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IMPACT OF MACROECONOMIC VARIABLES ON YIELD CURVE IN INDIAN FIXED INCOME MARKET

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Abstract

The objective of the paper is to study the impact of macroeconomic variables such as debt to GDP ratio, output growth, inflation, and monetary policy, ten-year benchmark US treasury yield, LIBOR, and exchange rate on curvature, level, and slope of the yield curve (YC) in Indian government securities market in the short run. The time period selected for the study was from January 1997 to December 2017. Data on government securities yield downloaded for RBI's database on the Indian economy. VAR and impulse response have been used for analysis. Results show that among seven macro-determinants only inflation and monetary policy impact the YC significantly. Specifically, inflation impacts the level but not the slope and curvature of the YC whereas monetary policy substantially impacts the level and slope, but its effect is insignificant on curvature.

Keywords: Government Securities, Slope, Level, Curvature of Yield Curve, Inflation, Monetary Policy.

JEL Classification Code: E430, E440

. Introduction

The yield curve (YC) shows the relationship between the yield and various maturities of government securities. Upward sloping YC shows the direct relationship between maturity and yield and vice versa. The shape of the YC, also called as spot rate curve, is dynamic in nature. It fluctuates with the changes in macroeconomic variables in the economy. With the fluctuations in YC borrowing cost and price of government securities also fluctuates. Thus, it becomes important to understand the determinants of YC so that investors and government can predict the fluctuations and adjust the strategies accordingly. To understand this dynamic nature of YC, various theories of the YC such as expectation hypothesis, liquidity preference theory, and market segmentation theory have been developed in the finance literature. Fisher, (1896) is the pioneer scholar in the development of the theory on the YC. He explained the relationship between short and long-term yield, and which later became the basis of the YC's expectation theory. He observed that though short and long-term yield tend to move together, fluctuations in the short-term yield are higher than the long-term yield. Keynes (1930), in the Treatise on Money, while exploring why short and long-term yield move together, argued that short-term yield affect monetary policy and which in turn, affect long-term yield. But later, Keynes (1936) abandoned the relationship between short and long-term yield. Based on his

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work on the general theory of employment, interest, and money, he considered long-term yield as a "highly conventional" or a "highly psychological phenomenon. Expectation theory, which explained the changes in YC, was further developed by number of scholars such as Lutz (1940), Hicks (1946), Malkiel (1970), and Roll (1970, 1971). All these scholars hypothesised that forward rates are unbiased predictors of the future short-term rates. In other words, irrespective of the time period of the investment returns remain the same. Also, to explain the fluctuations in the YC, Hicks (1946) argued that the investors prefer short-term bonds as they are more liquid, and hence, the YC is usually upward sloping. Later, while expanding this theory, Culbertson (1957) led to the development of liquidity preference theory of interest rates.

Expanding the same relationship further, Kessel (1971) argued that the YC could be explained jointly by the expectation and liquidity preference hypotheses. He argued that both theories are complementary to each other. To affect the long-term yield, the monetary authority must buy and sell long-term bonds in the open market. Modigliani and Sutch (1966) developed the theory of the YC and called it as 'theory of preferred habitats' (or: 'market segmentation theory'). Unlike Hicks (1946), Modigliani and Sutch (1966) argued that investors do not prefer liquid bonds but prefer bonds as per their requirements. For example, life insurance companies prefer to invest in long-term bonds, and commercial banks prefer to invest in short-term bonds. They do not generally shift from their preferred habitat, and thus the yield depends upon the demand and supply of the bonds in the preferred maturity. All these theories that include expectation hypothesis, liquidity preference, and preference habitat are significant in understanding the fluctuations in the YC. Further, it is well established that macroeconomic variables such as debt to GDP, affect the interest rate in the economy and which consequently impacts YC. As shown in next section , numbers of studies have explored and established the impact of macro-determinants either individually or in a few groups on the shape of the YC.

2. Literature Review

Manasse *et al.,* (2003) and Engen and Hubbard (2004) established that the ability of a country to pay back its debt is measured by the debt to GDP ratio. Alesina *et al.* (1992) and Lemmen (1999) showed that the yield is positively related to the level of public debt in twelve OECD countries including Australia, Canada, and Germany. Studies such as Alexander and Anker (1997), Lemmen and Goodhart (1999), Copeland and Jones (2001) and Codogno et al. (2003) also confirmed the direct relationship between public debt and interest rates. To extend the research further, Bernoth *et al.* (2004) and Baldacci and Kumar (2010) established direct relationship between debt, debt service ratio and default risk in both developed and emerging markets. Akram and Das (2019) discovered that the debt ratio of the Indian government has no significant impact on the Indian G-Secs yield over the long run. Thomas and Williams (2003) showed that higher output growth increases the real interest rate because of higher investment demand, lower savings and higher demand for transaction money. The study was conducted in context to the US economy. Afonso (2009) studied the ten-year G-Secs yield for fourteen EU countries and established that the yields are positively related to the better growth forecasts, and higher interest rates in the economy increase the yield and decrease the price of the G-Secs. Hence, the study argues that same relationship will also hold in developing

