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-RESEARCH ARTICLE-

THE DETERMINANTS OF EXCHANGE RATE VOLATILITY IN THE MENA REGION: NEW EVIDENCE USING A DYNAMIC PANEL DATA

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—Abstract—

This research investigates the factors shaping exchange rate fluctuations across 20 MENA economies over the period spanning Q1 1990 to Q4 2022. Exchange rate variability is initially quantified through a GARCH specification, while both short-term

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and long-term dynamics are evaluated using the Mean Group (MG) and Pooled Mean Group (PMG) estimation techniques. Empirical findings indicate that, for the overall sample, the interest rate differential, foreign direct investment (FDI), and economic expansion contribute to dampening exchange rate instability, whereas rising oil prices intensify it. Within oil-exporting economies, stronger institutional quality is associated with reduced volatility, while increases in oil prices and heightened political uncertainty amplify fluctuations. In contrast, for non-oil-exporting economies, economic growth and oil price increases exert upward pressure on exchange rate volatility, whereas the inflation differential plays a stabilising role, highlighting pronounced structural heterogeneity between the two groups. Accordingly, policy implications suggest that oil-exporting economies should pursue economic diversification alongside improvements in institutional quality. Conversely, non-oil-exporting economies should focus on strengthening political stability, advancing governance reforms, and maintaining credible monetary policy frameworks to ensure long-term exchange rate stability.

Keywords: Exchange Rate Volatility; MENA Region; GARCH Model; Mean Group (MG); Pooled Mean Group (PMG); Dynamic Panel Data.

INTRODUCTION

Exchange rate volatility has emerged as a defining characteristic of the modern global economic system, generating substantial macroeconomic and financial challenges for both advanced and developing economies. In contexts dominated by small and open economic structures, instability in exchange rates exerts direct effects on inflationary processes, external competitiveness, fiscal balance, and financial-market dynamics (Handoyo et al., 2024). Within the Middle East and North Africa (MENA) region, where most economies are highly open and deeply integrated with global trade networks, energy markets, and geopolitical forces, exchange rate volatility constitutes a core macroeconomic issue rather than a transient financial fluctuation. During the last three decades, MENA economies have undergone multiple phases of structural transformation shaped by oil price fluctuations, transitions in exchange rate regimes, episodes of political unrest, and evolving patterns of global economic integration. Collectively, these developments have reconfigured the region's macroeconomic framework, increasing the responsiveness of domestic systems to external disturbances. Although exchange rate movements are an inherent feature of open economy systems, heightened volatility introduces significant uncertainty, affecting inflation trajectories, investment decisions, public revenue streams, and financial-sector performance (Gatti et al., 2023).

A central structural characteristic of the MENA region lies in the clear dichotomy between oil-exporting and non-oil-exporting economies. Oil-exporting countries are

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heavily dependent on hydrocarbon income denominated in foreign currencies, which tightly connects fiscal outcomes and external balances to international oil price movements and exchange rate dynamics. Conversely, non-oil-exporting economies rely more extensively on diversified sectors such as manufacturing, services, remittances, tourism, and external capital inflows, rendering them more exposed to currency depreciation, inflationary pressures, and global interest rate fluctuations. Despite these fundamental differences, both categories exhibit sustained exchange rate volatility, indicating the coexistence of shared global influences alongside country-specific determinants.

Figure 1 illustrates estimated exchange rate volatility for oil-exporting MENA economies derived from GARCH modelling, capturing time-varying conditional variance for Algeria, Bahrain, Iran, Iraq, Kuwait, Libya, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. The visual evidence reveals pronounced clustering of volatility, characterised by alternating phases of heightened instability and relative tranquillity. This pattern is consistent with economies whose fiscal and external positions are closely aligned with hydrocarbon revenues and global commodity price cycles. Figure 2 presents analogous GARCH-based volatility estimates for non-oil-exporting economies, including Egypt, Jordan, Lebanon, Morocco, Tunisia, Syria, Yemen, Palestine, Djibouti, and Mauritania. In this group, volatility likewise demonstrates persistence; however, its behaviour appears more strongly linked to domestic macroeconomic imbalances, external financing constraints, and institutional or political disruptions rather than fluctuations in commodity prices.

A comparative assessment of the two figures highlights systematic differences in both the magnitude and underlying nature of exchange rate volatility across the two groups. Oil-exporting economies tend to display relatively higher but more episodic volatility, with sharp surges often aligned with global oil price shocks or changes in international financial conditions, followed by periods of stabilisation supported by substantial foreign exchange reserves and fiscal buffers. In contrast, non-oil-exporting economies exhibit more persistent and structurally embedded volatility, reflecting weaker external balances, constrained policy capacity, and heightened exposure to domestic inflationary pressures and political uncertainty. Taken together, these observations indicate that while exchange rate volatility is pervasive across the MENA region, its intensity, duration, and driving mechanisms differ systematically between oil-exporting and non-oil-exporting economies, reinforcing the necessity of treating these groups distinctly in both empirical investigation and policy formulation.

The region’s macroeconomic fragility is further intensified by limited economic diversification, enduring structural imbalances, and ongoing geopolitical tensions. Numerous MENA countries continue to confront recurrent political instability, governance deficiencies, and weak institutional performance, factors that undermine investor confidence and exert additional pressure on exchange rates. These domestic

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vulnerabilities are compounded by external influences, including fluctuations in demand from major global economies such as the United States and China, tightening global monetary conditions, and cycles in international commodity prices. Consequently, exchange rate volatility should be understood not merely as a financial-market outcome but as a fundamental driver of broader macroeconomic stability.

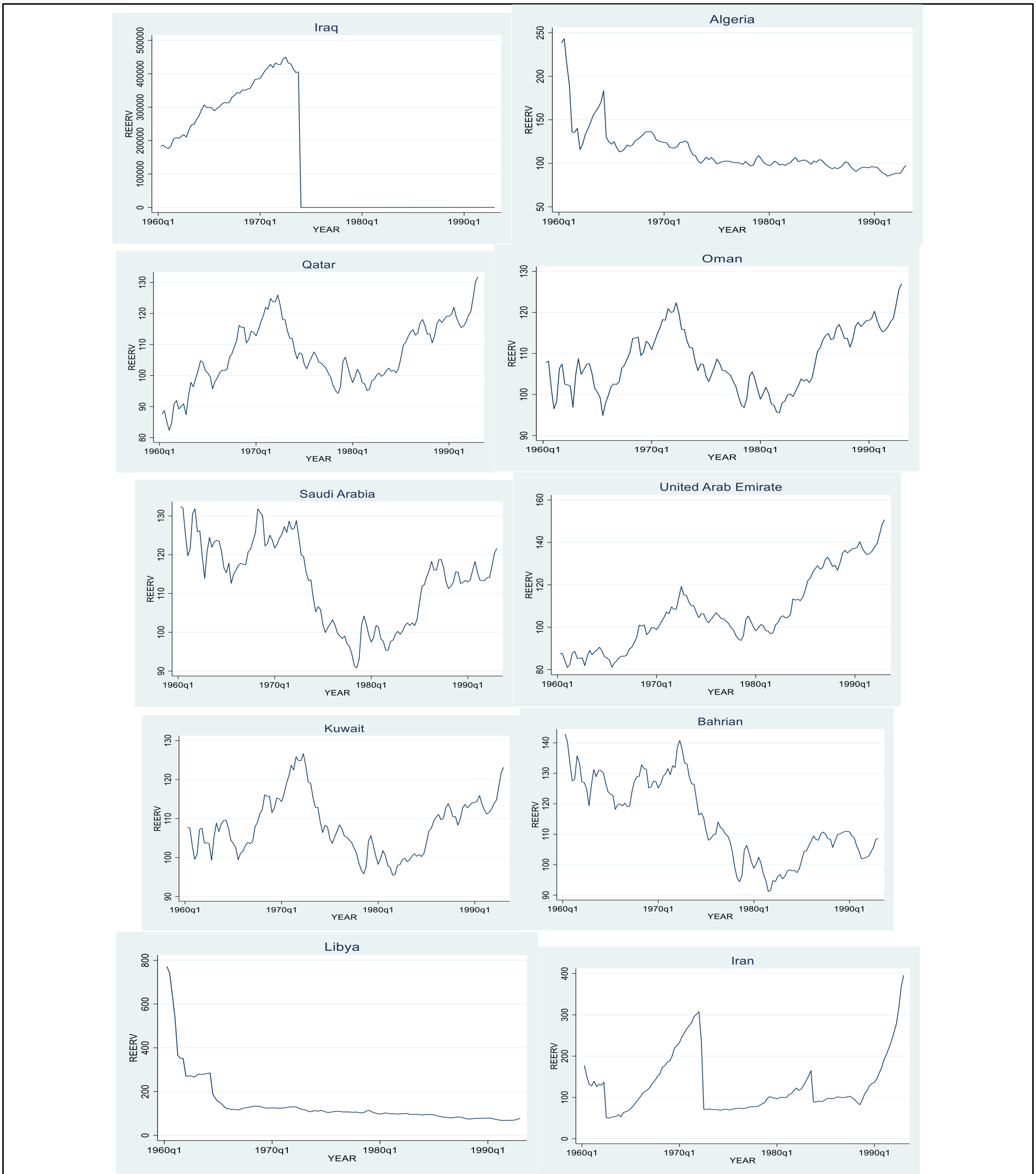

Figure 1: Exchange Rate Volatility in Oil Exporting Countries of the MENA Region: GARCH Model Estimates
Source: Author

