Time-varying Causality between Money Supply Growth and Inflation in Bangladesh: New Evidence from Quantity Theory of Money

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Abstract

This article investigates the causal relationship between money supply growth and inflation in Bangladesh to determine whether such a linkage holds as per the quantity theory of money. Unlike the previous literature, we applied time-varying causality tests, as suggested by Baum et al. (2022). The traditional Granger-causal results suggest that there exists weak unidirectional causality from money supply growth to inflation in Bangladesh. However, when we applied time-varying causality, heterogeneous causality is found over the study period, particularly around the periods of structural breaks and increasing macroeconomic instability.

JEL Classification: E51; C32; E31
Keywords: Broad Money; Inflation; Quantity Theory of Money; Time-varying Granger Causality

1 Introduction

The traditional quantity theory of money (QTM) argues that there exists a unity relationship between money supply growth (GM2) and inflation (INF) in the long run. The price level moves in the same direction and proportion with the money supply (Brown, 1911; Pigou, 1917). However, Friedman (1970) suggests that inflation occurs only when

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GM2 exceeds output growth. Thus, money supply is unlikely to cause inflation if its growth does not outweigh output growth.

While the monetarists believe in the existence of causality from GM2 to INF (Su et al., 2016; Wray, 1993), institutional theorists and structuralists argue in the reverse (Adams, 1993). Their argument is based on the fact that governments increase the money supply to finance economic activity in the face of rising prices. Post-Keynesian economists also oppose the idea of controlling inflation through money supply. They believe that bank credits play a pivotal role in the decision-making of firms and households, particularly in context of their effective demand (Moore, 1983). Moreover, the causality from GM2 to INF seems to change between periods contrary to the existing literature which concludes a static and homogeneous causality. Rather the causality experiences a dynamic and heterogeneous pattern. This study contributes to this context by investigating this time-varying causality (TVC) between GM2 and INF in Bangladesh.

Most of the empirical studies investigating causality in a dynamic structure used a bootstrap sliding window (rolling window) approach (Su et al., 2016). Among these studies, Hicham (2020) finds causality from money supply to inflation for Algeria. However, the causality is asymmetric in response to positive and negative monetary shocks. Eroglu and Yeter (2023) argues in favor of a unidirectional heterogeneous causality from money supply to inflation in Turkey, which is more sensitive to structural breaks. Empirical studies on Bangladesh have also found mixed results. Apart from Khan (2019) studies on Bangladesh show that there exists causality between GM2 and INF (Hossain, 2010; Jones and Sattar, 1988; Rahman, 2005; Roy et al., 2023). Rahman (2005) finds significant bidirectional causality from broad money growth to inflation using quarterly data over the sample: 1974:1 to 2003:4. Hossain (2010) also finds a statistically significant causal relationship between GM2 and INF.

Our paper contributes to the QTM literature in several important ways. First, whereas most extant studies focus on traditional Granger causality results, this study applies recently developed TVC techniques, as suggested by Baum et al. (2022). The traditional Granger test results may suffer from parameter instability in the presence of structural changes. This might lead to misleading results. Our paper addresses this concern by employing TVC tests which assume the causal relationship to be dynamic and heterogeneous.

Second, the context of Bangladesh provides an ideal set-up to test our hypothesis. The Bangladeshi economy has experienced major structural changes during the last two decades. Bangladesh adopted a floating exchange rate regime in 2003. The global financial crisis in 2008, and the COVID pandemic in 2019 also led to structural changes in the relationship between GM2 and INF. Thus, the dynamic links between these two

variables might show instability for Bangladesh across different subsamples (Balcilar and Ozdemir, 2013).

Finally, the paper suggests the presence of bidirectional causal relationships between GM2 and INF in Bangladesh with subsample rolling-window estimation. Our findings are in line with Friedman's modern QTM and fit the Bangladeshi facts well.

The rest of the paper is structured as follows. The theoretical framework between GM2 and INF is described in Section 2. Section 3 briefly outlines the estimation strategy. Section 4 presents the data and empirical results from the TVC tests. Finally, Section 5 concludes by outlining the implications of the results.

