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Revisiting the Response of the Term Structure of Interest Rates to Policy Rate Changes: Evidence from India

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Abstract:
This paper analyses the response of the term structure of market interest rates to changes in repo or reverse repo rate as announced by RBI to control liquidity in the system. I use the heteroskedastic consistent covariance matrix estimators, HC3 variant, for estimating different uni-variate regression models. For India, I conclude that announcement effects for short term interest rates are stronger, whereas longer term interest rates have responded weakly to the announcements of policy rate changes, though there do exist significant anticipatory-effects in case of longer maturity government securities.

Keywords: *RBI, Repo Rates, Reverse Repo Rates, the official discount rate, interest rates, announcement effects, liquidity.*

JEL: *E43, G14*

1. Introduction

The Reserve Bank of India, the Indian Central Bank, administers changes in repo rates as one of its principle monetary policy tools for liquidity management. The Repo (& the reverse Repo) rates have evolved in sophistication, and it is currently positioned under the Liquidity Adjustment facility[1] of RBI. More securities have been made eligible as collateral for such agreements and efforts have been made to increase the depth of inter-bank repo market. Repo rate changes have served not only as its liquidity management tool, but also as a signalling tool of interest rates for RBI. In this paper I try to assess its signalling power, that is, its announcement effect on the term structure of interest rates.

As per the expectations theory of interest rates, the theory advanced by Irvin Fisher, an investor's expectations of short term interest rates affect longer term interest rates. The repo rate, in India, is the official discount rate used to target short term interest rates and thereby control liquidity. It would be interesting to assess if the repo rate changes affect only short term interest rates, or they do have similar impact across the whole term structure. In other words, it would be insightful to study the response of short term interest rates and also long term interest rates to changes in the repo (& the reverse repo) rates in India.

The paper is structured as follows: Section-I reviews the literature on the term structure of interest rate reaction to official discount rate changes or other monetary policy changes. The literature largely comprises studies from the US, but I have tried to cover all the relevant studies done in the Indian context too. Section II describes the data, its sources and its specific features. I have considered both, the repo rate and also the reverse repo rate changes for our study. For the dependent variables I have taken interest rates for money market instruments ranging from daily to quarterly. I also assess the impact of repo (rev-repo) rate changes on G-Secs (government securities) of varying maturities, ranging from 1 year to 15 years. Section III describes the methodology adopted, and section IV describe Repo & Reverse Repo rates & its unique characteristics as observed in India. The empirical findings and the analysis are presented in Section V, and Section VI concludes.

2. Literature Review

The Fed funds rate have shown greater impact on shorter term interest rates, but a lesser impact on longer term interest rates in the US in 1970s(Cook & Hahn, 1989).There is also the presence of non-announcement effects on treasury security yields (Roley & Sellon, 1998). The changes in discount rates can be classified as the technical and the non-technical changes, which represent the expected and the unexpected components of discount rate changes. It has been observed that only non-technical changes exhibit announcement effects (Smirlock & Yawitz, 1985).A subsequent study provides support for this hypothesis that markets interest rates react to non-technical changes, but qualifies its conclusion saying that there it is not possible to differentiate this hypothesis from other hypotheses that provide reasons for such reactions (Thornton, 1994). Among some recent studies, Kuttner, 2001, has also provided empirical evidence in support of Smirlock & Yawitz (1985) study for data from fed funds futures markets.

[1]The Liquidity Adjustment Facility (LAF) is a facility introduced by RBI to provide a corridor short term interest rates, and it is based on Repo and Reverse Repo Auctions.

It has also been observed that discount rate changes not only affect interest rates corresponding the shorter maturities, but also have a significant bearing on the level of long term interest rates (Roley & Troll, 1984). Goukasian et al (2006) have also measured the expected & the surprise components of changes in the discount rate, and concluded in favour of significant responsiveness of short and medium term interest rates to Fed Funds Target Rate changes.

