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Economic Policy Uncertainty and Foreign Reserves: Empirical Evidence from BRIC Countries

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Abstract:

Purpose: *Over the past three decades, official foreign-reserve stocks have surged from under US $1 trillion in the early 1990s to more than US $12 trillion by 2022—largely held by emerging-market and developing economies. This study investigates how economic-policy uncertainty (EPU) and key macroeconomic variables influence reserve accumulation in the BRIC countries (Brazil, Russia, India, and China) over 2003–2023.*
Design/Methodology/Approach: *Employing panel unit-root tests to confirm mixed integration orders, we apply Pedroni, Kao, and Westerlund cointegration tests to establish long-run relationships, and then estimate both pooledmean-group (PMG) ARDL and fixed-effects models (selected via LM and Hausman tests).*
Findings: *Our results consistently show that higher EPU, faster GDP growth, and greater trade openness exert significant negative effects on reserves, whereas foreign direct investment inflows and currency depreciation boost reserve levels. Post-estimation diagnostics—including tests for normality, serial correlation, cross-sectional dependence, and heteroskedasticity—validate the reliability of our specification.*
Practical Implications: *We recommend that BRIC policymakers work to reduce policy uncertainty, promote stable FDI inflows, maintain exchange-rate stability, and manage trade openness to safeguard their foreign-reserve buffers.*
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1. Introduction

The past three decades have witnessed an unprecedented build-up of official foreign reserves, climbing from under US $1 trillion in the early 1990s to more than US $12 trillion by 2022, disproportionately held by emerging-market and developing economies (Tran and Le, 2020).

Central banks typically park these buffers in liquid, hard-currency assets (principally U.S. dollars and, to a lesser extent, euros) to insure against balance-of-payments crises, defend exchange-rate pegs, shore up sovereign creditworthiness, and ensure the smooth conduct of trade (Bibow, 2012). Yet holding large reserves carries its own costs—sterilization operations, foregone domestic investment, and potential distortions to monetary policy, so understanding the forces that drive reserve accumulation is of vital policy importance.

Scholarly explanations of reserve-holding behavior fall into two broad camps. The precautionary motive posits that economies exposed to volatile capital flows and sudden-stop risk hoard reserves as self-insurance—a view powerfully validated by the 1997-1998 Asian Financial Crisis, when well-imbued buffers distinguished crisis-resilient economies from those forced into painful adjustment (Chinn, Eichengreen, and Ito, 2024).

By contrast, the mercantilist motive argues that authorities, anxious to forestall excessive currency appreciation, actively intervene in foreign-exchange markets to accumulate reserves and preserve export competitiveness (Cheung and Qian, 2009). In reality, central banks often pursue a blend of these objectives, simultaneously aiming to guard against external shocks and influence the exchange-rate trajectory.

More recent work has begun to examine how economic policy uncertainty (EPU), unexpected shifts or ambiguity in fiscal, monetary, or regulatory policy—affects macro-financial outcomes (Baker, Bloom, and Davis, 2016) and, in turn, reserve needs. Three developments have fueled this line of inquiry, the spike in policy turbulence during and after the 2008 global crisis, the creation of high-frequency EPU indices, and the rise of computational methods capable of handling large, granular datasets (Bloom, 2014).

Empirical evidence shows that rising policy uncertainty destabilizes currency values via capital-flow reversals, altered export–import dynamics, and higher ambiguity premia demanded by risk-averse investors, which together amplify both the direct and indirect pressures on central-bank reserves (Liming *et al.,* 2020; Gabor-Tóth and Georgarakos, 2019; Brenner and Izhakian, 2018).

Despite these insights, virtually no study to date has directly quantified how EPU shapes reserve accumulation once traditional determinants—current-account

balances, exchange-rate regimes, real interest differentials, and measures of financial openness—are taken into account (Aizenman and Ilzetzki, 2019; Chinn *et al.,* 2024).

Aggregate risk proxies such as the VIX or global sovereign-spread indices may capture broad market volatility but overlook the idiosyncratic policy ambiguities that domestic firms and households face. Country-case analyses (e.g., Patnaik and Shah, 2010 for India; Benigno and Fornaro, 2014 for Latin America) hint that regulatory shocks and fiscal unpredictability can temporarily perturb reserve paths, but they rely on indirect measures or neglect the interaction with other macroeconomic factors (Velinov *et al.,* 2023).

This gap is especially salient in the BRIC economies, Brazil, Russia, India, and China, which together hold over half of all global reserves (Lusinyan, Surti, and Lozada, 2020). These four large emerging markets have each weathered episodes of abrupt policy shifts, India's post-2008 tax reforms, China's episodic capital-account tightening, and Russia's ruble defense operations, that likely heightened domestic EPU and, by extension, influenced their reserve strategies. Yet no research has systematically leveraged national-level EPU indices to trace how policy uncertainty interacts with conventional drivers to determine reserve buildup in these critical economies.

To address this lacuna, our paper pursues four interrelated objectives. First, we estimate the sensitivity of yearly reserve holdings to EPU shocks in each BRIC country, employing the Baker *et al.* (2016) indices. Second, we benchmark this sensitivity against the explanatory power of established factors, trade openness, net capital inflows, and exchange-rate pressures, to ascertain whether policy uncertainty contributes incremental insight.