2 Money Supply Growth and Inflation

Our empirical analysis of the causal relationship between GM2 and INF starts from the quantity equation of money:

$$MV = PY^T \tag{1}$$

where M = Money supply, V = Velocity of money, P = Price level, and Y^T = Real expenditure. Price level is generally measured by consumer price index and real expenditure is measured by GDP. In the long run, V and Y^T is assumed to be fixed, therefore, the price level is proportional to the money stock. Thus, a given change in the money supply induces an equal change in inflation (Lucas, 1980).

The existing literature suggests various sources of inflation both from the demand and supply sides. However, GM2 is argued as the key source of inflation in the long run (Friedman, 1969, 1970). There is also substantial debate in the literature on whether central bank can exploit money supply to control inflation. However, the broad consensus is that excess money growth, nominal money in excess of real GDP, can induce inflationary pressure (Jung, 2024). To this end, one of the widely used formulations of the quantity equation in growth rates is:

$$\Delta m - \Delta y = \Delta p - \Delta v \tag{2}$$

where Δ denotes growth rates and small letters denote logs. Velocity is assumed to be stationary. We also assume there is no link between money growth and real variables in the long run as per the QTM. Given the two assumptions, we estimated the simplest version of QTM, i.e. inflation is proportional to money growth only.

3 Estimation Strategy

A two-stage empirical analysis approach is used to test the hypothesis that broad money growth (GM2) contributes to inflation (INF) in Bangladesh, following Eroglu and Yeter (2023) and Fromentin (2023). In the first stage, we examined the correlation between GM2 and INF using traditional VAR Granger causality tests. To check the stationarity of the variables, we have applied traditional Augmented Dickey–Fuller (ADF) test. However, a variable may experience structural breaks in the mean, trend or both due to economic shocks, natural calamities or significant policy shifts. To account for such structural changes over the study period, unit root tests suggested by Perron (1989) and Zivot and Andrews (2002) are also used.[3] Then we run the traditional Granger causality tests for GM2 and INF assuming that the underlying time series are stationary, otherwise, the standard asymptotic distribution does not hold (Eroglu and Yeter, 2023; Sims et al., 1990; Toda and Phillips, 1994).

In the second stage, TVC tests are applied to investigate the direction, strength, and duration of the causality between GM2 and INF. Some of the earlier works like Granger (1996) mentioned the necessity of incorporating structural changes into econometric estimations. Recent econometric methods can produce Wald test statistics assuming causal links are dynamic and change with time.

The existing empirical works used three algorithms to datestamp when and how the causality changes over a study period. First, forward expanding (FE) window causality test proposed by Thoma (1994) is a standard forward recursion algorithm, and calculated from the equally sized sliding and FE windows (subsamples). As the name suggests the starting point remains fixed for FE window. Second, rolling (RO) window causality test was suggested by Swanson (1998), and developed by Balcilar and Ozdemir (2013). RO window assumes that the structural changes may change over time. Thus, the Wald test statistic series is generated by shifting the fixed window size forward for each observation. Third, recursive evolving (RE) window was developed by Shi et al. (2018) combining the FE method and the sliding window approach. The test regression is run for subsample and larger backward subsamples for a particular observation. Wald test statistics are derived for the entire sample, except for subsamples with the minimum window size. The FE, RO and RE algorithms generate a sequence of test statistics.[4]

[3] Perron (1989) and Zivot and Andrews (2002) proposed Phillips–Perron (PP) test and Zivot and Andrews (ZA) test, respectively by taking structural break into consideration. ZA test identifies the structural break endogenously.

