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LIQUIDITY, VIX & BAD NEWS IMPACT MOST OF THE FINANCIAL MARKET VOLATILITY IN INDIA; SURPRISINGLY, VOLATILITY DECLINES IN A CENTRAL BANK RATE HIKE CYCLE; RBI MAY LOOK AT MID SEGMENT OF YIELD CURVE FOR BETTER YIELD CURVE SIGNALLING & LESS VOLATILITY

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Policymakers has to control the inflation without harming economy and financial markets. Higher cost of capital and thereby lower operating margins impacts the growth as well as competitive landscape favoring established market players than the new entrants.

Financial markets in 2022 have remained volatile and edgy with the central banks globally in unison in a rate hike cycle. In fact, this is in complete contrast to post global financial crisis in 2008 when all central banks had cut rates in unison, but central banks in respective countries decided to take an exit from easy monetary policy separately, India included. With the prospect of a global slowdown in 2023, it could be eminently possible that central banks in respective countries start to unwind rates even in unison as inflation comes off the boil and slowdown starts to bite.

Meanwhile, we believe that equity and bonds become less correlated when the economic cycle slows. Challenges for investors also increases when both bond prices as well as equity prices fall together. Allocation to fixed income in current year has been a challenging area as low yield on government bonds lowers it's ability to offset losses incurred by investors during bear markets. Equity markets factors news, positive or negative, to reasonably value the stocks. Investors tend to chose asset allocation in equity markets by comparing with yields derived by short duration as well as long duration government securities.

Indian markets have remained volatile in 2022. However, market capitalization of BSE has increased by 137% in December 2022, in comparison with March 2020, highest among the prominent equity markets. Returns in Indian Equity market (BSE SENSEX) were 4.4 % on YTD basis with lesser volatility in comparison with other prominent equity markets. A granular look at the data reveals that both in terms returns and volatility, Indian markets logged in the best performance on a relative scale.

To understand the factors that explain market volatility in Indian context, we did a 2 stage analysis. **In first step, we estimated the volatility of BSE SENSEX returns with the help of a GARCH model and we confirmed the statistical robustness of the results**. **Firstly**, **results of the GARCH model suggests that BSE SENSEX returns are not driven by its lag, indicating Indian markets are forward looking, but are impacted by negative news.**

Secondly, **the market liquidity and movements in VIX index are significantly explaining the movements of the returns**. Increase in market liquidity has positive impact on BSE SENSEX returns, while VIX index which gauges the market sentiments especially fear of market participants in the form of 30 day projection of volatility, affects BSE Sensex returns negatively. 1 **unit (Rs Billion)** increase in Net liquidity increases the BSE SENSEX returns by 0.00004 unit. 1 unit increase in VIX index decreases the BSE SENSEX returns by 0.01449 unit. Results are significant at 1% level and are also robust.

In second step of our analysis, using estimated volatility of BSE SENSEX returns through GARCH model, **we measure the impact of federal funds rate, repo rate, and spread of government bond yields on the volatility of BSE SENSEX returns with the help of ARDL model**. **Federal Funds rate and Repo rate are estimated to be negatively impacting the BSE Sensex volatility**, **indicating in a rate hike cycle, market volatility declines as risk gets adequately priced**. **1 % increase in FFR and repo rate decreases the Volatility of BSE SENSEX returns by 0.244 and 0.346 unit respectively**. Results are found to be significant at 1% level.

But most importantly, 1% increase in difference (spread) between yields of 5 year government bond yield with respect to 1 year government bond yield is found to increase volatility of BSE SENSEX returns by 4.26 unit. This clearly indicates that the RBI may look at the mid segment of the yield curve more specifically in terms of signaling. Interestingly, the spread between 1 year and 6, 7 years are found to be statistically insignificant, implying the strong market preference to look at 5 year rates as signaling device. As expected, the yield spread between 1 year and 10 year is found to be statistically significant. 1% increase in difference (spread) between yields of 3 year, 4 year, and 10 year government bond yields with respect to 1 year government bond yield decreases volatility of BSE SENSEX returns by 0.98, 2.73, and 0.87 unit respectively. Results are found to be significant. Robustness of the aforementioned results has been checked with Threshold GARCH model predicted variance as Dependent Variable.