Third, we adopt a panel-cointegration and error-correction framework that disentangles the short-run reserve response to sudden policy surprises from the long-run re-equilibration toward target buffer levels. Finally, we test for asymmetries, exploring whether upward versus downward EPU shocks elicit different reserve reactions and whether these patterns vary across various BRIC countries..

By isolating economic policy uncertainty as a distinct driver of reserve accumulation in the BRIC context, our study offers three main contributions. Theoretically, it extends the precautionary-motive literature by treating domestic policy ambiguity as a liquidity constraint akin to sudden-stop risk. Empirically, it delivers the first multi-country quantification of how EPU alters reserve-holding behavior in the world's largest emerging markets.

From a policy perspective, our results will inform central banks and finance ministries on how to calibrate reserve targets amid growing policy unpredictability—striking a balance between the fiscal costs of large buffers and the insurance benefits they provide.

As emerging economies navigate an increasingly uncertain global environment—from trade disputes to regulatory overhauls—our findings underscore the importance of policy clarity as a stabilizing force in reserve management.

Methodologically, we compile a novel yearly dataset spanning 2003-2023 that merges central-bank reserve figures with compatable frequency, country-specific EPU measures. After checking the Breusch and Pagan Lagrangian multiplier test for random effects and hausman test for fixed effect and unit root tests for stationarity, we employ pooled mean group ARDL and the fixed effect model to estimate the parameters (Thalassinos *et al.,* 20150.

After applying these models, we also checked the cross sectional dependence and heteroscdasticity of the model. Results show that the model is free from cross sectional dependence and heteroscedasticity problems. The results indicate that EPU, GDP growth rate and trade openness have negative and significant impacts on foreign reserves. However, foreign direct investment and exchange rate have positive nexus with foreign reserves in BRIC countries.

Remaining of the study is structured in such a way that section two discusses the literature review, section three comprises the research methodology. However, results discussion and policy implicatios along with conclusion are presented in section four and five respectively.

2. Literature Review

Scholarly interest in the determinants of foreign-reserve accumulation has historically focused on two broad motives, precautionary self-insurance and mercantilist exchange-rate management, but has only recently begun to consider the role of policy-driven uncertainty. Early empirical work, drawing on cross-country panels, showed that reserve levels rise with wider current-account surpluses, greater financial openness, and more volatile capital flows (Aizenman and Marion, 2007; Lane and Milesi-Ferretti, 2007; Hakim and Thalassinos, 2021).

These studies typically employed fixed- or random-effects estimators and found that, in the wake of balance-of-payments crises, countries opportunistically rebuilt buffers, lending strong support to precautionary motives (Benigno and Fornaro, 2014). However, their focus on average effects across heterogeneous samples left open questions about how country-specific factors, such as institutional capacity or domestic policy credibility, might condition reserve responses.

A second strand of the literature highlighted mercantilist behavior, whereby central banks accumulate reserves to dampen appreciation pressures and support export competitiveness. Cheung and Qian (2009) used time-series models for China to demonstrate that large-scale intervention during export-led booms was associated with persistent sterilization operations and rising fiscal costs.

Similar country-case studies in Southeast Asia and Latin America found that, even in the absence of crises, policymakers actively managed exchange rates via reserve purchases to smooth real-effective exchange-rate paths (Chinn *et al.,* 2024). Yet these papers largely treated policy uncertainty as exogenous, neglecting the possibility that unpredictability itself might drive precautionary demand.

The emergence of formal measures of Economic Policy Uncertainty (EPU) provided a new lens through which to view reserve-management decisions. Baker, Bloom, and Davis (2016) first showed that higher EPU correlates with greater volatility in investment, hiring, and asset prices in advanced economies.

Subsequent research extended EPU's reach into emerging-market contexts, demonstrating that spikes in policy uncertainty dampen net capital inflows and raise sovereign-bond yields (Gulen and Ion, 2016; Caldara *et al.,* 2019). These findings suggest a channel whereby central banks, facing heightened uncertainty about fiscal or regulatory directions, might choose to bolster reserves beyond what traditional drivers would predict.

While expectations of macroeconomic fundamentals lie at the core of exchange-rate dynamics (Engel and West, 2005), the parallel channel through which economic policy uncertainty (EPU) shapes central-bank reserve management remains under-examined. Extant research largely treats reserves as a passive response to exchange-rate swings or current-account balances, yet rising policy ambiguity may itself drive reserve accumulation via both direct and indirect effects on currency and capital flows.

Empirical studies on EPU and exchange rates demonstrate that elevated policy uncertainty destabilizes currencies by spurring capital-flow reversals (Liming et al., 2020), altering trade balances, and raising the ambiguity premium demanded by investors (Gabor-Toth and Georgarakos, 2019; Brenner and Izhakian, 2018).

ARDL and quantile-regression analyses confirm significant short- and long-run impacts of EPU on exchange-rate levels and volatility across both advanced and emerging markets (Abid, 2020; Chang *et al.,* 2022; El-Abed *et al.,* 2022; Murad, 2022). However, these studies stop short of tracing how such exchange-rate pressures translate into reserve-holding decisions.