There are many studies that have studied the influence of discount rate changes and other macroeconomic variables on stock market changes (Hardouvelis, 1987; BS Bernanke; KN Kuttner,2005), and have concluded in the favour of stock markets' sensitivity to monetary policy changes. I do not review this strand of literature since these studies are outside the preview of my research question addressed in this paper.

There are few papers from India that study money market responses to monetary policy changes specifically, repo rate changes. Singh & Dhal (2008) distinguish between discriminatory price repo auctions and fixed price repo auctions, and test the sensitivity of call money rates to repo rate changes. They conclude that money market rates adjust to low or high repo rate changes almost similarly. But they do not study the impact of reverse repo rates on market interest rates, nor do they study the impact of repo rate changes on interest rates for longer maturities. Moreover, the repo rate change data considered by them is for the period ranging from 1992 to 1998. It is a well-documented fact that Repo rates have undergone greater evolution post that period and has been formally brought under the Liquidity Adjustment Facility of RBI, which makes the study using the more updated-data quite relevant.

Another study on India (Rituparna Das, 2009), tries to explain the impact of changes in 3-month Mumbai Interbank Offer Rate on G-secs of various maturities. The study concludes that short term interest rates are more sensitive to monetary policy changes (as proxied by MIBOR) compared to longer term interest rates. The argument for using MIBOR as monetary policy change proxy is wide acceptance as the benchmark rate. I use Repo rates and reverse repo rates as they are direct monetary policy tools to target short term interest rates, and hence could serve as more reliable proxy for studying announcement effects on the term of structure of interest rates.

Rai, Seth, & Mohanty (2007), study the effect of discount rates changes on the term structure in Japan, the UK, Germany and France. They do not distinguish between technical and non-technical components of discount rate changes (instead they make this distinction post facto), and they conclude that interest rates for shorter maturities are sensitive to discount rate changes, but long term interest rates show weak sensitivity to such changes.

3. Data

I have taken repo rates and reverse repo rates from the CMIE's Prowess Data base. I have also obtained the data on Mumbai Interbank Offer Rates (overnight, fortnightly, monthly & quarterly) as released by the National Stock Exchange (NSE) from the same source. The announcement dates for Repo & Reverse Repo rates are different from their effective dates, and I have considered the announcement dates for my study. The period for which I study the repo rate announcement effects on the money market & government securities rates, ranges from 1st January, 2005 to 31st December, 2009.

The number of repo or reverse repo rate change announcements varies from year to year. Some years had fewest Repo (or reverse REPO) rate changes, i.e., only twice each year, whereas some years (2003 & 2008) had as many as 6 instances (each) of rate changes. I was unable to use data on Repo (or Reverse Repo) rates prior to 2005 due to various reasons like unavailability of reliable information on announcement dates, due to significant change in sophistication of Repo rates post 2004, etc. As for our study announcement dates of rate changes are more relevant than the effective dates; also, it is important to maintain consistency in the characteristics of variable considered for study; hence, I chose to restrict our study to repo rate changes between 2005 and 2009.

Repo rate changes that are overlapping events, that is, if there is more than one announcement in a fortnight then only first of such data points is considered. Hence, I have tried to avoid the overlapping events, and thus avoided the confounding events that could jeopardize the estimates of announcement effects. This exercise leaves us with 15 events on policy rate changes compared to the original 17 events. Also, in the case of overnight MIBOR rate, an outlier data point (for 31st March 2007) has been removed, and hence wherever MIBOR-overnight rate is the regress and, I have 14 events, else for all other tests, I have 15 data points.

I have considered the following market interest rates as regress ands:

- Overnight NSE MIBOR Rates
- 14 day NSE MIBOR Rates
- 1 Month NSE MIBOR Rates
- Yield on 1 Yr. Government Securities
- Yield on 5 Yr. Government Securities
- Yield on 10 Yr. Government Securities
- Yield on 15 Yr. Government Securities

I have done some approximations in case of data on government securities yields. For some instances, the data on yield rates was missing for all the types of G-Secs, hence I have assumed that there was no change in the yields, and the rates have remained the same as the last available rate. It is a safe assumption to make as I observe in many cases that the rates pre and post such missing values have remained the same.