MARKET CAPITALIZATION OF EQUITY MARKETS

- Equity markets, being most vital area of market economy, gives access to capital to firms. Some of the largest equity markets are New York Stock Exchange, Nasdaq, Tokyo Stock Exchange, Shanghai Stock Exchange, and Euronext Europe. **Market capitalization of BSE has increased by 137% in December 2022, in comparison with March 2020, highest among the prominent equity markets.**
- Total return (YoY growth at year end level) of Indian Stocks (BSE SENSEX) and Indian Bonds (10 year G sec yield) shows an interesting picture. In CY 00, 01, 08, and 15 both Indian stocks and bonds returns had been negative. In CY 11 only, bonds have given positive returns while stocks have given negative return. In all other calendar years, stocks have given positive returns, and outperformed the returns in comparison to bonds in CY 04, 05, 06, 07, 09, 10, 13, 17, 18, 21 and 22.
- Returns in Indian Equity market (BSE SENSEX) are 4.4 % on YTD basis with lesser volatility in comparison with other prominent equity markets.
- BSE Sensex market capitalization has been increasing continuously with significant volatility attached with the returns.
- BSE Sensex returns are however more volatile in cases of extreme news events as under:

⇒ Black Monday 2011 refers to 8 August, 2011, when US and global stock markets crashed following the Friday night credit rating downgrade by Standard and Poor's of the United States sovereign debt from AAA, or "risk free", to AA+

⇒ On 20 Aug 2013, Sensex closed at 18,598 on fresh concerns about US stimulus withdrawal and rupee plunging to record low of 62, wiping out investor wealth by Rs 2 lakh crore.

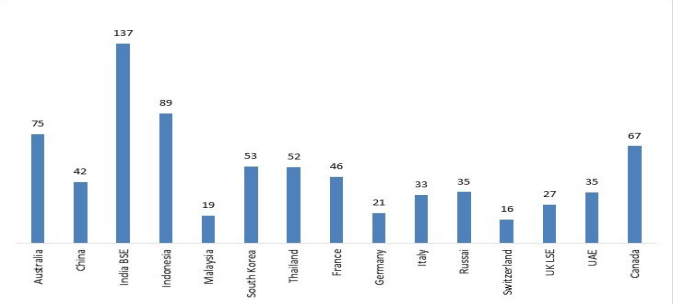
⇒ In 2015, greater volatility has been observed as a ripple effect due to fears over a slowdown in China. 2015 was hit by slowdown in global markets, including in the European markets; and weak Q3 of Indian firms, led by the banking and automobile sector. It is said to have taken a toll on the Indian stock exchanges. A week-long Lunar New Year holiday in the Chinese markets along with the US Fed uncertainty also added to the pressure. Major sell-off in global markets created a chain reaction impacting the markets world over including in India.

⇒ On 7 January 2015, all-round selling was triggered from operators following a sharp fall in the Asian markets as oil prices slipped to a fresh 5-1/2 year low.

⇒ With the advent of Covid 19 on 13.03.2020, SENSEX returns were very volatile.

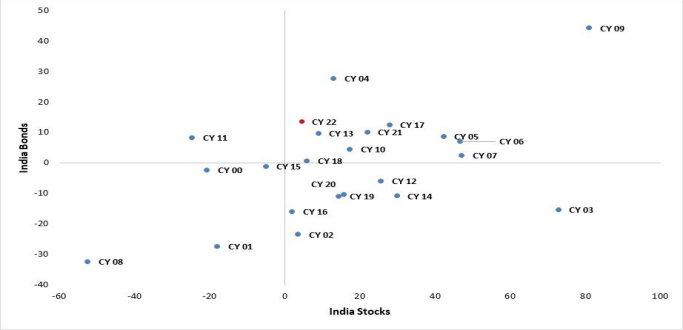
⇒ Further, volatility has been observed in SENSEX returns with Ukraine invasion on 25 February 2022.

