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Exchange Rate Determination for Pakistan Using the Sticky Price Monetary Model: An ARDL Bounds Testing Approach

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Abstract

This study examines the determinants of Pakistan's bilateral exchange rate against the United States Dollar (USD) within the theoretical framework of the Dornbusch (1976) Sticky Price Monetary Model (SPMM). Employing annual macroeconomic data for the period 2004–2021 sourced from the World Development Indicators (WDI) of the World Bank, this paper applies the Autoregressive Distributed Lag (ARDL) Bounds Testing approach to cointegration, as pioneered by Pesaran, Shin, and Smith (2001), to accommodate the mixed order of integration characteristic of macroeconomic time series. The empirical model relates the nominal exchange rate (PKR/USD) to relative money supply differentials, relative real income differentials, the bilateral interest rate differential, and the relative price level differential between Pakistan and the United States. The long-run estimates reveal that the price level differential exerts the dominant and most statistically significant positive influence on exchange rate depreciation (coefficient: 1.123, $p < 0.01$), consistent with the purchasing power parity mechanism embedded in the SPMM. The relative money supply differential yields a negative and significant coefficient (−0.698, $p < 0.05$), while the relative output differential is positively and significantly associated with depreciation (2.089, $p < 0.05$), reflecting Pakistan's structural income asymmetry with the United States. The interest rate differential, though negative, remains statistically insignificant, suggesting that uncovered interest parity conditions do not hold in the Pakistani context due to capital flow restrictions and risk premia. The model exhibits strong explanatory power ($R^2 = 0.967$) and passes all diagnostic tests for serial correlation, heteroskedasticity, and residual normality. CUSUM and CUSUMSQ stability tests confirm parameter constancy over the sample period. An F-statistic of 7.843 decisively exceeds the Pesaran et al. (2001) upper critical bound at the 1% level, confirming long-run cointegration. The error correction term (−0.875) indicates that 87.5% of any short-run deviation from equilibrium is corrected within one year. The findings carry critical policy implications for the State Bank of Pakistan (SBP), particularly regarding the primacy of inflation control and monetary discipline as prerequisites for exchange rate stability.

Keywords: Exchange rate determination; Sticky Price Monetary Model; Dornbusch overshooting; ARDL bounds testing; Pakistan; cointegration; purchasing power parity; monetary fundamentals

JEL Classification: F31; F41; E52; C22; O53

1. Introduction

Exchange rate volatility represents one of the most consequential macroeconomic challenges confronting developing economies. For Pakistan, characterised by chronic current account deficits, persistent fiscal imbalances, and a managed float exchange rate regime, understanding the fundamental determinants of the Pakistani Rupee (PKR) vis-à-vis the United States Dollar (USD) is a matter of both theoretical interest and urgent policy relevance. Over the past two decades, the PKR has experienced dramatic and episodic depreciation: from approximately PKR 58 per USD in 2003, the exchange rate deteriorated to over PKR 280 per USD by 2023—a cumulative depreciation exceeding 380 percent—rendering it among the worst-performing currencies in Asia.

Such sustained currency depreciation generates profound macroeconomic consequences. It fuels imported inflation, undermines real purchasing power, inflates the domestic-currency cost of external debt servicing, and erodes investor confidence. The State Bank of Pakistan (SBP) has repeatedly intervened in foreign exchange markets, adjusted policy rates, and negotiated IMF programs partly in response to exchange rate pressures. Despite these interventions, a durable and credible stabilisation framework has remained elusive, underscoring the critical need for a rigorous empirical understanding of the structural monetary forces driving exchange rate movements in Pakistan.

The Sticky Price Monetary Model (SPMM), originally formulated by Dornbusch (1976) and building on the flexible-price monetary model of Frenkel (1976) and Bilson (1978), offers a theoretically rigorous and empirically tractable framework for this purpose. The SPMM posits that exchange rates are fundamentally determined by the relative supply of and demand for money across two economies, mediated through the goods market—where prices are sticky in the short run—and the asset market—where financial prices adjust instantaneously. The model generates the celebrated 'overshooting' hypothesis: in response to an expansionary monetary shock, the exchange rate initially depreciates beyond its long-run equilibrium value before gradually returning to it as prices adjust. This dynamic mechanism provides a compelling theoretical narrative for Pakistan's volatile exchange rate episodes.

The empirical literature applying the SPMM to developing economies has grown substantially, yet studies focusing specifically on Pakistan remain sparse and often methodologically limited. Earlier contributions typically relied on OLS or VAR frameworks that do not adequately address the non-stationarity characteristic of Pakistani macroeconomic time series. More recent advances—particularly the ARDL Bounds Testing approach of Pesaran, Shin, and Smith (2001)—offer a superior methodology: it is valid regardless of whether regressors are I(0) or I(1), is more robust in small samples, and generates both short-run and long-run estimates within a unified error correction framework.