4. Methodology

I have adopted the approach followed by Rai, Seth, & Mohanty (2007) in estimating the effect of discount rate changes on the short-term and long-term market interest rates. I have made use of event study approach, and similar to the referred study have not distinguished between technical or non-technical changes, or expected or un-expected changes of repo (reverse repo) rates.

Many studies have adopted Nelson Siegel or Vasicek models for testing the announcement effects, and the paper by Das (2009) uses this methodology on Indian data. I have used an equivalently sophisticated method, wherein I estimate the ordinary least squares using heteroskedastic consistent covariance matrix estimators. Hence, I differ from many other papers on the models adopted for this empirical study.

Markets can react to changes in repo / reverse repo rates on different days around the announcement date and such reaction could be spread over a week before & after such dates. The markets could also react in expectation of an announcement, or there exists a possibility of delay in reactions due to various factors. Hence, I separately study the reactions on the announcement day (called day 0), a day before the announcement day (day -1), and a day after the announcement day (day +1). The day after the announcement is also studied because there is a possibility of delay in reaction, or some sort of persistence in announcement effect.

Market reactions spread over a few days post an announcement day are termed as learning effects in literature. Such effects could arise due to time taken to interpret the changes as favourable or unfavourable. I try to capture such effects by considering market reactions upto 7 days post the announcement day (day 0 to day +7). Similarly, I study the anticipatory effects by considering the market rate reactions 7 days prior to the announcement date (day -7 to day 0); and I study the total effects by capturing the reactions in the 14-day period, which the announcement date as the mid-point (day -7 to day +7).

Our explanatory variable or the independent variable for the regression model is the percentage change in the Repo rate or the Reverse Repo Rate. The dependent variable is the percentage change in the given market rate. Our regression model is:

$$\Delta M_{t-n,t+n} = \alpha + \beta\,(\Delta RR) + \varepsilon_t$$

Where,

$\Delta M_{t-n,t+n}$ = percentage change in a given Market Interest rate from (t-n) upto (t+m)

ΔRR = percentage change in Repo (Reverse-Repo) Rate

t = the announcement day, n= the nth day before or after the announcement day

I estimate the above model through ordinary least squares, but using the HC3 variant of the heteroskedastic consistent covariance matrix estimators. As reported by Rai, Seth, & Mohanty (2007), this was the method proposed by Long & Ervin (2000), and is considered to be suitable for such data which has small sample size, and also there is a need to correct for the heteroskedaticity.

5. Repo / Reverse-Repo Rate Changes

In our given sample period (2005 to 2009), the Reserve Bank of India made 17 announcements of rate changes, of which, nine times, reverse-repo rate change was announced, whereas repo rate change was announced sixteen times, that means, there was one such instance where only reverse repo change was announced, and eight such instances in case of repo rates.

Effective Date	Announcement Date	Reverse repo rate (in percentage)	Repo rate (in percentage)	Change in (rev repo or repo or both)
29-Apr-05	28-Apr-05	5	6	Reverse Repo
26-Oct-05	25-Oct-05	5.25	6.25	Both
24-Jan-06	24-Jan-06	5.5	6.5	Both
09-Jun-06	08-Jun-06	5.75	6.75	Both
25-Jul-06	25-Jul-06	6	7	Both
31-Oct-06	31-Oct-06	6	7.25	Repo
31-Jan-07	31-Jan-07	6	7.5	Repo
31-Mar-07	31-Mar-07	6	7.75	Repo
12-Jun-08	11-Jun-08	6	8	Repo
25-Jun-08	24-Jun-08	6	8.5	Repo
30-Jul-08	29-Jul-08	6	9	Repo
20-Oct-08	20-Oct-08	6	8	Repo
03-Nov-08	01-Nov-08	6	7.5	Repo
08-Dec-08	06-Dec-08	5	6.5	Both
05-Jan-09	02-Jan-09	4	5.5	Both
05-Mar-09	04-Mar-09	3.5	5	Both
21-Apr-09	21-Apr-09	3.25	4.75	Both