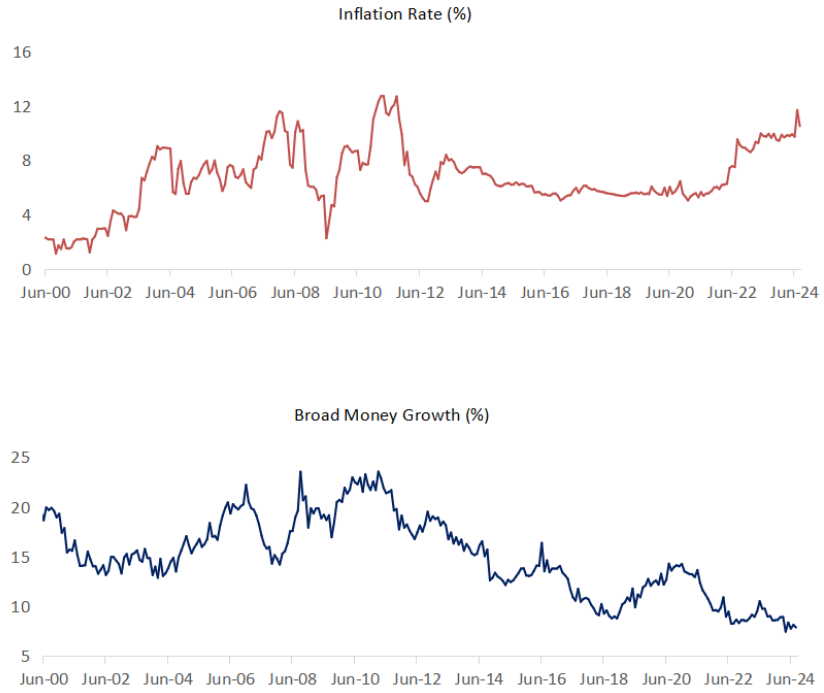
[4] See Shi et al. (2018), Baum et al. (2022), Fromentin (2023) and Eroglu and Yeter (2023) for details.

4 Data, Estimation and Results

4.1 Data

Our study covers data for Bangladesh from January 2000 to August 2024. We have used the growth of broad money as the money supply variable, GM2, and growth form of consumer price index as the inflation variable, INF. Both variables are plotted in Figure 1.

FIGURE 1: Inflation rate and broad money growth in Bangladesh



Source: Bangladesh Bank

4.2 Estimation

ADF, PP and ZA unit root test of GM2 and INF are summarized in Table 1. Both variables are not stationary in level, however, their first differences are stationary at the 1% level of significance. As both of the variables are integrated of order 1, our analysis proceeds with a log-augmented VAR model, where d=1. Then we test the causal relationship between GM2 and INF using a bi-variate VAR model with optimal lag length 2.[5]

[5]Both AIC and SIC suggest the optimal lag length 2. AIC and SIC stands for Akaike Information Criterion and Schwarz Information Criterion, respectively.

Table 1: Stationarity test results

	Intercept				Trend and Intercept				
	ADF	PP	ZA		ADF	PP	ZA		Decision
INF	-2.40	-2.55	-4.011	[2011.10]	-2.59	-2.75	-3.50	[2003.09]	I(1)
ΔINF	-16.29***	-16.31***	-16.53***	[2011.04]	-16.29***	-16.28***	-16.33***	[2016.03]	I(0)
GM2	-1.68	-1.35	-3.62	[2004.10]	-2.73	-2.48	-3.62	[2009.12]	I(1)
ΔGM2	-24.42***	-23.71***	-7.05***	[2011.05]	-24.42***	-23.72***	-6.89***	[2004.11]	I(0)

Note: Null Hypothesis: Has a unit root. Statistical significance at the 1% is indicated by ***.

Table 2: Granger-causality test results

	GM2 does not Granger cause INF		INF does not Granger cause GM2	
	Statistics	p-value	Statistics	p-value
Wald tests	0.18	0.67	0.28	0.60
	ΔGM2 does not Granger cause ΔINF		ΔINF does not Granger cause ΔGM2	
	Statistics	p-value	Statistics	p-value
Wald tests	2.92*	0.09	0.05	0.82

Note: * Denotes significance at the 10% level. These tests are used by Stata software.

4.3 Results

The full-sample Granger causality results from Wald tests are summarized in Table 2. The bootstrap p-values suggest that inflation does not Granger cause GM2, but GM2 does Granger cause inflation. However, the result is significant at only 10% level. This finding that GM2 has a positive effect on inflation is consistent with some of the existing literature (Eroglu and Yeter, 2023; Hossain, 2010; Rahman, 2005; Su et al., 2016). Eroglu and Yeter (2023) finds causality from GM2 to INF in Turkey from January 2007 to June 2022. Using quarterly data on Bangladesh's economy, Rahman (2005) also finds that the causality runs only from money growth to inflation or real income growth to inflation. Thus, money supply and real income growth are important factors in predicting future inflation. On the other hand, inflation does not help in predicting money or income growth.