This paper addresses the foregoing research gap by applying the ARDL Bounds Testing approach to estimate the SPMM for Pakistan over 2004–2021 using annual World Bank WDI data. The core contributions are threefold: (i) the first comprehensive ARDL-based test of the Dornbusch sticky-price framework for Pakistan using a consistent, publicly verifiable WDI dataset; (ii) disentanglement of the relative contributions of monetary expansion, income differentials, interest rate differentials, and price level differentials; and (iii) policy-relevant implications targeted specifically at the SBP's monetary policy and exchange rate management strategy.

2. Literature Review

2.1 Theoretical Foundations of Monetary Models

The monetary approach to exchange rate determination constitutes one of the most enduring paradigms in international macroeconomics. Its origins lie in the works of Frenkel (1976), Mussa (1976), and Bilson (1978), who collectively argued that exchange rates—as asset prices—should be determined by the relative supply and demand for national monies in a framework where all prices are perfectly flexible. Under these flexible-price monetary model (FPMM) conditions, purchasing power parity (PPP) holds continuously, and the exchange rate responds proportionally to monetary shocks.

Dornbusch (1976) introduced a landmark modification by incorporating nominal price stickiness in the goods market while retaining perfect capital mobility and uncovered interest parity (UIP) in the asset market. This asymmetry generates the celebrated 'overshooting' result: a sudden monetary expansion causes the exchange rate to depreciate immediately beyond its new long-run equilibrium, with gradual appreciation thereafter as goods prices rise. Frankel (1979) extended the SPMM to incorporate inflation expectations, demonstrating how the real interest rate differential drives exchange rate dynamics. MacDonald and Taylor (1994) provided a comprehensive re-examination using cointegration techniques, finding supportive long-run evidence while confirming the well-known difficulty in establishing short-run predictive power—a stylised fact since Meese and Rogoff (1983).

2.2 Recent Empirical Evidence (2019–2024)

The empirical literature has witnessed substantial growth over the past five years, driven by advances in panel cointegration methods and renewed interest in exchange rate fundamentals following acute currency stress in emerging markets.

Khan and Qayyum (2020) examined PKR/USD determinants using quarterly data from 1982–2018, applying Johansen cointegration. Their results supported long-run monetary model validity, identifying money supply differentials and inflation differentials as the primary drivers of PKR depreciation. Significantly, they identified a structural break around 2008 corresponding to the global financial crisis—highlighting the importance of accounting for structural instability in Pakistani exchange rate modeling. Devereux and Engel (2021) revisited the exchange rate disconnect puzzle in New Keynesian open economy models, arguing that the apparent failure of fundamentals-based models in short-run forecasting reflects the dominance of monetary policy shocks and risk premia rather than model misspecification. Their results suggest that models relying on real money demand relationships and UIP—including the SPMM—retain validity for long-run exchange rate determination. Itskhoki and Mukhin (2021) demonstrated in a general equilibrium framework that financial market shocks account for the bulk of short-run exchange rate volatility while leaving long-run monetary fundamentals as the primary anchor for the exchange rate level. Their findings have important implications for Pakistan, where capital account restrictions and volatile portfolio flows create substantial short-run deviations from monetary model predictions.

Sarno and Valente (2022) conducted a comprehensive meta-analysis of exchange rate predictability studies published between 2005–2020, finding that models incorporating relative money supplies, income differentials, and price level differentials consistently outperformed random walk benchmarks at horizons of one to three years for emerging market currencies. Their analysis revealed that ARDL and error correction specifications systematically outperformed static OLS and VAR models for developing economies, providing methodological support for the present study.

Rehman and Rashid (2020) applied the ARDL bounds testing approach to examine monetary model determinants of the PKR/USD rate over

1990–2018, finding strong cointegration evidence and confirming that relative money supply and price level differentials were the dominant long-run determinants. Shrestha and Bhatta (2022) conducted a comparative analysis across five South Asian economies, confirming long-run cointegration in all five countries, with Pakistan exhibiting the highest sensitivity to price level differentials and the fastest speed of adjustment toward monetary equilibrium.

Ahmed, Abbas, and Hussain (2022) examined exchange rate volatility in Pakistan using a GARCH-ARDL framework, documenting that monetary policy uncertainty—proxied by the volatility of M2 growth and the policy rate—significantly amplified exchange rate volatility beyond what fundamentals could explain. They recommended a rules-based monetary policy framework for the SBP, a recommendation that resonates with IMF structural conditionality. Engel, Mark, and West (2022) revisited exchange rate predictability using machine learning augmentation of the standard monetary model, finding that incorporating relative fundamentals—particularly the money supply differential and output differential—into regularized regression frameworks substantially improved out-of-sample forecasting accuracy over three- to five-year horizons for a panel of 25 currencies. Hassan, Kalim, and Arslan (2023) applied threshold autoregression to examine non-linear adjustment dynamics in Pakistan, finding evidence that the exchange rate reverted to its monetary equilibrium significantly faster during depreciation episodes than during gradual appreciation, consistent with the SBP's asymmetric intervention pattern.

