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The Impact of U.S. Quantitative Easing (QE) Announcements on Indian Government Bond Yields

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

This study investigates the impact of U.S. Quantitative Easing (QE) announcements on Indian Treasury yields. Two outstanding channels of spillover effects on bond yields documented in the existing literature are signaling channel and portfolio balance channel. This study decomposes Indian Treasury yields into yield expectations and risk premia to measure spillover effects of U.S. QE announcements. The impact on yield expectation measures signaling effect while the impact on risk premia measures portfolio balance effect. It is observed that FOMC announcements of Federal Reserve's Quantitative Easing (QE) policy treated as shocks to Indian government bond yields. To investigate the announcement effects on Indian government Bond yields, event study methodology is used to capture the change in the bond yields, yield expectation and risk premia of Indian bond market around that time especially during the first round of Quantitative Easing (QE1) policy announcement periods in one-day and two-day window period. To support event study results regression analysis method is implemented and found robust evidence supporting larger signaling effect than the portfolio balance effect. At last, this study uses Dynamic Nelson-Siegel (DNS) yield curve model to compute the relationship between the U.S. and Indian Bond market. DNS model involves two-step estimation using VAR regression on Indian government bond yields with U.S. 10-year Treasury yield changes as an exogenous variable. The statistical

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result of DNS estimation shows that U.S. 10-year Treasury yield change affects the Indian long-term bond yield during the financial crisis period.

Keywords: QE; yield curve; spillover; signaling effects; portfolio balance effects.

1 INTRODUCTION

During the global economic recession of 2008, when the macro-economists have tried to come up with an idea to rescue U.S. economy and when the U.S. Federal Reserve has lowered down treasury yields and kept the yields on low level, but it failed to stimulate the US economy then the Federal Reserve decided to launch unconventional monetary policy called Quantitative Easing (QE) programs which meant to purchase private assets in order to pump money into the financial system, to extend credit to business and industry and to encourage consumption. The main aim of QE program was to stabilize the U.S. economy but this program can be considered a macro-economic shock to the rest of the world which brought spillover effects to the global market economies especially for emerging market economies in the world. It would not only affect the capital flows but also affect the assets price movement in the emerging markets.

In literature, there are two measurable channels of a spillover effect on bond yields are found that is signaling and portfolio balance channels. The signaling channel works when the investors take QE announcement as a signal of a lower path of future short term interest rates of U.S. and think that it would have an impact on monetary policy decisions of emerging markets. So, the change in investorÇÖs expectation on emerging market monetary policy leads to change in the short rate expectations and also bond yields. The portfolio balance channel works when the central bank purchases assets and reduce the supply of assets held by private sectors. The reduction in the supply of assets would affect investors to rebalance in their portfolio by investing in substituting assets. So the inflow of funds into emerging market economies (EMEs) bond market would push up the bond prices and reduce the risk premia on Treasury bonds.

Various existing literature has documented on the effect of QE of developed countries on emerging market economies (EMEs) and shown that the assets prices of EMEs responded very sensitively by the unconventional monetary policy of developed countries but very few of these studies include Indian market. The global financial crisis of the U.S. in 2008 has not only affected its domestic market but also on the worldwide market very severely. After this incident, a lot has changed in the monetary transmission of the world. Economists who believed Ç£Decoupling TheoryÇ¥[1] were shocked to see how the Asian economies got affected by the subprime crisis. As far as the Indian economy is concerned; the recovery was very quick from 6.1% in the first quarter of 2009 to 8.9% in the fourth quarter of 2010 in GDP. Although the inflation (WPI) growth rate had shown a substantial rise from -0.31% in July 2009 to 9.90% in July 2010. The Reserve Bank of India has adopted rapid measure to overcome this financial crisis. The actions include the Central Bank of India (RBI) reduction in a reserved ratio by 500 bps. India is one of the biggest economies in Asia; it has very least impact from the global crisis, because of lower dependency on the global flow of capital and trade and large domestic demand for goods and service because of the substantial population.

As shown in Fig. 1, INR continues to become weak against the U.S. dollar during the QE period, and this exchange rate continues to rise indicating weaker Indian currency. The U.S is the largest importer of Indian primary goods and services in the past decades. Due to weaker INR against the dollar would make U.S. imports cheaper from India and would demand more for Indian export resulting in improving IndiaÇÖs trade deficit. Although this weaker exchange rate has brought imported inflation to the Indian market, yet we can observe from Fig. 2, that the Indian current account deficit (% to GDP) is negative, meaning the export receipts are more than the import receipts.

[1]A group of Latin economists who believed that Asian Economies especially emerging economies are no longer depends on U.S. for economic growth.

