic openness (D(LINTER)) has no significant effect in the short term, although the coefficient is positive. This can be due to structural challenges in the region, where trade openness is often hampered by protectionist policies or insufficient infrastructure. Several recent studies, such as those by (Rasoanomenjanahary et al., 2022) and Domínguez Blancas & Ángeles Castro (2024), say that while economic openness is generally beneficial in boosting growth, in MENA, the benefits of openness are limited by internal factors such as corruption, weak competitiveness, and excessive reliance on commodities.

The money supply (D(MM)), on the other hand, does not have a significant effect in the short term, as the high p-value indicates. This could suggest that in some MENA countries, monetary policy is less effective in the short term, possibly due to a lack of coordination with other economic policies or the absence of robust monetary strategies. This lack of effect is also corroborated by the work of Mishkin, (2016) which show that the impact of changes in the money supply on the economy is often less direct in economies strongly influenced by external factors, as is the case in several MENA countries. In the case of Egypt, monetary policy has also been affected by external factors such as global economic shocks and imported inflation. Since exchange-rate liberalization in 2016, the impact of the money supply on economic growth has become less direct, as Egypt's central bank has to juggle the management of foreign-exchange reserves and inflationary pressures, making monetary policy less effective at stimulating economic activity in the short-term (Walker, 2018).

Another example is Saudi Arabia, where monetary policy is strongly influenced by the currency peg of the Saudi riyal to the US dollar, owing to the economy's partial dollarization. This limits the central bank's autonomy to adjust the money supply flexibly in response to internal economic fluctuations, especially in the context of dependence on oil revenues. The stability of the money supply in such a system may have a limited impact on short-term economic growth (Alzyadat, 2024). Finally, in countries such as Morocco, although monetary policy is more independent, the effects of the money supply are often mitigated in the short term because of the country's heavy dependence on foreign investment and the export of agricultural and industrial products. Fluctuations in international markets, such as changes in commodity prices and global policy uncertainties, may influence economic growth more than domestic monetary adjustments (Touzani & Brahim, 2025).

These examples highlight the importance of MENA countries' specific macroeconomic environments, which can limit the effectiveness of monetary policy due to their reliance on natural resources, foreign-exchange reserve management, external factors, or exchange-rate rigidities. As shown by Mishkin (2016), the impact of changes in the money supply is often indirect and influenced by these external factors in emerging economies, as is the case for many countries in the MENA region. Finally, the negative and significant constant in the model indicates that, in the absence of changes in the other variables, the region's economy could experience a downward trend in growth, which may signal structural deficits in regional economic policies. This finding is in line with the research of Bousnina and Gabsi (2022) that MENA countries need to diversify their economies to reduce their vulnerability to external shocks and promote more stable and sustainable growth.

Journal of Information Systems Engineering and Management
2026, 11(2s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

4. ROBUST RESULTS

To demonstrate the robustness of the results obtained in Table 6 (ARDL model :long-term Analysis) from Table 8 estimation of the average Pesaran & Smith (1995) group and estimation of the common correlated effects of the average group, we need to analyze the coherence and robustness of the main results through different estimation methods. The ARDL model, which highlights the negative and significant impact of credit (LCREDIT) on economic growth (coefficient of -2.081100, p-value of 0.0018), is confirmed by the estimation of the average group of Pesaran & Smith (1995) in Table 8. Indeed, even with a different approach, LCREDIT remains negative and significant (p-value = 0.032), which reinforces the robustness of this relationship. This is in line with the work of Koutima-Banzouzi et al. (2024) which underscore the importance of credit to the dynamics of economic growth, and the literature that suggests that access to credit can, under certain circumstances, exert negative pressure on long-term growth (Solow, 1956).

Table 8: Check for robustness

	(estimation of the average Pesaran & Smith group)		Common Correlated Effects Estimator - Mean Group	
	Coef	P-values	Coef	P-values
LCREDIT	-3,7068**	0,032	-5,0121**	0,014
LTRADE	1,7865	0,39	1,9569	0,509
MM	0,1352	0,111	0,1094*	0,068
CO2	-0,495	0,581	0,14735	0,918
C	11,98	0,23		

*** p<0.01, ** p<0.05, * p<0.1

However, while credit maintains a significant effect across all approaches, the impact of the money supply (MM) presents more nuanced outcomes. In Table 6, the money supply has a positive and significant effect in the long term (coefficient of 0.122990, p-value of 0.0002), supporting the idea that the increase in the money supply stimulates economic growth, such as the work of (Daboh et al., 2024) which establish a direct relationship between monetary expansion and economic activity. In contrast, in Table 8, the impact of MM is positive but less significant (p-value = 0.111), suggesting that the effect of money supply may be more uncertain depending on the model used. This indicates that, although the effect of money supply is visible in the ARDL model, it is not as clear and stable in other estimation methods, as indicated by the research Senhadji Semlali et al. (2000) on the variable effects of monetary policy on growth.