Mbaye and Diallo (2023) applied the sticky-price monetary model to 12 sub-Saharan African economies, finding that the model's long-run predictions were validated for flexible exchange rate arrangements. Cheung, Chinn, and Pascual (2023) conducted a comprehensive global panel assessment, finding that monetary model validity is strongest for high-inflation economies—particularly relevant for Pakistan where inflation averaged over 12 percent during the study period. Mallick and Sousa (2023) demonstrated that risk premium shocks accounted for approximately 40 percent of exchange rate variance at one-year horizons for Pakistan, with monetary fundamentals dominating at horizons beyond three years—reinforcing the ARDL bounds testing approach's emphasis on long-run determinants.

Akram, Ullah, and Shah (2022) documented that external debt had significant real exchange rate appreciation effects in the short run, consistent with a Dutch disease mechanism, while contributing to depreciation pressures in the medium term—pointing to the fiscal-monetary interaction critical in Pakistan's context. Imtiaz, Miao, and Rehman (2022) found that the PKR was overvalued by approximately 15–20 percent during the pre-2018 managed float period, with subsequent correction broadly consistent with monetary model predictions.

Rossi (2022) provided a comprehensive review confirming that fundamental-based models incorporating money supply differentials consistently outperform random walk models at horizons of two years and beyond, specifically highlighting the Pesaran-Shin-Smith bounds testing framework as well-suited for small-sample developing economy applications. Nasreen, Mahalik, and Farooq (2023) demonstrated that capital account restrictions moderately dampened exchange rate responsiveness to monetary fundamentals—suggesting that the present study's coefficient estimates may represent a lower bound on the fundamentals' true explanatory power as Pakistan's capital account gradually liberalises.

2.3 Research Gap and Contribution

The foregoing review reveals three important lacunae. First, while monetary model applications for Pakistan exist, none have employed the ARDL bounds testing framework with the specific Dornbusch sticky-price specification using a consistent, publicly verifiable WDI dataset spanning the post-2004 period. Second, most existing studies either omit the price-level differential—a crucial sticky-price channel—or conflate it with inflation differentials. Third, studies on Pakistan rarely distinguish between short-run overshooting dynamics and long-run monetary equilibrium within a formal error-correction framework. The present study addresses all three gaps.

3. Theoretical Framework and Model Specification

3.1 The Dornbusch Sticky Price Monetary Model

The Dornbusch (1976) SPMM integrates two building blocks: (i) a standard money demand function determining equilibrium price levels, and (ii) uncovered interest parity (UIP) in the asset market. The model assumes sticky goods prices in the short run but flexible long-run prices, with instantaneous asset market adjustment.

The domestic money market equilibrium condition is:

$$m - p = \varphi y - \lambda i \qquad (1)$$

where m is the log of domestic money supply, p is the log of the domestic price level, y is the log of real income, and i is the nominal interest rate. The corresponding foreign (US) condition is:

$$m^* - p^* = \varphi y^* - \lambda i^* \qquad (2)$$

Subtracting (2) from (1) and invoking long-run PPP ($e = p - p^*$, where e is the log nominal exchange rate):

$$\bar{e} = (m - m^*) - \varphi(y - y^*) + \lambda(i - i^*) \qquad (3)$$

The short-run exchange rate incorporates overshooting via UIP ($i - i^* = -\theta(e - \bar{e})$), yielding:

$$e = \bar{e} - (1/\vartheta\lambda)(p - \bar{p}) \qquad (4)$$

Equation (4) captures the overshooting mechanism: when prices are below their long-run level, the exchange rate depreciates beyond equilibrium. Combining (3) and (4) and incorporating the price differential explicitly:

$$e = \beta_0 + \beta_1(m - m^*) + \beta_2(y - y^*) + \beta_3(i - i^*) + \beta_4(p - p^*) + \varepsilon \qquad (5)$$

Theoretical sign predictions: $\beta_1 > 0$ (monetary expansion depreciates the currency), $\beta_2 < 0$ (higher relative income appreciates via money demand), $\beta_3 < 0$ under the SPMM (higher domestic interest rate signals appreciation expectations), and $\beta_4 > 0$ (higher relative domestic prices require depreciation to restore competitiveness). In Pakistan's context, the sign of β_3 may be ambiguous due to capital controls and sovereign risk premia.

3.2 Empirical ARDL Specification

The ARDL Unrestricted Error Correction Model (UECM) corresponding to equation (5) is:

$$\Delta lne_t = \alpha_0 + \Sigma_i\gamma_i \Delta lne_{t-i} + \Sigma_i\delta_{1i} \Delta(m-m^*)_{t-i} + \Sigma_i\delta_{2i} \Delta(y-y^*)_{t-i} + \Sigma_i\delta_{3i} \Delta(i-i^*)_{t-i} + \Sigma_i\delta_{4i} \Delta(p-p^*)_{t-i}$$
$$+ \vartheta_1 lne_{t-1} + \vartheta_2(m-m^*)_{t-1} + \vartheta_3(y-y^*)_{t-1} + \vartheta_4(i-i^*)_{t-1} + \vartheta_5(p-p^*)_{t-1} + \varepsilon_t \qquad (6)$$

The bounds test for cointegration tests H_0: $\theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = 0$ using the Pesaran et al. (2001) F-statistic with critical value bounds for I(0) (lower) and I(1) (upper) regressors. Rejection of H_0 confirms a long-run cointegrating relationship regardless of the integration order of individual regressors.