Fig. 1. India-U.S Exchange Rate during QE Announcement Periods

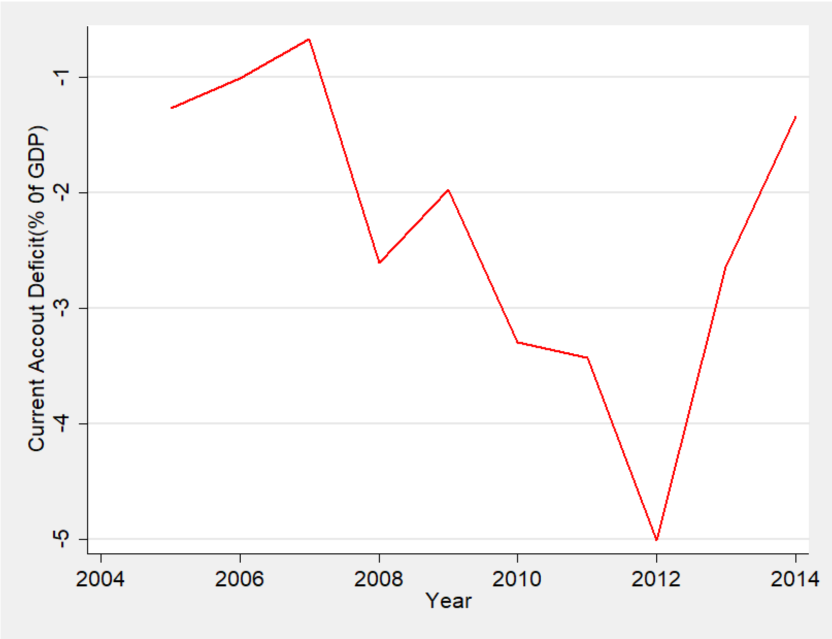

Fig. 2. Indian Current Account Deficit (% to GDP) during QE Periods

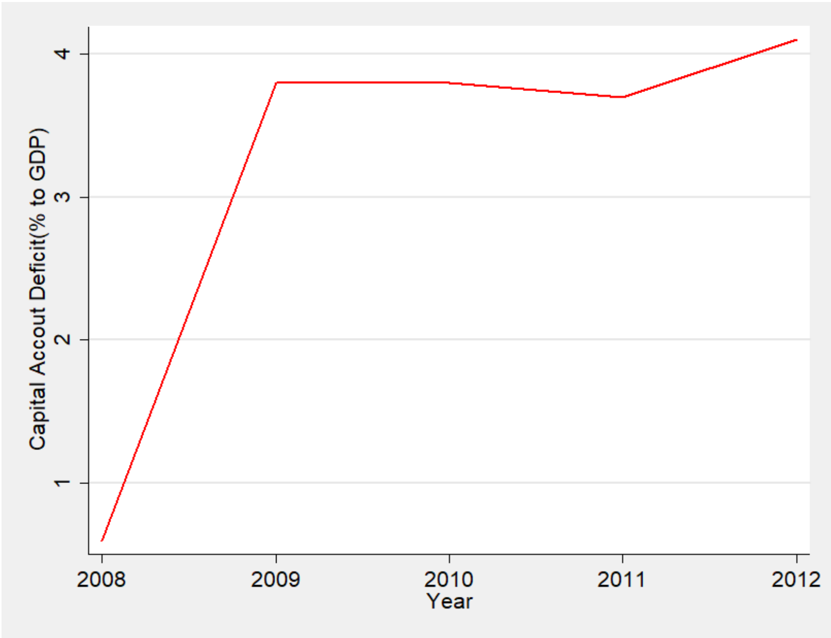

Fig. 3. Indian Capital Account Deficit (% to GDP) during QE Periods

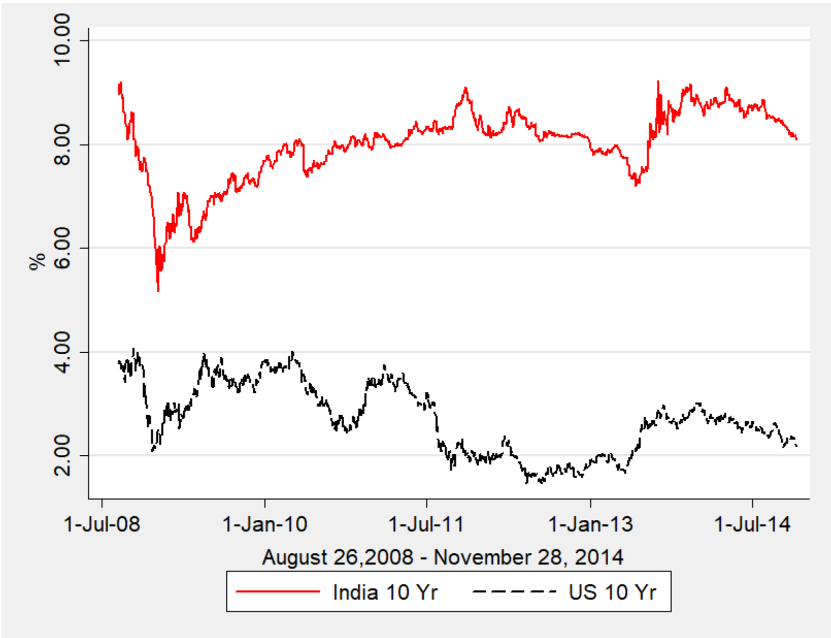

Fig. 4. India and U.S. 10-year Treasury Yields during QE Periods

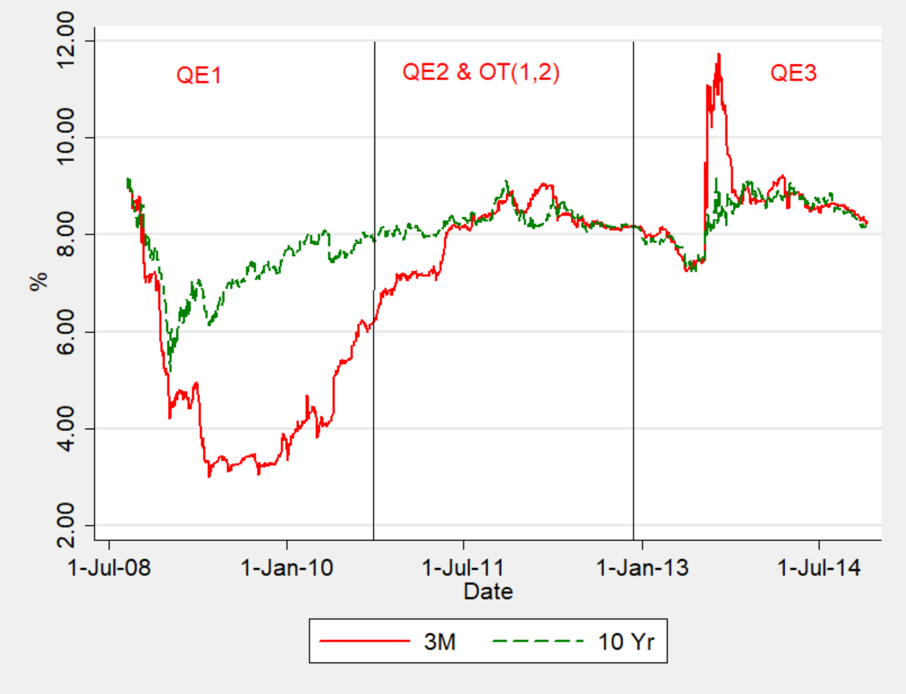

Fig. 5. Indian 3-month and 10-Year Treasury Yields during QE Periods

The other consequence of weaker Indian rupee against U.S. dollar would realize investorÇÖs lower return and therefore, the foreign investors would be less willing to invest in the Indian equity market. As shown in Fig. 3, the currency depreciation would increase the Indian capital account deficit from 0.6% in 2008 to 4.1% in 2012. The condition of Indian Bond market during QE periods indicates higher interest rates and this makes foreign investors to invest in India for getting higher returns. The Indian 10-year Treasury yield is higher than the U.S. 10- year Treasury yield resulting capital inflow to the Indian market.

As shown in Fig. 4, the U.S. Treasury yield continued to move between 2% to 4% during QE periods while the movement in Indian 10-Year Treasury yield was between 5% to 9% during this period. The difference in the yield between India and the U.S. had bought a foreign investment in emerging countries like India.

During 2013-14 IndiaÇÖs GDP growth rate was recorded 4.7% which was lowest since 1984-85. This slowdown in GDP indicates a recession in the economy, and at the same time, the exchange rate between INR-U.S. dollar continued to increase resulting INR depreciation. Indian CPI inflation was also recorded as high as around 11% during this period. To overcome this problem Reserve Bank of India (RBI) adopted a contractionary monetary policy by increasing repo rates and reverse repo rates. As shown in Fig. 5, the inverted Treasury yield curve of 3-months and 10-year during 2013-14 indicates a recession in the economy. The short-term yield is higher than the long-term yield, stating short period money became more expensive than the long maturity.

India considered as one of the largest economies in the world that has a strong trade relationship with the U.S[2]. This aim of this study focuses on the cross-country impact of U.S. unconventional monetary policy called

[2]According to Indian Ministry of Trade and Commerce (www.commerce.nic.in) in 2017, India exported $48.6 billion worth of Indian products to U.S. while imported $25.7 billion worth of U.S. products. U.S. is the second-largest trade partner with India after China.

QE Announcement shocks on Indian government bond market. Our study will also capture the spillover effects of the QE announcements, which may affect the Indian bond market through portfolio-balance transmission and signaling transmission. The portfolio balance approach would involve the private assets purchased by the government that reduce the bond supply, lower the term premium, and increases the chance of moving the fund to foreign market with higher yields. The signaling channel involves when the Federal Reserve through QE announcement maintains the low-level of future interest rates, the difference in yields between U.S. bond market and foreign bond markets will bring capital flows into the international bond markets.

To identify the impact of U.S. Quantitative Easing on the Indian bond market, I divide this study into three systematic phases. First, an event study methodology approach is used to capture the reaction in changes of Indian bond yields, yield expectation, and risk premia after U.S. QE announcements within one day to two days window interval after the QE announcements. Second, to support event study results and to measure signaling and portfolio balance effect, regression analysis is conducted on Indian bond yields, yield expectation and risk premia and third, to compute the cross-country relationship between the U.S. bond market and Indian bond market some interest rate models are constructed using the DNS methodology. The Indian government bond yields data are fitted to the DNS model and is computed using regression on the U.S. 10-year treasury yield changes to Indian government bond yields.

The organization of the rest of the paper is as follows: Section 2 summarizes former literature and empirical research conducted to study the impact of U.S.Quantitative Easing (QE). Section 3 presents the data sources and empirical methodology of the study. Section 4 contains empirical findings and discussions. Section 5 contains the concluding remarks and provides suggestions for further research, while APPENDIX(A) and APPENDIX(B) contains the miscellaneous empirical tables and graphs, respectively.

2 LITERATURE REVIEW

There are a few existing papers in the writing which have demonstrated the impacts of U.S. QE approach in various perspectives. [1] have shown the effects of U.S. QE on the local bond market itself. They found that QE1 decreased long term interest rates by very nearly 1% and evaluated the inferred impact of QE2 would be to lower long term interest rates by around 0.25%. Some other literature such as [2], [3], [4], and [5] have found a significant effect of U.S. Quantitative Easing on domestic Treasury yields. The impact of QE announcement made by Bank of England on its local assets prices has been investigated by [6]. [7] in their paper have studied the effect of the Asset Purchase Program suddenly introduced by the ECB from September 2014 onwards. Furthermore, the study conducted by [4] have found the significant impact of U.S. and U.K. QE announcements through portfolio and signaling channels and concluded that the decline in US yields was because of decrease in the expectation of future short rates while the decline in UK yields was due to the reduced risk premium. Similar research led by [8] and [9] contended that the bond yield would influenced by the lower long term interest rate while the QE2 program would not impact the general interest rates. It has been found in the papers of [10] and [11] that the most immediate transmission of QE program to developing markets is one of the most significant effects of QE on the worldwide market through capital inflows. The large portion of the high transmission has occurred amid the principal period of QE. These studies have shown a significant impact of QE announcements on financial markets.

With the collapse of Lehman Brothers in September 2008, the global financial crisis began. To overcome the subprime crisis, the U.S. government initiated Quantitative Easing by purchasing private assets at large scale and therefore it is also called Long Scale Asset Purchase (LSAP) policy. In U.S. QE was implemented in three distinct phases. The first round of QE started in November 2008 involving $1.7 trillion in debt purchase. The second period began in November 2010 consisits of an investment of $600 billion in long-term treasuries. The third round of QE covered the period from September 2012 to December 2012 requires a monthly purchase of $40 billion mortgage-backed securities (MBS). The rounds of QE were ended in May 2013 when the Central bank has declared to wrap up its unconventional financial approach. The effects of quantitative easing on emerging markets economies (EMEs) is studied by [13], [12] and [14] and found negative spillover effect on these markets due to macro-economic imbalances and weak financial sectors. [12] also pointed out the rise of unnecessary volatility in the global financial markets due to negative spillover effects caused by QE.

To analyze the effect of QE on bond yields of worldwide monetary market, the literature has not only suggested econometric models but also event study methodology which is a model-free analysis. [4] have used event window analysis by taking only one-day interval as the window length, while [15] have used within a two-day interval period after the QE announcements. We use both one-day and two-day window as the time difference between the US and India have suggested to take both window length for this study and to give bond market participants more time to understand the market situation. There are a few experimental models are recommended by existing literature. The term structure displaying proposed by [17] model and its expansions were done by [16] broadened the model by making it more adaptable by including the second arch and [18] made the model dynamic, by adding dynamic variables into the first model and named it as Dynamic Nelson-Siegel model. The DNS model is highly demanding for this research study because of its parsimony and encouraging results.[19] decomposes the yield curve into Expected yield and risk premia to measure signaling effect and portfolio balance effect respectively and found that portfolio balance effect is greater than the signaling effect in both U.S. and U.K. bond market.

3 DATA AND EMPIRICAL METHODOLOGY

3.1 Data

The empirical analysis of this research uses daily zero-coupon equivalent yield data of India form 26-Aug-2008 to 28-Nov-2014 6 obtained from investing.com, an investing website. The Reserve Bank of India has a lack of availability of daily data of different bond yields especially short term yields. The investing.com is widely used by researchers and a reliable source for the study on the financial market throughout the world. India secondary bond market (NSE & BSE) traded with more in corporate bonds, and therefore these secondary markets are lack of zero-coupon bond yield data of QE periods. U.S.10-year Treasury yield data is obtained from Federal Reserve website with daily frequency.

