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Does global spillover matter in the Indian money market? A vector error correction model

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Abstract: This study investigates the impact of transmission channels, including global liquidity, confidence, and exchange, on the Indian money market. The research aims to identify the predominant transmission channel and its influence on the repo and call money rates. A vector error correction model (VECM) analysed weekly data collected from the Reserve Bank of India, Bank of St. Louis, and Federal Reserve Bank from 29 April 2001 to 21 March 2021. The study finds a stable, genuine long-term relationship between call money rates and global liquidity, confidence channels and exchange channels. A long-run causality is also observed between call money rates and broad market indicators. Repo rates similarly exhibit a long-term, stable relationship with these factors, with short-term impacts observed from global liquidity and the exchange channel, but not from the VIX. The exchange channel and VIX are proven to be more predominant in influencing policy and call money rates.

Keywords: global spillover; vector error correction model; VECM; weighted average call money rate; WACR; repo rate; confidence channel.

JEL codes: E51, E52, E58.

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1 Introduction

The increasing financial contagion effect on emerging market economies (EMEs) as a result of increased integration with the global economy is one of the greatest concerns for policymakers. Growing integration has raised concerns about the exposure of the country's economy to various shocks originating from global spillovers. The transmission of global spillover, which resulted in financial instability in EMEs, occurred especially after the global financial crisis (GFC) of 2008. After the GFC, there was a notable increase in interest rate disparities between various economies around the world. As a result, central banks had to intervene by implementing monetary policies to stimulate their respective economies (Ammer et al., 2016). Therefore, the fundamental question that is relevant in this context is whether it is possible for EMEs like India, which is reasonably well-integrated with global financial markets, to implement an independent monetary policy without any externalities, such as quantitative easing (QE) and Fed tapering. Moreover, it is also important to note which transmission channels are the main obstacles to running an independent monetary policy. Several authors have addressed the question of spillover effect of the transmission of global monetary policy in the Indian context (Lakdawala, 2018; Patra et al., 2016; Acharya et al., 2017; Shareef and Prabheesh, 2020; Mishra and Burns, 2017) and international (Hofmann and Takats, 2015; Lim and Mohapatra, 2016; Passari and Rey, 2015). The studies conducted in India have primarily focused on analysing the spillover impact on foreign exchange and stock markets or bank lending. However, in order to ensure the effectiveness of an independent monetary policy, it is imperative to assess the impact of the transmission of spillover on the Indian money market and identify the channels through which spillovers may occur.

Monetary policy can be transmitted through several channels, such as interest rates, asset prices, exchange rates, and credit aggregates. The interest rate appears to be the most influential channel for monetary policy transmissions. For instance, when implementing an expansionary monetary policy, the cost of loans is expected to decrease, leading to an increase in both consumption and investment demand. Consequently, this can have an impact on the overall output and prices in the economy (Mohan and Patra, 2009).

Previous research has shown that global liquidity affects emerging economies through various channels, including liquidity, portfolio balances, confidence, and exchange rates. The liquidity channel is often measured by the three-month US Treasury Bill yield, while the Chicago Board Options Exchange Volatility Index (CBOE VIX) is used as a proxy for the confidence channel. The interest rate differential between the longer end of the spectrum in the USA and India is often used to measure the portfolio balance channel, and the dollar index is considered the exchange rate channel. Monetary policy transmission occurs through interest rates, credit aggregates, asset prices and exchange rates (Lim and Mohapatra, 2016; Acharya et al., 2017; Ammer et al., 2016; Patra et al., 2016; Mohan and Patra, 2009).

After identifying the transmission channels, it is important to consider the potential impact of global spillovers on money markets. A well-developed money market is crucial for the effective transmission of monetary policy to financial markets and the broader economy. The overnight rate or the shortest interbank interest rate is central to the monetary policy framework, with the call rate being a key reference point. Variations in interbank rates are likely to be transmitted to other interest rates across the term structure (Kumar, 2017; Würtz, 2003; Patra et al., 2016).

At this backdrop, this study is aimed to answer the following questions:

- Are global liquidity channels co-integrated with the Indian money market and policy rates?
- If so, which channel is predominant?
- Do transmission channels influence the repo rate as policy rates and weighted average call money rate (WACR) as a market-determined rate?
- Do transmission channels influence the repo rate as a policy rate and the WACR as market-determined rates differently?

The impact of global monetary policy and liquidity transmission on domestic economies is an unsettled issue (Patra et al., 2016). This study aims to investigate how global monetary policy shocks are transmitted to the Indian money market. Previous research has examined the transmission of international monetary policy spillovers across various financial markets in India, but little attention has been paid to the money market. A focus on the money market can help policymakers develop policies that are insulated from external factors, known as monetary policy independence.

The paper is structured as follows: Section 2 offers a brief literature review, while Section 3 outlines the research methodology employed. This section also provides a detailed description of the variables and data used in the study. Section 4 presents the study's empirical findings, with Section 5 serving as the concluding section.

2 Literature review

The researcher discovered that a significant amount of the current literature on global spillovers and the transmission of monetary policy could impact various aspects of a domestic economy. The research can be condensed into three main categories:

1 The impact of developed nations' conventional and unconventional monetary policies (UMPs) on the domestic economy through cross-border spillovers.

