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A note on monetary policy and long-term interest rates in India: an efficient markets approach

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ABSTRACT

The present study aims to empirically analyze the relationship between the growth in money supply and the long-term interest rates in India through the application of efficient market theory. The study uses quarterly data over a period from 2010 to 2023. The advantage of the efficient market approach is that it provides a theoretical structure for explaining the relationship between the money stock and long-term rates. From the evidence, it can be suggested that there is no strong evidence for the view that growth in money supply is negatively correlated with changes in long-term interest rates. The implications of the study depend on the treatment of money supply processes in terms of exogeneity. If the growth in money supply is assumed to be exogenous, then the result of the present study opposes the commonly held view that an increase in the money supply would decrease the long-term interest rate.

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Monetary policy; money supply; long-term interest rates; efficient market theory

1. Introduction

Central banks, governing monetary policy, attempt to influence the relative prices of money at different times and states, in other words, influencing the short-term and long-term interest rates by changing the stock of money. Although achieving the optimal targets of monetary policy¹ by adjusting the money supply growth is relatively uncomplicated, it ignores how the long-term interest rates react to these changes in money supply growth. This signals why the same level of monetary policy target brings about different economic performances at different times and in different states. Long-term interest rates play a crucial role in determining the level of economic activity. Intuitively, the capital goods essential for economic activities carry the property of irreversibility and indivisibility of investment purchase, which poses an optimal stopping constraint on investment decisions. Therefore, it is meaningless to expect that the monetary authority can raise aggregate demands for capital goods by merely changing the short-term interest

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¹Generally, the short-term interest rates and mainly determined through the combination of the inflation gap and gross domestic product (GDP) gap (Taylor, 1993).

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rate. This is because, in practice, a decline in the short-term interest rate is often followed by an increase in the long-term interest rate, discouraging agents from investing in capital assets.

However, a decline in long-term interest rates has an expansionary impact on investment and consumer expenditure through its effect on the valuation of capital, which has always been the key element in the monetary policy transmission mechanism. Thus, with an implicit belief that an effective monetary policy should consider both short-term and long-term interest rates to boost economic activity, it is essential that the central banks have a reliable view of the relationship between the changes in the money supply and interest rates in the economy.

1.1. Liquidity effect, income & price level effect and price anticipation effect

The effect of growth in money supply on the long-term (nominal) interest rate has always been a hotly debated issue in the field of monetary economics. According to the "Keynesian" structural macro-models, an increase in money supply growth leads to a decline in long-term interest rates. This view is based on the rationale that as demand for money is a decreasing function of nominal interest rate because of the opportunity cost of holding cash, so an increase in the supply of money must decrease the interest rates to maintain the money market equilibrium referred to as the "liquidity effect." The media has often reported that the country's government advises the central bank not to decelerate the growth in the money supply, as it may lead to an increase in interest rates to objectionable levels.

Milton Friedman (1968, 1969) argued that the so-called liquidity effect ignores the dynamic effects of the increase in the money supply. He proposed that increase in money supply has an expansionary effect on both real income and price level. This "income and price level effect" then tends to increase the interest rates through the general arguments of the money demand function and, therefore, can counter the liquidity effect. Friedman further suggested that an increase in money stock could also influence anticipations of inflation. This "price anticipation effect" through Fisher (1930) relation can reverse the decline in interest rates and, at times, could also overpower it by showing positive relation between money supply and interest rates. According to the Fisher equation, the nominal interest rate is equal to the real interest rate plus the expected rate of inflation (Fisher, 1896). If the real interest rates are not affected by monetary policy, the Fisher equation suggests that higher nominal interest rates are related to higher inflation rates. In the long run, high money supply growth rates lead to high inflation, and, therefore, Fisher's equation implies that an increase in money growth rate leads to an increase in nominal interest rates. This proposition supports the causal view that countries with high growth in money supply experience a rapid increase in interest rates. Thus, the above views apparently offer conflicting solutions to the central bank's quest to translate optimal interest rate targets into money supply growth.

1.2. Non-neutrality of money

In the past two decades, the macroeconomic views have converged to form a theoretical consensus termed the new consensus macroeconomics (NCM) (Rangarajan & Nachane,

2021). One of the viewpoints of the NCM tenets is that money is neutral, i.e., it has no independent impact on the economy except through interest rates (Woodford, 2007). This is evident from the fact that in recent years, the money supply is no longer an explicit concern for monetary policymakers across the globe, with the exception of the European Central Bank. According to the NCM framework, money supply reacts passively once the nominal interest rate is set, adjusting at a level defined by the LM curve (Patra & Kapur, 2010). For many years, the U.S. Federal Reserve Board has stopped reporting money-growth targets in monetary policy announcements. Although the European Central Bank reports a detailed analysis of monetary and credit developments in Pillar-2, its only purpose is to substantiate the implications of the economic analysis of Pillar-1. In India, the money supply only acts as an important adjunct to interest rate policy, with no specific targets set for monetary aggregates. Therefore, it may be said that monetary aggregates are now typically secondary when determining monetary policy.

However, it would be premature to conclude that monetary aggregates play an insignificant role without reference to empirical data. According to Rangarajan and Nachane (2021), the NCM model with monetary aggregates better explains the empirical reality. They suggested that without the monetary aggregates, the NCM model fails to capture the important effects of money supply on the IS curve. The neutrality of money is based on the assumption that the demand and supply of goods and services depend only on relative prices and are independent of money supply levels. However, studies like Bils and Klenow (2004), Balke and Wynne (2007), Anzuini et al. (2012), Pasten et al. (2020), Mongey (2021) and Afrouzi (2023) that tested the neutrality hypothesis empirically demonstrate that monetary policy shocks do impact relative prices and hence aggregate demand. Another alternative explanation for the non-neutrality of money is the misperception model of Lucas (1972), which holds that consumers and businesses are unable to discriminate between relative and aggregate price shocks. Under this assumption, Hercowitz (1982) showed that money supply shocks could result in a relative price distortion, where some prices change more than others but move in the same direction. Thus, based on the above arguments, it is possible that monetary aggregates could still have some impact on the economy.