Since the focus of this study is on yield curve estimation and decomposition, this study does not pursue the data generation method further and use the data from investing website (investing.com). Table 1 shows the descriptive statistics of Indian Treasury yields of 3-months, 6-months, 1-year, 2-years, 3-years, 5-years and 10-years.

Table 1. Descriptive Statistics of Indian Treasury Yield Data (Daily)

Maturity	N	Mean	Min	Max	SD	Kurtosis	Skewness
3 Months	1454	7.14	3	11.75	2.03	2.38	-0.71
6 Months	1454	7.22	3.3	11.57	1.89	2.34	-0.74
1 Year	1454	7.24	3.81	9.96	1.59	2.2	-0.8
2 Years	1454	7.41	4.42	9.86	1.21	2.44	-0.81
3 Years	1454	7.62	4.86	9.73	0.95	2.65	-0.77
5 Years	1454	7.91	5.13	9.71	0.77	3.41	-0.89
10 Years	1454	8	5.17	9.24	0.68	4.17	-1.05

N, Min, Max, SD present the total number of observations, minimum value, maximum value and standard deviation of data

Table 1 shows that Indian treasury yields are upward sloping and short maturity yields are more volatile than the longer maturity yields. We use daily data for this study, first to see U.S. QE announcements effect on Indian Bond market and second to decompose yield curve into expected yield and risk premia.

Furthermore, the descriptive statistics of expected yield and risk premia are shown in Table 2 and 3 respectively. The two components are extracted from Indian yields with the method described in Section 3.3.

In Table 2, it can be observed that the expected yields of short-term maturities are more volatile than the long-term maturities and overall the expected yields of observed maturities are upward sloping. Table 3 shows that the risk premia of longer-term yield curves are higher than the shorter-term yield curves. But the volatility of risk premia for longer yield curves is higher than the shorter-term.

Table 2. Descriptive Statistics of Daily Expected Yield Data

Expected Yields	N	Mean	Min	Max	SD	Kurtosis	Skewness
3 Months	1454	7.1	2.52	12.11	2.21	2.41	-0.76
6 Months	1454	7.1	2.6	12.05	2.2	2.38	-0.75
1 Year	1454	6.51	2.44	10.97	2.01	2.35	-0.75
2 Years	1454	7.1	2.66	11.78	2.17	2.29	-0.74
3 Years	1454	7.09	2.66	11.64	2.15	2.26	-0.74
5 Years	1454	7.08	2.67	11.42	2.1	2.23	-0.74
10 Years	1454	7.05	2.74	11.04	1.99	2.22	-0.74

N, Min, Max, SD present the total number of observations, minimum value, maximum value and standard deviation of data

Table 3. Descriptive Statistics of Daily Risk Premia Data

Risk Premia	N	Mean	Min	Max	SD	Kurtosis	Skewness
3 Months	1454	0.03	-0.36	0.55	0.19	3.28	1.16
6 Months	1454	0.12	-0.69	1.15	0.34	3.26	0.92
1 Year	1454	0.73	-1.15	2.43	0.51	4.84	0.46
2 Years	1454	0.32	-2.3	2.87	1.04	3	0.85
3 Years	1454	0.53	-2.18	3.44	1.27	2.64	0.88
5 Years	1454	0.83	-2.04	4.01	1.44	2.49	0.88
10 Years	1454	0.95	-2.27	4.14	1.45	2.39	0.73

N, Min, Max, SD present the total number of observations, minimum value, maximum value and standard deviation of data

3.2 Empirical Methodology

A yield curve or term structure model is very crucial to describe future interest rates. The uncertainty of future interest rates develops an attraction to model the yield curve and studies movement behavior. The yield curve modeling is an essential aspect for central banks and macro economists before taking monetary policy actions. Treasury yield is an essential factor for measuring a countryÇÖs economic performances. It shows the investorsÇÖ confidence in the government. This section starts from the event study methodology used to capture the reactions of Indian yield curve, yield expectation and risk premia due to U.S. Federal ReserveÇÖs QE announcements. The second section described the methods used to compute the relationship between U.S. and Indian bond market movements and uses Dynamic Nelson Siegel (DNS) model specifications. In the third section, the Indian Treasury yield is decomposed into yield expectation and risk premia from reduced form DNS model and VAR process. The last section of empirical methodology describes the regression analysis methodology to support Event study methodology and measures spillover effect via signaling effect and portfolio balance effect.

3.2.1 Event Study Methodology for QE Policy Announcement

Event study methodology is important as it is used to analyze the impact of Federal Reserve Quantitative Easing policy on Indian Bond Market. Event study captures the abnormal behavior of the Indian government bond yields, yield expectations and risk premia around the policy announcement days. The derivation of yield expectations and risk premia is included in Section 3.3. This methodology estimates the impact of QE announcements on Indian bond market by assuming other events constant to isolate our results.

This method captures the change of observed yields, yield expectations and Risk premia value before the QE policy announcement day and after the announcement due to QE announcement news. A proper choice of the window is critical for an event study. A short window may be not enough to fully capture the announcement's effect, creating a downward bias of these effects. On the other hand a long window may be contaminated by the effects of other events happening in this period. In the past, Christensen and Rudebusch (2013) have used only one-day interval as the window length, while Lucca and Moench (2014) have used within a two-day interval period after the QE announcements. The estimation windows used for this study include one-day and twoday window periods after the Federal Reserve made QE announcements. The time difference between the US and India have suggested using both time-window periods for this study to give bond market participants more time to understand the market situation. Appendix A contains all QE event dates used for the computation of event study.

3.2.2 The Dynamic Nelson-Siegel (DNS) Model

The Dynamic Nelson-Siegel (DNS) model is very useful to identify the expectation of bond market by analyzing the shape of the yield curve. It is generally observed that during the economic booming, the yield curve shape will be upward sloping, indicating the future interest rates may be higher than the current interest rates while during the recession, the yield curve shape will be flattering or downward sloping, showing the future interest rates may be less than current interest rates. Many types of research have been done on yield curve changes and concluded that the change in the structure of the yield curve is also affected by a small number of hidden factors. Most of the yield curve models are either theoretical rigorous but empirically less effective and vice versa. At any point in time, there may be dozens of different yields observed which corresponds to different bond yields. In the paper of Litterman and Scheinkman (1991) they introduced a three-factor model, in which the parameters correspond to level, steepness, and curvature movements in U.S. bond market and found that these parameters have well explained almost all variations in bond returns. In the past, the factor models proved tremendously appealing for statistical reasons. One of the popular approaches among the researchers is the Nelson-Siegel model that estimates the yield curve by using the three time-varying parameters, and they showed that these parameters defined as the level, slope and curvature, and the estimation results of these parameters are very efficient. The original model from Nelson-Siegel (1987) defines the yield rate curve model as:

$$y(t) = \beta_1 + \beta_2(\frac{1-e^{-\lambda\tau}}{\lambda\tau}) + \beta_3(\frac{1-e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}) + \varepsilon_t \tag{3.1}$$

Under this model, the parameters β_1, β_2, and β_3 are defined as the Level, Slope and Curvature of the yield curve with factor loadings of 1, $\frac{1-e^{-\lambda\tau}}{\lambda\tau}$, $\frac{1-e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}$ respectively and τ as maturity period. λ is the exponential decay rate. [18] mentioned that a small value of λ produces steady decay and better defines the curve at long maturities, whereas a larger value of λ produces high decay and can better explain the curve at short maturities. They argued that the value of λ should be taken where the factor loading of β_3 achieves a maximum at a medium rate. For the first time [18] proposed a model called Dynamic Nelson-Siegel (DNS) model which allows the parameters L_t, S_t and C_t to vary over time and makes it dynamic with additional parameters time t. The model is given as:

$$y_t(\tau) = L_t + S_t\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}\right) + C_t\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}\right) + \varepsilon_t(\tau) \tag{3.2}$$

It is noted that the parameters in this model are estimated from the observed bond yields $y_t(\tau)$. Under the Nelson-Siegel framework, any change in the parameters will allow yield curve to have different shape and size. As shown in figure 6, the factor loading of the level factor is constant which means that the interest rate of all maturities will change by the same amount. The loading of slope factor is a function which starts from 1 but goes to zero quickly indicating downward sloping and therefore, twisting the yield curve and changing the short-term interest rates by much larger amounts than the long-term interest rates. The loading of curvature factor starts from zero (and is thus not short-term) then increases and finally decays to zero (and is thus not long-term) and hence is viewed as a medium-term factor.

After getting the estimated values of parameters from the DNS model, the two-step estimation approach by [18] is introduced by fitting the data into Vector Autoregression (VAR) time series for capturing the impact of U.S. QE announcements on short, medium and long terms level of Indian Treasury yields. In literature, the VAR model is instrumental to study the impact of external policy shock on the domestic market[3]. VAR model is the extension of the univariate autoregressive model (AR), and the VAR process itself is very flexible and easy to use in multivariate time series. To analyze the relation between the U.S. bond market and Indian bond market, VAR regression on Indian bond yields with one day lag of 10-year US treasury yields changes $\Delta y_{t-1}^{U.S.-10year}$ as an

[3]Sims,C. (1980), Ç£ Macroeconomics and Reality,Ç¥ Econometrica, 70,1-47, Sims argued that a VAR can not only used for forecast economic time series but it can also be used to check the response and consequences of certain policy actions in macroeconomics. Since then it is used to check the effect of external policy shock.

exogenous variable is used. $\Delta y_{t-1}^{U.S.-10year}$ is taken as a proxy for U.S. monetary policy shock to Indian bond market. The equation of the VAR (1) model with one exogenous variable is

$$X_t = \mu + \beta_1 X_{t-1} + \beta_2 \Delta y_{t-1}^{U.S.-10year} + \varepsilon_t \tag{3.3}$$

Where X_t is a vector of latent variables L_t, S_t, and C_t observed from the DNS model, μ is a vector of additional constant and ε_t is a vector of one-step-ahead prediction errors.