2 The dissemination of domestic monetary policies to various international markets.

3 The spillover effect of the US monetary policy and economy.

The focus here is on the transmission of a developed economy's monetary policy to a domestic economy; thus, several kinds of literature have been examined (Al-Jasser and Banafe, 2006; Ball, 2006; Bhattarai et al., 2015; Borio and Filardo, 2011; Fratzscher et al., 2012; Lim and Mohapatra, 2016; Paul and Kalluru, 2020; Sahoo et al., 2020; Saxena, 2006; Buch et al., 2019; Shareef and Prabheesh, 2020; Aydoğan and Vardar, 2021) – on the cross-border spillover effects of monetary policies.

Evidence of the shock to developing economies from advanced countries' monetary policies has been presented in the vast empirical literature (Maćkowiak, 2007; Canova, 2015; Punzi and Chantapacdepong, 2017).

Jeon et al. (2020), Shareef and Prabheesh (2020), Bruno and Shin (2015), Cerutti et al. (2017), Cetorelli and Goldberg (2012), Chen et al. (2017) and Correa et al. (2017) empirically proved that foreign bank branches in domestic countries respond to changes in their home country's monetary policies.

All studies revolved around the spillover effect from advanced economies, mainly the USA (which affects transmission not only from interest rates but also through other channels). The spillover effect globally gets higher prominence and became a widely debated topic after the shock of the GFC. A significant number of studies exist (Ammer et al., 2016; Anaya et al., 2017; Okina and Shiratsuka, 2004; Schiltknecht, 2017) on UMPs to examine the impact on financial assets and a range of macroeconomic variables. Collectively, this research finds that the positive spillover of UMPs is a form of QE by the Federal Reserve and other central banks, thus stabilising the global economy.

Several empirical investigations have indicated that the instability of capital flows has an adverse effect on monetary, financial and macroeconomic stability. For instance, Fuertes et al. (2014) and Auer et al. (2019) demonstrated that portfolio investment, and short-term foreign loans, were the main causes of capital flow volatility to EMEs.

Warnock (2001) reveals that the real exchange rate affects the degree to which inflation is significantly greater in Latin American nations compared to Asian or industrialised nations.

In contrast, there are studies (Bhattarai et al., 2015; BIS Central, 2014) that examined the adverse effects of UMP on emerging economies. The research done by Acharya et al. (2017), Dilip (2019), Lakdawala (2018), Mohan and Patra (2009) and Paul and Kalluru (2020) examines the impact of UMPs on the Indian markets.

Dilip (2019) indicates a significant influence of the US term structure on Indian sovereign yields, suggesting a robust spillover effect. Dahlhaus and Vasishtha (2014) find that the impact of US monetary policy normalisation on portfolio flows to major EMEs is economically small. Patra et al. (2016) indicate that monetary policy transmission through the money and credit markets is not affected by global spillovers but is impacted by the debt market. Paul and Kalluru (2020) revealed that a 10% rise in the US QE results in a 25 bps reduction in the WACR and a 2–5 bps hardening of the Treasury Bill in India. Lakdawala (2018) observed that in the early 1990s, the Indian stock market did not respond to US monetary shocks. However, over the last two decades, the market has

become more responsive, with the most significant impact being observed following the 2008 financial crisis.

The complex interplay between the US economy and emerging economies has been the subject of numerous studies in recent years. Engler et al. (2023) argued that the economic news from the USA, particularly that pertaining to employment and economic activity, has a substantial impact on financial conditions in emerging nations, although news about inflation has less of an impact. Rather than being influenced by changes in US monetary policy, the dissemination of US economic news seems to be driven by the risk perceptions of foreign investors. In their investigation of the effects of interest rate adjustments following FOMC statements, Bauer and Swanson (2020) offered data that supported both the 'Fed information effect' and the 'Fed response to news' channels. Hoek et al. (2020) indicated that the effect of US interest rate increases on developing economies varies depending on the source, with rates driven by higher US growth having more muted spillover effects than rates generated by hawkish Fed policy or inflationary pressures. Asserting that both floating and pegged currencies had identical spillover effects and currency fluctuations in reaction to shocks in the euro area, Corsetti et al. (2021) called into question the notion that flexible exchange rates shield countries from external disruptions. They called this the 'insulation puzzle'. Miranda-Agrippino and Rey (2020) highlight that monetary policy shocks in the USA significantly impact global financial variables, contributing to the 'global financial cycle'. Following a US monetary contraction, there is a decrease in a global factor that influences risky asset prices worldwide. By observing the simultaneous movements of interest rates and stock prices around policy announcements, Jarociński and Karadi (2020) identify two distinct shocks: a surprise policy tightening that increases interest rates and lowers stock prices and a positive central bank information shock that raises both.

3 Methodology and data

3.1 Methodology

The study used statistical tests such as Johnsen cointegration, Granger causality, vector error correction model (VECM), and Wald test to examine the long-term and short-run causal relationships between money market proxies and various monetary policy transmission channels. The stationarity of the data was tested using ADF and PP tests. EViews 7 was used for the analysis.

3.2 Data and variables

Weekly data from April 29, 2001 to March 21, 2021, which consisted of 1,039 observations, were analysed in this study. The repo rate that is announced by the RBI proxies for monetary policy decisions in India. WACR represents the weighted average call rate, which proxies for the domestic interest rate. Data were obtained from the RBI, the Bank of St. Louis, and the Federal Reserve.

