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An Empirical Study on Impact of Changes in Macro Economic Variables on Bond Yield Curve - Evidence from Indian Corporate Bond Market

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Abstract
A well developed corporate bond market provides an alternative source of finance for firms and better yield for investors. It facilitates for economic development through channelization of savings into investments. Investments in bonds are not risk free. Bond yields are largely affected by changes in inflation and interest rates. In this study, selected corporate bonds are considered and aimed at analyzing the determinants of the yield curve by looking, how yield curve responds to a given change in macroeconomic variable. To test the impact, macroeconomic variables such as interest rate and inflation rate has been taken with latent factor such as slope, curvature and level (Short term, Medium term and long term interest rate). Latent factor has been derived from Nelson Siegel Model where slope = $[(y_t\ (3)-(\ y_t\ (120)]$, Curvature= $[2^*(\ y_t\ (48)-(\ y_t\ (31))-(\ y_t\ (120))$, Level= y_t (120)]. Data set of three years from 2012 to 2014 has been taken and the same data has been used for vector error correction model for an in-depth analysis. In order to run Vector Error Correction Model, Augmented Dickey fuller test has been used to check stationarity of the data. Johansen co-integration test is used to check the level at which variables are co-integrated and also to understand long run relationship of the variables. Impulse response functions have also been used to understand macroeconomic shock on latent variables, finally the results concluded that inflation rate shock affects positively to the inflation rate and interest rate shock affects negatively to the interest rate. Increase in inflation rate tends to decrease in one of the component of yield curve (i.e., level) which deters the investors from investing in bonds. Decrease in interest rate attracts to investors to purchase the bonds and when there is increase in interest rate investors usually sell bonds.
Keywords*:* Yield curve, Vector Error Correction Model, Inflation, Interest rate

1. Introduction

Ownership of a bond represents ownership of a series of future cash payments. Those cash payments are usually made in the form of periodic interest payments and the return of principal when the bond matures. In the absence of credit risk, the value of those future cash payments is a function of the required rate return of an investor based on inflation expectations. Bond yield, predominantly, affected by the changes in interest rates. Interest rates are revised by central bank from time to time based on inflation rate and other macro economic variables like market liquidity and supply of funds in the economy. Interest rate risk is the risk of changes in a bond's price due to changes in prevailing interest rates. Changes in short-term versus long-term interest rates can affect various bonds in different ways. Inflation - and expectations of future inflation - is a function of the dynamics between short-term and long-term interest rates. Bond yield curve can be constructed by plotting the prices of different maturity bonds. The yield curve shows the relationship between yield and maturity. Yield curve work best when plotting different maturity dates for the same type of bond. By comparing the bond yield that are similar, but with differing maturities, one can generate a graph which shows how yields change as the maturity date lengthens. Investigating relations between yields of different maturities was one of the first applications of co integration analysis. Empirical researches have shown that yield curve depicts a shift in line when there is a shock, which are often called “level,” “slope” and “curvature” (Litterman and Scheinkman 1991). Yield curve depicts a line that rises from lower interest rates on shorter-term bonds to higher interest rates on longer-term bonds. Researchers have found that shifts or changes in the shape of the yield curve are attributable to a few unobservable factors (Dai and Singleton 2000). The “level,” “slope” and “curvature names describe how the yield curve shifts or changes shape in response to a shock. Shock is an event like change in the interest rate or change in the inflation rate of a country.

A “level” shock changes the interest rates of all maturities by almost identical amounts, inducing a parallel shift that changes the level of the whole yield curve. The shock to the “slope” factor increases short-term interest rates by much larger amounts than the long-term interest rates, so that the yield curve becomes less steep and its slope decreases. The main effects of the shock focus on medium-term interest rates, and consequently the yield curve becomes more "hump-shaped" than before Tao Wu (2003). Researchers have developed models to estimate the characteristic movement of the macro economic factors. Few of these models, however, provide any insight about what these factors are, about the identification of the underlying forces that drive their movements or about their responses to macroeconomic variables. Yet these issues are of most interest to central bankers and macroeconomists.