A smaller body of work incorporates broader risk proxies, such as the VIX or sovereign-spread shocks, into reserve-demand models, finding that global volatility spikes prompt precautionary buffer buildups (Aizenman and Ilzetzki, 2019). Yet aggregate measures obscure the country-specific policy ambiguities captured by national EPU indices (Baker *et al.,* 2016), which have been shown to dampen gross investment, output, and trade flows (Baker *et al.,* 2016; Novy and Taylor, 2020) and to induce banks' liquidity hoarding (Berger *et al.,* 2022; Ozili, 2022).

Moreover, although research on financial crises notes that reserve drawdowns and rebuilds coincide with policy regime shifts (Chinn, Eichengreen, and Ito, 2024), few studies quantify the incremental effect of EPU shocks on reserve levels once conventional drivers are controlled for. This gap is especially striking for large emerging markets, where policy reversals are frequent, capital flows volatile, and reserves substantial, but the literature has yet to deploy high-frequency, country-specific EPU measures within a dynamic panel or error-correction framework.

By critically evaluating these strands, it becomes clear that a nuanced understanding of the EPU–reserves nexus demands:

(1) isolating domestic policy uncertainty from global-risk proxies;
(2) modeling both the immediate (exchange-rate-mediated) and gradual (precautionary-motive) reserve responses;
(3) accounting for cross-country spillovers and structural breaks. Our study addresses these needs by integrating national EPU indices with standard macro-financial controls in a cointegration/ECM setting, thereby filling a critical void in the literature on how policy ambiguity directly shapes reserve accumulation.

Despite these conceptual advances, empirical analyses of the EPU–reserves nexus remain scarce. A few macro-financial studies have incorporated global-scale uncertainty proxies, such as the VIX index or geopolitical-risk measures, and found that reserve holdings respond to international risk conditions (Aizenman and Marion, 2007). However, such aggregate indicators fail to capture domestic policy ambiguities that are directly observable by local firms, households, and policymakers.

Even within country-case analyses, the specific impact of national-level EPU on reserve behavior has not been systematically quantified. For example, while some work on India linked sudden regulatory changes to short-run reserve fluctuations (Patnaik and Shah, 2010), it did not distinguish policy-induced uncertainty from other forms of shock.

The BRIC economies present a particularly compelling setting in which to fill this gap. Collectively holding over half of global reserves, they combine large-scale buffer stocks with frequent shifts in fiscal, monetary, and regulatory regimes. Yet, to date, no study has jointly examined how EPU interacts with conventional determinants, current accounts, exchange-rate volatility, and capital-flow episodes, to shape reserve accumulation in these four countries.

Moreover, the dynamic adjustment of reserves in response to policy shocks, whether central banks immediately rebuild buffers or smooth their responses over several larger time spans, remains unexplored in a panel-cointegration framework.

In summary, while the literature robustly documents that reserves are driven by external vulnerabilities and active exchange-rate management, it has largely overlooked the degree to which central banks preemptively adjust buffers when policy paths are unclear. By integrating high-frequency, country-specific EPU indices with traditional macroeconomic drivers in a dynamic panel setting, the present study seeks to advance both theory and practice.

It will quantify the incremental impact of policy uncertainty on reserve demand, illuminate the speed of reserve adjustments to policy shocks, and offer policy-relevant insights for large emerging markets facing an ever more unpredictable policy environment.

3. Research Methodology

3.1 Data, Source, Variables and Model Specification

Data on economic policy uncertainty are sourced from Baker *et al.* (2016) via https://www.policyuncertainty.com/. We construct an annual EPU series by averaging the twelve monthly index values for each calendar year. Unlike event-based indicators tied to specific policy announcements or election cycles, the Baker *et al.* (2016) index provides a continually updated measure of policy risk. All other model variables are drawn from the World Bank's World Development Indicators database.

Although the EPU series begins in 1996, country-level data for India only commence in 2003; therefore, our empirical analysis covers the period 2003-2023. This study applies fixed effect model. The model to be estimated is shown in equation 1 as under:

$$\mathbf{RESM_{it}} = \boldsymbol{\alpha} + \boldsymbol{\beta_1}\mathbf{EPU_{it}} + \boldsymbol{\beta_2}\mathbf{FDIG_{it}} + \boldsymbol{\beta_3}\mathbf{GDPG_{it}} + \boldsymbol{\beta_4}\mathbf{ER_{it}} + \mathbf{TRADEG_{it}} + \mathbf{ui} + \boldsymbol{\epsilon_{it}} \quad (1)$$

Where:

RESMit is the foreign-exchange reserves of country i in year t,
EPUit denotes economic policy uncertainty,
FDIGit is foreign direct-investment to GDP,
GDPit is real GDP per capita growth
ERit is the exchange rate,
TRADEit measures trade to GDP,
Ui captures the country-fixed effect (time-invariant heterogeneity, such as institutional or structural factors),
α is the common intercept,
εit is the idiosyncratic error.

Estimating this "within" model effectively demeans each variable and nets out Ui, so that the coefficients β1–β5 are identified from year-to-year changes within each country.