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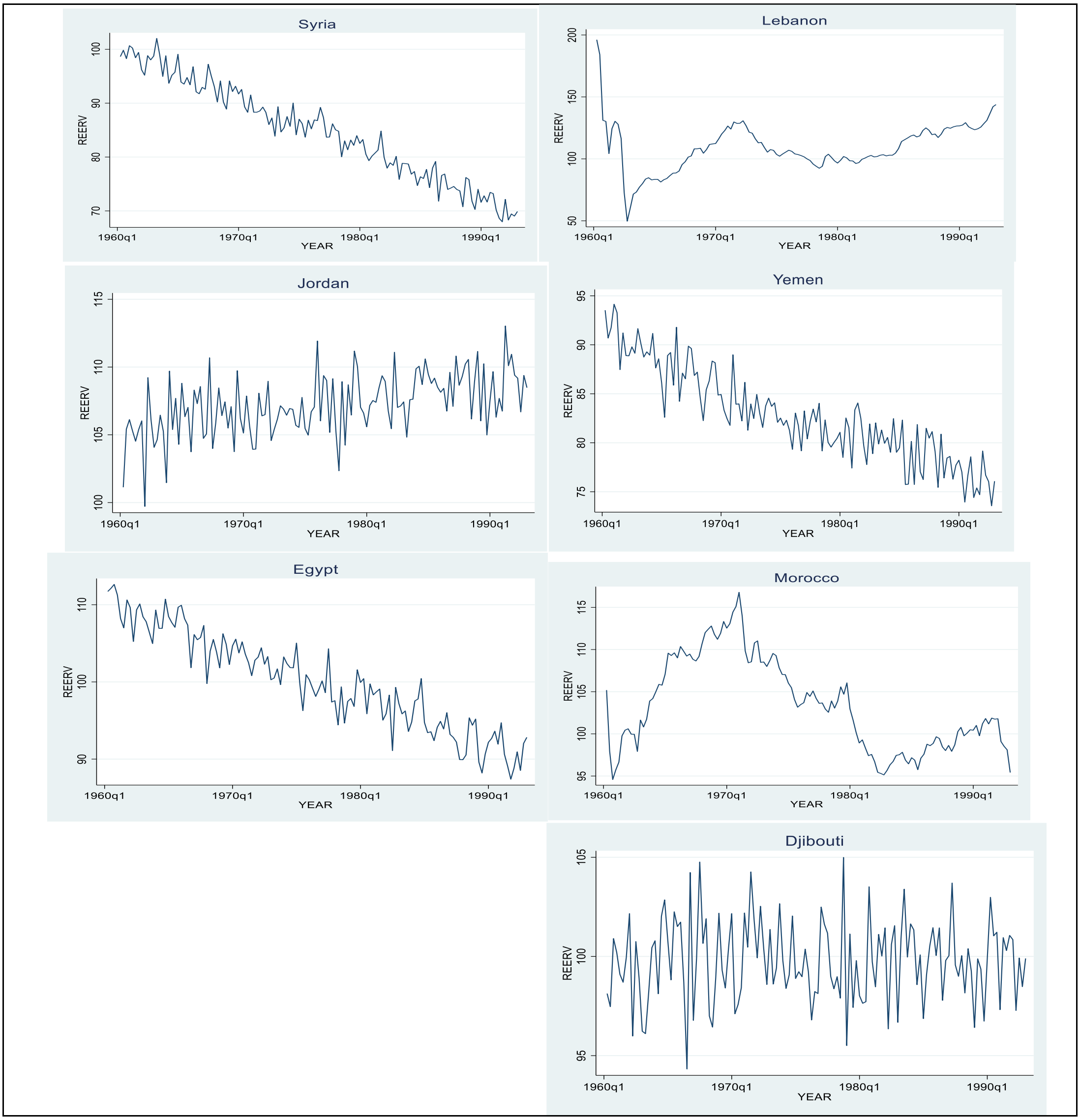

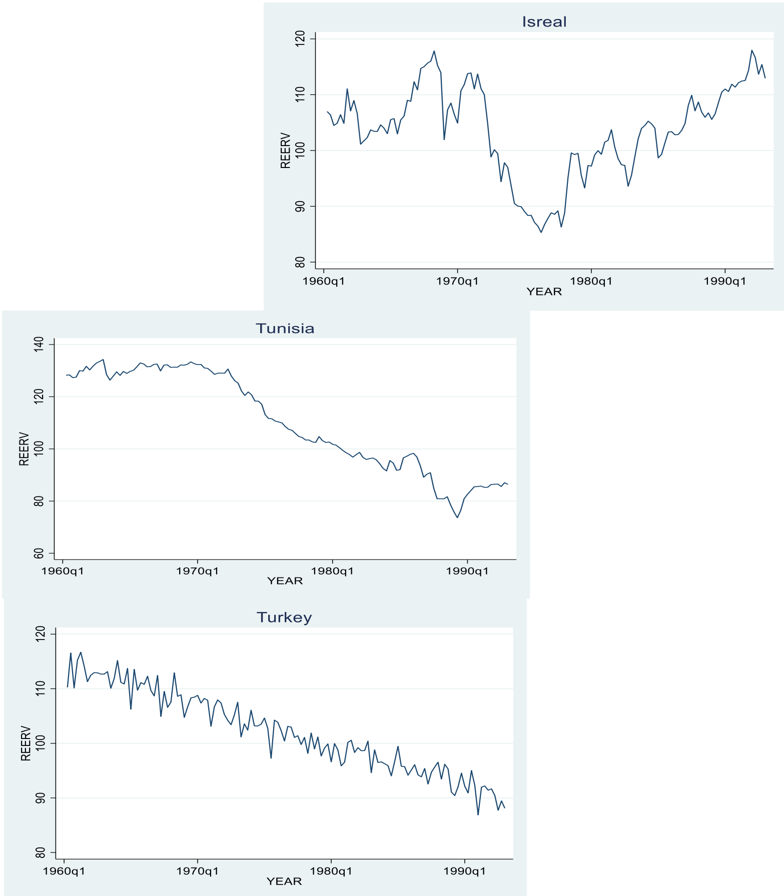

Figure 2: Exchange Rate Volatility in Non-oil Exporting Countries of the MENA Region: GARCH Model Estimates
Source: Author

Building on this context, the empirical literature has progressively concentrated on uncovering the macroeconomic and institutional drivers underlying exchange rate volatility. Core variables such as interest rates, inflation, and foreign exchange reserves have been extensively investigated across developing economies. Nevertheless, empirical outcomes remain inconclusive, with limited agreement regarding the relative explanatory power of these determinants. In addition, prior studies focusing on the

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MENA region predominantly adopt country-specific approaches or employ relatively short temporal spans, thereby constraining the external validity and generalisability of their findings. Consequently, a notable empirical deficiency persists in terms of comprehensive regional analysis utilising a rigorous dynamic panel framework. This study is designed to bridge this gap.

The principal aim of this research is to analyse the determinants of exchange rate volatility across the MENA region, a heterogeneous and strategically significant area marked by substantial economic and geopolitical diversity. The region encompasses hydrocarbon-rich economies characterised by persistent trade surpluses alongside countries dependent on imports, remittance inflows, and service-oriented sectors, exposing them to distinct configurations of internal and external shocks. In recent years, the Gulf Cooperation Council (GCC) economies have witnessed a surge in FDI, particularly within energy, infrastructure, and technology sectors, further shaping exchange rate behaviour. From a geopolitical perspective, the region continues to face complex challenges, including internal conflicts, territorial disputes, sectarian tensions, and the strategic involvement of major global actors such as the United States, Russia, and China. Historical developments, notably the Arab Spring and prolonged conflicts in countries such as Syria and Yemen, have further intensified these dynamics, influencing both economic resilience and susceptibility to volatility. By incorporating both macroeconomic fundamentals and institutional dimensions within this framework, the study seeks to generate a comprehensive understanding of the mechanisms driving exchange rate fluctuations in the MENA region.

This study advances the existing body of literature in five key respects. First, the GARCH framework is employed to derive a more precise estimation of conditional variance, thereby improving the measurement of volatility in the real effective exchange rate. Second, both MG and PMG estimators are utilised to distinguish between short-run adjustments and long-run equilibrium relationships in exchange rate volatility across the MENA region, offering more refined insights for policymakers and enabling context-specific policy design. Third, the analysis incorporates an extensive set of macroeconomic fundamentals alongside the Institutional Quality Index and geopolitical variables, facilitating a multidimensional assessment of the determinants of exchange rate volatility and clarifying the joint influence of economic and institutional factors.

Fourth, the study broadens the empirical scope by examining a balanced panel of 20 MENA economies. It further refines the analysis by explicitly differentiating between oil-exporting and non-oil-exporting countries, thereby accounting for the pivotal role of hydrocarbons in shaping macroeconomic outcomes and yielding more robust and differentiated insights. Fifth, the extended sample period from 1990 to 2022 enables the inclusion of major geopolitical and economic episodes, including the Gulf War, the Arab Spring, periods of economic sanctions, and the COVID-19 pandemic. This comprehensive temporal coverage allows for a more rigorous evaluation of exchange

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rate volatility under diverse and high-impact conditions, offering deeper insights into the adaptability and resilience of MENA economies in response to both external shocks and domestic disruptions.

This paper is structured as follows: Section 2 reviews the relevant literature on the determinants of exchange rate volatility. Section 3 outlines the data sources, empirical specification, and econometric methodology. Section 4 presents and interprets the empirical results. Section 5 reports the robustness analysis. Finally, Section 6 concludes with key findings and policy implications.

LITERATURE REVIEW

Early contributions examining exchange rate volatility emphasise the significance of macroeconomic fundamentals; however, empirical evidence remains highly fragmented and lacks convergence. For instance, country-specific analyses indicate that domestic indicators such as exports, inflation, and the GDP deflator play a central role in explaining fluctuations in Malaysia's real effective exchange rate, whereas evidence from West African economies (Dung & Okereke, 2022) demonstrates that variables including interest rates, inflation, and the current account influence exchange rate pressures through differing transmission channels. More recent strands of the literature extend this perspective by incorporating uncertainty and global financial conditions. In this regard, Aftab et al. (2024) show that both economic policy uncertainty (EPU) and global financial stress exert significant effects on exchange rate dynamics across a panel of advanced and emerging economies.

In a related context, empirical findings suggest that variations in crude oil prices, driven by EPU, exert dynamic and non-linear effects on China's real effective exchange rate (REER) over the period 1995–2021, generating short-term depreciation, medium-term appreciation, and heterogeneous long-term responses. Similarly, Zhang et al. (2022) employ a time-varying parameter structural vector autoregression with stochastic volatility (TVP-SVAR-SV) framework to assess the impact of oil price shocks on exchange rates between December 2005 and October 2021. Their results reveal substantial heterogeneity across different lag structures, underscoring the importance of accounting for time-varying effects in exchange rate modelling.

Further evidence is provided by Rashid and Basit (2022), who investigate the determinants of exchange rate volatility in selected Asian economies using a multivariate ARMA-GARCH framework over the period January 1997 to March 2019. Their findings indicate that fluctuations in foreign exchange reserves and government expenditure significantly contribute to exchange rate volatility. Likewise, Umoru (2023), employing a GARCH (1,1) specification for seven African economies over an extended sample period (1970–2023), identify a stable long-run relationship between exchange rate volatility and key macroeconomic variables, particularly inflation differentials and interest rate differentials, highlighting their relevance for exchange rate stabilisation policies.

