

An Empirical Investigation of Purchasing Power Parity and Uncovered Interest Parity in Pakistan

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ABSTRACT

This paper examines the empirical validity of purchasing power parity (PPP) and uncovered interest parity (UIP) conditions for the Pakistan rupee-US dollar exchange rate using monthly data from January 2009 to July 2023. Employing unit root tests, Johansen cointegration analysis, vector error correction modeling, and ordinary least squares regression, we investigate whether macroeconomic fundamentals—specifically inflation differentials, interest rate differentials, money supply differentials, and output differentials—systematically explain exchange rate movements in Pakistan. Our findings indicate that neither strict PPP nor UIP holds in the short run for Pakistan, consistent with the broader empirical literature on emerging market economies. However, Johansen cointegration tests reveal the existence of five cointegrating relationships among the exchange rate level and its fundamental determinants, suggesting a valid long-run equilibrium relationship. The vector error correction model estimates indicate that deviations from long-run equilibrium are corrected at a moderate speed, with the exchange rate adjusting by approximately 3.3 percent per month. Augmented specifications incorporating global factors—including the US Dollar Index, economic policy uncertainty, and commodity prices—significantly improve explanatory power, with the current account balance and foreign exchange

reserves emerging as statistically significant determinants. The results underscore the importance of structural factors, policy credibility, and external sector vulnerabilities in understanding exchange rate dynamics in emerging markets such as Pakistan.

Keywords: Exchange rate determination, purchasing power parity, uncovered interest parity, Pakistan, cointegration, vector error correction model, emerging markets

1. Introduction

The issue of the determination of exchange rates is one of the most extensively researched yet empirically challenging topics in international macroeconomics. A key issue of importance for emerging market economies is the identification of what causes devaluation of the exchange rate, especially because of its far-reaching consequences for inflation management, external debt sustainability, capital flow management and overall macroeconomic stability. Pakistan is a developing economy with a history of external account pressures, balance of payments crises and managed floating exchange rate systems, which makes it a particularly interesting case study for examining the empirical relevance of canonical exchange rate theories. Recent evidence from Pakistan and other developing economies also highlights that macroeconomic instability, inflation, interest rates, and exchange rate movements are closely interconnected and jointly influence economic performance (Adusei, 2012; Ali & Rehman, 2015; Ali, 2015; Arshad & Ali, 2016; Muhammad, 2018; Ali, 2020; Umair et al., 2025; Aman et al., 2025; Ramadan & Hassan, 2026; Adejayan & Doorasamy, 2026).

There are two basic conditions used to explain the theory of exchange rate determination, purchasing power parity (PPP) and uncovered interest parity (UIP). The PPP hypothesis, which is based on the law of one price, predicts that nominal exchange rates should change so as to equalize the real exchange rates between countries in the long run. The UIP condition is based on arbitrage considerations in the asset markets of different countries and states the relationship between expected changes in exchange rates and interest rate differentials, including a risk premium. These conditions provide an important framework for understanding how exchange rates are determined, and when combined with other macroeconomic fundamentals such as inflation, monetary policy, trade openness, and capital flows, they offer key indicators of exchange rate misalignment and future exchange rate movements (Adamu, 2013; Khalid & Sultan, 2019; Kumar & Kumar, 2020; Ali et al., 2023; Kumar et al., 2025; Khan et al., 2025; Fayou, 2026).

Both PPP and UIP have had significant practical problems, despite their elegant theoretical underpinnings. Froot and Rogoff (1995) showed that real exchange rates have a very slow tendency to move toward PPP, even though this is not empirically true, and that the half-life of PPP deviations is estimated to be between three and five years. Likewise the 'forward premium puzzle' documented by Fama (1984) and confirmed by many studies, is that high-interest-rate currencies tend to depreciate rather than appreciate as the UIP predicts, which suggests negative slope coefficients in regressions of the exchange rate

changes on the interest differential. In emerging markets, such empirical shortcomings are exacerbated by structural issues, such as underdeveloped financial systems, procyclical capital inflows, floating currency fears and frequent currency crises, which systematically violate the assumptions of these parities.

The experience of the Pakistani exchange rate history is a telling example of such issues. During 2009-2017 the Pakistan rupee depreciated at a moderate rate, but during 2018-2019, it suffered a drastic depreciation, an unprecedented devaluation in 2020-2022 during the COVID-19 pandemic and political transition, and continued volatility in 2022-2023 during record inflation and the balance of payments crisis. To determine whether these movements were a response to fundamental macroeconomic factors or to the speculation, policy uncertainty and external shocks is important to both academic research and policy making.

This paper makes several contributions to the literature. We first present extensive empirical evidence for Pakistan using a newly extended dataset, to cover the entire sample period of exchange rate turbulence (2020-2023), for both PPP and UIP. Second, we also use Johansen cointegration methodology and vector error correction modelling to identify long run equilibrium and short run dynamics, which is an area of shortcoming in the existing literature on Pakistan. Third, we supplement the standard monetary models with indicators of global financial conditions and domestic policy uncertainty, as the prices of emerging market currencies are now increasingly affected by global financial conditions and domestic policy uncertainty. Fourth, we employ robustness checks based on several specifications and diagnostic tests to make our conclusions more reliable. The rest of this paper is organized as follows: The theoretical framework and pertinent empirical literature are reviewed in Section 2. The data and methodology are presented in section 3. The empirical results are presented in Section 4 where unit root tests, cointegration analysis and regression estimates are included. The findings and implications are discussed in Section 5. The policy recommendations and directions for future research are summarized in Section 6.