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countries like India in context to the G-Secs. Further, it is also argued that the shape of the YC will also be affected. Inflation is another major factor affecting G-Secs yield and shape of YC. Fisher effect by Irving Fisher (1930) postulates that nominal interest rates in any period are equal to real interest rates and inflation. Mishkin and Simon (1995) found positive relationship between long-run interest rates and inflation in the Australian economy. Also, Diebold *et al.* (2006) established two-way impact of macroeconomic variables and movement of YC in the US economy. The authors also stated that slope and level of YC are strongly correlated with inflation and real activity respectively. Evans and Marshall (1998) and Afonso and Martins (2010) found that short-term interest rates are significantly affected by the monetary policy in the developed markets. Bernard and Gerlach (1996) remarked that for countries having independent monetary policy such as US and Germany the predictive power of term structure would be more robust for predicting output and inflation. Further, Estrella and Mishkin (1997) in their study put forth that YC is impacted by the stance of monetary policy in European and US countries. They also stated that the central bank can influence YC but cannot control it. The international factors like LIBOR, exchange rate, and US T-bills are equally essential to study their effect on Indian YC. Fluctuation in LIBOR affects the cost of borrowing of corporations since LIBOR acts as a benchmark rate for external commercial borrowings for corporations to borrow funds from international markets (RBI, 2019). Though interest rate that the corporations pay on the external commercial borrowings is tied up with the LIBOR, very meagre research is conducted to study the impact of these global benchmarks on Indian YC and the determinants, underlying the effect. Also, the exchange rate risk is another important factor affecting the local currency bond yield (Gadanecz *et al*., 2014). It is well documented that higher exchange rate risk results in higher expected return, and hence, the same effect is assumed in context to the G-SecYC. For example, depreciation in the exchange rate makes imports costly, which increases inflation and consequently affects G-Secs yield (Fisher effect) (Gagnon, 2008). Further, Subramaniam, and Prasanna (2018) found that depreciation in the exchange rate increases the level of the YC. In a recent study, Deleidi and Levrero, (2021) found that in US economy "monetary policy is able to permanently affect long-term interest rates and the central bank has a certain degree of freedom in setting the levels of the short-term policy rate". They used SVAR for data analysis. Also, in another recent study in Europe, Leombroni *et al*., (2021) showed that monetary policy of European Central Bank has powerful impact on YC. In the Indian context, thin research has been conducted on the impact of the macroeconomic determinants on the slope, level, and curvature of the YC, i.e., shape of the YC. Lastly, most of the studies on G-Secs are conducted in developed markets (e.g., Alesina *et al.* (1992); Lemmen, (1999); Alexander and Anker, (1997); Lemmen and Goodhart, (1999); and Copeland and Jones, 2001). Although considerable research has been devoted to the study of macroeconomic variables on the long-term government yield, the impact of these variables on curvature, level, and slope of YC in Indian context has yet not given significant attention. The objective of this study is to examine the effect of macroeconomic variables namely debt to GDP ratio, output growth, inflation and monetary policy, ten-year benchmark US treasury yield, LIBOR and exchange rate on curvature, level, and slope of YC in the Indian G-Secs market in short-run. The study proceeds as under. The following section focus upon

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methodology and time frame used for data analysis, then proceeding section discusses the results and findings and final section concludes the study.

3. Methodology

To assess how the macroeconomic variables affect the curvature, level, and slope of YC of government market securities in the short-run, Vector Auto Regression (VAR) is used. VAR is considered most as suitable as it helps in examining the true relationship between/ among the variables and how they are affecting each other. The VAR model is examined using following equation:

$$Y_{1t} = \alpha + \sum_{j=1}^{k} \beta_j Y_{t-j} + \sum_{j=1}^{k} \gamma_j X_{t-j} + \mu_{1t}$$

$$X_t = \alpha' + \sum_{j=1}^{k} \theta_j Y_{t-j} + \sum_{j=1}^{k} \gamma_j X_{t-j} + \mu_{2t}$$

Where the μ's are the stochastic error terms which are called impulse responses or shocks and, in the above model we assume that each equation contains k lag values of Y and X.

VAR methodology is also preferred and used by various scholars such as Ahokpossi *et al.* (2016), Kapur *et al.* (2018), Sensarma and Bhattacharyya, (2016) and Subramaniam and Prasanna (2018). For instance, in order to study the impact of macroeconomic variables such as exchange rate, inflation and policy rate in Asian G-Secs market Subramaniam and Prasanna (2018) used VAR. Similarly, Kapur *et al.* (2018) also used VAR to study how the monetary policy affects G-Secs yield.

3.1 Time Frame

Monthly data ranging from January 1997 to December 2017 forms the time base for the dataset. Variables are monthly, except for the debt to GDP ratio converted into monthly from quarterly time series using interpolation.

3.2 Variables

Variables include slope, level, and curvature. The slope represents the difference between yields of ten-year and one-year G-Secs. The level is an average of the one, five, and ten-year yields while curvature is taken as a sum of one year and ten-year minus two times the five-year yield (Bekaert *et al.* 2010, Sensarmaa and Bhattacharyya 2016, and Kapur *et al.* 2018).

Macroeconomic variables namely debt to GDP, index of industrial production (as a proxy for output growth), per US dollar exchange rate, LIBOR, and ten-year benchmark US treasury yield are used. The first difference of slope, level, curvature, debt to GDP ratio, index of industrial production, crude oil prices, bank rate, ten-year benchmark US treasury yield, London interbank offer rate, and Indian rupees per US dollar exchange rates are represented by DSLOPE, DLEVEL, DCURV, DD_GDP, DLN_IIP, DCRUDE_OIL_WTI, DBANK_RATE, DTRUS10T DLIBOR12_M, and DUSDINR, respectively.