Complementing this evidence, Ozkaya and Altun (2024) analyse the volatility of the Turkish lira using both GARCH and Lyapunov exponent methodologies over the period March 2019 to November 2021. Their results emphasise the critical role of global financial indicators, including the Volatility Index (VIX) and Credit Default Swaps (CDS), in shaping exchange rate volatility, thereby pointing to the importance of international financial spillovers in domestic currency dynamics. Despite the breadth of global evidence, research specifically addressing the determinants of exchange rate volatility within the MENA region remains relatively limited. A substantial proportion of the existing literature concentrates on developed economies or adopts broad cross-regional frameworks, often neglecting the distinctive economic configurations, institutional settings, and geopolitical complexities that define MENA economies. Therefore, the underlying drivers of exchange rate volatility in this region are not yet comprehensively understood, constraining the formulation of targeted and effective macroeconomic policies.

Moreover, although prior studies offer valuable insights, they are frequently restricted to individual country analyses or relatively short sample periods. Only a limited number of investigations explicitly focus on the MENA region, despite its pronounced exposure to oil price fluctuations, political transitions, and institutional constraints. Existing contributions, such as Kumar (2024), do not fully account for the region's structural heterogeneity or the geopolitical environment influencing exchange rate behaviour. This limitation highlights the need for a more comprehensive empirical assessment based on a consistent dynamic panel framework, which this study seeks to provide.

METHODOLOGY

Data Description

The analysis utilises a balanced quarterly panel dataset covering the period from 1990 to 2022 for a sample of 20 MENA economies. In line with the World Bank classification, these economies are systematically divided into oil-exporting and non-oil-exporting groups. The oil-exporting category comprises Saudi Arabia, the United Arab Emirates, Qatar, Kuwait, Oman, Bahrain, Iraq, Algeria, Libya, and Iran. In contrast, the non-oil-exporting group includes Yemen, Syria, Jordan, Lebanon, Egypt, Morocco, Tunisia, Turkey, Djibouti, and Israel.

The dataset is compiled from multiple authoritative sources to ensure reliability and consistency. Macroeconomic indicators are obtained from the International Financial Statistics (IFS) database of the International Monetary Fund, while institutional quality measures are drawn from the Worldwide Governance Indicators (WGI). Oil price data

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are sourced from the U.S. Energy Information Administration, complemented by additional relevant statistics from the Organization of the Petroleum Exporting Countries. Table 1 summarises the variables incorporated in the empirical model and reports the anticipated signs of their estimated coefficients, as guided by established theoretical frameworks and prior empirical findings.

Table 1: Description of Dependent and Independent Variables, Expected Sign of Coefficients, and Data Sources

Abbreviation	Variables	Descriptions	Expected sign	Data Sources
Dependent Variable				
REERV	Real Effective Exchange Rate Volatility	Measures the volatility of the real effective exchange rate, estimated using the GARCH framework.		IMF's International Financial Statistics (IFS)
Independent Variables				
Fundamental Variables				
INTD	Interest Rate Differential	Difference between MENA countries' interest rates and the U.S. Federal Funds Rate, capturing monetary policy divergence affecting exchange rate movements (Butt et al., 2023).	Positive	IMF's International Financial Statistics (IFS)
INFD	Inflation Differential	Difference between inflation in MENA countries and U.S. inflation, reflecting relative price imbalances influencing exchange rate volatility (El-Khodary et al., 2025).	Positive	IMF's International Financial Statistics (IFS)
RES	Foreign Exchange Reserve	Total central bank foreign reserves (USD), representing external buffer capacity against shocks (Kan & Leibrecht, 2020).	Positive	IMF's International Financial Statistics (IFS)

Table 1: Description of Dependent and Independent Variables, Expected Sign of Coefficients, and Data Sources (cont…)

Abbreviation	Variables	Descriptions	Expected sign	Data Sources
FDI	Foreign Direct Investment	Net FDI inflows as a percentage of GDP, capturing the role of foreign capital in influencing exchange rate stability (Yang & Peng, 2024).	Negative	IMF's International Financial Statistics (IFS)

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OIL	Oil Prices	Average Brent crude oil spot price (USD per barrel), reflecting global oil market influence on MENA currencies.	positive	Energy Information Administration (EIA)
Growth	Economic Growth	Growth rate of real GDP per capita (constant 2010 USD), representing economic performance and macroeconomic stability.	Negative	IMF's International Financial Statistics (IFS)
OPEN	Trade Openness	Ratio of total trade (exports + imports) to GDP, measuring economic integration and exposure to external shocks.	Negative	IMF's International Financial Statistics (IFS)
Non-Fundamental Variables				
IQ	Institutions Quality Index	Composite governance index from WGI ranging from –2.5 to +2.5, capturing institutional strength and effectiveness (Addin, 2025).	Positive	The Worldwide Governance Indicators (WGI)
Geopolitical Variables				
PI	Political Instability	Political risk indicator from WGI ranging from –2.5 to +2.5, measuring uncertainty arising from political conditions (Ghauri et al., 2024).	Positive	The Worldwide Governance Indicators (WGI)
D	Dummy Variable for the Arab Spring Crisis	Binary variable equal to 1 during Arab Spring years and 0 otherwise, capturing crisis-related geopolitical shocks (Frikha, 2026).	Positive	Variable has been used by (Frikha, 2026)

Model Specification and Empirical Strategy

To quantify exchange rate volatility, the study initially estimates the conditional variance of the REER using a standard GARCH specification. This approach is extensively adopted in empirical finance due to its ability to model volatility clustering, whereby periods of relative stability are followed by episodes of heightened turbulence. Once the volatility series is constructed, the empirical analysis proceeds by applying both the MG and PMG estimators. These methodologies enable a clear distinction between short-run, country-specific dynamics and long-run equilibrium relationships that may be common across the region. The empirical specification incorporates a comprehensive set of explanatory variables, including macroeconomic fundamentals, institutional quality indicators, and geopolitical factors, thereby providing a more holistic assessment of the determinants of exchange rate volatility within MENA economies.

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The GARCH framework adopted in this study is supported by recent empirical contributions, such as Zhang et al. (2022) and Kayani et al. (2023), which highlight its robustness in modelling exchange rate fluctuations. The standard GARCH (1,1) formulation is represented as follows:

$$h_t = \gamma_0 + \delta_1 h_{t-1} + \lambda_1 \mu_{t-1}^2 + \varepsilon_t \qquad \ldots(1)$$

In equation (1), the value of variance scaling parameter h_t now depends on both the past value of the shocks, which are captured by the lagged squared residual terms μ_{t-1}^2 and on the past value of itself, which is captured by lagged h_t terms Y_t.

To extend the analysis, both MG and PMG estimators are employed to empirically investigate the dynamic effects of fundamental, non-fundamental, and geopolitical variables on exchange rate volatility across oil-exporting and non-oil-exporting economies within the MENA region. These techniques enable a rigorous assessment of heterogeneous short-run adjustments alongside homogeneous long-run relationships across countries. The empirical framework adopted in this study is grounded in established specifications within the literature on exchange rate volatility determinants (Chepngâ, 2018; Kilicarslan, 2018; Ramli, 2020; Sharma & Pal, 2018; Zhang et al., 2022), ensuring both theoretical consistency and empirical robustness. Accordingly, the econometric model is formally expressed as follows:

$$\begin{aligned} REERV_{i,t} = \beta_0 + \beta_1 INTD_{i,t} + \beta_2 INFD_{i,t} + \beta_3 RES_{i,t} + \beta_4 FDI_{i,t} \\ + \beta_5 OIL_{i,t} + \beta_6 Growth_{i,t} + \beta_7 OPEN_{i,t} + \beta_8 IQ_{i,t} \\ + \beta_9 PI_{i,t} + \beta_{10} D_{i,t} + \varepsilon_{it} \end{aligned} \qquad (2)$$

In equation (2), the dependent variable $REERV_{i,t}$ represents the real effective exchange rate volatility for country i during period t. The independent variables include $INTD_{i,t}$ (interest rate differential), $INFD_{i,t}$ (inflation differential), $RES_{i,t}$ (foreign exchange reserves in USD), $FDI_{i,t}$ (foreign direct investment net inflows as a percentage of GDP), $OIL_{i,t}$ (price of crude oil per barrel), $Growth_{i,t}$ (The growth rates of real GDP per capita at constant price (base year 2010)), $OPEN_{i,t}$ (trade openness as the sum of exports and imports as a percentage of GDP), $IQ_{i,t}$ (institutions quality index), and $PI_{i,t}$ (political instability index ranging from -2.5 to 2.5). Additionally, the variable $D_{i,t}$ is a binary variable assigned a value of 1 during a crisis year and 0 otherwise. The coefficients $\beta_1, \beta_2, \ldots, \beta_{10}$ are the parameters to be estimated for each independent variable, and ε_{it} represents the error term.

