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# The Inflation-Uncertainty Nexus in Bangladesh

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## Abstract

This study examines the relationship between inflation and inflation uncertainty in Bangladesh, a timely issue given the country's recent experience with high inflation. Using monthly data from July 1994 to June 2025, the analysis applies GARCH and EGARCH models to estimate inflation uncertainty and assess the causal relationship between inflation and inflation uncertainty. The findings indicate that inflation has a positive and statistically significant effect on inflation uncertainty. In line with that, Granger causality tests reveal a unidirectional causal relationship between obtained inflation and inflation uncertainty. Unlike the previous studies, this study investigates the Time-Varying Granger Causality (TVGC) test for heterogeneous causal relationship between inflation and inflation uncertainty over the period as suggested by Baum et al. (2022). The results underscore the significance of inflation uncertainty in formulating the monetary policy for price stability in Bangladesh.

**JEL Classification: E31, D81, C32.**

**Keywords:** Inflation, inflation uncertainty, GARCH, EGARCH, Granger Causality, Time-varying Granger Causality.

## Introduction

Inflation is a vital economic phenomenon that reflects the general increase in the prices of goods and services within an economy. In Bangladesh, like in many emerging economies, inflation has been a persistent concern. However, inflation is not just about price increases; it also creates uncertainty about future price movements, which complicates economic decision-making. This inflation-uncertainty nexus—how inflation itself fuels uncertainty and how uncertainty, in turn, affects economic behavior—has significant implications for economic stability. According to Friedman (1977), higher inflation leads to greater inflation uncertainty, which distorts the price mechanism and results in a loss of economic welfare. Similarly, Ball (1992) argues that high inflation introduces uncertainty regarding future monetary policy, as it generates doubt about how policymakers will respond. Additionally, Cukierman and Meltzer (1986) assert that when monetary policymakers operate with discretion and asymmetric information, ambiguity regarding their preferences creates a credibility problem. This leads to the public anticipating higher inflation,

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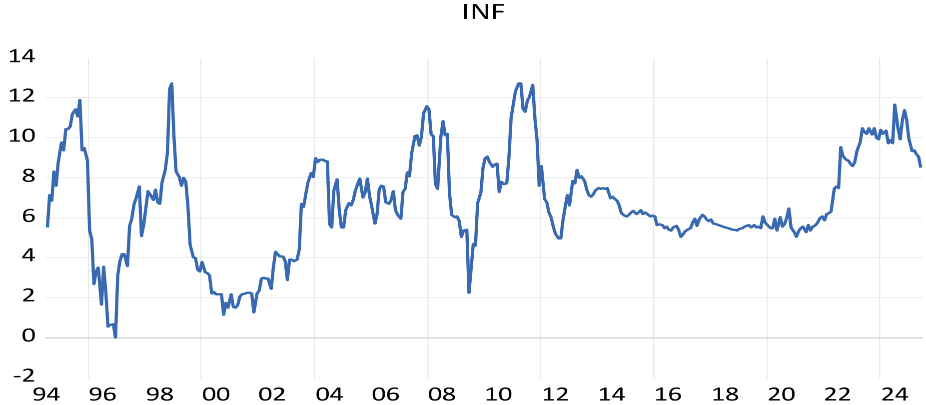
despite no corresponding increase in economic output. It emphasises the need for credibility and transparency in monetary policy. This research aims to explore how inflation and inflation uncertainty interact in Bangladesh's economy and to assess the broader economic implications of this relationship.

In recent years, high inflation has emerged as a significant challenge for Bangladesh, posing serious risks to the stability of the economy. Addressing inflation is critical to stabilising monetary policy and ensuring sustainable economic growth. In this study, we utilise monthly time series data on inflation in Bangladesh spanning from 1994 to 2025. The inflation variable (INF) is plotted in Figure 1, providing a visual representation of its fluctuations over the study period. This data serves as the basis for the empirical analysis, aiming to explore the dynamics of inflation and its potential impact on macroeconomic stability in Bangladesh.

**Figure 1**




The remainder of this paper is structured as follows: Section 2 presents the literature review, Section 3 describes the model specification in this study, Section 4 represents the data and estimation, Section 5 estimates the time-varying causality (TVC) tests, while Section 6 concludes by discussing the implications of the findings.