1.3. Interest rate channel of monetary transmission

The relationship between money supply and interest rates can also be inferred from the context of the interest rate channel of monetary transmission. Typically, monetary authorities regulate the monetary base and/or short-term interest rates. The changes in the policy rate or short-term interest rates are transmitted through the term structure of interest rates to affect the end-objectives of inflation and growth. So if the interest channel effectively achieves the ultimate objectives of price stability and economic growth, it suggests that the monetary authorities relatively succeed in influencing the term structure of interest rates by regulating the short-term interest rates actions through the liquidity operations.

Taylor (1995) found the traditional interest rate channel to be an effective channel of monetary transmission based on the financial market prices framework. Bernanke and Gertler (1995) argued that monetary policy instruments affect short-term interest rates; however, their influence on long-term interest rates is negligible, implying the

ineffectiveness of interest rate channels in stimulating investments and purchasing durable assets. Ramey (1993), by incorporating the vector error correction model (VECM), showed that the money channel was highly significant compared to other channels in the US economy. Bean et al. (2002) concluded that one of the significant reasons for the ineffectiveness of interest rate channels in impacting the aggregated demand was the presence of financial frictions in the economy. Smets and Wouters (2002) and Angeloni et al. (2003) found that the monetary policy shocks through the interest rate channel were the dominant channel in affecting consumption, investment, and real output in European countries. Gerstenberger (2020) observed that the interest rate channel remained effective in the post-crisis period in Germany, with firms demonstrating responsiveness to changes in the user cost. Baştav (2020) found that the interest rate channel is not operative in Turkey in the traditional or New Keynesian sense. Instead, increased demand leads to higher prices, which subsequently influence interest rates, and the reverse also holds true.

Results of empirical studies on emerging and developing economies are similar to those of developed countries. Disyatat and Vongsinsirikul (2003), using the vector autoregressive (VAR) framework, found that both the interest rate channel and bank channel play an important in transmitting monetary policy in Thailand. Amarasekara (2008) and Kabundi and Ngwenya (2011) concluded that the interest rate channel is the primary channel for monetary transmission in Sri Lanka and South Africa. Kabundi and Nonhlanhla further observed that the monetary policy shocks had a short-term effect on prices and aggregate demand using the factor augmented vector autoregressive (FAVAR) framework. Other studies like M. S. Mohanty and Turner (2008) and Mukherjee and Bhattacharya (2011) on emerging market economies (EMEs) concluded that the interest rate channel affects consumption, investment, and real output.

On the other hand, reviewing some studies on low-income countries disclosed that the weak domestic financial system and segmented large informal system impaired the effectiveness of traditional monetary transmission channels (Bhattacharya et al., 2011; Mishra et al., 2012). Interestingly, studies on monetary policy transmission in India depicted the importance of the interest rate channel. Al-Mashat (2003), by applying a structural vector error correction (VECM) model, confirmed the impact of interest rate channel on key macroeconomic variables. The RBI Working Group on Money Supply (Chairman: Y.V. Reddy, 1998) suggested the significant presence of an interest rate channel of monetary transmission. Reserve Bank of India (2005), incorporating the VAR framework, observed that the monetary tightening through positive policy rate shocks had a negative impact on real output and prices, and monetary easing through a positive money supply shock impacted real output and prices positively. Other empirical studies by Singh and Kalirajan (2007), Patra and Kapur (2010), and Pandit and Vashisht (2011) depicted the significance of the interest rate channel of monetary policy. Thus, from the literature on monetary policy transmission, it can be inferred that there exists a general consensus on the efficacy of the interest rate channel of monetary transmission through an adjunct of liquidity management.

Literature on the relationship between growth in money supply and long-term interest rates shows both lines of empirical work, i.e., a positive relation versus an inverse relationship between the money stock and long-term rates. Although "Keynesian" macro-econometric models are of the view that an increase in money

stock declines the long-term rates by imposing a fair amount of structure in the estimation process, as in Modigliani (1974), these models ignore the constraints imposed by the efficient market theory propounded by Fama (1970). Further, Mishkin (1981) suggested that macro-econometric models can lead to misleading results if financial market efficiency is not incorporated into these models. An alternative way is to apply the reduced form estimation method by regressing historical changes in long-term rates on the past changes in the money stock, Gibson (1970). However, the major challenge with this approach is that it neither imposes any theoretical framework nor provides any structure to the estimation process. This results in a large number of parameters being estimated with low statistical power.

Following the global financial crisis of 2007–08, particularly after the implementation of quantitative easing (QE) by the U.S. and various other countries, the liquidity channel has surfaced as a new channel of monetary policy (see Rodnyansky and Darmouni (2017), Chakraborty et al. (2020), DiMaggio et al. (2020) and others). Quantitative easing (QE) and the subsequent shift in the level of reserve money have generated substantial excess reserves within the banking system, thereby fostering the inclination to grant loans by commercial banks. Similar behavior by the monetary authorities was witnessed during the post-COVID-19 period when central banks worldwide adopted several unconventional monetary policy measures to inject liquidity into the economy. Following the footsteps of major central banks across the globe, the Reserve Bank of India implemented long-term repo operations (LTRO) and operation twist (OT) to infuse liquidity and flatten the yield curve to support the moribund economy (Lakdawala et al., 2023). It has been observed that during exceptional circumstances, monetary base expansion could be the sole policy tool available to the monetary authorities. This highlights the important role played by the money supply in the economy under exceptional situations. Therefore, the present study attempts to examine the role of the money supply during the exceptionally high liquidity phase from 2010 to 2023.

Although number of empirical studies have been done during the post-crisis period to understand the dynamics of the transmission mechanism through interest rate channel (Awdeh et al., 2020; Bhoi et al., 2017; Goyal and Agarwal, 2017; Iddrisu & Alagidede, 2020; Kapur and Behra, 2012; Khundrakpam and Jain, 2012; Kohli et al., 2019; D. Mohanty, 2012; Oyadeyi, 2023), only limited literature exists on the impact of money stock on long-term interest rates in the context of advanced economies and emerging and developing economies (some related literature like Amisano & Tristani, 2023; Cochrane, 2024; Deleidi & Levrero, 2021; Lakshmanasamy, 2022; Long et al., 2021; Rasool et al., 2020and others).