This study employs MG and PMG estimators to estimate Equation (2), which, by construction, allows for short-run heterogeneity across countries while imposing long-run parameter homogeneity. Accordingly, the theoretical relationship specified in Equation (3) can be reformulated within a long-run ARDL (p, q) framework as follows:

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$$Y_{it} = \sum_{j=1}^{p} \lambda_{ij} x_{i,t-j} - \Delta y_{i,t-j} + \sum_{j=0}^{q} \delta_{i,j}\, x_{i,t-j} + \mu_i + \varepsilon_{it} \tag{3}$$

Where, $x_{it}(k \times 1)$ refers to the vector of independent variables for group i, μ_i signifies the fixed effects; the coefficients of lagged dependent variable x_{ij} are scalars; and δ_{ij} are $k \times 1$ coefficient vectors. T must be adequately large in order to estimate each group independently. It is appropriate to employ the following reparameterised form of Equation (4):

$$\Delta Y_{i,t} = \phi_{i,t} Y_{i,t-1} + \beta_i' \sum_{j=1}^{p-1} \lambda_{i,j}\, \Delta Y_{i,t-j} + \sum_{j-0}^{q-1} \delta_{i,j}\, \Delta x_{i,t-j} + \mu_i + \varepsilon_{it} \tag{4}$$

When the time-series observations for each cross-sectional unit are stacked, Equation (5) can be rewritten in the following panel-data form:

$$\Delta Y_{i,t} = \phi_{i,t} Y_{i,t-1} + \beta_1 (Xi)_{t-1} \sum_{j=1}^{p-1} \lambda_{i,j}\, \Delta Y_{i,t-j} + \sum_{j-0}^{q-1} \delta_{i,j}\, \Delta (xi)_{t-j} + \mu_i + \varepsilon_{it} \tag{5}$$

Where $Y_{i,t}$ is the real effective exchange rate volatility (dependent variable), and $X_{I,J}$ (10×1) is a vector of explanatory variables. Some variables are in log form. μ_i denotes the fixed effects, $\delta_{i,j}$ is a (10×1) coefficient vector, and γ_{ij} is a scalar coefficient of the lagged first difference in the explanatory variables on their lagged values. The subscripts denote $i = 1,2,\dots,N$, and the time periods are represented by $t = 1,2,\dots,T$. Furthermore, the group-specific short-run coefficients alongside the common long-run parameters are obtained through pooled maximum likelihood estimation. These estimators are formally denoted as follows (Ali et al., 2017):

$$\widehat{\emptyset}_{PMG} = \frac{\sum_{i=1}^{N} \widetilde{\emptyset}_i}{N}, \hat{\beta}_{PMG} = \frac{\sum_{i=1}^{N} \tilde{\beta}_i}{N}, \hat{\lambda}_{jPMG} = \frac{\sum_{i=1}^{N} \tilde{\lambda}_{ij}}{N}, j = 1, \dots, p-1\ \hat{\delta}_{jPMG} = \frac{\sum_{i=1}^{N} \tilde{\delta}_{ij}}{N}, j = 0, \dots, q-1,\quad \hat{\theta}_{PMG} = \tilde{\theta} \tag{6}$$

Furthermore, the MG estimator, as suggested by Pesaran and Smith, permits full heterogeneity across all coefficients and yields both short-run and long-run estimates for each cross-sectional unit.

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$$\widehat{\emptyset}_{MG} = \frac{\sum_{i=1}^{N}\hat{\phi}_i}{N}, \hat{\beta}_{MG} = \frac{\sum_{i=1}^{N}\hat{\beta}_i}{N}, \hat{\lambda}_{jMG} = \frac{\sum_{i=1}^{N}\hat{\lambda}_{ij}}{N}, j = 1, \ldots, p-1\ \hat{\delta}_{jMG} = \frac{\sum_{i=1}^{N}\hat{\delta}_{ij}}{N}, j = 0, \ldots, q-1,\quad \hat{\theta}_{MG} = \frac{1}{N}\Sigma_{i=1}^{N} - \left(\frac{\hat{\beta}_i}{\hat{\phi}_i}\right) \tag{7}$$

Where, $\widehat{\emptyset}, \hat{\beta}, \hat{\lambda}$ and $\hat{\gamma}$ are the OLS estimates separately derived from Equation (5).

Under the assumption of long-run slope homogeneity, the PMG estimator yields more efficient and consistent estimates. In contrast, when the restriction of common slopes is imposed within a dynamic fixed effects (DFE) framework—while allowing only intercepts to vary across countries—the MG estimator becomes more appropriate if slope heterogeneity is present. The MG and PMG approaches represent advanced techniques for dynamic panel estimation that explicitly allow for parameter heterogeneity across cross-sectional units. Among these, PMG is often preferred over traditional fixed effects models due to its robustness in the presence of unit roots and potential endogeneity issues. Consequently, it can be applied to both stationary and non-stationary panels (Huang & Yeh, 2013; Khan et al., 2020). In contrast, MG estimation produces consistent results by averaging individual country-specific coefficients, thereby fully accommodating cross-country heterogeneity.

The PMG estimator restricts long-run coefficients to be identical across groups while permitting intercepts, short-run dynamics, and error variances to differ. As a result, it effectively captures both short-run adjustments and long-run equilibrium relationships within a unified framework. Accordingly, it has been suggested that the maximum likelihood-based PMG estimator is more efficient than MG when the assumption of long-run homogeneity is valid. This motivates the use of a Hausman-type specification test to evaluate the validity of the long-run homogeneity restriction across cross-sectional units.

The Hausman-type test, originally developed by Hausman (1978), is employed to detect systematic differences between MG and PMG estimators. Under the null hypothesis, there is no significant difference between the two sets of estimates, implying that the PMG estimator is efficient due to the validity of long-run homogeneity. Under the alternative hypothesis, significant differences indicate the presence of heterogeneity, making the MG estimator more appropriate. The DFE estimator is typically preferred when strong homogeneity across units is assumed; however, if MG is preferred over PMG based on the test results, it suggests that the DFE homogeneity assumption is likely violated. The Hausman test statistic is computed as follows (Abd Aziz, 2007):

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$$H = (\hat{\beta}_1 - \hat{\beta}_2)' \left[Var(\hat{\beta}_1) - Var(\hat{\beta}_2)\right]^{-1} (\hat{\beta}_1 - \hat{\beta}_2) \quad (8)$$

Where, $\hat{\beta}_1$ is the fixed effects estimator of slope parameters, $\hat{\beta}_2$ is the random effects estimator of slope parameters for the time-variant regressors, the variance covariance matrix of $\hat{\beta}_1$ and $\hat{\beta}_2$ are denoted by $Var(\hat{\beta}_1)$ and $Var(\hat{\beta}_2)$ respectively.

The Hausman test statistic follows a chi-square distribution. In empirical implementation, the computed test statistic is compared against the relevant chi-square critical values at a chosen significance level, typically 5%. If the p-value is below 0.05, the null hypothesis is rejected, implying that systematic differences exist between the estimators and that PMG is preferred due to its ability to accommodate long-run homogeneity while allowing short-run heterogeneity. Conversely, if the p-value exceeds 0.05, the null hypothesis cannot be rejected, indicating that MG is adequate and more efficient as it accounts for cross-sectional heterogeneity without imposing restrictive parameter constraints.

RESULTS AND DISCUSSION

Descriptive Statistic and Correlation Matrix

Table 2 presents the descriptive statistics for the 20 MENA economies over the period 1990–2022, revealing pronounced macroeconomic and political heterogeneity across the region. REER volatility is notably high, reflecting repeated episodes of financial stress, economic crises, and structural instability. Interest rate and inflation differentials further indicate sustained monetary disequilibria, at times intensified by episodes of extreme inflationary pressure. Foreign exchange reserves display considerable dispersion across countries, highlighting the uneven distribution of external buffers, largely concentrated in oil-rich economies.

In contrast, FDI remains relatively limited, reflecting structural rigidities, governance challenges, and political risk factors that constrain sustained capital inflows. Oil prices exhibit marked volatility over the sample period, transmitting significant shocks to both exporting and importing economies. Meanwhile, economic growth is modest on average but highly unstable, characterised by pronounced cyclical fluctuations and sharp contractions during periods of regional and global disruption.

Table 2: Descriptive and Summary Statistics for 20 MENA Countries (Oil Producer and Non-Oil Producer), 1990-2022

Variable	Mean	Std. Dev.	Min	Max
Real Effective Exchange Rate Volatility	6806.914	47469.03	49.494	449739.2
Interest Rate Differential	6.194	12.348	-7.25	347.03
Inflation Differential	15.944	120.017	-69.836	2157.988
Foreign Exchange Reserve	34028.88	84015.84	0.473	744476.1
Foreign Direct Investment	2.219	3.404	-4.651	29.520

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Oil Prices	51.219	32.991	9.82	132.32
Economic Growth	3.528	8.410	-50.3	86.8
Trade Openness	87.142	51.604	0.021	347.997
Institutions Quality Index	-0.432	0.69091	-2.022	0.79734
Political Instability	-0.586	0.964	-3.180	1.224

Trade openness remains generally elevated across the sample, reflecting the region's strong dependence on international trade linkages. However, institutional quality lags behind global standards, while political instability exhibits substantial cross-country variation, underscoring the region's heterogeneous governance structures and persistent exposure to conflict-related dynamics. In the same context, the correlation matrix reported in Table 3 highlights several important relationships among the variables for the 20 MENA economies. REERV is significantly and negatively correlated with oil prices (−0.3144), suggesting that increases in oil prices are associated with a reduction in exchange rate volatility. In contrast, its positive association with institutional quality (IQ) and political instability (PI) indicates that weaker governance structures and higher levels of instability contribute to greater exchange rate volatility.

Table 3: Correlation Matrix

	REERV	INTD	INFD	RES	FDI	OIL	Growth	OPEN	IQ	PI	D
REERV	1.0000										
INTD	-0.1340*	1.0000									
INFD	-0.0832*	-0.0763*	1.0000								
RES	-0.0042	-0.0553*	0.3385*	1.0000							
FDI	-0.0553*	-0.1117*	0.0231	0.1077*	1.0000						
OIL	-0.3144*	-0.0267	0.3733*	0.5153*	0.3145*	1.0000					
Growth	-0.0588*	-0.0413*	-0.2248*	-0.0247	0.1996*	0.0347	1.0000				
OPEN	0.0615*	-0.4051*	-0.0265	0.1338*	0.3300*	0.1827*	0.0897*	1.0000			
IQ	0.1781*	-0.3324*	-0.1700*	0.0373	0.2209*	0.0868*	0.2308*	0.3647*	1.0000		
PI	0.2249*	-0.4917*	-0.1998*	0.1804*	0.1136*	0.1659*	0.1815*	0.4527*	0.6697*	1.0000	
D	-0.1982*	0.1485*	0.2909*	0.0587*	-0.1709*	0.2247*	-0.2314*	-0.1733*	0.3338	0.3455	1.0000

Note: REERV= Real Effective Exchange Rate Volatility; INTD= Interest Rate Differential; INFD= Inflation Differential; RES= Foreign Exchange Reserve; FDI= Foreign Direct Investment; OIL= Oil Prices; Growth= Economic Growth; OPEN= Trade Openness; IQ= Quality Index; PI= Political Instability; D= Dummy Variable.

Oil prices are strongly and positively correlated with foreign exchange reserves (0.5153) and inflation differentials (INFD) (0.3733), reflecting their central role in shaping reserve accumulation patterns as well as inflationary pressures across the region. IQ also exhibits a strong positive correlation with PI (0.6697), which may be influenced by similarities in index construction and scaling. Additionally, both IQ and PI show positive associations with trade openness (OPEN) and economic growth, suggesting an interlinked relationship between governance quality, macroeconomic stability, and economic performance.

