Journal for Social Science Archives

Online ISSN: 3006-3310
Print ISSN: 3006-3302
Volume 3, Number 4, 2025, Pages 112 – 126
Journal Home Page
https://jssarchives.com/index.php/Journal/about

Inflation Persistence and Volatility Dynamics in Pakistan: Empirical Evidence and Policy Insights

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ARTICLE INFO

Article History:

Received:	*July*	*21, 2025*
Revised:	*August*	*30, 2025*
Accepted:	*September*	*25, 2025*
Available Online:	*October*	*06, 2025*

Keywords:

Inflation; Inflation Volatility; Exchange Rate; ARCH-family models; Granger Causality; Pakistan.

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ABSTRACT

Inflation and its volatility pose persistent risks for Pakistan's macroeconomic stability. Using monthly data from February 2021 to June 2024, this study examines the determinants of inflation and models its conditional volatility. The empirical strategy combines unit-root tests, ARCH-family models (GARCH, TGARCH, EGARCH), and Granger causality. In the mean equation, inflation is highly persistent (lagged coefficient ≈ 0.72, $p < 0.01$). Exchange-rate depreciation raises inflation materially (≈ 0.15–0.18, $p < 0.05$), while money supply has a modest effect and exports are small or insignificant in most specifications. Volatility estimates confirm clustering and high persistence: in GARCH(1,1), $\alpha+\beta$ is close to unity (≈ 0.91), indicating long-lasting shocks. TGARCH detects asymmetry, with negative and positive shocks affecting volatility differently. The EGARCH model fits best (AIC ≈ 1.742), capturing asymmetry, highlighting the strong role of the exchange rate, and a weaker effect of exports. Granger tests reveal bidirectional links between inflation and its volatility at longer lags, consistent with a feedback cycle in which high inflation breeds uncertainty and uncertainty raises inflation. Exchange-rate depreciation Granger-causes inflation, while money supply and exports show no short-run causal effects. Overall, inflation in Pakistan is persistent, exchange-rate sensitive, and volatility-driven. The evidence supports policies that stabilize the exchange rate, improve monetary transmission, and strengthen export competitiveness to anchor expectations and reduce price volatility.

Introduction

Inflation remains one of the most persistent macroeconomic concerns in developing economies. Beyond its level, the instability of inflation—how much it fluctuates—shapes investment, savings, wage bargaining, and welfare. Put simply, inflation is a sustained rise in the general price level that reduces the real value of money over time. Its movements are linked to monetary and real factors such as money supply, exchange rate, output, and external shocks. Volatility is the second part of the challenge. Inflation volatility refers to the dispersion or variability of inflation around its mean. In practical terms, higher volatility raises uncertainty about future prices, discourages long-term investment, and can misallocate resources. Much of the contemporary literature treats "inflation volatility" and "inflation uncertainty" as near synonyms. Understanding and measuring this volatility is therefore essential for credible monetary policy and macroeconomic planning.

Inflation is not only about its level (how high prices rise) but also about its stability (how much those prices fluctuate over time). The central idea, highlighted by Friedman (1977), is that higher inflation usually brings greater uncertainty about future prices. This uncertainty can distort economic decisions. Ball (1992) later explained the mechanism in formal models, showing that when inflation is high, it becomes harder for people to predict how governments and central banks will act. As a result, forecasting errors increase, and confidence in policy credibility declines. When uncertainty grows, businesses and households adjust their behavior in ways that hurt the economy. Firms may prefer shorter contracts, postpone long-term investments, and demand higher risk premiums. Even if the average inflation rate is not very high, the instability around it can discourage savings and productive investment, thereby slowing growth.

Pakistan's historical experience underscores the policy relevance. In Pakistan, episodes of rapid price increases have repeatedly eroded purchasing power and complicated policy choices. Inflation averaged low single digits in the 1960s, rose sharply in the 1970s alongside oil price shocks and nationalization, and remained sensitive to policy implementation gaps and external pressures in subsequent decades. Structural and political developments—currency devaluation, inconsistent liberalization, and fiscal and external imbalances—have increased pressures at different times, including pronounced spikes in the late 2000s. These episodes were frequently associated with movements in money supply, changes in energy tariffs, and commodity price swings Batool, Chandia, Sarwar, and Iqbal (2024); (Pervaiz, Manzoor, Gull, & Umar, 2024).

Theory and evidence suggest a close link between inflation and its volatility (Pervaiz, Manzoor, & Gull, 2025). Methodologically, generalized autoregressive conditional heteroskedasticity (GARCH) models and their variants have become standard tools to quantify this volatility and to test how current shocks feed into future variability. Prior applications using monthly data often indicate a positive relationship between inflation and its volatility, including in Pakistan, where GARCH-based studies report that periods of high inflation are accompanied by heightened uncertainty (Din, Din, Khan, & Naheed, 2024). However, important gaps still exist. First, the channels through which key macroeconomic drivers—money supply, exchange rate, and external sector activity—affect inflation and its volatility have not been examined together in a recent Pakistan-specific setting with consistent monthly data. Second, formal causality tests rarely evaluate the direction of influence among these variables alongside volatility models. Addressing both issues can improve the design of stabilization policies by distinguishing drivers of the inflation level from drivers of its instability.

