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IMPACT OF EXCHANGE RATE VOLATILITY ON ECONOMIC GROWTH: EVIDENCE FROM SELECTED OIC COUNTRIES

Aftab Alam*, Obiyathulla Ismath Bacha and Mansor H Ibrahim

INCEIF University, A0608, University Registration No. DU018 (W), Blok B, Lot 41, Seksyen 51, Jalan Tun Ismail, 50480 Kuala Lumpur, Malaysia

*Corresponding author: af.alam15@gmail.com; aa_alam@rediffmail.com

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ABSTRACT

This study examines how exchange rate volatility (ERV) impacts economic growth in 18 Organisation of Islamic Cooperation (OIC) countries (1985–2022) through direct and indirect channels. Using the CS-ARDL model and Dumitrescu-Hurlin causality tests, we analyse ERV's effects via inflation, FDI, external debt, trade, and financial development. Results show ERV significantly reduces long-term growth directly via uncertainty and indirectly through key determinants. While FDI, trade, and financial development support growth, inflation and external debt amplify ERV's negative effects. Robustness checks (CCEMG and AMG estimators) confirm these findings. OIC policymakers should implement OIC-wide local-currency swap networks and Sharia-compliant hedging instruments (waʿd-based forwards, murābaḥah swaps), strengthen Islamic money markets, and adopt inflation control with local-currency trade invoicing to mitigate ERV while boosting growth.

Keywords: Exchange rate volatility, Economic Growth, OIC, CS-ARDL, Dumitrescu-Hurlin Granger causality

INTRODUCTION

The impact of exchange rate volatility (ERV) on economic growth remains a subject of ongoing debate, highlighting the need for a nuanced understanding. This volatility, resulting from the dynamic business environment and macroeconomic changes (Anyanwu et al., 2017), has a dual effect. While fluctuating currency values can lead to an unpredictable economic environment, they can also serve as shock absorbers, helping economies adapt to external factors and encouraging more cautious monetary policies (Friedman, 1956). A stable exchange rate environment under a fixed exchange regime benefits investors (Mundell, 1961). However, it also means sacrificing monetary policy independence, which can hinder necessary adjustments and pose risks to economic development, especially in developing countries with inflexible wages and prices.

A stable and competitive real exchange rate positively contributes to economic growth, benefiting countries from their comparative advantages and favourable cross-border investments. On the other hand, large volatility in exchange rates creates uncertainty, affecting inflation, investment decisions and trade competitiveness. Excess volatility negatively impacts the trade balance, foreign direct investment (FDI), terms of trade, and business and consumer confidence (Guzmán et al., 2018), all important indicators of economic well-being. This volatility often stems from fluctuations in nominal exchange rates (Mussa, 1986), exacerbated by unforeseen shocks that drive unpredictable price movements (Clarida & Galí, 1994). These consequences are amplified in OIC economies by commodity-linked terms of trade shocks and dollarised balance sheets.

Empirical studies show the negative impact of ERV for both developed and developing nations in various ways, including trade competitiveness, investments, inflation and job growth (Schnabl, 2007; Rjoub, 2012; Jamil et al., 2012; Allen et al., 2016; Dal Bianco & Nguyen, 2017; Alagidede & Ibrahim, 2017; Latief & Lefen, 2018; Vo et al., 2019; Hatmanu et al., 2020; Ioan et al., 2020). Excessive fluctuations in the exchange rate create uncertainty and impact economic growth in several ways. Firstly, it renders real interest rates more volatile, as excessive volatility creates a complex interplay between inflation expectations, hedging costs, central bank actions and investor sentiment. Secondly, transaction costs for cross-border trade increase due to additional risk premiums, which reduce investor gains and constrain business activities. Thirdly, volatility creates uncertainty in international agreements, affecting trade flows and economic cooperation.

While the relationship between ERV and economic growth has been examined in diverse settings, bloc-wide evidence for the OIC remains limited, despite its scale and structural distinctiveness. The OIC's 57 member states account for a significant share of global output and resource endowments (World Bank, 2023) and exhibit shared features that plausibly alter ERV transmission: high commodity dependence (e.g., 18 members derive more than 70% of export revenues from fuels and minerals), evolving Islamic finance frameworks that shape intermediation and risk management (Islamic Financial Services Board, 2023), heterogeneous exchange-rate regimes ranging from GCC pegs to Turkey's float, and institutional initiatives to deepen intra-OIC trade such as TPS-OIC (Islamic Development Bank, 2021). Underdeveloped financial systems and dollarised balance sheets further constrain conventional hedging, heightening exposure to currency shocks (Ameziane & Benyacoub, 2022). Although multi-country studies cover OIC subsets like MENA [Middle East and North Africa] (Barguellil et al., 2018) and WAMZ [West African Monetary Zone] (Perekunah, 2020), and single-country analyses examine ERV channels in Pakistan (Mubarik, 2005) and Malaysia (Munir et al., 2009), none integrates these OIC-specific features into a systematic bloc-wide analysis of ERV transmission. This gap limits evidence-based policymaking for a coalition where standard stabilisation tools may be less effective.

Our sample comprises 18 OIC economies observed over 1985–2022, spanning commodity exporters (e.g., Algeria, Nigeria), pegs (e.g., Jordan), managed floats (e.g., Egypt), and free floaters (e.g., Turkey) to capture regime diversity and structural heterogeneity. To maintain consistent data coverage, we employ Bruegel's real effective exchange rate (REER) based measure of volatility to isolate currency shocks from inertial domestic price movements and reveal competitiveness risks that nominal series can obscure (Darvas, 2021). This window encompasses the 1990s commodity downturn, the 2014 oil price collapse that stress-tested pegs, and post-2010 intra-OIC trade initiatives (Islamic Development Bank, 2021). Shared vulnerabilities, high commodity exposure, limited reserves, and dollarised liabilities that amplify balance-sheet effects and create a cohesive context for studying ERV transmission under OIC-specific constraints (International Monetary Fund, 2023).

Against this backdrop, the study closes three critical gaps. First, it quantifies REER volatility's long-run impact on economic growth across a bloc-wide OIC panel. Second, it disentangles indirect transmission mechanisms via the determinant of economic growth, namely FDI, trade, inflation pass-through, financial development and inflation, clarifying the causal pathways that link REER volatility to growth. Third, it offers actionable policy insights tailored to the OIC's institutional and financial realities, especially those shaped by Islamic finance constraints. This framing, grounded in shared structural traits and regime diversity, offers a distinct empirical contribution to the ERV–growth literature (Ameziane & Benyacoub, 2022; Barguellil et al., 2018; Perekunah, 2020).

We employ a CS-ARDL panel model to examine the long- and short-run dynamics between economic growth, REER volatility (measured via moving standard deviation; Bahmani-Oskooee & Gelan, 2018), and key macroeconomic determinants of economic growth. To map the causal transmission of REER volatility to economic growth via its determinants, we apply the Dumitrescu-Hurlin panel causality test. Robustness checks, Common Correlated Effects Mean Group (CCEMG) and Augmented Mean Group (AMG) estimators, affirm the empirical validity of the results.

Findings reveal a twofold impact of ERV on growth. In the long run, ERV exerts a direct negative effect by heightening uncertainty, which dampens investment and real economic activity (Aizenman, 1992); short-run effects remain statistically muted. Indirectly, ERV disrupts growth via three transmission pathways: trade, investment, and inflation. Elevated volatility raises transaction costs and risk premia, curbing trade openness and deterring FDI (Rose, 2000). Additionally, it fuels inflation through an import pass-through mechanism, further constraining growth (Devereux & Engel, 2003). While financial system development offers a moderating buffer against ERV shocks, external debt consistently emerges as a standalone growth impediment. Based on these findings, OIC policymakers should prioritise bloc-wide local-currency swap arrangements and deploy Sharia-compliant hedging tools (e.g., waʿd-based forwards, murābaḥah swaps). Strengthening Islamic money markets and adopting inflation-focused local-currency invoicing strategies can mitigate REER volatility and foster resilient, inclusive growth.

LITERATURE REVIEW

The theoretical perspectives and empirical evidence show diverse and conflicting evidence between economic growth and ERV. According to Obstfeld and Rogoff (1998), uncertainty arising from ERV and government policies aimed at stabilising it (e.g., lowering interest rates) can negatively impact the domestic economy through currency overvaluation. However, Devereux and Engel (2003) suggest that its impact hinges on price-setting mechanisms within the economy. Empirical evidence further underscores this complexity, with Ozcelebi (2018) finding positive associations, while Dollar (1992), Bosworth et al. (1995) and Barguellil et al. (2018) discover negative associations between real exchange rate variability and economic growth. Ghura and Grennes (1993) and Bleaney and Greenaway (2001) find weaker evidence. These discrepancies highlight the critical role of data, methodology, study period, and country-specific factors, as emphasised by Phiri (2018). Aghion et al. (2006) argue that this disparity might be attributed to the influence of other unobserved fundamentals. They demonstrate that financial development offers hedging mechanisms, thereby mitigating the detrimental effects of ERV on productivity growth, particularly in less developed economies.

