Money supply determination for India: evidence from asymmetry statistics

Masudul Hasan Adil[1], Zeeshan Nezami Ansari[2], Kaushalesh Upadhyay[1]

Abstract

The present study examines the money supply determination process for India using recent data. The empirical investigation of our objective, which deviates from previously available literature, is constructed on assumption of asymmetric (nonlinear) causal nexus between money supply and monetary base through money multiplier. To this end, unlike previous studies, we empirically verify the nonlinearity in the series under study using series of linearity tests and linear and nonlinear unit root tests. The nonlinearity in the series leads us apply nonlinear autoregressive distributed lag model to establish the long run cointegrating relationship. Furthermore, we employ asymmetric Granger-causality test on the decomposed series. These methods help us establish money as an endogenous or exogenous variable during expansionary and contractionary stance of India's monetary policy distinctly in a nonlinear fashion. The study finds that both narrow and broad money measures are endogenous with an unstable money multiplier, which is further reinforced by the asymmetric Granger-causality results wherein monetary base Granger-causes money stocks. Thus, the nature of money during different phases of monetary policies carries out significant policy implications, for India's monetary policies, as an essential information or indicator variable to manage inflation effectively under its current flexible inflation targeting framework.

Keywords: money multiplier, endogenous and exogenous, asymmetric cointegration, asymmetric Granger causality, nonlinear unit root, dynamic multiplier, India.

JEL Classifications: E50, E51, E52, E58, E59.

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1. Introduction

The concept of money supply is a steppingstone for the macroeconomic theories and policy determination. The monetary transmission mechanisms using money supply, for instance, narrow (M1) and broad (M3) money measures, interest rates (i.e., short-and long-term interest rates), and monetary base (MB) have been widely researched in the literature (see, inter alia, Friedman and Schwartz, 1963; Meltzer, 1995, Mishkin, 1995). The behavior of money supply— its stability and determination are of paramount importance from policy perspective. The amount of available money supply and its stability in any economy play a significant role in framing an effective monetary policy as the money supply links the monetary and real sectors of the economy and exhibits the interaction between them. As Muralikrishna Bharadwaj and Pandit (2010, pp. 25–26) rightly mentioned, "*the relationship between the stock of money and its covariates must be stable if it has to be of any use for policy purposes, only then; policymakers can effectively target the ultimate objectives through intermediate variables like interest rates and liquidity."* The money supply remains stable when it is controlled by a monetary authority of the country's central bank.

Concerning money supply determination, the theoretical foundation can be obtained from two distinct theories. The monetarist school claims that the money supply is determined exogenously through country's Central bank (Friedman and Schwartz, 1963), which is obtained using money multiplier approach (Brunner, 1961; Brunner and Meltzer, 1964). This approach argue that money supply is determined by bank deposits, currency in circulation, and bank reverses. There is a direct proportional relationship between the monetary base and the money supply. The central bank can control the money supply through bank reverses, and this in turn is determined by bank deposits and currency in circulation. Thus, the monetarist school explains money supply determined in an exogenous framework by the Central bank using bank deposits and reserves. Contrary to it, post-Keynesian challenged this theory and argued that the money supply is determined endogenously through different economic agents in the money market (Moore, 1989; Palley, 1992). They proposed a portfolio choice approach, which claims that money supply is determined using assets and liability management (Goodhart, 1989). The behavior of economic agents, for instance, Central bank decisions, commercial bank portfolio choice, investment capacity of production

firms, and consumption needs of household borrowers and so on, determines the money supply (Moore, 1989; Palley, 1992). The supply of money fulfills the debt payment obligations for the production process and consumption needs; therefore, it is not the bank deposit rather bank credit which determines the money supply. Furthermore, economic systems, such as income and preferences of the agents, state of technology and tradeoffs in risk-return of assets determine the money supply (Darbha, 2002). In a nutshell, the supply of money supply is determined by the demand and supply forces of the money market but the monetary authorities. Therefore, in the post-Keynesian framework, money is determined endogenously, and it is demand-driven phenomenon rather supply side of the Central bank.

The research on money supply has gained momentum particularly post 2008 global financial crisis when the interest rate targeting was not been able to help specially at zero lower bounds. The significance of exploring money behavior is to conduct the monetary policy efficiently and achieve the macroeconomic goal variables. The mechanism of monetary policy would be fully operational with the identification and determination of the money supply; otherwise, the primary objective of monetary policy to achieve an economic growth and price stability remains unsuccessful. In the backdrop of preceding, money supply determination has recently gained traction. The strands of empirical literature on money supply determination are found to be either endogenous or exogenous in nature, which are examined methodologically under two different directions. The first group of studies (see, inter alia, Jayaraman and Choong, 2009; Nayan et al., 2016; Dedeoglu and Ogut, 2018 in Turkey) examine money supply in case of different countries using linear framework models. In particular, studies conclude that money supply are determined endogenously either through bank lending or unstable money multiplier in case of G7 and Euro-zone countries (see, inter alia, Howells and Hussein, 1998; Badarudin et al., 2013; Deleidi and Fontana, 2019; Deleidi and Levrero, 2019; Gocer and Ongan, 2020). Studies on emerging economies have investigated money supply and supports the endogenous determination of money supply either through bank lending or interest rates (see, inter alia, Sunge, 2018; Polanco and Schmidt, 2019; Barbosa et al., 2019; Rahimi, 2019 and Liu et al., 2022; Mukamuhire et al., 2024). Conversely, studies also support exogenous money supply determination in emerging economies (see inter alia, Ahmad and Ahmed, 2006; Bhatti and Khawaja, 2018). The findings of these studies on money supply determination are mixture of endogenous and exogenous in nature. Of those studies that reported either endogenous or exogenous, not all have explicitly examined for

Granger-causality testing; those that have examined for causality, however, mention mixed evidence under linear framework. Furthermore, lest the money supply determination is nonlinear in nature then the results of these studies would be mis-specified as they use linear framework.

The second group of studies have examined money supply determination using nonlinear or asymmetric framework. This method of modelling money supply is at a nascent stage. Though, we found plethora of studies which researched economic theories empirically and established the relationship among macroeconomic fundamentals using asymmetric approach to cointegration (see, inter alia, Kisswani and Elian, 2021; Mesagan et al., 2022; Pradeep, 2022; Nusair and Al-Khasawneh, 2022; Sharma, 2023; Deheri and Ramchandran, 2023; Zehri et al., 2024; Nusair et al., 2024). We found very few studies which utilized nonlinear methods, for instance, by utilizing an asymmetric cointegration framework in case of Canada and South Korea studies found money as an exogenous (see, Ongan and Gocer, 2019; 2020 b). Conversely, studies have also reported money as an endogenous variable using an asymmetric models in case of Japan and Turkey (Cepni and Guney, 2017; Dedeoglu and Ogut, 2018; Ongan and Gocer, 2023; Özden et al., 2024). The findings of these studies are mixed over endogenous and exogenous nature of money supply. Although these studies have concluded their findings on the behavior of money supply in a nonlinear framework, however, studies do not report the causal inferences in an asymmetric framework to support the evidence whether money is exogenous or endogenous.

Notably, emerging economies have always been important for empirical verification of the theories because of its economic transition from one phase to another. The behavior of economic functioning also changes due to structural changes in emerging economies. Consequently, these changes are also being reflected in policy determination. Therefore, investigation of theories in an emerging economy on the subject of policy determination has become of paramount importance. Noticeably, India is one such country, which comes under emerging economy categories and its monetary policy has also evolved over time[3]. There was also the evidence of financial deregulation and innovation during 1990s in India. Henceforth, it may be possible that money supply is affected by the market forces, as the post-Keynesian school of thought suggested, than solely controlled by the monetary authorities using monetary reserve. In the recent study, analysis of the monetary

[3] For detailed discussion over India's different monetary policy, see, inter alia, Adil and Rajadhakshya (2020) and Dua (2023).

aggregate showed that policy failed through the instrument of broad money supply from 2008 onwards (Dua, 2023). Consequently, the Government of India came up with the Report on Financial Sector Reforms in 2009 which proposed technology-based banking transaction for the purpose of achieving inclusive growth and stability of Indian economy. Furthermore, the digital mode of payment has increased more than twice during the pre and post COVID period 2019-24, however, the currency in circulation and reserve money increased approximately 1.5 times. Given the monetarist and post-Keynesian's contradictory viewpoints, the significance of the money supply determination in the emerging economy, rapidly expanding digital payments, and the statistical facts regarding monetary components motivate us examine money supply determination in the emerging economy India.