Table 1 Descriptive statistics

Variables	*Mean*	*SD*	*Maximum*	*Minimum*	*Skewness*	*Kurtosis*	*JB*
Repo	6.752743	1.208735	9	4	–0.41333	2.498725	40.46206 (0.00)
WACR	6.532131	1.594867	10.3792	3.0702	–0.41106	2.781653	17.63653 (0.00)
3 months yield	1.299547	1.485671	5.168	–0.013	1.170451	3.366139	243.0341 (0.00)
10 years yield	3.111014	1.198284	5.502	0.533	0.008236	2.006562	42.73716 (0.00)
DXY	89.63976	10.48518	119.9	71.66	0.73727	3.294103	97.87229 (0.00)
VIX	17.40666	7.336419	66.04	9.14	2.528383	12.69521	5176.293 (0.00)

Source: Estimated by author

3.2.1 Repo and WACR

As the money market is the primary arm of monetary policy transmission in India (Patra et al., 2016) the WACR was used to measure its impact on the money market. In India, it is utilised as the operational target for monetary policy and represents the unsecured portion of the overnight money market. This means that the liquidity management framework ensures that the WACR is close to the daily repo rate every day (Kavediya and Pattanaik, 2016). The liquidity adjustment facility (LAF) is designed with a policy repo rate at its core, operating within a corridor. This corridor includes an upper bound, known as the marginal standing facility (MSF), and a lower bound set by a fixed overnight reverse repo rate. The policy rate is positioned between these two boundaries (Mohanty, 2012).

Some transmission channels (e.g., credit or bank lending, interest rate, exchange rate and asset price) have been recognised from cross-country experience and the literature. Nevertheless, Bernanke and Blinder (1992) conclude that the interest rate channel is the most influential monetary policy indicator.

3.2.2 Chicago Board Options Exchange Volatility Index

The CBOE VIX is usually treated as a measure of risk appetite. It is also known as an index of market fear or measure of uncertainty in broader financial markets. It represents the implied volatility of Standard and Poor's (S&P) 500 index options and specifies the market's expectations of stock market volatility over the next 30-day period. Forbes and Warnock (2012), Nier et al. (2014) and Passari and Rey (2015) indicate that the VIX plays a dominant role in cross-border capital mobility. According to previous studies, a high VIX has a marginal effect on capital mobility. Globally, risky asset prices (equities and corporate bonds) are influenced by the VIX. The correlation between VIX and credit and leverage growth is negative. Taking a cue from the extant literature (Acharya et al., 2017; Forbes and Warnock, 2012; Illing and Aaron, 2005; Nier et al., 2014) identify the link between capital mobility or flight, asset prices, supply of credit, and the level of risk

appetite and examines the impact of the level of risk appetite on domestic monetary policy formulation.

3.2.3 DXY

The dollar index, DXY, signifies the exchange rate channel for spillover transmission. Naresh et al. (2018) examined the long-run spillover effect of the US dollar on the major stock indices of BRICS countries. Su (2016) studied the spillover effects between metal markets in the London Metal Exchange (LME) and the US exchange rate markets. Glick and Leduc (2013) investigated how the dollar has reacted to changes in the USA's conventional and UMP. According to them, the value of the dollar index plays a crucial role in the transmission of changes in monetary policy to the broader economy through currency value fluctuations. Consequently, it is essential to analyse the spillover impacts of the dollar index on cross-border monetary policy determinations.

3.2.4 Three-month and ten-year US Treasury Bill yield

The three months and ten years of US Treasury Bill yields represent the liquidity channel or are the primary indicators of the liquidity channel.

4 Empirical results

Because the present study is a time-series study, it is important to check the stationarity of the data. The most widely used tests for the unit root – ADF and PP have been conducted to determine the unit root features of the variable, which are reported in Table 2.

Table 2 Unit root tests

Variables	*ADF tests*		*PP test statistic*	
	Level	*First difference*	*Level*	*First difference*
WACR	–1.311413 (0.6258)	–17.94 (0.000)*	–1.5876 (0.4883)	–31.33628 (0.000)*
Repo	1.946	–7.406 (0.000)*	–1.58175 (0.4916)	–33.9822 (0.000)*
3 months US TB yield	–1.912	–6.911 (0.000)*	–0.99116	–21.69722 (0.000)
10 years US TB yield	–1.864	–33.616 (0.000)*	–1.19582 (0.6779)	–24.7873 (0.000)*
Dollar index	–2.466	–33.031 (0.000)*	–2.17992 (0.214)	–23.8691 (0.000)*
VIX	–7.700	–13.806 (0.000)*	–5.52875 (0.000)	–32.8599 (0.000)*

Source: Estimated by author

The following hypotheses have been set for the unit root test:

$1H_0$ Unit root (non-stationarity) exists in the dataset.

$1H_1$ Unit root (non-stationarity) does not exist in the dataset.

The results in Table 2 show that all the variables are non-stationary at level but stationary at the first difference in both tests.

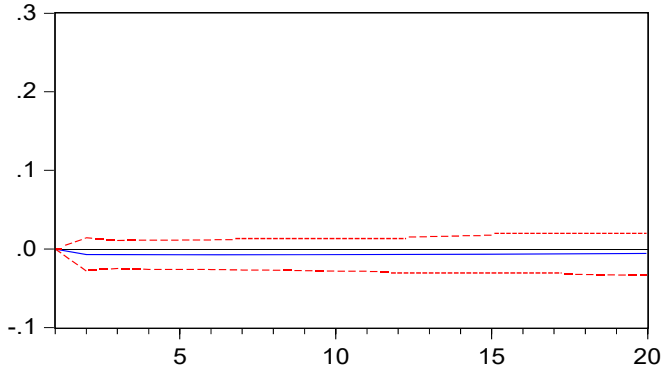
4.1 Impact on WACR

The following section examines the resilience of the money market, the first leg of monetary policy transmission in India.