Despite a plethora of research, the relationship between ERV and economic growth remains ambiguous. Thus, it is crucial to delve into the transmission channels through which ERV impacts the real economy. As aptly emphasised by FDI and macroeconomic stability. Each of these channels encompasses a complex interplay of direct and indirect effects, necessitating a multifaceted approach to examine the nuances of the ERV-Growth nexus comprehensively. Therefore, a critical review of existing literature examining the nexus between ERV, economic growth, and its key determinants (external trade, FDI, external debt, financial system and inflation) is indispensable.

Economic Growth, Trade Openness and ERV

Early economic theories, such as comparative advantage (Ricardo, 1817), laid the groundwork for understanding the potential of trade to unlock economic growth through specialisation and comparative cost advantages. Later theoretical advancements, like the new trade theory (Krugman, 1987) and endogenous growth theory (Romer, 1994), expanded on this foundation by highlighting the importance of increasing returns and knowledge diffusion in promoting trade-driven growth. However, contrasting perspectives like the Prebisch-Singer hypothesis (Prebisch, 1950) warn of potential long-term declines in terms of trade for developing countries, while the infant industry argument advocates for temporary protectionist policies to nurture nascent industries and foster future competitiveness.

Trade openness, the degree to which a country engages in international trade, has been empirically linked to enhanced economic growth (Keho & Wang, 2017). Herzer (2009) emphasises the positive association between trade and economic growth, suggesting that openness catalyses development. More recent studies offer nuanced insights. For instance, Nguyen and Bui (2021) found a non-linear impact of trade openness on ASEAN-6 countries' growth, suggesting a threshold beyond which benefits diminish. Niluka et al. (2023) highlight the first-order effects of specific products, like high-tech goods, on per capita income, with trade intensity having a secondary impact. Tahir and Azid (2015) finds a positive relationship between trade openness and growth in developing countries. Dowrick and Golley (2004) shows trade openness promoted convergence in earlier decades, but benefits have skewed towards more prosperous economies since the 1980s.

The exchange rate, the relative price of one currency against another, is pivotal in shaping international trade and influencing economic growth. Research indicates that currency fluctuations and overvaluation, where the domestic currency appreciates excessively, can disrupt trade dynamics and economic trajectory. Overvaluation makes exports more expensive, discouraging export-oriented investment and production, and potentially resulting in job losses. While it may make imports cheaper and stimulate domestic consumption, it can also undermine local investment, production and employment by increasing competitive pressure on domestic industries. Trade openness is a key transmission channel through which ERV affects economic growth. For instance, adopting a common currency with trade partners is theorised to reduce transaction costs and currency risk, enhancing bilateral trade flows (Rose, 2000). Empirical studies such as Arize et al. (2000), Olimov and Sirajiddinov (2008) and Bahmani-Oskooee and Gelan (2018) demonstrate that ERV can dampen trade performance, ultimately constraining growth. While greater openness offers growth opportunities, its effectiveness depends on a country's development level and the composition of traded goods. In this context, exchange rate stability fosters a more favourable trade environment, whereas heightened volatility tends to disrupt trade flows and undermine economic performance.

Economic Growth, Foreign Investment and ERV

A stable exchange rate environment is often associated with overall economic stability. Stability encourages investment by reducing uncertainty, as investors are more likely to allocate capital in a stable and predictable exchange rate environment (Ramey & Ramey, 1995; Aizenman, 1992). Conversely, high volatility introduces risk aversion among investors (Asteriou & Price, 2005; McKinnon & Schnabl, 2003). An unpredictable fluctuation in exchange rates introduces additional risk for portfolio investors, and they demand compensation for heightened volatility exposure (Dumas & Solnik, 1995; De Santis & Gérard, 1998), leading to a higher needed risk premium on their investments (Mahapatra & Bhaduri, 2019). Consequently, the level of ERV directly impacts investment decisions.

FDI is particularly sensitive to exchange rate fluctuations. Stable exchange rates attract FDI due to the sense of stability across developing countries (Cushman & De Vita, 2017); and volatile exchange rates generate uncertainty and discourage FDI inflows (Perekunah, 2020). ERV acts as an indicator of macroeconomic uncertainty, heavily influencing investor behaviour. Firms aiming for global expansion find stable exchange rates beneficial as they minimise risk and increase the feasibility of long-term projects (Dixit & Pindyck, 1994).

The relationship between ERV investment, and economic growth is inherently bidirectional. Investment drives growth by fostering capital accumulation, enhancing productivity and generating employment, each contributing to higher economic output. However, ERV can indirectly constrain growth by undermining investor confidence and deterring capital flows. In contrast, exchange rate stability nurtures a more favourable environment for both domestic and foreign investment, thereby supporting long-term economic expansion.

Economic Growth, Financial System Development and ERV

Financial system development is a critical catalyst for enhancing economic performance, a theme deeply rooted in economic discourse since the Shaw-McKinnon hypothesis (McKinnon, 1973). This framework underscores the role of financial systems in mobilising savings, channelling investments and sustaining economic growth. A wealth of empirical research reinforces this premise. Aghion et al. (2006), for instance, show that the long-term impact of exchange rate regimes on growth is conditional on the level of financial development: countries with advanced financial systems benefit from ERV-induced gains in productivity, while those with weaker systems experience adverse growth outcomes.

Khan and Senhadji (2000) confirm a positive association between financial development and economic expansion, though its strength varies depending on financial indicators, estimation techniques, data frequencies, and functional specifications. Similarly, Bekaert et al. (2005) highlight how deep financial markets enhance risk-sharing, lower capital costs and facilitate investment activity. Zinnaira et al. (2022) further demonstrate that robust equity markets contribute positively to growth, with Granger causality tests revealing a bidirectional relationship between financial market performance and economic expansion.

The effects of ERV, however, are multifaceted. While currency depreciation may encourage exports, elevated volatility often disrupts investment planning and induces uncertainty. Financial development magnifies this dynamic: countries with sophisticated financial markets are better equipped to navigate ERV through hedging instruments and portfolio diversification. These economies maintain stable investment flows and show greater resilience to external shocks. Conversely, nations with underdeveloped financial sectors are more susceptible to the destabilising effects of ERV—manifesting in erratic investment behaviour, capital flight and broader macroeconomic instability.

Economic Growth, External Debt and ERV

External debt poses significant challenges for developing economies, often resulting in capital outflows to foreign creditors through elevated debt servicing costs and currency depreciation. Dependence on foreign currency reserves for repayment limits domestic investment capacity and curtails long-term growth prospects. Countries that rely heavily on external borrowing must navigate a precarious balance, especially under volatile exchange rate conditions that intensify repayment risks. This dynamic has been extensively examined in foundational studies, notably Edwards (1984) and Cline (1985).

Edwards (1984) highlights the dual impact of ERV on debt burdens. First, sudden currency depreciation inflates the domestic cost of foreign-denominated debt, weakening repayment capacity. Second, exchange rate uncertainty undermines financial planning, deterring investment by creating unpredictable debt service obligations. Together, these mechanisms can perpetuate a vicious cycle of declining investor confidence and deepening debt strain. Edwards also notes that exchange rate misalignments, deviations from equilibrium based on economic fundamentals, are exacerbated by volatility, which erodes trade competitiveness and export revenues, further impeding debt sustainability. Cline (1985) reinforces this view, acknowledging that while external debt can support development under certain conditions, excessive reliance increases vulnerability to exchange rate fluctuations. He calls for prudent macroeconomic and financial policies to safeguard against destabilising effects and promote sustainable growth.

Recent empirical research further clarifies these dynamics. Fida et al. (2012) report long-run cointegration between exchange rates and external debt indicators in Pakistan, revealing sustained impacts of currency movements on debt levels. Fujii (2023) emphasises how currency concentration in debt portfolios can suppress domestic consumption when depreciation raises debt-servicing costs, underscoring the need for diversified currency composition. Likewise, Kim (2019) finds that ERV is associated with reduced dollar-debt ratios in economies with weaker financial systems, indicating a strategic retreat from foreign currency exposure under volatile conditions.

These findings underscore the central role of financial development in mitigating ERV risks. Countries with sophisticated financial markets possess better tools—hedging strategies, diversified portfolios and risk-sharing mechanisms—that enable them to maintain stable investment flows despite volatility. In contrast, less-developed financial systems lack these buffers, making them more susceptible to capital flight, erratic investment patterns and macroeconomic instability. Managing this complex interplay between ERV, external debt and economic growth is essential for advancing sustainable development in emerging economies.

Economic Growth, Inflation and ERV

In open-economy models with sticky prices, ERV influences inflation primarily through import pass-through. Depreciation raises local-currency import prices, while volatility increases precautionary markups and shortens price durations, amplifying CPI effects in a state-dependent manner (Dornbusch, 1976; Hakura & Choudhri, 2001; Ha et al., 2019). Pass-through intensifies during episodes of sharp depreciation and weak monetary credibility, particularly under dominant-currency invoicing. When nominal anchors are fragile, firms anticipate persistent fluctuations and adjust prices more swiftly. In contrast, stable inflation regimes anchor expectations, dampening price responsiveness (Forbes et al., 2018).