After reviewing the plethora of research in case of advanced and emerging economies in general, and India in particular, the present study highlights the following research gaps. First, plethora of studies are available in the advanced and emerging economies, however, literature on money behavior in India is small, which again produces mixed evidence. There are few studies that have examined the determination of money supply in Indian, however, they use linear models for estimation. For instance, Darbha (2002) establishes the long-term relationship between money supply and monetary base in case of India. Likewise, Dash (2017) claims that inflation could predict the future growth of money supply but vice versa. However, these studies fail to examine the sign and magnitude of the relationship. Second, previous studies did not examine money behavior under nonlinear framework by utilizing nonlinear stationarity tests and linearity tests for the variables under consideration. Third, to determine the money supply in India, earlier studies did not examine "hidden cointegration" along with nonlinear or asymmetric causal inferences in case of negative, positive, or a combination of the cumulative shocks, which is quite often evident among macroeconomic variables (Hatemi-J, 2012). Importantly, the asymmetric behavior among economic agents is quite evident due to two reasons: first, human's common tendency is to behave differently for the good news (positive shock) than the bad news (negative shock) conditions, and second, the existence of asymmetric or imperfect information in the market among economic agents (Akerlof, 1970). Finally, there is no literature on Indian money supply using recent data, especially after the introduction of the Report of Financial Sector Reforms 2009, wherein the role of market forces has increased in the money supply determination.

In the backdrop of the reviewed studies and their highlighted research gaps, we establish the novelty of the present study in the following manner. First, unlike previous studies, the present study extensively examines the nature of the series by applying linear unit root, for instance, ADF (1979) and PP (1988) tests and nonlinear unit root tests, for instance, Kapetanios, Shin, and Snell (KSS) (2003), Kruse (2011), and Hu and Chen (2016). Furthermore, we test the nonlinearity of the series under study by employing linearity test such as Teräsvirta Neural Network (TNN) test by Teräsvirta et al. (1993) and Broock-Dechert-Scheinkman (BDS) test by Broock et al. (1996). Second, previous studies on money supply determination merely establish cointegration using linear models. However, we extend the literature by analyzing the long run "hidden cointegrating" relationship between variables in an asymmetric or nonlinear way using nonlinear autoregressive distributed lag (NARDL) model developed by Shin et al. (2014). This model helps us establish the sign and magnitude of the relationship, which has implications for monetary policy formulation and the determination of the stability of the money supply. Third, we decompose the series under study into their positive and negative cumulative sums, which helps establish explicitly the impact of changes in the MB on different monetary measures during expansionary (increased MB) and contractionary (decreased MB) stances of monetary policies. Fourth, unlike previous studies, we examine multivariate normality and ARCH effect available in the series under consideration and based on the findings we employ asymmetric Granger-causality test developed by Hatemi-J (2012) than the simple Granger causality. This method helps in establishing the causal inference for negative. positive, or a combination of the cumulative shocks for the given series. Finally, post global financial crisis of 2008 when the interest rate targeting framework is potentially not effective at zero lower bound, thus money supply measures started getting attention for policy perspective; since then, this is the first study which uses the most recent data and having a policy implication for the India's current flexible inflation targeting framework. To these ends, the aim of this paper is to determine, in the post global financial crisis period of 2008, the nature of India's money supply whether it is endogenous or exogenous under an asymmetric or nonlinear framework which encompasses the contractionary or expansionary phases of monetary policies. Furthermore, unlike other studies, we establish the asymmetric Granger-causal inferences for the negative, positive, or a combination of the cumulative shocks of the variables under consideration.

Previewing our results, the present study finds that variables under consideration, namely monetary base (MB), narrow (M1) and broad money (M3) are following linear and nonlinear unit

root. The variables are also found to be nonlinear in nature. Depending upon the nature of the series and the objective of our current study, the application of asymmetric cointegration reveals the existence of asymmetric long run cointegrating relationship between variables for both the narrow money (M1) and broad money (M3) models. We find the evidence of unstable money multiplier for both the models, implying money as an endogenous variable during different phases of India's monetary policies, for instance, expansionary monetary policy denoted with positive partial sum of MB (MB^{+}) and contractionary monetary policy denoted with negative partial sum of MB (MB^{-}). Our test for asymmetric Granger causality suggests the causal relation running from decomposed monetary bases to the positive shock of money supply (M1 and M3), implying the importance of the variables in both models. The current finding of endogenous money supply helps monetary authorities of India in determining its money supply behaviour during its expansionary and contractionary monetary policy stances distinctly, which can help tracing inflation more prominently in its current flexible inflation targeting.

The remainder of the study is structured as follows. Section 2 describes the theoretical framework which motivates to conduct our empirical analysis. Furthermore, it describes the econometric methodologies utilized to establish whether money is endogenous or exogenous. In Section 3, we discuss the data and its transformation. Section 4 discusses the empirical findings, and we present the summary and concluding remarks in the final section.

2. Money multiplier specification and research methodology

2.1 Money multiplier specification

The present study focusses on establishing whether money supply is exogenous or endogenous in India's monetary policy framework. Wray (1992, p. 1145) explains the exogeneity of money supply as *"Exogeneity usually means that a variable is determined by the government, or it indicates a variable whose value is taken as given because the theorist does not wish to explain its determination. In the case of the money supply, exogeneity is usually used in the first sense: the assumption is that the central bank controls the money supply through its control of bank reserves."* The term endogenous is contrary to the exogenous and deferring in the sense any variable is determined within the system. Moore (1988, p. 384) rightly explains the endogenous money supply as *"An endogenous money supply is sometimes interpreted as implying that Central banks are passive and cannot affect the behaviour of money growth. This is clearly a*

misperception. An endogenous money supply simply denotes that the money supply is determined by market forces. Central banks are able to administer the level of short-term interest rates exogenously within a substantial range. This will obviously affect the quantity of credit and money demanded, and so the behaviour of money growth…Only once it is fully comprehended that the supply of credit money is inherently endogenous and that the money supply function should be viewed as horizontal in interest-money space, at a level of short-term interest rates established by the Central bank, can the base-multiplier relationship be understood for what it is: a purely descriptive tautology."

