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Full Length Article

The term structure of interest rates and macroeconomic factors: Evidence from Indian financial market

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Abstract

The term structure of interest rate per-se is not impeccable for explaining the behavior of the future economic conditions and hence incorporating macro factors in the term structure model is more tractable. The study uses monthly data of macro factors for a period of eighteen years from April 1998 to May 2016. Using structural vector auto regression estimates, Granger causality/block exogeneity wald test along with impulse response functions and forecast error variance decomposition analysis the study tests the proportion of term structure attributable to macro-economic shocks. The findings of the study show that short term rates are mainly influenced by the fiscal deficit present in emerging economies while long term rates get affected when market participants revise their expectation on yields. In addition, the output growth of the country is mainly depended on long and short rates and exchange rate fluctuations have a significant role in the fiscal deficit of the country.

JEL Classification: E43; E31; E2

Keywords: Term structure of interest rates; Inflation; Output growth; NEER; Monetary policy rate

1. Introduction

The need for examining the whole of the term structure of yield using few parameters gained prominence since Milton Friedman (1977). A parsimonious model of yield curve under no-arbitrage affine term structure conditions can predict the majority of the variations in the yield curve. Short rates as predictors of forward rate readily generate the typical yield curve shapes forming solution for the differential yield curve. The empirical yields model of Nelson and Siegel (1987) shows that spot rates in a differential equation forecast forward rates as a solution to the equation. Although the model gives a useful statistical description of yield curve Diebold-et al. (2005) questions the economic rationale behind the movements. In response to critics, Rudebusch and Wu (2008) adds macroeconomic fundamentals through a monetary policy reaction function using popular Taylor rule, in which short rate depends on inflation and output. Movements in yield curve are an outcome of the expectations of the market, which capture the changes in key macroeconomic fundamentals; namely inflation, growth and monetary policy. Therefore, the shape of the yield curve is a good reflector of monetary policy effectiveness, during inflation and growth in an economy.

The exponential three-factor affine term structure of interest rates of Balduzzi, Rajan Das, Foresi, and Sundaram (1996) shows that short rate, mean and volatility are the three factors that can explain the term structure fluctuations. The short rate posits dominant factor for entire term structure and gratifies

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the role of macroeconomic scenario. It serves as a benchmark for all other assets with different maturities since the long rates are the weighted average of current and expected short rates. Since the deployment of capital is a lengthy process, investment decisions mainly depend on long rates. The short rate stands for opportunity cost for holding money as in Mankiw, Goldfeld, and Shiller (1986) and is the key instrument for the monetary policies of the central banks. Further, it also helps to understand how monetary policy affects the real economic activities. Hence, term structure of interest rate conjectures the prediction as well as forecasting of interest related instruments within the framework of no-arbitrage condition (Hordahl, Tristani and Vestin 2006).

Nevertheless, macroeconomists observe the relationship between the interest rates and macroeconomic factors. According to Fama (1990), the information in the term structure provides the ex-ante values of the macroeconomic variables such as short rates and inflation. Similarly, Mishkin (1990) and Ang, Piazzesi, and Wei (2006) explains that the long run term structure contains information regarding future inflation. The slope factor or the spread between short and long rates can explain the future dynamics of inflation. Further, the nominal term structure of interest rate with long maturity explains not much about the real interest rates whereas the short end of term-structure is able to explain the real interest rates.

Mankiw and Miron (1986) evidenced that the predictive power of yield spread prior to the setting up of Federal Reserve in 1915. Whereas after that spread predictive power was diluted, and short rate showed random walk behavior indicating the interest rate smoothening by the Federal Reserve. According to Mankiw and Summers (1984, pp. 223–247), the term structure of interest rate is the inevitable, for the monetary policy evaluation. The monetary authority has direct control over the short rate where the aggregate demand relates itself with the long rate. Hence, term structure is useful in understanding the monetary policy transmission.