The purpose of adding an exogenous variable in the VAR model is to figure out the relationship between the Indian bond market and U.S. bond market movements and whether it is significant. The Augmented Dickey-Fuller (ADF) test is performed to check the unit root in the latent variable X_t and the optimal lag length criteria is selected by Ç£varsocÇ¥ command. The stable VAR model is stationary if eigenvalue of coefficients would be smaller than one. The VAR stability is checked by Ç£varstableÇ¥ command in STATA.

3.3 The Decomposition of Yields into Expected Yield and Risk Premia

As discussed in Section 1, this study investigates the signaling and portfolio balance effect of QE announcements on the Indian bond market by decomposing Indian Treasury yields into yield expectations and risk premia respectively. Understanding the changes in risk premia and market expectation of bond yields is not only crucial for effective trading strategy but also essential for policymakers to conduct effective monetary policies. Yield expectation is defined as a weighted average of expected future short rates and derives it through reduced form DNS model and VAR process while risk premia are defined as a component to compensate risk and can be obtained as the difference between observed yield and the expected yield without risk compensation.

Given the DNS model, the short rate (r_t) is define as the function of latent variables and is define as:

$$r_t = \delta_0 + \delta_1', \tag{3.4}$$

where $\delta_0 = 1$, $\delta_1 = \left[1, \left(\frac{1-e^{-\lambda}}{\lambda}\right), \left(\frac{1-e^{-\lambda}}{\lambda} - e^{-\lambda}\right)\right]'$, and $X_t = [L_t, S_t, C_t]$. The latent variables follow the VAR (1) process

$$X_t = \mu + \phi X_{t-1} + v_t, \tag{3.5}$$

where $v_t \sim N(0, \Omega)$, and and the expected future latent variables are defined as: $E_t\left(X_{t+i}\right) = \mu \sum_{i=1}^{n} \phi^{i-1} + \phi^i X_t$ The expected future short rates are define as:

$$E_t\left(r_{t+i}\right) = \delta_1' E_t\left(X_{t+i}\right) \tag{3.6}$$

Therefore expected yield $y_t^(e, n)$ without risk premium is the weighted average of expected future short rate.

$$y_t^{e,n} = \frac{1}{n}\left[\sum_{i=0}^{n-1} E_t\left(r_{t+i}\right)\right] \tag{3.7}$$

Then, risk premia $y_t^(p, n)$ is the difference between observed yield and expected yield

$$y_t^{p,n} = y_t^n - y_t^{e,n} \tag{3.8}$$

Thus, the decomposition of observed yield curve into expected yield and risk premia would identify signaling effect and portfolio balance effect on U.S. QE announcements on Indian Bond market respectively.

3.4 Regression Analysis with Additional Control Variables

One of the major shortcomings in event window Analysis is that it assumes other factors would have no impact on Indian Bond market. To overcome this problem, regression analysis with additional controls is used to support this research study and also to make our results efficient and robust. It is observed that several key monetary policy indicators of Reserve Bank of India (RBI) changed around the QE announcements dates[4]. The regression analysis introduces three different dummy variables of QE announcements of U.S. to measure the average effect on observed yield, yield expectation, and risk premia using standard OLS techniques. Also, some variables from Indian monetary policy operations and Indian financial markets are included as control variables in this study.

[4]After checking the observed data, we have found date some of the key monetary policy indicators like Repo rate, Reverse repo rate and Cash reserve ratio rate have changed by RBI around QE announcement days. Some changes were made exactly within same day of QE announcements while some changes were made by RBI within 7 to 10 days before QE announcement days which may contaminate event study results.

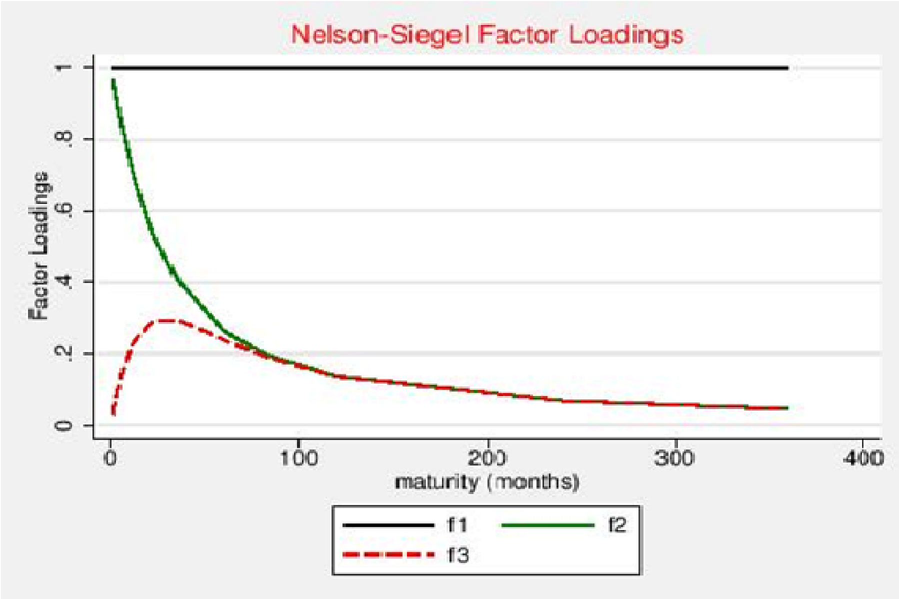

Fig. 6. Nelson-Siegel Factor Loadings

f1 = factor loading of level, f2 = factor loading of slope and f3 = factor loading of curvature

More precisely, this method performs separate regressions of the daily change in observed yields (Δy_t^n), expected yields $(\Delta y_t^{e,n})$ and risk premia $(\Delta y_t^{p,n})$ on dummy variables $Dummy_{t+i}^{U.S.}$ of QE events. Considering the time difference between India and U.S., three dummies (same day, one day and two day after QE announcements were made by Federal Reserve) are introduced to capture the impact of QE announcements effect on Indian bond market.

For regression analysis, two different strategies are used. The first strategy uses three dummy variables $Dummy_t^{U.S.}$ refer to dummy, whose value is 1 at the QE announcement day and 0 otherwise. $Dummy_{t+1}^{U.S.}$ is the dummy whose value is 1 at one day after QE announcement day and 0 otherwise. $Dummy_{t+2}^{U.S.}$ is the dummy whose value is 1 at two days after QE announcement day and 0 otherwise to measure the average effect of QE announcements on changes in Indian treasury yield, yield expectation and risk premia using OLS Technique.

$$\Delta y_t^n = \beta_0 + \beta_1 Dummy_t^{U.S.} + \beta_2 Dummy_{t+1}^{U.S.} + \beta_3 Dummy_{t+2}^{U.S} + \beta_4' Controlvariable_t + \varepsilon_t \tag{3.9}$$

$$\Delta y_t^{e,n} = \beta_0 + \beta_1 Dummyt^{U.S.} + \beta_2 Dummyt_{t+1}^{U.S.} + \beta_3 Dummyt_{t+2}^{U.S.} + \beta_4' Controlvariable_t + \varepsilon_t \tag{3.10}$$

$$\Delta y_t^{p,n} = \beta_0 + \beta_1 Dummy_t^{U.S} + \beta_2 Dummyt_{t+1}^{U.S} + \beta_3 Dummyt_{t+2}^{U.S} + \beta_4' Controlvariable_t + \varepsilon_t \tag{3.11}$$

The first strategy might not be very effective to find out the QE announcements effect on Indian bond market as QE announcements were implemented in three distinct phases from the period between 2008 to 2014 at different point of time so we assume that different QE announcements may have different magnitude of shock to the Indian bond market and therefore it is not very effective to study the impact of QE announcements alone.nSo, the second strategy uses the change of U.S. benchmark Treasury yield as a proxy for U.S. monetary policy shock to Indian bond market and introduced interaction between Dummy for QE announcements and change of U.S.10-year Treasury yield. This strategy measures the effect of U.S. QE on Indian Bond market by considering that different QE events have different impacts on Indian bond market and assumes that the change of U.S.10-year

Treasury yield measures the shock to the market.

$$\Delta y_t^n = \beta_0 + \sum_{i=0}^{2} \beta_i Dummy_{t+i}^{U.S} + \sum_{j=0}^{1} \beta_j \Delta y_{t-j}^{U.S.10-year} + \left(\sum_{k=0}^{2} \beta_k \left(Dummy_{t+k}^{U.S.} \right) * \Delta y_t^{U.S.10-year} \right) + \left(\sum_{n=0}^{2} \beta_n \left(Dummy_{t+n}^{U.S} \right) * \Delta y_{t-1}^{U.S.10-year} \right) + \beta_m' Controlvariables_t + \varepsilon_t \tag{3.12}$$

$$\Delta y_t^{e,n} = \beta_0 + \sum_{i=0}^{2} \beta_i \,\mathrm{Dummy}_{t+i}^{U.S.} + \sum_{j=0}^{1} \beta_j \Delta y_{t-j}^{U.S.10-year} + \left(\sum_{k=0}^{2} \beta_k \left(Dummy_{t+k}^{U.S} \right) * \Delta y_t^{U.S.10-year} \right) + \left(\sum_{n=0}^{2} \beta_n \left(Dummy_{t+n}^{U.S} \right) * \Delta y_{t-1}^{U.S.10-year} \right) + \beta_m' Controlvariables_t + \varepsilon_t \tag{3.13}$$

$$\Delta y_t^{p,n} = \beta_0 + \sum_{i=0}^{2} \beta_i Dummy_{t+i}^{U.S} + \sum_{j=0}^{1} \beta_j \Delta y_{t-j}^{U.S.10-year} + \left(\sum_{k=0}^{2} \beta_k \left(Dummy_{t+k}^{U.S} \right) * \Delta y_t^{U.S.10-year} \right) + \left(\sum_{n=0}^{2} \beta_n \left(Dummy_{t+n}^{U.S} \right) * \Delta y_{t-1}^{U.S.10-year} \right) + \beta_m' Controlvariables_t + \varepsilon_t \tag{3.14}$$