% Rise in Market capitalization (in Dec 22 in comparison with March 20)



Source: SBI Research

Total Return in Indian Stocks and Bonds



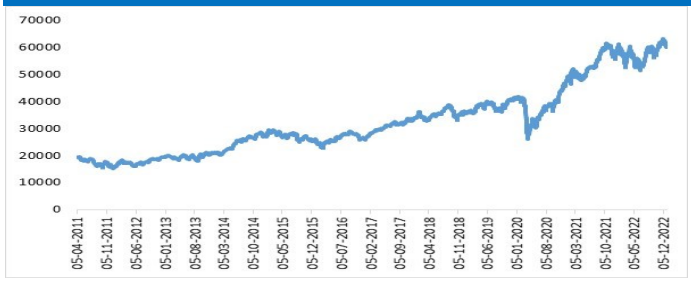
Source: SBI Research

Global Equity Market Returns and Volatility

Country/Region	Index	YTD Change	Volatility*
Russia	RTS	-44.3	102%
US	S&P 500	-21.1	34%
Switzerland	Swiss MKT	-16.1	28%
China	Shanghai Composite	-15.4	26%
Hong Kong	Hang sang	-15.2	70%
Germany	MDAX	-12.2	36%
Euro	Euro Stoxx	-11.1	34%
Japan	Japan	-10.9	19%
France	CAC40	-9.5	30%
US	Dow Jones	-9.2	28%
Great Britain	FTSE-100	0.1	12%
Indonesia	JCI	2.8	11%
India	Nifty 50	4.5	23%
	SENSEX Index	4.4	23%

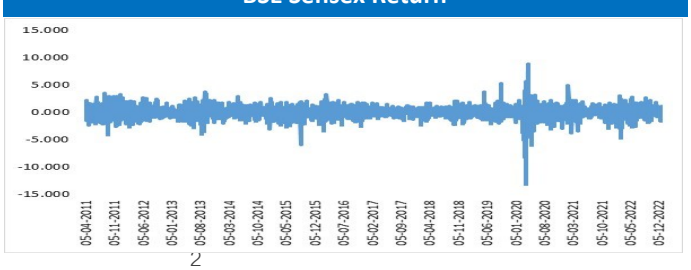
Source: SBI Research * (Max-Min)/Average

BSE Sensex Market capitalization



Source: SBI Research

BSE Sensex Return



Source: SBI Research

METHODOLOGY

- To estimate the impact of Repo rate, Federal funds rate and Government securities yield spread on stock market volatility, **in first part** the BSE SENSEX volatility with the help of GARCH model (robustness of the results has also been confirmed with incorporating the impact of bad news in the market with the threshold GARCH model). **In the second part** we estimated the impact of policy rates and bond yields spreads on the BSE SENSEX volatility (estimated previously by GARCH model) with the ARDL model.
- **We have estimated both the GARCH models and ARDL model for the period of 1 April 2011 to 19th December 2022.**

GARCH Model

- OLS models consider variance of the error terms as being constant over time. It However, financial time series has time varying volatility, called as volatility clustering, simply described as large changes in stock returns are followed by further large changes and vice versa. Unconditional (long run) variance may still follow the homoscedasticity assumption, in comparison with conditional (short run) variance.
- **Unconditional (long run) variance may have no use to investors in the financial market as such investors selecting the investment decision, not just focus on rate of return but also the variance (volatility) of the return, to clearly examine the riskiness attached with the investment.**
- To model the conditional (short run) variance of the model, ARCH model has been proposed by Engle.
- Simple Model assumes that

$$Y_t = \alpha + \beta X_t + u_t$$

u_t ~ iid N(0, σ^2)