The no-arbitrage term structure factors with macroeconomic data can better explain term structure factors per se (Rudebusch & Wu, 2008). Conversely, as opined by Ang and Piazzesi (2003), the time varying risk premia, accounts for both macro variables and latent factors. The macro factors are able to predict the short and medium term structure significantly in long run, with the major portion of level and slope factors assigned to inflation. Dewachter and Lyrio (2006) postulates that the level factor denotes the agents′ long-term inflation expectations, slope factor implies the future economic conditions and curvature embody the monetary policies respectively. The slope of the nominal yield curve as in Kung (2015) is empirically a strong predictor of economic growth and inflation, at business cycle frequencies.

Joint macro-term structures of interest rate models provide the structural relationship between macro economy and the financial markets. In line with this intuition, Dewachter, Lyrio, and Maes (2006) contend that macroeconomic factor such as inflation and output gap per se is not sufficient to explain the behavior of the long end of the yield curve. The term structures with macro factors are necessary for explaining those latent factors. Diebold, Rudebusch, and Borağan Aruoba (2006) examined the dynamic behavior of the latent term structure factors such as level, slope and curvature with macroeconomic factors. The study found that the future behavior of the term structure driven is by the macroeconomic factors. Along with macroeconomic factors, varying risk premia serves as the building blocks to reject the expectation theory.

As elucidated by Gürkaynak and Wright (2012) along with time-varying risk premia, the inflation uncertainty plays a major role for the variations in the term premia. Hence, the term structure of interest rate with macro factors relinquishes the anomalies of the term structure of interest rates. The impact of inflation and economic activity on the term structure factors such as level, slope, and curvature as in Joslin, Priebsch, and Singleton (2014) confirm inflation and output risks. Similarly, Bekaert, Cho, and Moreno (2010) establish the structural relationship of entire term structures with macroeconomic factors.

In the Indian context, studies like Kanjilal (2011), Sahoo and Bhattacharyya (2012), Sensarma and Bhattacharyya (2016) examined the term structure of interest rates with macroeconomic factors. Further, the study of Sensarma and Bhattacharyya (2016) focused on the impact of monetary policy variables on term structure factors than the macroeconomic variables. Unlike Sensarma and Bhattacharyya (2016), the present study considered gross fiscal deficit in the macro-finance model, since the fiscal deficit has a pivotal role in the macroeconomic framework for Indian economy meaning that the fiscal deficit either financed by monetizing or by issuing government dated securities.

The current study is this direction, tests the dynamic relationship between the term structures of interest rate factors such as level, slope and curvature with the macroeconomic factors namely output growth, inflation, gross fiscal deficit, nominal effective exchange rate (NEER) and the call money rate (CMR) as a monetary policy indicator. Since the shape of the term structure is in tandem with the macroeconomic developments of the economy, the current study attempts to test the macroeconomic repercussions on the term structures of interest rates. In addition, very few studies have tested the role of term structure in the presence of macroeconomic factors in emerging markets with a large amount of fiscal deficit. In this context, present study tries to analyze the term structure of interest rates with the macroeconomic factors to explain the dynamic interrelationship of interest rates.

The remaining sections are as follows, section two stands for data and methodology, section three explains the theoretical aspects of term structure under structural vector auto regression (SVAR) framework, section four devotes to results and discussion and section five concludes the study.

2. Data and methodology

The study considered the three latent term structure factors such as level, slope, and curvature. Term structure of interest rate factors namely level, slope and curvature are constructed in line with Bekaert et al. (2010). The variable namely, Index of Industrial Production (IIP) and Wholesale Price Index (WPI) stands for output and inflation factors in the macro-economic scenario. The central government finances its fiscal deficit either through issuing of bond or through monetizing of deficits. Therefore, the fiscal deficit variable has a significant role in shaping the term structure of interest rates. Hence the current study considered fiscal deficit variable for the structural VAR analysis. The call money market in India deals funds for two to 4 day as explained by Kanjilal (2011). Call money rate is a weekly weighted average of money market during the week, further it carries RBI policy stance like the federal fund rate as far as US is concerned and hence Call Money Rate (CMR) is considered as the monetary policy indicator. In order to understand the behavior of international shock, the study employed the nominal effective exchange rate (NEER). All variables are seasonally adjusted and log normally distributed. The monthly data for the macro variable collected from the Ministry of Statistics and Programme Implementation (MOSPI) Government of India. The term structure variable has obtained from RBI database on Indian economy for eighteen years spanning from April 1998 to May 2016.