The present study's empirical model of money supply determination is based on the most widely used *'money multiplier model'* of Brunner (1961) and Brunner and Metzler (1964). The money supply is determined through the monetary base, and the behavioral mechanism between these two is called the *'money multiplier model'*. The interdependency between the money supply and monetary base can be represented by the following equation:

$$MS = mm * MB \qquad (1)$$

where MS is the money supply measures used for both narrow (M1) and broad money (M3) measures, MB stands for the monetary base, and mm stands for the money multiplier. For simplicity, MS is taken from narrow money, which consists of currency in circulation (C) and demand deposit (D), that is, $MS = C + D$. MB is the monetary base, which comprises of currency in circulation (C) and bank reserves (R), that is, $MB = C + R$. Furthermore, the bank has to keep a ratio of demand deposits as a reserve in the Central bank, that is, $R = rD$. The currency issued for circulation by the Central bank is also a ratio of demand deposits, that is, $C = cD$. Finally, we divide the money supply definitional equation by the monetary base with the substitution of the value of bank reserves and currency in circulation as the ratio of deposits. Henceforth, the mathematically expression is as follows:

$$\frac{MS}{MB} = \frac{cD + D}{cD + rD} \qquad (2)$$

$$\frac{MS}{MB} = \frac{c + 1}{c + r} \qquad (3)$$

Thus, we rewrite Equation (1) to explain a stable money multiplier.

$$MS = mm * MB \qquad (1)$$

where $mm = \frac{c+1}{c+r}$, Equation (1) assumes that changes in the money supply (MS) are proportionately related to changes in the monetary base (MB) by means of a stable money multiplier (mm). The mathematical model for money multiplier can be expressed in an econometric model, as given in Equation (4), which is expressed in a double natural logarithmic form and added an error term.

$$lnMS_t = \alpha + \beta lnMB_t + e_t \qquad (4)$$

where e_t is the error term, and α is the natural log of mm. The stability of the money supply requires the monetary base to have proportionally cointegrated *one-to-one* (directly proportional) relationship with the money supply, which requires α must be 0 (natural logarithm of 1) and β must be 1. This implies that in the long run the Central bank may determine the money supply exogenously through a stable money multiplier. Thus, the stability of money supply (direct proportional relationship) with MB requires $\beta = 1$, and this would be concluded as exogenous money supply determination by the Central bank through bank reserves. Conversely, instability of money supply with MB referred as $\beta \neq 1$ and concluded as endogenous money supply determination, that is, money supply is not only determined by the central bank but also by the other factors or agents of the economy.

2.2 Research methodology

2.2.1 Nonlinear autoregressive distributed lag (NARDL) model

The long run co-integrating relationship between the money supply and the monetary base of Eq. (1) can be computed through the NADRL model proposed by Shin et al. (2014). This model is an extended version of the autoregressive distributed lag (ARDL) approach to cointegration given by Pesaran et al. (2001). The NARDL model has many advantages over other co-integration models (Shin et al., 2014). First, it distinguishes between the short and long-term causal impact of the monetary base on the money supply. Second, it takes care of endogeneity (reverse causality) issue through lag-dependent variables. Third, it is applicable irrespective of the order of integration of the variables, that is, I(0), I(1), or mixture of both but the I(2) or higher order. Finally, it considers asymmetric impact of MB on MS during expansionary and contractionary phases of monetary

policies distinctly by distinguishing the monetary base into positive cumulative sums (referred as expansionary monetary policy) and negative cumulative sums (referred as contractionary monetary policy). The long-run relationship between money supply and monetary base can be represented by the following ARDL model of Pesaran et al. (2001).

$$\Delta MS_t = \tau + \lambda_1 MS_{t-1} + \lambda_2 MB_{t-1} + \sum_{i=1}^{p} \theta_{1i} \Delta MS_{t-i} + \sum_{i=1}^{p} \theta_{2i} \Delta MB_{t-i} + e_t \qquad (5)$$

The Eq. (5) is estimated using the ordinary least squares (OLS) technique. The short-run dynamics are represented by differenced lag operator in money supply and the monetary base, whose coefficients are symbolized as θ_{1i} and θ_{2i}, respectively. These lag operators, in time, take endogeneity into account during OLS estimation. The long-run estimation is represented by λ_i, which is the computed relationship for the entire sample. The merit of the NARDL model over the ARDL is that it takes into consideration the asymmetric impact of the explanatory variable(s) on the response variable. To this aim, we decompose the *MB* into their positive and negative cumulative partial sums.

$$MB_t^+ = \sum_{t=1}^{T} \Delta MB_t^+ = \sum_{t=1}^{T} \max(\Delta MB_i, 0)$$

$$MB_t^- = \sum_{t=1}^{T} \Delta MB_t^- = \sum_{t=1}^{T} \min(\Delta MB_i, 0)$$

These decomposed monetary bases are incorporated into the linear ARDL model of Eq. (5) and represent asymmetry or nonlinearity through the positive and negative monetary bases in the ARDL model. Henceforth, the linear ARDL model turns into the NARDL.

$$\Delta MS_t = \rho + \phi_1 MS_{t-1} + \phi_2 MB_t^+ + \phi_3 MB_t^- + \sum_{i=1}^{p} \varphi_{1i} \Delta MS_{t-i} + \sum_{i=1}^{p} \varphi_{2i} \Delta MB_{t-i}^+ + \sum_{i=1}^{p} \varphi_{2i} \Delta MB_{t-i}^- + \varepsilon_t \qquad (6)$$

This model enables asymmetric impact by splitting the monetary base into an increase in the monetary base (MB^+) and a decrease in the monetary base (MB^-). The long-run impact of MB^+ and MB^- on the money supply will be determined with the coefficients' ϕ_2 and ϕ_3 sign and magnitude, respectively. If the coefficients of MB^+ (ϕ_2) and MB^- (ϕ_3) are equal to 1, then the money multiplier is stable and determined exogenously; otherwise ($\phi_2 \neq 1$ and $\phi_3 \neq 1$), the

money multiplier is unstable and determined endogenously. However, the different sign and scale of ϕ_2 and ϕ_3 will indicate an asymmetric impact of *MB* on *MS*; otherwise ($\phi_2 = \phi_3$) suggests a symmetric impact. The bound test was executed to determine the significance of short-and long-run coefficients of the monetary base for the NARDL model, as expressed in Eq. (6). The Wald statistics is applied to verify the asymmetric relationship between *MS* and *MB*. The null hypothesis for long-run relationship $\frac{\phi_2}{\phi_1} = \frac{\phi_3}{\phi_1}$ and for short-run relationship $\varphi_{2i} = \varphi_{3i}$. Furthermore, cumulative asymmetric dynamic multiplier (CADM) is utilized to test the impact of a partial unit increase in the monetary base (MB^+) and decrease in monetary base (MB^-) on money supply. It is represented as follows-

$$\delta_N^+ = \sum_{n=1}^{N} \left(\frac{\partial MS_{t+n}}{\partial MB_t^+} \right) \qquad (7)$$

$$\delta_N^- = \sum_{n=1}^{N} \left(\frac{\partial MS_{t+n}}{\partial MB_t^-} \right) \qquad (8)$$

The purpose of CADM is that as n reaches infinity, δ^+ and δ^- approach the long-run coefficient of MB^+ and MB^-, respectively.

2.2.2 Asymmetric Granger causality inference

In the final step, we employ asymmetric Granger-causality testing proposed by Hatemi-J (2012) to test the directional causality between decomposed *MS* and *MB*, such as negative, positive, or a combination of the cumulative shocks. There are three advantages of asymmetric Granger-causality over the simple Granger causality test (Hatemi-J, 2012). First, it is based on the causality framework proposed by Granger (1969) and, Toda and Yamanto (1995) however, it is extended by distinguishing between positive and negative shocks for different causal impacts. Second, it can be applied to the variables, either stationary or non-stationary. Third, it is calculated through the bootstrap simulation method, which does not rely on the assumption of normal distribution of series under consideration. Noticeably, there are several economic variables that are non-normal, and their volatility is time-varying. Therefore, looking at the advantages of this method, asymmetric causality test method along with bootstrap simulation would be the most appropriate to establish the causal inferences between *MB* and *MS*. The asymmetric Granger-causality testing can be expressed with the following equations.

$$MS_t = MS_{t-1} + e_{St} = MS_0 + \sum_{t=1}^{T} e_{St} \qquad (9)$$

$$MB_t = MB_{t-1} + e_{Bt} = MB_0 + \sum_{t=1}^{T} e_{Bt} \qquad (10)$$

Where MS_0 and MB_0 are the initial money supply and monetary base, e_{St} and e_{Bt} are error terms of money supply and monetary base equations, respectively. The error terms are decomposed into positive and negative cumulative sums while considering asymmetric shocks. The positive and negative cumulative shocks are defined as $e_t^+ = \max(e_t, 0)$ and $e_t^- = \min(e_t, 0)$, respectively. In the extended expression for asymmetric causality with positive and negative shocks (errors) will be

$$MS_t = MS_{t-1} + e_{St} = MS_0 + \sum_{t=1}^{T} e_{St}^+ + \sum_{t=1}^{T} e_{St}^- \qquad (11)$$

$$MB_t = MB_{t-1} + e_{Bt} = MB_0 + \sum_{t=1}^{T} e_{Bt}^+ + \sum_{t=1}^{T} e_{Bt}^- \qquad (12)$$