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4. Data Analysis And Results

4.1 Descriptive Statistics

Mean, standard deviation, range and number of observations of curvature, level and slope (i.e. dependent variables) and seven macroeconomic variables is given in table 1. The average percentage slope of the YC is 0.91, indicating that the difference between long and short-term G-Secs yield is around ninety-one basis points. Level, the second component of yield shows the average percentage yield of all the maturities, ranges from 13.07 to 4.81 percent. The average curvature value, the third component of YC is -0.35, reflecting that the two-time medium-term yield is higher than the average long and short-term yield in the Indian economy. Further, as shown by the standard deviation, fluctuations in slope are higher than level but lower than the curvature of the YC. Regarding descriptive statistics of other variables, crude oil prices range from $145.31 (June 2008) to $11.20 (November 1998) with a standard deviation of 29.76, which shows very high crude oil price fluctuations. Also, LIBOR's standard deviation is higher than US ten-year benchmark treasury bills, but its mean is lower than US ten-year benchmark treasury bills, which shows that LIBOR has a lower yield with a higher risk than US ten-year benchmark treasury bills. Similarly, the descriptive statistics of other independent variables are also given in the table 1.

Further, the overall changes in the YC from January 1997 to December 2017 concerning slope, level, and curvature are given in Figure 1. The figure shows that YC is dynamic, i.e., slope, level, and curvature changes over time.

Table 1 Descriptive Statistics of YC

Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Observations
SLOPE (%)	0.91	0.74	4.10	-1.21	0.86	252
LEVEL (%)	8.00	7.74	13.07	4.81	1.84	252
CURV (%)	-0.35	-0.16	0.97	-2.79	0.66	252
D_GDP (%)	53.09	52.12	64.49	44.48	5.43	252
LN_IIP (%)	5.82	5.10	23.68	-7.52	4.50	252
CRUDE_OIL_WTI (INR)	55.80	50.94	145.31	11.20	29.76	252
BANK_RATE (%)	7.21	6.50	12.00	6.00	1.43	252
TRUS10T (%)	3.82	3.90	6.88	1.46	1.42	252
LIBOR12_M (%)	2.90	2.00	7.45	0.54	2.10	252
USDINR (INR/USD)	49.42	46.53	68.24	35.74	8.66	252

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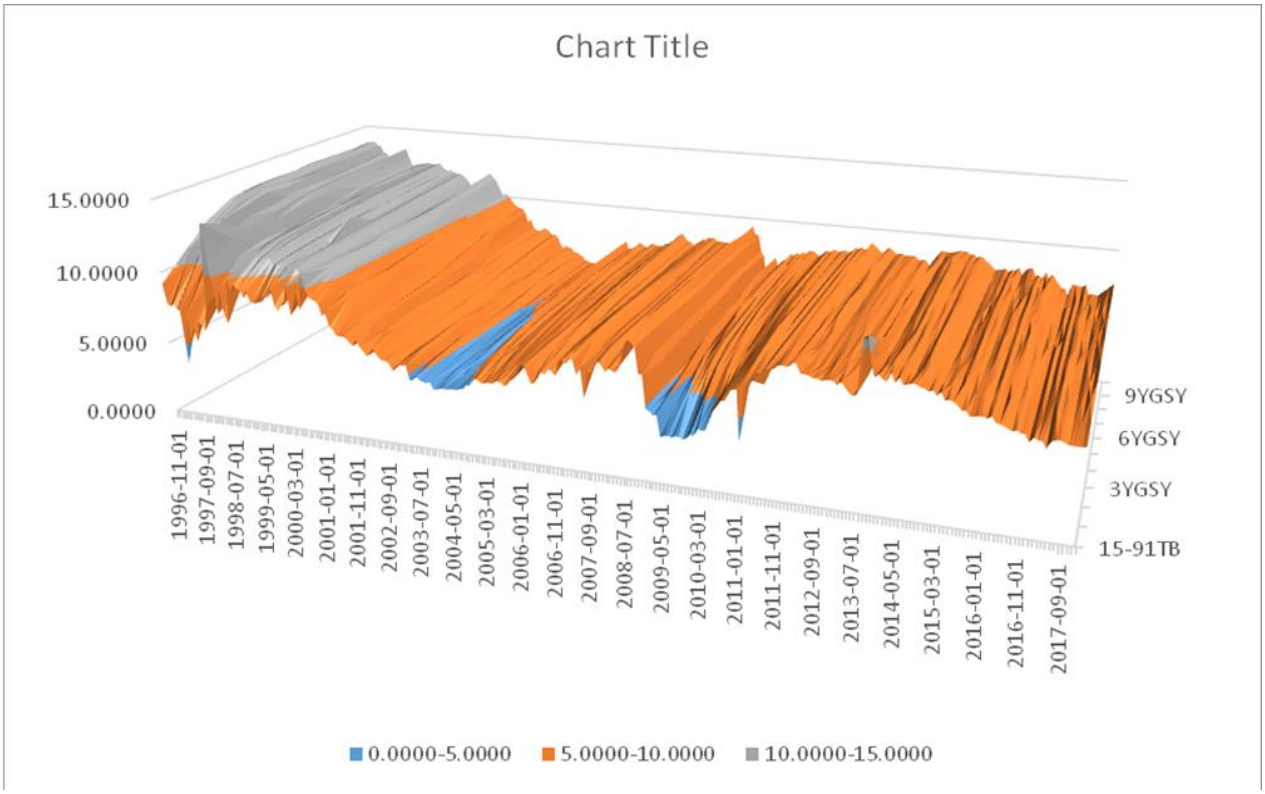
Source: *Authors' Calculations*

Variables: *SLOPE (Slope of YC), LEVEL (Level of YC), CURV (Curvature of YC) D_GDP (Debt to GDP ratio), LN_IIP (Index of industrial production), CRUDE_OIL_WTI (Crude oil prices), BANK_RATE (Bank rate), TRUS10T (Ten-year benchmark US treasury yield), LIBOR12_M (London interbank offer rate), USDINR (Indian rupee per US dollar exchange rate)*

Figure 1.1 Changes in YC



Source: Calculated from Yield Downloaded from RBI

3.2 Testing Stationarity

Augmented Dickey-Fuller (ADF) is used to test the stationarity of the dependent and independent variables (Table 2). Variables, namely level (LEVEL), debt to GDP ratio (D_GDP), crude oil prices (CRUDE_OIL_WTI), ten-year benchmark US treasury yield (TRUS10T), London interbank offer rate (LIBOR12_M), Indian rupees per US dollar exchange rate (USDINR) are found stationary after the first difference. Whereas, rest variables that include slope (SLOPE), curvature (CURV), index of industrial production (LN_IIP) and bank rate (BANKRATE) being stationary, their first differences are not required.