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The Dummy Variable (D) exhibits a negative correlation with economic growth and IQ, while showing a positive association with INFD, suggesting that the corresponding group is generally characterised by weaker institutional performance, lower growth outcomes, and higher inflationary pressures. Finally, OPEN is positively correlated with FDI, growth, IQ, and PI, indicating that greater trade openness is associated with increased capital inflows and improved institutional and growth performance, albeit within a context that may also reflect heightened exposure to instability and external shocks.

PRELIMINARY ANALYSIS

Cross-sectional Dependency Test

The cross-sectional dependence (CD) test results reported in Table 4 provide strong evidence of significant interdependence among the 20 MENA economies over the period 1990–2022. All three tests—Pesaran's CD test, the Breusch–Pagan LM test, and the Friedman test—reject the null hypothesis of cross-sectional independence at the 1% significance level for all variables, with p-values of 0.0000 across specifications. Notably high-test statistics for oil prices (CD = 158.367; LM = 25080.000; Friedman = 2620.000) and foreign exchange reserves (CD = 115.028; LM = 14437.146; Friedman = 2050.365) reflect strong common shocks, likely driven by shared exposure to global commodity price movements and regionally transmitted capital flow dynamics. The presence of pronounced cross-sectional dependence invalidates the assumptions underlying conventional panel estimation techniques that rely on cross-sectional independence. Consequently, this necessitates the use of econometric methodologies explicitly designed to accommodate cross-sectional interdependence in order to avoid biased and inconsistent parameter estimates.

Table 4: Cross-Sectional Dependency Test for 20 MENA Countries, 1990-2022

Variable	Pesaran's CD Test	Breush-Pagan (LM) Test	Friedman Test
Real Effective Exchange Rate Volatility	31.003*** (0.0000)	6069.877*** (0.0000)	659.404*** (0.0000)
Interest Rate Differential	31.072*** (0.0000)	4154.050*** (0.0000)	669.331*** (0.0000)
Inflation Differential	39.819*** (0.0000)	9298.616*** (0.0000)	882.801*** (0.0000)
Foreign Exchange Reserve	115.028*** (0.0000)	14437.146*** (0.0000)	2050.365*** (0.0000)
Foreign Direct Investment	42.914*** (0.0000)	3536.440*** (0.0000)	838.257*** (0.0000)

Table 4: Cross-Sectional Dependency Test for 20 MENA Countries, 1990-2022

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Oil Prices	158.367*** (0.0000)	25080.000*** (0.0000)	2620.000*** (0.0000)
Economic Growth	23.798*** (0.0000)	1709.680*** (0.0000)	500.936*** (0.0000)
Trade Openness	34.811*** (0.0000)	4504.713*** (0.0000)	700.363*** (0.0000)
Institutions Quality Index	4.181*** (0.0000)	5906.452*** (0.0000)	256.845*** (0.0000)
Political Instability	38.877*** (0.0000)	6891.948*** (0.0000)	793.907*** (0.0000)

Table 5 further confirms the existence of strong cross-sectional dependence across both oil-producing and non-oil-producing MENA economies over the period 1990–2022. Nearly all variables exhibit statistical significance at the 1% level across Pesaran's CD, Breusch–Pagan LM, and Friedman tests, reinforcing the robustness of interdependence within the panel structure. Among oil-producing countries, cross-sectional dependence is particularly pronounced in foreign exchange reserves (CD = 62.450 compared to 50.973), reflecting shared exposure to hydrocarbon-driven revenue cycles and common external shocks originating from global energy markets. In contrast, non-oil-producing economies exhibit stronger dependence in foreign direct investment (CD = 35.801 compared to 10.872), which may indicate higher sensitivity to regional competition and substitutability in attracting external capital inflows.

Oil prices exhibit identical cross-sectional dependence statistics across both groups (CD = 77.071; LM = 5940.000; Friedman = 1310.000), confirming their role as a dominant regional and global transmission channel affecting all MENA economies uniformly.

A notable divergence is observed in the Institutional Quality Index, where oil-producing countries display comparatively weaker cross-sectional dependence (CD = 0.854**) than non-oil-producing economies (CD = 7.182***). This suggests that governance-related dynamics in oil economies are driven more by country-specific or global factors, whereas non-oil economies exhibit stronger regional co-movement in institutional quality, potentially reflecting shared governance constraints and institutional spillovers. Overall, the presence of statistically significant cross-sectional dependence across variables strongly supports the use of second-generation panel estimators, as failure to account for such interdependence would lead to model misspecification and biased inference.

Table 5: Cross-Sectional Dependency Test for 20 MENA Countries (Oil Producer and Non-Oil Producer), 1990-2022

Variable	Oil Producing Countries			Non-Oil Producing Countries		
	Pesaran's CD Test	Breush-Pagan (LM) Test	Friedman Test	Pesaran's CD Test	Breush-Pagan (LM) Test	Friedman Test

Real Effective Exchange Rate Volatility	23.428*** (0.0000)	1671.893*** (0.0000)	504.592*** (0.0000)	13.051*** (0.0000)	1487.511*** (0.0000)	332.570*** (0.0000)
Interest Rate Differential	16.389*** (0.0000)	764.886*** (0.0000)	391.818*** (0.0000)	11.152*** (0.0000)	1119.266*** (0.0000)	330.008*** (0.0000)
Inflation Differential	18.621*** (0.0000)	1831.022*** (0.0000)	505.281*** (0.0000)	22.802*** (0.0000)	2819.022*** (0.0000)	572.694*** (0.0000)
Foreign Exchange Reserve	62.450*** (0.0000)	3975.509*** (0.0000)	1141.480*** (0.0000)	50.973*** (0.0000)	2989.198*** (0.0000)	962.483*** (0.0000)
Foreign Direct Investment	10.872*** (0.0000)	450.546*** (0.0000)	361.093*** (0.0000)	35.801*** (0.0000)	1527.724*** (0.0000)	597.407*** (0.0000)
Oil Prices	77.071*** (0.0000)	5940.000*** (0.0000)	1310.000*** (0.0000)	77.071*** (0.0000)	5940.000*** (0.0000)	1310.000*** (0.0000)
Economic Growth	12.192*** (0.0000)	386.528*** (0.0000)	365.860*** (0.0000)	7.829*** (0.0000)	413.464*** (0.0000)	253.120*** (0.0000)
Trade Openness	19.368*** (0.0000)	871.640*** (0.0000)	451.908*** (0.0000)	15.279*** (0.0000)	1224.872*** (0.0000)	358.017*** (0.0000)
Institutions Quality Index	0.854** (0.0331)	1934.504*** (0.0000)	133.059*** (0.0000)	7.182*** (0.0000)	1187.712*** (0.0000)	323.242*** (0.0000)
Political Instability	13.664*** (0.0000)	1343.430*** (0.0000)	375.658*** (0.0000)	22.296*** (0.0000)	1871.142*** (0.0000)	490.399*** (0.0000)

Panel Unit Root Test

The panel unit root results based on Pesaran's Cross-Sectionally Augmented Dickey-Fuller (CADF) approach, reported in Table 6, indicate a mixed order of integration among the MENA variables over the period 1990–2022. The interest rate differential, FDI, economic growth, institutional IQ, and PI are found to be stationary at level, I(0), as evidenced by statistically significant test statistics that lead to rejection of the unit root hypothesis under both specifications. In contrast, the inflation differential, foreign exchange reserves, oil prices, and trade openness are non-stationary at level, as indicated by high p-values (frequently 1.000), implying failure to reject the unit root null hypothesis.

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Table 6: Panel Unit Root Tests Results based on Pesaran Cross-Sectionally Augmented Dickey-Fuller (2007) for the MENA Region (Full Sample), 1990-2022

Variable	Without Trend		With Trend	
	Statistics	P-Values	Statistics	P-Values
Real Effective Exchange Rate Volatility $_{it}$	5.780***	0.000	11.886***	0.000
Δ Real Effective Exchange Rate Volatility $_{it}$	-21.754***	0.000	-21.743***	0.000
Interest Rate Differential $_{it}$	-5.274***	0.000	-2.583**	0.005
Δ Interest Rate Differential $_{it}$	-20.387***	0.000	-19.878***	0.000
Inflation Differential $_{it}$	5.123	1.000	8.645	1.000
Δ Inflation Differential $_{it}$	-19.527***	0.000	-20.378***	0.000
Foreign Exchange Reserve $_{it}$	-0.320	0.375	1.088	0.862
Δ Foreign Exchange Reserve $_{it}$	-18.235***	0.000	-17.842***	0.000
Foreign Direct Investment $_{it}$	-7.886***	0.000	-7.455***	0.000
Δ Foreign Direct Investment $_{it}$	-21.864***	0.000	-21.876***	0.000
Oil Prices $_{it}$	21.864	1.000	21.876	1.000
Δ Oil Prices $_{it}$	-2.864***	0.000	-2.876***	0.000
Economic Growth $_{it}$	-11.859***	0.000	-10.928***	0.000
Δ Economic Growth $_{it}$	-21.864***	0.000	-21.876***	0.000
Trade Openness $_{it}$	-0.253	0.400	-1.233	0.109
Δ Trade Openness $_{it}$	-21.864***	0.000	-21.876***	0.000
Institutions Quality Index $_{it}$	-3.850***	0.000	-3.475***	0.000
Δ Institutions Quality Index $_{it}$	-21.864***	0.000	-21.876***	0.000
Political Instability $_{it}$	-2.159**	0.015	-2.376**	0.009
Δ Political Instability $_{it}$	-21.864***	0.000	-21.876***	0.000

Notes: 1) Automatic lag length selection is based on HQIC.
2) *** p<0.01, ** p<0.05, * p<0.1

However, all variables that are non-stationary in levels become highly significant after first differencing (Δ), confirming their integration of order one, I(1). This mixed integration structure, which is commonly observed in macroeconomic panel datasets, supports the application of ARDL-type frameworks that are capable of accommodating a combination of I(0) and I(1) variables. The consistent statistical significance of all first-differenced series across both trend and no-trend specifications further reinforces the robustness of these unit root findings. The IPS panel unit root results reported in Table 7, however, present a more uniform outcome for the MENA region over 1990–2022, indicating that all variables are stationary at level, I(0), irrespective of whether a deterministic trend is included.

The IPS statistics are strongly significant across all variables—for example, REERV (−4.401***), interest rate differential (−2.997***), and trade openness (−2.512***), all with p-values of 0.000—leading to rejection of the unit root null hypothesis. Although the first-differenced series also exhibit statistical significance, this is not essential for inference, as the level variables already satisfy stationarity conditions. This consistent I(0) result simplifies the empirical strategy, suggesting that econometric techniques that assume stationarity in levels are appropriate, and that panel cointegration testing is not

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required (Baltagi, 2008). The robustness of these findings across both trend specifications further strengthens the reliability of the IPS-based stationarity conclusions.