Table 1: Repo Rate & Reverse Repo Rate Announcement (2005 to 2009)

Policy Rate	Mean	Median	Minimum	Maximum
Reverse_repo_rate	5.3676	6	3.25	6
Repo_rate	6.9265	7	4.75	9
	Std. Dev.	**C.V.**	**Skewness**	**Ex. Kurtosis**
Reverse_repo_rate	0.93172	0.17358	-1.3012	0.28442
Repo_rate	1.1917	0.17204	-0.20452	-0.71697

Table 2: Summary Statistics for Repo Rate & Reverse Repo Rate Announced between 2005 & 2009

The table I shows the repo rates or the reverse-repo rates as announced by RBI during the period of our study. The summary statistics for repo / rev-repo rate changes are given in table-II. The repo rates have hovered around the average of 6.9265 per cent and have never crossed the 9 per cent bar. Whereas the average reverse-repo rate for the sample period has been 5.3676 per cent, and has never crossed the 6 per cent limit. An interesting point to be noted here is the spread between the maximum repo rate and the maximum reverse repo rate is quite wide. Another interesting point to be paid attention to is that the repo (& the reverse repo) rates have witnessed their all-time lows in the last one year of my sample as a consequence of global credit crisis. The central bank was actively managing liquidity by frequently targeting the repo rates in 2008 which is evident from the maximum number of rate change announcements in the year. Interestingly it didn't change the reverse-repo rate so frequently during 2008 (just changed the rate only once).

6. Results & Analysis

Event window	Mumbai Interbank Offer Rate: Overnight	Mumbai Interbank Offer Rate Fortnight	Mumbai Interbank Offer Rate: Monthly	Mumbai Interbank Offer Rate: Quarterly
Day -1 to Day 0	-0.0209	0.0502	0.0184	-0.0060
p-value	0.8975	0.5846	0.8135	0.9470
Day 0 to Day +1	0.8235***	0.5926***	0.4808***	0.3732***
p-value	0.0000	0.0031	0.0019	0.0035
Day -1 to Day +1	0.8015***	0.6411***	0.5005***	0.3680**
p-value	0.0014	0.0039	0.0056	0.0159
Day -7 to Day 0	0.5689	0.2463**	0.1501	0.1632**
p-value	0.3005	0.0304	0.1195	0.0294
Day 0 to Day +7	0.2965	0.6698**	0.6529**	0.5114***
p-value	0.6796	0.0269	0.0197	0.0051
Day -7 to +7	0.9684*	0.8857***	0.7866***	0.6589***
p-value	0.0683	0.0059	0.0096	0.0016

The sample period for above results is 2005 to 2009. Note: Event window represents the day's prior (values with negative sign) or post (values with positive sign) the announcement day (day 0). P-values ***, **, * denote significance at the 1%, 5%, 10%, respectively. MIBOR -Overnight is the NSE MIBOR daily rate, MIBOR-fortnight is the NSE MIBOR rate for a fortnight, MIBOR-monthly is the monthly rate for NSE MIBOR, and MIBOR-Quarterly is the quarterly NSE MIBOR rate

Table 3: Market Response (MIBOR Rates) to Announcements of REPO Rate Changes

I present the results of the regression model in the tables III, IV, V and VI. These tables report the beta co-efficients of the captioned regressors, along with their respective p-values in the next row.