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Table 2 Stationarity of YC and Independent Variables

S. No	Variables	Level			First Difference			Remarks
		Lag Length	t-Statistic	Prob.	Lag Length	t-Statistic	Prob.	
1	SLOPE	1	-3.95	0.00	Not Required			Stationary at the level
2	LEVEL	0	-2.35	0.16	0	-15.12	0.00	Stationary after first difference
3	CURV	2	-3.79	0.00	Not Required			Stationary at the level
4	D_GDP	15	-0.58	0.87	15	-4.00	0.00	Stationary after first difference
5	LN_IIP	1	-3.94	0.00	Not Required			Stationary at the level
6	CRUDE_OIL_WTI	0	-1.77	0.39	0	-14.12	0.00	Stationary after first difference
7	BANK_RATE	0	-3.42	0.01	Not Required			Stationary at the level
8	TRUS10T	0	-1.87	0.35	0	-13.23	0.00	Stationary after first difference
9	LIBOR12_M	1	-1.56	0.50	0	-11.12	0.00	Stationary after first difference
10	USDINR	1	-0.95	0.77	0	-11.57	0.00	Stationary after first difference

Source: *Author's Calculations*

Variables: *SLOPE (Slope of YC), LEVEL (Level of YC), CURV (Curvature of YC) D_GDP (Debt to GDP ratio), LN_IIP (Index of industrial production), CRUDE_OIL_WTI (Crude oil prices), BANK_RATE (Bank rate), TRUS10T (Ten-year benchmark US treasury yield), LIBOR12_M (London interbank offer rate), USDINR (Indian rupee per US dollar exchange rate)*

3.3 Determinants of Slope of YC

3.3.1 Lag Structure

After identifying the variables' stationary level, number of lags are determined to run the VAR model. Table 3 shows the lag structure based on different criteria that include, "Sequential

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modified LR test statistic (each test at 5% level), Final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SIC) and Hannan-Quinn information criterion (HQ), which show different lags for VAR model". The study has used SIC criterion for the selection of the number of lags based on which two lags are selected.

Table 3 VAR Lag Order Selection of Slope of YC

"Lag	Log L	LR	FPE	AIC	SIC	HQ"
0	-2555.435	NA	0.184288	21.01176	21.12642	21.05794
1	-1816.915	1422.558	0.000732	15.48291	16.51486	15.89852
2	-1587.149	427.5152	0.000188	14.12417	16.07341 *	14.90922
3	-1454.558	238.0125	0.000108	13.56195	16.42848	14.71643 *
4	-1377.155	133.8687	9.73e-05	13.45209	17.23591	14.97600
5	-1315.481	102.6206	0.000100	13.47116	18.17227	15.36451
6	-1219.501	153.4115	7.87e-05	13.20902	18.82742	15.47180
7	-1138.892	123.5568 *	7.05e-05*	13.07288 *	19.60857	15.70510
8	-1106.391	47.68514	9.45e-05	13.33107	20.78406	16.33272

Source: *Author's Calculations*

Endogenous variables: *SLOPE (Slope of the YC), DD_GDP (First difference of debt to GDP ratio), LN_IIP (Index of industrial production), DCRUDE_OIL_WTI (First difference of crude oil prices), BANK_RATE (Bank rate), DTRUS10T (First difference of Ten-year benchmark US treasury yield), DLIBOR12_M (First difference of London interbank offer rate), DUSDINR (First differcnce of Indian rupee per US dollar exchange rate)*

Exogenous variables: C

** indicates lag order selected by the criterion*

3.3.2 Vector Autoregression Estimates of Slope of YC

Summary of VAR estimates presenting the impact of macroeconomic variables on the slope of YC is given in table 4. The table shows that except bank rate, no other macroeconomic variable - crude oil, debt to GDP ratio, London interbank offer rate, US ten-year benchmark treasury yield, and exchange rate have significant impact on the slope of the YC.

As shown in the table, the first lag of the bank rate's coefficient is negative and the second lag is positive, which implies that with tight monetary policy, the first slope decreases and then

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increases. The slope has a significant influence on itself as well i.e., a positive slope is followed by a positive slope after a first and second lag.

Table 4 Summery of the VAR estimates of Slope of YC

Lags of IV	Coefficient	Standard errors	t-statistics	Lags of IV	Coefficient	Standard errors	t-statistics
SLOPE(-1)	0.68	-0.06	10.77	**BANK_RATE(-1)**	-0.36	-0.07	-5.30
SLOPE(-2)	0.19	-0.06	3.17	**BANK_RATE(-2)**	0.35	-0.07	5.24
DD_GDP(-1)	0.12	-0.10	1.17	**DTRUS10T(-1)**	0.01	-0.11	0.13
DD_GDP(-2)	-0.06	-0.10	-0.61	**DTRUS10T(-2)**	0.05	-0.10	0.52
LN_IIP(-1)	-0.01	-0.01	-0.80	**DLIBOR12_M(-1)**	0.05	-0.14	0.37
LN_IIP(-2)	0.00	-0.01	-0.41	**DLIBOR12_M(-2)**	-0.09	-0.13	-0.69
DCRUDE_OIL_WTI(-1)	0.00	0.00	0.43	**DUSDINR(-1)**	-0.03	-0.03	-0.84
DCRUDE_OIL_WTI(-2)	0.00	0.00	0.46	**DUSDINR(-2)**	0.00	-0.03	-0.15