Empirical evidence from OIC economies reinforces this ERV–inflation linkage. In Türkiye, weak credibility accelerates the depreciation–inflation cycle via rapid import repricing and adaptive expectations, resulting in swift pass-through (Kaya et al., 2023; Gürkaynak et al., 2023). Nigeria exhibits nonlinear, asymmetric pass-through: depreciations transmit more forcefully than appreciations, due to import dependence and pricing sensitivity to volatility (Oyadeyi et al., 2024). Cross-country panel data reveal that oil-importing nations with limited subsidy buffers experience greater and more persistent ERPT, underscoring imported inflation risks across energy-exposed OIC members (Sek et al., 2019).

Linking these findings to growth dynamics, ERV-induced inflation erodes real incomes, heightens uncertainty and distorts relative prices—dampening growth when inflation breaches critical thresholds. For Indonesia, Chowdhury and Ham (2009) identify an inflation threshold of 8.5%–11%, above which growth deteriorates markedly, implying that ERV-driven price pressures can push economies into contractionary territory. More broadly, Akinsola and Odhiambo (2017) synthesise evidence showing a bidirectional, context-dependent inflation–growth relationship, while sustained inflation hampers growth via uncertainty and misallocation, sluggish growth can complicate disinflation efforts. These dynamics reinforce the policy imperative of containing ERV-induced inflation to safeguard both price stability and output. Credible nominal anchors, reduced exposure to dollar invoicing and rules-based mechanisms for energy price smoothing offer complementary safeguards against ERV's inflationary effects—without jeopardising long-term growth.

The reviewed literature highlights ERV's indirect yet potent impact on economic growth through key transmission channels. Elevated volatility discourages foreign investment, destabilises financial systems and disrupts trade flows—ultimately weakening growth trajectories. These cascading effects underscore the importance of managing ERV not only for price stability but also for preserving macroeconomic fundamentals. Targeted policies that mitigate ERV's spillovers are therefore essential to sustaining macroeconomic stability in exposed economies.

METHODOLOGY

The study examines the relationship between economic growth (proxied by Real GDP) and real effective ERV, hypothesising that ERV affects growth directly and indirectly through interconnected macroeconomic channels. The theoretical foundation integrates five complementary frameworks. First, Endogenous Growth Theory (Romer, 1994) identifies foreign trade (FTR) and FDI as conduits for technology diffusion and increasing returns to scale, implying that disruptions to trade and capital flows can stifle long-run growth. Second, the Uncertainty Channel (Aizenman, 1992) posits that ERV raises investment risk premia, leading to reduced capital formation and slower output expansion, a direct transmission mechanism. Third, Pass-Through Theory (Devereux & Engel, 2003), along with core macroeconomic principles (Fischer, 1993), links ERV to domestic inflation (INF), which erodes price stability and undermines economic efficiency, especially in import-dependent economies. Fourth, the Debt Overhang Hypothesis (Edwards, 1984) explains how rising total external debt (TED) can crowd out productive investment, amplifying the negative impact of ERV when liabilities are dollarised. Fifth, Financial Development Theory (Levine, 2005) asserts that well-functioning financial systems (FSD) facilitate efficient capital allocation and help absorb external shocks, mitigating currency instability's adverse effects.

These frameworks justify the empirical inclusion of FTR, FDI, INF, TED and FSD as growth determinants and transmission channels for ERV, following Ameziane and Benyacoub (2022). By rooting causal inference in established mechanisms (Pattillo et al., 2002; Aizenman & Marion, 1993), the model gains theoretical coherence and policy relevance.

Model Specification

The study proposes the following models.

$$\ln(GDP_{it}) = \beta_0 + \beta_1(FDI_{it}) + \beta_2 \ln(FTR_{it}) + \beta_3 \ln(FSD_{it}) + \beta_4 \ln(TED_{it}) + \beta_5(INF_{it}) + \beta_6 \ln(ERV_{it}) + \beta_{it} \quad (1)$$

Where, β indicate the slope of explanatory variables and cross-section are denoted by i(sampled countries), trepresents the period from 1985 to 2022. GDP, FDI, FTR, FSD, TED, INF and ERV represent gross domestic product, FDI, foreign trade, financial system development, total external debt, inflation and ERV. The Equation (1) reveals that the GDP is a function of FDI, FTR, FSD, TED, INF and ERV. Based on previous empirical studies, we expect positive signs for the variables FDI, FTR, and FSD ($\frac{GDP}{FDI} > 0$, $\frac{GDP}{ITR} > 0$, $\frac{GDP}{FSD} > 0$) due to their well-documented contributions to economic growth through capital inflows, trade expansion and financial inclusion, respectively. TED is expected to have a negative sign $\frac{GDP}{TED} < 0$; as higher external debt burdens can constrain growth through capital outflow pressures and increased debt servicing costs. The relationship between GDP and INF is complex and context-dependent ($\frac{GDP}{INF} \simeq 0$), while moderate inflation can stimulate investment and growth, excessive inflation can erode purchasing power and deter economic activity. The expected sign is, therefore, uncertain, potentially neutral, or insignificant in specific contexts but negative in others. For the ERV negative sign. ($\frac{GDP}{ERV} < 0$) is anticipated, as high ERV can create uncertainty, hinder investment, and disrupt trade flows. This parsimonious specification, grounded in established frameworks, mitigates omittedvariable endogeneity and goes beyond Granger causality by embedding tests in well-defined economic mechanisms for theoretically grounded interpretation of transmission channels.

Definition of Variables and Data Source

All variables are log-transformed except for *FDI* and *Inflation*, which are retained in linear form due to the presence of negative or zero values. GDP, measured in real terms in millions of domestic currencies, serves as the central indicator of economic activity and output. FDI is defined as the ratio of net FDI to GDP and reflects long-term cross-border capital flows; although typically expressed as a percentage, it is retained in linear form here to accommodate negative values. FTR captures the aggregate value of imports and exports in real terms and serves as a measure of trade openness. FSD, calculated as the ratio of broad money (M3) to GDP, indicates the depth, liquidity, and efficiency of the financial system. TED, expressed as a percentage of Gross National Income (GNI), denotes the external debt burden, highlighting macroeconomic vulnerability. Inflation is measured by the annual rate of change in the Consumer Price Index (CPI) and is expressed in linear form to address instances of non-positive values.

ERV captures FDI volatility, computed as the standard deviation of monthly REER changes over one year. REER is derived from bilateral exchange rates, relative price levels, and import-weighted trade shares. A decline in REER indicates real depreciation of the domestic currency, potentially boosting export competitiveness. Log-transformation of REER changes enhances interpretability by normalising distributional properties, allowing for more robust analysis of exchange rate variability and its associated risks and opportunities.

We employ a balanced panel dataset encompassing 18 OIC countries (Algeria, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Egypt, Gambia, Indonesia, Jordan, Malaysia, Morocco, Niger, Nigeria, Pakistan, Senegal, Sudan, Togo and Turkey) for the period from 1985–2022 (annual data). The variables, measures and data sources are presented in Table 1.

TABLE 1
Variables, measures and data sources

Variables	Code	Measures	Form	Source
Gross Domestic Product	GDP	LCU (million)	Natural Log	WBI
Foreign Direct Investment (net)	FDI	Net FDI/GDP	Linear	WBI
International Trade (Import Export)	FTR	LCU (million)	Natural Log	WBI
Financial system development	FSD	M3/GDP	Natural Log	WBI
Total External Debt	TED	% of GNI	Natural Log	WBI
Inflation (CPI)	INF	Inflation Rate	Linear	WBI
REER Volatility	ERV	Standard Deviation	Natural Log	Bruegel

Note: LCU = Local Currency Unit

Slope Homogeneity Test

Swamy (1970) introduced the first procedure for testing whether slope coefficients are equal across cross-sectional units in cointegration equations. Pesaran and Yamagata (2008) refined this approach with two delta statistics Δ and Δ_adj (adjusted for mean-variance bias) for small samples. Because both tests assume homoscedastic, serially uncorrelated errors, Pesaran and Yamagata also proposed HAC-robust versions of Δ and Δ_adj that remain valid in the presence of heteroscedasticity and autocorrelation. Under these tests, the null hypothesis of slope homogeneity is accepted if the *p*-value exceeds 0.05, indicating no significant differences in slopes across units.

Cross-Sectional Dependence Test

To assess cross-sectional dependence (CSD), we apply two residual-based CD tests: the standard CD statistic of Chudik and Pesaran (2015) and the bias-corrected version by Bailey et al. (2016). Both procedures evaluate the null hypothesis of cross-sectional independence in the model residual. Further, we apply Bailey et al.'s (2016) CD test on the variables themselves to detect CSD at the variable level.

Unit Root Test (Second-Generation

$$\Delta Y_{it} = \alpha_i + \beta_i Y_{i,t-1} + \gamma_i \overline{Y}_{t-1} + \sum_{j}^{p} \varphi_{ij} \Delta \overline{Y_{t-j}} + \sum_{j}^{p} \varphi_{ij} \Delta Y_{it-j} + \varepsilon_{i,t} \tag{2}$$

where α_i is a deterministic term, $\overline{Y}_{t-1}$ and $\Delta \overline{Y}_{t-j}$ are the lagged and first differences mean, respectively. The CADF test statistics average the individual ADF statistics estimated for each cross-sectional unit, and the CIPS test statistic is then the average of these CADF *t*-statistics.

$$\widehat{CIPS} = \frac{1}{N} \sum_{i=1}^{n} CADF_i \tag{3}$$

The CADF and CIPS tests the variables at levels and first differences to detect stationarity.