3. Structural vector autoregression (SVAR)

The studies such as Estrella and Mishkin (1997) and Evans and Marshall (1998), Ang and Piazzesi (2003) examined the term structure of interest rates with macro-economic factors under VAR framework. The current study employed SVAR model to examine the dynamic behavior of term structure of interest rates with macro variables. The study has considered three latent term structure factors and macro-economic factors in this regard. The structural VAR model for the present study is expressed as

$$AY_t = A_1{*}Y_{t-1} + A_2{*}Y_{t-2} + A_3{*}Y_{t-3}\ldots + A_p{*}Y_{t-p} + Be_t \tag{1}$$

We have selected lag length of two based on the AIC criterion. Here p stands for lag length and e stands for the structural shocks. Then the reduced form VAR described as

$$Y_t = A_1Y_{t-1} + A_2Y_{t-2} + A_3Y_{t-3}\ldots + A_pY_{t-p} + \varepsilon_t \tag{2}$$

Using Eqs. (1) and (2) the present study find the reduced form of residual from the structural model and can be expressed as

$$A\varepsilon_t = Be_t \tag{3}$$

In order to achieve the equality of Eqs. (3) and (4), a set of zero restriction is required on A and B matrices. Following the study of Amisano and Giannini (1997, pp. 1–28), the present study imposes restrictions on B matrix and A matrix considered as an identity matrix. The identifying restriction establishes the relationship between both structural as well as the reduced form innovations and is denoted as $e = B\varepsilon_t$ there by, we have

$$\begin{bmatrix} \varepsilon_{IIP} \\ \varepsilon_{WPI} \\ \varepsilon_{Deficit} \\ \varepsilon_{CMR} \\ \varepsilon_{NEER} \\ \varepsilon_{Level} \\ \varepsilon_{Slope} \\ \varepsilon_{Curvature} \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_{22} & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_{33} & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{44} & 0 & 0 & 0 & 0 \\ 0 & b_{52} & 0 & b_{54} & b_{55} & 0 & 0 & 0 \\ 0 & 0 & 0 & b_{64} & b_{65} & b_{66} & 0 & 0 \\ 0 & 0 & 0 & b_{74} & b_{75} & 0 & b_{77} & 0 \\ 0 & 0 & 0 & b_{84} & b_{85} & 0 & 0 & b_{88} \end{bmatrix} \times \begin{bmatrix} e_{IIP} \\ e_{WPI} \\ e_{Defcit} \\ e_{CMR} \\ e_{NEER} \\ e_{Level} \\ e_{Slope} \\ e_{Curvature} \end{bmatrix} \tag{4}$$

In the first row of the B matrix shows that the variable IIP is not influenced by other variables contemporaneously except the coefficient (b_{11}), whereas there is a lead-lag relation between IIP and other variables. Second row indicates that other variables are not affecting WPI except coefficient (b_{22}). Similarly, the variable deficits in the third row indicate that it not contemporaneously affected by other variables (except the coefficient (b_{33}) all b coefficient are zero). Fourth row indicate the monetary policy variable (CMR) not affected contemporaneously by all other variables except (b_{44}). In the fifth row, NEER simultaneously affects by WPI and CMR respectively because currency markets instantaneously responds to the both domestic as well as the international shocks. The sixth, seventh and eighth row indicates the influence of CMR and NEER on level, slope and curvature respectively.

Fig. 1 shows the government securities yield curve factors. According to the study of Sensarma and Bhattacharyya (2016), the liquidity of the government securities market is confined to certain maturities like one, five and ten-year hence these maturities are considered as a benchmark for short, medium and long maturities. The present study considered these maturities to construct the empirical proxies of the shape of the term structure of yields. The present study constructed the level factor by averaging the one, five and ten year yields. Slope factor determined by the spread between ten-year yield and one-year yield. The curvature factor finds by adding one-year yield and ten-year yield minus twice of five-year yield. The study of Bekaert et al. (2010) and Sensarma and Bhattacharyya (2016) constructed the yield factors in similar direction. Further, the study of Ang and Piazzesi (2003) and Diebold et al. (2006) showed that the empirical proxies of the yield curve closely correspond to the shape of the term structure estimated by using the Nelson and Siegel (1987) approach.