## 2. Literature Review

The relationship between inflation and inflation uncertainty has been widely studied, with numerous theories and empirical studies offering insights into how inflation affects economic stability. While much of the existing research has focused on developed economies, there is a notable gap in literature concerning developing countries like Bangladesh, where inflation dynamics and policy responses may differ significantly. Golob (1994) examines the relationship between inflation levels and the uncertainty surrounding future inflation. His findings suggest that higher inflation tends to increase inflation uncertainty, thereby complicating economic decision-making. This reinforces the notion that effectively managing inflation is critical to reduce economic unpredictability. In a similar vein, Javed et al. (2012) investigate the relationship between inflation and inflation uncertainty in Pakistan. Using ARMA-GARCH models and the Granger-causality tests the study analyses several decades of data to determine the direction of causality and the persistence of inflation volatility. The results support the Friedman-Ball hypothesis, indicating that higher inflation leads to increased inflation uncertainty. However, they find no evidence to suggest that inflation uncertainty significantly influences inflation rates, in contrast to the Cukierman and Meltzer (1986) hypothesis. This study highlights the importance of controlling inflation to mitigate economic uncertainty and provides valuable insights for monetary policy in emerging economies. Numerous studies have affirmed the Friedman-Ball hypothesis, suggesting that higher inflation increases inflation uncertainty. Brunner and Hess (1993) and Grier and Perry (1998) offer evidence supporting this hypothesis for G7 countries using ARCH and GARCH models, respectively. Similar results have been found in emerging markets, including Turkey (Nas and Perry, 2000; Neyapti and Kaya, 2000) and countries such as Jordan, the Philippines, and Turkey (Ozdemir and Fisunoglu, 2008).

In contrast, other research has provided evidence supporting alternative hypotheses. Baillie et al. (1996) support the Cukierman-Meltzer hypothesis in the UK, suggesting that inflation uncertainty influences inflation. Golob (1994) finds that inflation uncertainty has a positive impact on inflation in the United States, while Ricketts and Rose (1995) observe an increase in inflation uncertainty during periods of high inflation in Canada. However, findings within the US context remain mixed, with Grier et al. (2004) and Karanasos et al. (2004) reporting conflicting effects of inflation uncertainty on inflation. Additionally, studies examining the Devereux and Holland hypotheses reflect the complexity of this relationship across different economies (Fountas et al., 2006; Karanasos and Stefanie, 2008; Thornton, 2007). Collectively, these studies highlight the link between inflation and inflation uncertainty across both developed and developing economies.

In the case of Bangladesh, Lateef et al. (2020) examine four South Asian countries and find that higher inflation increases inflation uncertainty, thereby supporting the Friedman-Ball hypothesis. They emphasise the critical role of stable and credible monetary policy in reducing inflation volatility. Similarly, Hossain (2015) investigates the relationship between inflation volatility, economic growth, and monetary policy in Bangladesh. His study concludes that high inflation volatility adversely affects economic growth, further highlighting the need for consistent and credible monetary policy to stabilise inflation and foster long-term economic development.

Most of the empirical studies on the inflation-inflation uncertainty relationship have adopted a two-stage approach. In the first stage, the GARCH-type models are applied to construct a measure of inflation uncertainty. In the second stage, Granger causality tests are used to explore the direction of the relationship between inflation and inflation uncertainty. According to Fountas and Karanasos (2007), the majority of these studies provide significant support for the hypotheses of Friedman (1977) and Ball (1992), while the hypothesis of Cukierman and Meltzer (1986) receives less empirical backing. The choice of measures used to represent inflation uncertainty—especially in studies utilizing monthly data—plays a crucial role in shaping the observed relationship between inflation and inflation uncertainty (Albulescu et al., 2019; Fountas, 2001).

Most research on the inflation-inflation uncertainty relationship has focused on developed economies, with limited attention given to developing economies like Bangladesh. This gap is significant, as Bangladesh's unique economic structure and inflation dynamics may differ from those of developed markets. Examining this relationship in Bangladesh is crucial for targeted policy recommendations and enhancing understanding of inflation dynamics in emerging economies. This study aims to fill this gap by investigating inflation uncertainty in Bangladesh, contributing to the broader literature on inflation in developing countries.