Panel Cointegration Test

To establish the presence of a long-run equilibrium relationship among the panel variables, a prerequisite for estimating the CS-ARDL model, we employed Pedroni, Westerlund and Kao cointegration tests, each with distinct methodological foundations and assumptions. The Pedroni test, based on residual stationarity, accounts for cross-sectional heterogeneity through multiple statistics (including PP, modified PP and ADF variants). The Westerlund test, derived from error-correction dynamics, is robust to both cross-sectional dependence and heterogeneity, offering direct evidence of cointegration by evaluating group variance ratios. In contrast, the Kao test adopts a pooled residual approach, assuming a homogeneous cointegrating vector across panel units.

We begin with the panel data model $Y_{it} = \alpha_i + \beta_i x_{it} + \varepsilon_{i,t}$ where Y_{it} and x_{it} represent panel variables, α_i denotes individual effects, and $\varepsilon_{i,t}$ is the residual. The Pedroni test examines whether $\varepsilon_{i,t}$ is stationary by estimating $\varepsilon_{i,t} = \rho_i \varepsilon_{i,t} + \mu_{i,t}$ utilising up to seven statistics—four within-dimension (panel v, panel ρ, panel PP, panel ADF) and three between-dimension (group ρ, group PP, group ADF) to accommodate cross-sectional heterogeneity. However, in empirical practice, Panel PP, Panel ADF, and Group ADF are most commonly reported, as they balance robustness with interpretability and avoid redundancy in statistical outputs. The Westerlund test, based on an error-correction model $\triangle Y_{it} = \gamma_i (y_{it-1} - \beta_i x_{it-1}) + \sum_{k=1}^{p} \varphi_{ik} \triangle x_{it-k} + v_{i,t}$ identifies cointegration when $y_i < 0$, indicating long-run equilibrium adjustment. Lastly, the Kao test assumes homogeneity in the cointegrating vector $Y_{it} = \alpha + \beta x_{it} + \varepsilon_{it}$ and tests residual stationarity via $\varepsilon_{i,t} = \rho_i \varepsilon_{i,t} + u_{i,t}$. It applies several Dicky Fuller (DF) type statistics (modified DF, DF, ADF, unadjusted DF) to test the null hypothesis $\rho = 1$, with cointegration supported when $\rho < 1$.

Estimation Technique and Optimal Lag Lengths

Considering the diagnostic features of our panel—mixed integration orders of I(0) and I(1), slope heterogeneity and notable cross-sectional dependence, this study employs the Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) model proposed by Chudik and Pesaran (2015). This framework is designed for complex panel structures, accommodating mixed integration orders, accounting for common correlated effects, and enabling unit-specific dynamics and cointegration testing. To identify the optimal lag structure, we use the Akaike Information Criterion (AIC), which balances model fit with parsimony. The chosen lag structure of (1,1,0,1,0,0) reflects this balance and is consistently applied throughout the estimation process.

Cross-Sectional Augmented Autoregressive Distributed Lag

We employ the cross-sectionally augmented autoregressive distributed lag (CS-ARDL) technique to analyse long-run and short-run relationships. This approach, initially developed by Pesaran and Smith (1995), extended by Pesaran et al. (1999), and enhanced by Chudik and Pesaran (2015), is particularly suitable for panels where the time dimension (T) exceeds the cross-sectional dimension (N), (Westerlund, 2007) as in our data. The baseline ARDL model is specified as:

$$Y_{it} = \alpha_i + \sum_{k=1}^{p} \beta_{ij} Y_{i,t-k} + \sum_{k=0}^{q} \gamma_{it} X_{i,t-k} + u_{i,t} \tag{4}$$

Where stands for the country, i.e. 1,2, 3…, N; t represents time dimensions; k is the number of times lag and (p, q) are the lag orders. α_i represents a country-specific intercept term and $u_{i,t}$ is the composite stochastic disturbance term with a multifactor structure where $u_{i,t} = \pi_i G_t + \epsilon_{it}$. Hence, π_i is the $m \times 1$ matrix of factor loadings and G_t is the $m \times 1$ vector of unobserved common factors, and captures cross-sectional dependence with different degrees of intensity, depending on the magnitude of its corresponding loading. The ϵ_{it} idiosyncratic errors are assumed to be independently distributed across the cross-section and time series units, and uncorrelated with the unobservable regressors.

The ARDL technique produces a consistent estimate for I (0) or I (1) variables regardless of regressors' endogeneity, addresses reverse causality and distinguishes short-run dynamics from long-run equilibrium through its error correction representation:

$$\Delta Y_{it} = \alpha_i + \lambda_i (Y_{i,t-1} - \delta_i X_{i,t-k}) + \sum_{k=1}^{p-1} \beta_{ij}^{*} \Delta Y_{i,t-k} + \sum_{k=0}^{q-1} \gamma_{ij}^{*} \Delta X_{i,t-k} + \epsilon_{it} \tag{5}$$

Where; $\lambda_i = -(1 - \sum_{k=1}^{p} \beta_{ij})$, $\delta_i = \lambda_i^{-1} \sum_{k=0}^{q} \gamma_{it}$, $\beta_{ij}^{*} = -\sum_{k=j+1}^{p} \beta_{ij}$ and $\gamma_{ij}^{*} = -\sum_{k=j+1}^{q} \gamma_{it}$. The parameter λ_i is the error-correcting speed of the adjustment term. This parameter is expected to be negative if the variables exhibit a return to long-run equilibrium. δ_i defines the long-run and equilibrium relationship between X_{it} and Y_{it}. The β_{ij}^{*} and γ_{ij}^{*} captures the short-term dynamics between variables.

Traditional ARDL assumes cross-sectional error independence, which is violated by global factors (e.g., business cycles). Such dependence biases the estimate, particularly in mean-group estimators (Coakley et al., 2004). To resolve this, we implement the CS-ARDL extension (Chudik & Pesaran, 2015), which applies the Common Correlated Effects (CCE) approach (Pesaran, 2006). By incorporating cross-sectional averages of regressors, serving as proxies for unobserved common factors. Including their lagged values ensures consistency in estimation and effectively mitigates bias from cross-sectional dependence. Accordingly, the baseline CS-ARDL specification in levels (Equation [4]) is reformulated as follows:

$$Y_{it} = \alpha_i + \sum_{k=1}^{p} \beta_{ij} Y_{i,t-k} + \sum_{k=0}^{q} \gamma_{it} X_{i,t-k} + \sum_{k=1}^{p} \eta_j \overline{Y_{t-k}} + \sum_{k=0}^{q} \theta_i \overline{X_{t-k}} + \epsilon_{i,t} \tag{6}$$

Where; $\overline{Y_{t-k}} = N^{-1} \sum_{i=1}^{N} Y_{i,t-k}$ and $\overline{X_{t-k}} = N^{-1} \sum_{i=1}^{N} X_{i,t-k}$. Under the assumption of uncorrelated slopes and regressors, these cross-sectional averages eliminate dependence bias by proxying unobserved common factors. To jointly model dynamic adjustments, short-run dynamics, long-run equilibrium and cross-sectional dependence, we transform Equation (7) into its error-correction form (Equation [5]):

$$\triangle Y_{it} = \alpha_i + \lambda_i (Y_{i,t-1} - \delta_i X_{i,t-k}) + \sum_{k=1}^{p-1} \beta_{ij}^{*} \triangle Y_{i,t-k} + \sum_{k=0}^{q-1} \gamma_{ij}^{*} \triangle X_{i,t-k} + \sum_{k=1}^{p} \eta_j \overline{Y_{t-k}} + \sum_{k=0}^{q} \theta_i \overline{X_{t-k}} + \sum_{k=1}^{p-1} \varpi_k \overline{\triangle Y_{t-k}} + \sum_{k=0}^{q-i} \psi_i \overline{\triangle X_{t-k}} + \epsilon_{it} \tag{7}$$

Where, Y_{it} represents the dependent variables (GDP_{it}) and $X_{i,t}$ denotes the regressors (FDI_{it}, FTR_{it}, FSD_{it}, TED_{it}, INF_{it}, ERV_{it}). The term $\lambda_i(Y_{i,t-1} - \delta_i X_{i,t-k})$ captures deviation from long-run equilibrium with representing the error correction speed of adjustment (where a statistically significant negative value indicates convergence to equilibrium, e.g., trade stabilisation post-shock) and δ_i signify long-run coefficients. Short-run dynamics are captured by ΔY_{it} (first-differenced) and $\Delta X_{i,t-k}$ (first-differenced regressors), with β^*_{ik} and γ^*_{ik} quantifying immediate impacts. Cross-sectional dependence is mitigated through four spillover components $\overline{Y_{t-k}} = N^{-1}\sum_{i=1}^{N} Y_{i,t-k}$ and $\overline{X_{t-k}} = N^{-1}\sum_{i=1}^{N} X_{i,t-k}$ capture long-run spillovers (e.g., persistent cross-country trade trends) while, $\Delta\overline{Y_{t-k}} = N^{-1}\sum_{i=1}^{N} \Delta Y_{i,t-k}$ and $\Delta\overline{X_{t-k}} = N^{-1}\sum_{i=1}^{N} X\Delta_{i,t-k}$ represents short-run spillovers (e.g., synchronised quarterly trade growth fluctuations); the coefficient η_{ik}, θ_{ik}, ϖ_{ik} and ψ_{ik} measure spillover intensity (e.g., cross-border volatility transmission). This framework robustly addresses cross-sectional dependence through Pesaran's (2006) CCE methodology, accommodates mixed-order integration of variables and enables simultaneous analysis of short-run dynamics and long-run equilibrium relationships through its error correction specification.