I observe that announcement day effects of repo or reverse repo rate changes are positive & significant for the all the short term rates. The co-efficients of repo/ reverse repo rate changes are the highest for the MIBOR overnight rates (0.823524 for repo rates, 0.739373 for reverse-repo rates), but these co-effecients are decreasing in nature as one proceeds towards the longer maturity interbank offer rates. In other words, the overnight interbank offer rates move closely (in tandem) with repo/ reverse-repo rate changes, but the co-movement is not so strong for fortnightly, monthly or quarterly rates. This result is consistent with other papers referred in the literature. The same could also be interpreted from the results for MIBOR rates observed over 3-day period, day -1 to day +1.

I do not observe any anticipatory effects on short term (MIBOR) rates when observed over 7-day period prior to the announcement day (day -7 to day 0). Thought the effects are positive, the co-efficients are not significant, except in one case of MIBOR – fortnightly rate (co-efficient very small but significant at 5 per cent level).

Examining the learning effects by observing changes over 7 days post the announcement day, I find that there do not exist any learning effects for overnight interbank offer rates, but there do exist learning effects for other relevant higher maturity interbank rates. The learning effects exist in all instances of reverse-repo rate changes, and are highly significant too.

Event window	Mumbai Interbank Offer Rate: Overnight	Mumbai Interbank Offer Rate Fortnight	Mumbai Interbank Offer Rate: Monthly	Mumbai Interbank Offer Rate: Quarterly
Day -1 to Day 0	0.1356	0.0016	-0.0097	-0.0489
p-value	0.1214	0.9853	0.8977	0.5852
Day 0 to Day +1	0.7394***	0.5317**	0.4715***	0.4034***
p-value	0.0008	0.0166	0.0017	0.0090
Day -1 to Day +1	0.8667***	0.5363***	0.4657***	0.3574***
p-value	0.0000	0.0055	0.0001	0.0099
Day -7 to Day 0	0.2300	0.1560**	0.0903	0.1087
p-value	0.3505	0.0390	0.4086	0.1077
Day 0 to Day +7	0.9175***	0.7632***	0.7341***	0.5708***
p-value	0.0006	0.0033	0.0019	0.0000
Day -7 to +7	1.0708***	0.8923***	0.8081***	0.6652***
p-value	0.0036	0.0011	0.0026	0.0002
The sample period for above results is 2005 to 2009. Note: Event window represents the day's prior (values with negative sign) or post (values with positive sign) the announcement day (day 0). P-values = ***, **, * denote significance at the 1%, 5%, 10%, respectively. MIBOR -Overnight is the NSE MIBOR daily rate, MIBOR-fortnight is the NSE MIBOR rate for a fortnight, MIBOR-monthly is the monthly rate for NSE MIBOR, and MIBOR-Quarterly is the quarterly NSE MIBOR rate.				

Table 4: Market Response (MIBOR) to Announcements of Reverse REPO Rate Changes

When I check for the total effects observed over the fourteen-day period (7 days prior and 7 days post the announcement day), I observe that the co-efficients are close to unity and significant too. But these coefficients (like the ones for announcement day effects) are decreasing as one moves toward longer maturities.

Event window	1 YR. G-SEC Yield	5 YR. G-SEC Yield	10 YR. G-SEC Yield	15 YR. G-SEC Yield
Day -1 to Day 0	-0.0242	0.0123	0.0946*	0.1025
p-value	0.9111	0.7176	0.0508	0.4182
Day 0 to Day +1	-0.1897	0.1827*	0.0400	0.1188*
p-value	0.6874	0.0816	0.5935	0.0724
Day -1 to Day +1	-0.2273	0.1810	0.1900***	0.2712*
p-value	0.7641	0.1032	0.0002	0.0523
Day -7 to Day 0	0.0755	0.1786**	0.3114**	0.2692***
p-value	0.7908	0.0421	0.0138	0.0041
Day 0 to Day +7	0.0095	-0.0139	-0.3276	0.1871
p-value	0.9864	0.9596	0.4823	0.2534
Day -7 to +7	0.0070	0.1656	0.0083	0.4504**
p-value	0.9934	0.5508	0.9815	0.0351
The sample period for above results is 2005 to 2009. Note: Event Window represents the day's prior (values with negative sign) or post (values with positive sign) the announcement day (day 0). P-values = ***, **, * denote significance at the 1%, 5%, 10%, respectively. 1-Yr. G-Sec = Yield on 1-Yr. G-Sec, 5 Yr. G-Sec = Yield on 5 Yr. G-Sec, 10 Yr. G-Sec = Yield on 10 Yr. G-Sec, 15 Yr. G-Sec = Yield on 15 Yr. G-Sec				