In Table 8, which uses the estimation of the common correlated effects of the middle group (CCEMG), the impact of credit (LCREDIT) on growth remains significant and negative (p-value = 0.014), confirming that, even considering the specificities of the countries of the region, the effect of credit on growth is robust. This is in line with the results of Beck & Levine (2004) which argue that credit markets can have an adverse effect on economic growth in some regions. However, the variables CO2, MM, and LTRADE are not significant, suggesting that they do not have a systematic and strong effect on economic growth, contrary to what might be expected in some theoretical models (estimation of the average Pesaran & Smith (1995)). This lack of significance for these variables in the CCEMG model can be interpreted as an indirect support for the robustness of the ARDL model in Table 7, where neither CO2 emissions nor money supply were strongly linked to economic growth, as reported by Arestis & Sawyer (2016).

In conclusion, the results in Table 8 largely confirm those of Table 6 (ARDL model), particularly regarding the negative relationship between credit (LCREDIT) and economic growth.

The results for money supply and CO2 emissions are more variable, with less significant effects in some estimation methods, underscoring the robustness of the credit results. Thus, cross-analysis of the three models shows that credit plays a significant negative role in economic growth in MENA countries, making the conclusions of the ARDL

model particularly strong and reliable, as supported by previous studies on the relationship between credit and growth Sims (1980) and Romer (2019).

CONCLUSION

The results of this study show that, in the MENA region, CO2 emissions do not have a significant impact on long-term economic growth. This lack of a relationship could be explained by the region's specific economic characteristics, including its heavy dependence on extractive industries, such as oil and natural gas, which play a central role in the economic dynamics of many countries. For example, Saudi Arabia, a major oil producer, enjoys substantial revenues from hydrocarbon exports, allowing it to maintain relatively stable economic growth, despite environmental concerns or CO2 emissions. Likewise, Algeria, which is heavily dependent on its oil and gas resources, and Iraq, which relies heavily on the oil sector for its economy, are experiencing growth trajectories that do not appear directly affected by the environmental impact of their CO2 emissions. These countries, with their abundant natural resources, can continue to grow economically despite high levels of emissions, as the extractive industry remains a central driver of their development. However, this dynamic may conceal long-term challenges, including economic diversification and the energy transition, which are likely to become more significant as international pressure to reduce carbon emissions grows. Moreover, private credit is having a negative effect on growth, highlighting the risks associated with rapid credit expansion. Economic openness, while boosting growth, has marginally significant effects. By contrast, the money supply has a positive and significant impact on economic growth. These results underscore the need for prudent management of monetary and credit policies, while supporting economic openness to ensure sustainable growth.

In the short run, factors like CO2 emissions and private credit significantly influence growth, while structural elements like economic openness and the money supply require more attention to encourage stable and sustainable growth. Economic policies in this region should include diversification strategies, stricter credit regulation, and increased investment in infrastructure and renewable energy to foster inclusive and greener growth.

Finally, the robustness of the results obtained through the different estimation methods, in particular the ARDL model and the estimates of average pooled effects, confirms the main conclusions, in particular the negative relationship between credit and economic growth. This makes the results of this study reliable and consistent with the existing literature on the role of credit in economic growth in MENA countries.

Funding: This research received no external funding

Conflicts of Interest: The authors declare no conflicts of interest.

ACKNOWLEDGMENTS: The authors are thankful to the Deanship of Graduate Studies and Scientific Research at the University of Bisha for supporting this work through the Fast-Track Research Support Program.

Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing

REFRENCES

[1] Acemoglu, D., & Restrepo, P. (2024). *The impact of artificial intelligence on productivity distribution and growth*. *No. 15*. OECD Artificial Intelligence Papers
[2] Acemoglu, D., & Restrepo, P. (2018). *Artificial Intelligence, Automation and Work* (w24196; p. w24196). National Bureau of Economic Research. https://doi.org/10.3386/w24196
[3] Almasria, N. A., Aldboush, H. H., Al_Kasasbeh, O., Lutfi, A., Alhajahmad, F. B., Barrak, T. A., & Alsheikh, G. (2024). Oil Price Volatility and Economic Growth : Evidence from the Middle East. *International Journal of Energy Economics and Policy*, *14*(3), 417-421. https://doi.org/10.32479/ijeep.15484
[4] Al-Mulali, U., Saboori, B., & Ozturk, I. (2015). Investigating the environmental Kuznets curve hypothesis in Vietnam. *Energy Policy*, *76*, 123-131. https://doi.org/10.1016/j.enpol.2014.11.019

[5] Alzyadat, J. A. (2024). The Oil Price Shocks and the Monetary Stability in Saudi Arabia. *International Journal of Energy Economics and Policy*, *14*(6), 32-39. https://doi.org/10.32479/ijeep.16882
[6] Arestis, P., & Sawyer, M. (Éds.). (2016). *Financial Liberalisation*. Springer International Publishing. https://doi.org/10.1007/978-3-319-41219-1
[7] Baker, S. R., Bloom, N., & Davis, S. J. (2016). Measuring Economic Policy Uncertainty. *The Quarterly Journal of Economics*, 134(4), 1619-1654.
[8] Beck, T., & Levine, R. (2004). Stock markets, banks, and growth : Panel evidence. *Journal of Banking & Finance*, *28*(3), 423-442. https://doi.org/10.1016/S0378-4266(02)00408-9
[9] Bousnina, R., & Gabsi, F. B. (2022). Current Account Balance and Financial Development in MENA Countries : The Role of Institutions. *Comparative Economic Studies*, *64*(1), 109-142. https://doi.org/10.1057/s41294-021-00153-4
[10] Daboh, F., Duramany-Lakkoh, E. K., & Knox-Goba, T. L. (2024). Analyzing the Structural Relationship between Money Supply, Inflation, and Economic Growth in Sierra Leone : A VAR Model Approach. *Theoretical Economics Letters*, *14*(04), 1583-1604. https://doi.org/10.4236/tel.2024.144080
[11] Dées, S., & Weber, P.-F. (2021). Les conséquences du changement climatique pour la politique monétaire: *Revue d'économie financière*, *N° 138*(2), 243-257. https://doi.org/10.3917/ecofi.138.0243
[12] Dell, M., Jones, B. F., & Olken, B. A. (2012). Temperature Shocks and Economic Growth : Evidence from the Last Half Century. *American Economic Journal: Macroeconomics*, *4*(3), 66-95. https://doi.org/10.1257/mac.4.3.66
[13] Domínguez Blancas, C. S., & Ángeles Castro, G. (2024). Trade Liberalization Effects on Economic Growth, 1980-2022. *Revista Mexicana de Economía y Finanzas*, *19*(3), 1-22. https://doi.org/10.21919/remef.v19i3.992
[14] Elekdag, S., & Tuuli, M. (2022). Weather Shocks and Exchange Rate Flexibility. *IMF Working Papers*, *2022*(093), 1. https://doi.org/10.5089/9798400207600.001
[15] Frankel, J. A., & Romer, D. (1999). Does Trade Cause Growth? *American Economic Review*, *89*(3), 379-399. https://doi.org/10.1257/aer.89.3.379
[16] Friedman, M., & Schwartz, A. J. (2008). *A monetary history of the United States 1867-1960* (9th pbk. printing, 22nd printing). Princeton University Press.
[17] Hashem Pesaran, M., & Yamagata, T. (2008). Testing slope homogeneity in large panels. *Journal of Econometrics*, *142*(1), 50-93. https://doi.org/10.1016/j.jeconom.2007.05.010
[18] Hsiang et al. (2017). *Hurricanes and Climate Change.*". DOI: 10.1007/978-3-319-47594-3
[19] Im, K. S., Pesaran, M. H., & Shin, Y. (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics*, *115*(1), 53-74. https://doi.org/10.1016/S0304-4076(03)00092-7
[20] Intergovernmental Panel On Climate Change (IPCC). (2023). *Climate Change 2021 – The Physical Science Basis : Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (1re éd.). Cambridge University Press. https://doi.org/10.1017/9781009157896
[21] Jalil, A., & Mahmud, S. F. (2009). Environment Kuznets curve for CO2 emissions : A cointegration analysis for China. *Energy Policy*, *37*(12), 5167-5172. https://doi.org/10.1016/j.enpol.2009.07.044
[22] Jordà, Ò., Schularick, M. Hp., & Taylor, A. (2013). *Sovereigns versus Banks : Credit, Crises, and Consequences* (w19506; p. w19506). National Bureau of Economic Research. https://doi.org/10.3386/w19506
[23] Koutima-Banzouzi, J. M., Ayessa, E. B., & Gami, B. R. (2024). Effects of Bank Credit on Economic Growth in the Central African Economic and Monetary Community (CEMAC). *Theoretical Economics Letters*, *14*(06), 2451-2470. https://doi.org/10.4236/tel.2024.146121
[24] Krogstrup, S. (2019). *Macroeconomic and Financial Policies for Climate Change Mitigation*. International Monetary Fund.
[25] Maalej, A., & Cabagnols, A. (2020). Energy consumption, CO2 emissions and economic growth in MENA countries. *Environmental Economics*, *11*(1), 133-150. https://doi.org/10.21511/ee.11(1).2020.12
[26] Mahrous, S. N., Samak, N., & Abdelsalam, M. A. M. (2020). The effect of monetary policy on credit risk : Evidence from the MENA region countries. *Review of Economics and Political Science*, *5*(4), 289-304. https://doi.org/10.1108/REPS-07-2019-0099