Panel Granger Causality Test (Dumitrescu-Hurlin Causality Test)

We apply the Dumitrescu-Hurlin (Dumitrescu & Hurlin, 2012) panel Granger causality test. This method extends Granger's original bivariate approach by allowing dynamic coefficients to differ across cross-sectional units, thereby accommodating heterogeneity in causal relationships. The baseline bivariate specification is:

$$y_{it} = \alpha_{0i} + \sum_{k=1}^{p} \alpha_{ki} y_{it-k} + \sum_{k=1}^{p} \beta_{k,i} x_{it-k} + \epsilon_{it} \tag{8}$$

Where iy_{it} denoted trade (exports and imports) and x_{it} denotes REER or its volatility for country *i* at time *t*. The lag order *p* is chosen according to information criteria, and (α_{ki}, $\beta_{k,i}$) vary by unit. The test has two versions: the asymptotic and the semi-asymptotic. The asymptotic version is used when the time dimension (T) is larger than the cross-sectional dimension (*N*), and the semi-asymptotic version is used when *N* > T. Under the null hypothesis (H_0) for every cross-section *I* =1, …, *N*, the vector of lagged coefficients.

$$H_0\colon \beta_i = (\beta_{i1}, \ldots, \beta_{ik}) = 0 \qquad \forall_i 1, \ldots, N$$

which implies no Granger causality in any unit. The alternative hypothesis H_1 (heterogeneous non-causality) allows some units to exhibit causality while others do not: if $N_1$with ($0 \leq N_1 < N$), denotes the number of non-causal units, then:

$$H_1\colon \beta_i = 0\,(i = 1, \ldots, N_1), \qquad \beta_i \neq 0 \qquad (i = N_1 + 1, \ldots N)$$

The test statistic is based on the average of individual Wald statistics W_{it} and it has two versions. The $\overline{W}$ test assumes the W_{it} are independent and identically distributed, while the $\overline{Z}$ test allows for cross-unit dependence and heterogeneity. The $\overline{Z}$ test also has a modified version, $\tilde{Z}$ test, which adjusts for the degrees of freedom of the individual Wald statistics.

$$\overline{W}_{N,T}^{HNC} = \tfrac{1}{N}\textstyle\sum_{I=1}^{N} W_{it}, \qquad \overline{Z}_{N,T}^{HNC} = \sqrt{\tfrac{N}{2K}}\,(W_{N,T}^{HNC} - k)\; T, N \to \infty$$

$$\tilde{Z}_{N,T}^{HNC} = \sqrt{\tfrac{N}{2K}}\,(W_{N,T}^{HNC} - k(T - 2K - 1))\; T, N \to \infty$$

Where denotes each unit's individual Wald statistic $\overline{W}_{N,T}^{HNC}$, is the panel's average Wald; $\overline{Z}_{N,T}^{HNC}$ is its asymptotic standardisation and version of the test statistic and $\tilde{Z}_{N,T}^{HNC}$ is the semi-asymptotic version with the degrees-of-freedom adjustment. We reject the null of no Granger causality in the panel whenever the selected test statistic ($\overline{Z}$ or $\tilde{Z}$) exceeds the corresponding critical value from the standard normal distribution.

The causality analysis focuses on key determinants identified as significant through the CS-ARDL estimation and robustness checks using CCEMG and AMG methods. These include FDI, foreign trade, external debt, financial system development and inflation. To evaluate Granger causality, we report three variants of the Dumitrescu-Hurlin pooled test statistics: the standard Wald statistic $\overline{W}_{N,T}^{HNC}$, its asymptotic normalised form $\overline{Z}_{N,T}^{HNC}$ with associated p-values, and the finite-sample adjusted statistic $\tilde{Z}_{N,T}^{HNC}$ with p-values. The inference rests primarily on $\tilde{Z}$ to correct for the moderate time dimension.

The Dumitrescu-Hurlin test is conducted on level variables, justified by strong cointegration evidence across multiple tests (Pedroni ADF *t*-statistic: p = 0.0000; Westerlund variance ratio: p = 0.0035; Kao ADF *t*-statistic: p = 0.0000). Following Granger (1969) and Engle and Granger (1987), level specifications are essential for I(0)/I(1) cointegrated systems to preserve long-run equilibrium relationships. Applying first differences would remove the error-correction component, introduce bias, and contradict both the empirical cointegration results and best practices in cointegrated panel modelling (Canning & Pedroni, 2008). The CS-ARDL framework inherently supports this approach by embedding short-run dynamics within a long-run equilibrium structure.

RESULTS AND DISCUSSION

Preliminary Analysis

The summary statistics (Table 2) for key macroeconomic and financial variables, including GDP, FDI, international trade, financial system development (FSD), total external debt (TED), inflation and real effective ERV exhibit moderate to substantial dispersion across the panel dataset. The respective standard deviations suggest significant variation around the mean values, indicating diverse economic environments among the sampled countries. These differences likely stem from heterogeneity in national policies, macroeconomic conditions, and structural factors. Overall, the dataset underscores the multifaceted and uneven nature of the economic landscape represented in the sample.

TABLE 2
Descriptive statistics

Variables	Code	Obs.*	Mean	S. D.	Min	Max
Gross Domestic Product	GDP	684	10.547	1.837	6.340	13.99
Foreign Direct Investment (net)	FDI	684	2.108	3.272	–4.850	46.28
International Trade (Import Export)	FTR	684	13.116	3.317	1.100	22.78
Financial system development	FSD	684	3.520	0.763	1.640	4.95
Total External Debt	TED	684	3.550	1.250	–1.240	5.53
Inflation (CPI)	INF	684	13.020	28.170	–13.060	359.09
REER Volatility	ERV	684	0.025	0.042	0.002	0.495

Note: * (18 × 38 = 684)

Table 3 highlights key interrelationships among the studied variables. GDP shows a moderate positive correlation with foreign trade and financial system development, indicating that stronger trade activity and financial depth may contribute to economic expansion. In contrast, its weak negative association with FDI and external debt (TED) suggests that overdependence on foreign capital and debt might constrain domestic output.

TABLE 3

Correlation analysis

Variables	GDP	FDI	FTR	FSD	TED	INF	ERV
GDP	1.0000						
FDI	–0.1200	1.0000					
FTR	0.3654	–0.0748	1.0000				
FSD	0.4475	0.0929	–0.0056	1.0000			
TED	–0.2901	0.0903	–0.2078	–0.3625	1.0000		
INF	–0.0289	–0.0433	–0.3519	–0.1169	0.1639	1.0000	
ERV	0.0706	–0.0672	–0.2312	–0.1440	0.1675	0.3910	1.0000

Inflation displays minimal linkage with GDP but is moderately correlated with REER volatility, hinting at a potential trade-off between price stability and exchange rate fluctuations. Notably, all correlation coefficients remain well below the 0.8 threshold, minimising concerns about multicollinearity. These relationships signal potential linkages but do not imply causation; rigorous econometric methods are required to validate directional effects.

TABLE 4

Panel Unit Root Test (Second Generation)

Variables	Levels		First difference	
	CIPS	CADF	CIPS	CADF
GDP	–1.679	2.721	5.507***	–16.420***
FDI	–3.059***	–4.457***	7.349***	–23.001***
FTR	–2.442***	–1.438**	6.093***	–19.333***
FSD	–1.969**	0.086	–5.990***	–19.434***
TED	–1.690	2.752	–5.270***	–16.124***
INF	–3.866***	–8.998***	–7.335***	–24.386***
ERV	–5.189***	–15.669***	–9.021***	–30.046***

Note: ** and *** represent 5% and 1% significance levels, respectively.

Table 4 reports second-generation unit root tests (CIPS and CADF), assessing stationarity in both levels and first differences. At levels, FDI, FTR, INF and ERV are stationary, evidenced by statistically significant test statistics. In contrast, GDP, FSD and TED fail to reject the null hypothesis of a unit root, indicating non-stationarity in their levels. However, at first differences, all variables are stationary at the 1% significance level, confirming mixed integration orders—I (0)I(0) and I (1)I(1). This finding is critical in ensuring robustness and mitigating risks of spurious regression in subsequent econometric modelling.