Finally, cumulative sums for the positive and negative shocks of money supply and monetary base defined as $MS_t^+ = MS_0 + \sum_{t=1}^{T} e_{St}^+$, $MS_t^- = MS_0 + \sum_{t=1}^{T} e_{St}^-$, $MB_t^+ = MB_0 + \sum_{t=1}^{T} e_{Bt}^+$ and $MB_t^- = MB_0 + \sum_{t=1}^{T} e_{Bt}^-$. In the next step, the causal relationship between *MS* and *MB* is estimated through a vector autoregressive (VAR) model with time lag p. The positive relationship among variables is defined as:

$$MS_t^+ = \alpha_1 + \sum_{p=1}^{T} \beta_{1p} MS_{t-p}^+ + \sum_{p=1}^{T} \beta_{2p} MB_{t-p}^+ + e_{st}^+ \qquad (13)$$

$$MB_t^+ = \alpha_2 + \sum_{p=1}^{T} \beta_{3p} MB_{t-p}^+ + \sum_{p=1}^{T} \beta_{4p} MS_{t-p}^+ + e_{st}^+ \qquad (14)$$

Likewise, negative relationship among variables is defined as:

$$MS_t^- = \alpha_3 + \sum_{p=1}^{T} \beta_{5p} MS_{t-p}^- + \sum_{p=1}^{T} \beta_{6p} MB_{t-p}^- + e_{st}^- \qquad (15)$$

$$MB_t^- = \alpha_4 + \sum_{p=1}^{T} \beta_{7p} MB_{t-p}^- + \sum_{p=1}^{T} \beta_{8p} MS_{t-p}^- + e_{st}^- \qquad (16)$$

The asymmetric presence of the causal flow of concerned variables with positive and negative shocks will be tested through Eq. (13) to (16). The lag selection criteria that will be chosen using a variance-covariance matrix of the error term, the number of equations in the VAR model and the number of observations. To this end, Hatemi-J (2012) lag selection criteria *(HJC)* is utilized to select the optimal lag order (*p*) for the VAR model, which is expressed as follows:

$$HJC = \ln\left|\left(\hat{\xi}_j\right)\right| + j\left(\frac{n^2 lnT + 2n^2 ln(lnT)}{2T}\right), \qquad j = 0, \dots, p \qquad (17)$$

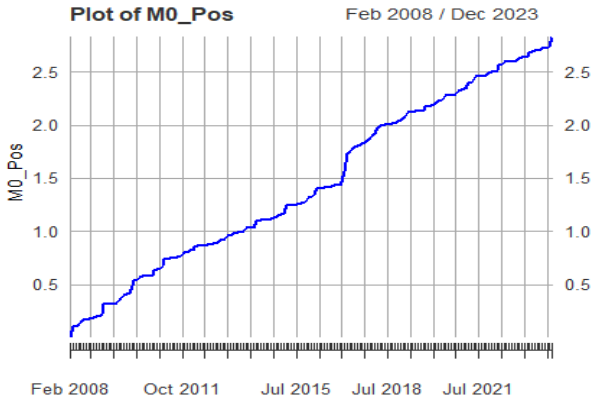
where $\left|\left(\hat{\xi}_j\right)\right|$ is the determination of the variance-covariance matrix of error, j is the number of lags order, n is the number of equations, and T is the number of observations in the VAR model. After the optimal lag order selection, in the next step, the null hypothesis of non-Granger causality, H_0: $C\beta = 0$ is tested by the following Wald-statistic method:

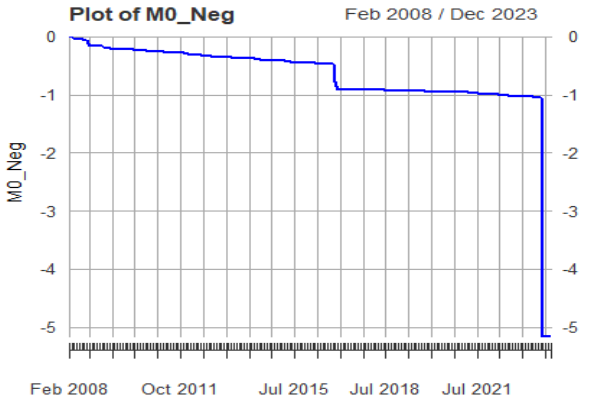
$$Wald\ (\chi^2) = (C\beta)'[C((Z'Z)^{-1} \otimes S_e)C']^{-1}(C\beta) \qquad (18)$$

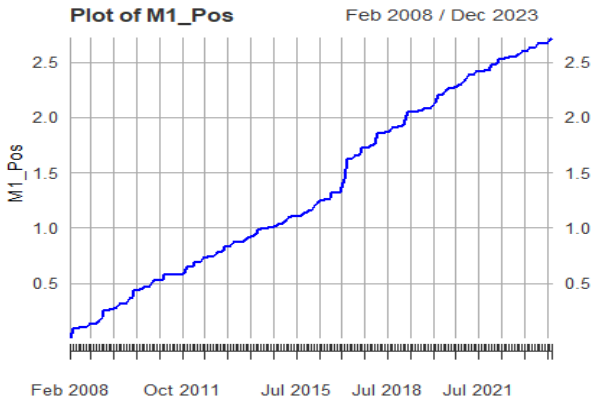
where β is the coefficient of variables, C is $p\ X\ n(1 + np)$ dimension matrix with elements 1 for a particular parameter and 0 for other parameters, Z is a matrix of variables, $\otimes$ represents the Kronecker product, and S_e is the variance-covariance matrix of unrestricted error terms.

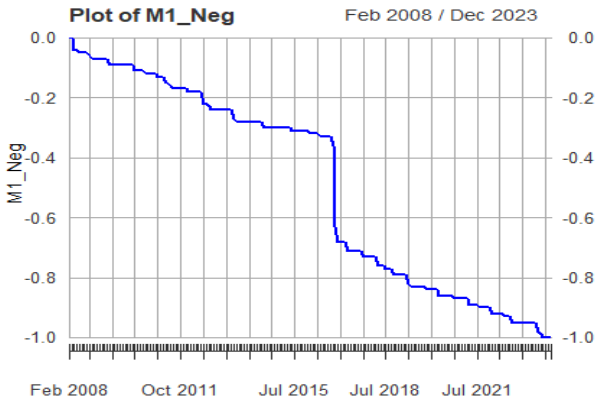
3. Data description

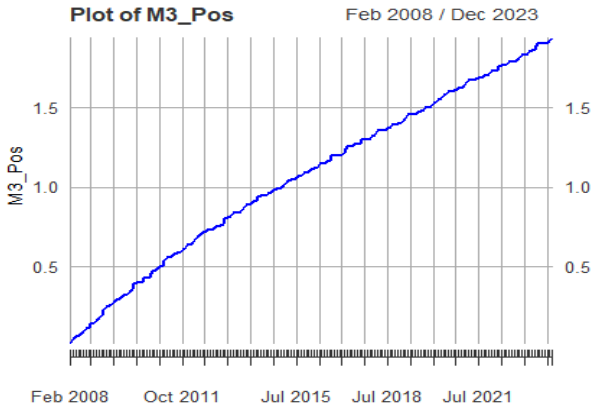
The present study empirically explores the money endogeneity or exogeneity issues in the case of India using recent data from 2008M01 to 2023M12. We extract data on variables such as monetary base *(MB),* narrow money *(M1),* and broad money *(M3)* from "the handbook of statistics on Indian economy" (HSIE) website, Reserve Bank of India (RBI). All series are extracted at monthly frequency in Indian national currency as unit of measurement and transformed into natural logarithmic form to scale down the magnitude and interpret the variables in elasticity form. Table 1 provides descriptive statistics for the variables under study. Figure 1 shows the plots of the series for without decomposition and with positive and negative decomposed series.