3.2 Process of Data Analysis

We begin by examining the raw data through descriptive statistics, correlation analysis, and panel unit-root tests to assess basic distributional properties, bivariate relationships, and stationarity. On the basis of unit root tests, this study employes the ARDL PMG model to capture long run as well as short run dynamic of foreign reserves management. It helps to give comparatively shrot run insights among the countries.

Next, we determine our estimation strategy: a Breusch–Pagan Lagrange-Multiplier test guides our choice between a pooled and a random-effects specification, and a Hausman test then informs the decision between random and fixed effects for robustness. Finally, we validate the chosen model by checking for serial correlation with a Breusch–Godfrey LM test, cross sectional dependence with Pesaran test and for heteroskedasticity using the Breusch–Pagan–Godfrey test, ensuring that our standard errors and inference remain reliable.

4. Results Discussion

4.1 Descriptive Statistics

Table 1 presents key summary statistics for our five main variables, each observed over 84 country-year observations. Central-bank reserves (resm) average 12.15 (billion USD), with a standard deviation of 4.12 and a span from 5.02 to 25.39, indicating that some BRIC economies hold twice as much in reserves as others. Economic Policy Uncertainty (epu), measured on the Baker *et al.* (2016) index, has a mean of 191.19 but a very large standard deviation of 163.29 and ranges from 49 to 792, underscoring pronounced swings in policy risk both within and across countries.

Foreign-direct-investment to GDP (fdig) averages 2.37 percent with a standard deviation of 1.23 percent, varying from a contraction of –1.76 percent to a boom of 4.55 percent. Real GDP per capita growth (gdp g) is somewhat more volatile, with a mean of 4.95 percent, SD of 4.14 percent, and a stretch from a deep recession of –7.8 percent to rapid expansion of 14.23 percent.

The nominal exchange rate (er), expressed in local currency units per US dollar, has a mean of 28.65 but a similarly large SD of 26.96, ranging from 1.67 to 85.16, reflecting both highly depreciated and relatively strong currency episodes. Finally, trade-to- GDP (tradeg) averages 42.37 percent with an SD of 10.85 percent, and lies

between 22.11 percent and 64.48 percent, indicating substantial heterogeneity in trade performance.

Altogether, these descriptive statistics reveal considerable dispersion and occasional extremes across the BRIC sample—particularly in policy uncertainty, exchange rates, and growth rates—highlighting the need for transformations (e.g., logs or differences) and robust estimation techniques (e.g., fixed effects and heteroskedasticity-robust standard errors) to ensure reliable inference.

Table 1. *Descriptive Statistics*

Variable	Obs	Mean	Std. Dev.	Min	Max
resm	84	12.151	4.123	5.018	25.39
epu	84	191.19	163.288	49	792
fdig	84	2.365	1.226	-1.756	4.554
gdpg	84	4.95	4.14	-7.8	14.231
er	84	28.649	26.962	1.673	85.162
tradeg	84	42.365	10.848	22.106	64.479

Source: *Own work.*

4.2 Skewness and Kurtosis Tests

Table 2 presents D'Agostino–Pearson tests of skewness and kurtosis for each of our six core variables, evaluating whether their distributions depart from normality. Foreign-exchange reserves (resm) exhibit significant skewness ($p = 0.029$) but no excess kurtosis ($p = 0.547$), and the combined chi-square (5.07, $p = 0.079$) narrowly misses rejecting normality at the 5 percent level—suggesting a slightly asymmetric but otherwise acceptably bell-shaped distribution.

Economic policy uncertainty (epu), by contrast, is decisively non-normal: both skewness and kurtosis tests return $p < 0.001$, and the joint statistic (33.77, $p < 0.001$) confirms pronounced asymmetry and fat tails. FDI to GDP (fdig) passes both tests (skewness $p = 0.141$; kurtosis $p = 0.350$; joint chi-square = 3.14, $p = 0.208$), indicating an approximately normal distribution.

GDP growth rate (gdpg) shows significant skewness ($p = 0.012$) and, with a joint chi-square of 7.06 ($p = 0.029$), rejects normality overall, pointing to an asymmetric distribution. The exchange rate (er) is also markedly non-normal, with both skewness ($p = 0.030$) and kurtosis ($p < 0.001$) significant and a combined chi-square of 22.25 ($p < 0.001$).

Finally, trade-to-GDP (tradeg) passes the skewness test ($p = 0.457$) but fails the kurtosis test ($p = 0.016$), yielding a joint chi-square of 6.00 ($p = 0.050$) that sits right at the 5 percent rejection threshold. In sum, aside from FDI to GDP, most variables display significant skewness or kurtosis, underscoring the need for robust estimation techniques that do not rely on strict normality assumptions.

Table 2. *Skewness and kurtosis tests for normality, Joint test*

Variable	Obs	Pr(skewne)	Pr(kurtosi)	Adj chi^2	Prob>chi^2
resm	84	0.029	0.547	5.070	0.079
epu	84	0.000	0.000	33.770	0.000
fdig	84	0.141	0.350	3.140	0.208
gdpg	84	0.012	0.238	7.060	0.029
er	84	0.030	0.000	22.250	0.000
tradeg	84	0.457	0.016	6.000	0.050

Source: *Own work.*

4.3 Coefficient of Correlation

Table 3 reports Pearson correlation coefficients for our six key variables, revealing a mix of weak to moderate relationships but no extreme collinearity. Central-bank reserves (resm) are moderately positively correlated with economic policy uncertainty (epu = 0.26) and FDI growth (fdig = 0.21), suggesting that higher policy ambiguity and stronger inward investment tend to go hand-in-hand with larger reserve cushions.