## 3. Model Specification

The key variables used in the study are inflation and inflation uncertainty. The data are analysed by applying ARCH, GARCH, and EGARCH models. This paper tests for Heteroscedasticity using the method proposed by Brown and Forsythe (1974), which determines whether the variance of the data differs across different time periods. The methodology employed in this paper closely mirrors that of Lateef et al. (2020) and Ananzeh (2015).To check the stationarity of the data, the Augmented Dickey-Fuller (ADF) test is employed. The Autoregressive Conditional Heteroscedasticity (ARCH) model, proposed by Engle (1982), laid the foundation for extensive research on modeling conditional volatility in empirical data. The Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model, also introduced by Engle, extends the ARCH model to better capture volatility clustering and persistence in time series data. These models are used to detect the presence of ARCH/GARCH effects. The ARCH model consists of two main components: the mean equation and the variance equation. In this study, the conditional variance equation is estimated to examine the dynamic behavior of inflation volatility over time.

**Mean equation**: $\mathrm{INF}_t = \mu + \sum_{j=1}^{p} \theta_j \mathrm{INF}_{t-j} + \varepsilon_t$

$\varepsilon_t \sim D(0, \delta_t)$

$\mathrm{INF}_t$ is the inflation and it simply an AR (p) process.

Here,

- $INF_t$ is the inflation rate at time (t ).
- $\mu$ is the constant or intercept of the model. It represents the long-run average inflation level.
- $\theta_j$ are the coefficients for the lags of the inflation series (i.e., the past inflation values). $\theta_j$ represents how much past values of inflation ($INF_{t-j}$) affect the current value of inflation.
- $INF_{t-j}$ is the inflation rate at time of (t-j), which is the value of inflation from (j) periods ago.
- $\varepsilon_t$ is the error term or residual at time (t). It represents the random shock or disturbance in the inflation rate at time (t)), and ideally, it should have zero mean and a certain variance.

**Variance equation:** $\delta_t = \omega_\circ + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-j}^2$

Here,

$\delta_t$ indicates the variance.

$\alpha_j$ are the coefficients that determine how much past squared error terms (the shocks) affect the current volatility.

$\varepsilon_{t-j}^2$ is the squared error term from ( j ) periods ago.

***Inflation Uncertainty***

In 1986, Bollerslev solely developed GARCH model. In this model the conditional variance is dependent on the previous lag and the squared residual terms of the lags. The complete general equation used for the inflation uncertainty series $\delta_t$ is given below.

$$\delta_t = \omega_\circ + \sum_{j=1}^{p} \beta_i \delta_{t-i} + \sum_{j=1}^{q} \alpha_j \varepsilon_{t-j}^2$$

Here,

- $\delta_t$ indicates conditional variance at time ( t ).
- $\omega_\circ$ is constant, representing the baseline level of volatility.
- $\beta_i$ are the coefficients for the lagged conditional variances. They capture the persistence of volatility over time.
- $\delta_{t-i}$ denotes the lagged values of the conditional variance. This term captures the impact of past volatility on current volatility.
- $\alpha_j$ is the coefficient for the lagged squared residuals $\varepsilon_{t-j}^2$, which capture the effect of past shocks (inflation disturbances) on current volatility.
- $\varepsilon_{t-j}^2$ is the squared residuals from past periods. These represent the shocks or disturbances in inflation that influence future volatility.

The exponential generalized Autoregressive conditional Heteroskedasticity proposed by Nelson in 1991 and is used to the model of inflation Uncertainty. It does not impose the non-negativity constraints on the parameters by modeling the logarithm of the conditional variance as compared to conventional GARCH models The EGARCH model is used to test the asymmetries in the terms of negative and positive shocks.