In this study, an efficient market model outlined by Mishkin (1981) based on efficient market theory has been applied to analyze the relationship between the growth in money supply and long-term interest rates in the context of India by using quarterly data over a period from 2010 to 2023. The advantage of this approach is that it provides a theoretical structure for explaining the relationship between the money stock and long-term rates. Further, the study incorporates the "Keynesian" liquidity preference view of interest rate determination in the efficient market model to better explain the relationship between the money stock and long-term rates.

Against this backdrop, the present paper is organized as follows. Section 2, describes the framework for an efficient market model that analyses the relationship between the growth in money supply and long-term interest rates. Section 3, discusses the data, the estimation method, and the results. Section 4, concludes the discussion.

2. The framework

According to the efficient market theory proposed by Fama (1976), in a capital market, security prices reflect all the available information. In specific terms, it implies that the probability distribution of future prices of securities assessed by the market is equal to the true probability distribution of future prices of securities conditional to the available information.

$$E_m(P_{i,t}|\Phi_{t-1}) = E(P_{i,t}|\Phi_{t-1})$$
(1)

Where, $(P_{i,t}) = price$ of security i at time t, $(\phi_{t-1}) = available$ information at time t - 1, E_m (... $| \phi_{t-1}) = unbiased$ market expectation at t - 1 and E_m (... $| \phi_{t-1}) = true$ expectation conditional to ϕ_{t-1} .

In order to empirically apply the above concept and to determine the equilibrium prices, it is important to describe the relationship between current prices and expected future prices. It is rational to assume that the market equates one-period expected return across all the securities, considering the constant liquidity risk premium. The one-period return for long-term bonds is given in equation (x),

$$BR^*_{t} = (P^*_{B,t} - P_{B,t-1} + C_{B,t-1})/P_{B,t-1}$$
(2)

Where, (*) indicates a random variable, (BR^*_t) = one-period nominal return for long-term bonds, which includes capital gain and coupon yield, (P_B) = price of long-term bond, and (C_B) = coupon

Thus, based on the above concepts, the market equilibrium model can be presented as,

$$E_m(BR^*_t | \Phi_{t-1}) = r_{t-1} + \theta$$
(3)

Where, $(r_{t-1}) =$ short-term interest rate and $(\theta) =$ constant liquidity risk premium.

Then, the efficient market theory implies that,

$$E(BR^*_t - r_{t-1} - \theta | \Phi_{t-1}) = 0$$
(4)

As $(BR_{t}^{*} - r_{t-1})$ in equation (4) is uncorrelated with any information available in the past, equation (4) can be transformed into a similar version of an efficient market model given in equation (5),

$$BR^*_t - r_{t-1} = \theta + \lambda (X_t - X^e_t) + \varepsilon_t$$
(5)

Where, (X_t) = explanatory variables for pricing long-term bonds, $X_t^e = E(X_t | \phi_{t-1})$, optimal expected values conditional to ϕ_{t-1} , (λ) = coefficient of explanatory variables, ε_t = error process with no autocorrelation, i.e., $E(\varepsilon_t | \phi_{t-1}) = 0$.

According to Muth (1961), when expected future short-term rates are "rational" (or optimally determined), the efficient market model shown in equation (5) is consistent with the expectation theory of term structure.

The efficient market model emphasizes that the $(BR^*_t - r_{t-1} - \theta)$ becomes non-zero only when a piece of new information is available in the market. This suggests that in equation (5), only anticipated changes in explanatory variables are correlated with $(BR^*_t - r_{t-1})$. The difference between the anticipated and unanticipated changes in variables and its impact was empirically explained by Barro (1977, 1978). In equation (5), it is assumed that the coefficient on r_{t-1} is equal to one. This assumption is based on the previous empirical work by Fama and Schwert (1977) and Mishkin (1981), where the given market equilibrium model failed to get rejected.

As discussed in the introduction, the objective of this research is to examine the relationship between the growth in money supply and long term-interest rates; therefore, substituting growth in money supply (MG_t) for X_t in the efficient market model equation (5) gives,

$$BR^*_t - r_{t-1} = \theta + \lambda_m (MG_t - MG^e_t) + \varepsilon_t$$
(6)

In India, the money supply is usually measured by broad money (M3) (Dash & Goyal, 2000; Kumar, 2023; Padhan, 2011; Rangarajan & Nachane, 2021; Sahu & Pandey, 2020). However, as there is no potential theoretical reason for estimating the model with one monetary aggregate, both narrow money (M1) and broad money (M3) are used for estimating the efficient market model in this study. The measurement of unanticipated growth rates of narrow money (M1G) and broad money (M3G) is explained in the data section.

The long-term interest rates are closely and inversely related to the prices of the long-term bonds, and this indicates that there is a high negative correlation between the change in the long-term interest rates and (BR*_t - r_{t-1}). Mishkin (1978), in his empirical study, showed that this correlation was about -0.96. Thus, as per the "Keynesian" macro-econometric model, if the unanticipated growth in the money supply is negatively correlated with long-term interest rates, then the coefficient (λ_m) on (MG_t - MG^e_t), unanticipated growth in the money supply should be significantly positive, i.e., $\lambda_m > 0$.

Here is an important caveat, the efficient market model in equation (5) never states that $(X_t - X_t^e)$ is exogenous, and therefore the (λ) estimates are consistent. A formal discussion on the consistency of (λ) can be found in Abel and Mishkin (1983). In other words, in an efficient market model, a significant coefficient (λ) never implies causation from unanticipated changes in variables to long-term bond prices and, thereby, longterm interest rates. Causation could be in the reverse direction or may be non-existent. It only shows that (BR*_t - r_{t-1}) correlates with unanticipated changes in variables. Therefore, one must be cautious in interpreting (λ) in terms of causality.

In the case of the money supply process, if it is exogenous, then the significant (λ) coefficient supports the "Keynesian" view that in the short-run increase in the money supply growth would lead to a fall in long-term interest rates. In literature money supply process as an exogenous factor has received some support, Sims (1972). However, if the money supply process is not exogenous, a view maintained by many critics of monetarist analysis, Jacobs et al. (1979) and Zellner (1979), the estimated (λ) coefficient may be inconsistent due to the simultaneous equation bias and can be misleading in explaining the impact of growth in money supply on long-term interest rates.