This study examines the determinants of inflation and the dynamics of inflation volatility in Pakistan using monthly data from February 2021 to June 2024. The dependent variable is the inflation rate; explanatory variables include its lag, lagged money supply, exports, and the exchange rate. This choice reflects both monetary and open-economy influences thought to transmit into prices within short horizons. The data are drawn from official national sources for macroeconomic indicators.

The study has three objectives: Firstly, it identifies the determinants of inflation in Pakistan within a short-horizon monthly setting; secondly, it measures the volatility of inflation via ARCH-family models, paying attention to persistence and asymmetry; and finally, it tests for causality among exchange rate, money supply, exports, inflation, and inflation volatility to understand lead–lag relations relevant for policy timing. These objectives translate into testable hypotheses about positive associations between inflation and monetary/external factors and about the linkage between inflation and its volatility. The study provides updated evidence on Pakistan's inflation dynamics in a period marked by shifting exchange-rate policies and evolving monetary conditions. Methodologically, it integrates volatility modeling with formal causality analysis in a compact monthly framework, enabling policy-relevant distinctions between sources of inflation pressure and sources of instability.

Literature Review

The Friedman–Ball view forms the foundation of most studies on inflation and uncertainty (Ball, 1992; Friedman, 1977). Most of the studies on inflation and uncertainty are built on the Friedman–Ball view. Early researchers tried to measure this uncertainty using simple statistical techniques such as rolling variances and squared forecast errors. However, a major methodological breakthrough came with the development of ARCH by Engle (1982). This model allowed researchers to estimate how volatility changes over time rather than treating it as constant. Bollerslev (1986) extended the approach with the GARCH (Generalized ARCH) model, which could capture the persistence of volatility—where periods of calm are followed by calm, and periods of turbulence by further turbulence, a phenomenon known as volatility clustering. Later models introduced asymmetry to reflect that not all shocks have the same effect. The EGARCH (Exponential GARCH) model given by Nelson (1991) allowed positive and negative shocks to affect volatility differently, while Glosten, Jagannathan, and Runkle (1993) developed the GJR-GARCH (Glosten-Jagannathan-Runkle GARCH) model to account for asymmetric effects in volatility, often called the leverage effect. In this model, "bad news" (negative shocks) typically increases volatility more than "good news" (positive shocks) of the same size. Collectively, these models transformed the study of "inflation uncertainty" from a vague concept into something that can be systematically estimated and tested with real data.

Cross-country studies mostly confirm the Friedman–Ball view: when inflation rises, uncertainty about future inflation also rises. In advanced economies, this link is visible, especially when central banks have weak credibility or are starting new inflation-targeting regimes (Conrad & Hartmann, 2019). In such cases, even moderate price increases can create large swings in expectations. By contrast, when institutions are strong and communication is clear, the overall level of uncertainty can remain low. However, sudden large shocks—such as oil price hikes or financial crises—still cause short-term spikes in volatility (Beckmann & Czudaj, 2024). The problem is often worse in developing countries. These economies have fewer buffers, such as strong reserves or credible central banks. Additionally, they experience increased pass-through from exchange rates to domestic prices, making them more vulnerable to supply shocks. For example, swings in the exchange rate or changes in administered energy prices quickly translate into consumer prices (Ha, Stocker, & Yilmazkuday, 2020). Results from ARCH-family models in these settings usually confirm strong volatility persistence. Both ARCH and GARCH terms are often large and significant. Asymmetric models also show that “bad news,” like sudden inflationary shocks, raises volatility more than “good news” of the same size. Granger causality tests add another layer: in most cases, inflation is found to cause higher uncertainty, though in times of currency crises or unstable policies, feedback effects can run in both directions (Balcilar & Usman, 2025).

What drives both inflation and its volatility? Three channels recur. First channel is money growth. Monetarist logic predicts a positive link, especially under fiscal dominance. Stylianou, Nasir, and Waqas (2024) and Pervaiz et al. (2024) showed that monetary aggregates and credit expansions served as the fundamental drivers of inflation in Pakistan. In particular, growth in broad money supply and increased availability of credit to the private sector contributed to persistent upward pressures on prices by stimulating aggregate demand beyond the productive capacity of the economy. This demand-side effect was further reinforced by fiscal imbalances, which often required monetary financing and thereby increased liquidity in circulation. Secondly, the exchange rate also played a significant role. Depreciation raises tradable prices and input costs; pass-through is larger when inflation is already high or credibility is weak (Atiq-ur-Rehman, Munir, & Bashir, 2024). Third, global and administered prices—oil, electricity, and food—arrive in lumpy adjustments that spike headline inflation and its variance (Carriere-Swallow, Firat, Furceri, & Jiménez, 2023).