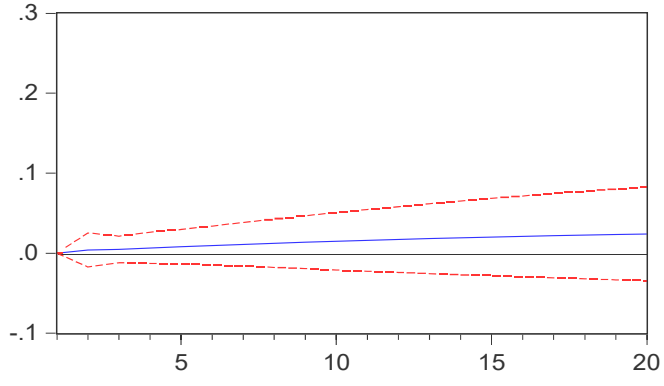
4.1.1 Impulse response function of WACR to various shocks

The response of the WACR was analysed using the impulse response function shown in Figure 1.

Figure 1 Impulse response in WACR to one standard deviation shock in variables, (a) response of WACR to three-month US TB yield (b) response of WACR to ten-year US TB yield (c) response of WACR to dollar index (d) response of WACR to VIX (see online version for colours)



(a)

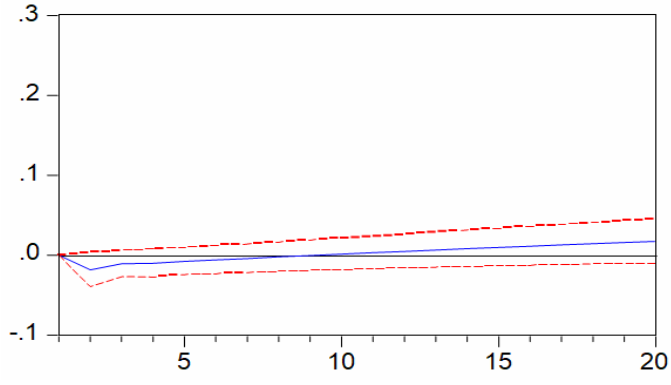


(b)

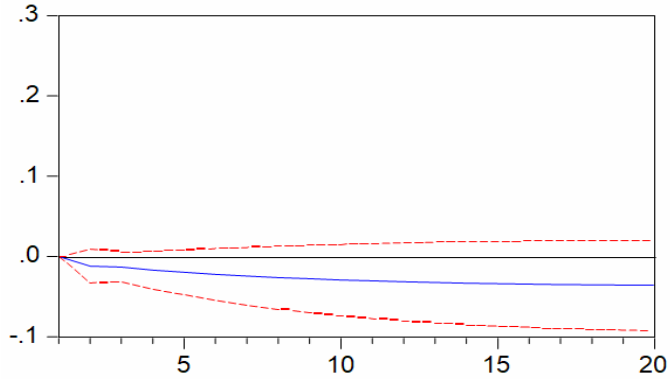
Note: Response to VAR innovations ± 2 SE.

Source: Estimated by author

Figure 1 Impulse response in WACR to one standard deviation shock in variables, (a) response of WACR to three-month US TB yield (b) response of WACR to ten-year US TB yield (c) response of WACR to dollar index (d) response of WACR to VIX (continued) (see online version for colours)



(c)



(d)

Note: Response to VAR innovations ± 2 SE.

Source: Estimated by author

Figure 1 displays the impulse functions of WACR to a positive innovation to the three-month US TB yield, ten-year US TB yield, dollar index and VIX. Figure 1(a) shows that the response of WACR to the three-month US TB yield is marginally negative, which indicates that an increase in the three-month US TB yield leads to a marginal decline in WACR in India initially, but after that flat movement is observed. Figure 1(b) depicts the response of the WACR to the ten-year US TB yield, which is marginally positive, but after that, an increasing trend is observed. Hence, the impact of an increase in the US TB yield on call money rates in India is marginal and inconclusive. However, a rise in US TB yield may result in the flight of foreign investment in the USA and a deterioration in the rupee value. A weakening of the rupee value increases the interest rates. Figure 1(c) implies an immediate significant negative response of WACR to the dollar index. However, after the tenth period, it started to increase following economic theory. This implies that a decline in rupee value results in a deterioration in

the call rate and immediately reverses the trend thereafter. The negative response of the WACR to a positive shock in the VIX is observed in Figure 1(d), which means that the large volatility caused by uncertainty in the market and investors' anxiety results in a dip in the interest rate.

4.1.2 Johansen cointegration

The number of cointegrating vectors can be determined by the following two tests: the *trace test* and the *maximum eigenvalue test*, the results of which are presented in Table 3.

