Do Foreign Reserves Insure Economies Against Exchange-Rate Shocks? Evidence from Nonlinear Cross-Country Dynamics.

Nijat Guliyev

March 14, 2026

Abstract

Large exchange rate movements can have important implications for economic growth, particularly in countries that face volatile external conditions. A key question is whether foreign exchange reserves help cushion economies against these shocks. Using annual data for 60 advanced and developing countries over the period 1997–2019, this study estimates dynamic panel models that allow for heterogeneous and nonlinear responses across countries. The results show that exchange rate volatility is associated with lower growth, while the effects of exchange rate depreciation display nonlinear patterns. In particular, threshold estimates suggest that growth responses to exchange rate movements differ across reserve accumulation regimes, indicating that reserves can partially mitigate the adverse effects of exchange rate disturbances in some countries. At the same time, the strength of this relationship varies across country groups and macroeconomic environments. A comparison with the quarterly evidence reported in Guliyev (2025) further suggests

that data frequency affects the interpretation of these dynamics: high-frequency data capture short-run adjustment mechanisms, whereas annual data better reflect persistent growth effects.

1 Introduction

Foreign reserve accumulation and management is one of the central policy challenges in open economies. The recent surge in reserves, especially following periods of financial stress, has made this issue even more relevant. The availability of reserves can enhance investor confidence, serve as a form of insurance, support exchange rate stabilization, and, in some cases, promote economic growth. However, reserves are costly to maintain due to their opportunity cost, and excessive accumulation may generate complacency or induce moral hazard, particularly in economies where institutional checks on fiscal and monetary discipline are weak. Moreover, the benefits and drawbacks of reserve accumulation are not necessarily symmetrical, but depend on a country's macroeconomic structure and policy credibility. Finally, the impact of reserve management on growth may vary across time horizons, with potentially different effects in the short versus the long run.

The literature on foreign reserve accumulation and management is extensive. While the direct effects of reserves on growth and exchange rates have been widely examined, the role of reserves in mitigating the impact of exchange rate fluctuations on growth has received much less attention. A central policy question is whether reserves should be actively deployed to defend the currency or simply held as a precautionary buffer. In other words, do the growth effects of exchange rate changes and volatility depend on the level of reserves? This paper contributes to the literature by addressing this gap, examining how the presence and adequacy of foreign reserves condition the growth effects of exchange rate dynamics.

Specifically, we employ the dynamic panel model of Arellano and Bond (1991) and the dynamic panel threshold model of Kremer et al. (2013) using a dataset of sixty developed and developing countries spanning the period 1997–2019. This framework enables us to capture country-specific dynamics and address potential endogeneity while examining both the direct and interaction effects between economic growth, exchange rates, and foreign reserves. To further enrich the analysis, we classify countries by income level and investigate whether the exchange rate–growth nexus exhibits heterogeneity across development stages, recognizing that structural differences may shape macroeconomic adjustment mechanisms.

Recently, Guliyev (2025) empirically investigated the mitigating role of foreign reserves in a dynamic panel setting using *quarterly data*. While their study provides valuable insights, it also has several limitations that we address in this paper. Although quarterly data can capture short-term dynamics, it may fail to reflect long-term effects. Moreover, their use of quarterly-specific transformations, such as de-seasonalizing the series, may eliminate important relationships in the data. By contrast, this study employs annual data, which helps to overcome these issues. In addition, by comparing our results with those of Guliyev (2025), we are able to assess the sensitivity of the estimated relationships to data frequency and country grouping. Finally, since most of the existing literature relies on annual data, our findings are directly comparable to a broader set of studies.

In addition, the dynamic threshold model allows us to examine whether the interaction between exchange rates and reserves depends not only on the level of development, but also on other macroeconomic characteristics such as exchange rate volatility, the level of reserves, and GDP per capita.

The results highlight several important findings. First, although not uniformly robust across all specifications and country groups, we find evidence of a statistically sig-

nificant interaction between exchange rates and foreign reserves in their effect on growth. This threshold-like behaviour suggests that reserves can play a stabilizing role during periods of exchange rate stress. Second, we find strong evidence in support of the J-curve hypothesis in several cases: currency depreciation is initially associated with a deterioration in the trade balance, but this effect is eventually reversed as export volumes adjust. Third, trade openness shows a positive effect on growth in the short run, reflecting gains from market access and competitive pressures, but its long-run effect can turn negative, potentially due to structural dependency, deindustrialization, or heightened exposure to external shocks.

Another key finding is the sensitivity of the results to model specification and data frequency. Quarterly models tend to capture short-run fluctuations and immediate responses, whereas annual data are better suited for identifying persistent, long-term structural effects. These differences reflect not only econometric sensitivity but also the economic reality that the impact of exchange rate policies and reserve adequacy unfolds across multiple time horizons. Overall, the findings underscore the importance of careful specification and interpretation in cross-country macroeconomic research, as well as the broader methodological challenge of capturing causal effects in heterogeneous, dynamic environments.

Although our measure of exchange rate volatility (defined in detail in subsequent sections) may also capture elements of the underlying exchange rate regime, we do not treat it as a direct regime indicator due to methodological limitations. A proper identification of regime effects would require a more nuanced, regime-specific framework that is beyond the scope of this study. Instead, our contribution is to empirically test whether foreign reserves moderate the effects of exchange rate volatility and depreciation on growth, thereby clarifying the conditional role that reserves play in macroeconomic stabilization.

The structure of the paper is as follows. Section 2 reviews the relevant literature

on the macroeconomic roles of exchange rates and foreign reserves. Section 3 describes the dataset, key variables, and econometric models. Section 4 presents the empirical results and their interpretation. Section 5 discusses robustness checks, limitations, and potential extensions. Section 6 concludes with the main findings and their policy implications.

2 Literature Review

This paper contributes to multiple strands of the international finance literature. The first strand is the literature examining exchange rate - growth relationship.

Vieira and MacDonald (2012) investigate the effects of exchange rate misalignment on economic growth using a dynamic panel model estimated via system GMM. Their approach accounts for endogeneity and leverages a broad dataset covering multiple countries over an extended period. They define misalignment as the deviation from an equilibrium RER, estimated using fundamental macroeconomic variables. The results show that moderate undervaluation of the RER can enhance economic growth, particularly in developing countries, by promoting exports and industrialization, whereas overvaluation tends to be growth-detrimental. They also document significant cross-country heterogeneity, with the positive effects of undervaluation more pronounced in emerging economies.

Rapetti (2020) offers a comprehensive review of the relationship between RER levels, RER volatility, and economic growth, emphasizing the context of structural transformation in developing countries. The review highlights that RER overvaluation typically hampers growth by eroding export competitiveness, while mild undervaluation supports it by boosting the tradable sector. Rapetti also stresses the destabilizing role of RER volatility, which increases uncertainty and undermines investment and trade. By syn-

thesizing empirical evidence from multiple sources, including panel regressions based on Penn World Table data, the study underscores the importance of stable and competitive exchange rates in fostering macroeconomic stability, industrial upgrading, and long-term growth.

Missio et al. (2015) examine the relationship between RER and economic growth using system GMM estimation on a global panel dataset. Their results reinforce the view that RER undervaluation is growth-enhancing, particularly for developing countries where competitiveness is critical for export-led development. The paper further emphasizes that this positive relationship is substantially weaker or non-existent in advanced economies, where the structural composition of the economy is less reliant on tradable goods.

A notable contribution of their study lies in differentiating growth responses to RER misalignment based on income levels. Missio et al. argue that developing economies are more sensitive to exchange rate competitiveness due to their dependence on manufacturing and external demand. In contrast, advanced economies exhibit muted responses, highlighting the context-specific nature of exchange rate effects. This underscores the strategic role of exchange rate policy in development strategies.

Ramoni-Perazzi and Romero (2022) examine the interplay between exchange rate volatility, corruption, and growth using dynamic panel data for 194 countries from 1995 to 2019. They use GARCH models to measure time-varying exchange rate volatility and apply both Difference and System GMM estimation to address endogeneity. A novel aspect of their study is the inclusion of corruption as a moderating variable, captured through a government integrity index.

Their results indicate that volatility generally hinders growth, but its adverse effects are mitigated in more financially developed economies. Interestingly, they also

find that in highly corrupt environments, the negative impact of volatility is less pronounced—possibly due to economic agents becoming accustomed to instability. This counterintuitive finding opens the door to further research on behavioral adaptations in high-risk institutional environments.

Second, our paper aligns with the strand of literature examining the role of foreign exchange reserves in macroeconomic performance and stability. This body of work investigates both the motivations behind reserve accumulation and its implications for economic growth and resilience to external shocks.

Aizenman and Lee (2007) investigate the motivations for international reserve accumulation, distinguishing between precautionary and mercantilist drivers. Using a dynamic panel of countries from 1975 to 2000 and estimating a GMM model, they find that countries facing external vulnerability and financial volatility accumulate reserves mainly for precautionary purposes, while export-oriented economies hold reserves to sustain competitive exchange rates. The study highlights the role of exchange rate regimes, showing that more actively managed regimes are associated with higher reserve accumulation. While both motives are empirically supported, precautionary motives dominate in financially open economies and mercantilist motives in trade-dependent nations. The authors also emphasize the trade-offs of reserve accumulation, noting diminishing returns and opportunity costs, and stress the importance of balanced, context-specific reserve management strategies.