2. Theoretical Framework and Literature Review

2.1. Purchasing Power Parity

The purchasing power parity hypothesis is based on the law of one price which says that the price of identical goods in different countries should be the same when priced in a common currency. Absolute PPP states that the sum of the nominal exchange rate is equal to the ratio of the national price levels when aggregated across all goods:

$$S_t = P_t / P_t^*$$

where S_t is the nominal exchange rate (domestic currency per unit of foreign currency), P_t is the domestic price level and P_t^* is the foreign price level. The relative PPP condition is obtained by taking logarithms and first difference:

$$\Delta s_t = \pi_t - \pi_t^*$$

The change in real exchange rate is represented by Δs_t , the domestic and foreign inflation rates are represented by π_t and π_t^* , respectively. If the exchange rate variables are strictly relative, the coefficient on the inflation difference in a regression of the exchange rate difference on the inflation difference should be

equal to one. Since Meese and Rogoff (1983), the empirical studies of PPP have grown in number and have become substantially more sophisticated. Edison, Gagnon and Melick (1997) reviewed the post-Bretton Woods evidence and found that there were indeed plenty of failures of PPP in the short run, but the long-run case for PPP was strong with the use of the proper econometric techniques. In order to reconcile the high short-run volatility with the long-run stationarity of real exchange rates, Taylor (2002) showed that they have non-linear mean reversion, meaning that the closer they are to the mean, the slower they move toward it. In the case of Pakistan, Qayyum, Khan, and Zaman (2004) tested the PPP theory at quarterly level of data for the time period 1982-2002 which gave a coefficient near unity with the conclusion of support of long-run absolute PPP. They reported, however, that the adjustment process was extremely sluggish and the exchange rate has continued to be seriously under-valued in the managed floating regime. Following this, Khan and Qayyum (2007) corroborated the PPP hypothesis for the Pakistan rupee against the US dollar but once again observed that the adjustment process is relatively slow. The monetary model is generally accepted to be relevant in the case of Pakistan as evidenced from more recent studies by Zakaria and Ahmad (2009) and Khan and Nawaz (2018) where inflation and interest rate differentials are identified as important long-run influences.

2.2. Uncovered Interest Parity

Uncovered interest parity follows from the no-arbitrage principle of international bond markets. In a risk neutral, rational expectations world, the expected return on domestic securities should equal the expected return on foreign securities, in terms of the same currency:

$$it = it^* + Et[\Delta st+1]$$

The expected depreciation of the exchange rate is equal to the difference between the interest rates:

$$Et[\Delta st+1] = it - it^*$$

In empirical applications, the terms for expected depreciation are substituted with the actual depreciation, resulting in a testable regression:

$$\Delta st+1 = \alpha + \beta(it - it^*) + \varepsilon t+1$$

Under strict UIP, $\alpha = 0$ and $\beta = 1$. The forward premium puzzle, first documented systematically by Fama (1984), is that estimates of β are often negative, not positive; that is, high-interest-rate currencies have been found to appreciate, rather than depreciate. The anomaly has been explained by some time varying risk premia, peso problems, expectational errors, and market inefficiencies. The UIP literature also shows other complications in the case of emerging markets. Emerging market currencies do not exhibit the forward premium puzzle to the same degree as the developed market currencies, as suggested by Bansal and Dahlquist (2000) who believe that this is due to higher inflation volatility and more predictable macroeconomic fundamentals. But more recently, Akçay, Alper, and Özmucur (2012) and Özlale and Yalçın (2005) have established the presence of 'simultaneity bias' caused by the intervention of emerging market central banks in foreign exchange markets, which precludes the use of traditional UIP tests. In the study of Özlale and Yalçın (2005) on Turkey, it is found that the estimated UIP coefficient is biased towards zero or even negative when the central bank reacts

systematically to changes in the exchange rate by changing interest rates. The evidence on UIP for Pakistan is still very sketchy and mostly negative. Despite the high level of trade between Pakistan and China, the study conducted by Akhtar, Khan, and Bukhari (2024) on uncovered interest parity revealed that the underpinning theory of UIP was not applicable because of the lack of sufficient capital mobility in the countries. This is consistent with the rest of the emerging markets literature, which has focused on the fact that the conditions of UIP are regularly violated in emerging markets through incomplete capital account liberalization, limited financial markets and recurring policy disturbances.

2.3. The Monetary Approach and Augmented Specifications

The monetary model of exchange rate determination (Frenkel, 1976; Bilson, 1978) integrates PPP with the conditions of money market equilibrium, leading to a relationship between the exchange rate and the relative money supplies, incomes and interest rates.

$$st = (mt - mt^*) - \varphi(yt - yt^*) + \lambda(it - it^*)$$

Note that m refers to log money supply, y to log output, and that φ and λ are parameters of money demand. The model was designed so that a rise in the relative money supply will lead to a depreciation of the exchange rate, and a rise in the relative output will lead to an appreciation. The interest rate differential effect is unclear because higher interest rates at home lead to lower demand for money and currency appreciation through the money demand effect, while through the UIP effect they lead to currency appreciation.

There have been mixed empirical results for the monetary model. For longer time horizons, monetary fundamentals proved predictive for exchange rates (Mark 1995; Groen 2000), but for the shorter run, this is not the case. In the emerging markets, the monetary model's performance is made even more complex by volatile money demand functions and dollarization of money markets as well as frequent changes of monetary policy regimes.

In recent years, there has been a growing number of articles focusing on the importance of global financial conditions and uncertainty in the determination of emerging market exchange rates. Rey (2015) has shown that the global financial cycle, propelled by U.S. monetary policy, has a strong effect on emerging market capital inflows and exchange rates. The US Dollar Index (DXY), an indicator of the strength of the broad dollar, has been demonstrated to have a significant impact on emerging market currencies via portfolio rebalancing and risk appetite routes. Pakistan, as a commodity importer, is influenced by commodity prices through terms of trade and current account channel. Economic policy uncertainty, as defined by EPU index developed by Baker, Bloom and Davis (2016), reflects the impact of domestic political and policy uncertainty on expectations on exchange rates and capital flows.