Table 3 Results of cointegration tests

Unrestricted cointegration rank test (trace)				
No. of CE(s)	*Eigenvalue*	*Statistic*	*Critical value*	*Prob.*
None*	0.075654	85.82726	69.81889	0.0016
At most 1	0.035806	40.19909	47.85613	0.2155
At most 2	0.021896	19.0504	29.79707	0.4893
At most 3	0.009602	6.209786	15.49471	0.6707
At most 4	0.001057	0.613451	3.841466	0.4335
Unrestricted cointegration rank test (maximum eigenvalue)				
No. of CE(s)	*Eigenvalue*	*Statistic*	*Critical value*	*Prob.*
None*	0.075654	45.62817	33.87687	0.0013
At most 1	0.035806	21.14869	27.58434	0.2673
At most 2	0.021896	12.84062	21.13162	0.467
At most 3	0.009602	5.596335	14.2646	0.6654
At most 4	0.001057	0.613451	3.841466	0.4335

Note: *Denotes the 5% significance level.

Source: Estimated by author

The trace statistics indicate the null hypothesis that – *there is no cointegration among the WACR, three months' US TB yield, ten years' US TB yield, dollar index, and VIX* are rejected at the 5% level. This is also supported by the trace statistics, which is more than the critical value (85.83 > 69.82). The maximum eigenvalue reinforced the trace statistics results, which shows that the null hypothesis that there is no cointegration among variables is rejected at the 5% level. This is also supported by the eigenvalue statistics, which is more than the critical value (45.63 > 33.88). Therefore, it can be inferred that there is at least one cointegrating vector between the variables, so we can estimate the VECM.

The *Johansen normalised cointegration coefficients* illustrated below reject the null hypothesis that *there is no cointegration against the alternative of a cointegrating relationship in the model*.

$$\begin{aligned} \text{WACR} = {} & 0.3250\ \text{3-month US TB yield} - 0.83326\ \text{10-year US TB yield} \\ & (0.2537) \qquad\qquad (0.5967) \\ & -0.0687\ \text{dollar index} + 0.2567\ \text{VIX} \\ & (0.0304) \qquad\qquad (0.0441) \end{aligned}$$

(Standard errors are displayed in parentheses).

Hence, the equation might be interpreted as the three-month US TB yield having a positive impact on WACR in the long-run, while WACR is a target variable. Again, the ten-year US TB yield had a negative effect on WACR. While the dollar index has a negative impact, the VIX has a positive impact on WACR. Both the dollar index and VIX significantly affect WACR in the long-run. The standard errors provide an indication of the precision of the estimates of the coefficients.

The standard errors displayed in parentheses are used to test the statistical significance of the coefficients. A coefficient is considered statistically significant if its absolute value is greater than two times its standard error. In this case, the coefficients of the dollar index and VIX have absolute values that are greater than two times their respective standard errors, suggesting that they are statistically significant.

The presence of cointegration implies that the relationship between the variables is not due to chance or a common trend, but rather a genuine and stable relationship that reflects a long-run equilibrium between the variables. VECM was applied to correct the disequilibrium in the cointegration relationship. It also tests the long- and short-run causality among the cointegrated variables. The correction of disequilibrium is performed using the mean of the error correction term (ECT).

The VECM equation for the dependent variable WACR is as hereunder:

$$\begin{aligned} \mathrm{D(WACR)} = {} & \mathrm{C(1)} * \mathrm{WACR}(-1) + 0.214088141353 * \mathrm{\_3\_MONTH\_YIELD}(-1) \\ & -0.100812166056 * \mathrm{\_10\_YEARS\_YIELD}(-1) + 0.368741650268 \\ & * \mathrm{VIX}(-1) - 0.0881721583193 * \mathrm{DXY}(-1) - 5.43779274092 \end{aligned}$$

C(1) in the VECM equation represents the coefficient on the lagged dependent variable WACR(–1), indicating the speed of adjustment towards the long-run equilibrium relationship between WACR and the other variables. If C(1) is negative and significant, it suggests the existence of long-run causality among the variables. The ECT being negative (–0.00882) and significant at a 5% level confirms the presence of long-run causality between WACR and the other variables (refer to Appendix). The coefficients on the lagged variables show the short-run effect of a one-unit increase in each independent variable on the change in WACR. The coefficients indicate that an increase in three months yield and VIX results in an increase in WACR, while an increase in ten years yield and DXY leads to a decrease in WACR.

4.1.3 Wald test

The Wald test is used to test whether the variables have a statistically significant impact on the WACR individually or as a group in the short-run. The results of the test are shown in Table 4.

To examine the short-run impact of the three-months' US TB yield on the repo rate, the following null hypothesis is examined:

$$2\mathrm{H}_0 : \mathrm{C(4)} = \mathrm{C(5)} = 0$$

Coefficients C(4) and C(5) signify a three-month US TB yield with a two-period lag. The chi-square value in Table 4 reveals that the null hypothesis that *coefficients C(4) and C(5) cannot jointly influence the WACR* is accepted. Hence, it is inferred that there is no short-run impact running from the three-month US TB yield to WACR.

To examine the short-run impact of the ten-year US TB yield on the WACR, the following null hypothesis was examined:

$$3H_0: C(6) = C(7) = 0$$

The chi-square values in Table 4 reveal that the null hypothesis framed as coefficients C(6) and C(7) cannot jointly influence the repo rate. Hence, it is inferred that there is no short-run impact running from the three-month US TB yield to WACR.