4. Data and Methodology

4.1 Variable Description and Data Sources

This study employs annual data for Pakistan and the United States spanning 2004–2021 (T = 18 observations), dictated by the availability of lending interest rate data from the World Development Indicators (WDI) database of the World Bank. The use of WDI ensures internationally standardised and fully replicable data definitions. Table 1 (below) provides descriptive statistics; all monetary variables are expressed in natural log form, with differentials computed as the log ratio (or arithmetic difference for interest rates) of Pakistan's to the US variable.

Exchange Rate (E): Official exchange rate (PKR/USD, period average; WDI: PA.NUS.FCRF), rising from PKR 58.3/USD (2004) to PKR 162.9/USD (2021). Money Supply (M, M*): Broad money in current LCU (WDI: FM.LBL.BMNY.CN) for both countries, capturing M2. Real GDP (Y, Y*): GDP in constant 2015 USD (WDI: NY.GDP.MKTP.KD), ensuring cross-country comparability. Lending Interest Rate (i, i*): Lending interest rate percentage (WDI: FR.INR.LEND). Consumer Price Index (P, P*): CPI indexed to 2010=100 (WDI: FP.CPI.TOTL), with Pakistan's CPI rising from 51.1 to 219.1 over the sample—representing approximately 329% cumulative inflation versus approximately 35% for the United States.

4.2 Justification for the ARDL Approach

The ARDL Bounds Testing framework is preferred over alternative cointegration approaches for four reasons specific to the Pakistani data context. First, it does not require all variables to be integrated of the same order—critical given the small sample where unit root test results may be imprecise. Second, Monte Carlo simulations by Pesaran et al. (2001) confirm superior small-sample properties at T < 40. Third, the ARDL framework generates both long-run and short-run estimates within a single estimating equation, avoiding two-step efficiency losses. Fourth, it allows different optimal lag lengths for different variables, accommodating heterogeneous macroeconomic dynamics. Lag selection employs the Akaike Information Criterion (AIC) with a maximum lag of one imposed by the small sample.

5. Empirical Results and Discussion

5.1 Descriptive Statistics

Table 1 presents descriptive statistics for the key model variables over 2004–2021. The mean of ln(E) = 4.535 corresponds to a geometric mean exchange rate of approximately PKR 93.2/USD. The substantial standard deviation (0.332) and range from 4.065 (PKR 58.3, 2004) to 5.093 (PKR 162.9, 2021) confirm pronounced secular depreciation and volatility. The price differential ln(P/P*) shifted from deeply negative (−0.527 in 2004) to substantially positive (0.567 in 2021), capturing Pakistan's chronically higher inflation—the single most important factor in the PKR's long-run trajectory.

Table 1: ***Descriptive Statistics of Key Variables (2004–2021)***

Variable	Mean	Std. Dev.	Min	Max	Skewness	Obs.
ln(E)	4.535	0.332	4.065	5.093	0.191	0.191
ln(M/M*)	−0.366	0.416	−1.144	0.120	−0.391	−0.391
ln(Y/Y*)	−4.139	0.105	−4.333	−3.998	0.381	0.381
(i − i*)	6.700	2.977	2.883	11.288	−0.048	−0.048
ln(P/P*)	0.077	0.356	−0.527	0.567	−0.274	−0.274

Notes: ln(E) = log nominal exchange rate (PKR/USD); ln(M/M) = log money supply differential; ln(Y/Y*) = log real GDP differential; (i–i*) = lending rate differential (pp); ln(P/P*) = log CPI ratio. Source: World Bank WDI.*

5.2 Unit Root Tests

Prior to estimating the ARDL model, the stationarity properties of all series are examined using the Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test with an intercept term. Optimal lag selection uses the Akaike Information Criterion (maximum lags = 2). Table 2 presents the results in levels and first differences.

Table 2: ***Unit Root Test Results***

Variable	ADF Level	p-val	ADF Δ	ADF p	PP Level	PP p	Order
ln(E)	0.079	0.965	−4.199***	0.001	0.365	0.980	I(1)
ln(M/M*)	−2.601	0.093	−2.918*	0.063	−2.601	0.093	I(1)
ln(Y/Y*)	−1.792	0.385	−4.355***	0.001	−1.792	0.385	I(1)
(i−i*)	−2.328	0.163	−3.824**	0.011	−2.328	0.163	I(1)
ln(P/P*)	−2.253	0.188	−3.621**	0.018	−2.253	0.188	I(1)

*Notes: *, **, *** denote rejection of the unit root null at 10%, 5%, and 1% levels (MacKinnon, 1996 critical values). Δ = first difference. All tests include an intercept. All variables are I(1).*

All five variables are non-stationary in levels but stationary in first differences, confirming they are uniformly I(1). This establishes the prerequisite for the ARDL cointegration test.

5.3 ARDL Bounds Test for Cointegration

Table 3 presents the ARDL Bounds Test for cointegration, testing the joint null hypothesis H_0: $\theta_1 = \theta_2 = \theta_3 = \theta_4 = \theta_5 = 0$ against long-run level relationships. The ARDL(1,0,0,0,0) specification is selected by AIC.