To investigate the direction, strength and duration of the causality between GM2 and INF, we then moved to the second stage estimation. The Granger-causality results using FE, RO and RE algorithm also support the full sample results, see Table 3. The results show that we fail to reject the null hypothesis of no Granger causality from GM2 to INF when apply the FE window. In all other cases, from GM2 to INF, the computed statistic exceeds the 95th and 99th percentile of the empirical distribution of the bootstrap test statistics which implies strong rejection of the null hypothesis at the 5% and 1% level of significance, respectively. Therefore, it provides evidence of Granger causality between GM2 and INF. On the other hand, from INF to GM2, Granger causality exists at 5% level which becomes insignificant at 1% level.

TABLE 3: Wald tests for Granger causality

Direction of causality	Max Wald FE	Max Wald RO	Max Wald RE
GM2 → INF	5.407	24.999	24.999
	(8.943)	(8.945)	(9.008)
	[13.566]	[12.945]	[13.566]
INF → GM2	3.431	11.12	12.46
	(9.740)	(9.791)	(9.935)
	[16.643]	[15.932]	[16.643]

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 499 replications, and robust to heteroskedasticity.

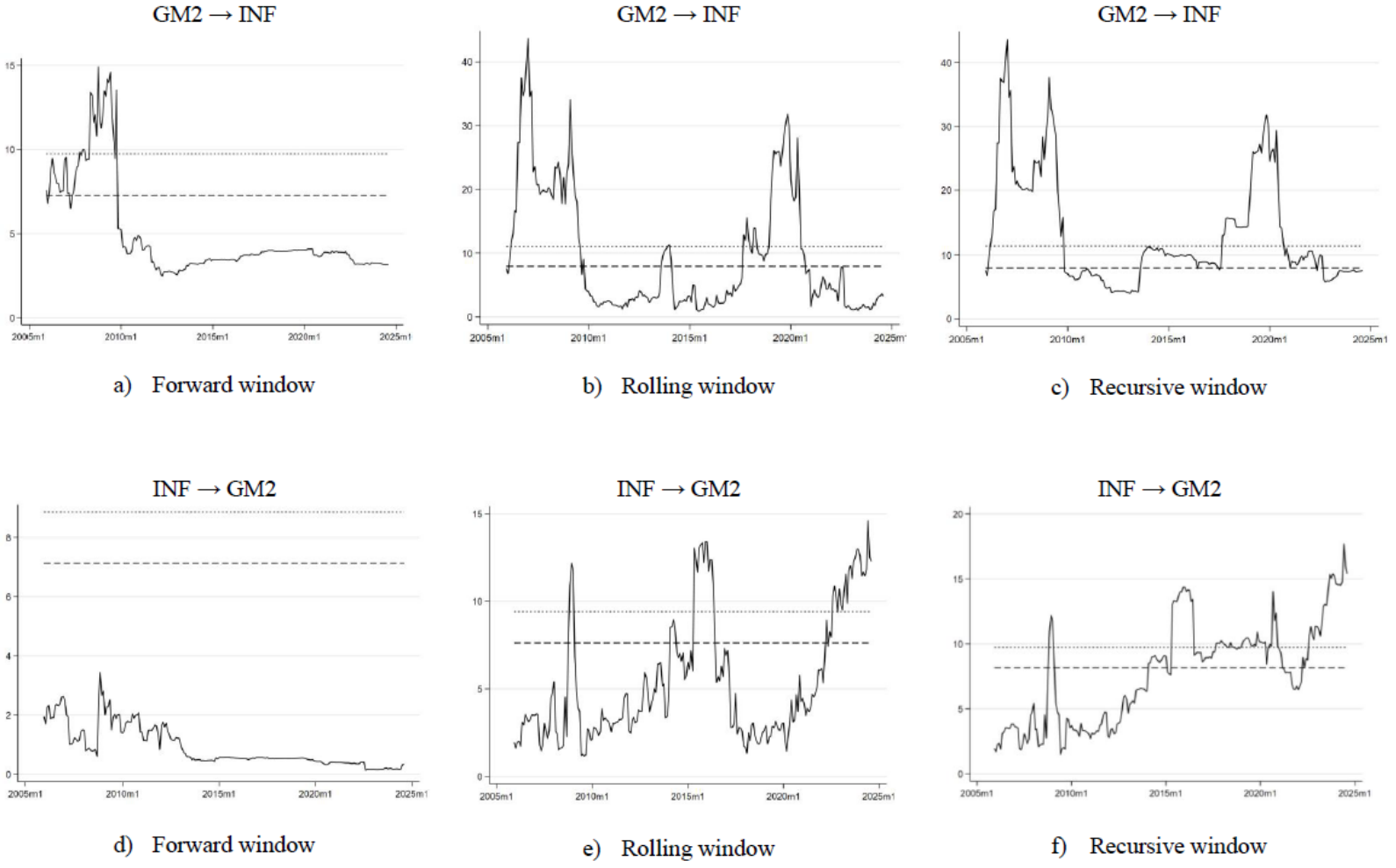
The second stage TVC test results are presented in Figure 2. The solid line presents the maximum Wald test statistics summarizing the variation of causality over time. On the other hand, the dotted and dashed lines report the resistant critical values obtained with the bootstrap method at 5% and 10% level of significance, respectively. For a statistically significant causal relationship, the solid line must be above the dotted line (5% critical value) or above the dashed line (10% critical value). When the solid line lies below these two lines, it suggests that there is no causality at the 5% and 10% level of significance over the relevant sample period. In addition to investigating the presence and absence of causality, the results also show the periods when causality begins, and ends. It also shows the pattern of the causality, particularly how the strength of causality changes over different time horizons.