According to the neoclassical view, the money supply grows through the mechanism which is exogenous to the pressures of financial markets, i.e., strictly through processes adopted by the central bank. However, Post Keynesians believe that the growth in the

money supply is fundamentally determined by the pressures rising endogenously within the financial markets. According to this view, when banks and other financial intermediaries hold insufficient reserves in the process of credit creation, the central bank must accommodate the needs of banks and financial intermediaries. Otherwise, it would threaten the functioning of the financial system, and hence the economy may collapse (Moore, 1979, 1986, 1988, 1989; Nicholas Kaldor, 1985a, 1985b; Sidney; Weintraub, 1978b, 1978a). This accommodative money supply endogeneity has an important policy implication, and it suggests that the central bank's role as a major independent influencer of money supply growth is not as important as assumed in the mainstream literature.

In this paper, no evidence has been provided on the exogeneity of the money supply process, and, therefore, the estimates of (λ) coefficient will only provide information about the correlation between the unanticipated growth in money supply and changes in long-term interest rates.

From the literature on demand for money, the liquidity preference approach shown in equation (7) provides certain relevant information that might be incorporated into the efficient market model, Goldfeld et al. (1973) and Laidler (1977).

$$ln(M/P)_t = \alpha_0 + \alpha_1 ln(Y_t) - \alpha_2 ln(R_t) + u_t$$
(7)

Where (M_t) = money stock, (Y_t) = real income, (R_t) = representative interest rates, (P_t) = price level, (u_t) = error term, and $(\alpha_0, \alpha_1, \alpha_2)$ = positive coefficients.

To solve for change in $ln(R_t)$, equation (7) can be transformed into equation (8),

$$\Delta ln(R_t) = (\alpha_1/\alpha_2) \Delta ln(Y_t) - (1/\alpha_2) \Delta ln(M_t) + (1/\alpha_2) \Delta ln(P_t) + (1/\alpha_2)(u_t - u_{t-1}) + (\alpha_0/\alpha_2)$$
(8)

Thus equation (8) implies that the long-term interest rates and the bond prices are related not only to growth in money supply but also related to growth in real income and growth in the price level. Incorporating this information into an efficient market model would lead to equation (9).

$$BR^*_t - r_{t-1} = \theta + \lambda_m (MG_t - MG^e_t) + \lambda_y (YG_t - YG^e_t) + \lambda_\pi (\pi_t - \pi^e_t) + \varepsilon_t$$
(9)

Where, $(YG_t) = \text{growth in real income}$, $(\pi_t) = \text{inflation rate, and } (\lambda_m, \lambda_y, \lambda_\pi)$ are coefficients. equation (9) can be seen as an efficient market analog of the money demand function, and it also incorporates the essential elements of the interest models of Feldstein and Eckstein (1970).

The sign and magnitude of (λ) coefficients in equations (6) and (9) are assumed to be dependent on the underlying structural theory like liquidity preference. The unanticipated increase in the growth of income would have a negative effect on bond returns and, thereby, an increase in long-term interest rates. On the other hand, an unanticipated increase in inflation would also lead to an increase in interest rates, as the unanticipated increase in inflation reduces the real money balance in the economy. This effect of unanticipated inflation is further supported by Cagan (1956) adaptive expectation model, Fisher (1930) relationship, and Friedman (1956) money demand function. Thus, the coefficient of unanticipated growth in the income and inflation should be negative in equation (9), i.e., $\lambda_y < 0$ and $\lambda_{\pi} < 0$.

3. The data, the estimation method and the results

The quarterly data over a period from 2010 to 2023 have been used in this empirical study. The descriptions of the variables used in the estimation process efficient market models of equation (6) (BR*_t - $r_{t-1} = \theta + \lambda_m (MG_t - MG^e_t) + \epsilon_t)$ and equation (9) (BR*_t - $r_{t-1} = \theta + \lambda_m (MG_t - MG^e_t) + \epsilon_t)$ and equation (9) (BR*_t - $r_{t-1} = \theta + \lambda_m (MG_t - MG^e_t) + \lambda_v (YG_t - YG^e_t) + \lambda_\pi (\pi_t - \pi^e_t) + \epsilon_t)$ are as follows,

3.1. Dependent variables

 (\mathbf{BR}_t) = quarterly return of long-term government bonds from the beginning to the end of the quarter. Long term is defined as 10 years or more than 10 years to maturity. Following equation (2), $BR_t = (P_{B,t} - P_{B,t-1} + C_{B,t-1})/P_{B,t-1}$

Where, $P_{B,t}$ = price of long-term bond at the end of the quarter (last traded price of the last day of the quarter) and $P_{B,t-1}$ = price of long-term bond at the beginning of the quarter (last traded price of the first day of the quarter), and C_B = accrued interest over the quarter.

 (\mathbf{r}_{t-1}) = quarterly yields on the 91-day Treasury bill rate at the beginning of the quarter.

3.2. Explanatory variables

 $(M1G_t)$ = quarterly growth rate of narrow money (M1) by taking the first difference series of log of average level² of M1 in the last month of the quarter.

 $(M3G_t)$ = quarterly growth rate of broad money (M3) by taking the first difference series of log of average level³ of M3 in the last month of the quarter.

 (IPG_t) = quarterly growth rate of the index of industrial production (IIP) by taking the first difference series of log of IIP in the last month of the quarter.

 (π_t) = quarterly consumer price index (CPI) inflation rate by taking the first difference series of log of CPI in the last month of the quarter.

 $(\mathbf{TR}_t)^4$ = quarterly yields on the 91-day Treasury bill rate of the last trading day in the quarter. The long-term bond returns have been computed from the security prices obtained from the Clearing Corporation of India Limited (CCIL). Apart from this, all the data have been obtained from the Database on Indian Economy of Reserve Bank of India (RBI). In this study, the estimation of the efficient market models equations (6) & (9), and estimation of anticipated measures of growth in money supply, growth in income, and inflation rate using time-series models equation (10) is done using the R software.