Where, $\sum_{\mathrm{j}=0}^{1} \left(\Delta y_{t-j}^{U.S.10-year} \right)$ are the changes of U.S. 10-year Treasury yield curve and first order lag of change of U.S.10-year Treasury yield curve respectively and consider as U.S. monetary policy shock to the Indian bond market. Under these two different strategies, this study captures the impact of U.S. Quantitative Easing on Indian Government bond yields, yield expectation, and risk premia. A wide range of control variables is added to this regression analysis. The first set of control variables are the key Indian monetary policy indicators like Repo rate (RR), Reverse repo and Cash reserve ratio (CRR). To see the lasting effect two lagged terms of dummy variables of these monetary policy indicators are included. Another set of control variables are added from the Indian Stock market which is daily log return of National Stock Exchange Index benchmark market index, i.e. NIFTY 50 and the change in the daily log return of NIFTY 50. U.S.-India daily exchange rate is also included in this study and at last the change in one day lag of dependent variable is added in the regression equations in order to capture the first order autoregression.

4 EMPIRICAL RESULTS AND DISCUSSION

This section discusses the estimation results from event study methodology, DNS estimation, and regression analysis respectively. The last section of this chapter covers results and findings.

4.1 Event Study Results

Following [4] and [15], one-day and two-day window periods is used to capture the changes in Indian treasury yield, yield expectation, and risk premia. As shown in Table 4, the U.S. Treasury yield changes during the QE1 period are much larger than any other periods by the Federal Reserve QE announcements.

It is shown that in QE1, U.S. 5-year, 7-year, and 10-year Treasury yield curve significantly dropped by 95, 101 and 99 basis points. While the movement in QE2 and QE3 was relatively very lower. APPENDIX(B) contains graphical representation of event study results of U.S. and Indian bond markets.

To observe the response in the Indian treasury yield curves during QE announcement periods, this study constructs the event study tables for one-day and two-day window interval.

Following U.S, Indian Treasury yields have also dropped after the first three announcements but in a milder degree. However, on November 28, 2008, RBI announced downward revision in deposit rate and Prime lending rates and on December 08, 2008 RBI announced to reduce Repo rates and Reverse repo rates. As these are the key monetary policy indicators of the Indian economy, it is believed that reduction in these rates exerts influence on Indian Treasury yields. After the fourth QE announcement on January 28, 2009, U.S. 10-year Treasury yield increased dramatically as the Fed failed to announce a purchase, disappointing markets and raising yields significantly. We can find the same reactions in India as Indian 10-year Treasury yield has increased at a higher degree of 9.1 bps and 14.3 bps in one-day and two-day window respectively. On March 18, 2009, Fed confirmed the purchase of long-term Treasury bonds and the U.S. 10-year Treasury yield experienced the most dramatic drop of 26 bps. However, Indian 10-year yield dropped by only 5.6 bps after the 5th QE announcement. Although in other QE1 announcements U.S. 10-year Treasury yields did not change significantly, and changes of Indian 10-year Treasury yield followed the same direction except 7th QE announcement in two-day window with the U.S. In total, announcements during the QE1 periods reduce U.S. 10-year yields by 99 basis points while Indian 10-year yield reduces 17.5 basis points in one-day and 24.5 basis points in two-day window periods. On September 21, 2011, the Fed decided to purchase 400 billion Treasury bonds with maturities between 6 and 30-year in total before the end of July 2012 and sell the same amount of Treasury bonds with maturity less than 3-year. This announcement reduced the U.S.10-year Treasury yield and Indian short-term yields fell more than the long-term yields in the two-day window period.

In general, it is observed that Indian 10-year Treasury yield reacted to U.S. QE announcements in a similar trend with the U.S. Treasury 10-year yield. Overall we observed from Table 5 and 6 that the responses in Indian bond yields changes are bigger in the two-day than one-day window periods especially in QE1.

Table 7 and 8 report the summary of one-day and two-day window period changes in Indian Treasury yields expectation. According to event study results, the response in the two-day window period is bigger for medium and long-term yield expectations during QE1 period. In two-day window period Indian 10-year expected yield dropped by 51.9 and 25.6 bps during 2nd and 3rd QE announcements. The Indian 10-year expected Treasury yield curve is reduced by 14.9 basis points and 89.9 basis points in QE1 events of one-day and two-day window periods, showing the downward movement in the same direction with U.S. 10-year treasury yield curve.

Table 9 and 10 shows the changes in risk premia in one-day and two-day window periods after QE announcements. According to results, it can be viewed that the risk premium of Indian 10-year Treasury curve changes downward to 16.9 basis points and 26.2 basis points in one-day and two-day window periods and overall QE1. Short-term risk premia dropped higher than medium and long-term risk premia in one-day window period during QE1. From event study analysis, it is very much clear that the changes in yield expectation are larger than the changes in risk premia in overall QE announcements which indicates greater signaling effect than portfolio balance effect.

4.2 DNS Estimation Results

[18] proposed a model called Dynamic Nelson-Siegel model which allows the parameters $L_t,\ S_t,\ C_t$ to vary over time and making it dynamic with additional parameters time t. Following [18], this study derived the value of lambda (λ) as 0.0609.

After getting the estimated values of parameters from the above model, the two-step estimation approach by Diebold and Li (2006) is introduced by fitting the data into vector autoregression (VAR) to capture the linkage between the U.S. and Indian Bond Market.

Table 12 shows the Augmented Dicky- fuller test for level, slope and curvature respectively and found that all these variables are stationary. In Table 13, we have shown the optimal lag selection criteria for VAR process, using varsoc command and found that the optimum lag selection criteria for VAR process is significant at Lag order one for Akaike Information Criterion (AIC) , Hannan-Quinn Information Criterion (HQIC) and Schwarz-Bayesian Information Criterion (SBIC). Therefore, this study choses Lag order of one based on AIC and SBIC criteria. Table 14 show the estimation results from VAR model with the exogenous variable $\Delta y_{t-1}^{U.S.10-year}$ which is the one day lag of 10-year U.S. treasury yield change. This exogenous variable is very important as it indicates the impact of US policy shocks on the level, slope, and curvature of Indian Bond yields which is estimated through the DNS model in the first step. The bold values in the diagonal represent the persistency of each factor, Level, slope and curvature dynamics and it is observed that slope seems to be more volatile shocks among the DNS model. All the eigenvalues are within one which indicates that the VAR model is stationary. The coefficients of the exogenous variable $\Delta y_{t-1}^{U.S.10-year}$ is significant indicating that the impact of financial crisis period which is during the early phase of QE1, the U.S. bond yields changes affect the Indian long-term bond yield.

4.3 Regression Analysis with Additional Controls

All the regression Tables of Indian observed yields, yield expectations, and risk premia are reported in APPENDIX(A). Table 15 and 16 reports the regression results of daily changes in observed Indian yields, on U.S. QE announcements dummies under two different strategies discussed in section 3.4 respectively. For brevity, we only report the estimated coefficients on QE event dummies in regression Tables.

In Table 15, QE announcements seem to decrease Indian yields. This study includes only 20 QE events from the literature. The regression analysis shows that changes in Indian 3-year and 5-year observed yields have a significant impact of QE events in the one-day window period while on same day Indian 5-year Treasury yield has an impact of QE announcements and two after QE announcements have no impact on Indian Treasury yields.

The results of Table 16 are more intuitive as by assigning a proxy for U.S. monetary policy shock and introducing interaction terms have produced very remarkable and consistent results. $(\Delta y_{t+1}^{U.S.10-year})$ has a higher significant impact on medium-term and long-term Treasury yields. The interaction effect is quite significant on different bond yields at different maturities, which indicates that with U.S. monetary policy shocks QE events have a significant impact on Indian Treasury yields of medium-term and long-term maturities. More precisely, Table 16 portrayed better estimates of QE announcements effect on Indian Treasury bond yields indicating second strategy more effective for this research study.

We put more focus on regression analysis of yield expectations and risk premia as to measure signaling and portfolio balance effect. The impact of U.S QE announcements on yield expectation measures signaling effect while the impact on risk premia measures portfolio balance effect. Tables 17 and 18 show the effects of U.S. QE announcements on yield expectations under two different strategies. In Table 17, $Dummy_{t+2}^{U.S.}$ significantly decrease the yield expectations of medium-term and long-term maturities while $Dummy_{t+1}^{U.S.}$ only affects Indian 10-year Treasury yield curve and $Dummy_{t}^{U.S.}$ remains insignificant at all levels.