Table 4 Wald test (WACR)

Variables	*Chi-square*		
	Value	*df*	*Probability*
3-month US TB yield	0.582929	2	0.7472
10-year US TB yield	0.248719	2	0.8831
Dollar index	0.141678	2	0.9316
VIX	3.225006	2	0.1994

Source: Estimated by author

Short-run causality from the dollar index to the WACR was studied using the following null hypothesis:

$$4H_0: C(8) = C(9) = 0$$

The chi-square value in Table 4 indicates that there is no short-run impact running from the dollar index to WACR. Short-run causality from VIX to WACR was studied using the following null hypothesis:

$$5H_0: C(10) = C(11) = 0$$

The chi-square value in Table 4 indicates that there is no short-run impact running from VIX to WACR.

Therefore, it can be inferred from the above discussion that the variables may not have a statistically significant impact on WACR individually or as a group. It also means that the variables have a significant long-run, stable and genuine relationship (established by the Johansen cointegration test), but their short-run dynamics are weak or noise dominates the short-run relationship.

4.2 Impact on Repo

The following section aims to assess the resilience of the money market by analysing the impact on the Repo market.

4.2.1 Impulse response function of repo to various shocks

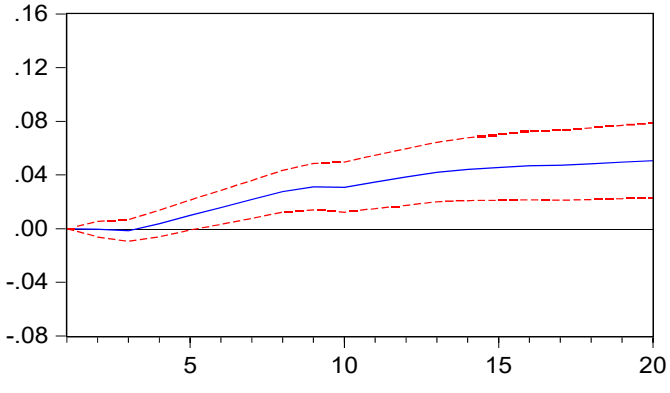
Figure 2 shows the response functions of the repo rate to a positive shock to other variables. The response of the repo rate to the three-month' TB yield was found to be positive [Figure 2(a)], which suggests that a rise in the three-month US Treasury Bill yield increases the repo rate in India. The response of the repo rate to the ten-month US TB yield appears to be the same as that of the three-month TB rate [Figure 2(b)].

Figure 2(c) indicates a negative response of the repo rate to a positive shock in the US dollar index. This implies that, while the USD is gaining strength relative to other major currencies, it results in a decline in the repo rate in India. Figure 2(d) exhibits the response of the repo rate to a positive shock in VIX. This reveals that after an increase in uncertainty, investors fear that the RBI prefers to keep the repo rate stable for up to eight periods.

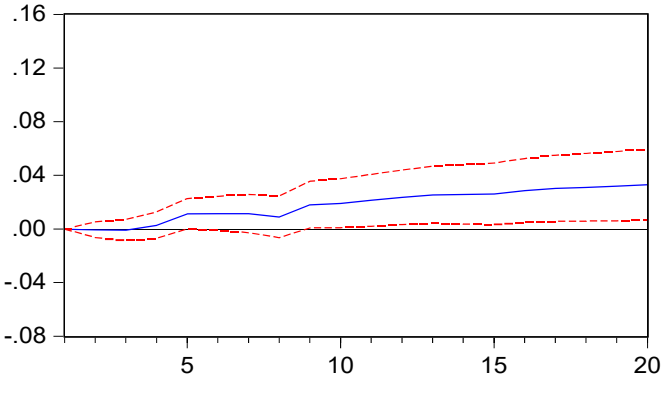
4.2.2 Johansen cointegration

Johansen cointegration was applied to determine the number of cointegrating vectors using *the trace test* and *the maximum eigenvalue test*, the results of which are shown in Table 5.

Figure 2 Impulse response in repo to one standard deviation shock in variables, (a) response of repo to _3_MONTHS (b) response of repo to _10_YEARS (c) response of repo to DXY (d) response of repo to VIX (see online version for colours)



(a)

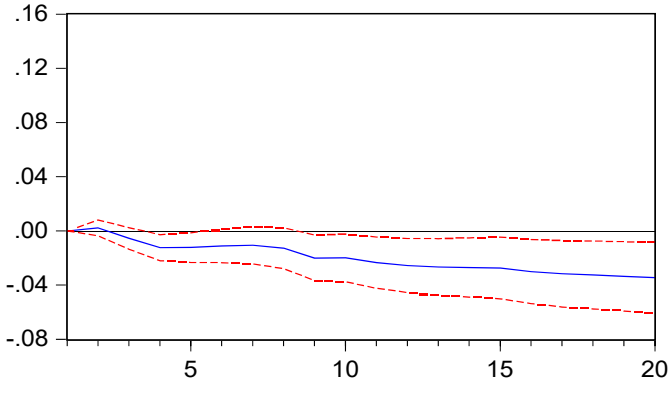


(b)

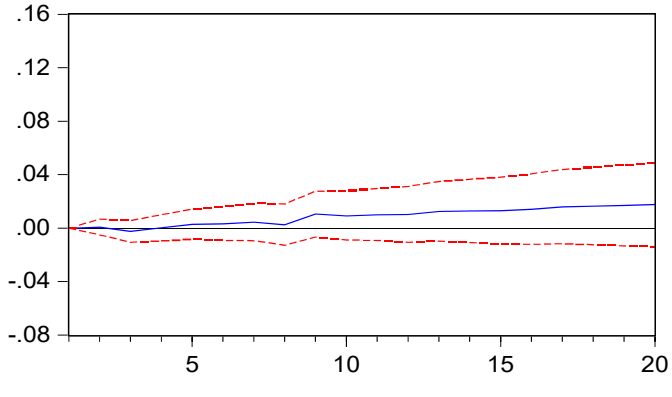
Note: Response to VAR innovations ± 2 SE.