It is important to mention here that the use of averaged data in efficient market models can lead to misleading results (Working, 1960). Therefore, in this study, bond returns are measured from bond prices at specific points in time, i.e., the beginning and end of the quarter. Further, an attempt has been made to measure the other variables using the data points as closely as possible to the end of the quarter. The use of data that is close to the end of the quarter is imperative for the estimation of equations (6) and (9) of an efficient market model. Quarterly averaged data fail to explore the relationship

²Although the use of averaged data in efficient market models can lead to misleading results, Working (1960), the log of the average level of M1 and M3 in the last month of the quarter (Mishkin, 1981), has been taken to capture the level of money supply better, as the Reserve Bank of India compiles M1 and M3 fortnightly in India.

³Ibid.

 $^{{}^{4}(}TR_{t})$ is an explanatory vector of variables ($Z_{i,t-1}$) applied in equation (10) for the estimation of anticipated measure of variables ($X_{i,t}$) discussed in equation (10)

between bond returns and unanticipated variables of the efficient market model. For more details about the use of data for efficient market models, please refer to Mishkin (1981) and Working (1960). Because of this, the index of industrial production (IIP), which is the only indicator for which monthly data are available, has been used as a proxy for real income in equation (9) of the efficient market model instead of real gross domestic product (GDP), which is a quarterly estimate and a more broad measure of real income. The limitation of using IIP is that it tracks the performance of only the industrial sector in India and thus partially measures real income. However, considering the larger interest in estimating the efficient market model of equation (9), the monthly data of IIP get precedence over quarterly estimates of GDP.

Figure 1 shows the return of long-term government bond in percentage (left axis), log of narrow money (M1), and log of broad money (M3) (right axis) from 2010 to 2023. From the figure, it can be observed that both narrow and broad money supply have been growing at a steady rate; however, long-term bond returns are pretty volatile, with a range of around positive 6% to negative 8%.

Now, in order to estimate the efficient market models, anticipated measures of growth in money supply, growth in income, and inflation rate have to be determined. It is assumed that the anticipated measures of these variables are optimal linear forecasts and can be estimated using time-series models shown in equation (10).

$$X_{i,t} = \beta_i Z_{i,t-1} + u_t \tag{10}$$

Where, X_i is the growth in money supply (MG), the growth in income (IPG) and the inflation rate (π), subscript (i) refers to either of these variables, $Z_{i,t-1}$ is a vector of variables containing information available at the time (*t*-1), and β_i is a vector of coefficients.

In equation (10), a critical issue is the methodology for defining the specification of the time-series model. To exclude any variable as a predictor of $X_{i,t}$ based on the theoretical grounds is sometimes not justifiable. For example, in the money growth equation, the



Figure 1. Bond return, narrow money and broad money in India. Note: This figure shows quarterly return of long-term government bond in percentage (left axis), log of narrow money (M1), log of broad money (M3) (right axis) from 2010 to 2023.

theory is inconclusive in suggesting which variable is to be excluded. Therefore, it is suggested that an atheoretical statistical procedure might be superior to economic theory for defining the specification of the time-series model. In order to validate the robustness of estimated results of efficient market models, two methods for specifying time-series models of equation (10) have been used here.

An uncomplicated way to determine anticipated measures of growth in money supply, growth in income, and inflation is to use univariate autoregressive time series models. It has been seen from the past researches that autoregressive models of the fourth-order are helpful in reducing the residuals to white noise. Thus, in this study, autoregressive time series models of the fourth-order have been used to determine anticipated measures of the variables. However, according to Chow (1960) tests, it was observed that univariate time-series models suffer from the problem of unstable coefficients. Therefore, in this study, the multivariate time-series models have also been used to determine the anticipated measures of the variables using the following method.

In the multivariate time-series models, each of the four variables (M1G, M3G, IPG, and π) are regressed on its four lagged values and four lagged values of the other three variables as well as four lagged values of the following variables, quarterly yields on 91-day Treasury bill rate (TR), India's foreign trade balance (FTB), and fiscal deficit of the central of government of India (FD). The source of these other variables is the Database on Indian Economy of Reserve Bank of India (RBI). The other variables have been considered based on the literature review, Fair (1978) and Mishkin (1981).

Table 1 shows the results obtained from the univariate autoregressive time series models for the anticipated measures of M1G, M3G, IPG, and π . The results of the p-values depict a fair amount of persistence in the univariate time series model of growth in money supply, industrial production, and inflation. This indicates that the "income and price level" and "price anticipation" effects explained in Friedman (1968, 1969) are potentially important. Table 2 shows the results obtained from the multivariate autoregressive time series models. From the results of the R-squared value, it can be seen that the multivariate models are having much better fit than the corresponding univariate model.

Now, in order to estimate the efficient market model, a two-step procedure outlined in Barro (1977, 1978) and Mishkin (1981) has been used in this study. The residuals obtained from time-series models shown in Tables 1 and 2 can be used as proxies for the corresponding unanticipated changes in the variables for estimating equations (6) and (9). The two-step procedure implicitly assumes that the covariance of (β) and (λ) estimates are zero. The estimates of the efficient market model using the two-step procedure are shown in Table 3. Panel (A) in the table contains estimates based on the residuals from the univariate models of Table 1, and panel (B) estimates are based on the residuals obtained from the multivariate model of Table 2. In this study, both unanticipated growth rates of M1 and M3 are used for estimating the efficient market model, as there is no potential theoretical reason for estimating the model with one monetary aggregate.