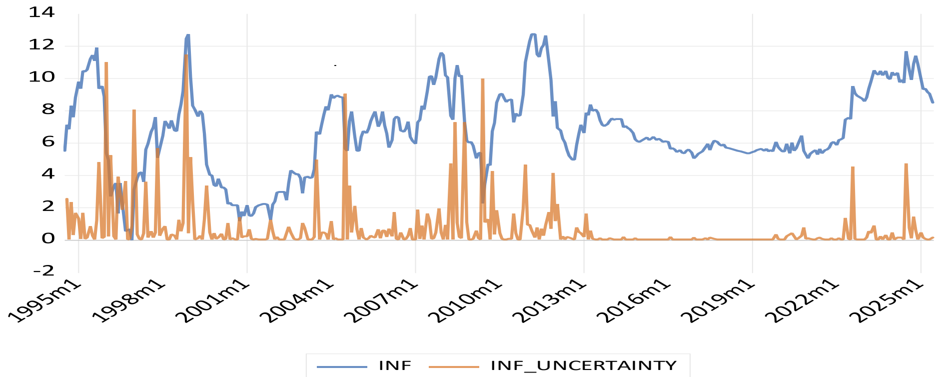
The variance equation of this model is given below:

$$\ln(\delta_t) = \omega_0 + \sum_{j=1}^{p} \beta_i \ln(\delta_{t-i}) + \sum_{j=1}^{q} \alpha_j \, {}^{\varepsilon_{t-j}}\!/\!\sqrt{\delta_{t-j}} + \sum_{j=1}^{q} \gamma_j \, {}^{\varepsilon_{t-j}}\!/\!\sqrt{\delta_{t-j}}$$

Hence the estimated parameters are $\omega, \beta, \ \alpha$ and $\gamma$. When $\gamma$ is non-zero, the impact of inflation on inflation uncertainty is asymmetric. But when $\gamma$ becomes positive, then increased inflation indicates more inflation uncertainty.

This model is particularly useful for modeling inflation uncertainty, as it provides a more accurate depiction of how volatility and shocks interact in economic time series, especially in the presence of asymmetric effects.

**Figure 2**




A plot of inflation uncertainty series and their inflation rates is presented together in Figure 2. Figure 2 illustrates the series for both inflation and inflation uncertainty. The graph demonstrates a clear positive relationship between the magnitude of inflation and the level of uncertainty, where periods of elevated inflation are accompanied by increased uncertainty. Additionally, the graph reveals a significant degree of persistence in inflation uncertainty over time, which aligns with the characteristics of the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model, suggesting that past volatility has a substantial influence on current uncertainty. The Granger Causality test is proposed by Granger in 1969. This test is used to check the existence of the causality between the inflation and inflation uncertainty. This technique is used to test for forecasting of one variable on the other.

## 4. Data and Estimation

Before estimating the mean and GARCH equations, we need to determine the stationarity for the inflation series. The results of Augmented Dickey-Fuller test indicate that Bangladesh's inflation is stationary at the level I(0) at the 1%, 5%, and 10% significance levels.

The ARCH model is used to measure the volatility of inflation and the EGARCH model is used to measure the effect in asymmetric shocks of variance on inflation. The following Table-1 showed the conditional mean and variance equations designed for Bangladesh. The ARCH and GARCH models are ranked by minimising the Akaike Information Criterion (AIC) and Schwarz Bayesian Criterion (SBC). Models with the lowest AIC and SBC values are considered the best fit, effectively explaining heteroscedasticity. The ARCH model is applied and one by one the best fitted model is obtained on the basis of AIC and SBC. The AR (1) process is used to test the autoregressive order of inflation of mean equation series. The EGARCH model is used to test the asymmetries in the terms of positive and negative shocks of inflation uncertainty.