2. Literature Review

Pierre. L. Siklos (2000) observed that the slope of yield curve of New Zealand contain useful economic information. Study finds that Short horizon (2 years or <) term structure of New Zealand behaves as in the expectations hypothesis of the term structure. Andrea Carrieroet, al., (2003), investigates on the hypothesis that the empirical rejections of the expectations theory (ET) of the term structure of interest rates can be caused by improper modeling of expectations. Findings suggest that fluctuations in risk premium in explaining the deviation from the ET is reduced when some forecasting model for short term rates is adopted and a proper evaluation of uncertainty associated to policy rates forecast is considered. Moorad Choudhry (2003), finds that the swap curve is currently the only viable alternative instrument in the sterling debt markets, but its use is not necessarily entirely satisfactory. Andrew Ang et, all., (2005), study find that the term spread forecasts GDP, but these regressions are unconstrained and do not model regressor endogens. Researcher builds a dynamic model for GDP growth and yields that completely characterizes expectations of GDP. Charles L. Evans and David Marshall (2006), studied the macroeconomic shocks on variability of nominal treasury yields, inducing parallel shifts in the level of the yield curve and finds that the fiscal policy shocks have greater impact on interest rate variability. Chien,Yun Chang et, all., (2011), studied the relationship between macroeconomic determinants and yield curve and concludes that the prediction of yield curve factors, bank discount rate and consumer price inflation can be more accurate when previous macroeconomic determinants and yield curve factors information are taken into account. Ong Tze San et, all., (2012), studied the relationship between term structures of interest rate, financial and macroeconomic variables in Malaysian market and Findings of study affirms that some macroeconomic variables do not have significant impact on maturity spreads. Maturity spread does react positively when there is change in money supply and negatively impact on current account influence on maturity spread. Some other variables considered in the study such as stock market returns, gross domestic product, industrial production index, inflation rate and trade balance variables have no impact on maturity spread. Muharam (2013), attempted to develop a model of government bond yield determinants and test hypothesis about the effect of inflation, foreign reserves, local interest rate, stock market return, exchange rate, foreign interest rate, world oil prices, real sector performance, and conditional variances on government bond yield. Conclusion of the study is Foreign exchange reserves have negatively effect on the yields of government bonds. In practical terms this means that if the liquidity of a country's troubled which shown by the decrease in non-gold reserves then the yields of government bonds will rise and the values of investments will decline. For this reason, in managing the portfolio investors should pay attention to the movement of foreign exchange reserves. Suresha & Murugan (2014) studied the risk involved in bond investment, relationship between inflation rate, interest rate and bond price and states when inflation rate and open market interest rates increases, causes for increased market expectation and fall in bond prices. The study evidently states that there is an inverse relationship between interest rate and bond price. Inflation will affect bond prices and real rate of return.

3. Research Methodology

This study attempts to find effect of macro-economic variables like interest rate and inflation rate on bond index yield curve and examine impulse of interest rate and inflation rate on components of yield curve such as slope, curvature and level as propounded in Nelson Siegel Model. It also attempts to provide empirical evidence on inverse relationship between corporate bond prices and interest rate. Monthly closing, listed corporate bonds data from January 2012 to December 2014 was collected from BSE website. In order to know the effects of macroeconomic variables such as interest rate and inflation rate and its impact on bond index yield curve. The emphasis of the research is to understand the changes in endogenous variables such as latent factor (slope, curvature and level) to the changes takes place in exogenous variables that is interest rate and inflation rate.

Nelson-Siegel Model

Nelson-Siegel model use to determine the latent factor yield curve components are calculated using the following formula:

Slope = $\left[(Y_t(3)) - (y_t(120))\right]$

Curvature = $\left[2 \times (y_{t(}48)) - (y_t(3)) - (y_t(120))\right]$

Level = $\left[y_t(120)\right]$ with y_t representing yield.