The coefficients of unanticipated growth in M1G of equations (6) and (9) of panel (A) do not provide strong support for the view that an unanticipated change in the growth of money supply is inversely correlated with long-term bond yields. Although the coefficients (λ_m) have a positive sign (equation (6) is 0.0416 and equation (9) is 0.0528), they

	Dependent Variables (X _i)				
	M1G	M3G	IPG	(π)	
		Coefficients			
Constant Term	0.0523***	0.0321*	0.0237	0.0205**	
M1G(-1)	(0.0056) -0.4376*** (0.0074)	(0.0553)	(0.3237)	(0.0368)	
M1G(-2)	-0.3645*				
M1G(-3)	-0.2732 (0.1701)				
M1G(-4)	-0.0052 (0.8921)				
F-Test (p value)	0.0644				
M3G(-1)		-0.3107*			
M3G(-2)		(0.0659) -0.0359 (0.7034)			
M3G(-3)		0.0346			
M3G(-4)		0.5473**			
F-Test (p value) IPG(–1)		0.0329	-0.3658*		
IPG(-2)			(0.0875) -0.5764** (0.0274)		
IPG(-3)			-0.3636		
IPG(-4)			0.3550		
F-Test (p value) π (1)			0.0067	-0.0627	
,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,				(0.6528)	
π (-2)				-0.3518	
π (-3)				0.2038	
π (-4)				0.3121**	
F-Test (p value)				0.0030	
R-squared	0.2438	0.2770	0.3399	0.4325	
Std. Error	0.0612	0.0128	0.0562	0.0220	
Durbin-Watson Test	1.8702	2.0461	1.8875	2.2794	
	(0.4207)	(0.6712)	(0.2879)	(0.6011)	

Table 1. Univariate time-series Model [from equation (10), $X_{i,t} = \beta_i Z_{i,t-1} + u_t$, where, X_i is (M1G), (M3G), (IPG) and (π) and $Z_{i,t-1}$ is four lagged values of each of the four variables (M1G, M3G, IPG, and π)].

(i) Figures in parenthesis in the rows of lagged variables and constant term show the p-value of the t-test of H_0 : individual regression coefficients = 0, (ii) Figures in parenthesis in the row of Durbin–Watson test show the p-value of H_0 : the residuals from an ordinary least-squares regression are not autocorrelated, (iii) Figures in parenthesis in rows of F-statistic test show p-value of null hypothesis that the joint coefficients of four lagged values are equal to zero, and (iv) ***, **and *denote 1%, 5% and 10% significance levels, respectively.

are insignificant at a 5% significance level and also very small in magnitude. As the quarterly data has been used in this study, a one percent increase in quarterly bond returns corresponds to approximately a 10 basis point decrease in the long-term bond rates. Thus, the coefficient (λ_m) of M1G indicates a 1% unanticipated increase in growth in money supply is associated, on average, with a 0.5 basis point decrease in long-term bond rates. However, as mentioned above, these coefficients are not significant at a 5%

	Dependent Variables (X _i)					
	M1G	M3G	IPG	(π)		
	Coefficients					
Constant Term	0.2874	0.0135	0.1723	-0.0038		
	(0.1384)	(0.354)	(0.3170)	(0.8381)		
M1G(-1)	-0.0514	0.0627	0.4652	0.0408		
	(0.7123)	(0.2013)	(0.3530)	(0.6271)		
M1G(-2)	0.4312	0.1235*	0.1737	-0.0252		
	(0.1717)	(0.0621)	(0.8300)	(0.7430)		
M1G(-3)	-0.3241	-0.04614	0.3213	-0.0526		
	(0.3678)	(0.4878)	(0.7840)	(0.4781)		
M1G(-4)	-0.4178	-0.0685	-0.3278	-0.0605		
	(0.3111)	(0.1713)	(0.4570)	(0.4330)		
F-Test (p value)	0.4017	0.0860	0.8237	0.6373		
M3G(-1)	-5.7780*	-1.3660**	-2.1851	-0.8009		
	(0.0680)	(0.0263)	(0.45/0)	(0.2080)		
M3G(-2)	-4./830	-1.2/30^	-0.8580	-0.0452		
$M_{2}C(2)$	(0.2355)	(0.0609)	(0./210)	(0.8610)		
WI3G(-3)	4.7650	0.0040	2.5250	-0.1569		
M3G(-4)	(0.2000)	(0.0420)	(0.3340)	(0.8740)		
M30(-4)	(0.3487)	(0.0631)	(0.5460)	(0.9820)		
F-Test (n value)	0 2116	0.0376	0 7520	0.5706		
IPG(-1)	-0.4566	-0.0634	-0.3173	0.0523		
	(0.1320)	(0.1754)	(0.8233)	(0.6140)		
IPG(-2)	-0.8853	-0.0798	0.3576	0.3662		
	(0.2583)	(0.3224)	(0.593)	(0.2300)		
IPG(-3)	-1.6920**	-0.2813**	-0.0637	0.0909		
	(0.0235)	(0.0279)	(0.7680)	(0.8250)		
IPG(-4)	-1.6750**	-0.1875**	-0.07131	0.0157		
	(0.0306)	(0.0225)	(0.6720)	(0.8930)		
F-Test (p value)	0.0392	0.1507	0.8325	0.6710		
π (-1)	2.8730	0.2872	-2.3760	0.4875		
	(0.2396)	(0.3941)	(0.5720)	(0.4960)		
π (2)	1.4810	0.7712*	-0.8788	-0.03215		
(- 2)	(0.4872)	(0.0656)	(0.7370)	(0.7501)		
π (-3)	0.4522	0.3145	1.4890	0.1/26		
- (1)	(0.738)	(0.2863)	(0.6370)	(0.1820)		
11 (4)	-0.11/3	-0.0842	-0.0850	0.4992		
E Tost (n value)	(0.7713)	(0.3697)	(0.7920)	(0.2920)		
r = rest (p value) TP(_1)	0.2022	6 8211**	0.7674	-5 0710		
	(0.0369)	(0.0248)	(0.5920)	(0 1440)		
TB(2)	-19 4228	-6 1840*	-13 6637	5 6734		
	(0.1787)	(0.0948)	(0.6793)	(0.2896)		
TR(-3)	-13.1730	-0.7336	14.6660	1.7750		
	(0.3327)	(0.5655)	(0.5680)	(0.5840)		
TR(-4)	-5.6112	-0.0226	-14.6254	-1.6786		
	(0.6043)	(0.7394)	(0.3590)	(0.6815)		
F-Test (p value)	0.0823	0.1748	0.7990	0.5863		
FD(-1)	-0.2873**	-0.0395**	0.0763	0.0248		
	(0.0317)	(0.038)	(0.7034)	(0.3290)		
FD(-2)	-0.1953	-0.0117	-0.0851	-0.0153		
	(0.1332)	(0.4724)	(0.6020)	(0.5035)		
FD(-3)	-0.1760	0.0168	-0.0579	0.0076		
50(1)	(0.1898)	(0.3294)	(0.7620)	(0.7089)		
FD(-4)	-0.1804	-0.0029	0.3260	0.0295		
E Test (n velu-)	(0.1348)	(0./822)	(0.3551)	(0.4960)		
r-rest (p value)	0.1927	0.1813	0.3860	0.590/		

Table 2. Multivariate time-series Model[from equation (10), $X_{i,t} = \beta_i Z_{i,t-1} + u_t$, where, X_i is (M1G), (M3G), (IPG) and (π) and $Z_{i,t-1}$ is four lagged values of each of the four variables (M1G, M3G, IPG, and π) and four lagged values of the other three variables and as well as four lagged values of (TR, FTB, FD)].