Energy and commodity shocks are another pillar. In the G7, structural VARs show oil price changes feeding both inflation and interest rates (Wen, Zhang, & Gong, 2021). In food-heavy CPIs, weather and trade policy can swing staples sharply and propagate into headline volatility (Beirne, Renzhi, & Panthi, 2024). These facts underscore a practical point: credible rules and transparent communication can dampen variance even when shocks cannot be fully offset. South Asian evidence is consistent. For India, Khan, Adil, and Husain (2023) find a positive inflation–uncertainty link using GARCH on monthly CPI/WPI. For Bangladesh, ARCH/EGARCH models uncover persistence, asymmetry, and central roles for pass-through and administered prices (Rafa & Basher, 2023). These studies converge on one message: the regime—targeting framework, exchange-rate arrangement, and fiscal discipline—shapes how shocks morph into uncertainty.

Pakistan fits the global story with local dynamics. For example, Jamil and Majeed (2015) showed that higher inflation raised inflation uncertainty and that macro uncertainty interacted with growth. Studies also highlighted the classic drivers—money supply, exchange rate, and administered prices—as the main correlates of Pakistan’s inflation dynamics (Adil, Bhatti, Waqar, & Amin, 2022; Stylianou et al., 2024). Pass-through was non-trivial and state-dependent; it was larger in high-inflation phases and uneven across CPI groups. Volatility models for Pakistan usually found significant persistence (large ARCH+GARCH sums) and asymmetric responses in EGARCH/GJR specifications, consistent with the pattern seen in peer economies (Batool et al., 2024).

Research Methodology

Research Design and Data

This study adopts a quantitative, monthly time-series design to explain Pakistan’s inflation level and to model its conditional volatility. The sample spans February 2021 to June 2024—short enough to reduce regime drift, long enough to capture policy and external shocks. Inflation is measured as the year-over-year CPI rate. Money is M2 growth (Y/Y). The exchange rate is the end-month PKR/USD expressed as a log return so that positive values denote depreciation. Exports are monthly growth in a single currency (kept consistent). Series are aligned to month-end, drawn from official sources, and cross-checked against known events (fuel tariff resets, exchange-rate steps). Transformations target stationarity: log-differences where standard, and year-over-year interpretive value is higher. Seasonality is inspected and, if needed, controlled with monthly dummies. Unit roots are tested using ADF and PP, with KPSS as a complement; potential breaks around policy shifts are screened and handled with shift dummies in robustness.

The analysis proceeds in three steps. First, time-series properties are established using unit-root testing to avoid spurious inference. Second, after confirming the presence of conditional heteroskedasticity, volatility is modeled with ARCH/GARCH to capture persistence in shocks and with asymmetric extensions—EGARCH and TGARCH—to test whether "bad news" and "good news" affect volatility differently. Third, Granger causality tests are applied to trace directional links among inflation, its volatility, money supply, exchange rate, and exports. This combined strategy allows the study to distinguish correlates of the inflation mean from the determinants of its variability while also clarifying temporal precedence.

Econometric Framework

The inflation process is modeled in the mean and in the variance. The conditional mean follows an autoregressive distributed-lag form that embeds monetary and open-economy channels:

$$\boldsymbol{\pi_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \pi_{t-i} + \beta_1 m_{t-1} + \beta_2 er_{t-1} + \beta_3 x_{t-1} + \gamma D_t + \varepsilon_t} \text{ ---------- } (\boldsymbol{i})$$

Where, $\boldsymbol{\pi_t}$ is CPI inflation, $\boldsymbol{m_t}$ is M2 growth, $\boldsymbol{er_t}$ is the exchange rate return (PKR/USD), $\boldsymbol{x_t}$ is export growth, $\boldsymbol{D_t}$ contains seasonality and event dummies, and $\boldsymbol{(\varepsilon_t \sim (0, h_t)}$**.** Lags $\boldsymbol{p}$ are set by AIC/SIC with a monthly cap. Expected sign are $\boldsymbol{\beta_1 > 0}$ (money-inflation link and $\boldsymbol{\beta_2 > 0}$ (depreciation pass- through). While $\boldsymbol{\beta_3}$ is empirical.

The conditional heteroskedasticity is tested on $\boldsymbol{\varepsilon_t}$ using Engle's ARCH LM test. If present, we model $\boldsymbol{h_t = Var(\varepsilon_t | \mathcal{F}_{t-1})}$ with ARCH-family specification.

GARCH(1,1)(baseline):

$$\boldsymbol{h_t = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1}} \text{ ---------- } (\boldsymbol{ii})$$

Capturing volatility clustering via $\boldsymbol{\alpha}$ (shock) and $\boldsymbol{\beta}$ (persistence) (Bollerslev, 1986; Engle, 1982).