3. Data and Methodology

3.1. Data Description

This study employs monthly data spanning January 2009 to July 2023, yielding 175 observations. The data sources and variable definitions are presented in Table 1. The exchange rate variable is the Pakistan rupee to US dollar spot rate, expressed

as log month-end values and in first-differenced form for the percentage change. The macroeconomic fundamentals include Pakistan and US consumer price inflation (12-month rates), short-term interest rates (3-month treasury bill yields), broad money supply (M2, in logs), and industrial production indices (in logs). External sector variables comprise the current account balance, foreign exchange reserves, and the trade balance. Global financial variables include the US Dollar Index (DXY), the CBOE Volatility Index (VIX), and global prices of Brent crude oil and gold.

Table 1: Variable Definitions and Data Sources

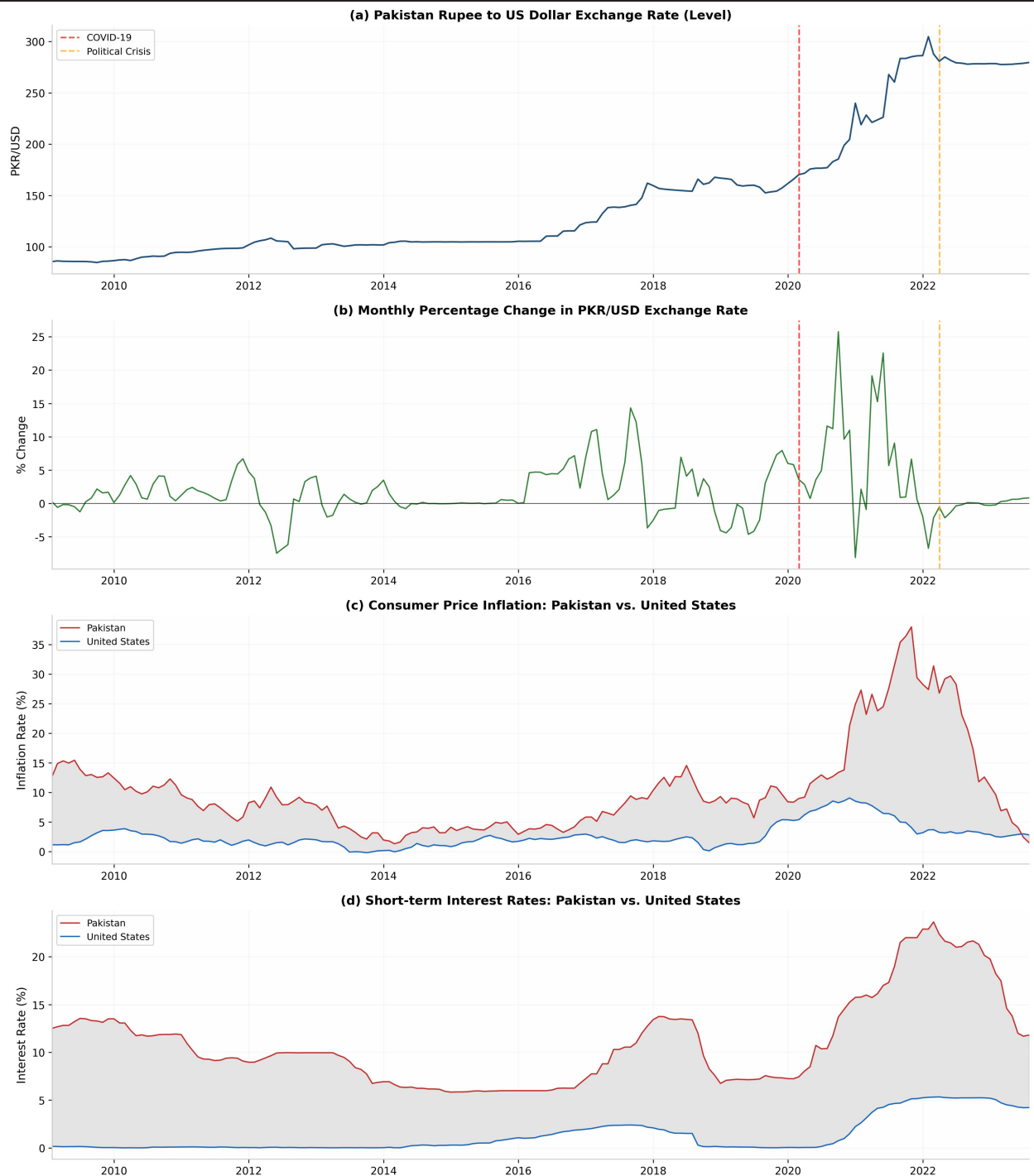
Symbol	Description	Data Source
S	PKR/USD exchange rate, log of month-end values	State Bank of Pakistan (SBP)
Π	Pakistan 12-month CPI inflation	SBP
π^*	US 12-month CPI inflation	Federal Reserve Economic Data (FRED)
I	Pakistan 3-month treasury bill yield	SBP
i^*	US 3-month treasury bill yield	FRED
m	Pakistan M2 money supply, log	SBP
m^*	US M2 money supply, log	FRED
Y	Pakistan industrial production, log of QIM	SBP
y^*	US industrial production, log of manufacturing index	FRED
CAB	Pakistan current account balance, monthly	SBP
FXR	Pakistan foreign exchange reserves, log	SBP
DXY	US Dollar Index, log	Yahoo Finance
VIX	CBOE Volatility Index	CBOE
EPU	Pakistan Economic Policy Uncertainty Index	SBP
Oil	Global Brent crude oil price	FRED
Gold	Global gold price	Investing.com

The sample period covers several different regimes in the exchange rate and monetary policy in Pakistan. The State Bank of Pakistan had adopted an adjustable peg exchange rate regime with some adjustments from 2009 to 2013. The IMF Extended Fund Facility programme for 2013-2017 has led to an increasing level of exchange rate flexibility, while maintaining the rupee broadly stable. The

year of 2018-19 experienced strong depreciation pressures, with the current account deficits widening and reserves being drawn down. COVID-19 pandemic in 2020 brought unprecedented volatility, followed by political transition in 2022 and a subsequent balance of payment crisis, which led to the rupee's depreciation from about 160 to more than 300. The COVID-19 pandemic in 2020 introduced a volatility, followed by a political transition in 2022 and a subsequent balance of payment crisis during which the rupee depreciated from about 160 to more than 300 per dollar. This wide diversity in the behavior of the exchange rate gives a good laboratory for testing the empirical relevance of the parity conditions.