Augmented Dickey-Fuller Unit Root Tests
This test is conducted to find stationary among different time series. Here are the various cases of the test equation: The null hypothesis of the Augmented Dickey-Fuller t-test is
Null hypothesis 0:0=θH (i.e. the data needs to be differenced to make it stationary)
Alternative hypothesis 0:1<θH (i.e. the data is stationary and doesn't need to be differenced)

- When the time series is flat (i.e. doesn't have a trend) and potentially slow- turning around zero, use the following test equation:

$$\Delta z_t = \theta z_{t-1} + \alpha_1 \Delta z_{t-1} + \alpha_2 \Delta z_{t-2} + \cdots + \alpha_p \Delta z_{t-p} + a_t$$

- When the time series is flat and potentially slow-turning around a non-zero value, use the following test equation:

$$\Delta z_t = \alpha_0 + \theta z_{t-1} + \alpha_1 \Delta z_{t-1} + \alpha_2 \Delta z_{t-2} + \cdots + \alpha_p \Delta z_{t-p} + a_t .$$

- When the time series has a trend in it (either up or down) and is potentially slow-turning around a trend line you would draw through the data, use the following test equation:

$$\Delta z_t = \alpha_0 + \theta z_{t-1} + \gamma t + \alpha_1 \Delta z_{t-1} + \alpha_2 \Delta z_{t-2} + \cdots + \alpha_p \Delta z_{t-p} + a_t .$$

The number of augmenting lags (p) is determined by minimizing the Schwartz Bayesian information criterion or minimizing the Akaike information criterion or lags are dropped until the last lag is statistically significant. T-statistic on the θ coefficient to test whether you need to difference the data to make it stationary or you need to put a time trend in your regression model to correct for the variables deterministic trend. The test is left-tailed.
Vector error correction model
Johansen co integration test was conducted to known the variables are co-integrated or not in order to conducted vector error correction model. Vector error correction model aims to analyze the determinants of the yield curve of Indian corporate bonds by looking at how the yield curve responds to shocks for the considered economic variables. Vector Error Correction Model (VECM) is used to study the factors which affect the yield curve dynamics in the form of restricted Vector Autoregressive (VAR). This additional restriction must be given for non-stationary yet co-integrated data form. When two or more variables found in an equation at level data become unstationary, there's a possibility of cointegration on the equation.
Impulse response function
The Impulse Response Function gives the jth-period response when the system is shocked by a one-standard-deviation shock. Impulse Response function can be defined as

$$IRF(j) = \tilde{y}_{\tau-1+j} - \bar{y}_{\tau-1+j}$$

Linear processes: The IRF is independent of the particular draws for . Thus we can simply start at the steady state (that is when has been zero for a very long time)

$$IRF(j) = \sigma\rho^{j-1}$$

Often you cannot get an analytical formula for the impulse response function, but simple iteration on the law of motion (driving process) gives you the exact same answer.

4. Analysis and Results:

Table 01 Augmented Dickey Fuller Test

	t-Statistic	Coefficient	C	R^2
D(SLOPE)	-10.55898 (0.0000)	1.859466 (0.0000)	-0.004689 (0.5326)	0.776991
D(CURVATURE)	-8.890208 (0.0000)	-1.618678 (0.0000)	-0.005069 (0.6012)	0.711805
D(LEVEL)	-10.49462 (0.0000)	-1.854171 (0.0000)	0.004648 (0.5388)	0.774865
D(INFLATIONRATE)	-4.182193 (0.0025)	-0.715753 (0.0002)	-0.103959 (0.2833)	0.553414
D(INTERESTRATE)	-5.277177 (0.0001)	-1.213446 (0.0000)	-0.018386 (0.7929)	0.516548

The variable considered for Augmented Dickey- Fuller test is bond price forming slope, curvature, level, and the macro economic variables (inflation rate & interest rate). Variable slope has unit root at first level difference with test equation of intercept. Alternative hypothesis has been accepted with t-statistics at 10.55898 which is greater than critical values at 1%, 5%, and 10% level and the probabilities is 0.0000 which is less than 5% and R-square is 77.69% is not reaching significant percentage of 85% to 100%. The coefficient of variable slope at first level difference is -1.859466 which is considered viable. Variable curvature has unit root at first level difference with test equation of intercept. T-statistics at 8.890208 which is greater than critical values at 5%. The coefficient of variable slope at first level difference is -1.618678 which is considered viable. Alternative hypothesis has been accepted and null hypothesis has been rejected. The variable level has unit root at first level difference with test equation of intercept. Alternative hypothesis has been accepted with t-statistics at 10.49462 which is greater than critical values at 5%, level. The coefficient of variable slope at first level difference is -1.854171 which is feasible. R-square value 77.48% clearly indicates that it is not reaching significant level