(Continued)

	Dependent Variables (X _i)					
	M1G	M3G	IPG	(π)		
	Coefficients					
FTB(-1)	4.75E-07	1.31E-07	2.29E-06	2.72E-07		
	(0.3602)	(0.2556)	(0.1846)	(0.1540)		
FTB(-2)	-2.5E-07	-4.2E-08	-7.2E-07	-3.1E-07		
	(0.7764)	(0.6061)	(0.5660)	(0.2319)		
FTB(-3)	-2.7E-06**	-3.6E-07**	-2.4E-07	4.06E-08		
	(0.0329)	(0.0291)	(0.7560)	(0.7640)		
FTB(-4)	1.84E-06	1.23E-07	6.04E-08	-3.5E-07		
	(0.1078)	(0.2892)	(0.8620)	(0.2952)		
F-Test (p value)	0.1624	0.1186	0.4853	0.3899		
R-squared	0.7528	0.7970	0.8687	0.8971		
Std. Error	0.0265	0.0045	0.0639	0.0104		
Durbin-Watson Test	1.3616	1.4855	1.3996	1.6284		
	(0.1497)	(0.2489)	(0.1172)	(0.2796)		

Table 2. (Continued).

(i) Figures in parenthesis in the rows of lagged variables and constant term show the p-value of the t-test of H_0 : individual regression coefficients = 0, (ii) Figures in parenthesis in the row of Durbin–Watson test show the p-value of H_0 : the residuals from an ordinary least-squares regression are not autocorrelated, (iii) Figures in parenthesis in rows of F-statistic test show p-value of null hypothesis that the joint coefficients of four lagged values are equal to zero, and (iv) ***, **and *denote 1%, 5% and 10% significance levels, respectively.

Table 3. Estimates of efficient market Model using two-step procedure [efficient market models equation (6) (BR*_t - $r_{t-1} = \theta + \lambda_m(MG_t - MG^e_t) + \epsilon_t)$ and equation (9) (BR*_t - $r_{t-1} = \theta + \lambda_m(MG_t - MG^e_t) + \lambda_y$ (YG_t - YG^e_t) + $\lambda_{\pi}(\pi_t - \pi^e_t) + \epsilon_t$)].

Coefficients of Dependent variable:	BR* _t - r _{t-1}						
Estimation							
Models	(M1G -	(M3G –	(IPG -			Std.	Durbin-
Eqs (6) & (9)	M1G ^e)	M3G ^e)	IPG ^e)	(π - π ^e)	R ²	Error	Watson Test
(A) Using residuals from univariate	0.0416				0.0119	0.0294	2.1017
models	(0.4290)						(0.5898)
	0.0528		-0.1804**	-0.8891**	0.2948	0.0253	2.0267
	(0.4534)		(0.0199)	(0.0251)			(0.4276)
		0.2903			0.0118	0.0283	2.0127
		(0.4520)					(0.4975)
		0.0664	-0.1838**	-0.8655**	0.2854	0.0254	2.0349
		(0.8673)	(0.0183)	(0.0357)			(0.4455)
(B) Using residuals from	-0.6204				0.0860	0.0283	2.1939
multivariate models	(0.1070)						(0.6946)
	0.7353		-0.0268*	-5.1690**	0.1878	0.0272	2.1042
	(0.1885)		(0.0762)	(0.0593)			(0.4794)
		1.3770			0.0084	0.0285	2.0054
		(0.4780)					(0.3785)
		1.5149	-0.1346*	-3.4362	0.1698	0.0276	2.1598
		(0.6400)	(0.0681)	(0.1242)			(0.5604)

(i) Figures in parenthesis of the coefficients show the p-value of the t-test of H_0 : regression coefficients = 0, (ii) Figures in parenthesis in the row of Durbin–Watson test show the p-value of H_0 : the residuals from an ordinary least-squares regression are not autocorrelated, and (iii) ***, **and *denote 1%, 5% and 10% significance levels, respectively.

significance level. The coefficients (λ_m) of M1G in panel (B) lead to a similar conclusion as above (equation (6) is -0.6204, and equation (9) is 0.7353). The coefficients are insignificant at a 5% significance level and relatively small in magnitude even after using residuals from the multivariate time-series process. One interesting observation

is that (λ_m) of M1G in panel (B) of equation (6) is negative (-0.6204); the deviation in sign could be due to the low R-squared value (0.2438, Table 1) of the univariate model in determining the anticipated measure of M1G. The deviation in sign is not seen in (λ_m) of M1G in panel (B) of equation (9), which is positive (0.7353); the reason may be due to the relatively high R-squared value (0.7528, Table 2) of the multivariate model in determining the anticipated measure of M1G. However, as the coefficients are insignificant, this suggests that there is no strong association between the unanticipated growth in money supply and the long-term bond yields. This is also evident from Figures 2 and 3, which show no strong relationship between (BR*_t - r_{t-1}) and unanticipated growth in narrow and broad money supply based on the residuals from the univariate and multivariate models.

The coefficients of unanticipated growth in M3 in panels (A) (equation (6) is 0.2903 and equation (9) is 0.0664) and (B) (equation (6) is 1.3770 and equation (9) is 1.5149) show more positivity; however, these coefficients are insignificant at a 5% significance level and are quite similar using the residuals of univariate and multivariate time-series process. This indicates that the estimates of unanticipated growth in broad money (M3G) are not very sensitive to the specification of the time-series processes. The coefficients of unanticipated growth in industrial production and inflation align with the theoretical views. For both the efficient market models of equations (6) and (9), including M1 and M3, the coefficients are negative and are mostly significant at 5% significance level.