EGARCH(1,1) (asymmetry in log-variance):

$$\boldsymbol{lnh_t = \omega + \beta lnh_{t-1} + \alpha \left|\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right| + \theta\left(\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right)} \text{ ---------- } (\boldsymbol{iii})$$

where $\boldsymbol{\theta \neq 0}$ indicates sign asymmetry; negative shocks can raise volatility more than positive shocks (Nelson, 1991).

GJR-GARCH(1,1) (threshold asymmetry):

$$\boldsymbol{\mathrm{h}_t = \varepsilon + \alpha\varepsilon_{t-1}^2 + \gamma I(\varepsilon_{t-1} < 0)\varepsilon_{t-1}^2 + \beta h_{t-1}} \text{ ---------- } (\boldsymbol{iv})$$

With $\boldsymbol{\gamma > 0}$ implying "bad news effects" (Glosten et al., 1993).

Model selection relies on log-likelihood and information criteria, backed by diagnostics on standardized residuals and their squares (Ljung–Box), re-tests for remaining ARCH, and distributional checks. If heavy tails persist, Student-t or GED errors are used, and inference relies on QML-robust standard errors.

Causality, Identification, and Robustness

Temporal precedence is assessed with Granger causality after settling the preferred mean–variance specification. Two questions are central: do money growth, depreciation, or export growth help predict inflation beyond its own lags; and do inflation and its estimated volatility predict each other? Bivariate tests use the standard setup; for example, testing whether $\boldsymbol{m_t}$ Granger-causes $\boldsymbol{\pi_t}$:

$$\boldsymbol{\pi_t = \delta_0 + \sum_{i=1}^{p} \delta_i \pi_{t-i} + \sum_{j=1}^{q} \phi_j m_{t-j} + \mu_t} \quad ---------- \quad (\boldsymbol{v})$$

With $\mathbf{H_0}: \boldsymbol{\phi_1 = \cdots = \phi_q = 0}$. Analogous pairs are run for $\boldsymbol{(er_t, \pi_t)}$, $\boldsymbol{(x_t, \pi_t)}$, and $\boldsymbol{\left(\sqrt{\widehat{h_t},\ \pi_t}\right)}$. If levels show cointegration, a small VECM nests the long-run relationship, while a short-run Granger causality is tested via Wald restrictions on lagged differences, and an error-correction term captures adjustment. Identification is handled through timing, proxies, and sensitivity. Regressors enter with at least one lag to respect information flow and limit simultaneity. As a robustness probe, the bilateral return er_t is replaced by an external currency pressure proxy (e.g., a global dollar index) or by partner-inflation to isolate exogenous components of pass-through. Volatility results are verified across GARCH, EGARCH, and GJR forms and under normal, Student-t, and GED innovations. Because administered prices can create discrete jumps, months with unusually large fuel or electricity adjustments are temporarily excluded, and the models are re-estimated to verify that findings are not event-driven. Definitions are rotated—M2 vs. M1, PKR/USD vs. NEER/REER, y/y inflation vs. seasonally adjusted m/m—to ensure conclusions do not hinge on a single measure.

Estimation proceeds by maximum likelihood with QML-robust inference. We report coefficients, robust standard errors, and test statistics for the mean equation; variance parameters emphasize persistence ($\alpha + \beta$ in GARCH; β in EGARCH) and asymmetry ($\theta\ in\ EGARCH;\ \gamma\ in\ GJR$). Residual diagnostics document cleared serial correlation and absence of leftover ARCH. A short hold-out produces one-step-ahead forecasts for μ_i and h_t; forecast loss comparisons (e.g., MSE for the mean, QLIKE for variance) provide a practical check that the chosen specification predicts as well as it explains.

The design follows established macro-volatility practice while remaining pragmatic for Pakistan's data. It uses official monthly series, transparent transformations, tight timing, explicit variance modeling, and formal causality. It also acknowledges limits on short samples and discrete policy moves. The combination of asymmetry modeling, alternative error distributions, break controls, and repeated diagnostics cannot eliminate these issues, but it strengthens credibility and policy relevance.

Results and Discussion

Result of Unit Root Test

Table 1 reports the results of the Augmented Dickey–Fuller (ADF) unit root tests for all variables. The findings indicate that the inflation rate was stationary with trend at the 10% significance level, while its first difference became strongly stationary at the 1% level with an ADF statistic of –6.7421 (p=0.0000). Similarly, the exchange rate and money supply appeared non-stationary at their levels, as suggested by high p-values (0.9999 and 0.1550, respectively). However, once differenced, both variables turned stationary, supported by large negative test values of –11.9784 and –8.2874, highly significant at the 1% threshold. In contrast, exports were already stationary at level, with an ADF statistic of –9.1125 (p=0.0000), confirming their stability without differencing. Overall, the test outcomes reveal a combination of I(0) and I(1) variables within the dataset.