Table 5: Market Response (G-SEC Yields) to Announcements of REPO Rate Changes

I report the empirical findings for long-term interest rate responses to repo / Reverse-Repo rate changes in table V & VI. Contrary to the expectations theory of interest rates, but consistent with results of other papers on the US data, I do not find significant announcement day effects. When observed for only the announcement day effect, the co-efficients in certain instances are significant at 10 per cent level, but the co-efficients per-se are close to zero. Hence, I can interpret that immediate co-movement of G-Secs with repo/reverse- repo rate changes are either none or negligible. But when this response is tested by considering changes over the 3-day period, I do observe significant co-efficients, but such co-efficients are very low & almost close to zero.

An interesting finding that requires attention is the presence of significant anticipatory effects for these longer maturity government securities. Though the magnitude of these co-efficients is small, it is significant at one per cent and five per cent levels in most of the cases. I do not observe any significant learning effects, nor do the total effects suggest significant response to the repo or reverse repo changes.

6. Conclusion

This paper studies the response of short-term money market rates and long-term government security rates to repo and reverse-repo rate changes as announced by RBI since 2005. The repo or reverse repo rate changes have been not so frequent in India, but they gained momentum in 2008 and 2009 as a consequence of the global credit crisis. Hence, my period of study, 2005 to 2009 is an interesting mix of events that capture the highs and the lows, and also the stable periods of the Indian economy.

Event window	1 YR. G-SEC Yield	5 YR. G-SEC Yield	10 YR. G-SEC Yield	15 YR. G-SEC Yield
Day -1 to Day 0	-0.0589	0.0231	0.0636*	-0.0481
p-value	0.8314	0.5743	0.0692	0.4045
Day 0 to Day +1	-0.2497	0.2062**	0.0106	0.1065**
p-value	0.6797	0.0247	0.8922	0.0464
Day -1 to Day +1	-0.3253	0.2127**	0.1403***	0.1191
p-value	0.7407	0.0271	0.0044	0.3508
Day -7 to Day 0	0.1250	0.2218***	0.3104***	0.1684**
p-value	0.7059	0.0027	0.0083	0.0348
Day 0 to Day +7	-0.0271	-0.0377	-0.3384	0.0974
p-value	0.9674	0.9139	0.5633	0.5889
Day -7 to +7	0.0053	0.1860	0.0037	0.2656
p-value	0.9959	0.6035	0.9936	0.1594
The sample period for above results is 2005 to 2009. Note: Event window represents the day's prior (values with negative sign) or post (values with positive sign) the announcement day (day 0). P-values = ***, **, * denote significance at the 1%, 5%, 10%, respectively. 1-Yr. G-Sec = Yield on 1-Yr. G-Sec, 5 Yr. G-Sec = Yield on 5 Yr. G-Sec, 10 Yr. G-Sec = Yield on 10 Yr. G-Sec, 15 Yr. G-Sec = Yield on 15 Yr. G-Sec				

Table 6: Market Response (G-SEC Yields) to Announcements of Reverse REPO Rate Changes

As hypothesized, the short term interest rates respond better to the repo or the reverse-repo rate changes, though the response among such short term rates is decreasing with the increasing maturities. The anticipatory effects are absent, but there do exist significant learning effects in certain instances, especially with respect to the changes in reverse repo rates. The long term yields on government securities have shown very weak immediate responses to repo or reverse repo rate changes, though there do exist significant anticipatory effects in government securities of longer maturities.

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