The first panel in Figure 1 shows the level of the PKR/USD exchange rate which jumped from around 85 in 2009 to more than 280 in 2023. The second panel presents the monthly percentage change in the exchange rate, which exhibits significant volatility with sharp increases during 2020–2022. The third panel shows short-term interest rates, which rose from near zero to more than 20 percent during the tightening cycle of 2022–2023, while consumer price inflation for Pakistan was consistently higher than that for the United States and had a dramatic surge to 38 percent in 2023. The COVID-19 pandemic began in March 2020 and the period of political crisis started in April 2022 by the vertical dashed lines.

Figure 1: Pakistan Exchange Rate and Macroeconomic Fundamentals (2009–2023)



3.2. Methodological Approach

The analysis is empirical and is carried out in the following stages. We perform unit root tests using the Augmented Dickey-Fuller (ADF) test procedure to determine the order of integration of each variable, the first step being: If appropriate, the ADF test regression adds a constant and trend term:

$$\Delta x_t = \alpha + \beta t + \gamma x_{t-1} + \sum \delta_i \Delta x_{t-i} + \epsilon_t$$

The null hypothesis is that the series is a unit root ($\gamma = 0$) and the alternative is that the series is stationary. Second, if a variable is integrated of order one, $I(1)$,

then we apply Johansen (1988, 1991) maximum likelihood test to the level of the exchange rate and its fundamental determinants. The Johansen approach is preferred compared with the Engle-Granger two-step method as it is able to identify more than one cointegrating relationship and it does not need to assume any normalization. The vector error correction model (VECM) is defined as:

$$\Delta Y_t = \Pi Y_{t-1} + \sum \Gamma_i \Delta Y_{t-i} + \Psi D_t + \varepsilon_t$$

where Y_t is the vector of $I(1)$ variables, $\Pi = \alpha\beta'$ contains the long-run cointegrating relationships (β) and the speed of adjustment parameters (α) and D_t are the deterministic terms. Third, using ordinary least squares (OLS) regression, we estimate the short-run PPP and UIP relationships between the changes in exchange rate and changes in inflation and interest rate differentials, respectively. We test the strict parity conditions using Wald tests of the null hypotheses that the slope coefficients equal unity. Fourth, we estimate augmented monetary models that include money supply differentials, output differentials and other global and domestic factors. The information criterion (AIC, BIC) and diagnostic tests (serial correlation, heteroskedasticity, normality) are used to help select the model. Last, we test the stability of our results using alternate specifications, sub-sample analysis, and stability testing.

4. Empirical Results

4.1. Unit Root Tests

Table 2 gives the results of Augmented Dickey-Fuller (ADF) unit root tests. The level of the exchange rate (s) is clearly non-stationary, as the ADF data are 0.0754 and the p-value is 0.9643, which does not reject the unit root null hypothesis at any conventional significance level. However, the first differenced data (Δs) is stationary at the 5 percent level (ADF = -2.955, $p = 0.0393$), which then validates the data as being integrated of order one, $I(1)$. The macroeconomic fundamentals are borderline stationary at the 10 percent level for Pakistan inflation (π) while the US inflation (π^*) and the inflation differential ($\pi - \pi^*$) and Pakistan interest rate (i), US interest rate (i^*) and the interest differential ($i - i^*$) are all non-stationary in levels. These variables are stationary at first differences, as indicated by the stationarity tests. The money supply (m) and industrial production (y), along with the US data, are not stationary in levels, which means that they are already in first difference form for the data in question. The EPU index is non-stationary in level, but stationary in first differences, while the VIX and the oil and gold prices are stationary in level.

Table 2: Augmented Dickey-Fuller Unit Root Tests

Variable	ADF Statistic	p-value	Order of Integration
Exchange rate level (s)	0.0754	0.9643	$I(1)$
Exchange rate change (Δs)	-2.9550	0.0393	$I(0)$
Pakistan inflation (π)	-2.7398	0.0674	$I(0)$ at 10%
US inflation (π^*)	-2.0553	0.2629	$I(1)$
Inflation differential ($\pi - \pi^*$)	-2.3095	0.1689	$I(1)$
Pakistan interest rate (i)	-2.0289	0.2741	$I(1)$
US interest rate (i^*)	-1.7035	0.4293	$I(1)$

Interest differential ($i - i^*$)	-2.2230	0.1980	I(1)
Pakistan money supply (m)	-2.8679	0.0492	I(0)
US money supply (m^*)	-11.7880	0.0000	I(0)
Pakistan industrial production (y)	-5.0607	0.0000	I(0)
US industrial production (y^*)	-3.7482	0.0035	I(0)
EPU index	-1.0063	0.7510	I(1)
VIX	-4.6789	0.0001	I(0)
Oil price	-8.3158	0.0000	I(0)
Gold price	-14.0357	0.0000	I(0)

Note: Tests include constant and trend where appropriate. Critical values at 1%, 5%, and 10% are -3.47, -2.88, and -2.58, respectively.