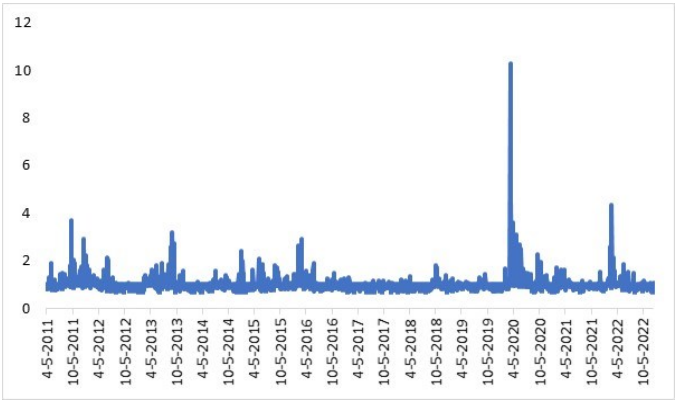
- However, Engel under the ARCH (1) process proposed that

$$\sigma_t^2 = \gamma_0 + \gamma_1 u_{t-1}^2$$

- Under the ARCH (1) model, when a big shock happens in period t-1, the value of u_t will also be bigger and vice versa.
- Under the GARCH model, proposed by Bollerslev in 1986, the modified variance equation proposed under GARCH (1) process is as under:

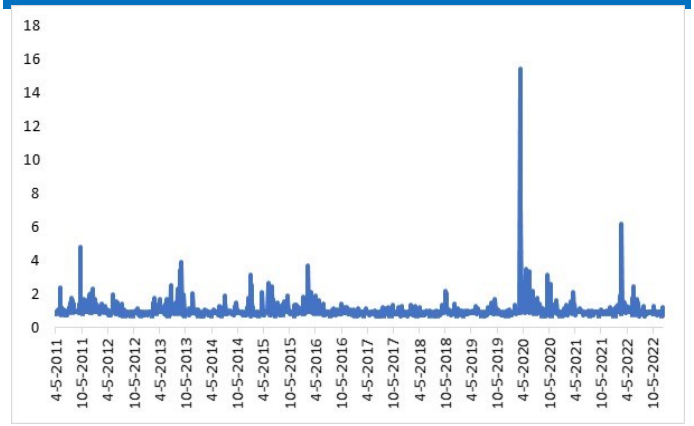
$$\sigma_t^2 = \gamma_0 + \delta_1 \sigma_{t-1}^2 + \gamma_1 u_{t-1}^2$$

Conditional variance predicted by GARCH model



Source: SBI Research

Conditional variance predicted by Threshold GARCH model



Source: SBI Research

- We estimate the Threshold GARCH model introduced by Zaokian in 1990 capturing the asymmetry between positive and negative news (shock) by adding a dummy variable in the variance equation as under:

$$\sigma_t^2 = \gamma_0 + \delta_1 \sigma_{t-1}^2 + \gamma_1 u_{t-1}^2 + \theta u_{t-1}^2 d_{t-1}$$

- d_t takes the value of 1 for u_t <0, and 0 otherwise. So, for good news, impact is γ and for bad news impact is $\gamma + \theta$.

Under the methodology, we have estimated the GARCH (1) model. For the robustness check of the results of GARCH (1) model, we estimated Threshold GARCH (1) model.

- BSE SENSEX Returns, Net Liquidity and VIX Index are all I(0) i.e. stationary variables.
- Impact of news has been quantified more with higher magnitude, in the conditional variance predicted by Threshold GARCH model.