The variable inflation rate has unit root stationary at first level difference with test equation of intercept. Alternative hypothesis has been accepted with t-statistics at 4.182193 which is greater than critical values at 5%. The coefficient of variable slope at first level difference is -0.715753 which is sustainable. R-square is 54.34% which is lesser than significant value and Durbin Watson test is 1.927646 which tells there is no auto-correlation. The variable interest rate has unit root stationary at first level difference with test equation of intercept. Alternative hypothesis has been accepted with t-statistics at 5.277177, which is greater than critical values at 5%. The coefficient of variable slope at first level difference is -1.213446 which is justifiable for stationery. R-square value 51.65% which is less than significant level.

Table 02 Johansen Co Integration Test

Unrestricted Co-Integration Rank Test (Trace)				
Hypothesized No. of CE(s)	Eigen value	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.581711	50.30073	47.85613	0.0289
At most 1	0.312782	20.66691	29.79707	0.3787
At most 2	0.207295	7.913367	15.49471	0.4747
At most 3	0.000441	0.015011	3.841466	0.9023

Trace test indicates 1 co integrating eqn(s) at the 0.05 level. * denotes rejection of the hypothesis at the 0.05 level. **MacKinnon-Haug-Michelis (1999) p-values

Johansen co integration test have been conducted to understand whether the variables Slope Curvature, Level and Inflation rate are co integrated, and is there any long run relationship exist between theses variable and does these variables move together in long run. Trace Statistic and Max-Eigen Statistic affirms co integration of Slope, curvature, level and inflation rate. Trace statistic test indicates at most 1 co integrating equations have been accepted at 0.05 level and the probability value is 0.3787 which is more than 5%. Max-Eigen Statistic test also indicates at most 1 co integrating equations have been accepted at 0.05 level and probability value 0.4752.

Table 03 Johansen Co Integration Test

Unrestricted Co integration Rank Test (Trace)				
Hypothesized		Trace	0.05	
No. of CE(s)	Eigen value	Statistic	Critical Value	Prob.**
None *	0.637794	61.84180	47.85613	0.0014
At most 1	0.317665	27.31335	29.79707	0.0942
At most 2	0.219487	14.31736	15.49471	0.0746
At most 3 *	0.159111	5.892049	3.841466	0.0152

Trace test indicates 1 co integrating eqn(s) at the 0.05 level. * denotes rejection of the hypothesis at the 0.05 level. **MacKinnon-Haug-Michelis (1999) p-values