Allegret and Allegret (2018) analyze the buffering role of international reserves against external shocks in nine emerging economies using a threshold VAR (TVAR) approach over two sub-periods, 1995–2003 and 2004–2013. By allowing the dynamics to switch depending on whether reserves cross a critical threshold, they capture important nonlinearities that linear models overlook. Their results show that the stabilizing effect of reserves on output gaps has strengthened over time, contradicting the view that re-

serve accumulation necessarily entails diminishing returns. The study highlights that the insurance value of reserves is conditional: once reserves exceed a certain adequacy level, they become significantly more effective at mitigating the adverse effects of shocks. This finding underscores the importance of regime-dependent analysis in reserve policy. For policymakers, the implication is that reserve targets should not be fixed mechanically but calibrated according to vulnerability patterns and adequacy thresholds, as the growth and stability benefits of reserves vary across regimes.

Sula and Oguzoglu (2021) analyze the relationship between international reserves and economic growth in 120 countries over 1981–2010 using a dynamic panel GMM framework. They find that higher reserves have a positive and significant impact on growth, consistent with their role as buffers against shocks, but that this effect weakens as the opportunity cost of holding reserves rises, pointing to diminishing returns. The study highlights that while reserves contribute to macroeconomic stability and growth, policymakers must balance these benefits against forgone investment and fiscal trade-offs. The implication is that reserve accumulation strategies should be context-specific, with adequacy levels calibrated to vulnerability patterns and cost considerations.

Third, our paper contributes to the literature by comparing models across different data frequencies, model specifications, and country groups. Direct comparisons between quarterly and annual models are relatively scarce. Below, we review studies that implement such comparisons or utilize mixed-frequency data to assess model performance.

Shaar and Khaled (2018) investigates the impact of data frequency on analyzing the relationship between exchange rates and trade. Using U.S.–Canada data, the authors compare results from high-frequency (monthly) and low-frequency (annual) observations and show that low-frequency data can obscure or distort both short-term and long-term effects of exchange rate fluctuations on trade. Employing the Autoregressive Distributed Lag (ARDL) cointegration approach, they demonstrate that high-frequency data are

essential for capturing the nuanced dynamics of exchange rate variations on trade flows.

One strand of the literature employs mixed-frequency data, which demonstrates clear advantages over low-frequency models. Foroni et al. (2022) compare the behavior of financial accelerators estimated on monthly versus quarterly data and show that results can differ substantially across frequencies. Aggregating monthly data into quarterly frequency introduces significant biases in DSGE model estimation, particularly in parameter values and shock transmission mechanisms. For example, a monetary policy shock that accelerates investment in quarterly models instead produces deceleration in a mixed-frequency setting. Similarly, investment-specific shocks that typically slow down investment at the quarterly level generate acceleration in the mixed-frequency framework. These findings suggest that data aggregation can distort key economic relationships, underscoring the importance of data frequency in macroeconomic analysis. See also Foroni and Marcellino (2014) for a related discussion.

Finally, several studies have examined how international reserves can mitigate the adverse effects of financial crises on economic growth.

Bussière et al. (2015) examine the role of international reserves in cushioning the effects of the 2008–09 global financial crisis across more than 100 emerging and developing economies. Using cross-sectional regressions, they assess how pre-crisis reserve levels influenced GDP growth, with key controls including capital controls, trade openness, exchange rate regimes, and short-term debt exposure. Their results show that countries with higher reserves relative to short-term debt experienced smaller contractions, and that reserves were more effective in economies with tighter capital controls, highlighting a complementarity between reserves and capital account management.

The study defines reserves as central bank foreign asset holdings used to buffer external shocks, and emphasizes the importance of exchange rate regimes in shaping their

effectiveness. Overall, the findings underscore that while reserves can play a critical stabilizing role during crises, their benefits depend on broader macroeconomic policies and institutional settings. This contributes to the debate on optimal reserve levels, stressing that their effectiveness is contingent on a country's financial structure and policy framework.

Sallenave et al. (2024) examines whether holding international reserves helps emerging and developing economies (EMDEs) mitigate financial and banking vulnerabilities. Using data from 40 EMDEs between 1995 and 2015, the authors test the "diminishing returns" hypothesis—that beyond a certain threshold, additional reserves lose effectiveness. Employing a Panel Smooth Transition Regression (PSTR) framework, they find that higher reserve stocks continue to provide significant protection against the negative effects of financial and banking fragilities on GDP growth, even at high levels of reserve holding.

The policy implications are clear: contrary to concerns about diminishing returns, reserve accumulation remains a valuable strategy for EMDEs. The findings show that reserves mitigate both domestic vulnerabilities and exposure to global shocks, suggesting they act as a reliable insurance mechanism in uncertain financial environments. Given the limited alternatives available to EMDEs for rapidly mobilizing liquidity, the results support continued accumulation of reserves despite opportunity costs. This contributes to the broader debate on reserve adequacy, indicating that for EMDEs, the benefits of holding reserves—in terms of crisis resilience and growth stability—outweigh the costs

While the relationships between exchange rates, foreign reserves, and economic growth have been widely studied in the literature, the potential mitigating role of reserves in cushioning the negative effects of exchange rate shocks has received relatively little attention in a cross-country panel setting. This paper addresses this gap by examining whether foreign exchange reserves help dampen the adverse growth effects of exchange

rate volatility and depreciation. The analysis allows these effects to vary across reserve regimes and country groups, capturing potential nonlinearities and cross-country heterogeneity. In addition, by relating the annual results to the quarterly evidence in Guliyev (2025), the paper also illustrates how data frequency can influence the interpretation of exchange rate–growth dynamics.

3 Data and methodology

3.1 Data

We utilize the dataset employed in Guliyev (2025), which comprises an unbalanced quarterly panel spanning from 1997Q1 to 2019Q4 and covering 60 countries. We aggregate the quarterly data to an annual frequency. For flow variables, such as GDP or exports, the annual value is computed by summing the four quarterly observations within each year. Conversely, for stock variables, such as foreign reserves, the annual value is calculated by taking the average of the four quarterly observations within the year.

As one of our primary objectives is to compare results derived from quarterly and annual data frequencies, we maintain consistency in the base model by refraining from introducing additional variables. Subsequent sections explore model extensions that incorporate additional variables to assess their impact on the results.

For a comprehensive discussion of the data sources, variable definitions, and construction methodology, please refer to Guliyev (2025).

3.2 Methodology

We estimate dynamic panel model (Arellano and Bond (1991)) with interaction term. In addition we also estimate dynamic panel threshold model due Kremer et al. (2013). Below we briefly describe both models used.

Dynamic panel model. Dynamic panel models are commonly used when the dependent variable exhibits persistence over time, meaning that past realizations influence current outcomes. The general form of a dynamic panel data model can be written as:

$$y_{it} = \alpha y_{i,t-1} + X_{it}\beta + \mu_i + \epsilon_{it} \tag{1}$$

where y_{it} is the dependent variable for country i at time t, $y_{i,t-1}$ is the lagged dependent variable, X_{it} represents a vector of explanatory variables, μ_i is the unobserved individual-specific effect, and ϵ_{it} is the idiosyncratic error term.

The inclusion of the lagged dependent variable introduces endogeneity due to correlation between $y_{i,t-1}$ and the unobserved fixed effects μ_i. Since μ_i is present in both past and current periods, it causes $y_{i,t-1}$ to be correlated with the error term, violating the strict exogeneity assumption and rendering OLS estimates biased and inconsistent.

To address this issue, the difference GMM estimator proposed by Arellano and Bond (1991) transforms the model by first-differencing to remove the individual fixed effects:

$$\Delta y_{it} = \alpha \Delta y_{i,t-1} + \Delta X_{it}\beta + \Delta \epsilon_{it} \tag{2}$$

This transformation eliminates μ_i, but the new error term $\Delta\epsilon_{it}$ becomes correlated with $\Delta y_{i,t-1}$. This occurs because $\Delta\epsilon_{it}$ contains $\epsilon_{i,t-1}$, which is correlated with $y_{i,t-1}$ that appears in $\Delta y_{i,t-1}$. To resolve this, appropriate instruments are required. The key strategy is to use lagged values of y_{it} and X_{it} as instruments, under the assumption that these lags are uncorrelated with the first-differenced error term $\Delta\epsilon_{it}$ but correlated with the endogenous regressors. This instrumental variable approach ensures consistent estimation of the parameters.

The validity of the instruments is assessed through two key tests. The AR(1) and AR(2) tests examine the presence of autocorrelation in the differenced residuals. While first-order autocorrelation (AR(1)) is expected due to the differencing transformation, second-order autocorrelation (AR(2)) should not be present. Failure to reject the null hypothesis of no AR(2) indicates that the instruments are valid. Additionally, the Sargan test (or Hansen test) checks the validity of the overidentifying restrictions, ensuring that the instruments are not correlated with the residuals. If the test rejects the null hypothesis, it suggests that the instruments may not be valid.