Source: *Author Calculations*

T-statistics more than 2 is considered significant; IV: Independent Variables

Variables: *Slope (Slope of YC), DD_GDP (First difference of debt to GDP ratio), LN_IIP (Index of industrial production), DCRUDE_OIL_WTI (First difference of crude oil prices), BANK_RATE (Bank rate), DTRUS10T (First difference of Ten-year benchmark US treasury yield), DLIBOR12_M (First difference of London interbank offer rate), DUSDINR (First difference of Indian rupee per US dollar exchange rate)*

(-1): First lag ; (-2): Second lag

3.3.3 Impulse Response

The Impulse Response function, showing the relationship between the slope of the YC and macroeconomic variables using one-unit shock in the residual, is presented in figure 2. The

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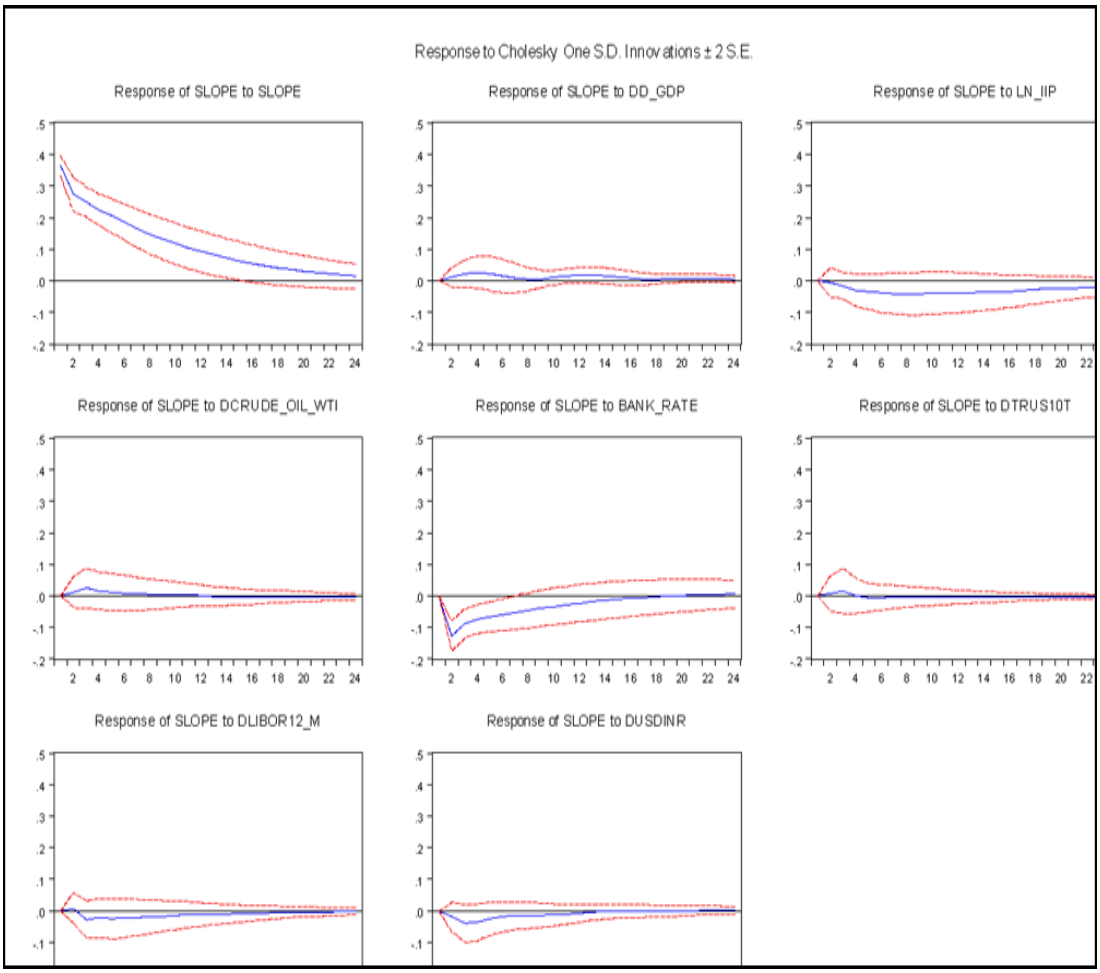
figure shows that the bank rate has a negative effect on the slope for around seven months; after this period, the effect decreases and becomes insignificant. This implies that with tight monetary policy, the slope of the YC decreases. This result is consistent with the VAR estimates of the slope. The figure also shows that lags of slope have significant effect on the slope for around fifteen months. Further, excluding monetary policy and the slope, all other macroeconomic variables such as debt to GDP ratio, index of industrial production, inflation, ten-year benchmark US treasury yield, LIBOR, and Indian rupee per US dollar exchange rate have insignificant impact on the slope of the YC.

Figure 2 Impulse Response of Slope of YC



Source: Author's Calculations

3.4 Determinants of Level of YC

3.4.1 Lag Structure of Level of YC

Lag order selection criteria for the level of the YC is shown in table 5. as per SIC criteria, two lags are selected for analysis, .