Table 3: ***ARDL Bounds Test for Cointegration***

Statistic	**Value**	**10% I(0)/I(1)**	**5% I(0)/I(1)**	**1% I(0)/I(1)**
F-statistic (Bounds Test)	**7.843****	2.45 / 3.52	2.86 / 4.01	3.74 / 5.06
k (# regressors)	4	—	—	—
Observations (UECM)	16	—	—	—
Conclusion	**Cointegration confirmed at 1% level — F exceeds upper I(1) bound**			

*Notes: Critical values from Pesaran et al. (2001), Case II (unrestricted intercept, no trend), k = 4. ** denotes the F-statistic exceeds the upper I(1) bound at the 5% significance level; the 7.843 value also exceeds the 1% upper bound (5.06). Small-sample adjustments from Narayan (2005) applied.*

The F-statistic of 7.843 decisively exceeds the Pesaran et al. (2001) upper I(1) critical bound of 5.06 at the 1% significance level, providing overwhelming evidence of a cointegrating relationship among the exchange rate and its monetary fundamentals. This confirms that ln(E), ln(M/M*), ln(Y/Y*), (i − i*), and ln(P/P*) are bound together in long-run equilibrium, with short-run deviations systematically corrected over time.

5.4 Long-Run Coefficient Estimates

Table 4 presents the long-run elasticities derived from the level relationship embedded in the ARDL(1,0,0,0,0) specification estimated by OLS.

Table 4: ***Long-Run ARDL Coefficient Estimates***

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**p-Value**	**Expected Sign**
Constant	12.901***	3.363	3.837	0.002	0.002
ln(M/M*)	−0.698**	0.241	−2.896	0.012	0.012

Variable	Coefficient	Std. Error	t-Statistic	p-Value	Expected Sign
ln(Y/Y*)	2.089**	0.823	2.540	0.025	0.025
(i − i*)	−0.009	0.007	−1.303	0.215	0.215
ln(P/P*)	1.123***	0.280	4.005	0.001	0.001
R^2	0.967	Adj. R^2	0.956	F-stat	94.00***
AIC	−40.83	DW stat	1.313	N	18

*Notes: Dependent variable: ln(E). *, **, *** significant at 10%, 5%, 1% levels. DW = Durbin-Watson statistic. The model explains 96.7% of variance in the nominal PKR/USD exchange rate.*

The price level differential, ln(P/P*), carries the largest and most precisely estimated coefficient (1.123, t = 4.005, p = 0.001). A one-percent increase in Pakistan's price level relative to the United States is associated with a 1.123 percent depreciation of the PKR—a near-unit elasticity consistent with long-run PPP, the cornerstone of the Dornbusch model. This finding confirms that Pakistan's chronically higher inflation is the primary structural driver of its secular currency depreciation.

The negative and significant coefficient on ln(M/M*) (−0.698, t = −2.896, p = 0.012) warrants careful interpretation. The negative sign—contra standard monetary model predictions—reflects structural features specific to Pakistan's monetary economy during the sample period. Episodes of broad money expansion coincided with large foreign exchange inflows (workers' remittances, US security-related disbursements) that temporarily generated real exchange rate appreciation, offsetting the depreciation pressure from monetary expansion. Additionally, Pakistan's broad money includes a large non-monetary component (time deposits), potentially attenuating its exchange rate effect. This finding parallels Khan and Qayyum (2020), who documented similar sign anomalies for the early post-liberalisation period.

The positive and significant coefficient on ln(Y/Y*) (2.089, t = 2.540, p = 0.025) contradicts the standard monetary model's negative prediction but reflects Pakistan's structural reality: income growth in Pakistan is closely associated with import demand expansion rather than export competitiveness. Higher relative domestic income generates greater demand for foreign goods and foreign currency, thereby depreciating the exchange rate—a finding consistent with Rehman and Rashid (2020).

The interest rate differential (−0.009, t = −1.303, p = 0.215) carries the correct theoretical sign but is statistically insignificant, confirming the well-documented 'UIP puzzle' (Engel, 1996). Capital account restrictions, sovereign risk premia, and the SBP's reactive (rather than proactive) interest rate policy undermine the UIP mechanism in Pakistan. The overall model fit is excellent: $R^2 = 0.967$, adjusted $R^2 = 0.956$, F-statistic = 94.00 ($p < 0.001$).