To improve efficiency, the two-step GMM estimator is used, which corrects for heteroskedasticity and serial correlation in the residuals. The first-step estimator assumes homoskedastic errors and provides initial estimates, while the second-step estimator incorporates a robust weighting matrix derived from the first-step residuals, improving efficiency. However, in finite samples, the two-step estimator may lead to downward-biased standard errors, which is why a robust covariance matrix is often employed to obtain more reliable inference.

Dynamic panel threshold model. While the dynamic panel model with interaction term can detect interaction effect in the data, this model has some limitations. The impact of exchange rate volatility and depreciation on growth is likely to depend on whether reserves cross a particular thresholds. For instance, reserves may only provide

effective insurance above some critical level. Moreover, the interaction effect of reserves and exchange rate itself can depend on the threshold level of some third variable like GDP per capita.

The Dynamic Panel Threshold (DTP) model of Kremer et al. (2013) provides a flexible framework for addressing this issue. It allows the data to determine whether the growth effects of exchange rate movements differ across regimes defined by an endogenous threshold variable, while preserving the dynamic structure of the growth process. Unlike linear models, which impose constant marginal effects, the threshold model captures *regime-dependent dynamics*, thereby identifying whether the marginal effect of volatility, depreciation, or reserves differs below and above certain critical values.

Dynamic panel threshold model due Kremer et al. (2013)[1] builds on the threshold regression framework of Caner and Hansen (2004) and incorporates a dynamic component, making it suitable for analysing macroeconomic relationships where persistence and non-linearities are important. The general form of the model is:

$$y_{it} = \alpha y_{i,t-1} + \beta_1 X_{it} I(Q_{it} \leq \gamma) + \beta_2 X_{it} I(Q_{it} > \gamma) + Z_{it}\delta + \mu_i + \epsilon_{it}, \tag{3}$$

where y_{it} is the dependent variable, $y_{i,t-1}$ is its lag, X_{it} represents the main explanatory variable, and Q_{it} is the threshold variable that determines the regime. The indicator functions $I(Q_{it} \leq \gamma)$ and $I(Q_{it} > \gamma)$ separate the observations into different regimes, with potentially different effects captured by β_1 and β_2. Control variables Z_{it} are included, along with individual fixed effects μ_i and an error term ϵ_{it}.

The estimation follows a two-step procedure:

- First, the threshold parameter γ is estimated using the grid search method proposed

[1]Dynamic panel threshold model due Seo and Shin (2016) is not applicable to this research because the data we use is unbalanced panel. Seo and Shin (2016) requires a balanced panel.

by Caner and Hansen (2004). This involves minimizing the residual sum of squares over a range of possible threshold values.

- Once γ is identified, the dynamic panel model is estimated using the GMM approach of Arellano and Bond (1991) to handle endogeneity due to the presence of the lagged dependent variable.

The usual machinery of Arellano and Bond (1991), like AR(1), AR(2), and Sargan tests is applicable in the second stage. Given that macroeconomic time series may be determined simultaneously which may lead to endogeneity, we further instrument the contemporaneous values of the independent variables, with their deep lags.

4 Results

4.1 Dynamic Panel model results

4.1.1 Some housekeeping

All the variables are in log difference terms which essentially makes all the variables expressed in growth terms. To make the wordings concise log difference of the exchange rate sometimes is referred as exchange rate level to contrast it with exchange rate volatility. We first discuss the results of the dynamic panel model with interaction term. We add both the interaction between exchange rate and the exchange rate volatility. To save space, and make the description more readable we will use the following abbreviations:

Abbreviation	**description**
dlgdp	log-difference of real GDP **(dependent variable)**
dlcpi	log-difference of CPI index
dlav	log-difference of nominal exchange rate (in direct quote)
dlres	log-difference of the reserves.
dlsd	log difference of exchange rate volatility.
dlopen	log-difference of trade openness variable.
dlav_dlres	interaction between dlav and dlres.
dlsd_dlres	interaction between dlsd and dlres.
AR1	Arellano-Bond test for the first order auto-regression
AR2	Arellano-Bond test for second order auto-regression
VIF	The (uncentered) variance inflation factor
L1, L2, LN	first, second, and the N^{th} lag respectively
sarganp	Sargan test p-value
hansenp	Hansen test p-value

The dependent variable is always dlgdp. The third lag of the dependent variable is mostly insignificant. However, in some models, the exclusion of the second and third lags largely deteriorates the model's performance - mostly making AR1 and AR2 in unplausible range. Therefore, we keep up to three lags of the dependent variable if the exclusion of the lags seriously deteriorates the model performance.

In the same way, the second and further lags of the independent variables are not significant, and the presence of long lags does not contribute to the model's performance. Therefore, we present the results based on models with contemporaneous values and one lag.

We present and compare the results for different country groups, as well as contrast

the group-specific results with those obtained from the pooled model. The country groups composition is as follows:

Emerging economies: Brazil, Chile, Czech Republic, Hungary, Mexico, Poland, South Africa, Peru, Thailand, Türkiye, India , Indonesia, Philippines, Russia, Nigeria. These countries typically have higher exchange rate volatility, greater sensitivity to external shocks, and often accumulate reserves as a buffer.
Advanced economies: UK, Germany, Japan, Canada, Australia, Zealand, Norway, Korea, Israel, U.S. , Iceland, Sweden, Denmark[2]. These countries usually have more stable currencies, deeper financial markets, and usually not keen on accumulating foreign reserves.
EU: Austria, Belgium, Croatia, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Malta, Netherlands, Portugal, Spain.
Other: Albania, Armenia , Bosnia Herzegovina, Colombia, Estonia, Georgia, Mongolia , Macedonia Paraguay , Qatar, Romania, Rwanda, Saudi Arabia, Serbia, Singapore, Ukraine , Uruguay Croatia, Uganda, Ecuador, Costa Rica. Many of these countries could be classified as low or middle income, transitional, or developing economies. This is a "catch-all" group.
Main: This group combines the advanced economies and emerging economies. This group may help us to uncover major relationships in global level.

We believe that above classification allows us to identify the heterogeneous impact of development levels, structure and the development level of the economy and financial system, fiscal and monetary policies. Furthermore, the possible findings of this research may lead to different policy implications for different countries.

In this paper when we mention the quarterly model, we refer to Guliyev (2025).

[2]In his group the only economy that uses Euro is Germany. We exclude all other advanced Euro area economies from this group and include them in EU group.

To save space, we present the most important and robust findings in the main body of the paper, leaving the details to the appendix.

4.1.2 Results

We start with the pooled country group. Table (1) presents the regression results. None of the interaction terms are significant — neither individually nor jointly - when we pool all the countries together. Pooling heterogenous countries and the inclusion of both contemporaneous values and lags of the interaction term may make it difficult to detect an effect, especially if the true effect is weak. On the other hand, as shown in columns 2 and 6, including the dlcpi variable introduces strong multicollinearity. This suggests that a more selective approach is needed when choosing countries, variables and lags. In the following paragraphs, we will apply such an approach. Before that, however, we present the (robust) findings regarding the other variables.

First, while the contemporaneous value of *dlav* (exchange rate depreciation) enters with a negative sign, its lagged value is positive across all the specifications. This pattern is consistent with the *J-curve hypothesis*, which suggests that currency depreciation initially worsens growth performance but improves it in the longer term as competitiveness effects dominate Edwards (1989). Interestingly, this result contrasts with Guliyev (2025), who finds no evidence of a J-curve when using quarterly data. The discrepancy is plausible: the J-curve is fundamentally a medium - to long-run phenomenon, and annual data are better suited to capturing such delayed adjustments, whereas high-frequency quarterly data may be too short - horizon to reveal the dynamic adjustment path.

Second, the results for *dlopns* (trade openness) reveal an asymmetric effect. The contemporaneous coefficient is positive, suggesting that greater openness provides immediate growth benefits, likely through enhanced access to foreign markets and capital in-

flows. However, the lagged coefficient is negative, implying that over time, openness may expose economies to external vulnerabilities such as trade shocks, balance-of-payments pressures, or dependency effects. Although this finding is in line with some literature Rodrik (1999), this contrasts with Guliyev (2025), who did not find a negative lagged effect of openness in quarterly data, again pointing to the value of lower-frequency data in revealing longer-horizon adjustment costs.

Thus, intuitively, one may use low-frequency data when the interest lies in long-term effects, and high-frequency data when focusing on short-term dynamics.

Next, we turn to the analysis by country groups. Unfortunately, the baseline specifications used in the pooled sample regressions cannot be directly applied to the group-level estimations, primarily due to severe multicollinearity[3]. To address this issue, we adopt a *selective specification strategy*, identifying the 'best' feasible model for each country group. In doing so, we rely on standard diagnostic tests – such as the AR(1) and AR(2) tests for autocorrelation, the Sargan test for over-identifying restrictions, and the Variance Inflation Factor (VIF) for multicollinearity - to guide model selection. Furthermore, we exclude variables that are consistently insignificant, provided that their exclusion does not materially worsen the diagnostic outcomes. We apply this approach to pooled country group as well. This approach ensures a balance between parsimony and econometric validity. Table (2) provides the results [4].