TABLE 5
Panel Cointegration Test

Test	Statistics	*p*-value
Pedroni Test for Cointegration		
Modified Phillips–Perron t	–0.8559	0.1960
Phillips–Perron t	–14.8011	0.0000
Augmented Dickey-Fuller t	–13.3257	0.0000
Westerlund Test for Cointegration		
Variance ratio	–2.6923	0.0035
Kao Test for Cointegration		
Modified Dickey-Fuller t	–10.5910	0.0000
Dickey-Fuller t	–12.9690	0.0000
Augmented Dickey-Fuller t	–5.9700	0.0000
Unadjusted modified Dickey-Fuller t	–38.1777	0.0000
Unadjusted Dickey-Fuller t	–19.9975	0.0000

Table 5 presents the results of multiple cointegration tests used to examine long-run relationships among the variables. The Pedroni test shows strong cointegration signals, with both Phillips–Perron (PP) and Augmented Dickey–Fuller (ADF) (Dickey & Fuller, 1979) statistics rejecting the null hypothesis at the 1% level, whereas the modified PP statistic remains inconclusive (p = 0.1960). The Westerlund test reports a significant variance ratio of –2.6923 (p = 0.0035), indicating robust panel-wide error-correction behaviour. Additionally, the Kao test yields consistently negative and statistically significant values (p = 0.0000), confirming cointegration under homogeneity assumptions. These findings collectively support the presence of a stable long-run equilibrium, methodologically reinforcing the suitability of CS-ARDL estimation as a next step.

TABLE 6
Slope Homogeneity Test

Statistics		Values
$\bar{\Delta}$	$\bar{\Delta} = \sqrt{N}\left(\frac{N^{-1}\bar{S}-k}{\sqrt{2k}}\right) \backsim \chi_k^2$	27.929***
$\bar{\Delta}_{adj}$	$\bar{\Delta}_{adj} = \sqrt{N}\left(\frac{N^{-1}\bar{S}-k}{v(T,k)}\right) \backsim N(0,1)$	31.433***
$\bar{\Delta}_{HAC}$	$\bar{\Delta}_{HAC} = \sqrt{N}\left(\frac{N^{-1}S_{HAC}-k}{\sqrt{2k}}\right) \backsim \chi_k^2$	36.925***
$(\bar{\Delta}_{HAC})_{adj}$	$(\bar{\Delta}_{HAC})_{adj} = \sqrt{N}\left(\frac{N^{-1}S_{HAC}-k}{v(T,k)}\right) \backsim N(0,1)$	41.557***

Notes: *** represent 1% significance levels. N = cross sections; S = Swamy test statistic, k = independent variables; HAC = Heteroskedasticity and autocorrelation consistent

All four test statistics standard delta ($\bar{\Delta}$), adjusted delta ($\bar{\Delta}_{adj}$), HAC-based delta ($\bar{\Delta}_{HAC}$), and HAC-adjusted delta ($(\bar{\Delta}_{HAC})_{adj}$) are highly significant at the 1% level. This is evidenced by elevated test values: 27.929, 31.433, 36.925 and 41.557, respectively. The consistent rejection of the null hypothesis across these tests, as reported in Table 6, confirms the presence of slope heterogeneity among cross-sectional units.

TABLE 7
Test Cross-sectional dependence in residuals

Test	Statistics	Values
CD_{NT}	$\sqrt{\frac{2}{N(N-1)}}\sum_{i=1}^{N}\sum_{j=i+1}^{N}\frac{1}{\sqrt{T}}\sum_{t=1}^{T}\xi_{it}\xi_{j}$	–2.12 (0.034)**
CD_{BKP}	$\sqrt{\frac{TN(N-1)}{2}}\hat{\bar{\rho}}N$	4.05 (0.000)***

Note: ** and *** represent 5% and 1% significance levels, respectively.

The results from Table 7 confirm the presence of cross-sectional dependence in the model residuals. Both the CD_{NT} (–2.12, p = 0.034) and CD_{BKP} (4.05, $p < 0.001$) tests reject the null hypothesis of independent errors, suggesting that unobserved common factors may influence multiple units simultaneously.

TABLE 8
Test cross-sectional dependence in variables

Test	Statistics	GDP_{it}	FDI_{it}	TRO_{it}	FSD_{it}	TED_{it}	INF_{it}	ERV_{it}
CD_{BKP}	$\sqrt{\frac{TN(N-1}{2}}\hat{\rho}N$	72.68***	11.94***	71.76***	24.08***	31.71***	17.63**	15.32***

Note: *** signicance at 1% level.

This conclusion is further substantiated by Table 8, which shows robust evidence of CSD across all variables, with highly significant CD_{BKP} statistics ranging from 11.94 to 72.68 ($p < 0.01$). These values highlight notable interdependence among sample countries, implying that macroeconomic shocks or structural patterns may be jointly shared across units—potentially biasing estimates if not properly addressed.

The dataset reveals considerable variation across macroeconomic indicators, supported by diagnostic results that confirm slope heterogeneity and significant cross-sectional dependence in residuals and variables. These findings imply interdependencies and country-specific dynamics that invalidate standard panel assumptions. As cointegration has been confirmed, indicating long-run equilibrium relationships among the variables, the Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) model is adopted as a suitable estimation strategy. Its ability to accommodate slope heterogeneity, cross-sectional dependence, and mixed integration orders ensures robust and unbiased inference of both short-run dynamics and long-run cointegrated associations across interlinked economies.

CS-ARDL Estimates (Long and Short Run Relationships)

Table 7 reports the outcome of the CS-ARDL estimate. All the economic growth determinants except inflation have statistically significant effects on economic growth. The impact is positive for the FDI (lagged value), level of foreign trade (FTR) and depth and development of the financial system (FSD) ($\frac{\Delta GDP}{\Delta FDI} > 0, \frac{\Delta GDP}{\Delta FTR} > 0, \frac{\Delta GDP}{\Delta FSD} > 0$). The short- and long-term show that an increase in these variables leads to GDP growth. The level of external debt exerts a negative impact. ($\frac{\Delta GDP}{\Delta TED} < 0$) Whereas the impact of inflation is insignificant on economic growth, both in the short and long term. The volatility in the REER shows a negative sign $\frac{\Delta GDP}{\Delta TED} < 0$ in the long term, unpredictable ERV can create uncertainty, hinder investment, and disrupt trade flows, thus impacting economic growth.

TABLE 9
Long- and short-run relationship

Long-run			Short-run		
Variables	**Slope coefficient**	**Standard error**	**Variables**	**Slope coefficient**	**Standard error**
FDI_{it}	0.0152 (0.004)	0.0054	$\Delta l.\ln GDP_{it}$	0.4992 (0.000)***	0.0673
$\ln FTR_{it}$	0.1074 (0.007)***	0.0399	ΔFDI_{it}	0.0025 (0.296)	0.0024
$\ln FSD_{it}$	0.1244 (0.010)**	0.0483	$\Delta l.FDI_{it}$	0.0026 (0.015)**	0.0225
$\ln TED_{it}$	–0.0738 (0.043)**	0.0365	$\Delta \ln FTR_{it}$	0.0453 (0.000)***	0.0121
INF_{it}	–0.0026 (0.187)	0.0019	$\Delta l.\ln FSD_{it}$	0.0547 (0.015)**	0.0225
$\ln ERV_{it}$	–0.0246 (0.031)**	0.0114	$\Delta \ln TED_{it}$	–0.0370 (0.004)**	0.0127
ECT (–)	–0.5008 (0.000)***	0.0673	ΔINF_{it}	–0.0009 (0.105)	0.0005
–	–	–	$\Delta \ln ERV_{it}$	–0.0054 (0.132)	0.0036

Note: ** and *** represent 5% and 1% significance levels, respectively

The CS-ARDL estimations, core findings remain consistent with theoretical expectations: FDI, trade openness and financial system development exhibit statistically significant and positive effects on growth, whereas external debt dampens growth; inflation is statistically insignificant. ERV shows a significant negative long-run effect but no short-run impact, consistent with uncertainty and pass-through mechanisms that operate cumulatively (Aizenman, 1992; Devereux & Engel, 2003; Barguellil et al., 2018).

FDI exhibits a positive relationship with economic growth. A 1% increase in the lagged FDI-to-GDP ratio leads to a 0.26% short-term and a larger 1.52% long-term increase in real GDP. This finding highlights the importance of FDI in stimulating economic expansion through investment, technological advancements, and job creation. The amplified long-term effect suggests that FDI's primary benefits manifest over time, resulting in sustained growth fueled by continuous investment and knowledge spillovers.

Like FDI, foreign trade demonstrates a positive association with economic growth. A 1% increase in FTR leads to a 0.045% and 0.107% increase in real GDP in the short and long run, respectively. This finding aligns with previous research by Keho and Wang (2017), suggesting that trade openness fosters economic growth through mechanisms such as economies of scale, increased competition, and access to new markets. Notably, the stronger long-term impact (0.107% vs. 0.045%) echoes the pattern observed with FDI, potentially reflecting the time required for businesses to adjust and fully capitalise on new trade opportunities and heightened competition.

Financial system development (FSD) exhibits a positive relation with economic growth. A 1% increase in FSD leads to a 0.055% and 0.124% increase in real GDP in the short and long term, respectively. This finding aligns with earlier studies by Khan and Senhadji (2000), Bekaert et al. (2005), and Zinnaira et al. (2022), suggesting its crucial role in facilitating resource allocation, mobilising savings, and promoting investment for growth. Notably, the stronger long-term impact (0.124% vs. 0.055%) reflects the potential for FSD to foster a more efficient and stable financial environment over time, ultimately leading to sustained growth through enhanced investment and innovation.

A 1% increase in External Debt (TED) results in a statistically significant decrease in real GDP, with a stronger negative impact in the long term (0.074%) compared to the short term (0.037%). This finding aligns with Fujii (2023) and suggests that high levels of TED can hinder economic growth, likely due to factors such as increasing debt servicing costs, crowding out private investment and heightened vulnerability to external shocks. The observed long-term effect emphasises how the burden of debt compounds over time, requiring higher servicing costs and potentially diverting resources away from productive investments that could support economic growth.