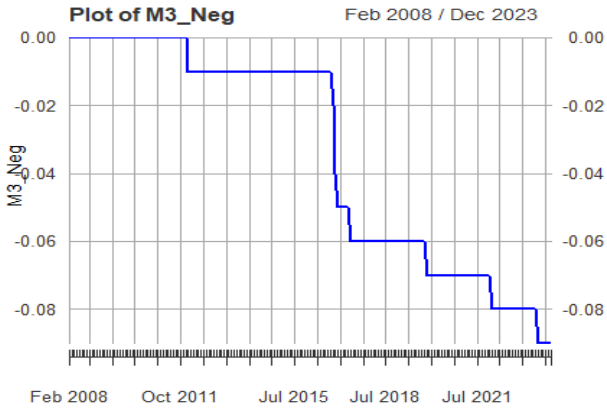

Plot of M0_Pos
Feb 2008 / Dec 2023
M0_Pos
2.5
2.0
1.5
1.0
0.5
Feb 2008
Oct 2011
Jul 2015
Jul 2018
Jul 2021

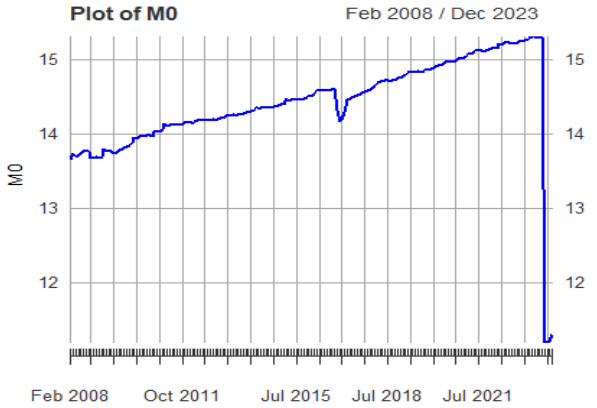

Plot of M0_Neg
Feb 2008 / Dec 2023
M0_Neg
0
-1
-2
-3
-4
-5
Feb 2008
Oct 2011
Jul 2015
Jul 2018
Jul 2021

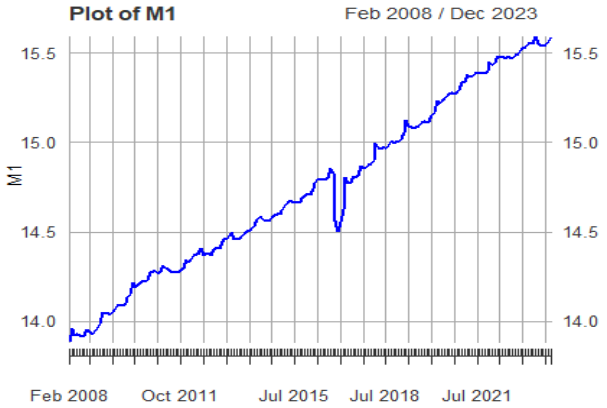

Plot of M1_Pos
Feb 2008 / Dec 2023
M1_Pos
2.5
2.0
1.5
1.0
0.5
Feb 2008
Oct 2011
Jul 2015
Jul 2018
Jul 2021


Plot of M1_Neg
Feb 2008 / Dec 2023
M1_Neg
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
Feb 2008
Oct 2011
Jul 2015
Jul 2018
Jul 2021


Plot of M3_Pos
Feb 2008 / Dec 2023
M3_Pos
1.5
1.0
0.5
Feb 2008
Oct 2011
Jul 2015
Jul 2018
Jul 2021


Plot of M3_Neg
Feb 2008 / Dec 2023
M3_Neg
0.00
-0.02
-0.04
-0.06
-0.08
Feb 2008
Oct 2011
Jul 2015
Jul 2018
Jul 2021


Plot of M0
Feb 2008 / Dec 2023
M0
15
14
13
12
Feb 2008
Oct 2011
Jul 2015
Jul 2018
Jul 2021


Plot of M1
Feb 2008 / Dec 2023
M1
15.5
15.0
14.5
14.0
Feb 2008
Oct 2011
Jul 2015
Jul 2018
Jul 2021

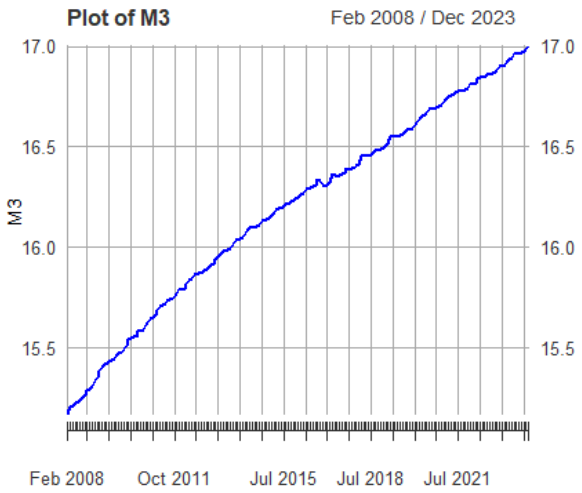


Figure 1: Time series plots of the variables under study for the period 2008M1 to 2023M12

Table 1: Descriptive statistic

Variables	MB	M1	M3
Minimum	11.195	13.867	15.152
Maximum	15.311	15.593	17.004
Mean	14.411	14.738	16.188
Standard deviation	0.660	0.499	0.509
Skewness	-2.154	0.118	-0.271
Kurtosis	8.825	-1.148	-1.012
Correlation matrix			
MB	1.000		
M1	0.515	1.000	
M3	0.517	0.986	1.000

The mean value of M3 is more than M1 and MB as M3 represents broader picture which consists of currency in circulation, demand deposit, and time deposit. The maximum and minimum value indicate fluctuation of the data and standard deviation implies the volatility of the variables. Thus, MB has more fluctuation and volatility than M1 and M3. The skewness and kurtosis figures confirm all variables are non-normal. Previewing our correlation matrix panel result, the relationship of M1 and M3 with MB is positive, however, it is not one to one relation rather partially correlated with the magnitude of 0.515 and 0.517, respectively. This implies that monetary base and money supply is not directly proportionally related to each other.

4. Empirical analysis

4.1 Stationarity tests

In an econometric analysis, first, we determine the stationarity properties of the variables under study, for instance, MB, M1, and M3. To this aim, we utilize augmented Dickey-Fuller (ADF) by Dickey and Fuller (1981) and Phillips and Perron (PP) by Phillips and Perron (1988) unit root tests. The test statistics show that at level series are nonstationary of order one at the given conventional significance level, as we fail to reject the null hypothesis of presence of unit root in the series against the alternative of difference stationary, as given in Table 2. This outcome suggests that the monetary aggregates at level are not mean reverting, which is a common characteristic of many macroeconomic time series. Nevertheless, they become stationary after first differencing. Thus, all series under study follow integrated of order one (that is I(1)) process. This implies that series contains long run information, therefore, we proceed further to establish the long run cointegrating relationship between variables. However, there are various cointegration techniques in the literature to examine the long run relationship. The choice of the techniques attributed to the nature of the time series whether they are linear or nonlinear and the objective of our present study, which leads us test the linearity of the series in the next step.