Table 1: Augmented Dickey Fuller (ADF) Unit Root Tests

Variable	Lag (AIC)	Constant: ADF (p)	Constant + Trend: ADF (p)	Order	Decision
Inflation rate	1	−1.4872 (0.5400)	−3.3011*** (0.0790)	I(0)	Stationary with trend at 10%
Δ Inflation rate	0	−6.7421* (0.0000)	—	I(0)	Stationary
Exchange rate	1	2.1033 (0.9999)	0.4120 (0.9975)	I(1)	Non-stationary at level
Δ Exchange rate	0	−11.9784* (0.0000)	—	I(0)	Stationary
Export	0	−9.1125* (0.0000)	—	I(0)	Stationary
Money supply	2	−2.3650 (0.1550)	−2.4275 (0.3680)	I(1)	Non-stationary at level
Δ Money supply	0	−8.2874* (0.0000)	—	I(0)	Stationary

Notes: Critical values (MacKinnon, 1% / 5% / 10%): with constant −3.62 / −2.94 / −2.61; with constant + trend −4.20 / −3.53 / −3.20. Stars denote significance at 5%, 1%, and 10%.

Heteroscedasticity ARCH- LM test

Table 2 presents the ARCH–LM test applied to the pre-model residuals. The F-statistic was 8.9148 with a probability value of 0.0034, while the Obs*R-squared statistic stood at 7.8462 with a probability of 0.0051. Both results are highly significant, leading to the rejection of the null hypothesis of no ARCH effects. This clearly demonstrates the presence of conditional heteroskedasticity, meaning that the variance of the residuals changes over time and is influenced by past shocks. The detection of heteroskedasticity implies that ordinary least squares (OLS) estimates may be inefficient, and therefore more sophisticated volatility models are required. In this context, the results strongly justify the application of ARCH-family frameworks such as GARCH and EGARCH, which are specifically designed to model volatility clustering. This outcome is consistent with earlier empirical findings in the inflation volatility literature, where similar tests have revealed time-varying variance in macroeconomic data (e.g., Friedman's hypothesis and subsequent studies on developing economies). Thus, the confirmation of heteroskedasticity not only validates the methodological choice but also strengthens the reliability of subsequent model estimations.

Table 2: ARCH-LM Test (Pre-model)

Statistic	Value	df	Prob.	Decision
F-statistic	8.914763	1	0.0034	Reject H_0 (no ARCH). Conditional heteroskedasticity is present.
Obs*R-squared	7.846219	1	0.0051	

Notes: Monthly data, N = 41; LM lag q = 1.

Correlogram squared Residuals

Figure 3 illustrates the correlogram of squared residuals for the estimated model. The autocorrelation (AC) and partial autocorrelation (PAC) values are significant at several lags, particularly at lag 1 where AC is 0.512 and the Q-statistic is 11.600 with a probability of 0.001. Even at higher lags, such as lag 4 (Q=17.740, p=0.001) and lag 12 (Q=30.890, p=0.001), the probabilities remain highly significant. These results suggest that the null hypothesis of no serial correlation in squared residuals is rejected at multiple points, confirming strong evidence of volatility clustering in the data. The persistence of significant Q-statistics across different lags highlights those shocks to inflation are not short-lived; instead, they carry forward, influencing volatility in subsequent periods. This reinforces the earlier ARCH–LM results, which also indicated the presence of conditional heteroskedasticity. From a methodological perspective, these findings provide further justification for the use of ARCH-family models that account for time-varying volatility.

Such patterns are consistent with Engle's (1982) seminal work, where squared residuals often exhibited serial correlation, making ARCH and GARCH models particularly suitable. Moreover, studies on inflation dynamics in developing economies have similarly reported volatility clustering, reflecting the influence of supply shocks, fiscal imbalances, and external disturbances. In line with this literature, the correlogram results here validate the choice of advanced heteroskedasticity models to capture the complex behavior of inflation volatility.

Table 3: Correlogram squared Residuals

Lag	AC	PAC	Q-Stat	Prob
1	0.512	0.512	11.600	0.001
2	0.033	−0.372	11.750	0.003
3	−0.195	−0.008	13.420	0.004
4	−0.301	−0.228	17.740	0.001
5	−0.178	0.121	19.240	0.001
6	0.027	0.059	19.870	0.001
7	0.163	0.176	21.270	0.002
8	0.212	−0.041	24.030	0.001
9	0.076	−0.018	24.620	0.002
10	−0.021	−0.045	24.940	0.004
11	−0.201	−0.290	27.380	0.002
12	−0.267	0.096	30.890	0.001
13	0.078	0.051	31.430	0.002
14	0.221	−0.131	34.670	0.001
15	0.158	−0.012	36.370	0.001
16	0.088	0.027	37.760	0.001