While inflation is insignificant in CS-ARDL, it becomes significant and negative in robustness checks, indicating state- and model-dependent inflation–growth interactions typical in ERPT environments (Hakura & Choudhri, 2001; Ha et al., 2019). ERV's long-run negativity in CS-ARDL aligns with imported inflation and uncertainty channels materialising over time (Forbes et al., 2018).

REER volatility, while statistically insignificant in the short term, is a 1% increase in REER volatility, which leads to a 0.0246% decrease in real GDP in the long term. This indicates that ERV can negatively impact economic growth by creating uncertainty for businesses, hindering investment, and disrupting trade flows, which aligns with the work of Barguellil et al. (2018). The error correction term (ECT) is negative (–0.5008) and significant at 1% level. This suggests that approximately 50.08% of disequilibrium in real GDP is corrected in each period, indicating a strong cointegration relationship between the variables. This implies that short-run deviations from equilibrium tend to be adjusted in the long run.

The result allows us to conclude that variation in economic growth is related to the direct impact of ERV as well as other macroeconomic factors, including FDI, trade openness and depth, and the development of the financial system, both in the short and long term, in these sampled countries.

Robustness Check

To ensure the reliability of findings obtained from the CS-ARDL method, we employ two additional techniques tailored for handling cross-sectional dependence (CD): the CCEMG and AMG estimators. Introduced by Pesaran (2006), CCEMG assumes a single "main effect" (β) that applies to all countries but allows for additional country-specific "tweaks" (ωj). This translates into the estimator $\beta j = \beta + \omega j$, where β represents the common parameter across countries, while ωj captures individual deviations assumed to be random and independent [$\omega j \backsim IID\ (0, V\omega)$]. This approach effectively mitigates CD asymptotically and accommodates heterogeneous slope coefficients across group members by simply averaging each country's coefficient. Focusing on the average effect can isolate the main effect (β) while disregarding the country-specific adjustments.

Building upon CCEMG, the AMG estimator by Eberhardt and Teal (2010) explicitly addresses the unobserved common effect within the model. This method incorporates the shared influence as a separate variable in the analysis, which is particularly relevant when this influence is substantial. By doing so, AMG estimates both the group-specific and common effects, ultimately capturing the impact on all countries while providing a more explicit estimation through direct inclusion. Notably, the AMG estimator utilises a first-differenced Ordinary Least Squares (OLS) approach for pooled data and further includes year dummies in the analysis. The model can be written as follows:

Where i represents a cross-section; i = 1, 2, 3, …, and time dimension t = 1, 2, 3, …,. The model incorporates both country-specific fixed effects α_i and heterogeneous deterministic trends c_{it}. α_i is associated with the respective independent variables $\beta_{i,1} = \frac{\alpha_{i1}}{1-\alpha_{i1}}, \beta_{i,2} = \frac{\alpha_{i2}}{1-\alpha_{i2}}, \cdots \beta_{i,6} = \frac{\alpha_{i6}}{1-\alpha_{i6}}$. This allows for the coefficient of each independent variable ($\beta_{i,1}$) to capture country-specific effects, reflecting potential heterogeneity in their impact across different countries. The error term represents the short-run dynamics and their adjustment towards the long-run. $u_{i,1} = (\eta_i f_t + \varepsilon_{it})$ where f_t captures the unobserved common dynamic process (e.g., global technological progress), and ε_{it} signifies the country-specific error. Notably, the common shocks f_t can be stationary or non-stationary without affecting the estimation validity (Kapetanios et al., 2011).

The AMG estimation explicitly estimates f_t giving economic meaning to the common dynamic process ($\hat{\mu}_t^{va\Delta}$). One possible interpretation of $\hat{\mu}_t^{va\Delta}$ t is total factor productivity (TFP), with d_i representing the implicit factor loading on common TFP. Importantly, the model allows for serial correlation and weak cross-sectional dependence in the error terms ε_{it}. However, it requires the regressors and common factor to be identically distributed.

TABLE 10
CCEMG and AMG estimates

Variable	Dependent variable: Real Gross Domestic Product (RGDP)			
	CCEMG		AMG	
	Slope coefficient	Standard error	Slope coefficient	Standard error
FDI_{it}	0.0068 (0.091) *	0.0041	0.0140 (0.015) **	0.0058
ln FTR_{it}	0.0726 (0.000) ***	0.0726	0.0677 (0.001) ***	0.0196
ln FSD_{it}	–0.0072 (0.833)	0.0342	0.0719 (0.096) *	0.0431
ln TED_{it}	–0.0414 (0.058) *	0.0218	–0.0400 (0.092) *	0.0237
INF_{it}	–0.0016 (0.066) *	0.0009	–0.0015 (0.065) *	0.0008
$lnERV_{it}$	–0.0029 (0.373)	0.0032	–0.0081 (0.108)	0.0051
CDP~	-	-	1.0274 (0.000) ***	0.2417
Country trend	0.0090 (0.404)	0.0108	–0.0048 (0.599)	0.0091
Constant	0.0032 (0.599)	0.7938	9.0051 (0.000) ***	0.4821

Notes: CDP~ = common dynamic process. *, ** and *** represent 10%, 5% and 1% significance levels, respectively.

Table 8 presents the CCEMG and AMG estimates. The findings reveal statistically significant and positive relationships between GDP and FDI, i.e., $\left(\beta_{FDI}^{CCEMG}\right)_{10\%} = 0.68, \left(\beta_{FDI}^{AMG}\right)_{5\%} = 1.4\%$ and between GDP and TRO, i.e., $\left(\beta_{FDI}^{CCEMG}\right)_{10\%} = 0.68, \left(\beta_{FDI}^{AMG}\right)_{5\%} = 1.4\%$ under both CCEMG and AMG estimates. However, the relationship between GDP and FSD is inconsistent across methods, showing insignificance in CCEMG but positive significance in AMG, i.e., $\left(\beta_{FSD}^{AMG}\right)_{10\%} = 7.2\%$. Interestingly, the impact of TED differs from the CS-ARDL model, exhibiting a negative and significant relationship with GDP under both estimation techniques, i.e. $\left(\beta_{TED}^{CCEMG}\right)_{10\%} = 4.14\%, \left(\beta_{FDI}^{AMG}\right)_{10\%} = 4.0\%$. This suggests that increasing external debt burdens might hinder economic growth. Notably, both CCEMG and AMG highlight a significant and negative relationship between GDP and inflation $\left(\beta_{INF}^{CCEMG}\right)_{10\%} = -0.16\%, \left(\beta_{INF}^{AMG}\right)_{10\%} = -0.15\%$.

While ERV exhibits a negative association with GDP in both CCEMG and AMG models, it lacks statistical significance, suggesting no direct impact on economic growth. Interestingly, the CS-ARDL model indicates a significant negative influence of ERV on growth in the long run but not in the short run. Overall, the robustness of the model is strengthened by the inclusion of CCEMG and AMG estimates, as they provide similar statistical significance ranging between 1% and 10%. Additionally, the significant common dynamic process at the 1% significance level $\hat{\mu}_t^{va\Delta} = 1.027$ suggests the presence of unobserved country-specific factors that positively influence economic growth.

CCEMG and AMG reinforce the core associations: FDI and trade are growth-enhancing; TED and inflation are growth-reducing. The emergence of inflation's significance here, despite its insignificance in CS-ARDL, is consistent with estimator sensitivity to common factors and pass-through persistence (Pesaran, 2006; Eberhardt & Teal, 2010; Ha et al., 2019). ERV remains negative but insignificant in CCEMG/AMG, indicating the strongest evidence for a direct impact in the long run (CS-ARDL). FSD's mixed significance likely reflects methodological differences: CCEMG's factor-structure absorption versus AMG's explicit common-factor control (Pesaran, 2006; Eberhardt & Teal, 2010).

Panel Granger Causality Test (Dumitrescu-Hurlin Causality Test)

Dumitrescu-Hurlin (2012) causality tests (Table 11) demonstrate significant causal pathways at multiple levels: ERV exhibits unidirectional causality toward FDI and FSD at 5% and 10% significance levels, respectively. Bidirectional causality operates between ERV and FTR and between ERV and inflation at 1% significance level, respectively. No causal relationships exist between ERV and total external debt (TED).