**Table 1: The estimation coefficient of inflation in the case of Bangladesh**

| | Mean Equation | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ARCH (1) | | | | GARCH(1,1) | | | | EGARCH(1,1) | | | |
| Variables | Coefficient | SE | Z-statistics | p-value | Coefficient | SE | Z-statistics | p-value | Coefficient | SE | Z-statistics | p-value |
| Constant | 6.758 | 0.833 | 8.108 | 0.000 | 5.595 | 0.474 | 11.801 | 0.000 | 5.721 | 0.456 | 12.524 | 0.000 |
| INF(-1) | 0.949 | 0.013 | 68.170 | 0.000 | 0.948 | 0.013 | 73.086 | 0.000 | 0.947 | 0.012 | 76.668 | 0.000 |
| | Variance Equation | | | | | | | | | | | |
| | ARCH (1) | | | | GARCH(1,1) | | | | EGARCH(1,1) | | | |
| | Coefficient | SE | Z-statistics | p-value | Coefficient | SE | Z-statistics | p-value | Coefficient | SE | Z-statistics | p-value |
| ω | 0.605 | 0.032 | 18.719 | 0.000 | 0.002 | 0.001 | 2.907 | 0.004 | -0.189 | 0.028 | -6.628 | 0.000 |
| ∝ | 0.073 | 0.073 | 0.054 | 0.000 | 0.149 | 0.023 | 6.578 | 0.000 | 0.240 | 0.038 | 6.235 | 0.000 |
| β | | | | | 0.873 | 0.015 | 57.805 | 0.000 | 0.088 | 0.021 | 4.185 | 0.000 |
| γ | | | | | - | - | - | - | 0.983 | 0.004 | 225.289 | 0.000 |
| AIC | 2.422 | | | | 2.050 | | | | 2.028 | | | |
| SBC | 2.464 | | | | 2.103 | | | | 2.092 | | | |

The minimum values of the AIC and SBC suggest the GARCH (1, 1) effects are present of the series in inflation because the value of $\beta$ is positive and significant. In EGARCH the value of the $\gamma = 0.983$ show that the presence of asymmetric information and also it is non zero. The value of $\gamma$ is positive and significant, it shows that positive shocks to inflation and create more inflation uncertainty.

The performances of the GARCH model proposed by Bollerslev (1986) which constitute the most widely employed GARCH-type models in the relevant literature to generate inflation uncertainty. The outcomes, presented in Table 1, EGARCH type model perform significantly better than the GARCH type models considered for Bangladeshi data examined.

**Table 2: Granger Causality Test**

| **Equation** | Chi-Square Statistic | Degrees of Freedom (df) | p-value (Prob > chi2) | Decision |
|---|---|---|---|---|
| **$H_0$: Inflation does not Granger Cause Inflation uncertainty** | 6.5432 | 2 | 0.038 | Reject $H_0$: Inflation Granger causes Inflation uncertainty |
| **$H_0$: Inflation uncertainty does not Granger Cause Inflation** | 4.2947 | 2 | 0.117 | Fail to reject $H_0$:Inflation uncertainty does not Granger Cause Inflation |

For estimating the strong relation in this stage, in this paper Granger causality test has done. Then, the Granger causality test results show that- Inflation Granger-causes inflation uncertainty: The p-value of 0.038 indicates a significant relationship, meaning past inflation values can help predict inflation uncertainty. However, inflation uncertainty does not Granger-cause inflation: The p-value of 0.117 is not statistically significant, suggesting that past inflation uncertainty does not help predict inflation (Table 2).

## 5. Time varying causality

To explore the study further, we apply the time-varying Granger causality test developed by Shi et al. (2020) and advocated by Baum et al. (2022). The results reveal clear evidence of unidirectional, heterogeneous, time-varying Granger causality between inflation and inflation uncertainty throughout the majority of the study period across all the economies included in the analysis.

This study employs the TVC test to examine the direction, strength, and duration of the causality between inflation (INF) and inflation uncertainty (INF_uncertainty), highlighting the heterogeneous nature of causal relationships over time. Following Granger (1996), who emphasised the importance of accounting for structural changes in econometric models, this study utilises three algorithms to identify when and how causality evolves over the sample period. The first, the Forward (FE) window causality test (Thoma, 1994), uses a fixed starting point and equally sized subsamples to track causal links. The second, the Rolling (RO) window causality test (Swanson, 1998; Balcilar and Ozdemir, 2013), shifts the window forward with each observation to capture time-varying structural changes. Finally, the Recursive Evolving (RE) window method (Shi et al., 2018) combines the FE approach with a sliding window to run regressions over subsamples, generating Wald test statistics for the entire sample, excluding the smallest window sizes. These algorithms provide a sequence of test statistics to assess dynamic causality.

The time-varying Granger-causality results using the FE, RO, and RE algorithms also support the full sample findings (Table 3). The full-sample and time-varying results (Table 3) show that the FE window fails to reject causality from INF to INF_uncertainty, but both the RO and RE windows reject the null hypothesis at the 5% and 1% levels of the empirical distribution of the bootstrap test statistics, indicating robust causality from INF to INF_uncertainty. Causality in the opposite direction, from INF_uncertainty to INF, appears to be weak both at the 5% level and 1% level applying RO and RE windows. Furthermore, in this case, the FE window still shows no evidence of causality. Therefore, it provides evidence of Granger causality between INF and INF_uncertainty.