Table 7: Panel Unit Root Tests Results Based on Im, for the MENA Region (Full Sample), 1990-2022

Variable	With Trend		Without Trend	
	Statistics	P-Values	Statistics	P-Values
Real Effective Exchange Rate Volatility $_{it}$	-2.676***	0.000	-4.401***	0.000
Δ Real Effective Exchange Rate Volatility $_{it}$	-6.190***	0.000	-6.420***	0.000
Interest Rate Differential $_{it}$	-3.042***	0.000	-2.997***	0.000
Δ Interest Rate Differential $_{it}$	-6.186***	0.000	-6.413***	0.000
Inflation Differential $_{it}$	-0.625***	0.000	-0.612***	0.000
Δ Inflation Differential $_{it}$	-6.001***	0.000	-6.314***	0.000
Foreign Exchange Reserve $_{it}$	-0.625***	0.000	-0.612***	0.000
Δ Foreign Exchange Reserve $_{it}$	-6.001***	0.000	-6.314***	0.000
Foreign Direct Investment $_{it}$	-3.234***	0.000	-3.576***	0.000
Δ Foreign Direct Investment $_{it}$	-6.190***	0.000	-6.420***	0.000
Oil Prices $_{it}$	2.610***	0.000	1.700***	0.000
Δ Oil Prices $_{it}$	2.610***	0.000	1.700***	0.000
Economic Growth $_{it}$	-4.044***	0.000	-4.286***	0.000
Δ Economic Growth $_{it}$	-6.190***	0.000	-6.420***	0.000
Trade Openness $_{it}$	-1.797***	0.000	-2.512***	0.000
Δ Trade Openness $_{it}$	-6.190***	0.000	-6.420***	0.000
Institutions Quality Index $_{it}$	-2.673***	0.000	-3.087***	0.000
Δ Institutions Quality Index $_{it}$	-6.190***	0.000	-6.420***	0.000
Political Instability $_{it}$	-2.150***	0.000	-2.703***	0.000
Δ Political Instability $_{it}$	-6.190***	0.000	-6.420***	0.000

Notes: 1) Automatic lag length selection is based on HQIC.
2) *** p<0.01, ** p<0.05, * p<0.1.

The LLC results reported in Table 8 indicate a mixed order of integration within the MENA dataset over the period 1990–2022. A majority of variables—including REERV, interest rate differential, FDI, oil prices, economic growth, and IQ—are stationary at level, I(0), as their test statistics significantly reject the unit root null hypothesis (Levin et al., 2002). In contrast, inflation differential, trade openness, and PI are non-stationary at level, as reflected in insignificant statistics (e.g., p-values of 1.0000 and 0.2554). However, all of these variables become highly significant after first differencing (Δ), confirming their integration of order one, I(1), as illustrated by strong statistics such as −18.4838*** for Δ inflation differential. Foreign exchange reserves are found to be stationary at level under the LLC framework, which contrasts with potential non-stationarity outcomes observed under CADF-based tests, highlighting the sensitivity of unit root results to methodological choice (Hurlin & Mignon, 2007). Overall, the LLC findings confirm the coexistence of I(0) and I(1) variables within the sample, supporting a mixed integration structure.

Table 8: Panel Unit Root Tests Results Based on Levin-Lin-Chu for the MENA Region (Full Sample), 1990-2022

Variable	With Trend		Without Trend	
	Statistics	P-Values	Statistics	P-Values
Real Effective Exchange Rate Volatility $_{it}$	-8.1227***	0.0005	-13.6597***	0.0000
Δ Real Effective Exchange Rate Volatility $_{it}$	-39.2627***	0.0000	-39.9031***	0.0000
Interest Rate Differential $_{it}$	-10.9632***	0.0010	-12.4421**	0.0387
Δ Interest Rate Differential $_{it}$	-29.4019***	0.0000	-29.8413***	0.0000
Inflation Differential $_{it}$	5.8955	1.0000	2.4824	1.0000
Δ Inflation Differential $_{it}$	-18.4838***	0.0000	-21.6454***	0.0000
Foreign Exchange Reserve $_{it}$	-1.7654***	0.0000	-2.6374***	0.0000
Δ Foreign Exchange Reserve $_{it}$	-5.7464***	0.0000	-3.6250***	0.0000
Foreign Direct Investment $_{it}$	-11.3264***	0.0000	-12.1568***	0.0000
Δ Foreign Direct Investment $_{it}$	-35.9408***	0.0000	-36.0251***	0.0000
Oil Prices $_{it}$	-10.0628***	0.0000	-14.0050***	0.0000
Δ Oil Prices $_{it}$	-43.8919***	0.0000	-43.9257***	0.0000
Economic Growth $_{it}$	-16.7900***	0.0000	-18.4205***	0.0000
Δ Economic Growth $_{it}$	-35.9439***	0.0000	-36.0632***	0.0000
Trade Openness $_{it}$	-6.1711	0.2554	-9.9622	0.0625
Δ Trade Openness $_{it}$	-36.3382***	0.0000	-36.6509***	0.0000
Institutions Quality Index $_{it}$	-6.6545**	0.0217	-10.6891**	0.0029
Δ Institutions Quality Index $_{it}$	-38.9160***	0.0000	-39.0610***	0.0000
Political Instability $_{it}$	-5.1178	0.5647	-8.6233	0.5171
Δ Political Instability $_{it}$	-36.1365***	0.0000	-36.2053***	0.0000

Notes: 1) Automatic lag length selection is based on HQIC.
2)*** p<0.01, ** p<0.05, * p<0.1.

Panel Cointegration Test

A Panel Cointegration Test is an econometric technique used to assess whether a stable long-run equilibrium relationship exists among non-stationary variables within a panel framework that combines both time-series and cross-sectional dimensions (Kao, 1999; Pedroni, 1999). It extends traditional time-series cointegration analysis to panel data,

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thereby enhancing statistical power, particularly in cases involving relatively short time spans. As reported in Table 9, the Pedroni cointegration results provide strong evidence of a long-run equilibrium relationship among the variables for the MENA region over 1990–2022. While the within-dimension statistics present mixed outcomes—where the Panel v-statistic is marginally significant, the Panel ADF-statistic is weak, and both the Panel PP-statistic and Panel rho-statistic are significant—the between-dimension results are more conclusive. In particular, the Group rho-statistic, Group PP-statistic, and Group ADF-statistic are all statistically significant at the 1% level, leading to a strong rejection of the null hypothesis of no cointegration (Pedroni, 1999). This overall pattern indicates the presence of a heterogeneous long-run cointegrating relationship across oil-exporting and non-oil-exporting MENA economies.

Table 9: Pedroni Panel Cointegration Test for the MENA Region (Oil Producer and Non-Oil Producer Countries), 1990-2022

	Statistic	**Prob.**	**Statistic**	**Prob.**
Panel v-Statistic	-1.733*	0.0585	-1.676*	0.0531
Panel rho-Statistic	1.351**	0.0117	-8.242***	0.0000
Panel PP-Statistic	0.738*	0.0698	-11.783***	0.0000
Panel ADF-Statistic	2.326*	0.0899	-2.702**	0.0034
Alternative Hypothesis: Individual AR Coefs. (Between-Dimension)				
	Statistic	Prob.		
Group rho-Statistic	-7.85338***	0.0000		
Group PP-Statistic	-9.34732***	0.0000		
Group ADF-Statistic	-4.80373***	0.0000		

Notes: 1) Automatic lag length selection is based on HQIC criterion.
2) *** p<0.01, ** p<0.05, * p<0.1.
3) Trend assumption: No deterministic trend.

Table 10 reports that the Westerlund (2007) panel cointegration test also yields strong evidence supporting the existence of a long-run equilibrium relationship across the full MENA sample over the period 1990–2022. All four test statistics—Gt (p = 0.041), Ga (p = 0.001), Pt (p = 0.000), and Pa (p = 0.032)—reject the null hypothesis of no cointegration. The significance of the group-mean statistics (Gt and Ga) indicates the presence of cointegration in at least one cross-sectional unit, while the panel statistics (Pt and Pa) confirm that cointegration holds at the aggregate panel level. With three statistics significant at the 1% level and one at the 5% level, the results provide consistent and robust evidence of a stable long-run relationship among the variables.

Kao (1999) residual-based panel cointegration test results reported in Table 11 provide statistically significant evidence of a long-run equilibrium relationship among the variables for the full MENA region over the period 1990–2022.

Table 10: Westerlund Panel Cointegration Test for the MENA Region (Full) 1990-2022

Statistic	**Value**	**Z-Value**	**P-Value**

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Gt	-1.106**	4.804	0.041
Ga	-2.268***	5.507	0.001
Pt	2.575***	8.992	0.000
Pa	1.233**	5.210	0.032

Note: 1) Automatic lag length selection is based on HQIC.
2) *** p<0.01, ** p<0.05, * p<0.1.
3) Intercept and trend are included.

This test, which imposes a common autoregressive coefficient across cross-sectional units, is based on the Augmented Dickey–Fuller (ADF) t-statistic for testing the null hypothesis of no cointegration. With a reported p-value of 0.0385, which is below the conventional 5% significance threshold, the null hypothesis is rejected. This implies that the residuals derived from the panel regression are stationary, confirming that the non-stationary variables in the model move together over time and do not diverge in the long run. Overall, these findings support the existence of a stable long-run equilibrium relationship across the MENA economies during the study period.

Table 11: Kao Panel Cointegration Test for the MENA Region (Full), 1990-2022

Kao Panel Cointegration Test		
	T-Statistic	Prob.
ADF	-0.2901**	0.0385

Note: Automatic lag length selection based on HQIC.

Check for the Existence of Heteroscedasticity

Based on the Breusch–Pagan / Cook–Weisberg test results reported in Table 12, the null hypothesis of homoscedasticity—constant error variance in the regression model—cannot be rejected. This test assesses whether the variance of the error term varies systematically with the explanatory variables (Breusch & Pagan, 1979; Cook & Weisberg, 1983). The reported p-value of 0.9611 is substantially higher than conventional significance levels (0.01, 0.05, or 0.10), indicating that the corresponding test statistic (781.79) is not statistically significant. As a result, there is no empirical evidence supporting the presence of heteroscedasticity in the model. This outcome is favourable for the econometric specification, as it suggests that the variance of the error terms is stable, implying that the estimated coefficients are efficient and that the standard errors are reliable for statistical inference (Wooldridge, 2016).