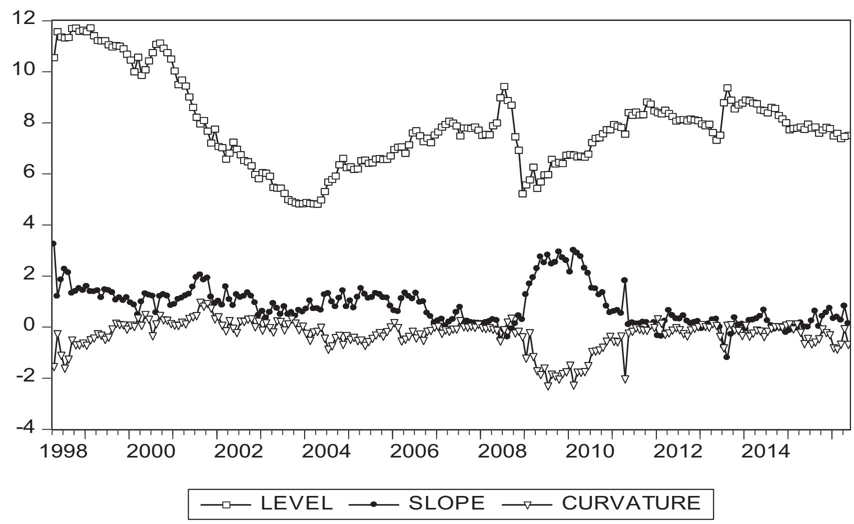

Fig. 1. (Level, slope, curvature).

4. Results and discussions

Table 1 shows the results of the unit root tests. All the variables except level factor are stationary at level for both Augmented Dickey-Fuller test statistic and Phillips-Perron test statistic. Table 2 indicates the VAR Lag order selection criteria and the present study considered two as an optimal lag length based on Akaike Information Criterion.

Table 3 shows the results of VAR granger causality/block exogeneity wald tests. The output growth variable is granger caused by the fiscal deficit, level and slope factors show that the fiscal deficit has a significant influence on the output growth. Further, the granger causality of level and slope factors to output growth shows the long and short-term conditions of the economy influenced by the output growth. Inflation is granger caused by the level variable shows that the level variable can capture the long-term inflation prospects of the economy. The fiscal deficit is granger caused by the NEER, Level, and the curvature variables showing that the deficit can have an international influence and its repercussions on long and medium term impact on the economy. NEER is granger caused by output growth documents that output growth is a significant determinant of the nominal effective exchange rate among the trade partners. The level factor is granger caused by curvature and the slope is granger caused by deficit implies that the deficit has a significant influence on the future behavior of the economy. Finally, the Curvature variable is granger caused by the level factor shows that the long-term influences on the medium term behavior of the yield curve.

Table 1
Unit root Results.

Variables	Augmented Dickey-Fuller test statistic		Phillips-Perron test statistic	
	LEVEL	First difference	LEVEL	First difference
IIP	−23.0319***	NA	−23.0319***	NA
WPI	−3.06723**	NA	−2.78405*	NA
DEFICIT	−14.3723***	NA	−14.3902***	NA
CMR	−5.02568***	NA	−4.884***	NA
NEER	−0.29332	−12.0644***	−0.1276	−11.9205***
LEVEL	−1.81116	−13.6891***	−1.94872	−13.7146***
SLOPE	−3.49404**	NA	−3.39844**	NA
CURVATURE	−2.90125**	NA	−3.90916**	NA

***, ** and* indicates significance level of 1, 5 and 10 percent respectively.

Table 2
VAR Lag order selection criteria.

Lag	Akaike information criterion (AIC)	Schwarz information criterion (SC)	Hannan-Quinn information criterion (HQ)
0	−4.442208	−4.314272	−4.390483
1	−10.62202	−9.470597*	−10.15649[a]
2	−10.83522[a]	−8.660302	−9.955887

[a] Indicates lag order selected by the criterion [Endogenous variables: IIP WPI DEFICIT CMR, DNEER, DLEVEL, SLOPE, CURVATURE]. The lag length for VAR is chosen as 2 based on AIC.