Reserves show virtually no association with GDP growth (gdp = 0.02), a modest positive link with trade growth (tradeg = 0.13), and a moderate negative correlation with the exchange rate index (er = –0.27), indicating reserves are lower when the currency weakens (a higher er value).

Economic policy uncertainty itself is negatively related to FDI (–0.38) and GDP growth (–0.27), and to a lesser extent trade growth (–0.20), which is consistent with the view that policy ambiguity dampens investment, output, and trade flows. FDI growth is strongly negatively correlated with the exchange rate (–0.56), reflecting that capital inflows tend to coincide with currency strength, and shows a small positive association with GDP growth (0.16).

GDP growth correlates positively with trade growth (0.44) but has almost no relationship with the exchange rate (–0.08). Finally, trade growth and the exchange rate display a moderate positive correlation (0.38), implying that periods of expanding trade often accompany a depreciating currency.

Overall, these correlation patterns underscore theoretically plausible links, such as policy uncertainty's dampening effect on FDI and growth, and the interplay between capital flows, exchange rates, and reserves, while confirming that no pair of

regressors is so highly correlated (|r| > 0.8) as to raise severe multicollinearity concerns.

Table 3. *Matrix of correlations*

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) resm	1.000					
(2) epu	0.261	1.000				
(3) fdig	0.211	-0.382	1.000			
(4) gdpg	0.020	-0.273	0.163	1.000		
(5) er	-0.274	-0.133	-0.562	-0.075	1.000	
(6) tradeg	0.126	-0.199	0.029	0.441	0.382	1.000

Source: *Own work.*

4.4 Unit Root Test Results

Table 4 reports the results of Levin–Lin–Chu panel unit-root tests for each of our six core variables, using an intercept and a Bartlett kernel (8 lags). The null hypothesis in each case is that the panel contains a unit root (non-stationary series).

In levels, most variables fail to reject non-stationarity: reserves (resm) show a test statistic of –1.0519 (not significant), economic policy uncertainty (epu) is +0.5590 (not significant), FDI growth (fdig) is +0.2233 (not significant), the exchange rate (er) is +1.1398 (not significant), and trade growth (tradeg) is –0.5259 (not significant). Only real GDP per capita growth (gdpg) rejects the null at conventional levels (test statistic = –1.3951, $p<0.01$), indicating it is stationary in levels, I(0).

After first differencing, every series becomes stationary: reserves Δresm (–4.9399, $p<0.01$), EPU Δepu (–4.9141, $p<0.01$), FDI growth Δfdig (–5.2477, $p<0.01$), exchange rate Δer (–3.2846, $p<0.05$), and trade growth Δtradeg (–3.2012, $p<0.05$) all strongly reject the unit-root null.

In short, five of the six variables are integrated of order one—I(1)—while GDP per capita growth is I(0). This mixed order of integration justifies the use of an ARDL (PMG) framework, which can jointly handle I(0) and I(1) series without risking spurious regression, and allows us to investigate both the long-run equilibrium relationships and the short-run dynamics among our core macro-financial variables.

Table 4. *Levin Lin Chu Unit Root Test*

Variable	level	1st differ	Remarks
resm	-1.0519	-4.9399*	I(1)
epu	0.5590	-4.9141 *	I(1)
fdig	0.2233	-5.2477*	I(1)
gdpg	-1.3951	-5.5195 *	I(1)
er	1.1398	-3.2846 *	I(1)

tradeg	-0.5259	-3.2012 *	I(1)
Bartlett	Kernel 8.00		

Source: *Own work.*

4.5 Kao, Pedroni and Westerlund Co-integration Tests

Table 5 reports the results of three complementary panel-cointegration tests, Westerlund (2007), Pedroni (1999), and Kao (1999), which collectively assess whether a stable long-run equilibrium binds our variables. The Pedroni tests, based on residuals from group-specific regressions, allow for heterogeneity in intercepts and trend coefficients and produce several test statistics (panel-v, panel-rho, panel-t, and group-t) that all strongly reject the null of "no cointegration" at conventional significance levels (Pedroni, 1999).

Complementing these, the Kao test imposes a homogeneous cointegrating vector across cross-sections but still rejects non-cointegration, confirming a shared equilibrium relationship (Kao, 1999). Finally, the Westerlund error-correction-based tests, which allow for cross-sectional dependence and directly target the existence of an error-correction mechanism, similarly yield significant $Z\alpha$ and $Z\tau$ statistics, indicating that deviations from the long-run path are corrected over time (Westerlund, 2007).

Taken together, the unanimous rejection of the null hypothesis across all three methodologies provides robust evidence that our panel of foreign-reserve holdings, economic policy uncertainty, FDI growth, GDP growth, exchange-rate movements, and trade growth share a common stochastic trend and gravitate toward a long-term equilibrium.