Table 2. Stationarity tests

Variables	ADF test statistic At level	ADF test statistic At first difference	PP test statistic At level	PP test statistic At first difference
MB	-0.741	-9.426***	-0.800	-13.775***
M1	-2.373	-4.664***	-3.755	-13.895***
M3	-3.538	-5.878***	-3.946	-16.291***

4.2 Linearity tests

In the next step, the present study employs linearity tests to examine the nature of the series extensively. Each variable under study is subjected to the widely used linearity tests, for instance, TNN and BDS tests. These tests are crucial in determining whether linear models are sufficient for capturing the underlying relationships or if nonlinear approaches are necessary. The results of TNN and BDS linearity tests exhibit that series under consideration are nonlinear in nature, as given in Table 3. It is evident that each series rejects the null hypothesis of linearity at a given conventional significance level against the alternative of nonlinearity. This implies that each series exhibits the presence of nonlinearity in the series.

Table 3: Linearity tests

Variables	TNN test	BDS test
	Test statistic	Test statistic
MB	5.905*	24.097***
M1	53.932***	52.285***
M3	42.096***	50.975***

4.3 Nonlinear unit root tests

It is essential to note that the standard unit root tests assume the nature of the data-generating process as linear. However, if the underlying series follows a nonlinear process, then utilizing a standard unit root tests will produce a spurious result. Therefore, in order to ensure completeness of the results, the present study employs nonlinear unit root tests, for instance, KSS (2003), Kruse (2011), and Hu and Chen (2016). The null hypothesis of "linear unit root" is examined against an alternative of "nonlinear local-explosive smooth transition autoregressive (ESTAR)" process. Each series except *MB* exhibits the evidence of nonlinear unit root in either of the three possible cases. Thus, the evidence of nonlinearity in the series reinforces the application of the nonlinear ARDL approach to cointegration.

Table 4: Nonlinear unit root test

Variables	KSS (2003)			Kruse (2011)			Hu and Chen (2016)		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
MB	-0.76	-0.38	-0.18	3.80	6.56	5.78	4.98	7.04	6.00
M1	5.17***	-0.36	-3.09	27.45***	11.63**	9.53	27.31***	6.58	20.66***
M3	13.68***	-1.93	-3.26*	227.84***	17.89***	10.57	129.77***	19.56***	11.32

4.4 Long-and short-run dynamic asymmetric coefficients' estimates

Based on the objective of the present study and the evidence of non-linear unit root present in the data motivates us to apply non-linear ARDL model, which distinguishes the positive and negative impact of monetary base on narrow and board money supply. Table 5 presents the dynamic asymmetric coefficient estimates' results, which consist of Panel A, Panel B, and Panel C indicate the long-run, short-run coefficient estimates, and diagnostic tests, respectively. The second and fourth column report the coefficient estimates for model 1 (narrow money, i.e., M1) and model 2

(broad money, i.e., M3), respectively. In case of both the models, all the long-run coefficients' estimate are significant except (MB^-). The evidence of significant estimate for (MB^+) and insignificant estimate for (MB^-) imply the presence of asymmetry for narrow money (M1) model. Likewise, in case of M1, the short-run results represent that positive partial sum for MB (MB^+) is significant while the negative partial sum for MB (MB^-) is insignificant at different lag lengths. This implies the presence of asymmetry in the short-run as well. Nevertheless, the clear sign of asymmetries could be concluded explicitly after having a formal testing of asymmetries on the short-and long-run coefficient estimates using Wald test, which we report in the next table. After all, the short-and long-run coefficient estimates exhibit that the increase or positive partial sum (MB^+) and decrease or negative partial sum (MB^-) of monetary base have proportional cointegrating relationship with M1 and M3 as we get the significant coefficient estimates. Furthermore, it is important to note that in both models the coefficient estimates are far lower than one, this implies the existence of an unstable money multiplier and an endogenous money supply determination in the case of the RBI in the short-and long-run both. The diagnostic tests are reported in Panel C for both the models (M1 and M3), which conclude that both models satisfy the series of conventional diagnostic testing.

Table 5: Dynamic asymmetric coefficient estimates

	Model 1: Dependent variable M1		Model 2: Dependent variable M3	
Panel A: Long-run estimates				
Variables	Coefficient	p-value	Coefficient	p-value
$Mi_{,t-1}$	-0.115	0.00	-0.037	0.00
MB^+_{t-1}	0.075	0.00	0.027	0.01
MB^-_{t-1}	0.009	0.19	0.019	0.09
Panel B: Short run estimate				
$\Delta Mi_{,t-1}$	0.130	0.09	-0.228	0.00
$\Delta Mi_{,t-2}$	-	-	-0.079	0.30
$\Delta Mi_{,t-3}$	-	-	-0.084	0.30
$\Delta Mi_{,t-4}$	-	-	-0.074	0.35
$\Delta Mi_{,t-5}$	-	-	-0.025	0.74
$\Delta Mi_{,t-6}$	-	-	0.176	0.35
$\Delta Mi_{,t-7}$	-	-	-0.079	0.30
ΔMB^+_t	0.722	0.00	0.143	0.00
ΔMB^+_{t-1}	-0.194	0.09	0.065	0.05
ΔMB^+_{t-2}	-0.064	0.50	0.007	0.82
ΔMB^+_{t-3}	-	-	-0.063	0.05
ΔMB^-_t	0.004	0.55	0.002	0.27

ΔMB^{-}_{t-1}	-0.011	0.26	-0.018	0.10
ΔMB^{-}_{t-2}	-0.010	0.28	-0.019	0.09
ΔMB^{-}_{t-3}	-	-	-0.017	0.12
constant	1.594	0.00	0.580	0.00
Panel C: Diagnostic tests				
Tests	Statistic	p-value	Statistic	p-value
Autocorrelation	58.25	0.03	37.390	0.59
Heteroskedasticity	43.25	0.00	0.299	0.58
Functional form	5.118	0.00	0.253	0.86
Jarque-Bera test	15795	0.00	16.360	0.00

Note: For every Mi, i stands for either M1 or M3 depending upon estimated model M1 or M3

4.5 Asymmetry statistics

Table 6 presents all the asymmetry statistics for both the models, M1 and M3. Panel A reports the asymmetric cointegration between money stocks and monetary base. The short-and long-run coefficient estimates are meaningful provided there exists long-run cointegrating relationship between variables. As it is evident from the result, we find the evidence of cointegration for M1 and M3 models using "bounds-testing approach", which implies that the series are cointegrated in the long-run as the calculated F-statistics are greater than the upper critical bound value, and, in turn, we reject the null hypothesis of no cointegrating relationship between variables. Panel B reports the normalised long-run coefficient estimates for both the models. In model M1, only the increase (MB^{+}) in the monetary base has a significant impact on M1, as the coefficient estimate is significant. This implies that the RBI's expansionary monetary policy (MB^{+}) has a significant impact on M1 but the contractionary monetary policy (MB^{-}). And in the long run, the money supply (M1) is more exogenous during the phase of monetary policy expansion than the contraction, as the magnitude is higher during expansion as compared with contraction. It is worth mentioning that their coefficient estimates are lower than one, which show less than one-to-one cointegrated proportional relation. It implies that RBI's money multiplier is unstable and endogenous determination of money supply (M1) in the long run. Moreover, the coefficient of positive partial sum (MB^{+}) is greater in magnitude as compared with negative (MB^{-}), implying that the RBI's money supply (M1) is more exogenous during expansionary phase and has more of a determining role on the money supply determination during expansionary monetary policy than its contractionary policy.