Fig. 2 panel A shows the impulse response function of level, slope, and curvature factors to the shocks in the call money rate. The response of level variable to a shock in call money rate shows monetary policy impact up to two periods on the average level of the yield curve. The response of slope to a structural shock in a call money rate shows negative across the tenth period and indicates that the monetary policy rate is committed to the flattened behavior of the yield curve. Our third graph in Fig. 2A depicts the response of curvature of yield curve to a shock in call money rate shows positive up to the tenth period. Further, the curvature of the yield curve to a shock in call money rate shows that the hump-shaped behavior consistent with developed market studies like Ang and Piazzesi (2003) and Diebold et al. (2006). However, the study of Sensarma and Bhattacharyya (2016) shows that the weak hump-shaped behavior of the curvature in response to the monetary policy and argued that the medium term instruments are less attractive for the investors in comparison with both short and long-term yields influence of the monetary

Table 3
VAR granger causality/block exogeneity wald tests.

Endogenous variables	IIP	Lagged endogenous variables						
		WPI	DEFICIT	CMR	DNEER	DLEVEL	SLOPE	CURV
IIP	–	0.910	6.017**	3.530	1.228	7.787**	9.348***	2.956
WPI	1.414	–	2.367	0.498	4.552	5.205*	0.651	0.222
DEFICIT	4.227	0.324	–	1.799	9.425***	4.902*	0.739	7.772**
CMR	0.843	1.253	1.146	–	2.215	0.751	2.575	1.554
DNEER	31.713***	1.085	0.962	1.102	–	2.695	1.384	0.597
DLEVEL	1.600	4.114	0.326	2.785	1.064	–	1.922	5.277*
SLOPE	0.514	0.373	5.914**	0.654	0.902	2.572	–	0.208
CURV	2215	2.450	1.809	3.002	3.255	6.650**	2.372	–

The values in the table indicate the Chi-square values &***, ** and* indicates significance level of 1, 5 and 10 percent respectively.

policy. The weak demand for the five-year yield became an impediment in forming the hump – shaped or curvature behavior of yield curves.

Table 4 shows the forecast error variance decomposition analysis. It consists of determining the extent of behavior for each variable in the system by the different structural innovations at different horizons. The level factor determined by the WPI and call money rate indicates that the inflation and monetary policy has a significant influence in forming the average level of the yield curve. The slope is determined by the call money rate indicates that the monetary policy has significant determinant for the flattening yield curve. Curvature affected by the CMR and WPI shows that the inflation and monetary policy plays a significant role for determining the medium term shape of the yield curve. Further, the variable NEER on determining the curvature shows how the exchange rate shock influences the domestic medium term yields.

Table 5 shows the proportion of the forecast error variance of the macroeconomic variables and monetary policy variable explained by the yield curve factors namely level, slope, and curvature. The focus of the study is on the main three factors level, slope and curvature hence our explanations were concentrated on these term structure factors. IIP explained by the slope variable indicate that slope can explain the real economic activities of the economy. Further, the WPI determined by the level factor shows that the level factor contains information regarding the ex-ante behavior of inflation. The deficit is explained by the curvature factor (3.50) implies that deficit has medium term impact on the economy. CMR is explained by the slope factor implies that short run behavior of yield curve could explain the monetary policies of the central bank. NEER explained by the slope factor implies that the shock from the NEER affects the economy on short-run nature.

The findings of the study show that output growth of a country influences the short and long rates along with the fiscal deficit. Further long rates explain the inflation while fiscal deficit owes mainly due to exchange rate fluctuation. The monetary policy indicator is captured by level and slope factors while exchange rate fluctuation is mainly influenced by output growth and inflation. We find that short-term rates are mainly influencing the fiscal deficit and the market participants are revising their expectations based on long rate.