Establishing this cointegration relationship justifies the subsequent estimation of long-run coefficients—and the associated short-run dynamics—using an Autoregressive Distributed Lag (ARDL) Pooled Mean Group framework, which can accommodate variables integrated of different orders (Pesaran, Shin, and Smith, 1999).

Table 5. *Cointegration tests*

Westerlund co integration test		
Test name	**statistics**	**probability**
Variance ratio	1.7890	0.0368
Pedroni cointegration test		
Test name	**statistics**	**probability**
Modified Phillips–Perron t	3.1230	0.0009
Phillips–Perron t	2.3645	0.0090
Augmented Dickey–Fuller t	1.7123	0.0434
Kernel	Bartlett	
lags	0.00 (Newey–West)	

Kao Cointegration test		
Test name	**statistics**	**probability**
Modified Dickey–Fuller t	-2.2696	0.0116
Dickey–Fuller t	-1.8618	0.0313
Augmented Dickey–Fuller t	-1.4762	0.0699
Unadjusted modified Dickey–Fuller t	-1.1694	0.1211
Unadjusted Dickey–Fuller t	-1.5327	0.0627
Kernel	Bartlett	
Lags:	1.25 (Newey–West)	
Augmented lags	3	

Source: *Own work.*

4.6 Results of Pannel ARDL Model

The ARDL–PMG estimates confirm that economic policy uncertainty, foreign direct investment, GDP growth, the exchange rate, and trade growth each play distinct roles in shaping BRIC's reserve dynamics over 2003-2023. In the long run, a one-point increase in the EPU index reduces annual reserve accumulation by 0.01 units ($t = –2.50$, $p = 0.015$), underscoring how heightened policy ambiguity weakens central-bank buffer building.

When policymakers signal that future fiscal, monetary, or regulatory decisions may be erratic, private investors typically pull back, triggering capital-flow reversals. Central banks often deploy reserves to stabilize the exchange rate or to provide liquidity support to domestic banks, which draws down buffers. Moreover, heightened EPU can tighten government budgets, through lower tax receipts and higher borrowing costs, leaving fewer resources available to replenish reserves.

By contrast, stronger FDI growth exerts a powerful positive effect, each percentage-point rise in FDI boosts reserves by 1.62 units ($t = 2.60$, $p = 0.011$), highlighting the direct infusion of foreign capital into official FX stocks. Foreign direct investment (FDI) delivers a direct inflow of foreign currency into the host economy, often in the form of equity investments or reinvested earnings. When multinational firms set up operations, build factories, or acquire domestic assets, they convert their foreign capital into local currency, and the unspent portion is typically deposited with the central bank.

These net inflows bolster the country's foreign-exchange coffers, expanding reserves. Moreover, because FDI is generally longer-term and less prone to sudden reversals than portfolio flows, central banks view it as particularly "sticky" and reliable, further encouraging the accumulation of these inflows in official reserves.

Robust GDP growth, meanwhile, eases precautionary motives, cutting reserve growth by 0.86 units per percentage-point of growth ($t = –3.76$, $p < 0.001$). Rapid

output expansion improves public finances, deepens domestic credit markets, and raises confidence in external solvency.

As a result, the precautionary imperative to hold large reserves weakens: authorities can afford to reallocate part of their hard-currency assets back toward social and infrastructure spending. In periods of sustained growth, reserve accumulation often gives way to reinvestment in the domestic economy, hence the observed negative coefficient.

And a one-unit depreciation of the exchange rate increases reserve accumulation by 0.17 units ($t = 2.61$, $p = 0.011$), reflecting both valuation gains and intervention efforts to stabilize the currency. A weaker domestic currency raises the local-currency valuation of any existing foreign-currency stocks.

For example, a one-dollar reserve holding is worth more rupees, pesos, or rubles after a depreciation—so even without new purchases, reserves appear to grow in domestic-currency terms. In addition, many emerging-market central banks intervene during periods of currency weakness by purchasing foreign currency to smooth excessive volatility or to rebuild lost valuation.

These defensive purchases directly add to the reserve stock. Together, the valuation effect (higher local-currency worth of existing reserves) and active FX market intervention explain why depreciations and valuations work hand-in-hand to raise official reserve levels. Trade growth's long-run coefficient is positive but statistically insignificant, suggesting that once these other forces are accounted for, trade fluctuations do not systematically alter reserve trends.

Short-run dynamics differ: rising trade growth leads to a significant 0.32-unit drawdown in reserves ($t = –5.79$, $p < 0.001$), consistent with central banks selling FX to smooth volatility during export or import surges. While higher export volumes bring in foreign currency, trade surges also tend to appreciate the domestic currency, prompting central banks to sell FX to prevent "over-appreciation" and protect competitiveness.

Similarly, when imports jump, more reserves are used to pay for essential goods. Thus, even though trade openness expands the pool of FX, it simultaneously increases the demand for intervention—both to smooth exchange-rate volatility and to finance rising import bills—leading to a net drawdown of reserves.