BSE SENSEX VOLATILITY (CONDITIONAL VARINCE) ESTIMATION WITH GARCH MODEL –STEP 1

- Relationship of BSE SENSEX Returns has been estimated on it's lag as well as Net Liquidity and VIX Index.
- **With the results of the GARCH model, it is estimated that returns are not driven by its lag. Further, the market liquidity and movements in VIX index are significantly explaining the movements of the returns.**
- **Increase in market liquidity has positive impact on BSE SENSEX returns, while VIX index which gauges the market sentiments especially fear of market participants in the form of 30 day projection of volatility, affects BSE Sensex returns negatively**. Results are significant at 1% level.
- 1 unit (INR Billion) increase in Net liquidity increases the BSE SENSEX returns by 0.00004 unit. 1 unit increase in VIX index decreases the BSE SENSEX returns by 0.01449 unit. Both ARCH and GARCH terms are found to be significant at 1% level.
- To confirm the robustness of the results, we have estimated the Threshold GARCH model to incorporate the asymmetric impact of good as well as bad news. And results of the threshold GARCH model confirms the results estimated with GARCH model. Threshold GARCH term found to be significant at 10% level.

After estimating the stock market volatility (σ_t^2), we estimated the impact of policy rates and G sec spreads to check whether the impact of changes in the policy rates and G-secs are driving the volatility in the stock market.

GARCH Model Results
(BSE SENSEX Returns as Dependent Variable)

S. No	Variable	Coefficient	Standard Error	Z value	P value
1	BSESensexReturn (1)	.0125555	.0187119	0.67	0.502
2	NetLiquidity	.0000459	9.60e-06	4.78	0.000***
3	VIXIndex	-.0144912	.0029012	-4.99	0.000***
4	Constant	.2561933	.054553	4.70	0.000***
5	ARCH (1)	.1698602	.0515677	3.29	0.001***
6	GARCH(1)	.7794281	.3005232	2.59	0.009***
7	Constant	.0848038	.2732396	0.31	0.756

Source: SBI Research
*** significant at 1% level

Threshold GARCH Model Results
(BSE SENSEX Returns as Dependent Variable)

S. No	Variable	Coefficient	Standard Error	Z value	P value
1	BSESensexReturn (1)	.015948	.0181915	0.88	0.381
2	NetLiquidity	.0000434	9.50e-06	4.57	0.000***
3	VIXIndex	-.0126629	.0028775	-4.40	0.000***
4	Constant	.2257104	.0542671	4.16	0.000***
5	ARCH (1)	.2565362	.0838354	3.06	0.002***
6	GARCH(1)	.823159	.3134819	2.63	0.009 ***
7	TARCH (1)	-.1518841	.0789551	-1.92	0.054*
8	Constant	.0576756	.2809381	0.21	0.837

Source: SBI Research
*** significant at 1% level
* significant at 10 % level

ARDL MODEL –STEP 2

- ARDL (Autoregressive Distributed lag) is an infinite lag distributed model. Dependent variable is not just explained by explanatory variables but also the lagged dependent variable.

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \ldots + \beta_p Y_{t-m} + \alpha_i X_t^i + \gamma_0 X_t + \gamma_1 X_{t-1}$$

m, and n are number of years of lag,

ε_t is disturbance term,

β_i are coefficients of lagged dependent variables,

α_i are coefficients for long run relationships and

γ_i are coefficients of short run relationships,

Federal Funds rate and repo rate are found to be I(1) variables

- Spread of 2 year and 1 year government bond yield has been found to be I(0)
- Spread of 3 year, 4 year, 5 year, 6 year, 7 year, and 10 year government bond yield with respect to 1 year government bond yield are found to be I(1).
- GARCH model predicted variance has been found to be I (0) and Threshold GARCH model predicted variance has been found to be I(1).
- **Since all the variables for the ARDL model are either I (0) or I(1), and none of them pertains to higher order of differencing, giving basis for moving ahead with ARDL model.**
- Further, H0 of 'no level relationship' of Pesaran, Shin and Smith Bound test has been rejected at 10% level for ARDL model using GARCH model predicted variance as dependent variable but it remain inconclusive for

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ARDL model using Threshold GARCH model predicted variance as dependent variable. Nevertheless, negative sign of the adjustment factor in both models along with significance at 1% level, signify level relationship in both the aforesaid ARDL models