Estimation of ARCH/GARCH model

Table 4 presents the GARCH(1,1) results for inflation in Pakistan. In the mean equation, lagged inflation is highly significant (coef. = 0.7225, p = 0.0000), confirming strong persistence. The constant is also significant (1.1020, p = 0.0000). Money supply has a positive but only marginal effect (0.0660, p = 0.0825). Exchange rate depreciation exerts a clear positive impact on inflation (0.1450, p = 0.0124), while exports show a negative but insignificant effect (–0.0125, p = 0.1275). The variance equation confirms volatility clustering. Both ARCH(1) ($\alpha = 0.1420$, p = 0.0000) and GARCH(1) ($\beta = 0.7720$, p = 0.0000) are significant, with their sum ($\alpha+\beta = 0.9140$) close to unity, indicating that shocks are long-lasting. Model fit is acceptable (log-lik = –31.15, AIC = 1.8350), and the adjusted R^2 (0.5294) shows that about half of inflation variation is explained.

These results imply that Pakistan’s inflation is highly persistent and sensitive to exchange rate movements, reflecting vulnerability to external shocks in an import-dependent economy. The persistence of volatility supports Friedman’s (1977) hypothesis that higher inflation generates greater uncertainty. Overall, the GARCH(1,1) estimates highlight the structural persistence of inflation and the enduring nature of volatility in Pakistan’s macroeconomic environment. These results imply that Pakistan’s inflation is highly persistent and sensitive to exchange rate movements, reflecting vulnerability to external shocks in an import-dependent economy. The persistence of volatility supports Friedman’s (1977) hypothesis that higher inflation generates greater uncertainty. Overall, the GARCH(1,1) estimates highlight the structural persistence of inflation and the enduring nature of volatility in Pakistan’s macroeconomic environment.

Table 4:GARCH(1,1): Determinants of inflation in Pakistan

Panel A: Mean equation (Eq. i)

Regressor	Symbol	Coef.	SE	z-stat	p-value
Inflation CPI	π_{t-1}	0.7225	0.0230	31.413	0.0000
Constant	D_t	1.1020	0.0355	31.058	0.0000
M2	m_{t-2}	0.0660	0.0380	1.737	0.0825
Exchange rate return	$\Delta \ln er_{t-1}$	0.1450	0.0580	2.500	0.0124
Export	x_{t-1}	−0.0125	0.0082	−1.524	0.1275

Panel B: Variance equation (GARCH(1,1)) (Eq. ii)

Parameter	Symbol	Value	SE	z-stat	p-value
Constant	ω	0.0220	0.0120	1.833	0.0668
ARCH(1)	α	0.1420	0.0265	5.358	0.0000
GARCH(1)	β	0.7720	0.0205	37.659	0.0000
Persistence	$\alpha+\beta$	**0.9140**	—	—	—

Notes: Innovation: Student-t; Estimation: ML (QML-robust). Monthly data, May 2015–July 2018 (N = 41); Model fit: Log-lik = −31.15; AIC = 1.8350; SIC = 2.1763; R^2 = 0.5690; Adj. R^2 = 0.5294; DW = 1.2210.

Estimation of TGRACH Test

Table 5 presents the results of the Threshold GARCH (TGARCH) model, which allows for asymmetry by distinguishing the effects of positive and negative shocks on inflation volatility. In the mean equation, lagged inflation remains strongly significant (coef. = 0.7685, p = 0.0000), further confirming persistence in inflationary behavior. The constant term is also significant (0.9820, p = 0.0000), while money supply exerts a positive and statistically significant effect (coef. = 0.0730, p = 0.0369). Exchange rate returns have a positive but weaker impact, being marginally insignificant at the 10% level (p = 0.0968). Exports again show a negative but non-significant relationship (–0.0131, p = 0.1234), similar to the GARCH(1,1) results.

Turning to the variance equation, the TGARCH model reveals important new insights. While the ARCH(1) term is insignificant (α = 0.0665, p = 0.2989), the GARCH(1) parameter is highly significant (β = 0.9585, p = 0.0000), suggesting strong persistence in volatility. Most notably, the leverage parameter (γ = –0.2680, p = 0.0011) is negative and highly significant, confirming the presence of an asymmetric effect. This means that "bad news" shocks (unexpected increases in inflation) tend to reduce volatility less than "good news" shocks, highlighting a nonlinear response of inflation volatility to different types of shocks. The persistence level (α+β = 1.0250) slightly exceeds unity, implying that volatility shocks are highly enduring and may even accumulate over time. The model fit improves slightly over the GARCH(1,1), with a lower AIC (1.780 vs. 1.8350), indicating better explanatory power. These results carry several implications. First, the persistence of inflation again validates Friedman's (1977) hypothesis that high inflation fuels volatility, while the asymmetric effect detected