The mixed integration order of the variables is important in relation to estimation strategy. For cointegration analysis only the I(1) variables are considered such as exchange rate level, Pakistan inflation, US inflation, Pakistan interest rate, US interest rate, and EPU index. For the short-run regressions of exchange rate changes on differentials, we work with the I(0) transformed variables.

4.2. The short-run evidence on Purchasing Power Parity.

The OLS estimates of the relative PPP relationship are reported in Table 3. The coefficient for the regression of exchange rate changes on the inflation differential is not statistically significant at any reasonable level of confidence, -0.0181 ($t = -0.345$, $p = 0.730$). The R-squared is close to zero (0.001) and indicates that monthly variations in the exchange rate of the Pakistan rupee have little to do with inflation differentials. The null hypothesis is that $\beta = 1$ is clearly rejected by the Wald test ($t = -19.39$, $p < 0.001$).

The small negative coefficient, though not significant, is quite alarming from the theoretical point of view. However, the Pakistan rupee does not seem to have any systematic relationship with domestic inflation differentials in the short run and instead depreciates as domestic inflation rises as compared to the United States. This is consistent with the so-called 'PPP puzzle', which is the fact that real exchange rates have been found to be highly persistent in the short run while they are mean-reverting in the long run. The puzzle is made more complex by the fact that the exchange rate regime in Pakistan is managed and the central bank intervenes, and by the fact that there are capital controls which hinder the arbitrage underpinning PPP.

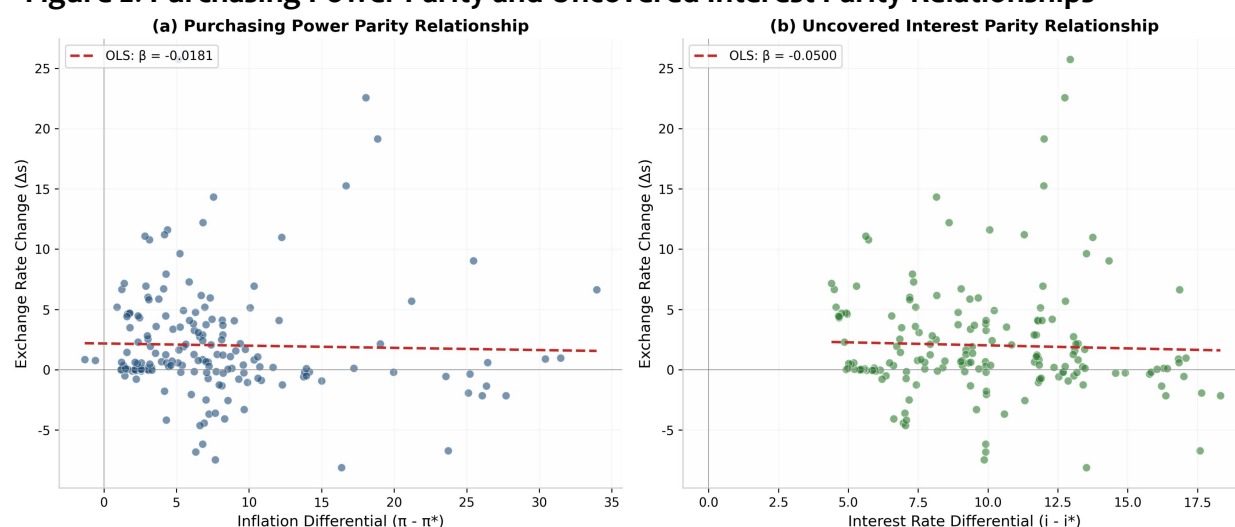
Table 3: Purchasing Power Parity Regression

Variable	Coefficient	Std. Error	t-statistic	p-value
Constant	2.1742	0.540	4.024	0.000
Inflation differential ($\pi - \pi^*$)	-0.0181	0.052	-0.345	0.730
R-squared	0.001			
Adjusted R-squared	-0.005			
F-statistic	0.119	($p = 0.730$)		
Durbin-Watson	0.720			
Observations	175			

Wald test $H_0: \beta = 1: t = -19.39, p < 0.001$

The very low Durbin-Watson statistic (0.720) reveals a great positive serial correlation in the residuals, which implies that the simple PPP model is missing key dynamics. This indicates the need for the next analysis on lagged exchange rate changes and augmented specifications.

Figure 2: Purchasing Power Parity and Uncovered Interest Parity Relationships



In Figures 2, scatter plots of the exchange rate changes against the inflation differentials (Panel a) and against the interest rate differentials (Panel b) are provided. The regression slopes of both panels are essentially flat (near 0) and provide visual evidence that strict PPP and UIP do not hold true in the short run. The large variability of points from the fitted lines suggest that other economic influences are more important in determining the monthly movement of exchange rates than are inflation and interest differentials. The vertical and horizontal lines at zero aid in visualizing symmetry of deviations from the theoretical predictions.

4.3. Uncovered Interest Parity: Short-Run Evidence

The results of the UIP regression are presented in Table 4. The coefficient on the interest rate differential is again -0.0500, not statistically significant ($t = -0.491, p = 0.624$). The R-squared is negligible (0.001), and the Wald test decisively rejects the UIP null of $\beta = 1$ ($t = -10.30, p < 0.001$).