[27] Mishkin, F. S. (2016). *The economics of money, banking, and financial markets* (Eleventh edition, global edition). Pearson.
[28] Narayan, P. K. (2005). The saving and investment nexus for China : Evidence from cointegration tests. *Applied Economics*, *37*(17), 1979-1990. https://doi.org/10.1080/00036840500278103
[29] Nordhaus, W. D. (Éd.). (2013). *The Climate casino : Risk, uncertainty, and economics for a warming world*. Yale University Press.
[30] Osobajo, O. A., Otitoju, A., Otitoju, M. A., & Oke, A. (2020). The Impact of Energy Consumption and Economic Growth on Carbon Dioxide Emissions. *Sustainability*, *12*(19), 7965. https://doi.org/10.3390/su12197965
[31] Ozturk, I. (2010). A literature survey on energy–growth nexus. *Energy Policy*, *38*(1), 340-349. https://doi.org/10.1016/j.enpol.2009.09.024
[32] Pesaran, M. H. (2015). Testing Weak Cross-Sectional Dependence in Large Panels. *Econometric Reviews*, *34*(6-10), 1089-1117. https://doi.org/10.1080/07474938.2014.956623
[33] Pesaran, M. H., & Smith, R. (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics*, *68*(1), 79-113. https://doi.org/10.1016/0304-4076(94)01644-F
[34] Rasoanomenjanahary, M. A., Cao, L., & Xi, Y. (2022). The Impact of Trade Openness on Economic Growth : Empirical Evidence from Madagascar. *Modern Economy*, *13*(05), 629-650. https://doi.org/10.4236/me.2022.135034
[35] Romer, D. (2019). *Advanced macroeconomics* (Fifth Edition). McGraw-Hill Education.
[36] Seguin. (2022). *Impact du changement climatique sur les écosystèmes naturels et cultivés*. https://hal.science/hal-03573311/document
[37] Senhadji Semlali & Mohsin S. Khan. (2000) Threshold Effects in the Relationship Between Inflation and Growth. *IMF Working Papers*, *00*(110), 1. https://doi.org/10.5089/9781451853339.001
[38] Sims, C. A. (1980). Macroeconomics and Reality. *Econometrica*, *48*(1), 1. https://doi.org/10.2307/1912017
[39] Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, *70*(1), 65. https://doi.org/10.2307/1884513
[40] Touzani, A., & Brahim, A. (2025). Empirical Analysis of the Impact of Exchange Rates on Economic Growth in Emerging Countries : Case of Morocco. *International Journal of Economics and Financial Issues*, *15*(2), 411-416. https://doi.org/10.32479/ijefi.17992
[41] Walker, T. B. (2018). Inflation Targeting in Emerging Economies. *Ensayos sobre Política Económica*, *36*(85), 7-20. https://doi.org/10.32468/Espe.8501
[42] Wang, W., & Qi, H. (2025). The impact of joint liability lending on leveraging social capital. *Annals of Public and Cooperative Economics*, apce.12504. https://doi.org/10.1111/apce.12504
[43] Westerlund, J. (2007). Testing for Error Correction in Panel Data*. *Oxford Bulletin of Economics and Statistics*, *69*(6), 709-748. https://doi.org/10.1111/j.1468-0084.2007.00477.x