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Table.5: VAR Lag Order Selection of Level of YC

"Lag	Log L	LR	FPE	AIC	SIC	HQ"
0	-2372.603	NA	0.041177	19.51314	19.62780	19.55932
1	-1801.021	1100.998	0.000643	15.35263	16.38458	15.76824
2	-1555.850	456.1784	0.000146	13.86762	15.81687 *	14.65267
3	-1417.069	249.1239	7.93e-05	13.25466	16.12119	14.40914*
4	-1349.178	117.4185	7.74e-05	13.22277	17.00659	14.74668
5	-1287.752	102.2077	8.00e-05	13.24387	17.94498	15.13722
6	-1192.524	152.2083	6.31e-05	12.98790	18.60631	15.25069
7	-1124.003	105.0290 *	6.24e-05*	12.95084 *	19.48653	15.58306
8	-1084.046	58.62527	7.87e-05	13.14792	20.60090	16.14957

Endogenous variables: *LEVEL (Level of the YC), DD_GDP (First difference of debt to GDP ratio), LN_IIP (Index of industrial production), DCRUDE_OIL_WTI (First difference of crude oil prices), BANK_RATE (Bank rate), DTRUS10T (First difference of Ten-year benchmark US treasury yield), DLIBOR12_M (First difference of London interbank offer rate), DUSDINR (First differcnce of Indian rupee per US dollar exchange rate)*

Exogenous variables: C

* indicates lag order selected by the criterion

3.4.2 Vector Autoregression Estimates of Level of YC

A summary of the VAR estimates (table 6) shows that the bank rate is the most important factor followed by crude oil affecting the level of the YC. This shows that monetary policy and inflation have significant impact on the level of the YC. The table also shows that the impact of inflation is positive on the level of the YC, i.e., with an increase in inflation average yield increases. On the other hand, monetary policy has a significant positive impact after the first month and a significant negative impact after the second month. Other macroeconomic variables do not have significant impact on the level of the YC.

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Table 6 Summary of VAR Estimates of Level of YC

Lags of IV	Coefficient	Standard errors	t-statistics	Lags of IV	Coefficient	Standard errors	t-statistics
DLEVEL(-1)	-0.10	-0.06	-1.74	**BANK_RATE(-1)**	0.41	-0.06	6.72
DLEVEL(-2)	-0.10	-0.06	-1.79	**BANK_RATE(-2)**	-0.40	-0.06	-6.78
DD_GDP(-1)	-0.12	-0.09	-1.28	**DTRUS10T(-1)**	0.02	-0.09	0.16
DD_GDP(-2)	0.02	-0.09	0.26	**DTRUS10T(-2)**	-0.06	-0.09	-0.62
LN_IIP(-1)	0.00	-0.01	-0.67	**DLIBOR12_M(-1)**	0.14	-0.12	1.18
LN_IIP(-2)	0.01	-0.01	1.18	**DLIBOR12_M(-2)**	0.01	-0.12	0.08
DCRUDE_OIL_WTI(-1)	0.02	0.00	4.05	**DUSDINR(-1)**	0.05	-0.03	1.70
DCRUDE_OIL_WTI(-2)	0.01	0.00	3.18	**DUSDINR(-2)**	-0.02	-0.03	-0.63

Source: *Author Calculations*

t-statistics more than 2 is considered significant

Variables: *Level (Level of YC), DD_GDP (First difference of debt to GDP ratio), LN_IIP (Index of industrial production), DCRUDE_OIL_WTI (First difference of crude oil prices), BANK_RATE (Bank rate), DTRUS10T (First difference of Ten-year benchmark US treasury yield), DLIBOR12_M (First difference of London interbank offer rate), DUSDINR (First difference of Indian rupee per US dollar exchange rate)*

(-1): First lag ; (-2): Second lag

3.4.3 Impulse Response of Level of YC

Figure 3 shows the Impulse Response functions of the level of the YC with the one-unit shock in the residual. Impulse Response function, twenty-four months horizon using ± 2 standard error confidence band, shows that bank rate has a significant positive impact up to three months, and crude oil has a significant impact up to four months, after that the impact of these variables become insignificant. No other macroeconomic variables in the figure have a significant impact on the level of the YC. These results are consistent with the VAR estimates.