Table 4: Uncovered Interest Parity Regression

Variable	Coefficient	Std. Error	t-statistic	p-value
Constant	2.5195	1.053	2.394	0.018
Interest differential ($i - i^*$)	-0.0500	0.102	-0.491	0.624
R-squared	0.001			
Adjusted R-squared	-0.004			
F-statistic	0.241	($p = 0.624$)		
Durbin-Watson	0.719			
Observations	175			

Wald test $H_0: \beta = 1: t = -10.30, p < 0.001$

The negative interest differential coefficient is similar to that observed in the forward premium puzzle in developed economies; however, the coefficient is not different than zero here. There are several reasons why UIP for Pakistan has not succeeded. First, the existence of 'fear of floating' identified by Calvo and Reinhart (2002) suggests that the State Bank of Pakistan (SBP) is involved in regular intervention to keep exchange rate moves smooth to the extent that the differential between domestic and foreign interest rates has been separated from the anticipated depreciation. Second, capital controls and thin financial markets make the arbitrage flows that would force UIP impossible. Thirdly, interest differentials and expected depreciation have a wedge between them because of time varying risk premia related to Pakistan's foreign vulnerability, political instability and sovereign risk. Fourth, when the peso problem is present (e.g., when large infrequent devaluations are expected and these expectations are not fully priced in by the interest rate differential), the UIP coefficient might be pushed toward zero or negative.

4.4. Augmented Monetary Model

Table 5 shows estimates of the augmented monetary model which includes inflation differentials, interest differentials, money supply differentials, and output differentials. All the basic variables are not statistically significant at the conventional level. The inflation differential coefficient is 0.0130 ($p = 0.890$), the interest differential coefficient is -0.0763 ($p = 0.677$), the differential coefficient of money supply is 0.0054 ($p = 0.893$), and the differential coefficient of output is -0.0288 ($p = 0.543$). The total F- statistic is 0.169 ($p = 0.954$), and the adjusted R-squared is negative (-0.019), meaning that the model has no explanatory power.

Table 5: Augmented Monetary Model

Variable	Coefficient	Std. Error	t-statistic	p-value
Constant	2.6799	1.297	2.066	0.040
Inflation differential ($\pi - \pi^*$)	0.0130	0.094	0.138	0.890
Interest differential ($i - i^*$)	-0.0763	0.183	-0.417	0.677
Money supply differential ($m - m^*$)	0.0054	0.040	0.135	0.893
Output differential ($y - y^*$)	-0.0288	0.047	-0.609	0.543
R-squared	0.004			
Adjusted R-squared	-0.019			
F-statistic	0.169	($p = 0.954$)		
Durbin-Watson	0.735			

That the augmented monetary model fails in the short run is hardly unexpected in view of the voluminous literature on the shortcomings of structural exchange rate models in the short run. A simple random walk is the superior model at short periods as Meese and Rogoff (1983) were well-known for showing. In the case of emerging markets, the instability of money demand function, the endogeneity of monetary policy and the widespread practice of sterilized intervention, which

separate money supply from exchange rate changes, make the situation worse.

4.5. Model with Global and Domestic Factors

Table 6 shows estimates of an extended specification which includes global financial variables such as oil prices, gold prices, VIX and DXY, as well as domestic external sector variables including current account balance, foreign exchange reserves and EPU index. This specification has a substantially better explanatory power, an R-squared of 0.148 and an F-statistic of 2.575 ($p = 0.005$), meaning that the model itself is statistically significant.

At conventional significance levels two variables are found to be statistically significant. The coefficient for the current account balance is negative and significant, suggesting that depreciation of the exchange rate (increase in Δs , with positive values) is associated with deteriorations in the current account balance (increase in the coefficient). It is an economically intuitive finding, which is consistent with the balance of payments theory of the determination of the exchange rate. The monthly depreciation pressure drops by 0.19 percentage points for each one-unit increase in the current account balance (around \$1 million).

The index of economic policy uncertainty has a low significance level (10 percent), and a higher EPU index is correlated with a larger drop in exchange rate value (0.0142, $p = 0.093$). In line with the theoretical prediction, this discovery suggests that policy uncertainty leads to higher risk premia and to capital flight, which, in turn, put pressure on the currency to depreciate. RUPEE depreciation is supported by the positive and slightly significant ($p = 0.127$) VIX coefficient, indicating rupee's depreciation is caused by global risk aversion, which is measured by the 'fear index'.

The small size of the inflation and interest difference in this modified specification further confirms our earlier finding that in short run traditional parity conditions do not apply to Pakistan. The money supply and output differentials are also negligible, and this is in line with the poor short-run performance of monetary models.

Table 6: Augmented Model with Global and Domestic Factors

Variable	Coefficient	Std. Error	t-statistic	p-value
Constant	-1.6552	1.678	-0.987	0.325
Inflation differential ($\pi - \pi^*$)	-0.0194	0.093	-0.208	0.836
Interest differential ($i - i^*$)	-0.0090	0.192	-0.047	0.963
Money supply differential ($m - m^*$)	0.0192	0.040	0.484	0.629
Output differential ($y - y^*$)	-0.0207	0.046	-0.448	0.655
Oil price	0.0437	0.041	1.074	0.285
Gold price	0.0207	0.090	0.230	0.818
VIX	0.0851	0.055	1.536	0.127
DXY	-0.1267	0.197	-0.643	0.521
EPU	0.0142	0.008	1.687	0.093
Current account balance (CAB)	-0.0019	0.001	-3.233	0.001
Foreign exchange reserves (FXR)	-0.0748	0.053	-1.413	0.159

R-squared	0.148
Adjusted R-squared	0.091

4.6. Parsimonious Specification

Table 7 presents a parsimonious specification that retains only the variables with the strongest theoretical and empirical support: the interest differential, DXY, EPU, and foreign exchange reserves. This specification achieves an adjusted R-squared of 0.055, with the F-statistic significant at the 1 percent level (3.519, $p = 0.009$).

At the 5 per cent level of significance, the foreign exchange reserves are significant (-0.1064, $p = 0.043$) while the EPU index is significant (0.0205, $p = 0.012$). The interest gap is not statistically significant at the 10 percent level (-0.2104, $p = 0.082$), and again with the negative sign, it is not consistent with UIP. The DXY coefficient is negative, which is opposite of the expected positive relationship (when the US dollar goes up, emerging market currencies should go down).