In Table 18, we observed that the interaction effects of $Dummy_t^(U.S.) * \Delta y_{t-1}^{U.S.10-year}$ is significant for yield expectations and seems that QE announcements have significantly decrease yield expectations of medium-term and long-term Treasury yields, concluding that with U.S. monetary policy shock QE announcements have significantly decreased yield expectations within the first day. These coefficients of interaction effects are higher in Table 18 than Table 19 indicating second strategy provides broader picture of QE announcements effect on Indian Treasury yields with better statistical results.

In Table 19, $Dummy_t^{U.S.}$ has significant impact only on 5-year risk premium within one day and $Dummy_{t+2}^{U.S.}$ significantly affects the risk premium of 10-year bond yield. The overall impact of $Dummy_{t+1}^{U.S.}$ remain insignificant for risk premia.

In Table 20, the U.S. monetary policy effect $(\Delta y_{t-1}^{U.S.10-year})$ is positive significant for short-term and medium-term risk premia with consistency in signs, while different interaction effects have a significant impact on risk premia at different maturities. Unlike yield expectations, the interaction effect of QE announcements on risk premia is different at different maturities.

Finally, we see more consistent and robust regression results of QE announcements on yield expectations, concluding greater signaling effect than portfolio balance effect on the Indian bond market.

4.4 Discussions

The strong trade relationship between India and the U.S. has shown a strong correlation between both markets. The large and structured Economy of the U.S. indicated that there must be a relationship in bond yields returns across global markets driven by the U.S. macroeconomic shocks beyond macroeconomic news announcement. This study observed that the event study provides a better picture to capture the reactions of the Indian bond market around U.S. QE announcement days. The two-day interval window of observed Indian yields, yield expectations, and risk premia are provided with meaningful results. The two-day window has shown a more significant impact than one-day window periods with more consistent results. The change on the yield expectation of Indian 10-year and 3-months Treasury yield curves is larger than change in risk premium in QE1 period of two-day window period, which is showing the effect on expected future short rates are higher than the term premia. Therefore, QE announcements have greater signaling effect than portfolio balance effect. The regression analysis also supports our event study results. By decomposing the observed yields into yield expectations and risk premia, regressions provide statistical support that the decline in the bond yield is primarily because of the sharp decline of the average expected short-rates and not because of reduced term premiums. The effect of QE announcements on India average expected short rates are higher than QE effects on reduced term premiums. In this case, the Reserve Bank of India might have protected the Indian economy by taking a necessary monetary policy that contributes to lowering long-term interest rates expectations. Adding interaction terms makes regression analysis more meaningful with event studies results. The interaction effect particularly implies that during the financial crisis not only U.S. unconventional monetary policy but also U.S. conventional monetary policy has a significant impact on Indian bond market.

The DNS estimation results on U.S. 10-year Treasury yield change as an exogenous variable to Indian government bond yields is statistically significant for Indian long-term yields. This may indicate that long-term interest rates being sensitive to macroeconomic shocks during the financial crisis.

5 CONCLUSIONS

This study quantified the impact of U.S. Quantitative Easing (QE) policy announcements on Indian bond market in three steps: decomposing Treasury yield into yield expectation and risk premia , using event study methodology to capture the changes in Indian Treasury yield, yield expectation and risk premia around the announcement dates and regression analysis to support event study and to measure signaling and portfolio balance effect of U.S. Quantitative Easing (QE) and at last using Dynamic Nelson Siegel (DNS) model for Indian bond yields with 10-year U.S. Treasury yield changes as an exogenous variable to capture the financial linkages between Indian and U.S. Bond markets.

The preliminary results from the event study suggested that the changes in Indian Treasury yield, yield expectation and risk premia around QE announcement days are quite significant especially QE1 periods. However, the impact of QE was more substantial in the two-day window period for Indian Treasury yield while changes in yield expectation are more significant than the risk premia in overall QE events, indicating greater signaling effect.

Literature has documented a significant spillover effect of U.S QE announcements on EMEs financial markets. This research work contributes to the literature on the spillover effects on the Indian bond market in detail. By decomposing Indian Treasury yield into yield expectation and risk premia, this paper measures signaling and portfolio balance effects respectively. Regression analysis of U.S. QE on yield expectation and risk premia provides statistical evidence that the signaling effect is larger than the portfolio balance effect on the Indian bond market.

To analyze the significant relationship between Indian and U.S. bond market, the DNS model consists of Indian government bonds yield was constructed using VAR regression on the changes of U.S. 10-year treasury yield. The statistical results show that the U.S. QE news announcement affects the Indian government bond yields, especially on long-term Treasury yield during the financial crisis.

This study may be extended in the future by incorporating some macroeconomic variables into the yield curve models. The DNS model used in this study may be extended by combining it with VAR dynamics of macroeconomic variables such as inflation and exchange rate. The decomposition of Indian Treasury yield into yield expectation and risk premia is done in the presence of no arbitrage framework. Christenson.et.al (2011) develop a new class of affine arbitrage-free model (AFNS) based on DNS model in continuous time, Hong.et.al (2016) proposed discrete arbitrage-free Nelson-Siegel term structure model to decompose yield curve into yield expectation and risk premia which can be used in future to measure signaling and portfolio balance effect under arbitrage-free framework in both discrete and continuous time.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX(A)

Table 4. U.S. Treasury Yields Changes Following the QE Announcements

		Bond Maturity											
Event	Date	1 Month	3 Months	6 Months	1 Year	2 Years	3 Years	5 Years	7 Years	10 Years	20 Years	30 Years	Unit
QE1	25-Nov-08	3	-3	-1	0	-16	-12	-18	-22	-24	-16	-15	bps [t]
QE1	1-Dec-08	7	6	0	-9	-10	-11	-22	-22	-21	-20	-23	bps
QE1	16-Dec-08	5	1	-5	-5	-10	-14	-16	-15	-16	-13	-12	bps
QE1	28-Jan-09	3	6	1	1	2	7	11	11	12	16	18	bps
QE1	18-Mar-09	1	-3	-5	-9	-23	-31	-46	-53	-51	-34	-26	bps
QE1	12-Aug-09	0	-1	0	-1	-3	-2	1	3	1	9	9	bps
QE1	4-Nov-09	1	-1	-1	-2	-1	0	3	4	7	7	7	bps
QE1	10-Aug-10	1	0	0	-1	-2	-3	-8	-7	-7	-3	-1	bps [b]
QE1	**Total**	**21**	**5**	**-11**	**-26**	**-63**	**-66**	**-95**	**-101**	**-99**	**-54**	**-43**	**bps**
QE2	27-Aug-10	0	-1	0	2	5	6	11	12	16	16	16	bps [t]
QE2	21-Sep-10	0	0	0	0	-4	-5	-9	-11	-11	-8	-8	bps
QE2	15-Oct-10	-1	0	0	0	-1	-1	2	5	7	8	7	bps
QE2	3-Nov-10	0	0	0	0	0	-2	-4	-2	4	13	16	bps
QE2	22-Jun-11	0	-1	-1	-2	-1	-1	1	2	2	1	1	bps
QE2	13-Jul-11	0	-2	-2	-2	0	-1	-2	-2	0	-1	-2	bps
QE2	21-Sep-11	1	0	1	2	3	7	3	-3	-7	-13	-17	bps
QE2	20-Jun-12	0	0	2	2	2	2	3	3	1	-5	-3	bps [b]
QE2	**Total**	**0**	**-4**	**0**	**2**	**4**	**5**	**5**	**4**	**12**	**11**	**10**	**bps**
QE3	12-Dec-12	0	-1	-3	-2	1	0	2	5	6	-2	-6	bps [t]
QE3	18-Sep-13	0	0	0	-1	-5	-11	-19	-21	-17	-11	-9	bps
QE3	18-Dec-13	-1	0	1	-1	-2	-1	3	4	4	3	2	bps
QE3	29-Jan-14	-1	-1	0	0	-2	-4	-7	-7	-8	-7	-6	bps [b]
QE3	**Total**	**-2**	**-2**	**-2**	**-4**	**-8**	**-16**	**-21**	**-19**	**-15**	**-17**	**-19**	**bps**

Source: FOMC release report dates selection is based on Neely (2010) and Gagnon (2012).QE=Quantitative Easing; bps=basis point (1bps=0.01%)

Table 5. Indian Bond Yields Changes One-Day after QE Announcements

		Bond Maturity							
Event	Date	3 Months	6 Months	1 Year	2 Years	3 Years	5 Years	10 Years	Unit
QE1	26-Nov-08	5	5	0.9	5.1	-9.8	-1.3	-16.4	bps [t]
QE1	2-Dec-08	-5	-10	-19	17.9	-4.9	-3.8	-7	bps
QE1	17-Dec-08	-7	-7	4.9	-8.4	-6.4	-18.6	7.8	bps
QE1	29-Jan-09	5	0	5.1	-2.7	-0.1	-3.4	9.1	bps
QE1	19-Mar-09	5	0	12.7	-0.1	3.4	-14.7	-5.6	bps
QE1	13-Aug-09	5	2	-6.4	-0.6	3.9	2.1	-0.4	bps
QE1	5-Nov-09	-3.5	-1	-11.3	-3.6	-1.4	-3.5	-3.4	bps
QE1	11-Aug-10	10	0	-5.5	-3.2	-5.5	-9.9	-1.6	bps [b]
QE1	**Total**	**14.5**	**-11**	**-18.6**	**4.4**	**-20.8**	**-53.1**	**-17.5**	**bps**
QE2	30-Aug-10	-10	-10	-3.7	0	-6	0	1.7	bps [t]
QE2	22-Sep-10	0	0	-0.9	-0.7	-3.4	-1.2	-1.5	bps
QE2	18-Oct-10	10	10	4.8	-0.7	0.4	3.5	2.5	bps
QE2	4-Nov-10	-5	0	-4.4	1.2	3.1	6	3	bps
QE2	23-Jun-11	1	-3	0.5	-1.2	-1.9	0.1	-2.1	bps
QE2	14-Jul-11	0	-5	2	0.4	-0.3	-0.2	3.1	bps
QE2	22-Sep-11	-5	2	4.9	0.3	-1.5	-2	0.2	bps
QE2	21-Jun-12	0	5	-6.1	-0.5	-1.1	-2.7	-4.3	bps [b]
QE2	**Total**	**-9**	**-1**	**-2.9**	**-1.2**	**-10.7**	**3.5**	**2.6**	**bps**
QE3	13-Dec-12	-2	-1	-1.2	-0.8	-0.4	-1.9	-1.9	bps [t]
QE3	19-Sep-13	-54	-42	-17.6	-19	-26.9	-22.5	-17.7	bps
QE3	19-Dec-13	1	0	-8.2	-9.7	3.8	-6.1	-4.3	bps
QE3	30-Jan-14	0	8	-4.2	-5.1	-3.9	4.2	4.6	bps [b]
QE3	**Total**	**-55**	**-35**	**-31.2**	**-34.6**	**-27.4**	**-26.3**	**-19.3**	**bps**

Source: FOMC release report dates selection is based on Neely (2010) and Gagnon (2012).QE=Quantitative Easing; bps=basis point (1bps=0.01%).