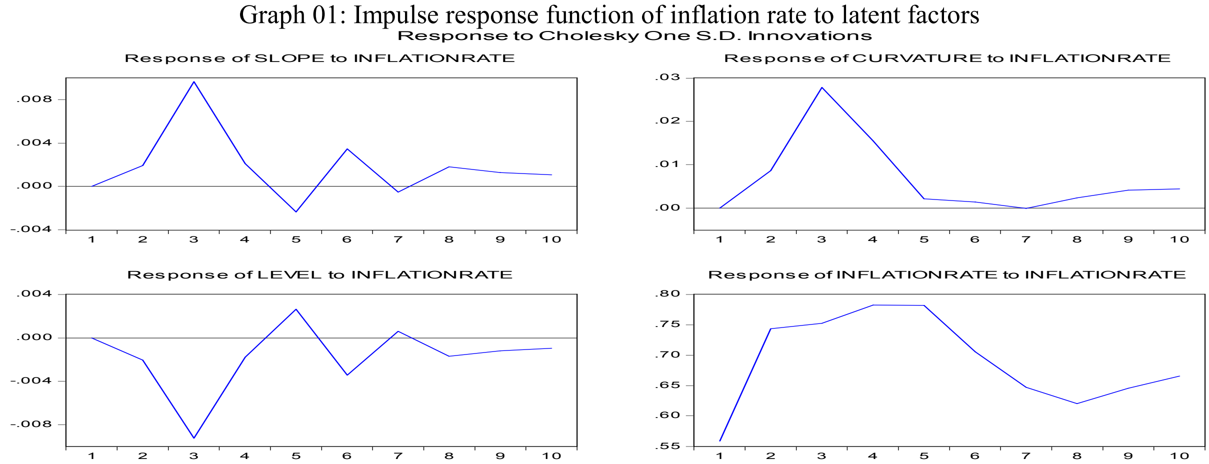
Variables such as slope, curvature, level and interest rate has been proved as co integrated under Johansen co integration test. There exists 1 co integrated vector or 1 error term as per Trace statistic and Max-Eigen Statistic. It implies that there exists a long run relationship among four variables. Trace statistic test co integrating equations have been accepted at 0.05 level and the probability value is 0.0942 which is more than 5%. Max-Eigen Statistic test also co integrating equations has been accepted at 0.05 level and probability value 0.4526.

Table 04 Vector Error correction Model on Inflation Rate

VEC Estimates	Co integrating Eq:	SLOPE(-1)	CURVATURE(-1)	LEVEL(-1)
INFLATIONRATE	CointEq1	1.000000	0.033123	0.975282
			(0.00986)	(0.01426)
			[3.35768]	[68.3914]
INTEREST RATE	CointEq1	1.000000	0.132936	1.010511
			(0.04736)	(0.04729)
			[2.80705]	[21.3684]
INFLATIONRATE(-1)		C		
	-0.000476	-0.018481		
	(0.00027)			
	[-1.74186]			
INTEREST RATE (-1)	0.014035	-0.157992		
	(0.00285)			
	[4.92395]			

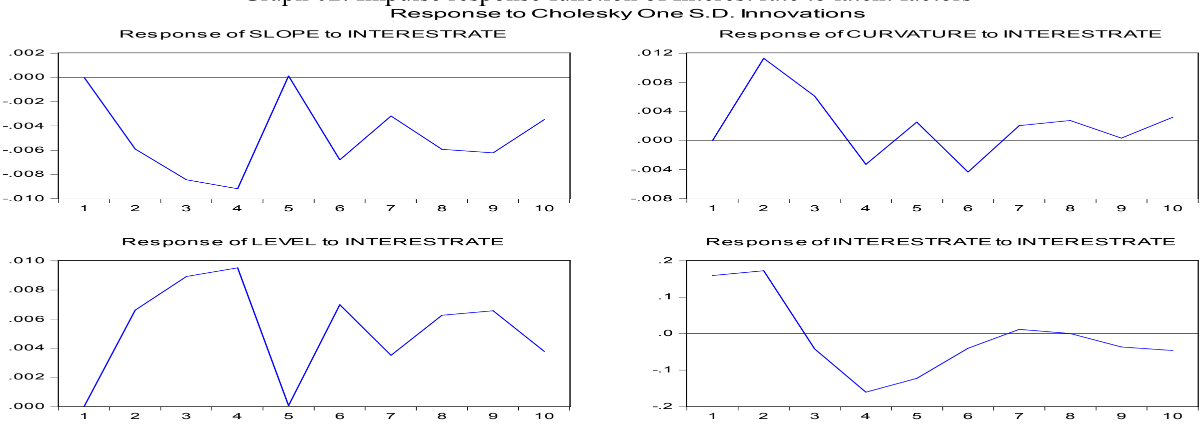
Table 04 represents the VECM estimates of each variable, which have been included in the auto regression. The lags have been selected on the basis of optimum lag lengths criteria suggested by Akaike information criterion (AIC) and Schwarz information criterion (SIC). Further all the roots of characteristic polynomials of endogenous variables lie within the unit root circle, which is a clear indication of auto regression equation satisfying the stability condition along with stationary is taken. Vector error correction model is the systems equation where all variables can be sort with one co integrated equation and two lags for each depended variable and finally one constant. Each variable has coefficient, standard error and t-value. The significance of the dependent variable can be explained with the help of p-value and variables considered are Slope, Curvature, Level, and inflation rate. There are totally 40 observations out of which C11, C12, C16, and C19 are significant with the p-values of 0.01%, 3.24%, 3.13% and 2.33% respectively. Rest of the variables is said to be insignificant because its p-value is greater than 5%. Influence of independent variables on the respective dependent variables (R^2) such as slope, curvature, level, and inflation rate is 57.95%, 72.38%, 57.40% and 20.11% respectively, which is not with in significant levels i.e is 85% to 100%. The autocorrelation in the residuals has been tested in Durbin Watson statistics for slope, curvature, level and inflation rate is 1.96, 0.61, 1.96, and 2.12 respectively. Slope, curvature, level represents there is no autocorrelation and inflation rate is indicates there is auto correlation. 'P' value for 40 observations of all dependent and independent variables were insignificant (as p values are more than 0.05). So we cannot reject null meaning that there is no short causality running from independent variables to dependent variables. Influence of independent variables on the respective dependent variables (R2) such as slope, curvature, level, and interest rate is 57.66%, 51.14%, 57.64% and 83.45% respectively; all variables are not reaching significant level that is 85% to 100%. The autocorrelation in the residuals has been tested in Durbin Watson statistics for slope, curvature, level and interest rate is 1.96, 2.26, 1.96, and 1.92 respectively. Slope, level, and interest rate represents there is no autocorrelation and curvature indicates there is auto correlation.