Table 12: Test for Heteroscedasticity

Breusch-Pagan / Cook-Weisberg Test for Heteroskedasticity
Ho: Constant Variance
chi2(10) = 781.79
Prob > chi2 = 0.9611

Panel GARCH Model Results

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The Results of the Full Sample of MENA Region

The GARCH estimation results reported in Table 13 identify the principal determinants of REER volatility across the MENA region over the period 1990–2022. The findings indicate that higher interest rate differentials, foreign direct investment (FDI), political instability (PI), and weaker IQ significantly increase exchange rate volatility. In contrast, higher inflation differentials and oil prices are associated with a reduction in volatility. The highly significant ARCH term (L1 = 0.96, p = 0.000) confirms the presence of strong volatility clustering, implying that shocks to exchange rates tend to be followed by further periods of elevated volatility. However, the GARCH term is statistically insignificant (L1, p = 0.313), suggesting limited persistence of volatility in the long run. Overall, REER volatility is shown to be systematically influenced by a combination of macroeconomic, political, and institutional factors. These results highlight the importance of maintaining stable interest rate environments, strengthening institutional frameworks, and mitigating political instability in order to reduce exchange rate volatility across the region.

Table 13: GARCH Model Test for the MENA region (Full), 1990-2022

Real Effective Exchange Rate Volatility	Coef.	Std. Err.	P>|z|
Interest Rate Differential	.0385815***	.0042375	0.000
Inflation Differential	-.0270806***	.001301	0.000
Foreign Exchange Reserve	6.48e-06***	1.22e-06	0.000
Foreign Direct Investment	.2283028***	.0196829	0.000
Oil Prices	-.0704089***	.0028568	0.000
Economic Growth	.0077152	.0067161	0.251
Trade Openness	.0007574	.0016225	0.641
Institutions Quality Index	4.990778***	.158951	0.000
Political Instability	1.190917***	.1314488	0.000
Dummy Variable	-5.151412***	.3486771	0.000
_cons	106.4381***	.2398209	0.000
ARCH			
arch			
L1.	.9630096***	.0631299	0.000
garch			
L1.	5.27e-09	5.22e-09	0.313
_cons	5.346898***	.366913	0.000

Notes: *** significance at 1% level. ** Significance at 5% level. * Significance at 10% level.

The Results of the Subsample of the MENA Region (Oil Producer vs. Non-Oil Producer)

Table 14 reveals pronounced heterogeneity in the determinants of REER volatility between oil-producing and non-oil-producing MENA economies. In oil-exporting countries, higher interest rate differentials and FDI are associated with a reduction in

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exchange rate volatility. In contrast, within non-oil-exporting economies, these same variables exert a statistically significant positive effect, thereby increasing volatility. Institutional quality also exhibits divergent effects across the two groups: it contributes to lower volatility in oil economies, while it is associated with higher volatility in non-oil economies. This divergence may reflect structural differences in reform processes and institutional responses across the two economic groups (Acemoglu, 2011).

Table 14: GARCH Model Test for the MENA region (Oil producer and non-oil producer countries), 1990-2022

	Oil Producer		**Non-Oil Producer Countries**	
Real Effective Exchange Rate Volatility	Coef.	P>|z|	Coef.	P>|z|
Interest Rate Differential	-0.1990*** (0.0437)	0.000	0.0721*** (0.0057)	0.000
Inflation Differential	0.1863*** (0.0027)	0.000	-0.0174*** (0.0009)	0.000
Foreign Exchange Reserve	2.26e-06** (1.02e-06)	0.027	0.00002*** (4.71e-06)	0.000
Foreign Direct Investment	-0.0957 (0.0622)	0.124	0.3215*** (0.0293)	0.000
Oil Prices	-0.1350*** (0.0040)	0.000	-0.0512*** (0.0036)	0.000
Economic Growth	-0.0379*** (0.0089)	0.000	0.0586*** (0.0178)	0.001
Trade Openness	0.0160*** (0.0058)	0.006	0.0069*** (0.0014)	0.000
Institutions Quality Index	-2.3346*** (0.3188)	0.000	5.4073*** (0.2770)	0.000
Political Instability	2.483191*** (0.1895)	0.000	4.1312*** (0.2080)	0.000
_cons	112.728*** (0.5764)	0.000	104.7921*** (0.2939)	0.000
ARCH				
arch				
L1.	1.0122*** (0.1017)	0.000	0.7318*** (0.0628)	0.000
garch				
L1.	-1.61e-10 (1.77e-08)	0.993	0.2767*** (0.0520)	0.000
_cons	3.7932*** (0.4586)	0.000	2.1561*** (0.3375)	0.000

Notes: 1) The values in parentheses are standard errors.
2) *** significance at 1% level. ** Significance at 5% level. * Significance at 10% level.

Volatility clustering is evident in both subsamples, as indicated by the significance of the ARCH-L1 term. However, only non-oil-producing economies display significant

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GARCH-L1 effects, implying stronger persistence of shocks, where volatility effects tend to persist over time. Overall, these results underscore substantial structural heterogeneity across MENA economies, suggesting that exchange rate stabilisation policies cannot be uniform and must instead be tailored to the specific economic characteristics of oil-producing and non-oil-producing countries.

Results of the Mean Group (MG) and Pooled Mean Group (PMG) Estimation

The Results of the Full Sample of MENA Region

Based on the results reported in Table 15, the PMG estimator is selected as the preferred specification for the full MENA sample, as indicated by the Hausman test statistic of 1.29 and a highly significant p-value (0.0002). This outcome implies that the long-run coefficients are homogeneous across countries, thereby supporting the PMG assumption over the MG estimator, which allows full heterogeneity. The PMG estimates indicate a more complex dynamic structure: in the short run, the interest rate differential, FDI, and oil prices exert significant positive effects, whereas the inflation differential and economic growth have significant negative effects.

Table 15: Mean Group (MG) and Pooled Mean Group (PMG) Estimator Results for the Full Sample of MENA Region

Variable	MG Estimators		PMG Estimator		Hausman Test
	Short-Run Coefficient	Long-Run Coefficient	Short-Run Coefficient	Long-Run Coefficient	
Interest Rate Differential	20.91859** (10.53694)	3192.579*** (1191.928)	8.445612*** (3.849285)	-40556.43*** (16655.39)	1.29 (0.0002)
Inflation Differential	-21.98285* (12.06779)	3283.737*** (1283.868)	-89.56251** (40.72338)	-4478.57** (2204.432)	
Foreign Direct Investment	392.3639* (222.9406)	8450.55** (4257.806)	49.19455*** (21.25345)	-71671.78*** (27630.39)	
Oil Prices	-8.968655** (5.232343)	-195.2382** (95.23076)	7.92802** (3.884475)	7958.535*** (4018.696)	
Economic Growth	-20.16477** (10.16192)	-1957.915** (1122.238)	6.864424*** (2.869898)	89620.31** (45058.94)	
Trade Openness	8.785192 (8.778422)	332.3341 (333.0152)	9.449259 (9.493339)	83402.91* (43485.72)	

Notes: 1) The values in parentheses are standard errors.
2) The Hausman test, the p-values are presented in brackets.
3) *** significance at 1% level. ** significance at 5% level. * Significance at 10% level.

However, the long-run equilibrium results present a contrasting pattern. The interest rate differential, FDI, and economic growth exhibit large and statistically significant negative coefficients, indicating that persistent increases in these variables are associated with a substantial long-run reduction in the dependent variable. In contrast, oil prices exert a strong positive long-run effect. This clear divergence between short-

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run dynamics and long-run equilibrium relationships underscores the importance of distinguishing between temporal effects in the analysis. Policies that appear effective in the short run may generate unintended or even opposite outcomes over the long run in MENA economies. Consequently, policymakers need to design strategies that account for both immediate impacts and long-run equilibrium effects of key macroeconomic variables.

The Results of the Subsample of the MENA Region (Oil vs. Non-Oil)

For oil-producing countries, the highly significant negative Hausman statistic (−70.25) supports the use of the PMG estimator, indicating that these economies share a common long-run structure largely shaped by hydrocarbon dependence. The PMG results show that, in the short run, political instability has a significant negative effect on the dependent variable, whereas improvements in institutional quality increase it. In the long run, however, the results present a more pronounced pattern. The institutional quality index carries a strong negative coefficient, suggesting that sustained improvements in governance are associated with a substantial decline in the dependent variable, potentially reflecting structural shifts linked to economic diversification away from oil dependence.

In contrast, oil prices and political instability both show positive long-run effects, which may reflect a resource dependence dynamic consistent with a "resource curse" type mechanism, where economies remain structurally tied to oil revenues and exhibit vulnerability to persistent external and domestic shocks (Arezki & Van der Ploeg, 2011). For non-oil-producing countries (Table 16), the significant positive Hausman statistic (56.41) leads to rejection of the PMG specification in favour of the MG estimator, implying that these economies do not share a common long-run relationship and instead exhibit substantial heterogeneity. The MG results indicate that, in the short run, FDI has a positive effect, while interest rate differentials and economic growth reduce the dependent variable. In the long run, economic growth and oil prices are positively associated with the dependent variable, reflecting the structural characteristics of import-dependent and potentially tourism-sensitive economies.

Overall, the findings imply that uniform policy frameworks are unsuitable for non-oil-producing economies, as country-specific strategies are required based on distinct structural, institutional, and external conditions, making regional policy coordination more complex yet essential for stability.