TABLE 11
Dumitrescu-Hurlin (2012) Causality Tests

Causality	$W_{N,T}^{HNC}$	$Z_{N,T}^{HNC}$	*p*-value	$\hat{Z}_{N,T}^{HNC}$	*p*-value	Remarks
$ERV_{it} \rightarrow FDI_{it}$	1.925	2.775	0.006	2.322	0.020**	Causality from ERV to FDI
$ERV_{it} \nrightarrow FDI_{it}$	1.419	1.257	0.209	0.960	0.337	No causality
$ERV_{it} \rightarrow FTR_{it}$	2.171	3.514	0.0004	2.985	0.003***	Causality from ERV to FTR
$FTR_{it} \rightarrow ERV_{it}$	6.391	16.172	0.0000	14.345	0.000***	Causality from FTR to ERV
$FSD_{it} \rightarrow ERV_{it}$	1.776	2.329	0.0199	1.922	0.055*	Causality from FSD to ERV
$ERV_{it} \nrightarrow FSD_{it}$	1.389	1.167	0.2432	0.879	0.379	No causality
$ERV_{it} \nrightarrow TED_{it}$	1.389	1.167	0.2432	0.879	0.379	No causality
$TED_{it} \nrightarrow ERV_{it}$	1.432	1.296	0.1949	0.995	0.320	No causality
$ERV_{it} \rightarrow INF_{it}$	2.386	4.157	0.0000	3.562	0.001***	Causality from ERV to INF
$INF_{it} \rightarrow ERV_{it}$	3.867	8.600	0.0000	7.549	0.000***	Causality from INF to ERV

Note: * , ** and *** represent 10%, 5% and 1% significance levels, respectively

The significant causal patterns identified validate our methodological choice to apply the Dumitrescu-Hurlin test to level variables. This approach preserves long-run equilibrium relationships essential for detecting causal pathways in cointegrated systems. Differencing would obscure these interactions by eliminating the error-correction mechanism demonstrated in our CS-ARDL estimates.

ERV's growth impact operates through three indirect channels: investment (ERV deters FDI), trade (volatility disrupts commerce), and prices (exchange-rate pass-through raises inflation). Although financial system development affects ERV (FSD → ERV at 10%), the lack of ERV → FSD (p = 0.379) excludes FSD as a transmission path. Accordingly, ERV depresses growth via a direct long-run effect and indirect effects running exclusively through FDI, trade, and inflation—consistent with the uncertainty channel for investment (Aizenman, 1992), trade-cost mechanisms for openness (Rose, 2000), and pass-through models for prices (Devereux & Engel, 2003).

Integrated Transmission Channels of ERV to Economic Growth

ERV affects economic growth through direct and indirect pathways. The evidence indicates a clear, direct channel: ERV depresses growth in the long run, consistent with uncertainty effects that accumulate and impair investment planning and real activity, with short-run impacts muted in line with a gradual transmission of uncertainty to real outcomes (Aizenman, 1992).

Three indirect channels complement this direct effect and are jointly supported by the estimators and the causality analysis.

1. Trade channel: ERV is associated with disruptions to external trade, while trade openness is growth-enhancing in the CS-ARDL and robustness estimators. The causality results show feedback between ERV and trade, consistent with volatility raising transaction and hedging costs, reducing contract certainty and lowering trade volumes—thereby dampening growth (Rose, 2000).
2. Investment channel: ERV precedes movements in FDI in the causality tests, while FDI is consistently growth-positive across models. This pattern aligns with uncertainty-driven investment responses: Volatility elevates risk premia and financing frictions, deterring cross-border investment and weakening a key driver of long-run growth (Aizenman, 1992).
3. Inflation channel: ERV and inflation are bidirectionally related in the causality results. Although inflation is not significant in the CS-ARDL, it is negative and significant in the robustness estimators, supporting an import pass-through interpretation whereby ERV fuels inflation that, once salient, undermines growth (Devereux & Engel, 2003).

The Financial System Development (FSD) strengthens growth across specifications and shows a causal relationship with ERV at the 10% level, but not vice versa, indicating a buffering effect: more developed financial systems can dampen the formation or propagation of volatility, indirectly protecting growth. Total external debt (TED) hampers growth directly across various estimators but does not have a causal connection with ERV, implying its negative impact operates independently of volatility mechanisms and is better managed through liability strategies rather than ERV-focused tools.

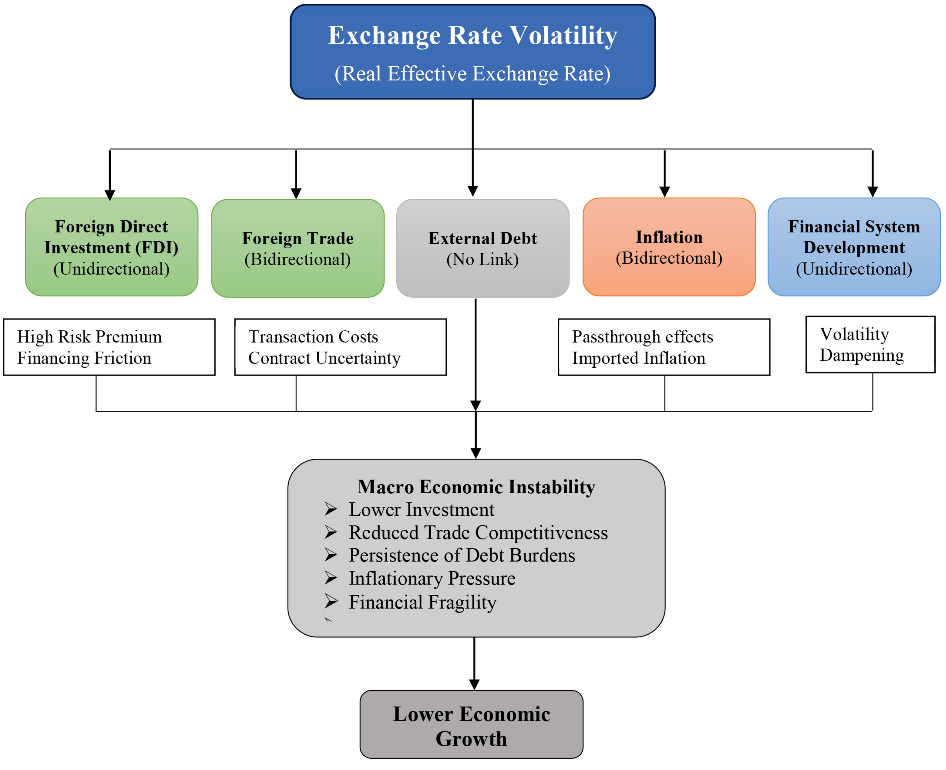

FIGURE 1: Transmission Channels (Indirect)

Overall, the CS-ARDL findings identify the long-term direct negative influence of ERV and the growth-promoting effects of trade, FDI and FSD; CCEMG/AMG analyses confirm these directions and additionally underscore inflation's role in damping growth; and the Dumitrescu-Hurlin tests establish the causal directions among ERV, trade, FDI, inflation and FSD. Collectively, these results depict a coherent transmission framework: a slow-moving direct uncertainty effect and indirect effects through trade, investment, and price stability, with FSD functioning as a moderator and TED as a separate constraint (Aizenman, 1992; Rose, 2000; Devereux & Engel, 2003).

CONCLUSION AND POLICY IMPLICATIONS

This study investigates the complex relationship between ERV and economic growth in 18 OIC member countries over 38 years (1985–2022), employing the CS-ARDL model to test direct and indirect effects. Empirical results reveal that FDI, trade openness, and financial system development positively contribute to growth in both the short and long run. External debt exerts a negative impact primarily through high servicing costs and investor pessimism linked to debt overhang. External shocks, such as rising interest rates and currency fluctuations, further constrain public investment in growth-enhancing sectors.

ERV impedes growth through two main channels. First, a long-run direct effect consistent with uncertainty theory reduces investor confidence and disrupts strategic planning. Second, an indirect pathway operates through inflation pass-through, trade contraction, and diminished FDI inflows, confirmed via Dumitrescu-Hurlin causality analysis. Volatility discourages cross-border transactions, alters pricing behaviour and undermines competitiveness, particularly in import-dependent economies. These channel effects are substantiated by CCEMG and AMG robustness checks that address cross-sectional dependence. Our results affirm that ERV's negative impact is statistically and economically meaningful. Its long-run drag aligns with theoretical frameworks on investment risk and imported inflation (Aizenman, 1992; Devereux & Engel, 2003), while inflation's model-sensitive significance underscores the importance of nominal credibility in trade-dependent contexts. Accordingly, ERV is not merely a statistical artifact but a multidimensional policy challenge requiring nuanced interventions.

To support economic stability in OIC countries, policymakers should prioritise exchange rate stabilisation through empirically grounded instruments. In particular, we recommend the creation of an OIC-wide local-currency swap and clearing network to mitigate FX liquidity shocks and stabilise intra-OIC trade. These initiatives can reduce ERV exposure and enhance regional trade resilience. Additionally, deploying Sharia-compliant hedging tools such as waʿd-based forwards and murābaḥah swaps offers context-specific ERV protection for exporters, importers and long-term investors. These instruments would improve FDI prospects and strengthen financial system development while aligning with Accounting and Auditing Organization for Islamic Financial Institutions (AAOIFI) standards.

Inflation control and external debt management remain critical. Reducing inflation volatility lowers pass-through effects, while prudent debt structuring can alleviate macroeconomic constraints tied to FX liabilities. Complementary measures include deepening Islamic money markets, incentivising local-currency invoicing and enhancing risk-sharing in cross-border investments. Together, these interventions reinforce the positive effects of trade, FDI and financial development on growth and mitigate ERV's adverse impact.

Finally, the study acknowledges its contextual limitations. The use of panel CS-ARDL and focus on OIC economies may constrain broader generalisability. Additional factors—such as regime classifications or omitted control variables—could influence outcomes and merit further investigation. Future research should extend the framework to diverse country groupings and refine ERV channel interactions, enabling more targeted policy formulation across varying macroeconomic contexts.

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