Table 5:TGARCH(1,1): Determinants of inflation in Pakistan

Panel A: Mean equation (Eq. i)

Regressor	Symbol	Coef.	SE	z-stat	p-value
Inflation CPI	π_{t-1}	0.7685	0.0520	14.778	0.0000
Constant	D_t	0.9820	0.2100	4.676	0.0000
M2	m_{t-2}	0.0730	0.0350	2.086	0.0369
Exchange rate return	$\Delta\ln er_{t-1}$	0.0955	0.0575	1.661	0.0968
Export	x_{t-1}	−0.0131	0.0085	−1.542	0.1234

Panel B: Variance equation (TGARCH/Glosten) (Eq. iv)

Parameter	Symbol	Value	SE	z-stat	p-value
Constant	ω	0.0231	0.0102	2.265	0.0235
ARCH(1)	α	0.0665	0.0640	1.039	0.2989
Leverage (bad news)	γ	−0.2680	0.0820	−3.268	0.0011
GARCH(1)	β	0.9585	0.0370	25.912	0.0000
Persistence	α+β	**1.0250**	—	—	—

Note: Innovation: Normal; Estimation: ML (QML-robust). Monthly data, N = 41; Model fit**:** Log-lik = −29.88; AIC = 1.780; SIC = 2.141.

Estimation of EGARCH Test (Asymmetric Test)

Table 6 presents the EGARCH results, which capture both asymmetry and shock size in inflation dynamics. In the mean equation, lagged inflation is strongly significant (0.8021, p = 0.0000), confirming persistence. The constant is also significant (0.7682, p = 0.0000). Money supply has a positive effect (0.0281, p = 0.0316), while exchange rate depreciation shows a stronger and highly significant impact (0.1760, p = 0.0000) compared to earlier models. Exports are negative and highly significant (–0.0086, p = 0.0000), indicating that greater export activity reduces inflationary pressures. The variance equation highlights clear asymmetry. Both the size effect (–2.8450, p = 0.0000) and asymmetry term (–1.9210, p = 0.0000) are significant, suggesting that positive and negative shocks affect volatility differently. The negative parameter implies that adverse shocks raise volatility less than favorable ones. Unlike GARCH and TGARCH, the persistence parameter (0.0610, p = 0.5827) is insignificant, indicating that shocks dissipate more quickly. EGARCH also provides the best fit, with the lowest AIC (1.742) and highest log-likelihood (–28.94).

Overall, the EGARCH findings confirm strong inflation persistence, emphasize the dominant role of exchange rate movements, and highlight the stabilizing effect of exports. The model also captures asymmetry more effectively than GARCH or TGARCH, showing that shocks are not neutral but differ by direction. This makes EGARCH the preferred framework for explaining Pakistan's inflation volatility.

Table 6:EGARCH(1,1): Determinants of inflation in Pakistan

Panel A: Mean equation (Eq. iii)

Regressor	Symbol	Coef.	SE	z-stat	p-value
Inflation CPI	π_{t-1}	0.8021	0.0280	28.643	0.0000
Constant	D_t	0.7682	0.1562	4.919	0.0000
M2	m_{t-2}	0.0281	0.0131	2.147	0.0316
Exchange rate return	$\Delta\ln er_{t-1}$	0.1760	0.0230	7.652	0.0000
Export	x_{t-1}	−0.0086	0.0007	−12.292	0.0000

Panel B. Variance equation (EGARCH) (Eq. iii)

Parameter	Symbol	Value	SE	z-stat	p-value
Constant	ω	0.6550	0.2323	2.820	0.0048
Size effect	α	−2.8450	0.4649	−6.121	0.0000
Asymmetry (leverage)	θ	−1.9210	0.3393	−5.661	0.0000
Persistence	β	0.0610	0.1112	0.549	0.5827

Notes: Innovation: GED; Estimation: ML (QML-robust). Monthly data, N = 41; Model fit: Log-lik = −28.94; AIC = 1.742; SIC = 2.116.

Post estimation tests

Table 7 reports the post-estimation ARCH–LM test results. The F-statistic (0.2974, p = 0.5867) and Obs*R-squared (0.3221, p = 0.5704) are insignificant, indicating that the null of no ARCH effects cannot be rejected. This confirms that the GARCH/EGARCH framework has successfully captured volatility clustering, leaving no residual heteroskedasticity. The absence of remaining ARCH effects validates the model's reliability. It shows that persistence and asymmetry in inflation dynamics are well explained within the chosen specification. This aligns with Engle's (1982) recommendation that ARCH-family models be verified through diagnostic checks. For Pakistan, where inflation is sensitive to monetary and exchange rate shocks, the robustness of the EGARCH model strengthens the credibility of the empirical results. Overall, the test reassures that the final specification is both methodologically sound and consistent with the broader inflation–volatility literature.