Source: Estimated by author

Figure 2 Impulse response in repo to one standard deviation shock in variables, (a) response of repo to _3_MONTHS (b) response of repo to _10_YEARS (c) response of repo to DXY (d) response of repo to VIX (continued) (see online version for colours)



(c)



(d)

Note: Response to VAR innovations ± 2 SE.

Source: Estimated by author

The trace statistics indicate the null hypothesis that *there is no cointegration among the repo, three months US TB yield, ten years US TB yield, dollar index, and VIX* is rejected at the 5% level. This is also supported by the trace statistics value, which is more than the critical value (78.65 > 69.82). The *maximum eigenvalue* reinforced the trace statistics results, which show that the null hypothesis – that *there is no cointegration among the above-mentioned variables*, is rejected at the 5% level. This is also supported by the eigenvalue statistics value, which is more than the critical value (48.87 > 33.88). Therefore, it can be inferred that one cointegrating vector exists between the variables. Therefore, researchers can estimate a VECM.

The Johansen normalised cointegration coefficients illustrated below reject the null hypothesis that there is no cointegration against the alternative of a cointegrating relationship in the model.

$$\text{Repo rate} = 1.097426\ \text{3-months' US TB yield} - 0.251609\ \text{10-years US TB yield}$$
$$(0.51167) \qquad (0.62858)$$
$$-0.15653\ \text{dollar index} + 0.652237\ \text{VIX}$$
$$(0.05557) \qquad (0.08599)$$

(Standard errors are displayed in parentheses).

Table 5 Results of cointegration tests

Unrestricted cointegration rank test (trace)				
No. of CE(s)	*Eigenvalue*	*Statistic*	*Critical value*	*Prob.*
None*	0.046385	78.65424	69.81889	0.0083
At most 1	0.012774	29.78164	47.85613	0.73
At most 2	0.008386	16.55275	29.79707	0.6728
At most 3	0.004932	7.887252	15.49471	0.4775
At most 4	0.002717	2.7993	3.841466	0.0943
Unrestricted cointegration rank test (maximum eigenvalue)				
No. of CE(s)	*Eigenvalue*	*Statistic*	*Critical value*	*Prob.*
None*	0.046385	48.87261	33.87687	0.0004
At most 1	0.012774	13.22889	27.58434	0.8719
At most 2	0.008386	8.665494	21.13162	0.8584
At most 3	0.004932	5.087952	14.2646	0.7307
At most 4	0.002717	2.7993	3.841466	0.0943

Note: *Denotes the 5% significance level.

Source: Estimated by author

The coefficients suggest that there is a cointegrating relationship between the variables, meaning that the relationship between variables is stable and not due to chance or short-term fluctuations, but rather reflects a long-run equilibrium between the variables. Specifically, an increase in three-month' US TB yield and VIX are positively associated with an increase in repo rate, while an increase in ten-year' US TB yield and dollar index are negatively associated with an increase in repo rate.

The standard errors displayed in parentheses indicate that all coefficients except the 10-year' US TB yield have absolute values that are greater than two times their respective standard errors, suggesting that they are statistically significant.

4.2.3 Long-run and short-run causality

In the VECM equation, C(1) represents the coefficient of the cointegrating equation (long-term causality).

$$\text{D(REPO)} = \text{C(1)} * \text{REPO}(-1) + 1.0476 * \text{\_3\_MONTHS'}(-1) - 0.0255$$
$$* 10\_\text{YEARS}(-1) - 0.0786 * \text{DXY}(-1) + 0.7528 * \text{VIX}(-1) - 14.0485$$

Table 6 reveals that C(1), which signifies the residual at the one-period lag of the cointegrating vector between the three-months' US TB yield, the ten-years' US TB yield,

the dollar index the VIX, and the repo rate, is not negative and significant. Therefore, long-run causality cannot be established between the three-month US TB yield, ten-years US TB yield, dollar index, VIX and repo rate.

Table 6 Long-run causality test statistics

	Coefficient	*Std. error*	*t-statistic*	*Prob.*
C(1)	0.000535	0.000677	0.789408	0.4301
C(2)	–0.06566	0.032008	–2.05139	0.0405*
C(5)	0.066958	0.030909	2.166299	0.0305*
C(8)	0.185431	0.030582	6.063362	0*
C(9)	0.105421	0.031105	3.389266	0.0007*
C(13)	0.070099	0.035129	1.995473	0.0463*
C(17)	0.077681	0.035067	2.215203	0.027*
C(23)	0.073492	0.02591	2.836427	0.0047*
C(27)	0.076341	0.025948	2.942085	0.0033*
C(30)	–0.00783	0.003115	–2.51534	0.0121*
C(31)	–0.00877	0.003105	–2.82312	0.0049*
C(36)	–0.00822	0.003093	–2.65849	0.008*
C(45)	0.002189	0.000919	2.38128	0.0174*

Note: *Denotes 5% significance level.

Source: Estimated by author

The short-run causal relationships among the variables were established using the *Wald test*, the results are shown in Table 7.