The estimated error-correction term of –0.34 ($t = –3.96$, $p < 0.001$) reveals that roughly 34 percent of any deviation from the long-run equilibrium is corrected within one year, indicating a relatively swift return to target reserve levels after shocks. Overall, these results illustrate that policy uncertainty and domestic growth temper reserve accumulation, while foreign investment and currency pressures drive it, and that short-run trade shocks prompt active reserve use—features that

central-bank policymakers must balance when setting buffer targets under shifting economic conditions.

Table 6. *ARDL model Results* Selected model: PMG(1,0,0,0,0,1)

Long Run			Short Run and ECT		
Variable	**coefficient**	**P-Value**	**Variable**	**Coefficient**	**P-Value**
epu	-0.010064*	0.0147	D(tradeg)	-0.320993*	0.0000
fdig	1.626357*	0.0112	ECT	-0.340126*	0.0002
gdpg	-0.862256*	0.0003			
er	0.171039*	0.0110			
tradeg	0.068462	0.5245			
F-statistics	7.262828				
constant	2.989532	0.0828			

Source: *Own work.*

4.6.1 Short Run Comparasion Among BRIC Countries

Table 7 compares the short-run dynamics of reserve adjustments across the four BRIC economies, focusing on the error-correction term (ECT) and the immediate impact of trade growth (ΔTRADEG).

Speed of Adjustment (ECT): Russia, Brazil, and China all exhibit statistically significant negative ECT coefficients, indicating that when reserves deviate from their long-run equilibrium, these countries correct the gap within one period. Brazil's ECT of –0.5035 ($p = 0.0017$) is the largest in absolute value, implying that roughly 50 percent of any disequilibrium is eliminated each year—by far the swiftest among the four. China follows with an ECT of –0.4311 ($p < 0.001$), adjusting about 43 percent of the deviation annually. Russia's ECT of –0.3156 ($p = 0.0036$) indicates a more gradual but still meaningful 32 percent correction per year. In contrast, India's ECT of –0.1103 is small and statistically insignificant ($p = 0.1312$), suggesting that deviations from equilibrium persist well beyond one year and that India's reserve-accumulation process is much slower to self-correct.

Trade-Openness Effects (ΔTRADEG): Short-run trade shocks—reflecting the central bank's use of reserves to smooth currency pressures—also vary in their immediate impact. Russia and China display large, significant negative coefficients on ΔTRADEG (–0.4197, $p = 0.0122$ for Russia; –0.4030, $p < 0.001$ for China), indicating that a one-percentage-point rise in trade growth draws down reserves by roughly 0.4 units in the same period. India shows a somewhat smaller but still significant effect (–0.2759, $p = 0.0015$), drawing down reserves by 0.28 units per point of trade growth. Brazil's short-run trade coefficient (–0.1854) is negative but fails to reach significance ($p = 0.2389$), suggesting that Brazil's central bank may be less active, or uses different instruments, in offsetting trade-related currency movements.

Comparative Insight: Taken together, these results paint a picture of three BRIC countries—Brazil, China, and Russia—that both actively deploy reserves in response to trade shocks and rapidly close any short-run gaps back to their long-run reserve paths. India, by contrast, shows neither a strong trade-driven reserve drawdown nor a rapid correction toward equilibrium, pointing to a more passive or smoothed reserve-management approach. These cross-country contrasts underline how institutional frameworks, market depth, and policy priorities shape the speed and mechanics of reserve adjustment in large emerging economies.

Table 7. *Short Run Comparasion of BRIC countries*

Russia		
Variable	**Coefficient**	**P-Value**
ECT	-0.315608	0.0036
D(TRADEG)	-0.419709	0.0122
Constant	0.891234	0.0995
Brazil		
ECT	-0.503524	0.0017
D(TRADEG)	-0.185351	0.2389
Constant	3.714189	0.0018
India		
ECT	-0.110301	0.1312
D(TRADEG)	-0.275887	0.0015
Constant	-0.121544	0.7030
China		
ECT	-0.431074	0.0001
D(TRADEG)	-0.403024	0.0000
Constant	7.474249	0.0001

Source: *Own work.*

4.6.2 Robustness Tests

To further validate our ARDL–PMG findings, we re-estimated the core specification as a static fixed-effects panel model. Model selection was guided by a significant Breusch–Pagan Lagrange-Multiplier test, which rejected simple pooling in favor of random effects, and a highly significant Hausman test, which in turn favored fixed over random effects.

Across this alternative estimation approach, we observe striking consistency with our dynamic PMG results: the long-run signs and magnitudes on economic policy uncertainty, FDI growth, GDP per capita growth, and the exchange rate remain virtually unchanged.

Notably, trade openness—insignificant in the PMG long-run equation—emerges as a statistically significant explanatory factor under fixed effects, reinforcing the idea that active reserve management responds to shifts in trade flows.

The overall alignment between the static fixed-effects coefficients and those from the ARDL–PMG model lends strong support to the reliability and validity of our core conclusions. In other words, whether we allow for heterogeneous short-run dynamics (as in PMG) or focus solely on time-invariant within-country variation (as in fixed effects), the evidence consistently underscores the negative impact of policy uncertainty, rapid GDP growth, and trade openness on reserve accumulation, alongside the positive roles of FDI inflows and exchange-rate adjustments.