The results from the second-stage time-varying causality (TVC) test are displayed in Figure 3. The solid line represents the maximum Wald test statistics, which illustrate how causality varies over time. In contrast, the dotted and dashed lines show the critical values at the 5% and 10% significance levels, respectively, derived from the bootstrap method. To establish a statistically significant causal relationship, the solid line must lie above the dotted line (5% critical value) or the dashed line (10% critical value). When the solid line falls below both of these thresholds, it indicates the absence of causality at the 5% or 10% levels during the corresponding period. These

**Table 3 Wald tests for Granger Causality**

| Direction of causality | Max Wald FE | Max Wald RO | Max Wald RE |
|---|---|---|---|
| **INF→INF_Uncertainty** | 7.631 | 40.169 | 40.310 |
| | (7.916) | (7.809) | (8.098) |
| | [10.682] | [10.530] | [10.682] |
| **INF_Uncertainty→ INF** | 2.156 | 15.612 | 15.696 |
| | (6.622) | (7.626) | (7.626) |
| | [10.249] | [12.643] | [12.643] |

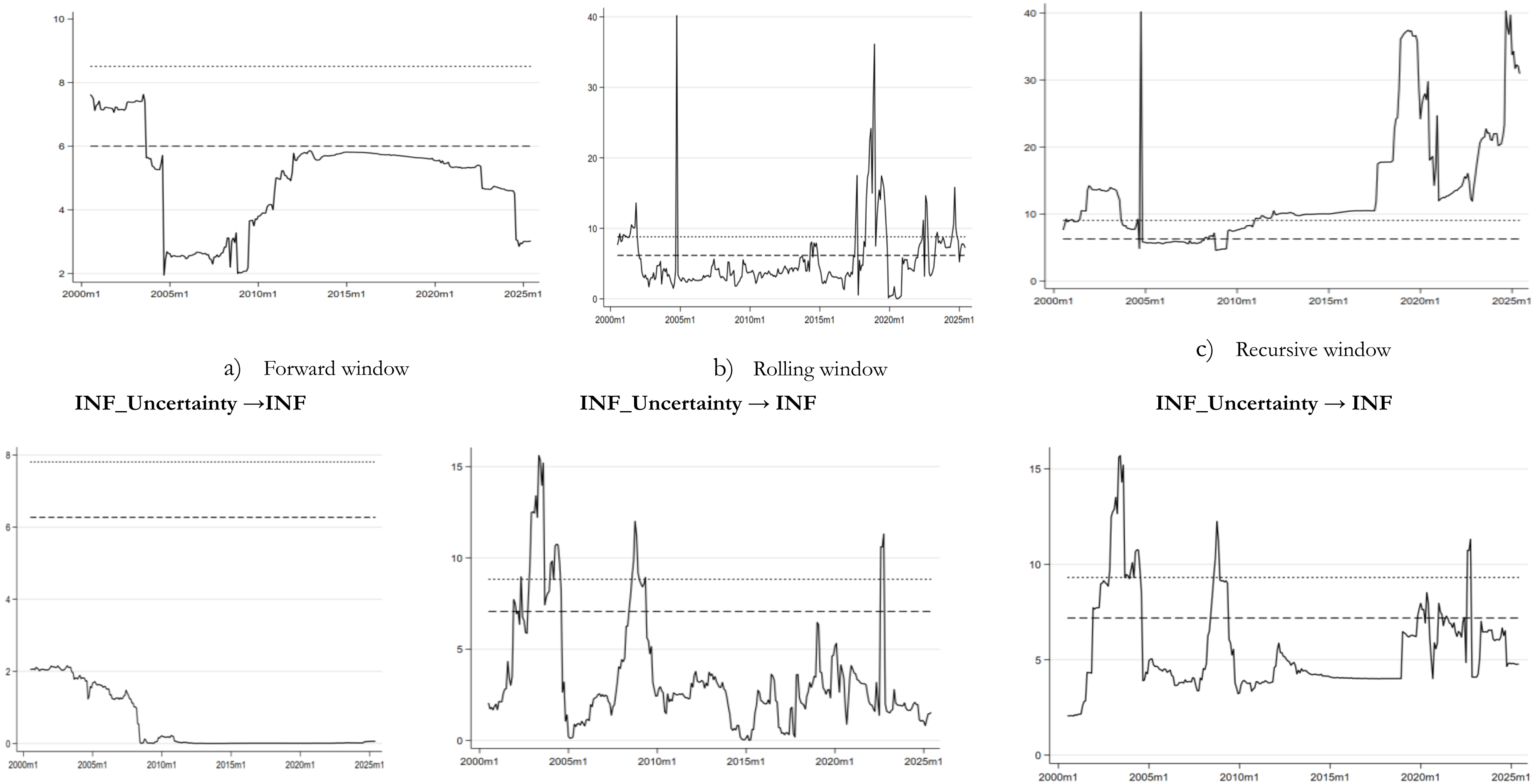
Note: The underlying model is a bi-variate VAR(2) model estimated with a trend. The minimum window size is set at 72 observations. The values in parentheses and brackets report the 95th and 99th percentiles of the empirical distribution of the bootstrap test statistics, respectively. The Wald test statistics are based on 199 replications, and robust to heteroskedasticity.