- **Remarkably, Federal Funds rate and Repo rate are estimated to be negatively impacting the BSE Sensex volatility. 1 % increase in FFR and repo rate decreases the BSE SENSEX Volatility by 0.244 and 0.346 unit respectively. Results are found to be significant at 1% level.**
- 1% increase in difference (spread) between yields of 3 year, 4 year, and 10 year government bond yields with respect to 1 year government bond yield decreases BSE SENSEX volatility by 0.98, 2.73, and 0.87 unit respectively. Results are found to be significant at 1%, 1% and 10% respectively.
- 1% increase in difference (spread) between yields of 2 year, 6 year, 7 year government bond yields with respect to 1 year government bond yield are not found to be significantly affecting BSE SENSEX volatility.
- **1% increase in difference (spread) between yields of 5 year government bond yield with respect to 1 year government bond yield is found to increase BSE SENSEX volatility by 4.26 unit.**
- Significant short run relationship has also been found in spread of 3 year, 4 year, 5 year, 6 year, 7 year and 10 year government bond yields with respect to 1 year government bond yield with BSE SENSEX volatility.
- The adjustment coefficient has also been found to be negative and significant at 1% level signifying converging in the model i.e. significant long run relationship.
- Significant short run relationship between spread of 6 year, and 7 year government bond yield with respect to 1 year government bond yield with BSE SENSEX volatility, in the absence of no long run relationship signifies weak causality. No short run and long run relationship of spread of 2 year and 1 year government bond yield with BSE SENSEX volatility is found. Rest of the bond yields spreads have strong causal relationship with BSE SENSEX volatility.
- Robustness of the results has been checked with Threshold GARCH model predicted variance as Dependent Variable. The aforementioned results have been confirmed even in the case of asymmetric news impact on stock market volatility with higher level of significance. In robustness check, only exception found is in short run relationship of spread of 4 year and 1 year government bond yield with BSE SENSEX volatility.

ARDL model (GARCH model predicted variance as Dependent Variable)

S.No.	Variable	Coefficient	Standard Error	T statistic	P value
1	ADJ Final variance (1)	-.1758746	.0379935	-4.63	0.000***
Long Run Relationship					
2	FFR	-.2442872	.0878124	-2.78	0.005***
3	Repo	-.3460406	.1174692	-2.95	0.003***
4	Spread2-1	.2556804	.4453089	0.57	0.566
5	Spread3-1	-.9811447	.3646314	-2.69	0.007***
6	Spread4-1	-2.733478	1.007852	-2.71	0.007***
7	Spread5-1	4.261891	1.238238	3.44	0.001***
8	Spread6-1	-.4252531	.594437	-0.72	0.474
9	Spread7-1	-.2136105	.4625999	-0.46	0.644
10	Spread10-1	-.8779653	.4608477	-1.91	0.057*
Short Run Relationship					
11	Spread3-1	-.5153152	.2138106	-2.41	0.016**
12	Spread4-1	.536288	.3732864	1.44	0.151
13	Spread4-1 (1)	.8490619	.3225408	2.63	0.009***
14	Spread5-1	.6542213	.3398524	1.93	0.054 *
15	Spread5-1 (1)	-1.163368	.3365753	-3.46	0.001***
16	Spread6-1	.4848499	.2748244	1.76	0.078*
17	Spread7-1	.6464488	.2845341	2.27	0.023**
18	Spread10-1	-1.362369	.3363208	-4.05	0.000***
19	Spread10-1 (1)	.5605386	.2912692	1.92	0.054*
20	Constant	.6258988	.1366552	4.58	0.000***

Source: SBI Research
*** significant at 1% level
** significant at 5% level
* significant at 10% level.