Table 6. Indian Bond Yields Changes Two-Days after QE Announcements

		Bond Maturity							
Event	Date	3 Months	6 Months	1 Year	2 Years	3 Years	5 Years	10 Years	Unit
QE1	28-Nov-08	20	15	0.7	1.3	-14.5	-2.6	-12.3	bps [t]
QE1	3-Dec-08	-40	-45	-56	-24.1	-29.4	-18.7	-22.1	bps
QE1	18-Dec-08	-30	-27	-5.2	-10.9	-10.8	-50.6	-1.6	bps
QE1	30-Jan-09	0	0	-1.2	-0.7	-2	3	14.3	bps
QE1	20-Mar-09	-5	-10	11.8	-6	-0.3	-8.5	5.6	bps
QE1	14-Aug-09	5	0	-8.3	0.6	5.6	10.3	5	bps
QE1	6-Nov-09	-0.9	0	-6.6	-17.7	-8.7	-7.9	-12.7	bps
QE1	12-Aug-10	20	0	2.8	-3.9	-4	-6.9	-0.7	bps [b]
QE1	**Total**	**-30.9**	**-67**	**-62**	**-61.4**	**-64.1**	**-81.9**	**-24.5**	**bps**
QE2	31-Aug-10	-10	-5	1.5	-2.7	-4.5	-4.8	-4	bps [t]
QE2	23-Sep-10	5	0	-1.9	-0.8	-1.1	-1	-4.3	bps
QE2	19-Oct-10	15	10	3.8	0.6	0.8	1.7	1.6	bps
QE2	8-Nov-10	0	5	-5.5	11.9	9.9	5.7	5.7	bps
QE2	24-Jun-11	0	0	-0.5	0.4	-0.6	0.9	-0.6	bps
QE2	15-Jul-11	-5	-5	-0.5	1.6	0.7	-2.8	0.3	bps
QE2	23-Sep-11	-5	5	0.1	-1.3	-2.8	-3.1	1.1	bps
QE2	22-Jun-12	0	0	0.7	-2.8	-1	-3.4	-3.9	bps [b]
QE2	**Total**	**0**	**10**	**-2.3**	**6.9**	**1.4**	**-6.8**	**-4.1**	**bps**
QE3	14-Dec-12	-1	0	-10.5	0.3	-2.4	-6.6	-3.7	bps [t]
QE3	20-Sep-13	-65	-48	-6	4.3	-4	13.9	20.3	bps
QE3	20-Dec-13	1	1	-0.9	-0.6	6.2	-1.5	0.8	bps
QE3	31-Jan-14	0	10	-2.8	-4.7	-3.8	2.7	1.1	bps [b]
QE3	**Total**	**-65**	**-37**	**-20.2**	**-0.7**	**-4**	**8.5**	**18.5**	**bps**

Source: FOMC release report dates selection is based on Neely (2010) and Gagnon (2012).QE=Quantitative Easing; bps=basis point (1bps=0.01%).

Table 7. Indian Expected Yields Changes One-Day after QE Announcements

		Bond Maturity							
Event	Date	3 Months	6 Months	1 Year	2 Years	3 Years	5 Years	10 Years	Unit
QE1	26-Nov-08	4.8	5.2	5.2	6.3	6.4	5.9	3.8	bps [t]
QE1	2-Dec-08	-13.5	-12.6	-10.3	-8.8	-7.3	-5.4	-3.5	bps
QE1	17-Dec-08	-1.6	-2.3	-3.1	-5.4	-6.7	-8.3	-9.7	bps
QE1	29-Jan-09	6.6	5.9	4.4	2.9	1.7	0.4	-0.6	bps
QE1	19-Mar-09	5.4	5.7	5.7	6.9	7.1	6.8	5.3	bps
QE1	13-Aug-09	2.6	2.3	1.9	1.4	1.1	0.7	0.3	bps
QE1	5-Nov-09	-3.9	-4.1	-4	-4.9	-5.3	-5.7	-6.2	bps
QE1	11-Aug-10	8.8	7.9	5.9	3.6	1.7	-0.9	-4.3	bps [b]
QE1	**Total**	**9.2**	**8.1**	**5.7**	**2**	**-1.2**	**-6.5**	**-14.9**	**bps**
QE2	30-Aug-10	-10.8	-10.7	-9.6	-9.9	-9.4	-8.7	-7.2	bps [t]
QE2	22-Sep-10	0.6	0.5	0.2	-0.2	-0.5	-0.9	-1.5	bps
QE2	18-Oct-10	12.6	12	10.2	9.5	8.4	7	5.2	bps
QE2	4-Nov-10	-5.2	-5	-4.3	-3.9	-3.3	-2.3	-0.6	bps
QE2	23-Jun-11	-0.4	-0.4	-0.4	-0.5	-0.6	-0.8	-1	bps
QE2	14-Jul-11	-1.6	-1.6	-1.5	-1.7	-1.6	-1.5	-1	bps
QE2	22-Sep-11	-1.4	-1.2	-0.8	-0.2	0.1	0.5	0.8	bps
QE2	21-Jun-12	1.4	1.3	1.1	0.8	0.5	0	-1	bps [b]
QE2	**Total**	**-4.8**	**-5.1**	**-5**	**-6.1**	**-6.4**	**-6.6**	**-6.3**	**bps**
QE3	13-Dec-12	-2	-1.9	-1.6	-1.5	-1.4	-1.3	-1.2	bps [t]
QE3	19-Sep-13	-52.5	-51.4	-45.6	-46.5	-44.5	-42	-38.6	bps
QE3	19-Dec-13	0.2	-0.2	-0.7	-1.9	-2.7	-3.7	-5.1	bps
QE3	30-Jan-14	5.1	4.3	2.8	0.9	-0.4	-1.9	-3	bps [b]
QE3	**Total**	**-49.2**	**-49.1**	**-45**	**-49**	**-48.9**	**-48.8**	**-48**	**bps**

Source: FOMC release report dates selection is based on Neely (2010) and Gagnon (2012).QE=Quantitative Easing; bps=basis point (1bps=0.01%).

Table 8. Indian Expected Yields Changes Two-Days after QE Announcements

		Bond Maturity							
Event	Date	3 Months	6 Months	1 Year	2 Years	3 Years	5 Years	10 Years	Unit
QE1	28-Nov-08	22.6	21.6	18.4	16.7	14.2	10.4	4.4	bps [t]
QE1	3-Dec-08	-49.3	-49.7	-46	-51.3	-51.9	-52.5	-51.9	bps
QE1	18-Dec-08	-25.5	-25.4	-23	-24.8	-24.8	-25	-25.6	bps
QE1	30-Jan-09	2.4	1.5	0.3	-1.7	-2.8	-3.7	-3.5	bps
QE1	20-Mar-09	-3.8	-3.8	-3.5	-3.9	-3.9	-3.8	-3.4	bps
QE1	14-Aug-09	0.8	0.5	0.1	-0.5	-0.7	-0.7	0.2	bps
QE1	6-Nov-09	1.9	1.1	-0.1	-2.6	-4.3	-6.9	-10.5	bps
QE1	12-Aug-10	16.8	15.6	12.7	10.3	7.9	4.6	0.4	bps [b]
QE1	**Total**	**-34.2**	**-38.6**	**-41.3**	**-57.9**	**-66.3**	**-77.4**	**-89.9**	**bps**
QE2	31-Aug-10	-8	-7.6	-6.5	-6.1	-5.5	-4.9	-4.4	bps [t]
QE2	23-Sep-10	3.1	2.9	2.5	2.2	1.8	1.2	0.1	bps
QE2	19-Oct-10	15.8	15.1	12.8	11.9	10.5	8.7	6.1	bps
QE2	8-Nov-10	-2.1	-1.5	-0.6	1.1	2.3	4.1	6.5	bps
QE2	24-Jun-11	-0.2	-0.2	-0.1	-0.1	-0.1	0	0	bps
QE2	15-Jul-11	-6	-5.7	-4.8	-4.2	-3.5	-2.7	-1.6	bps
QE2	23-Sep-11	0.1	0	-0.1	-0.5	-0.7	-1.1	-1.4	bps
QE2	22-Jun-12	0.5	0.5	0.4	0.4	0.2	-0.1	-0.8	bps [b]
QE2	**Total**	**3.1**	**3.5**	**3.6**	**4.7**	**5**	**5.2**	**4.5**	**bps**
QE3	14-Dec-12	-1.6	-1.8	-1.9	-2.6	-3	-3.6	-4.5	bps [t]
QE3	20-Sep-13	-67.9	-65.4	-56.5	-53.5	-47.5	-38.4	-24	bps
QE3	20-Dec-13	0.1	0.2	0.3	0.7	0.9	1.1	1.4	bps
QE3	31-Jan-14	5.8	5.1	3.9	2.5	1.4	0	-1.5	bps [b]
QE3	**Total**	**-63.7**	**-61.8**	**-54.1**	**-52.9**	**-48.2**	**-40.9**	**-28.5**	**bps**

Source: FOMC release report dates selection is based on Neely (2010) and Gagnon (2012).QE=Quantitative Easing; bps=basis point (1bps=0.01%).