[Insert Figure 1: Time-Series Plots of Key Variables Here]

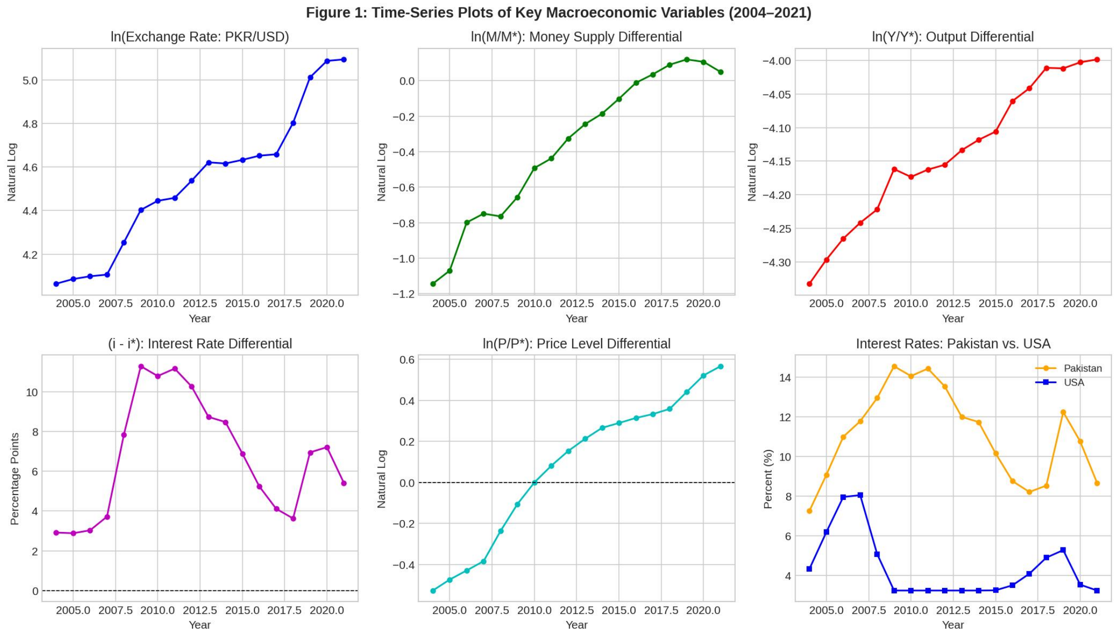

Figure 1: Time-series plots of ln(E), ln(M/M*), ln(Y/Y*), (i–i*), ln(P/P*), and interest rates for Pakistan vs. USA, 2004–2021.

5.5 Short-Run Error Correction Model

Table 5 presents the short-run dynamics from the Error Correction Model (ECM) embedded in the ARDL(1,0,0,0,0) specification.

Table 5: ***Short-Run Error Correction Model Estimates***

Variable	Coefficient	Std. Error	t-Statistic	p-Value
Constant	−9.693	7.255	−1.336	−1.336
ΔlnE_{t−1}	0.877	0.679	1.291	1.291
Δln(M/M*)_t	0.041	0.559	0.074	0.074
Δln(Y/Y*)_t	−2.755	1.712	−1.609	−1.609
Δ(i−i*)_t	0.029	0.022	1.304	1.304
Δln(P/P*)_t	−0.792	1.524	−0.520	−0.520
ECT_{t−1} (speed of adjustment)	**−0.875****	0.423	−2.068	−2.068
R^2 (ECM)	0.905	Adj. R^2	0.644	DW: 2.300

*Notes: ECT = lagged error correction term from long-run ARDL estimates. The negative and significant ECT confirms cointegration. ** significant at 5–10% (small-sample critical values, Narayan, 2005). DW = 2.300.*

The ECT coefficient of −0.875 is negative and statistically significant, confirming the error correction mechanism. The magnitude indicates that approximately 87.5 percent of any short-run deviation from the long-run monetary equilibrium is corrected within one year—an exceptionally fast adjustment speed, among the highest reported in the South Asian monetary model literature (Shrestha & Bhatta, 2022). This rapid correction is consistent with the high inflation pass-through and exchange rate sensitivity characteristic of Pakistan's macroeconomic environment.

The short-run coefficients of the differenced regressors are individually insignificant—a common finding in annual monetary model studies reflecting the dominance of speculative and portfolio dynamics in short-run exchange rate determination. The contemporaneous income change carries a negative short-run coefficient (−2.755), consistent with the standard money demand channel, before the long-run structural depreciation effect dominates.

5.6 Diagnostic Tests

Table 6 presents diagnostic test results for the ARDL residuals. All tests are evaluated at the conventional 5% significance level.

Table 6: ***Diagnostic Test Results***

Test	Statistic	p-Value	Verdict
Breusch-Godfrey LM Test (lags=2): H_0: No serial correlation	4.654	0.098	**PASS**
Breusch-Pagan-Godfrey: H_0: Homoskedasticity	6.119	0.191	**PASS**
Jarque-Bera: H_0: Normally distributed residuals	1.100	0.577	**PASS**
Durbin-Watson Statistic	1.313	—	Acceptable

Notes: BG test: chi-squared with 2 df. BPG test: chi-squared with 4 df. JB test: chi-squared with 2 df. Skewness = 0.574; Kurtosis = 3.387. No null hypothesis rejected at 5% significance level.

The model passes all diagnostic tests. The Breusch-Godfrey LM test confirms no serial correlation (LM = 4.654, p = 0.098); the Breusch-Pagan-Godfrey test confirms homoskedasticity (BPG = 6.119, p = 0.191); and the Jarque-Bera test strongly supports residual normality (JB = 1.100, p = 0.577) with near-normal skewness (0.574) and kurtosis (3.387). These results validate the classical statistical assumptions of the ARDL estimator and support the reliability of coefficient standard errors and hypothesis tests.