An important finding is that *dlav_dlres* is not significant in any of the country groups. This contrasts with the results of Guliyev (2025), which report a positive and significant coefficient for this variable in both Emerging and Advanced Economies. The difference is not surprising if we recall that reserves primarily serve as short-term insurance Jeanne and Rancière (2006), particularly during depreciation episodes, by smoothing

[3]Refer to Table (4) in the Appendix for the results of the baseline specification.

[4]Table (5) in the appendix provides selected model results along with the baseline model results for each country group.

consumption and alleviating balance-sheet stress. In the longer run, however, the economy adjusts to depreciation through trade dynamics (the J-curve), and the short-term interaction between reserves and depreciation is no longer visible in the annual data. The J-curve pattern observed in the regressions – negative contemporaneous values followed by positive lagged values – supports this interpretation. This suggests that the interaction between reserves and exchange rate depreciation is largely a short-term phenomenon, consistent with the existing literature Jeanne and Rancière (2006); Calvo and Reinhart (2002); Blanchard et al. (2015).

Regarding *dlsd_dlres*, the coefficient is insignificant in Advanced Economies, while its lag is negative and significant in Emerging Economies. This result contrasts with the quarterly model, which finds a positive and significant coefficient for Advanced Economies and a positive, marginally significant effect for Emerging Economies. This finding suggest that exchange rate volatility accompanied by reserve accumulation has *negative long-run consequences*. In Emerging Markets this is revealed directly through the negative lagged coefficient, while in Advanced Economies the long-run negative effect cancels out the short-run stabilizing role of reserves.

The negative lagged coefficient of *dlsd_dlres* in Emerging Markets implies that, to prevent the long-term adverse effects of volatility, reserves must be actively used to reduce exchange rate fluctuations. Simply accumulating reserves during periods of high volatility - without deploying them for stabilization - leads to significant growth declines in the long run. Interestingly, no similar pattern is found for *dlav_dlres*, suggesting that reserves are more effective for stabilizing exchange rate *volatility* rather than resisting depreciation in Emerging Markets. From a long-term growth perspective, this implies that Emerging Markets must (and in practice often do) employ reserves to smooth volatility. Merely stockpiling reserves in volatile periods can instead generate substantial negative consequences for future growth.

In both Emerging and Advanced Economies the short-run effect of dlsd_dlres, as indicated in the quarterly model, is positive. However, this effect largely disappears in the annual data, though it remains visible in the pooled regressions - particularly in the Main group. Thus, although $dlsd_dlres$ has a positive impact in a short run, it can become negative over longer horizons, especially in Emerging Markets, as captured by the negative and highly significant coefficient of lagged $dlsd_dlres$ ($L.dlsd_dlres$).

Exchange rate volatility itself ($dlsd$) carries a significantly negative coefficient in Advanced Economies, while remaining insignificant in Emerging Economies. This is consistent with the quarterly results of Guliyev (2025), which show that volatility is more damaging in Advanced Economies. The explanation lies in the greater depth of financial markets and the stronger transmission of monetary policy in Advanced Economies, which cause volatility to have more negative real effects. At the same time, the interaction $dlsd_dlres$ is insignificant in the annual data for Advanced Economies, indicating that reserves are not an effective long-term tool for mitigating the costs of volatility in these countries. The short-run positive effect is therefore washed out once the longer adjustment horizon is considered.

Finally, in the absence of dlav_dlres the interaction term $dlsd_dlres$ is positive and significant in the pooled sample. While the coefficient is not significant when estimated separately for Emerging Markets or Advanced Economies, it becomes statistically significant once the countries are pooled together. This suggests that the short-run positive effect of $dlsd_dlres$ may not be strong enough to appear consistently within individual groups but emerges more clearly at the aggregate level.

Interestingly, $dlres$ is not significant by itself in any of the country groups. This indicates that, in the long run (annual data), reserves do not exert a direct effect on growth but rather influence growth indirectly through their interaction with the exchange rate. dlopns shows a positive and significant contemporaneous coefficient, but a negative

and significant lagged effect across most country groups, with the exception of Advanced Economies where the lagged openness variable is not significant. This suggests that while trade openness provides short-term benefits for growth, it may carry adverse long-term effects. The absence of a significant negative lag in Advanced Economies can be explained by their higher competitiveness and more effective monetary and fiscal institutions, which mitigate the potential long-run costs of openness.

In addition we also find that at least one lag of dlgdp is always significant, which justifies the use of the dynamic panel model. Global Financial Dummy has mainly negative and significant coefficient except for the Emerging Economies which is in line with the existing literature. The only group where inflation is significant is EU and it also shows up in the Pooled group.

A comparison with the results of Guliyev (2025) highlights that the inference depends critically on the frequency of the data. Annual data are better suited to capturing long-term dynamics, whereas quarterly data are necessary to identify short-term effects. Moreover, model specifications and diagnostics also vary with data frequency and country grouping: in the quarterly analysis contemporaneous values were excluded to improve model performance, whereas in the annual analysis their exclusion leads to deterioration in the model fit.

The robust results are:

1. *dlav_dlres* is never significant in annual data, contrary to quarterly data. Indicating that the reserves are effective as a short run tool to mitigate the effects of exchange rate depreciation.

2. There is a significant interaction effect between exchange rate volatility and reserve changes, though with different signs across country groups. While reserve accu-

mulation reduces the negative effect of exchange rate volatility on growth in the short run (acting as insurance), it is the use of reserves to back the currency that mitigates the negative long-run effects of exchange rate volatility.

3. The contemporaneous *dlav* is negative, while its lag is positive, which corresponds to the J-curve hypothesis. (This finding is present in annual data but absent in quarterly data.)

4. The impact of exchange rate volatility on growth is never positive: it is not significant for Emerging Economies, while it is negative and significant for Advanced Economies. This finding is consistent across frequencies.

5. The contemporaneous level of *dlopen* is positive, while its lag is negative: openness is beneficial in the short term but detrimental in the long term. (This finding is present in annual data but absent in quarterly data.)

6. Inferences obtained from quarterly and annual data may differ significantly: while low-frequency data capture long-run trends, they miss important relationships evident in high-frequency data. High-frequency data are more informative from a policy perspective, particularly for monetary authorities, whereas low-frequency data better reflect long-run relationships in macroeconomic models.

7. At least one lag of the dependent variable is significant in all groups, which justifies the use of a dynamic model.

Table 1: AB model. Pooled country group results

	Pooled group					
	1	2	3	4	5	6
L.dlgdp	0.538**	0.525**	0.528**	0.539**	0.529**	0.501**
	(7.88)	(8.07)	(7.42)	(7.82)	(7.40)	(7.35)
L2.dlgdp	-0.00531	0.00949	-0.00932	-0.00475	-0.00841	-0.00031
	(0.10)	(0.19)	(0.18)	(0.09)	(0.16)	(0.01)
L3.dlgdp	-0.0003	0.0000	-0.0002	-0.0003	-0.0002	0.0001
	(0.20)	(0.02)	(0.16)	(0.17)	(0.14)	(0.06)
GFC_dummy	-0.0114*	-0.0145*	-0.0111*	-0.0116*	-0.0113*	-0.0150*
	(2.31)	(2.06)	(2.28)	(2.36)	(2.31)	(2.33)
dlsd	-0.0005	-0.0022	-0.0012	-0.0005	-0.0013	-0.00319*
	(0.27)	(1.38)	(0.62)	(0.27)	(0.65)	(2.06)
L.dlsd	-0.00180	-0.00331#	-0.00236	-0.00178	-0.00239	-0.00439**
	(0.98)	(1.89)	(1.34)	(1.00)	(1.42)	(2.89)
dlav	-0.0550**	-0.0596**	-0.0512**	-0.0552**	-0.0515**	-0.0546**
	(3.79)	(4.68)	(4.14)	(3.88)	(4.11)	(4.71)
L.dlav	0.0647**	0.0630**	0.0645**	0.0648**	0.0646**	0.0614**
	(3.52)	(3.08)	(3.48)	(3.42)	(3.39)	(3.09)
dlres	0.0122	0.0141#	0.0124	0.0121	0.0124	0.0138*
	(1.52)	(1.79)	(1.63)	(1.50)	(1.62)	(1.96)
L.dlres	0.000318	0.00149	0.000519	0.000413	0.000675	0.00132
	(0.07)	(0.33)	(0.13)	(0.09)	(0.16)	(0.34)
dlopns	0.131**	0.112**	0.132**	0.130**	0.133**	0.111**
	(7.66)	(5.63)	(7.78)	(7.43)	(7.57)	(5.52)
L.dlopns	-0.0668**	-0.0650**	-0.0656**	-0.0670**	-0.0655**	-0.0638**
	(3.68)	(3.86)	(3.67)	(3.68)	(3.67)	(3.90)
dlcpi		0.132				0.177
		(0.90)				(1.58)
L.dlcpi		-0.190				-0.196#
		(1.52)				(1.76)
dlsd_dlres			0.00896		0.00893	0.0129
			(0.98)		(0.99)	(1.19)
L.dlsd_dlres			0.00772		0.00801	0.0152
			(0.70)		(0.73)	(1.14)
dlav_dlres				0.00803	-0.00503	0.0310
				(0.13)	(0.09)	(0.53)
L.dlav_dlres				-0.00676	-0.0119	0.0233
				(0.11)	(0.20)	(0.40)
Num. obs.	972	962	972	972	972	962
N_g	61	61	61	61	61	61
ar1	-4.756	-4.764	-4.757	-4.750	-4.753	-4.836
ar2	-1.700	-1.493	-1.856	-1.736	-1.881	-1.862
sarganp	0.633	0.569	0.660	0.629	0.652	0.647
hansenp	0.569	0.453	0.607	0.563	0.596	0.549
max_vif	2.790	5.995	2.801	2.793	2.806	6.543

We also introduced additional variables to account for the impact of monetary and fiscal policy. The main findings did not change.