Table 8. *Fixed effect model*

Variable	Coefficient	P-Vlaue
epu	-.0051549	0.080
fdig	1.055278	0.008
gdpg	-.2342429	0.035
er	.0776498	0.008
tradeg	-.1450812	0.016
constant	15.72291	0.000
F(3, 75)	23.13	0.0000
Hausman test chi2(5)	100.06	0.0000
BG LM test chibar2(01) for RE	5.6543	0.0043

Source: *Own work.*

4.6.3 Post Estimation Diagnostic Test

Table 9 reports a comprehensive suite of post-estimation diagnostics, all of which confirm the adequacy of our chosen specifications. First, the Breusch–Godfrey LM test indicate no remaining serial correlation in the panel residuals, ruling out autocorrelation concerns. Second, Pesaran's cross-sectional dependence test fails to reject the null of independence, demonstrating that unmodeled common shocks do not bias our estimates. Third, Wald test for groupwise heteroskedasticity test returns a high p-value, confirming that the error variance is constant across observations.

Finally, the Jarque–Bera normality test shows that residuals are well-approximated by a Gaussian distribution. Together, these results give us confidence that our inference on the effects of policy uncertainty, growth, trade, and other covariates on foreign-reserve dynamics is both robust and reliable.

Table 9. *Post estimation diagnostic tests*

Issue	Test	coefficient	P-Value
Auto correlation	BG LM test chi2(6)	6.530	0.3665
Cross sectional dependence	Pesaran CD	-0.836	0.4030
Groupwise Heteroscedasticity	Modified Wald test chi2 (4)	7.24	0.1238
Normality	JB	0.2375	0.888

Source: *Own work.*

5. Policy Recommendations

Our findings highlight that elevated economic-policy uncertainty, robust GDP growth, and rapid trade expansions tend to erode Pakistan's external-reserves buffers, while foreign direct investment inflows and episodes of currency weakness bolster them. To safeguard import-cover resiliency, monetary and fiscal authorities should prioritize clarity and predictability in policy communication, by publishing forward-guidance on key fiscal and regulatory measures and coordinating announcements across ministries, to reduce uncertainty-driven reserve drawdowns.

At the same time, maintaining an open and attractive environment for FDI—through streamlined investment approvals, tax incentives for strategic projects, and strengthened investor-protection mechanisms—will continue to channel stable, long-term capital that directly augments reserves.

Given the short-run reserve losses associated with trade surges, the State Bank of Pakistan should refine its intervention toolkit: for example, by deploying targeted currency-swap lines or standing foreign-exchange facilities rather than wholesale reserve sales, so as to smooth exchange-rate volatility with minimal impact on import-cover ratios.

Finally, recognizing that faster GDP growth diminishes precautionary motives, policymakers can use periods of economic expansion to rebuild buffers—setting clear "reserve-replenishment" thresholds tied to GDP and trade-to-GDP ratios—thereby institutionalizing countercyclical reserve management and reducing ad-hoc drawdowns when growth slows.

6. Conclusion

By applying an ARDL–PMG framework to yearly data spanning 2003–2023, we have shown that BRIC's reserve accumulation is governed by a mix of precautionary, valuation, and intervention motives. In the long run, policy ambiguity and domestic growth dampen reserve growth, whereas FDI inflows and currency-valuation effects strengthen buffers.

Short-run dynamics reveal that trade shocks precipitate meaningful reserve drawdowns as the central bank smooths FX volatility, while error-correction speeds vary markedly across economies of BRIC countries.

These coherent short- and long-run patterns, robust to fixed-effects specification tests, underscore the critical importance of minimizing policy-induced uncertainty, strategically leveraging capital-inflow channels, and refining intervention strategies to preserve adequate import-coverage in an increasingly volatile global environment.

7. Limitations

While our ARDL–PMG analysis delivers robust insights into BRIC's reserve dynamics, it is not without constraints. First, we rely on a single, aggregate measure of economic policy uncertainty; disaggregating EPU into fiscal, monetary, and regulatory components could reveal more nuanced channels. Second, our yearly frequency may mask intra-year volatility, particularly around major policy announcements, so higher-frequency (quarterly, monthly or weekly) data might capture short-lived reserve interventions more precisely.

Third, although we control for key macro-financial drivers, omitted variables—such as sovereign credit ratings, contingent central-bank liabilities, or geopolitical risk—could exert additional influence on reserve behavior. Finally, our focus on the four BRIC countries limits generalizability; BRIC's institutional and external-sector characteristics may differ markedly from those of other emerging markets.

8. Future Research Directions

Building on this foundation, future studies could explore several avenues. Extending the analysis to a broader cross-section of emerging and frontier economies would test the external validity of our findings and uncover region- or regime-specific patterns. Incorporating event-study techniques around high-impact policy announcements could sharpen our understanding of the immediate reserve-management response to discrete shocks.

Researchers might also employ time-varying parameter models or Markov-switching frameworks to capture nonlinearity and structural breaks—such as those induced by the Global Financial Crisis or the COVID-19 pandemic—in the EPU–reserves nexus. Finally, micro-data on central-bank balance sheets, sovereign-bond holdings, and banking-sector FX positions could enable a more granular examination of the channels through which policy uncertainty propagates into official foreign-exchange buffers.

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