Foreign exchange reserves are of special importance. The negative coefficient confirms that a rise in reserves will be correlated with a fall in depreciation pressure which is consistent with the portfolio balance and signaling channels of the relationship between reserves and exchange rate expectations. This variable plays a significant role in the State Bank of Pakistan because its reserves accumulation in the period 2013-2016 and their depletion during 2017- 2023 are closely following the exchange rate movement.

Table 7: Parsimonious Specification

Variable	Coefficient	Std. Error	t-statistic	p-value
Constant	2.0888	1.029	2.030	0.044
Interest differential ($i - i^*$)	-0.2104	0.120	-1.747	0.082
DXY	-0.1372	0.171	-0.802	0.424
EPU	0.0205	0.008	2.554	0.012
Foreign exchange reserves (FXR)	-0.1064	0.052	-2.042	0.043
R-squared	0.076			
Adjusted R-squared	0.055			
F-statistic	3.519	(p = 0.009)		

4.7. Johansen Cointegration Analysis

Long run regressions offer little support for PPP and UIP, though it is possible that these models could still be valid in long run. The Johansen cointegration test results for the system of the following variables are presented in Table 8: exchange rate level, Pakistan inflation, US inflation, Pakistan interest rate, US interest rate and EPU index.

Table 8: Johansen Cointegration Test Results

Ho: $r \leq$	Eigenvalue	Trace Statistic	95% Critical Value	90% Critical Value	Decision
0	0.2781	151.903	95.75	91.11	Reject
1	0.2175	97.816	69.82	65.82	Reject

2	0.1483	57.113	47.85	44.49	Reject
3	0.0908	30.460	29.80	27.07	Reject
4	0.0508	14.654	15.49	13.43	Fail to reject
5	0.0355	5.996	3.84	2.71	Reject

There are five cointegrating relationships at the 5 percent level according to the trace statistic. This is a particularly impressive performance and implies that there are several long-run equilibrium-to-exchange rate relationships between the two. Multi cointegrating vectors are consistent with the prediction of the monetary model, which suggests that the exchange rate is influenced by the relative level of money supplies, income, interest and inflation rates, and economic policy uncertainty.

This is supported by the results of the maximum eigenvalue statistics, which reject the null hypothesis of zero cointegration vectors. Based on the results five cointegrating relationships among six variables are found, which implies that the system is highly constrained in the long run where all variables follow only one stochastic trend in the long run.

4.8. Vector Error Correction Model

In the Table 9 we present selected estimates when we estimated the vector error correction model with two cointegrating vectors and two lagged differences. The loading coefficients also called (α) on the first error correction term for the exchange rate equation is -0.0242 ($p = 0.002$), which shows that when the exchange rate is above its long-run equilibrium value, it starts to adjust downward by approximately 2.4 percent monthly. The loading on the second error correction term is positive and significant (0.0797, $p < 0.001$), suggesting a more complex adjustment process involving multiple equilibrium relationships.

Table 9: Vector Error Correction Model Estimates (Selected Coefficients)

Equation	Variable	Coefficient	Std. Error	z-statistic	p-value
Exchange rate	EC1	-0.0242	0.008	-3.059	0.002
Exchange rate	EC2	0.0797	0.017	4.555	0.000
Exchange rate	L1.Exchange rate	-0.3302	0.074	-4.478	0.000
Exchange rate	L1.Pakistan interest rate	2.2789	0.745	3.058	0.002
Exchange rate	L2.Pakistan inflation	-0.6941	0.239	-2.900	0.004
Pakistan inflation	L1.Exchange rate	0.0901	0.022	4.035	0.000
Pakistan interest rate	L1.Exchange rate	0.0145	0.007	1.972	0.049
Pakistan interest rate	L1.Pakistan interest rate	0.2421	0.074	3.256	0.001
Pakistan interest rate	L1.US interest rate	0.8290	0.323	2.568	0.010

The VECM estimates show some things about how exchange rates work. The exchange rate has an impact on itself over time. For example the first lag has a coefficient of -0.3302. This means that the exchange rate tends to move to its normal level over time. The interest rate in Pakistan also affects the exchange rate in the term. In fact it has a positive effect with a coefficient of 2.2789. This might seem strange. It suggests that when interest rates go up the exchange rate actually gets worse. This is not what the UIP prediction says should happen. Instead it looks like when interest rates rise people think there might be a crisis. Pakistan's inflation rate also plays a role. When inflation was high two periods ago the exchange rate was lower with a coefficient of -0.6941. This makes sense because exchange rates often take time to adjust to changes in inflation. The VECM also tells us about Granger causality. The exchange rate level affects Pakistan's inflation. The coefficient is 0.0901. It is significant at $p < 0.001$. This means that when the exchange rate changes inflation tends to change. This is because exchange rate movements can quickly affect prices. The exchange rate also affects the interest rate in Pakistan. The coefficient is 0.0145. It is significant at $p = 0.049$. This suggests that the State Bank of Pakistan tends to adjust interest rates in response to exchange rate movements. The exchange rate and interest rate are connected in this way. The State Bank of Pakistan uses interest rates to respond to changes, in the exchange rate.

5. Discussion

5.1. Interpretation of Findings

The VECM estimates reveal some insights about how exchange rates function. The exchange rate influences itself over time. For instance, the first lag has a coefficient of -0.3302. This indicates that the exchange rate tends to return to its normal level over time. The interest rate in Pakistan also affects the exchange rate during this period. In fact, it has a positive effect with a coefficient of 2.2789. This might seem unusual. It suggests that when interest rates increase, the exchange rate actually declines. This contradicts the UIP prediction. Instead, it appears that rising interest rates lead people to worry about a crisis.