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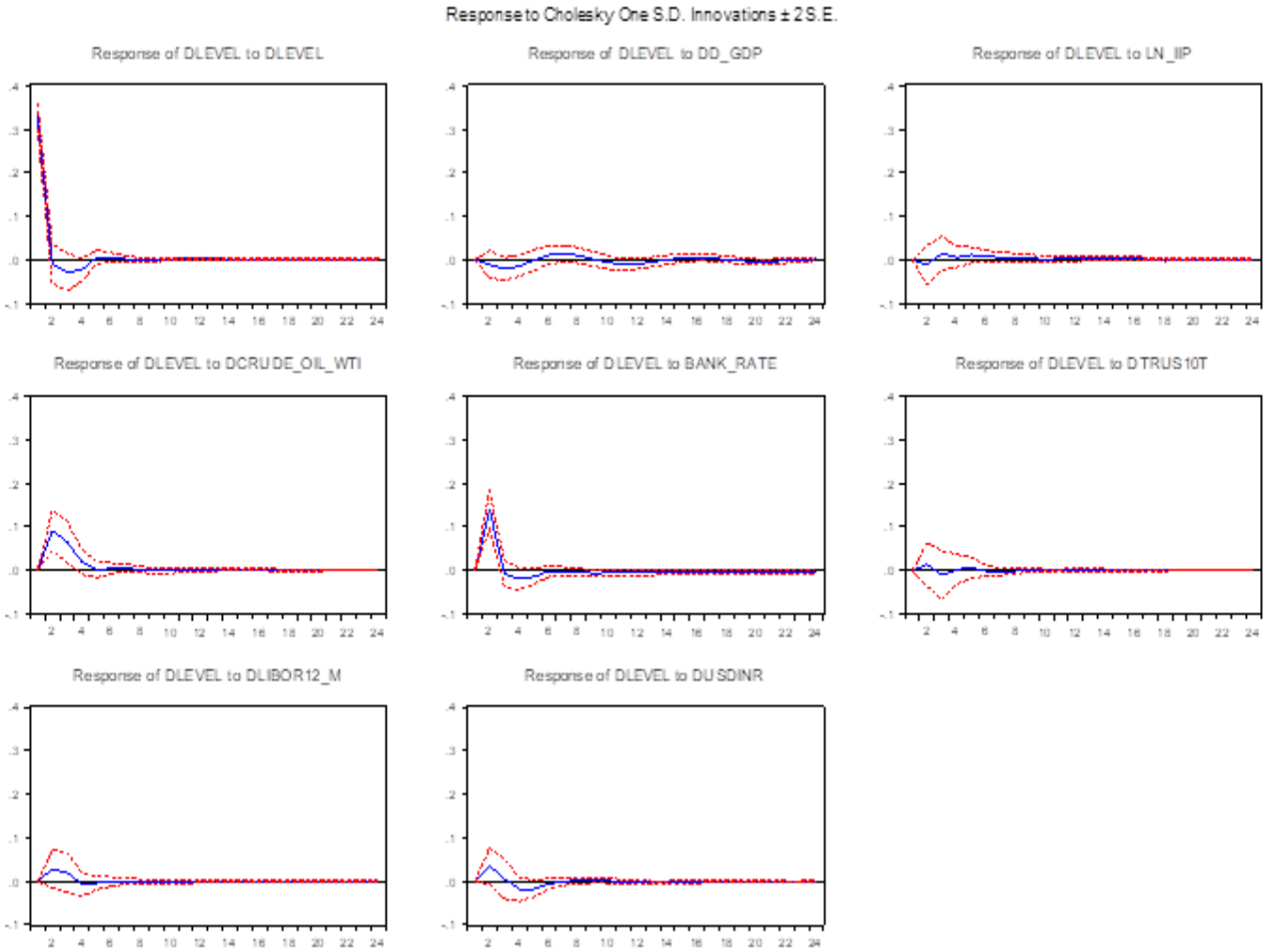
Figure 3 Impulse Response of Level of the YC



Source: Author's Calculations

3.5 Determinants of Curvature of YC

1.8.1 Lag Structure of Curvature of YC

As in the case of slope and level of the YC, based on SIC, two lags are selected for the VAR model (Table 7)

Table 7 VAR Lag Order Selection Criteria of Curvature of YC

"Lag	Log L	LR	FPE	AIC	SIC	HQ
0	-2488.419	NA	0.106398	20.46245	20.57711	20.50863
1	-1801.164	1323.809	0.000643	15.35381	16.38576	15.76942
2	-1579.274	412.8608	0.000177	14.05963	16.00887*	14.84467
3	-1441.998	246.4228	9.72e-05	13.45900	16.32553	14.61348*
4	-1374.701	116.3903	9.54e-05	13.43198	17.21580	14.95589
5	-1310.618	106.6300	9.65e-05	13.43130	18.13241	15.32464

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6	-1217.428	148.9507	7.74e-05	13.19204	18.81044	15.45482
7	-1139.540	119.3856*	7.09e-05*	13.07820*	19.61389	15.71042
8	-1093.768	67.15770	8.52e-05	13.22761	20.68059	16.22926

Endogenous variables: *CURV (Curvature of the YC), DD_GDP (First difference of debt to GDP ratio), LN_IIP (Index of industrial production), DCRUDE_OIL_WTI (First difference of crude oil prices), BANK_RATE (Bank rate), DTRUS10T (First difference of Ten-year benchmark US treasury yield), DLIBOR12_M (First difference of London interbank offer rate), DUSDINR (First difference of Indian rupee per US dollar exchange rate)*

Exogenous variables: C

** indicates lag order selected by the criterion*

3.5.2 Vector Autoregression Estimates of Curvature of YC

VAR results are summarised in Table 8. The table shows that excluding curvature itself, no other macroeconomic variable has significant impact on the curvature of YC in the Indian G-Secs market. This implies that macroeconomic variables have no significant impact on the medium-term yield as medium-term yield represents the hum in the curvature of the YC.

3.5.3 Impulse Response of Curvature of YC

Figure 4 shows the Impulse Response function. The figure shows that no macroeconomic variable has significant impact on the curvature of YC except debt to GDP ratio and curvature. Curvature has a significant impact for around thirteen months, and debt to GDP ratio has a significant impact for four months, after which impact decreases and becomes insignificant. Also, the impact is negative, which means that with an increase in debt to GDP ratio, curvature of YC decreases.

Table 8 Summery of the VAR estimates of Curvature of YC

Lags of IV	**Coefficient**	**Standard errors**	**t-statistics**	**Lags of IV**	**Coefficient**	**Standard errors**	**t-statistics**
CURV(-1)	0.56	-0.06	8.78	**BANK_RATE(-1)**	0.09	-0.06	1.45
CURV(-2)	0.27	-0.06	4.42	**BANK_RATE(-2)**	-0.07	-0.06	-1.18
DD_GDP(-1)	-0.18	-0.09	-1.88	**DTRUS10T(-1)**	0.11	-0.10	1.06
DD_GDP(-2)	0.07	-0.10	0.68	**DTRUS10T(-2)**	0.02	-0.10	0.25
LN_IIP(-1)	0.01	-0.01	0.92	**DLIBOR12_M(-1)**	-0.20	-0.13	-1.53