Table 7 Wald test (repo rate)

Variables	*F-statistic*			*Chi-square*		
	Value	*df*	*Probability*	*Value*	*df*	*Probability*
3-month US TB yield	2.607603	(9,982)	0.0056	23.46843	9	0.0052
10-year US TB yield	2.325127	(9,982)	0.0137	20.92614	9	0.013
Dollar index	2.470725	(9,982)	0.0087	22.23653	9	0.0082
VIX	1.180735	(9,982)	0.3036	10.62662	9	0.3022

Source: Estimated by author

4.2.3.1 The three-month' US TB yield to repo rate

To examine the short-run impact from the three-month US TB yield to the repo rate, the following null hypothesis was examined:

$$6H_0: C(11) = C(12) = C(13) = C(14) = C(15) = C(16) = C(17) = C(18) = C(19) = 0$$

If coefficients C(11)–C(19) jointly influence the repo rate, that is, the null hypothesis is rejected. This means that short-run impact from the three-month US TB yield to the repo rate would be established. Coefficients C(11) to C(19) signify the three-month US TB yield from one period to a nine-period lag. The chi-square value in Table 7 reveals that

the null hypothesis that *coefficients C(11) to C(19) cannot jointly influence the repo rate* – is rejected. Hence, it is inferred that there is *short-run causality running from the three-month US TB yield to the repo rate*.

4.2.3.2 Ten-year US TB yield to repo rate

To examine short-run causality from the ten-years' US TB yield to the repo rate the following null hypothesis was examined:

$$7H_0: C(20) = C(21) = C(22) = C(23) = C(24) = C(25) = C(26) = C(27) = C(28) = 0$$

The coefficients C(20) to C(28) signify the ten-year US TB yield from one period to a nine-period lag. The chi-square value in Table 7 reveals that the null hypothesis that *coefficients C(20) to C(28) cannot jointly influence the repo rate* – is rejected. Hence, it is inferred that there is short-run impact running from the ten-year US TB yield to the repo rate in India.

4.2.3.3 Dollar index (DXY)

To examine the short-run causality from the dollar index to the repo rate, the following null hypothesis is examined:

$$8H_0: C(29) = C(30) = C(31) = C(32) = C(33) = C(34) = C(35) = C(36) = C(37) = 0$$

Coefficients C(29) to C(37) signify that the dollar index ranges from one period to a nine-period lag. The chi-square value in Table 7 reveals that the null hypothesis – *coefficients C(29) to C(37) cannot jointly influence the repo rate* – is rejected. Hence, short-run impact runs from the dollar index to the repo rate.

4.2.3.4 VIX

To examine short-run causality from the VIX to the repo rate, the following null hypothesis is examined:

$$9H_0: C(38) = C(39) = C(40) = C(41) = C(42) = C(43) = C(44) = C(45) = C(46) = 0$$

Coefficients C(38)–C(46) signify that the VIX ranges from one period to a nine-period lag. The chi-square value in Table 7 reveals that the null hypothesis, *coefficients C(38) to C(46), cannot jointly influence the repo rate*. Hence, we infer that there is no short-run impact from the VIX to the repo rate.

5 Summary and conclusions

This study examines the impact of global monetary policy and liquidity transmission shocks on the Indian money market. Weekly data from April 29, 2001 to March 21, 2021, is used to address the issue of maintaining the independence of domestic monetary policy by insulating the money market from external shocks. The study suggests that policymakers cannot fully insulate domestic money markets from the transmission of

global spillovers. Global liquidity, exchange rates, and confidence channels play an important role in global monetary policy transmission to Indian money markets.

The study indicates a long-term, stable, and genuine relationship between call money rates and broader factors such as global liquidity, confidence channels and exchange channels. A long-run causality is revealed between WACR and the broader factors. An increase in three-month yield and VIX results in an increase in WACR, while an increase in ten-year yield and DXY leads to a decrease in WACR. Similarly, there is also a long-term, stable, and genuine relationship between repo rates and these same broader factors. However, no long-run causality between the repo and the broader factors is revealed in the study. The short-term impact is observed from global liquidity and the exchange channel to the repo rate, which means these factors have a relatively immediate impact on the repo market but not on the VIX. However, the short-term impact is not witnessed from WACR to the transmission channels.

The exchange channel and VIX are proven to be more predominant in influencing the policy rate and call money rates.

Despite the RBI's active liquidity management framework, the Indian money market is influenced by global monetary policy shocks sourced from various transmission channels. The study's empirical findings have several policy implications. Policymakers in India need to stabilise the domestic economy irrespective of the nature and sources of shocks.

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Appendix

Long-run causality test statistics

	Coefficient	*Std. error*	*t-statistic*	*Prob.*
C(1)	–0.00882	0.004357	–2.02411	0.0434
C(2)	–0.247157	0.041706	–5.92619	0
C(3)	–0.034599	0.041635	–0.83101	0.4063
C(4)	–0.063794	0.10002	–0.63782	0.5238
C(5)	–0.036301	0.099681	–0.36417	0.7159
C(6)	0.030534	0.083245	0.366798	0.7139
C(7)	–0.026538	0.082635	–0.32115	0.7482
C(8)	–0.001236	0.003292	–0.37533	0.7076
C(9)	–0.000103	0.003249	–0.03168	0.9747
C(10)	–0.01865	0.010566	–1.76504	0.0781
C(11)	0.003641	0.010673	0.341086	0.7332
C(12)	–0.001472	0.010729	–0.13721	0.8909