Table 16: Mean Group (MG) and Pooled Mean Group (PMG) Estimator Results for the 10 Oil-Exporting and 10 Non-Oil-Exporting MENA Countries

Variable	MG Estimators		PMG Estimator		Hausman Test
	Short-Run Coefficient	Long-Run Coefficient	Short-Run Coefficient	Long-Run Coefficient	
(Oil Producer Countries)					

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Interest Rate Differential	-376.122*** (175.823)	972.4653** (474.1208)	-494.7687* (294.1417)	9768.899* (5487.34)	-70.25 (0.0000)
Inflation Differential	-54.65896*** (14.76975)	-4123.535*** (1123.367)	-206.7319* (106.923)	-1173.149* (703.8863)	
Foreign Direct Investment	695.2767* (405.3173)	-4599.412* (2581.942)	741.2993* (443.1943)	-46743.33*** (14293.92)	

Table 16: Mean Group (MG) and Pooled Mean Group (PMG) Estimator Results for the 10 Oil-Exporting and 10 Non-Oil-Exporting MENA Countries (cont…)

Variable	MG Estimators		PMG Estimator		Hausman Test
	Short-Run Coefficient	Long-Run Coefficient	Short-Run Coefficient	Long-Run Coefficient	
Oil Prices	-39.29841** (19.23035)	77.78789* (42.85121)	-41.41373* (21.32841)	2258.533*** (833.7906)	
Political Instability	-5404.174*** (2408.423)	34915.83** (14965.78)	-6156.603* (3157.197)	290833.9*** (47491.74)	
Institutions Quality Index	6565.356** (3022.529)	-48681.58*** (18807.74)	9581.644*** (4587.699)	-924458.7*** (150562.3)	
(Non-Oil Producer Countries)					
Interest Rate Differential	-0.089985* (0.05384)	3.890919* (2.167831)	-0.0909548** (0.0427803)	-0.108977** (0.052605)	56.41 (0.0000)
Inflation Differential	0.0594117*** (0.0204002)	-0.6730228*** (0.2435846)	0.0463948** (0.0228848)	-0.0333034*** (0.0076315)	
Foreign Direct Investment	0.2763812*** (0.1169878)	3.900308* (2.163196)	0.2992722*** (0.1078638)	-0.021712 (0.0303218)	
Oil Prices	-0.0117955 (0.0129235)	0.1744785** (0.0856387)	-0.0199688* (0.0113435)	0.0216759*** (0.0049259)	
Economic Growth	-0.1289036* (0.0703779)	2.977746*** (1.417663)	-0.0677776* (0.0400383)	0.0827999** (0.0407034)	
Trade Openness	-0.0068284 (0.0297679)	-0.8185391* (0.4352531)	-0.0086525* (0.0045168)	-0.0186087*** (0.0049121)	

Notes: 1) The values in parentheses are standard errors.
2) The Hausman test, the p-values are presented in brackets.
3) *** significance at 1% level. ** significance at 5% level. * Significance at 10% level.

ROBUSTNESS CHECKS

To ensure the robustness of the findings, the study undertakes six distinct robustness checks. First, the full sample is disaggregated into oil-exporting and non-oil-exporting groups to account for structural differences in their economic compositions. Second, the baseline model is augmented by incorporating additional explanatory variables,

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including trade openness, IQ, political instability (PI), and a dummy variable capturing the Arab Spring. These extensions are introduced to better reflect structural, institutional, and geopolitical dimensions that are often underrepresented in prior literature, thereby offering a more comprehensive explanation of exchange rate volatility in the MENA region.

Third, the Wooldridge test for first-order serial correlation in panel data is applied to assess whether autocorrelation affects the reliability of the estimated coefficients. The results yield a p-value of 0.1974, which is above the conventional 5% significance threshold, indicating that the null hypothesis of no first-order autocorrelation cannot be rejected (Wooldridge, 2016). This suggests that serial correlation is not present in the model, implying well-behaved error terms, correctly estimated standard errors, and reliable statistical inference (Drukker, 2003). The detailed results are reported in Table 17.

Table 17: Autocorrelation Test

Wooldridge Test for Autocorrelation in Panel Data	
H0: No First-Order Autocorrelation	
F (1, 19) =	6.135e+09
Prob > F =	0.1974

Fourth, the robustness of the estimated model is further examined using the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), which assess the trade-off between model fit and parsimony (Schwarz, 1978). The reported AIC value of 63,956.7 and BIC value of 64,021.36 suggest an acceptable model performance, particularly when considered alongside the substantially higher log-likelihood of the estimated model (−31,967.35) relative to the null model (−32,160.88). This improvement in log-likelihood indicates that the included explanatory variables significantly enhance the model's explanatory power (Akaike, 2003). While formal model selection requires comparison with alternative specifications based on AIC and BIC values, the current results nonetheless indicate that the estimated model provides a strong and statistically supported representation of the underlying data-generating process (Burnham, 2002). The detailed results are reported in Table 18.

Table 18: Model Selection Criteria

Akaike's Information Criterion and Bayesian Information Criterion						
Model	Obs	ll(null)	ll(model)	df	AIC	BIC
	2,639	-32160.88	-31967.35	11	63956.7	64021.36

Note: N= Obs used in calculating BIC; see [R] BIC note.

Fifth, the study assesses the normality of the model residuals to verify compliance with a key econometric assumption underlying many estimation procedures. The residual density plot provides a visual evaluation of this assumption by comparing the empirical

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distribution of residuals with an idealised normal (bell-shaped) distribution. The Figure 3 indicates a broadly symmetric distribution centred around zero, suggesting that the residuals closely approximate normality. However, minor deviations in the tails are observable, indicating slight departures from perfect normality. Such departures are common in applied panel data settings. Given the large sample size, the Central Limit Theorem provides additional support for the reliability of statistical inference even in the presence of mild non-normality (Wooldridge, 2016). The graphical results are presented in Figure 3.

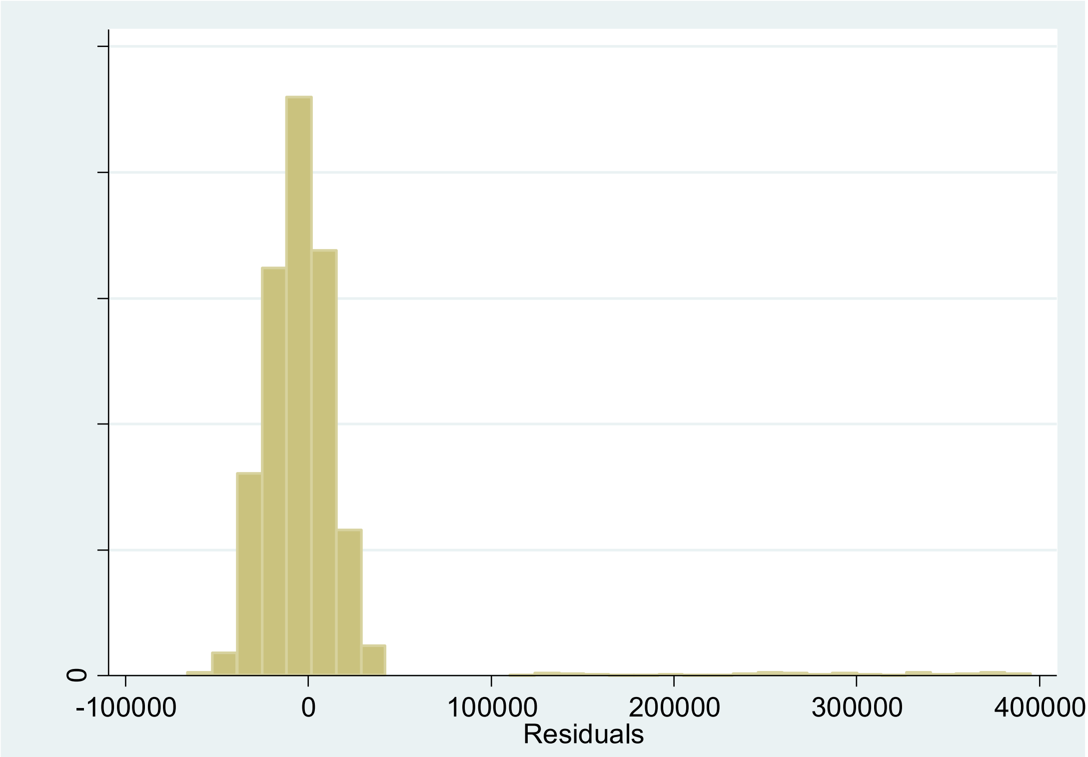

Figure 3: Normality Test

Sixth, the study examines multicollinearity among the explanatory variables using the Variance Inflation Factor (VIF) to ensure precise and reliable coefficient estimation (Wooldridge, 2016). The results show that all VIF values are well below the conventional threshold of 5, with the maximum value of 1.37 observed for trade openness and a mean VIF of 1.50. This confirms the absence of any meaningful multicollinearity within the model. These findings indicate that the explanatory variables provide distinct and non-redundant information, thereby enhancing the stability of the estimated coefficients. Consequently, the marginal effects derived from the model are robust, and the interpretation of each variable's impact on exchange rate volatility remains statistically reliable. The detailed results are reported in Table 19.

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Table 19: Multicollinearity Test

Variable	VIF	1/VIF
Trade Openness	1.37	0.731541
Oil Prices	1.31	0.761818
Foreign Direct Investment	1.28	0.778780
Interest Rate Differential	1.17	0.853667
Inflation Differential	1.15	0.869274
Economic Growth	1.07	0.933953
Mean VIF	1.50	

SUMMARY AND CONCLUSIONS

This study examined the determinants of exchange rate volatility across 20 MENA countries over the period Q1 1990 to Q4 2022, distinguishing between oil-exporting and non-oil-exporting economies. By integrating a GARCH-based volatility measure with MG and PMG estimators, the analysis captures both short-run country-specific dynamics and long-run regional equilibrium relationships. The empirical findings reveal several key results. For the full sample of 20 MENA countries, the PMG long-run estimates indicate that interest rate differentials, FDI, and economic growth exert negative effects on exchange rate volatility, while oil prices have a positive effect, reflecting heterogeneous structural responses across the region. For oil-exporting countries, PMG results show that institutional quality significantly reduces volatility, whereas oil prices and political instability increase it in the long run, highlighting the structural dependence of these economies on hydrocarbon revenues. For non-oil-exporting countries, where the Hausman test supports the MG estimator, the long-run results suggest that economic growth and oil prices increase exchange rate volatility, while the inflation differential reduces it, indicating distinct adjustment mechanisms relative to oil-dependent economies.

From a policy perspective, oil-exporting countries should focus on strengthening institutional frameworks, improving governance quality, and reducing dependence on volatile oil revenues through economic diversification strategies. Maintaining sufficient foreign exchange reserves and ensuring credible monetary policy frameworks can further support exchange rate stability. For non-oil-exporting economies, priority should be given to enhancing political stability, implementing structural reforms, and improving economic competitiveness to reduce vulnerability to external shocks. At the regional level, strengthening institutional quality, narrowing governance gaps, deepening financial markets, and improving transparency are essential for mitigating exchange rate volatility. In addition, coordinated regional policy efforts aimed at stabilising capital flows, anchoring inflation expectations, and reinforcing monetary policy credibility can further contribute to a more stable exchange rate environment.

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