5. Conclusion

To summarize, the current study analyzed the joint macro-finance model to understand the dynamic interlink between the macroeconomic developments and the financial markets. The present study employed three latent term structure factors such as level, slope, curvature and the macroeconomic factors such as output growth, inflation, fiscal deficit and NEER. Further, the study investigates the monetary policy impact on the term structure of the yield, since the monetary policy transmits to the real economic activity through the term structure of short to long yields. The study found the impact of monetary policy in shaping the behavior of yield curve. The impulse response analysis finds that the monetary policy factor has a significant influence on shaping the average level of the yield curve. The response of slope to a structural shock in a call money rate shows negative across the tenth period and indicates that the monetary policy rate is committed for stabilizing the yield curve. Further, the response of curvature of the yield curve to a shock in call money rate shows hump-shaped behavior indicating that the medium-term five-year yield plays a significant role in shaping the term structure of interest rates. The forecast error variance decomposition analysis of yield curve shows that the level, slope and curvature factors are determined by the WPI and call money rate indicating that the inflation and monetary policy has a significant influence in forming the long, short and medium term behavior of the yield curve. NEER on determining the curvature shows how the exchange rate shock influences the domestic medium term yields. Further, the proportion of the forecast error variance of the macroeconomic variables and monetary policy variable explained by the yield curve factors documented that the IIP explained by the slope variable indicate that slope can explain the real economic activities of the economy. The deficit explained by the curvature factor implies that deficit has medium term impact on the economy. CMR explained by the slope factor implies that short run behavior of yield curve could explain the monetary policies of the central bank. NEER