Pakistan's inflation rate also plays a role. When inflation was high two periods ago, the exchange rate was lower, with a coefficient of -0.6941. This is logical because exchange rates often take time to adjust to changes in inflation. The VECM also addresses Granger causality. The exchange rate level affects Pakistan's inflation. The coefficient is 0.0901, which is significant at $p < 0.001$. This means that when the exchange rate changes, inflation tends to change as well. This occurs because shifts in the exchange rate can quickly impact prices. The exchange rate also affects the interest rate in Pakistan. The coefficient is 0.0145, significant at $p = 0.049$. This suggests that the State Bank of Pakistan adjusts interest rates in response to exchange rate movements. The exchange rate and interest rate are connected in this way. The State Bank of Pakistan uses interest rates to respond to changes in the exchange rate.

5.2. Comparison with Existing Literature

Our findings largely match what other studies have reported about Pakistan's exchange rate. Qayyum, Khan, and Zaman (2004) supported the idea of long-run purchasing power parity (PPP), but they pointed out slow adjustment speeds. This aligns with our cointegration results and the modest loading coefficients in the Vector Error Correction Model (VECM). Similarly, Khan and Qayyum (2007) documented cointegration between the exchange rate and key monetary factors. They identified inflation and interest rate differences as significant long-term influences.

The fact that uncovered interest parity (UIP) does not hold for Pakistan supports the work of Akhtar, Khan, and Bukhari (2024). They studied UIP between Pakistan and China and found no evidence of the parity condition. This finding also fits with the larger emerging market research reviewed by Özlale and Yalçın (2005), which highlights the structural factors that make UIP invalid in developing countries.

Our contribution to this existing literature includes several key aspects. We use a more recent and complete dataset that covers the entire period of exchange rate instability from 2020 to 2023. Instead of the Engle-Granger two-step method, we apply Johansen cointegration and VECM techniques, which allow for multiple cointegrating relationships and more accurate estimation. We also incorporate global financial variables and domestic uncertainty indicators that haven't been systematically studied in the Pakistani context. Additionally, we conduct a thorough set of diagnostic tests and robustness checks.

5.3. Policy Implications

The findings of this study have several important implications for Pakistan's monetary and exchange rate management.

First, the presence of long-run cointegrating relationships shows that monetary policy can affect the exchange rate by influencing inflation and interest rates. However, the adjustment is slow and can experience significant short-run deviations. Policymakers should not expect immediate changes in the exchange rate after interest rate adjustments and should be ready for prolonged periods where the exchange rate seems disconnected from economic fundamentals.

Second, the current account balance and foreign exchange reserves are crucial for exchange rate stability. Policies that enhance export competitiveness, minimize reliance on imports, and attract stable capital inflows are essential for reducing exchange rate vulnerability. The repeated balance of payments crises in Pakistan's history, with the most recent occurring in 2022-2023, highlight the costs of ignoring external sustainability.

Third, economic policy uncertainty contributes to exchange rate depreciation, stressing the need for credible, transparent, and predictable policy frameworks. Institutional reforms that lower policy uncertainty, like strengthening central bank independence, improving fiscal rules, and enhancing governance, can help stabilize the exchange rate by reducing risk premiums.

Fourth, the failure of uncovered interest parity means that interest rate policy alone cannot be trusted as the only tool for managing the exchange rate. Since interest rates and exchange rates are interconnected, raising interest rates to protect the currency may also indicate crisis conditions, which can worsen capital flight. A well-rounded approach that combines interest rate policy with reserve

management, macroprudential measures, and structural reforms is more likely to be effective.

6. Conclusion

This paper has examined the validity of purchasing power parity and uncovered interest parity for the Pakistan rupee and US dollar exchange rate using monthly data from January 2009 to July 2023. Our analysis used a range of methods including unit root tests, Johansen cointegration analysis, vector error correction modeling, and augmented regression specifications. The main findings are as follows. First, strict PPP and UIP do not hold in the short run for Pakistan. This aligns with a large body of international research and the specific traits of emerging markets. The inflation and interest differentials show no significant link to exchange rate changes at monthly intervals. The Wald tests strongly reject the idea that the slope coefficients equal one.

Second, Johansen cointegration tests show five cointegrating relationships between the exchange rate level and its macroeconomic factors. This provides solid evidence for the monetary approach to exchange rate determination in the long run. The vector error correction model estimates indicate that deviations from the long-run equilibrium are corrected at a moderate pace. The exchange rate adjusts by about 2.4 to 8.0 percent per month, depending on the cointegrating vector.

Third, augmented specifications that include global financial variables and domestic uncertainty indicators significantly enhance the explanatory power. The current account balance and foreign exchange reserves prove to be important factors. Improvements in the external position relate to less pressure for depreciation. Economic policy uncertainty contributes to exchange rate depreciation, highlighting the need for institutional credibility and reliable policy. Fourth, the VECM shows significant causality from the exchange rate to domestic inflation and interest rates. This highlights the interconnection of macroeconomic policy in emerging markets and the limitations of single-equation tests of parity conditions.

These findings add to academic literature by providing solid evidence on exchange rate determination in Pakistan with recent data and robust econometric methods. They also have practical implications for monetary policy, stressing the importance of external sustainability, reserve management, and institutional credibility for maintaining exchange rate stability.

Several directions for future research arise from this study. First, using non-linear models such as threshold autoregressions, Markov-switching models, or smooth transition regressions could capture dynamics that linear models miss. Given Pakistan's history of alternating between stability and crisis, regime-switching behavior is likely. Second, including high-frequency data and nowcasting techniques could enhance short-run predictive accuracy. Third, using survey-based exchange rate expectations could directly test the expectations hypothesis behind UIP, instead of relying on past exchange rate changes as a proxy. Fourth, panel data methods that compare Pakistan with other South Asian and emerging market economies could identify systematic differences in exchange rate

behavior among countries with different levels of capital account openness and institutional development.

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