Likewise, the normalised estimates of M3 model indicate that both increase (MB^+) and decrease (MB^-) in the monetary base (MB) have long run cointegrating relationship with M3 as their coefficients' estimate are significant at the given conventional significance level. However, it is important to note that their coefficient estimates are lower than one, which indicates the existence of less than one-to-one cointegrated proportional relation. This finding implies an unstable money multiplier and endogenous money supply (M3) determination for the RBI in the long run. One of the plausible explanations is that the retail digital payment is continuously growing in India due to the introduction of electronic mode of payment system. India quickly adopted technological retail payment system and also upgraded digital payment infrastructure after the Committee of Financial Sector Reforms, 2009. This led to marginal increase in the currency in circulation and reserve money, however, there is substantial increase in the digital retail payments. Consequently, money supply determination is more prone to market forces led by digital payments than the reserve money, this signifies endogenous determination of money supply in India. Furthermore, the coefficient of positive partial sum (MB^+) is greater in magnitude as compared with negative partial sum (MB^-). This signifies that the RBI's money supply (M3) is more exogenous during expansionary phase and has more of a determining role on the money supply determination during expansionary monetary policy than its contractionary policy. In addition to above, the comparative results between M1 and M3 exhibits that the RBI's expansionary monetary policy has more of a determining role on broad money measure (M3) as compared with narrow money (M1). This finding implies that the RBI has more control over money supply, and it becomes more exogenous when the measure of money supply is taken as broad money measure as it has less liquidity component such as time deposit. In the final step, Panel C reports the asymmetric tests for models M1 and M3. The application of Wald test on the short-run and long-run coefficients' estimates in case of both the models, while checking the short-and long-run asymmetries, confirm that both increase (MB^+) and decrease (MB^-) in the monetary base (MB) have an asymmetric or nonlinear impacts on M1 and M3. The current findings of short-and long-run asymmetries presence in the monetary base helps central bank of India (that is, RBI) in determining its money supply during its expansionary and contractionary monetary policy stance distinctly.

Table 6: Asymmetry statistics

Panel A: Asymmetric cointegration					
Test statistic	k	Value	90% level	95% level	99% level

F_{PSS} for M1 model	2	4.336	2.45	3.52	2.86	4.01	3.74	5.06
F_{PSS} for M3 model	2	5.330	2.45	3.52	2.86	4.01	3.74	5.06

Panel B: Asymmetric normalised long-run coefficients

Models		Long-run effect [+]			Long-run effect [-]		
	Explanatory variable	Coefficient	F-statistic	p-value	Coefficient	F-statistic	p-value
M1 model	*MB*	0.654	314.00	0.00	-0.078	1.60	0.21
M3 model	*MB*	0.738	48.66	0.00	-0.503	4.71	0.03

Panel C: Asymmetric tests

Models		Long-run asymmetry		Short-run asymmetry	
	Explanatory variable	F-statistic	p-value	F-statistic	p-value
M1 model	*MB*	215.50	0.00	7.60	0.01
M3 model	*MB*	3.06	0.08	6.33	0.01

4.6 Dynamic multipliers

In the final step, we examine the dynamic impact of *MB* on *M1* and *M3*, as given in Figure 2 and 3, respectively, by using cumulative dynamic multipliers. Figure 2 depicts the asymmetric adjustment in M1 attributed to positive and negative impulse in the MB. The dashed green line shows the impact of positive shock in MB on M1, likewise dashed crimson line shows the impact of negative shock. Since beginning, positive and negative shocks exhibit a departure from one another, particularly in case of M1. However, the response in M3 to positive and negative shocks is more pronounced in a distant time horizons, such as post fourth period. Over time, the positive effect stabilizes at a higher level, while the negative effect remains close to zero or slightly negative. In the long run, the extent of an increased M1 caused by a positive shock in MB is greater than the negative shock. Consequently, we get the evidence of adjustment asymmetry explicitly in our response variable (M1) as it is evident by the deviations between the two shocks. It is further important to note that the current finding of asymmetric adjustment under cumulative dynamic multiplier plot reinforces to the observed asymmetry in our empirical analysis using Wald test. In that, the extent of increased narrow money was more pronounced by expansionary than contractionary monetary policy.

Moreover, a continuous blue line depicts an asymmetry line, which moves way above the zero-axis line and along with positive MB throughout the time horizons, therefore, this implies that in the long-run the expansionary shock of MB will have a more substantial effect on M1 than the contractionary shock of MB, which is moving on zero axis line until third period and after that it

is moving below the zero-axis line across the time period. In the backdrop of preceding, these characteristics of dynamic multipliers strengthens the asymmetric adjustment in India's narrow money measure. Likewise, we can also visualise effect of MB on M3 in Figure 3. Thus, India's monetary policy have an asymmetric effect on money supply measures over time.

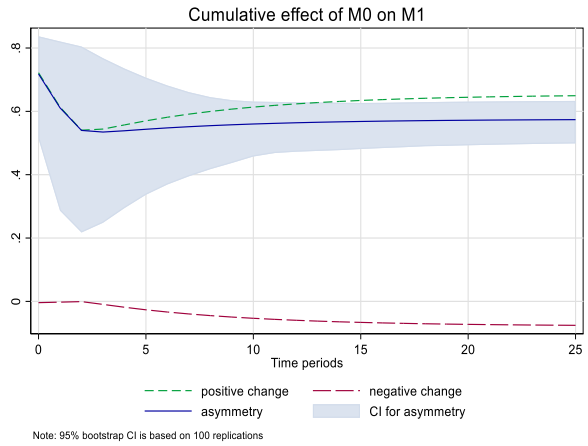


Figure 2: Dynamic multiplier for M1

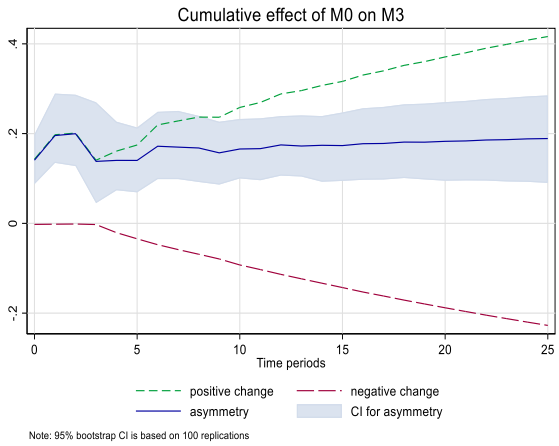


Figure 3: Dynamic multiplier for M3

4.7 Asymmetric Granger causality

4.7.1 Multivariate normality and ARCH results

After the evidence of long run equilibrium relationship between variables, the present study establishes the causal relation. To this aim, we employ an asymmetric Granger causality using bootstrap method with leverage adjustments developed by Hatemi-J (2012). This method gives valid inference even if the series under investigation follows non-normal distribution and contains potential ARCH volatility (Hatemi-J, 2012). Table 7 reports multivariate normality and ARCH tests in the VAR model for series under study. The result exhibits that the null hypothesis of multivariate normality is rejected strongly, in the case of both models *M1* and *M3*, irrespective of whether the VAR model is examined either without decomposition or for negative, positive, or a combination of the cumulative shocks. Likewise, in case of both models *M1* and *M3*, the null hypothesis of no multivariate ARCH effect is also rejected strongly regardless of whether the VAR model is examined either without decomposition or for negative, positive, or a combination of the cumulative shocks. Henceforth, the present study employs asymmetric Granger causality test using

bootstrap method in this particular case as the standard method, which is based on the assumption of normality and constant variance, is not likely to perform precisely.