Table 7: ARCH-LM test (Post-model-diagnosis)

Statistic	Value	Df	Prob.
F-statistic	0.2974	1	0.5867
Obs*R-squared	0.3221	1	0.5704

Notes: After preferred GARCH/EGARCH; LM lag q = 1; N = 41.

Estimated Granger Causality Test

The Granger causality results provide mixed evidence on the drivers of inflation in Pakistan. Panel A shows a two-way relationship between inflation and its volatility. Inflation volatility significantly Granger-causes inflation at longer lags ($p = 0.0174$ at lag 6; $p = 0.0091$ at lag 8), while inflation also feeds back into volatility over the same horizon ($p = 0.0088$ at lag 4). This bidirectional link confirms Friedman’s (1977) argument that high inflation and volatility reinforce each other, creating a self-sustaining cycle of instability. Panel B finds no causal link between money supply and inflation in either direction. This result departs from the monetarist view but is consistent with evidence that Pakistan’s weak monetary transmission mechanisms limit the short-run role of money supply in price dynamics.

Panel C highlights the exchange rate as a key determinant. Exchange rate depreciation significantly Granger-causes inflation at lags 6 and 8 ($p < 0.05$), but inflation does not Granger-cause exchange rate changes. This one-way causality underscores the country’s vulnerability to external shocks, particularly given its dependence on imports and exposure to currency fluctuations. Finally, Panel D indicates no causality between exports and inflation. Neither variable significantly influences the other, suggesting that trade flows are shaped by structural and external factors rather than short-term domestic price changes. Overall, the results emphasize that inflation in Pakistan is driven primarily by volatility itself and by exchange rate movements, while money supply and exports play no direct short-run role. These findings highlight the importance of exchange rate management and credible policy frameworks to contain inflationary pressures and stabilize expectations.

Table 8: Granger causality

Null hypothesis	F(4)	p(4)	F(6)	p(6)	F(8)	p(8)	Decision
A) Inflation volatility (INFV) ↔ Inflation (INF)							
INFV does not Granger-cause INF	1.732	0.1679	3.412	0.0174	4.290	0.0091	Reject at 6–8
INF does not Granger-cause INFV	4.116	0.0088	2.287	0.0746	2.198	0.0853	Reject (6–8)
B) Money supply (MS) ↔ Inflation (INF)							
MS does not Granger-cause INF	1.168	0.3342	0.513	0.8046	0.737	0.6451	Do not reject
INF does not Granger-cause MS	0.044	0.9965	0.274	0.9499	0.382	0.9164	Do not reject
C) Exchange rate (EXC) ↔ Inflation (INF)							
EXC does not Granger-cause INF	1.642	0.1792	2.865	0.0261	2.781	0.0214	Reject at 6–8
INF does not Granger-cause EXC	0.812	0.5206	0.941	0.4708	0.902	0.5052	Do not reject

D) Exports (EXP) ↔ Inflation (INF)							
EXP does not Granger-cause INF	0.794	0.5316	0.301	0.9347	0.350	0.9223	Do not reject
INF does not Granger-cause EXP	0.059	0.9940	0.178	0.9809	0.523	0.8114	Do not reject

Conclusion

This study examined the determinants of inflation and its volatility in Pakistan using monthly data from 2021 to 2024. The results show that inflation is persistent and heavily influenced by exchange rate movements. Money supply had only a limited role, while exports were generally insignificant in shaping short-term price dynamics. Volatility analysis confirmed strong clustering effects. Shocks to inflation were not short-lived but carried forward over time. The EGARCH model provided the best fit, capturing both persistence and asymmetry. It showed that adverse and favorable shocks affect volatility in different ways.

Granger causality tests revealed a two-way relationship between inflation and its volatility. High inflation created more volatility, and higher volatility reinforced inflationary pressures. Exchange rate depreciation also emerged as a clear driver of inflation, while money supply and exports did not show causal effects in the short run. Overall, the findings highlight three key points. Inflation in Pakistan is persistent. Exchange rate shocks are the main source of volatility. And the interaction between inflation and its volatility creates a cycle that complicates stabilization efforts. Policy should therefore focus on credible exchange rate management, improving monetary transmission, and reducing structural vulnerabilities. Clear communication and stronger institutions can also help anchor expectations and dampen volatility.

Policy Recommendations

The findings suggest a few important recommendations. First, there is a strong need to strengthen exchange rate management, as currency depreciation was identified as a major driver of inflation. Ensuring a more stable exchange rate through credible interventions and reducing import dependence can help contain inflationary pressures. Second, monetary policy transmission should be enhanced so that policy signals are more effective in influencing credit markets and inflation expectations. A responsive banking system and better coordination between fiscal and monetary authorities can make this possible. Finally, promoting export-led stability is also important. Expanding and diversifying exports will not only bring in foreign exchange but will also ease pressure on domestic prices, thereby reducing the vulnerability of inflation to external shocks.

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