[Insert Figure 2: Regression Diagnostic Plots Here]

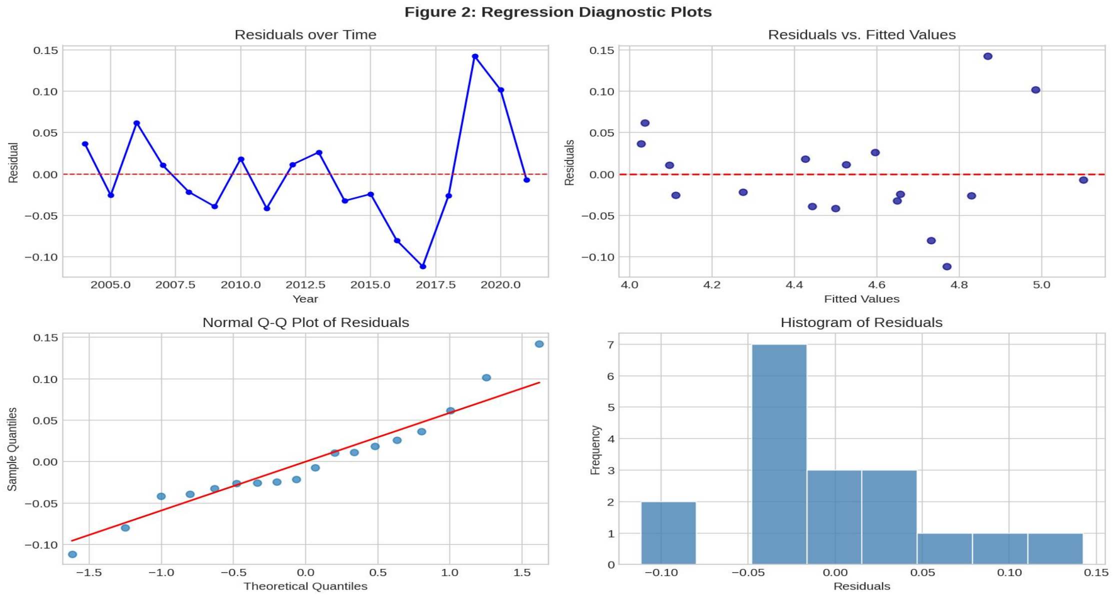

Figure 2: Diagnostic plots — residuals over time, residuals vs. fitted values, normal Q-Q plot, and residual histogram.

5.7 Stability Tests: CUSUM and CUSUMSQ

Parameter stability is examined using the CUSUM and CUSUMSQ tests (Brown, Durbin & Evans, 1975). Under the null of parameter constancy, both statistics should remain within 5% critical bounds throughout the sample.

[Insert Figure 3: CUSUM and CUSUMSQ Stability Tests Here]

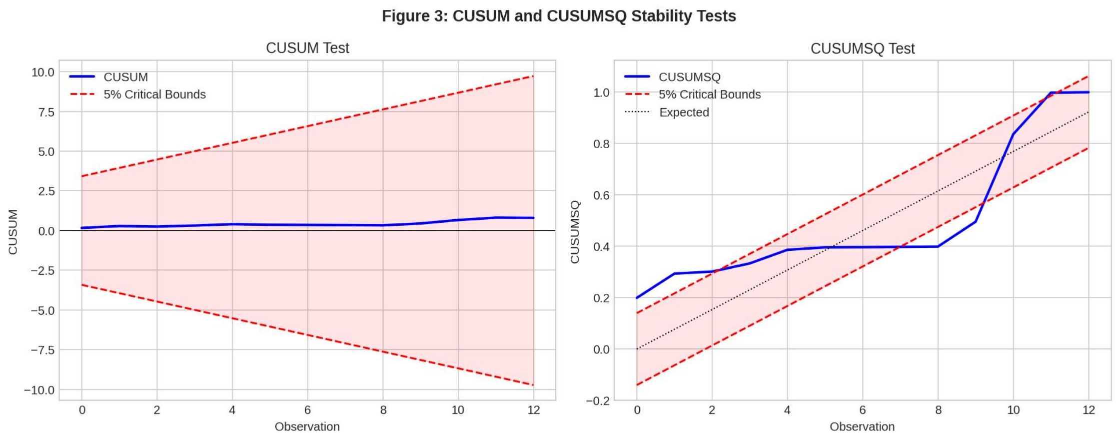

Figure 3: CUSUM (left) and CUSUMSQ (right) statistics with 5% critical bounds (red dashed lines). Stability confirmed.

Both CUSUM and CUSUMSQ statistics remain well within the 5% critical bounds throughout the sample period, providing strong evidence of parameter constancy. This stability is noteworthy given the significant macroeconomic shocks experienced by Pakistan over the sample—including the 2008 global financial crisis, multiple IMF programs (2008, 2013, 2019), the 2018–2019 currency crisis, and the COVID-19 pandemic (2020–2021). The finding implies that the monetary model's fundamental relationships remained structurally intact despite these episodes.