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LN_IIP(-2)	0.00	-0.01	0.53	**DLIBOR12_M (-2)**	-0.05	-0.13	-0.39
DCRUDE_OIL_WTI (-1)	0.00	0.00	-0.80	**DUSDINR(-1)**	0.01	-0.03	0.34
DCRUDE_OIL_WTI (-2)	0.00	0.00	-0.49	**DUSDINR(-2)**	0.04	-0.03	1.43

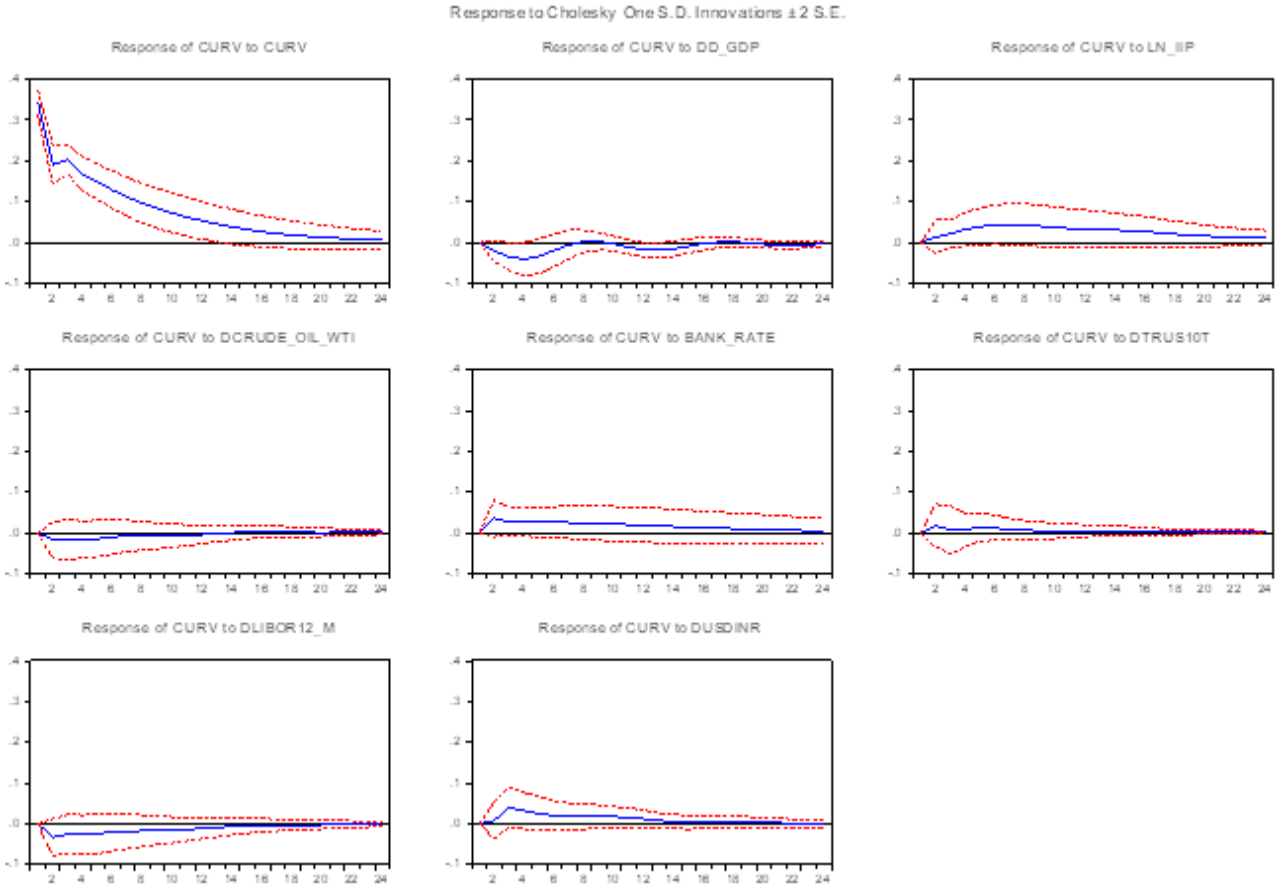
Source: *Author Calculations*

T-statistics more than 2 is considered significant

Variables: *Curv (Curvature of YC), DD_GDP (First difference of debt to GDP ratio), LN_IIP (Index of industrial production), DCRUDE_OIL_WTI (First difference of crude oil prices), BANK_RATE (Bank rate), DTRUS10T (First difference of Ten-year benchmark US treasury yield), DLIBOR12_M (First difference of London interbank offer rate), DUSDINR (First difference of Indian rupee per US dollar exchange rate)*

(-1): First lag ; (-2): Second lag

Figure 4 Impulse Response of Curvature of the YC



Source: *Author's calculations*

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4. Conclusion

The objective of the study is to examine the impact of the macroeconomic variables on the shape of the YC in the short run. Based on VAR model results, this study finds that inflation significantly impacts the level but not slope and curvature of the YC. Monetary policy is another macroeconomic variable that substantially impacts the level and slope, but its effect is not significant for curvature. These results might be because monetary policy has minimum impact on medium-term yield represented by hump in the curvature. The Impulse Response function suggests that the debt to GDP ratio has a significant negative impact only on the curvature of the YC, i.e., the debt to GDP significantly impacts the medium-term yield. However three variables, i.e., US benchmark treasury yield, LIBOR, and exchange rate, have no significant impact on the shape of YC. This may be because the Indian government generally borrows from the domestic market and percentage share of investment by international portfolio investors is very less (i.e. less than 5%) (RBI, n. d.) and hence international factors have no significant effect on the shape of the YC. Further, VAR estimates and Impulse Response function show that the index of industrial production, which is the proxy of output growth, has no significant impact on the shape of the YC.

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