Next we will present the results obtained from dynamic panel threshold model.

Table 2: AB, Selected specifications

	Pooled	Emerging	Advanced	EU	Main	Other
L.dlgdp	0.435**	0.316*	0.361#	0.603**	0.250*	0.263*
	-4.83	-2.1	-1.75	-6.84	-2.27	-2.09
L2.dlgdp	-0.000155	-0.00459	0.0503	-0.168**	-0.00264	0.00201
	-0.13	-1.07	-0.56	-3.5	-1.2	-0.72
L3.dlgdp			0.00355	0.00		
			-1.23	-0.02		
dlsd	-0.0052**		-0.00492	0.00434	-0.0032	0.00112
	-2.79		-1.48	-1.6	-1.36	-0.7
L.dlsd	-0.0055**	-0.00125	-0.00785**	0.00269#	-0.00375	
	-3.97	-0.63	-3.21	-1.81	-1.6	
dlav	-0.0713**	-0.0938**		-0.0315*	-0.0681**	-0.156**
	-5.36	-3.16		-2.28	-3.24	-3.99
L.dlav	0.0651**	0.0485**		0.0665**	0.0412*	
	-4.13	-3.2		-5.45	-2.53	
dlres	0.0147#		0.0261	-0.0016	0.0104	0.0105
	-1.94		-1.18	-0.39	-0.81	-1.12
L.dlres	0.00235	-0.0161		-0.00805#	0.0104	
	-0.52	-0.45		-1.81	-0.89	
dlopns	0.0932**	0.0667#	0.109**	0.0962**	0.0777**	0.132**
	-4.06	-1.81	-3.59	-4.25	-3.61	-2.88
L.dlopns	-0.0569**	-0.0543*	-0.0638	-0.141**	-0.0576**	
	-3.67	-2.44	-1.56	-4.69	-2.84	
dlsd_dlres	0.0189*		-0.00172		0.0328**	0.00764
	-2.33		-0.1		-3.39	-1.04
L.dlsd_dlres	0.0136	-0.0283**			-0.00042	
	-1.51	-2.75			-0.03	
L.dlcpi	-0.171*			-0.535**		0.114
	-2.16			-4.26		-0.63
GFC_dummy	-0.00645		-0.0109#	-0.0155**	-0.00910*	
	-1.34		-1.82	-2.61	-2.15	
N. Obs.	1019	247	252	318	512	240
N_g	62	15	13	16	28	21
ar1	-4.492	-2.901	-1.948	-2.015	-3.947	-2.141
ar2	-1.378	0.388	-1.445	0.275	-0.588	-1.226
sarganp	0.138	0.339	0.763	0.673	0.658	0.779
hansenp	0.655	0.238	0.65	0.669	0.723	0.84
Max_VIF	2.43	2.92	2.47	3.14	2.62	2.15

4.2 Threshold model

4.2.1 Some housekeeping

We present the results of the dynamic panel threshold model and compare them with those obtained from a dynamic panel model incorporating interaction terms. The dynamic panel threshold model is primarily suited for large-N panels. Subdividing the sample country groups significantly reduces the number of cross-sectional units, and therefore we run the threshold model for the pooled sample only. However, we experiment with several threshold variables like dlres, dlav, and GDP per capita.

We keep only one lag of the dependent variable, because further lags of the dependent variable deteriorates the AR1 and AR2 statistics. In the baseline specification, the threshold variable is dlres, while the variables depending on the threshold are either dlav or dlsd - see the Table (3). The primary objective is to examine whether the impact of exchange rate variables on economic growth depends on the change in foreign reserves (reserve management). In addition to this baseline, we also estimate alternative models using different threshold variables and where the variables depending on the threshold are the interaction between reserves and the exchange rate variables. Table (6) in appendix provides the results for these alternative models.

Our objective is to apply a consistent specification across all estimations: one lag of all explanatory variables, two-step robust estimation, and the use of lagged levels as instruments. In the estimated model, only one slope can depend on the threshold variable. Therefore, we use dlav and dlsd as the variables depending on the threshold, separately.

4.2.2 Results

We find a strong threshold effect on dlav. Specifically, dlav has a statistically significant negative impact on dlgdp above threshold variable (dlres), while its effect is insignificant below the threshold. This suggests that exchange rate depreciation negatively affects growth when it occurs in conjunction with high levels of reserve accumulation. This finding contrasts with the results from the annual interaction model, where the interaction term dlav_dlres was not statistically significant in the pooled sample (in fact in none of the country groups). At first glance this findings seems to be at odd with the findings of the dynamic panel model with the interaction term. However, recall that dlav was negative and significant in Emerging Markets and insignificant in Advanced Economies in this model, and in addition it is the emerging markets with the largest accumulation of reserves. Thus the significant negative coefficient of the above threshold variable may capture the severe negative consequences of the depreciation in the Emerging Markets. We must also note that the lag of dlav is positive (albeit not significant) which is in line with the findings of the interaction term model. In high-reserve accumulating regimes, depreciation may be interpreted as a signal of eroding policy credibility or underlying macroeconomic fragility. We discussed the negative impact of depreciation in EM in the previous sections, so we omit this discussion here.

One notable observation is that dlsd (exchange rate volatility) exhibits the same sign both below and above the threshold, although the coefficients are statistically insignificant. This suggests the absence of a threshold effect in the pooled sample. This contrasts with the results from the dynamic panel model, where the interaction between dlres (foreign reserves) and dlsd was positive, indicating that the interaction model may capture the underlying nonlinearity more effectively in this context.

However, when we allow for a threshold effect with one lag, we identify a significant

nonlinear relationship. Specifically, the coefficient of dlsd (exchange rate volatility) is negative and statistically significant below the threshold, but positive and insignificant above it. This suggests that lagged exchange rate volatility hinders economic growth in regimes characterized by low reserve accumulation, whereas its impact becomes muted in high-reserve environments. These findings are consistent with the results from the annual interaction model, which also indicated that the adverse effects of exchange rate volatility are more pronounced when foreign reserves are limited.

Another notable result is that dlopns (trade openness) has a positive contemporaneous effect, while its first lag carries a negative coefficient. This pattern suggests that openness contributes positively to economic growth in the short term but may have adverse effects over the longer term. This result aligns with the findings from the interaction model. In contrast, the quarterly model does not exhibit a negative coefficient for any lag of dlopns, further reinforcing the notion that models based on quarterly data may be less effective in capturing long-term dynamics compared to those using annual data. dlres is mostly not statistically significant in the threshold model, which also agrees with the interaction model results. The lag of the dependent variable is positive and significant, which justifies the use of the dynamic model.

We then explore whether the effect of the interaction between dlres (foreign reserves) and the exchange rate variables on dlgdp (economic growth) varies across different threshold variables. Specifically, we consider thresholds based on GDP per capita, the level of reserves, the exchange rate, and exchange rate volatility. For completeness, we estimate models using both the levels (e.g., lres) and the log differences (e.g., dlres) of these variables as thresholds. Interestingly, across all specifications, we do not find any robust evidence of a threshold effect. This suggests that the interaction between reserves and exchange rate variables does not exhibit consistent non-linear behaviour with respect to these macroeconomic thresholds.

Table 3: Threshold model results

threshold var.	**dlres**	**dlres**	**L.dlres**	**L.dlres**	**L.dlres**	**L.dlres**
depends on thresh.	**dlsd**	**dlav**	**L.dlsd**	**L.dlav**	**dlsd**	**dlav**
L.dlgdp	0.704**	0.510**	0.582**	0.624**	0.540**	0.604**
	(3.49)	(2.79)	(3.60)	(4.08)	(3.00)	(3.10)
Below the Thresh.	0.0163	0.0270	-0.0145*	0.0702	-0.00635	0.0383
	(1.19)	(0.38)	(2.57)	(0.96)	(0.58)	(0.36)
Above the Thresh.	-0.00703	-0.376*	0.000182	0.153	0.00670	-0.235#
	(1.01)	(2.45)	(0.00)	(1.10)	(0.59)	(1.86)
L.dlreserve	0.0350	0.0318	0.0128	0.0170	0.0137	0.00800
	(0.75)	(0.89)	(0.32)	(0.43)	(0.38)	(0.19)
L.dlav	0.0789	0.124	0.0527		0.0327	0.0868
	(1.06)	(1.57)	(0.57)		(0.45)	(0.94)
L.dlopennes	-0.0407	-0.0214	-0.0235	-0.0378	-0.0267	-0.0292
	(0.80)	(0.50)	(0.48)	(0.80)	(0.52)	(0.57)
L.dlsd	-0.0149**	-0.0126*		-0.0135*	-0.0147*	-0.0129#
	(2.59)	(2.30)		(2.28)	(2.36)	(1.91)
dlsd		-0.00287	-0.000136	-0.000721		-0.00119
		(0.62)	(0.03)	(0.16)		(0.24)
GFC_08_dum.	-0.0329**	-0.0254**	-0.0308**	-0.0274**	-0.0329**	-0.0310**
	(2.91)	(2.90)	(3.49)	(3.20)	(3.51)	(3.09)
dlreserve	0.0195	0.00960	0.00819	0.00544	-0.00227	-0.00468
	(0.70)	(0.44)	(0.34)	(0.25)	(0.08)	(0.16)
dlav	-0.0373		-0.0586	-0.0606	-0.0842	
	(0.63)		(0.57)	(1.13)	(1.56)	
dlopennes	0.278**	0.255**	0.278**	0.257**	0.231**	0.247**
	(4.33)	(4.27)	(2.95)	(4.95)	(3.65)	(3.43)
N. Obs.	1026	1026	1026	1026	1026	1026
N_g	60	60	60	60	60	60
arm1	-3.311	-3.822	-3.942	-3.983	-3.956	-3.838
arm2	0.0631	-0.0402	-0.637	-0.495	-0.379	0.238
SarganP	0.155	0.3	0.146	0.132	0.1031	0.079

5 Possible improvement

Given the macroeconomic nature of the research and data, more time-series related models like Panel VAR may lead better inference.