According to Figure 2, the causal links between GM2 and INF show a heterogeneous pattern. In general, all the plots suggest that Granger-causal relationships between these two variables are extremely time-varying and dynamic. The relationships also depend on the type of recursive algorithm used to generate the test statistics. While the RO and RE algorithms pick up the causal channel, FE window fails to do so, particularly in the later half of the sample, see Figure 2(a) and Figure 2(d), respectively.[6]

Our main results suggest that there exists strong evidence of causality from GM2 to INF occurring in two rounds in our data with the RO and RE windows. The first round of causality persists from 2006 to 2010; see Figure 2(b) and Figure 2(c), respectively. Then the second round of causality starts in the late 2017 and continues till early 2020. The results also suggest that causality is formed due to the increasing political instability and global financial crisis in that period, therefore, the inflationary situation was getting worse. Similarly, the COVID-19 outbreak at the end of 2019 also led to global economic and health instability, which could explain the causality outcomes of the second round. These results are similar to Eroglu and Yeter (2023). They also found heterogeneous causality using Turkish data, which was more sensitive to structural breaks. In contrast, weak evidence of TVC from inflation to GM2 is also apparent in early 2015 and again after 2022; see Figure 2(d) and Figure 2(e), respectively.

[6]This result comes from a well-known issue with the FE window that it is not responsive to the lateral changes over the sample period (Baum et al., 2022).

FIGURE 2: TVC tests between GM2 and INF



a) Forward window b) Rolling window c) Recursive window

d) Forward window e) Rolling window f) Recursive window

Notes: The underlying bi-variate VAR(2) model is estimated with a trend. The 10% and 5% bootstrapped critical values (horizontal dashed and dotted lines, respectively) are based on 499 replications, and robust to heteroskedasticity.

5 Conclusion

The causal linkages between GM2 and INF in Bangladesh have been investigated in line with the QTM. While traditional Granger causality results suggest the existence of an weak unidirectional causality from GM2 to INF, the TVC test results reflect heterogeneous causality throughout the sample, depending on the structural breaks and economic shocks. Particularly, the strength of the causality increases when a shock is experienced in the sample.

Policymakers could therefore use this time-varying causal linkage between GM2 and INF to discern the impact of monetary policy on controlling inflation. By analyzing factors that led to a significant pattern in a particular sample period, can improve the understanding of monetary policy spillover. The study has certain caveats. First, it excludes other variables determining inflation, particularly the supply side variables. Second, the study was conducted only for Bangladesh. By incorporating economies with different levels of inflation (high or low) and structural characteristics, future studies can lead to significant comparative analysis.

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