Figure 2. Relationship between (BR*_{t - rt-1}), and unanticipated growth in narrow & broad money supply - univariate autoregressive approach. This figure shows the difference between quarterly nominal return of long-term government bond and short-term interest rate (BR*_t - r_{t-1}) in percentage (left axis), unanticipated growth in narrow money supply (M1G_t - M1G^e_t) in percentage (left axis) and unanticipated growth in narrow money supply (M3G_t - M3G^e_t) in percentage (right axis). Unanticipated growth in narrow and broad money supply has been obtained from the univariate autoregressive time series models.



Figure 3. Relationship between (BR*_{t - rt-1}), and unanticipated growth in narrow & broad money supply – multivariate autoregressive approach. This figure shows the difference between quarterly nominal return of long-term government bond and short-term interest rate (BR*_t - r_{t-1}) in percentage (left axis), unanticipated growth in narrow money supply (M1G'_t – M1G'^e_t) in percentage (left axis) and unanticipated growth in narrow money supply (M3G'_t – M3G'^e_t) in percentage (right axis). Unanticipated growth in narrow and broad money supply has been obtained from the multivariate autoregressive time series models.

4. Conclusion

The present study aims to explore the relationship between the growth in money supply and long-term interest rates. From the results, it can be concluded that there is no strong evidence for the view that growth in money supply is negatively correlated with changes in long-term interest rates. The findings of the study are certainly of interest as they contradict the conventional wisdom derived from many structural macro-econometric models that there exists a negative relationship between the growth in money supply and long-term interest rates. The results reinforce the neutrality of money tenet of new consensus macroeconomics (NCM), i.e., money supply has no independent impact on the economy (Iranmanesh & Jalaee, 2021; Issaoui et al., 2015; Kam et al., 2019; Monjazeb et al., 2020; Pishbahar & Rasouli, 2019). Further, the findings of the study reveal that during the sample period of the study spanning from the post-Global Financial Crisis (GFC) era to the post-COVID-19 period, characterized by exceptionally high liquidity, the money supply exhibited no significant relationship with long-term interest rates in India. This observation suggests that despite substantial injections of liquidity into the financial system, long-term interest rates remained largely unaffected by changes in the money supply over the long term. In the post-COVID-19 period, long-term interest rates in India, particularly government bond yields, remained relatively stable despite a significant increase in money supply. This stability can be attributed to several factors. Firstly, the increased government borrowing to finance pandemic relief measures exerted upward pressure on long-term yields. Secondly, heightened uncertainty about future economic conditions made investors cautious, diminishing the typical impact of an increased money supply on lowering long-term rates. Consequently, while the money supply experienced substantial growth, long-term interest rates in India exhibited a more muted response. This phenomenon reflects the intricate interplay of monetary policy, fiscal pressures, and investor sentiment during the pandemic.

The limitation of the study is that the estimation process involved is subject to variations along the dimensions like the choice of monetary aggregate, the identification of relevant variables included in the X-vector, the specification of the time-series model, the sample period, and the econometric techniques. Therefore, one must be cautious in interpreting the results.

The implications of the above conclusion depend on the treatment of money supply processes in terms of exogeneity. If the growth in money supply during the sample period is assumed to be exogenous, i.e., through unconditional central bank initiatives that are exogenous to financial market pressure, then the interpretation of the results would be pretty straightforward, i.e., the result opposes the commonly held view that an increase in the money supply would decrease the long-term interest rate. This indicates that the central banks cannot bring down the longterm interest rates by increasing the money supply, at least in the short run, and the monetary transmission mechanism based on structural macro-econometric models may require some alteration. It has been observed that during the COVID-19 period, conventional monetary policy tools proved inadequate for stimulating the real economy. Consequently, monetary authorities implemented unconventional measures, such as Operation Twist (OT) and Long-Term Repo Operations (LTRO), to reduce the yield spread. Empirical evidence indicates that some of these unconventional monetary policy actions had a significant signaling channel component, whereby market participants interpreted the announcements as indicative of a lower future path for the short-term policy rate. Furthermore, it has been observed that the Reserve Bank of India's (RBI) forward guidance was more effective during the pandemic than in the preceding years (Lakdawala et al., 2023). This suggests that unconventional monetary policy interventions may be an important mechanism for influencing long-term interest rates when the conventional money supply channel has a limited effect on the behavior of the term premium.

However, if unanticipated growth in money supply is not exogenous, i.e., if the unanticipated growth in money supply is correlated with the contemporaneous error term (ε_t), then the estimates of the efficient market model would be inconsistent and may lead to misleading interpretations. It can be a case where the central bank increases the money stock in reaction to an unanticipated increase in long-term rates in order to smoothen the yield curve. This results in a positive correlation between the error term (ε_t) and the unanticipated growth in money supply (MG_t - MG^e_t), and thus, the commonly held view that a negative relationship exists between the growth in money supply and long-term interest rates based on many structural macro-econometric models cannot be ruled out.

However, if the endogeneity is based on a situation where the central bank adjusts the growth in money supply within a quarter in response to the past publically available information, then there may be no correlation between the error term (ε_t) and the unanticipated growth in money supply (MG_t - MG^e_t), and, therefore, the endogeneity in the sense of Granger (1969) causality in the direction from interest rate to money growth cannot indicate the inconsistency of (λ_m) estimates. Thus, if the commonly held view is retained in monetary economics

that the increase in money stock leads to a decrease in long-term rates, then further research is required to reveal a positive correlation between the contemporaneous error term (ε_t) and the unanticipated growth in money supply.

The findings of this study have significant implications for understanding the impact of money stock on long-term interest rates in the context of India. The study applied the efficient market model, which provides a theoretical framework for explaining the relationship between money stock and long-term interest rates. The study concludes that there is no strong evidence supporting the view that growth in money supply is negatively correlated with changes in long-term interest rates in India. Consequently, monetary authorities may need to rely on alternative channels or devise other unconventional mechanisms to steer the real economy.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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