ARDL model (Threshold GARCH model predicted variance as Dependent Variable)

S. No	Variable	Coefficient	Standard Error	T statistic	P value
1	ADJ Final variance (1)	-.154674	.0432983	-3.57	0.000***
Long Run Relationship					
2	FFR	-.3697021	.1506124	-2.45	0.014**
3	Repo	-.5794092	.2104311	-2.75	0.006***
4	Spread2-1	.3916993	.7089252	0.55	0.581
5	Spread3-1	-1.289827	.5940363	-2.17	0.030**
6	Spread4-1	-2.583685	1.452379	-1.78	0.075*
7	Spread5-1	4.921069	1.904157	2.58	0.010**
8	Spread6-1	-.9687514	.9778504	-0.99	0.322
9	Spread7-1	.0414575	.7300343	0.06	0.955
10	Spread10-1	-1.452838	.7640547	-1.90	0.057*
Short Run Relationship					
11	Spread3-1	-.5177055	.2935092	-1.76	0.078*
12	Spread4-1	-			
13	Spread4-1 (1)	-			
14	Spread5-1	1.384751	.431806	3.21	0.001***
15	Spread5-1 (1)	-1.340205	.4182053	-3.20	0.001***
16	Spread6-1	.7640741	.3827318	2.00	0.046**
17	Spread6-1 (1)	.7522618	.3393388	2.22	0.027**
18	Spread7-1	.9031609	.3809519	2.37	0.018**
19	Spread10-1	-2.051757	.4598003	-4.46	0.000***
20	Spread10-1 (1)	.8927551	.4013861	2.22	0.026**
21	Constant	.8554083	.1887991	4.53	0.000***

Source: SBI Research
*** significant at 1% level
** significant at 5% level
* significant at 10% level.

GARCH model: Unit root tests							
S.No	Variable	Test Statistic	P value	Variable	Test Statistic	P value	I
1	BSESensex	1.325	0.9967	D.BSESensex	-36.748	0.0000.	I(1)
2	BSESensexReturn	-51.265	0.0000	-	-	-	I(0)
3	NetLiquidity	-3.528	0.0073	-	-	-	I(0)
4	VIXIndex	-7.634	0.0000	-	-	-	I(0)
Source: SBI research							

ARDL model: Unit root tests							
S.No	Variable	Test Statistic	P value	Variable	Test Statistic	P value	I
1	FFR	1.827	0.9984	D.FFR	-34.739	0.0000	I(1)
2	Repo	-0.175	0.9414	D.repo	-34.953	0.0000	I(1)
3	Spread2-1	-6.900	0.0000	-	-	-	I(0)
4	Spread3-1	-1.700	0.4313	D.Spread31	-45.734	0.0000	I(1)
5	Spread4-1	-2.570	0.0993	D.Spread41	-46.583	0.0000	I(1)
6	Spread5-1	-2.475	0.1216	D.Spread51	-45.481	0.0000	I(1)
7	Spread6-1	-1.939	0.3138	D.Spread61	-44.970	0.0000	I(1)
8	Spread7-1	-2.134	0.2312	D.Spread71	-45.588	0.0000	I(1)
9	Spread10-1	-1.517	0.5249	D.Spread101	-44.255	0.0000	I(1)
10	Predicted GARCH model Variance	-3.651	0.0048	-	-	-	I(0)
11	Predicted Threshold GARCH model Variance	-2.616	0.0898	D. Predicted Threshold GARCH model Variance	-21.685	0.0000	I(1)
Source: SBI Research							

Pesaran, Shin, and Smith (2001) bounds test H0: no level relationship												
	Kripfganz and Schneider (2020) critical values and approximate p-values						ARDL model using the GARCH model predicted variance as Dependent Variable			ARDL model using the Threshold GARCH model predicted variance as Dependent Variable		
	10% level		5% level		1% level		P value			P value		
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)	F and t values	I(0)	I(1)	F and t values
F	1.870	2.979	2.118	3.286	2.627	3.903	0.000	0.000	8.532	0.000	0.000	5.857
t	-2.564	-4.559	-2.860	-4.891	-3.435	-5.507	0.000	0.087	-4.629	0.006	0.409	-3.572
Decision							H0 Rejected at 10% level			Decision of rejection of H0 remained inconclusive		

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