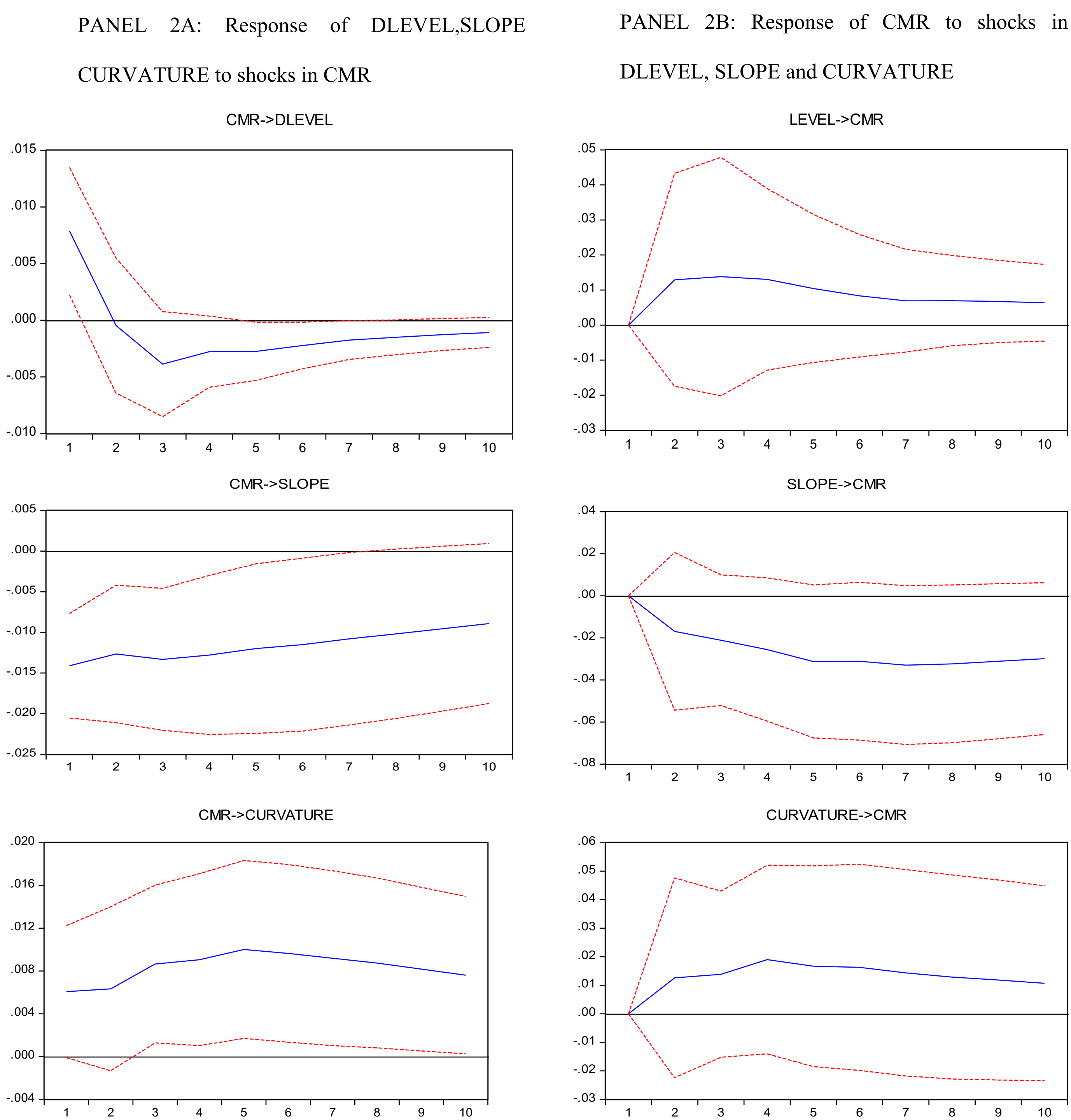

Fig. 2. Monetary policy and yield curves-impulse responses. These graphs show the dynamic interactions between yield curve's Level, Slope, Curvature and monetary policy indicator (Call Money Rate = CMR). The impulse responses are the lines within the dotted line (standard error bands).

Table 4
Forecast error variance decompositions for the yield curve.

Months ahead	IIP	Proportion of forecast error variance accounted by						
		WPI	DEFICIT	CMR	DNEER	DLEVEL	SLOPE	CURVATURE
DLEVEL								
1	0.000	0.011	0.000	3.583	0.191	96.213	0.000	0.000
5	0.571	2.092	0.262	4.841	0.621	87.529	1.179	2.902
10	0.557	2.740	0.264	5.372	0.617	85.131	1.179	4.137
SLOPE								
1	0.000	0.012	0.000	8.601	0.215	0.000	91.170	0.000
5	0.064	0.334	0.807	11.698	0.127	0.950	85.949	0.067
10	0.049	1.200	0.602	13.101	0.104	1.100	83.743	0.097
CURVATURE								
1	0.000	0.045	0.000	1.784	0.786	0.000	0.000	97.382
5	0.319	1.153	1.003	6.600	1.768	0.852	0.506	87.795
10	0.270	3.768	1.087	10.393	1.578	0.763	1.466	80.671

Note: this table shows the proportion of the forecast error variance of the yield curve's DLevel, Slope and Curvature as explained by different factors including IIP, WPI, Deficit, CMR and DNEER.

Table 5
Forecast error variance decompositions for the macroeconomic variables.

Months ahead	Proportion of forecast error variance accounted by							
	IIP	WPI	DEFICIT	CMR	DNEER	DLEVEL	SLOPE	CURVATURE
IIP								
1	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	88.949	0.079	2.925	1.107	0.442	1.658	4.133	0.702
10	88.263	0.171	2.912	1.167	0.443	1.667	4.635	0.738
WPI								
1	0.000	100.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.022	97.070	0.716	0.059	0.111	1.918	0.050	0.051
10	0.014	94.700	0.929	0.976	0.178	2.574	0.185	0.440
DEFICIT								
1	0.000	0.000	100.000	0.000	0.000	0.000	0.000	0.000
5	1.733	0.137	89.573	0.500	3.718	1.094	0.391	2.851
10	1.715	0.154	88.250	0.598	3.703	1.089	0.987	3.500
CMR								
1	0.000	0.000	0.000	100.000	0.000	0.000	0.000	0.000
5	0.381	2.070	0.212	92.141	0.639	0.727	2.694	1.131
10	0.352	3.529	0.200	85.288	0.564	0.886	7.300	1.876
DNEER								
1	0.000	5.472	0.000	0.599	93.927	0.000	0.000	0.000
5	9.200	5.585	0.726	0.670	80.991	1.457	1.048	0.319
10	9.134	5.568	0.738	0.730	80.266	1.497	1.713	0.351

Note: This table shows the proportion of the forecast error variance of the IIP, WPI, Deficit, CMR and DNEER explained by the yield curve's DLevel, Slope and Curvature.

explained by the slope factor implies that the shock from the foreign exchange market influences ex-ante short-term interest rates.

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