Table 7: Multivariate normality and ARCH tests in the VAR model

Variables in the VAR model	Multivariate normality		Multivariate ARCH		VAR order
	Test statistics	p-value	Test statistics	p-value	
Model 1: The narrow money model M1					
$(M0,\ M1)$	25.655	0.00	188.630	0.00	5
$(M0^{+},\ M1^{+})$	10.632	0.00	508.193	0.00	7
$(M0^{-},\ M1^{-})$	38.518	0.00	164.949	0.00	2
$(M0^{+},\ M1^{-})$	14.442	0.00	529.567	0.00	5
$(M0^{-},\ M1^{+})$	25.905	0.00	189.023	0.00	9
Model 2: The broad money model M3					
$(M0,\ M3)$	23.609	0.00	189.272	0.00	7
$(M0^{+},\ M3^{+})$	19.189	0.00	721.547	0.00	7
$(M0^{-},\ M3^{-})$	42.262	0.00	186.676	0.00	4
$(M0^{+},\ M3^{-})$	12.959	0.00	601.725	0.00	5
$(M0^{-},\ M3^{+})$	21.886	0.00	186.777	0.00	5

4.7.2 Asymmetric Granger causality using bootstrap simulations

To empirically explore, in more depth, whether money is exogenous or endogenous during the expansionary and contractionary phases of monetary policies, we introduce an asymmetry in the Granger causality testing by decomposing the series under study into its cumulative sums of positive and negative shocks. Henceforth, this method helps in reinforcing our finding that money is endogenous during expansionary or contractionary phases of monetary policies. Furthermore, we test their significance using bootstrap critical values, which we fail to address in the symmetric Granger causality testing by Granger (1969). Table 8 reports the results of the asymmetric causality tests for the variables under study in terms of without decomposition, negative, positive, or a combination of the cumulative shocks. In case of *M1* model, the null hypothesis that the increase in the monetary base (MB^{+}) shock do not Granger-cause the positive narrow money ($M1^{+}$) is rejected at conventional significance level. It suggests that expansionary monetary policy Granger-causes increase in *M1*. Likewise, we find the similar evidence in case of decrease in the monetary base (MB^{-}) to positive cumulative sum of narrow money ($M1^{+}$). It indicates contractionary monetary policy Granger-causes increase in *M1*.

In the case of *M3* model, we find the evidence of rejecting the null hypothesis that the increase in the monetary base (MB^+) shock do not Granger-cause the positive broad money ($M3^+$) at conventional significance level. It suggests expansionary monetary policy Granger-causes increase in *M3*. Similarly, we reject the null hypothesis that a decrease in monetary (MB^-) base shock does not Granger-cause positive cumulative sum of broad money ($M3^+$). It indicates contractionary monetary policy Granger-causes increase in *M3*. In the backdrop of preceding, the present study finds that both narrow and broad monetary measures are endogenous in nature regardless of whether the stance of the RBI's monetary policy is expansionary or contractionary. Thus, the asymmetric Granger causality result reinforces the finding of money endogeneity established through asymmetric ARDL model.

In a nutshell, the present study introduced new methodology—asymmetric ARDL approach to cointegration and asymmetric Granger causality using bootstrap method—in examining the money endogeneity or exogeneity issues, which provides an insight to the central bank of India in determining their money supply processes in their expansionary or contractionary monetary policies distinctly. Consequently, this may help monetary authorities as an essential information or indicator variable to manage inflation effectively under the current flexible inflation targeting framework.

Table 8: The asymmetric Granger causality results using the bootstrap simulations

Model 1: The narrow money model M1				
Null hypothesis	Test value	Bootstrap CV at 1%	Bootstrap CV at 5%	Bootstrap CV at 10%
$MB \neq> M1$	0.022	12.313	3.613	2.251
$MB^+ \neq> M1^+$	3.344	7.789	3.916	2.423
$MB^- \neq> M1^-$	0.058	8.445	2.470	1.425
$MB^+ \neq> M1^-$	0.018	9.605	3.217	2.026
$MB^- \neq> M1^+$	6.254	16.037	6.679	4.445
Model 2: The broad money model M3				
$MB \neq> M3$	0.004	8.221	4.041	2.708
$MB^+ \neq> M3^+$	10.773	8.256	5.753	4.317
$MB^- \neq> M3^-$	0.088	26.713	7.259	4.465
$MB^+ \neq> M3^-$	0.023	8.022	3.638	2.384
$MB^- \neq> M3^+$	9.370	12.542	6.213	3.967

5. Conclusion

The comprehensive study on money supply determination is inevitable for an effective monetary policy implementation by the Central bank as it is a steppingstone for the macroeconomic theories and policy formulation. Therefore, it is essential to know the nature of money supply in any economy whether it is endogenous or exogenous during expansionary or contractionary phases of monetary policies. However, it is evident and widely accepted since the pioneer work of Akerlof (1970) and Stiglitz (1974) that the markets exist with an asymmetric information phenomenon. Against this backdrop, the emerging economies, in the present study we consider India, may witness inefficiency in the financial market in the presence of asymmetric information. Consequently, it may lead Central bankers to behave asymmetrically in the money supply determination process during the expansionary and contractionary stances of monetary policies formulation.

The previous literature in emerging and advanced economies, in general, and India, in particular, has examined money supply determination symmetrically. Therefore, in case of potential asymmetry attributed to asymmetric information phenomenon the result based on symmetric relation may be misleading. To overcome this issue, the present study aims to re-examine the money supply determination in case of India, using recent data 2008M01 to 2023M12, from the methodological perspective which postulates that there may exist asymmetric or nonlinear relationship between India's monetary base and the money supply through the linkage of the money multiplier. To this aim, first, we employ linear and nonlinear unit root tests and linearity tests to examine the nature of the series. Second, depending upon the nature of the series and the objective of our current study, we utilize the nonlinear ARDL approach to cointegration to capture the asymmetric or nonlinear long run cointegrating relationship between variables. This model decomposes the series under study into their positive and negative partial sums, which helps examine the asymmetric impact of explanatory variable on the response variable. Consequently, the original *MB* series is decomposed into positive cumulative sums or increase (MB^{+}) implies expansionary monetary policy and negative cumulative sums or decrease (MB^{-}) implies contractionary monetary policy. Thus, the nonlinear ARDL model helps understand how does money supply respond to expansionary or contractionary monetary policies separately. Furthermore, it helps establish whether money is endogenous or exogenous through stable or unstable money multiplier. Third, based on an asymmetric information phenomenon, we employ

asymmetric Granger-causality test by Hatemi-J (2012), which establishes the causal inferences for the negative, positive, or a combination of the cumulative shocks of the series under study.

The empirical findings of the present study reveal the following. First, we find the evidence of nonlinear unit root and nonlinearity in the series. Second, the application of nonlinear ARDL reveals the existence of asymmetric long run cointegrating relationship between variables. Furthermore, the money multiplier for both monetary measures, that is, M1 and M3 are found to be unstable, which implies money supply determination process for India is endogenous both during the RBI's expansionary and contractionary phases of monetary policies. However, the endogeneity is more prevalent in case of narrow money measure (M1) than broad (M3). This can be interpreted as the RBI is having more power to determine M3 than M1. Furthermore, the endogeneity is more obvious during RBI's contractionary phase of monetary policy than expansionary. This can be interpreted as the RBI's expansionary monetary policy has more of an influencing role in the determination of broad money supply than its contractionary monetary policy. Third, in case of both monetary measures, the asymmetric Granger-causality establishes the causal inferences from expansionary and contractionary monetary bases to positive money supply shocks, which reinforces the evidence of endogeneity found in case of nonlinear ARDL.

In the backdrop of the preceding, the current finding from both the models signifies as the measure of money broaden, the RBI is having more control during increase of money supply or expansionary monetary policy, emphasizing the importance of understanding these asymmetries for an effective policy implementation. These findings provide crucial insights to the Central bank, suggesting that conventional linear approaches may not adequately capture the dynamics of India's monetary system. Moreover, the nonlinear behaviour identified in this study suggests that more sophisticated models may be required to forecast accurately the effects of monetary policy actions in the Indian context; as the economy continues to grow and faces new challenges, these insights will be essential for effective monetary policy.

In a nutshell, our research contributes to a deeper understanding of the asymmetric nature of India's money supply determination by introducing an asymmetric ARDL approach to cointegration and asymmetric Granger causality using bootstrap method in examining the money endogeneity or exogeneity issues during expansionary and contractionary monetary policies distinctly. The findings of the present study carry out significant policy implications for India's evolving monetary

landscape wherein the monetary authorities of the Central bank may consider the nature of the money supply as an essential information or indicator variable to manage inflation effectively under its current flexible inflation targeting framework.

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