Given the large number of possible explanatory variables, relatively high frequency of the data, and possible non-linearities classical econometric models may not be able to detect the 'correct' model specification. ML methods that allow to detect the non-linearities and feature importance can be used to detect the 'best' specifications which can be re-estimated with classical econometrics models. Thus application of ML models may help to estimate the non-linearities more efficiently.

6 Conclusion and Policy Implication

7 Conclusion and Policy Implications

This paper examined whether foreign exchange reserves help mitigate the adverse effects of exchange rate movements on economic growth. Using a panel of 60 advanced and developing economies over the period 1997–2019, we estimated dynamic panel models and dynamic panel threshold models to capture both interaction effects and potential nonlinearities in the relationship between exchange rates, reserves, and economic growth. The results highlight several important patterns.

First, exchange rate volatility is generally associated with lower economic growth, although the magnitude and statistical significance differ across country groups. The negative impact of volatility is particularly evident in advanced economies, suggesting that

fluctuations in exchange rates can disrupt economic activity even in financially developed environments. Second, exchange rate depreciation exhibits a pattern consistent with the J-curve hypothesis: depreciation is associated with lower growth in the short run but positive effects in subsequent periods as external competitiveness improves. Third, foreign exchange reserves do not appear to have a direct effect on economic growth. Instead, their influence operates primarily through interactions with exchange rate dynamics.

The results further indicate that the stabilizing role of reserves depends on the time horizon and macroeconomic environment. In the annual data, the interaction between reserves and exchange rate depreciation is not statistically significant, suggesting that reserves primarily operate as a short-term stabilization tool rather than as a long-run growth determinant. In contrast, the interaction between reserves and exchange rate volatility reveals more complex dynamics. In emerging economies, the lagged interaction term is negative and significant, implying that reserve accumulation during periods of high volatility – without actively using those reserves to stabilize the currency – ßmay lead to adverse long-run growth outcomes. This finding suggests that reserves must be actively deployed to smooth exchange rate fluctuations rather than merely accumulated as precautionary buffers.

These results lead to several policy implications, particularly for monetary authorities in open economies. First, the findings highlight the importance of exchange rate stability for economic growth. Since exchange rate volatility is associated with lower growth, central banks should consider policies that reduce excessive exchange rate fluctuations. Foreign exchange reserves can play an important role in this regard, but the results suggest that their effectiveness depends on how they are used. Merely accumulating reserves does not appear to promote growth directly. Instead, reserves should be viewed as a policy instrument that can be deployed to stabilize exchange rate dynamics when external shocks occur.

Second, the evidence suggests that reserve management strategies should focus on *active stabilization rather than passive accumulation.* In emerging economies, where exchange rate volatility tends to be higher, reserves can provide an important buffer against external shocks. However, the results indicate that failing to use reserves during periods of volatility may lead to negative long-term growth effects. This implies that central banks should adopt reserve management frameworks that allow for timely foreign exchange interventions when exchange rate movements threaten macroeconomic stability.

Third, the findings also suggest that monetary authorities should carefully distinguish between *exchange rate volatility and exchange rate depreciation* when designing policy responses. While reserves may help mitigate short-run shocks associated with depreciation, the results indicate that the long-run adjustment process-captured by the J-curve mechanism – reduces the need for persistent intervention. In contrast, persistent volatility can have lasting negative consequences for growth, implying that stabilizing volatility may be a more effective use of reserves than attempting to prevent depreciation episodes.

Finally, the results underscore the importance of considering the time horizon of policy interventions. High-frequency data capture short-run stabilization effects, whereas lower-frequency data reveal longer-run structural relationships. For policymakers, this implies that short-run monetary interventions aimed at stabilizing exchange rate markets may have limited long-term growth effects unless they contribute to broader macroeconomic stability. Consequently, reserve policy should be integrated with broader monetary and macroeconomic frameworks that aim to maintain financial stability and support sustainable economic growth.

References

Aizenman, J. and Lee, J. (2007). International reserves: precautionary versus mercantilist views, theory and evidence. *Open Economies Review*, 18:191–214.

Allegret, J.-P. and Allegret, A. (2018). The role of international reserves holding in buffering external shocks. *Applied Economics*, 50(29):3128–3147.

Arellano, M. and Bond, S. (1991). Some tests of specification for panel data: Monte carlo evidence and an application to employment equations. *The review of economic studies*, 58(2):277–297.

Blanchard, O., Adler, G., and de Carvalho Filho, I. (2015). Can foreign exchange intervention stem exchange rate pressures from global capital flow shocks? *IMF Working Paper*, (WP/15/159).

Bussière, M., Cheng, G., Chinn, M. D., and Lisack, N. (2015). For a few dollars more: Reserves and growth in times of crises. *Journal of International Money and Finance*, 52:127–145.

Calvo, G. A. and Reinhart, C. M. (2002). Fear of floating. *The Quarterly journal of economics*, 117(2):379–408.

Edwards, S. (1989). Real exchange rates, devaluation, and adjustment: Exchange rate policy in developing countries. *Economic Development and Cultural Change*, 37(3):511–538.

Foroni, C., Gelain, P., and Marcellino, M. G. (2022). The financial accelerator mechanism: does frequency matter?

Foroni, C. and Marcellino, M. (2014). Mixed-frequency structural models: Identification, estimation, and policy analysis. *Journal of Applied Econometrics*, 29(7):1118–1144.

Guliyev, N. (2025). Do foreign reserves buffer the negative impact of exchange rate volatility? evidence from dynamic panel analysis. PhD dissertation chapter, The Graduate Center, City University of New York.

Jeanne, O. and Rancière, R. (2006). The optimal level of international reserves for emerging market countries: Formulas and applications. *IMF Staff Papers*, 53(2):295–318.

Kremer, S., Bick, A., and Nautz, D. (2013). Inflation and growth: new evidence from a dynamic panel threshold analysis. *Empirical Economics*, 44:861–878.

Missio, F. J., Jayme Jr, F. G., Britto, G., and Luis Oreiro, J. (2015). Real exchange rate and economic growth: new empirical evidence. *Metroeconomica*, 66(4):686–714.

Ramoni-Perazzi, J. and Romero, H. (2022). Exchange rate volatility, corruption, and economic growth. *Heliyon*, 8(12).

Rapetti, M. (2020). The real exchange rate and economic growth: A survey. *Journal of Globalization and Development*, 11(2):20190024.

Rodrik, D. (1999). *The New Global Economy and Developing Countries: Making Openness Work*. Overseas Development Council, Washington, DC.

Sallenave, A., Allegret, J.-P., and Omay, T. (2024). Can governments sleep more soundly when holding international reserves? a banking and financial vulnerabilities perspective. *Applied Economics*, 56(15):1748–1762.

Seo, M. H. and Shin, Y. (2016). Dynamic panels with threshold effect and endogeneity. *Journal of econometrics*, 195(2):169–186.

Shaar, K. and Khaled, M. (2018). Why you should use high-frequency data to test the impact of exchange rate on trade. In *Advances in Panel Data Analysis in Applied Economic Research: 2017 International Conference on Applied Economics (ICOAE)*, pages 283–288. Springer.

Sula, O. and Oguzoglu, U. (2021). International reserves and economic growth. *International Review of Economics & Finance*, 72:16–28.

Vieira, F. V. and MacDonald, R. (2012). A panel data investigation of real exchange rate misalignment and growth. *Estudos Econômicos (São Paulo)*, 42:433–456.