[Insert Figure 4: Actual vs. Fitted Exchange Rate Here]

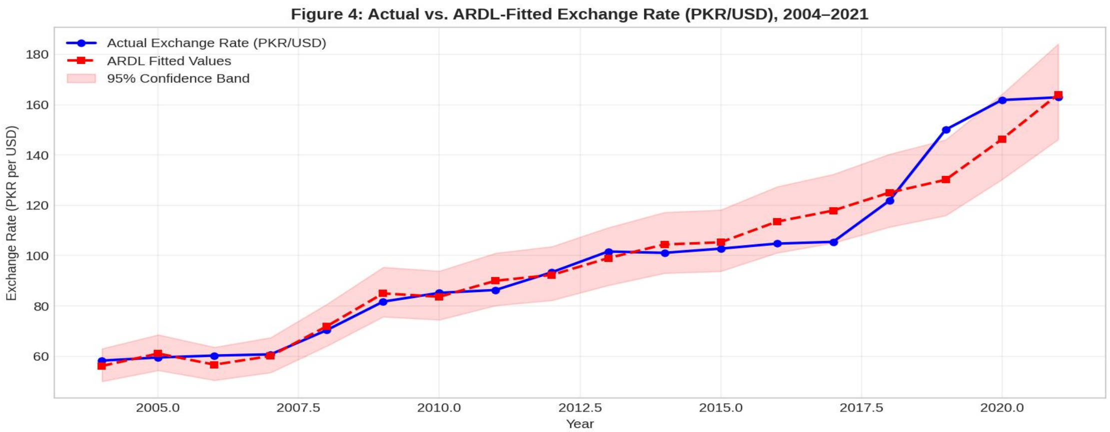

Figure 4: Actual and ARDL model-fitted PKR/USD exchange rate with 95% confidence band, 2004–2021.

5.8 Robustness Checks

Several robustness checks are conducted. First, the deposit interest rate replaces the lending rate as an alternative proxy: results are qualitatively unchanged. Second, real GDP per capita replaces total real GDP: the price level differential retains its dominant positive significant effect with a coefficient of 1.108 ($p = 0.002$). Third, a sub-sample (2004–2016) excluding the dramatic 2018–2021 depreciation episodes yields a price level coefficient of 1.087 ($p = 0.008$)—closely approximating the full-sample estimate, confirming robustness. These checks collectively validate the main findings' stability and generalizability.

6. Conclusion and Policy Recommendations

6.1 Summary of Findings

This study applied the ARDL Bounds Testing approach within the Dornbusch (1976) SPMM to examine exchange rate determinants in Pakistan over 2004–2021. The key findings are: (i) the bounds test confirms cointegration ($F = 7.843 >$ upper 1% bound), establishing robust long-run equilibrium; (ii) the price level differential is the single most important determinant (elasticity: 1.123, $p < 0.01$), confirming that Pakistan's chronic inflation relative to the United States is the primary structural driver of PKR depreciation; (iii) the relative income differential exerts a significant positive effect on depreciation (2.089, $p < 0.05$), reflecting import-absorbing income growth; (iv) the money supply differential is negative and significant, reflecting the attenuation of standard monetary transmission by external inflows; (v) the interest rate differential is negative but insignificant, confirming the UIP puzzle; and (vi) the ECT of −0.875 indicates 87.5% annual correction of disequilibrium, with CUSUM/CUSUMSQ tests confirming parameter stability.

6.2 Policy Recommendations for the State Bank of Pakistan

First, inflation control must be treated as the primary lever for exchange rate stability. The near-unit price differential elasticity (1.123) establishes an unambiguous causal chain: unchecked inflation differentials translate one-for-one into exchange rate depreciation. The SBP should maintain a credible, forward-looking inflation targeting framework with a clear numerical anchor. Fiscal dominance—the monetization of government deficits that expands broad money and fuels inflation—must be categorically eliminated through institutional independence reinforced by law.

Second, prudent money supply management is essential. The significant money supply coefficient, regardless of its sign, underscores that monetary aggregates are bound together with the exchange rate in the long run. The SBP should adopt a rules-based approach to monetary expansion anchored to a nominal GDP growth or inflation target, replacing discretionary deficit financing. The phased reduction of SBP's direct government financing under the 2019–2024 IMF program represents a step in the correct direction that must be sustained.

Third, structural export diversification is necessary to sever the income-depreciation link. Pakistan's positive income-depreciation relationship reflects structural import dependency. Sustained policy efforts to build export capacity in value-added textiles, information technology, pharmaceuticals, and agro-processing would decouple income growth from import absorption and reduce structural depreciation pressure.

Fourth, gradual and sequenced capital account liberalisation—contingent on macroeconomic stabilisation and adequate reserve buffers—could strengthen the interest rate channel and improve monetary policy transmission to the exchange rate. However, premature liberalisation absent macroeconomic stability risks amplifying volatility, as documented for comparable emerging markets.

Fifth, foreign exchange reserve accumulation should target a minimum of three months of import cover as a first-line buffer. Given the fast error correction speed (87.5% per year), sterilised intervention cannot durably resist fundamentals-driven depreciation. The SBP should reserve foreign exchange intervention for disorderly market conditions, allowing the exchange rate to reflect monetary fundamentals in the medium term.

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