Graph 01: Impulse response function of inflation rate to latent factors



Impulse response has been reported as per the Cholesky order, impulse response functions shows the response of the selected variable for a one standard deviation positive shock from independent variable. In the impulse response function there was an obvious response by slope, curvature, and level and inflation rate. To its own positive standard deviation shock which is until the year 10, for one standard deviation shock to slope, curvature, level, and inflation rate shows that in slope it gradually increase up to 3 years and comes down, again it raise to some extent, so there is abnormal fluctuation occurring for the given shock from inflation rate change. In curvature, it increases and in 7th year it reaches to zero, but, it doesn't have a negative effect and there on, it increases from the shock given from in inflation rate. Shock given from inflation rate, level is showing the negative effect and it increases over time, but, it again due to shock, fall negative.

Graph 02: Impulse response function of Interest rate to latent factors



To its own positive standard deviation shock which is until the year 10, for one standard deviation shock to slope, curvature, level, and interest rate shows that for given change in one percent of shock in interest rate, slope has a huge impact and it react negatively for the changes that happens in interest rate. In curvature reacts positive till 3rd year and between 3-7 there will fluctuations and will have a negative impact for the changes that happens in interest rate. Shock given from interest rate level is showing the positive effect it increases over time but it again due to shock it falls negative. Shock for interest rate for the given changes in interest rate is in the 3rd year, it falls and from there on there will be negative impact for the changes.

5. Conclusions

This study empirically analyzes the determinants of corporate bond yield curve in India and also explains yield curve fluctuations in the corporate bond and its vulnerability, if there are variations in macro-economic variables, such as interest rate and inflation rate. In the study conducted due to the positive shock from inflation rate there tend to increase in slope and curvature (Short term interest rate and medium term interest rate) and decrease in level (long term interest rate). Increase in inflation rate tends to decrease in one of the component of yield curve (i.e., level) which deters the investors from investing in bonds. One percent positive standard deviation shock of interest causes negative response in interest rates, and the same pattern has been found from the positive shock of interest rate on slope and curvature (short term interest rate and medium term interest rate) but this has increased in level (long term interest rate) until the year 4, decreased thereafter and would likely to recover after the year 5. Decrease in interest rate attracts to investors to purchase the bonds, and when there is increase in interest rate investors usually sell bonds. For a growing corporate bond market in India supportive policies are very much necessary to increase the intensity of the trade by both domestic as well as foreign investors.

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