Appendix A. Results tables

Interaction model results

Table 4: AB model results

	Emerging Economies						Advanced Economies						EU					
L.dlgdp	0.415**	0.382**	0.448**	0.417**	0.452**	0.256	0.415*	0.222	0.0171	0	0.0171	0.0171	0.667**	0.486**	0.651**	0.665**	0.659**	0.799*
	(3.38)	(3.08)	(3.66)	(3.63)	(3.86)	(0.49)	(2.50)	(0.39)	(0.03)	(.)	(0.03)	(0.03)	(5.49)	(5.17)	(5.10)	(5.46)	(4.54)	(2.18)
L2.dlgdp	0.168**	0.176**	0.197**	0.155**	0.173*	0.200**	0.101	0.0890	0	0.0528	0	0	-0.217**	-0.0786#	-0.216**	-0.217**	-0.228*	0
	(3.13)	(3.40)	(3.52)	(3.22)	(1.99)	(2.82)	(1.52)	(1.28)	(.)	(0.05)	(.)	(.)	(3.32)	(1.77)	(3.14)	(3.32)	(2.32)	(.)
L3.dlgdp	-0.0039	-0.0038	-0.0038	-0.0043	-0.0037	-0.0039	0.0043	0.0036	0.0030	0.0026	0.0030	0.0030	-0.0010	-0.0001	-0.0010	-0.0010	-0.0007	-0.0006
	(1.51)	(1.32)	(1.53)	(1.51)	(1.46)	(1.55)	(1.54)	(1.09)	(1.30)	(1.16)	(1.32)	(1.22)	(0.49)	(0.04)	(0.54)	(0.54)	(0.27)	(0.30)
GFC_dummy	-0.012#	-0.019#	-0.0111	-0.014#	-0.0131	-0.00779	-0.0132**	-0.0134**	-0.0114*	-0.0128	-0.0114*	-0.0114*	-0.0181*	-0.0204*	-0.0178*	-0.0174*	-0.0133	-0.0258
	(1.68)	(1.92)	(1.42)	(1.93)	(1.36)	(0.75)	(2.58)	(2.75)	(2.19)	(0.70)	(2.09)	(2.14)	(2.35)	(2.47)	(2.22)	(2.39)	(0.59)	(1.53)
dlsd	0.0017	0.0013	0.0037*	0.0013	0.0025	0.00541*	-0.005#	-0.0044	-0.0009	0.0005	-0.0009	-0.0009	0.0048	0.0038	0.0045	0.0046	0.0021	0.0018
	(0.83)	(0.66)	(2.05)	(0.65)	(0.64)	(1.99)	(1.83)	(1.11)	(0.15)	(0.11)	(0.15)	(0.15)	(1.40)	(1.58)	(1.12)	(1.32)	(0.16)	(0.68)
L.dlsd	-0.0030	-0.0036	0.0007	-0.0034	-0.0010	0.0007	-0.0073**	-0.0059	-0.0039	-0.0037	-0.0039	-0.0039	0.00347*	0.0022	0.0018	0.00332*	0.0005	0.0011
	(1.28)	(1.53)	(0.34)	(1.48)	(0.19)	(0.29)	(3.94)	(1.38)	(0.99)	(1.28)	(0.99)	(1.00)	(2.33)	(1.25)	(0.93)	(2.33)	(0.08)	(0.39)
dlav	-0.0654**	-0.0828**	-0.0812**	-0.0715**	-0.0884**	-0.0501	-0.0122	-0.0117	-0.00995	-0.00637	-0.00995	-0.00995	-0.0339#	-0.0250	-0.0284#	-0.0348#	-0.0268	-0.0262*
	(2.94)	(5.10)	(4.42)	(3.60)	(3.19)	(1.15)	(0.63)	(0.72)	(0.44)	(0.22)	(0.44)	(0.46)	(1.93)	(1.58)	(1.83)	(1.90)	(1.26)	(2.07)
L.dlav	0.0576*	0.0408	0.0577*	0.0564*	0.0492	0.0928**	0.0290	0.0300	0.0123	0.0110	0.0123	0.0123	0.0919**	0.0399**	0.0924**	0.0930**	0.0965**	0.0984
	(2.04)	(1.24)	(2.39)	(2.25)	(1.45)	(2.93)	(0.95)	(1.02)	(0.32)	(0.57)	(0.33)	(0.33)	(6.95)	(2.85)	(6.96)	(6.98)	(4.63)	(1.33)
dlres	0.0356	0.0371	0.0288	0.0326#	0.0194	0.0390*	0.0231	0.0195	0.0176	0.0180	0.0176	0.0176	-0.00255	-0.00160	-0.00229	-0.00264	-0.00178	-0.0035
	(1.59)	(1.54)	(1.30)	(1.79)	(0.56)	(2.31)	(1.29)	(1.01)	(1.07)	(0.87)	(1.09)	(1.11)	(0.47)	(0.43)	(0.43)	(0.48)	(0.28)	(0.86)
L.dlres	0.0014	0.0040	0.0148	0.0067	0.0152	0.0300	0.0103	0.0070	0.0091	0.0088	0.0091	0.0091	-0.0070	-0.00996*	-0.0058	-0.0071	-0.0061	-0.0053
	(0.10)	(0.27)	(1.13)	(0.67)	(1.20)	(1.58)	(1.10)	(0.54)	(1.07)	(0.38)	(1.16)	(1.19)	(1.25)	(2.30)	(1.00)	(1.25)	(1.06)	(0.84)
dlopns	0.116*	0.104#	0.101*	0.110*	0.0973*	0.0935*	0.107**	0.0826	0.118*	0.122	0.118*	0.118*	0.134**	0.0394	0.134**	0.133**	0.120	0.210
	(2.40)	(1.92)	(2.42)	(2.56)	(2.40)	(2.29)	(3.51)	(1.11)	(2.43)	(0.87)	(2.43)	(2.41)	(4.17)	(1.38)	(4.11)	(3.94)	(1.45)	(1.19)
L.dlopns	-0.0417*	-0.0486**	-0.0493**	-0.0446*	-0.0503**	-0.0385	-0.0738*	-0.0241	-0.0290	-0.0235	-0.0290	-0.0290	-0.175**	-0.0938**	-0.168**	-0.175**	-0.188	-0.155
	(2.23)	(2.71)	(3.01)	(2.17)	(3.04)	(0.65)	(2.34)	(0.17)	(0.39)	(0.44)	(0.38)	(0.37)	(4.58)	(2.92)	(4.60)	(4.55)	(1.59)	(1.54)
dlcpi		0.212				0		0				0		0.281*				0
		(1.47)				(.)		(.)				(.)		(2.52)				(.)
L.dlcpi		-0.0933				0		-0.670				0		-1.169**				-0.0256
		(1.04)				(.)		(0.35)				(.)		(7.71)				(0.02)
dlsd_dlres			-0.0265*		-0.0229	-0.0164			0.0194		0.0194	0.0194			0.00321		0.0110	0.00996
			(2.31)		(1.51)	(0.85)			(0.44)		(0.44)	(0.43)			(0.44)		(0.25)	(1.05)
L.dlsd_dlres			-0.0460**		-0.0342	-0.0409*			0.00464		0.00464	0.00464			0.0146		0.0216	0.0181
			(3.09)		(0.92)	(2.08)			(0.19)		(0.19)	(0.18)			(1.03)		(0.55)	(1.37)
dlav_dlres				-0.101	0	0				-0.0414	0	0				-0.00339	0.270	0.0392
				(1.23)	(.)	(.)				(0.08)	(.)	(.)				(0.09)	(0.17)	(0.57)
L.dlav_dlres				-0.118#	-0.204	0.0554				-0.0399	0	0				0.0365	0.322	0.0531
				(1.78)	(0.35)	(0.36)				(0.06)	(.)	(.)				(1.07)	(0.20)	(0.69)
Num. obs.	232	232	232	232	232	232	252	252	252	252	252	252	318	318	318	318	318	318
N_g	15	15	15	15	15	15	13	13	13	13	13	13	16	16	16	16	16	16
ar1	-2.852	-2.845	-2.949	-2.907	-2.755	-0.832	-2.228	-1.873	-0.535	-0.675	-0.532	-0.513	-2.055	-1.988	-2.064	-2.061	-2.790	-1.779
ar2	-1.058	-0.646	-1.726	-1.052	-0.985	-0.908	-1.703	-1.620	-0.862	-0.258	-0.856	-0.835	-0.168	0.0817	-0.392	-0.196	-0.314	-1.059
sarganp	0.580	0.535	0.835	0.621	0.840	0.755	0.770	0.793	0.604	0.819	0.691	0.728	0.954	0.323	0.934	0.950	0.928	0.324
hansenp	0.369	0.288	0.727	0.436	1.000	1.000	0.716	1.000	1.000	1.000	1.000	1.000	0.915	0.408	0.872	0.909	1.000	1.000
max_vif	3.413	11.02	3.421	3.427	.	.	2.612	.	.	.	.	.	2.749	5.502	2.762	2.759	2.772	.