visualisations also identify when causality begins, ends, and how its strength changes over time. The results confirm substantial heterogeneity across the FE, RO, and RE approaches: while RO and RE detect dynamic causal links, the FE window fails to capture causality, especially in the later part of the sample (Figures 3a and 3d).

Two major episodes of strong causality running from INF to INF_uncertainty emerge in the RO and RE results: 2003–2005 and late 2010–2025 (Figures 3b and 3c). The prolonged inflation and uncertainty in Bangladesh during 2010–2025 are driven by a mix of global cost-push shocks, including rising fuel, food, and raw material prices, first worsened by the COVID-19 pandemic and later exacerbated by the Russia-Ukraine conflict. These external pressures, combined with a foreign exchange crisis that devalued the Taka, increased import costs, and domestic weaknesses like inefficient supply chains and market manipulation, led to persistently high inflation. Initially accommodative monetary policy also heightened demand, undermining confidence in price stability. This evolving causality mirrors the findings of Eroglu and Yeter (2023), who documented similar patterns in Turkey, with sensitivity to structural breaks over time.

On the other hand, weaker evidence of time-varying causality from INF_uncertainty to INF is observed during 2003-2005 and again after 2022 (see: Figures 3e and 3f). These periods show less pronounced causality, indicating that the relationship from INF_uncertainty to INF was weaker during these times.

**Figure 3: TVC Test between Inflation (INF) and Inflation Uncertainty (INF_uncertainty)**



**INF→ INF_Uncertainty**

a) Forward window

**INF→ INF_Uncertainty**

b) Rolling window

**INF→ INF_Uncertainty**

c) Recursive window

**INF_Uncertainty →INF**

d) Forward window

**INF_Uncertainty → INF**

e) Rolling window

**INF_Uncertainty → INF**

f) Recursive window

## 6. Conclusion

This study investigates the causal relationship between inflation and inflation uncertainty in Bangladesh. The traditional Granger causality test indicates unidirectional effect from inflation to inflation uncertainty, while the time-varying causality (TVC) analysis reveals heterogeneous and shock-dependent causal patterns. Notably, the strength of this relationship intensifies during periods of economic disruption, highlighting the sensitivity of inflation dynamics to structural breaks and external shocks.

These findings suggest that policymakers can use the evolving causality between inflation and inflation uncertainty to better assess the effectiveness and spillover of monetary policy across different periods. Overall, inflation and inflation uncertainty as joint indicators of macroeconomic stability can be integrated into regular monitoring and decision-making frameworks. Treating these two measures as a joint indicator will allow for earlier detection of macroeconomic instability, more timely monetary policy adjustments, and improved communication of policy intentions. This approach can strengthen the overall monetary policy framework, enhance investor confidence for long-term planning, and support broader macroeconomic stability. However, the study has caveats; it excludes key supply-side determinants of inflation and focuses solely on Bangladesh. Future research involving multiple countries with varying inflation regimes and structural features could offer valuable comparative insights.

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