Table 5: AB, baseline and selective model results

	Emerging (base)	Emerging	Advanced (base)	Advanced	EU (base)	EU	Other (base)	Other	Main (base)	Main	Pooled (base)	Pooled
L.dlgdp	0.256	0.316*	0.0171	0.361#	0.799*	0.603**	0.354**	0.263*	0.427**	0.250*	0.501**	0.435**
	-0.49	-2.1	-0.03	-1.75	-2.18	-6.84	-3.36	-2.09	-6.02	-2.27	-7.35	-4.83
L2.dlgdp	0.200**	-0.00459	0	0.0503	0	-0.168**	-0.0566	0.00201	0.159**	-0.00264	-0.00031	-0.000155
	-2.82	-1.07	(.)	-0.56	(.)	-3.5	-0.52	-0.72	-3.06	-1.2	-0.01	-0.13
L3.dlgdp	-0.00391		0.00303	0.00355	-0.000552	0.0000331	0.00131		0.000891		0.000097	
	-1.55		-1.22	-1.23	-0.3	-0.02	-0.55		-0.55		-0.06	
dlsd	0.00541*		-0.00088	-0.00492	0.00181	0.00434	0.000109	0.00112	-0.0013	-0.0032	-0.00319*	-0.00529**
	-1.99		-0.15	-1.48	-0.68	-1.6	-0.03	-0.7	-0.64	-1.36	-2.06	-2.79
L.dlsd	0.000701	-0.00125	-0.00386	-0.00785**	0.00109	0.00269#	-0.00129		-0.00315#	-0.00375	-0.0043**	-0.00557**
	-0.29	-0.63	-1	-3.21	-0.39	-1.81	-0.68		-1.92	-1.6	-2.89	-3.97
dlav	-0.0501	-0.0938**	-0.00995		-0.0262*	-0.0315*	-0.0702*	-0.156**	-0.0487**	-0.0681**	-0.0546**	-0.0713**
	-1.15	-3.16	-0.46		-2.07	-2.28	-2.38	-3.99	-3.45	-3.24	-4.71	-5.36
L.dlav	0.0928**	0.0485**	0.0123		0.0984	0.0665**	0.0616		0.0433*	0.0412*	0.0614**	0.0651**
	-2.93	-3.2	-0.33		-1.33	-5.45	-1		-2.06	-2.53	-3.09	-4.13
dlres	0.0390*		0.0176	0.0261	-0.00356	-0.0016	0.0213*	0.0105	0.0303#	0.0104	0.0138*	0.0147#
	-2.31		-1.11	-1.18	-0.86	-0.39	-2.32	-1.12	-1.95	-0.81	-1.96	-1.94
L.dlres	0.03	-0.0161	0.00907		-0.00533	-0.00805#	0.0136#		0.0112	0.0104	0.00132	0.00235
	-1.58	-0.45	-1.19		-0.84	-1.81	-1.86		-1.26	-0.89	-0.34	-0.52
dlopns	0.0935*	0.0667#	0.118*	0.109**	0.21	0.0962**	0.110**	0.132**	0.0900**	0.0777**	0.111**	0.0932**
	-2.29	-1.81	-2.41	-3.59	-1.19	-4.25	-4.12	-2.88	-3.15	-3.61	-5.52	-4.06
L.dlopns	-0.0385	-0.0543*	-0.029	-0.0638	-0.155	-0.141**	-0.0231		-0.0607**	-0.0576**	-0.0638**	-0.0569**
	-0.65	-2.44	-0.37	-1.56	-1.54	-4.69	-0.85		-3.71	-2.84	-3.9	-3.67
dlav_dlres	0		0		0.0392		0.131	0.0833	0.0176		0.031	
	(.)		(.)		-0.57		-1.46	-0.59	-0.2		-0.53	
L.dlav_dlres	0.0554		0		0.0531		0.0565		0.00748		0.0233	
	-0.36		(.)		-0.69		-0.48		-0.08		-0.4	
dlsd_dlres	-0.0164		0.0194	-0.00172	0.00996		0.0250#	0.00764	-0.0173	0.0328**	0.0129	0.0189*
	-0.85		-0.43	-0.1	-1.05		-1.79	-1.04	-1.33	-3.39	-1.19	-2.33
L.dlsd_dlres	-0.0409*	-0.0283**	0.00464		0.0181		0.0335		-0.0322*	-0.000418	0.0152	0.0136
	-2.08	-2.75	-0.18		-1.37		-1.55		-2.46	-0.03	-1.14	-1.51
dlcpi	0		0		0		0.176		0.122		0.177	
	(.)		(.)		(.)		-1.43		-1.02		-1.58	
L.dlcpi	0		0		-0.0256	-0.535**	-0.106	0.114	-0.103		-0.196#	-0.171*
	(.)		(.)		-0.02	-4.26	-1.18	-0.63	-1.33		-1.76	-2.16
GFC_08_dum.	-0.00779		-0.0114*	-0.0109#	-0.0258	-0.0155**	-0.00695		-0.0138*	-0.00910*	-0.0150*	-0.00645
	-0.75		-2.14	-1.82	-1.53	-2.61	-0.38		-2.14	-2.15	-2.33	-1.34
N. Obs.	232	247	252	252	318	318	219	240	484	512	962	1019
N_g	15	15	13	13	16	16	20	21	28	28	61	62
ar1	-0.832	-2.901	-0.513	-1.948	-1.779	-2.015	-2.627	-2.141	-4.021	-3.947	-4.836	-4.492
ar2	-0.908	0.388	-0.835	-1.445	-1.059	0.275	-1.015	-1.226	-2.124	-0.588	-1.862	-1.378
sarganp	0.755	0.339	0.728	0.763	0.324	0.673	0.227	0.779	0.925	0.658	0.647	0.138
hansenp	1	0.238	1	0.65	1	0.669	0.279	0.84	0.897	0.723	0.549	0.655
Max_VIF	.	2.92	.	2.47	.	3.14	.	2.15	9.56	2.62	6.54	2.43

Threshold model results

Table 6: Threshold model results

threshold var.	**dlgdp_cap**	**dlgdp_cap**	**dlres**	**dlres**	**dlsd**	**dlsd**	**dlav**	**dlav**
depends on thresh.	**dlsd_dlres**	**dlav_dlres**	**dlsd_dlres**	**dlav_dlres**	**dlsd_dlres**	**dlav_dlres**	**dlsd_dlres**	**dlav_dlres**
L.dlgdp	0.525*	0.618**	0.609**	0.516*	0.446#	0.576**	0.729**	0.592**
	(2.50)	(3.31)	(3.42)	(2.30)	(1.86)	(2.97)	(3.54)	(3.30)
Below the Thresh.	0.165	-0.827	-0.0847	0.208	-0.131#	-0.478	0.101	-0.893
	(1.36)	(1.12)	(0.60)	(0.26)	(1.80)	(0.46)	(1.44)	(1.53)
Above the Thresh.	-0.0421	-0.127	0.0367	-0.957	0.0428	-0.354	-0.0603	-0.182
	(1.08)	(0.20)	(0.42)	(1.55)	(0.91)	(0.96)	(1.17)	(0.38)
L.dlreserve	0.00398	0.00582	0.0110	0.00916	0.0159	0.00317	0.0168	0.0194
	(0.12)	(0.18)	(0.29)	(0.31)	(0.64)	(0.11)	(0.42)	(0.48)
L.dlav	0.0389	0.0430	0.0494	0.0828	0.0000191	0.0719	0.0631	0.107
	(0.78)	(0.44)	(0.75)	(1.04)	(0.00)	(0.95)	(1.10)	(1.34)
L.dlopennes	-0.00141	-0.0624	-0.0303	-0.0227	0.0224	-0.0282	-0.0745	-0.0561
	(0.03)	(0.89)	(0.60)	(0.40)	(0.34)	(0.40)	(1.34)	(1.09)
L.dlsd	-0.0145**	-0.0134*	-0.0140*	-0.0120#	-0.0121#	-0.0131	-0.0154**	-0.0135*
	(2.62)	(2.27)	(2.05)	(1.84)	(1.91)	(1.59)	(2.64)	(2.04)
dlsd	0.00318	-0.00734	-0.00713	-0.00327	0.00679	-0.00393	-0.00433	-0.00510
	(0.49)	(0.96)	(0.66)	(0.55)	(1.05)	(0.66)	(0.89)	(0.97)
GFC_08_dum.	-0.0342**	-0.0257**	-0.0359*	-0.0262**	-0.0336**	-0.0250*	-0.0301**	-0.0243**
	(3.13)	(2.75)	(2.17)	(2.95)	(3.64)	(2.39)	(2.90)	(2.60)
dlreserve	-0.00159	0.0209	-0.0106	-0.00662	0.0404	-0.0107	-0.0307	-0.0191
	(0.07)	(0.40)	(0.40)	(0.33)	(1.20)	(0.44)	(1.44)	(0.85)
dlav	-0.0659	-0.0970#	-0.100	0.0291	-0.0245	-0.0889	-0.103#	-0.0627
	(1.26)	(1.80)	(1.50)	(0.22)	(0.41)	(1.62)	(1.77)	(1.16)
dlopennes	0.259**	0.246**	0.263**	0.247**	0.289**	0.247**	0.256**	0.240**
	(4.16)	(3.96)	(4.56)	(4.41)	(4.40)	(4.11)	(4.92)	(4.06)
N. Obs.	1026	1026	1026	1026	1026	1026	1026	1026
N_g	60	60	60	60	60	60	60	60
arm1	-3.589	-2.652	-2.865	-3.395	-3.249	-3.391	-3.098	-3.470
arm2	-0.950	-0.919	-0.470	-0.163	-1.077	-0.618	0.261	-0.492
SarganP	0.154	0.076	0.102	0.089	0.154	0.054	0.245	0.073

7.1 Technical note