Table 9. Indian Risk Premia Changes One-Day after QE Announcements

		Bond Maturity							
Event	Date	3 Month	6 Months	1 Year	2 Years	3 Years	5 Years	10 Years	Unit
QE1	26-Nov-08	-0.2	-4.3	-1.2	-16.2	-7.2	-20.2	-3.5	bps [t]
QE1	2-Dec-08	2.6	-8.7	26.7	2.4	1.6	-3.5	4.8	bps
QE1	17-Dec-08	-4.7	8	-3	0.3	-10.3	17.5	-4.6	bps
QE1	29-Jan-09	-5.9	0.7	-5.6	-1.8	-3.8	9.7	-0.8	bps
QE1	19-Mar-09	-5.7	7	-7	-3.7	-21.5	-10.9	-13.3	bps
QE1	13-Aug-09	-0.3	-8.3	-2	2.8	1.4	-0.7	0.6	bps
QE1	5-Nov-09	3.1	-7.3	1.3	3.9	2.2	2.8	4.1	bps
QE1	11-Aug-10	-7.9	-11.4	-6.8	-7.2	-9	2.7	-4.2	bps [b]
QE1	**Total**	**-19.1**	**-24.3**	**2.4**	**-19.6**	**-46.6**	**-2.6**	**-16.9**	**bps**
QE2	30-Aug-10	0.7	5.9	9.9	3.4	8.7	8.9	2.4	bps [t]
QE2	22-Sep-10	-0.5	-1.1	-0.5	-2.9	-0.3	0	3.6	bps
QE2	18-Oct-10	-2	-5.4	-10.2	-8	-3.5	-2.7	-0.6	bps
QE2	4-Nov-10	5	-0.1	5.1	6.4	8.3	3.6	9.1	bps
QE2	23-Jun-11	-2.6	0.9	-0.7	-1.3	0.9	-1.1	-5.5	bps
QE2	14-Jul-11	-3.4	3.5	2.1	1.3	1.3	4.1	-2.5	bps
QE2	22-Sep-11	3.2	5.7	0.5	-1.6	-2.5	-0.6	6.5	bps
QE2	21-Jun-12	3.7	-7.2	-1.3	-1.6	-2.7	-3.3	4.1	bps [b]
QE2	**Total**	**4.1**	**2.1**	**4.9**	**-4.3**	**10.1**	**8.9**	**17.1**	**bps**
QE3	13-Dec-12	0.9	0.4	0.7	1	-0.6	-0.7	0.6	bps [t]
QE3	19-Sep-13	9.4	28	27.5	17.6	19.5	20.9	11	bps
QE3	19-Dec-13	0.2	-7.5	-7.8	6.5	-2.4	0.8	1.1	bps
QE3	30-Jan-14	3.7	-7	-6	-3.5	6.1	7.6	-0.3	bps [b]
QE3	**Total**	**14.1**	**13.8**	**14.4**	**21.5**	**22.5**	**28.7**	**12.5**	**bps**

Source: FOMC release report dates selection is based on Neely (2010) and Gagnon (2012).QE=Quantitative Easing; bps=basis point (1bps=0.01%).

Table 10. Indian Risk Premia Changes Two-Days after QE Announcements

		Bond Maturity							
Event	Date	3 Months	6 Months	1 Year	2 Years	3 Years	5 Years	10 Years	Unit
QE1	28-Nov-08	-6.6	-17.7	-15.4	-28.7	-13	-16.7	-9.9	bps [t]
QE1	3-Dec-08	4.7	-10	27.2	22.5	33.8	29.8	6.9	bps
QE1	18-Dec-08	-1.6	17.8	13.9	14	-25.6	24	-1.5	bps
QE1	30-Jan-09	-1.5	-1.5	1	0.8	6.7	17.8	3.5	bps
QE1	20-Mar-09	-6.2	15.3	-2.1	3.6	-4.7	9	-13.7	bps
QE1	14-Aug-09	-0.5	-8.4	1.1	6.3	11	4.8	0.4	bps
QE1	6-Nov-09	-1.1	-6.5	-15.1	-4.4	-1	-2.2	0	bps
QE1	12-Aug-10	-15.6	-9.9	-14.2	-11.9	-11.5	-1.1	-11.9	bps [b]
QE1	**Total**	**-28.4**	**-20.7**	**-3.5**	**2.2**	**-4.5**	**65.4**	**-26.2**	**bps**
QE2	31-Aug-10	2.6	8	3.4	1	0.1	0.4	4.3	bps [t]
QE2	23-Sep-10	-2.9	-4.4	-3	-2.9	-2.2	-4.4	1.1	bps
QE2	19-Oct-10	-5.1	-9	-11.3	-9.7	-7	-4.5	-3.6	bps
QE2	8-Nov-10	6.5	-4.9	10.8	7.6	1.6	-0.8	10.6	bps
QE2	24-Jun-11	0.2	-0.4	0.5	-0.5	0.9	-0.6	-2.7	bps
QE2	15-Jul-11	0.7	4.3	5.8	4.2	-0.1	1.9	1.6	bps
QE2	23-Sep-11	5	0.2	-0.8	-2.1	-2	2.5	8.3	bps
QE2	22-Jun-12	-0.5	0.3	-3.2	-1.2	-3.3	-3.1	0	bps [b]
QE2	**Total**	**6.5**	**-5.9**	**2.2**	**-3.6**	**-12**	**-8.6**	**19.6**	**bps**
QE3	14-Dec-12	1.8	-8.6	2.9	0.6	-3	0.8	1.5	bps [t]
QE3	20-Sep-13	17.4	50.5	57.8	43.5	52.3	44.3	19.1	bps
QE3	20-Dec-13	0.8	-1.2	-1.3	5.3	-2.6	-0.6	1.7	bps
QE3	31-Jan-14	4.9	-6.7	-7.2	-5.2	2.7	2.6	0.9	bps [b]
QE3	**Total**	**24.8**	**33.9**	**52.2**	**44.2**	**49.4**	**47**	**23.2**	**bps**

Source: FOMC release report dates selection is based on Neely (2010) and Gagnon (2012).QE=Quantitative Easing; bps=basis point (1bps=0.01%).

Table 11. Calculation of Factor Loadings of DNS Model

Maturity (In Months)	Factor Loadings of Level	Factor Loadings of Slope	Factor Loadings of Curvature
1	1	0.970159	0.029242 [t]
3	1	0.913968	0.08095
6	1	0.83766	0.143741
12	1	0.709464	0.227941
24	1	0.525544	0.293679
36	1	0.405196	0.293547
60	1	0.266588	0.240701
84	1	0.194307	0.188305
120	1	0.136745	0.136074 [b]

Table 12. ADF Test for Level, Slope and Curvature

Variables	t-stats	p-value
L_t	-3.631	**0.0002** [t]
S_t	-3.442	**0.0004**
C_t	-3.052	**0.0012** [b]

Table 13. Optimum Lag-Selection Criteria

Lag order(s)	p-value	AIC	HQIC	SBIC
0		6.23362	6.26142	6.30223 [t]
1	0.004	**-8.29667***	**-8.09288***	**-7.78881***
2	0.189	-8.13185	-8.04651	-7.67919
3	0.206	-8.09124	-7.93004	-7.39946
4	0.335	-8.01452	-7.75919	-7.06536 [b]

$^{***}p < 0.01,\ ^{**}p < 0.05,\ ^{*}p < 0.1$

Table 14. DNS Estimation with Exogenous Variable

2[4]*Independent Variable(s)	Dependent Variable(s)		
	L_t	S_t	C_t
2[1]*L_{t-1}	0.982***	0.023***	0.0068 [t]
	(0.006)	(0.008)	(0.023)
2[0]*S_{t-1}	0.004**	0.998***	-0.0096
	-0.002	-0.003	-0.007
2[0]*C_{t-1}	0.0082***	0.010***	0.965***
	(0.003)	(0.004)	(0.011)
2[0]*$\Delta y_{t-1}^{10y,US}$	0.139***	-0.093	0.057
	(0.050)	(0.062)	(0.178)
2[1]*Constant	0.159***	-0.184***	-0.103
	(0.054)	(0.066)	(0.191) [b]
Eigenvalue	0.998	0.984	0.962

Note: Standard errors are in parentheses.

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 15. Regression of Indian Bonds Yields Changes on U.S. QE Announcements

2[4]*Independent Variable(s)	Dependent Variable(s)						
	3 Months	6 Months	1 Year	2 Years	3 Years	5 Years	10 Years
2[0]*$Dummy_t^{U.S.}$	0.005	-0.005	-0.018	0.001	-0.02	**-0.027***	-0.005
	(0.026)	(0.024)	(0.022)	(0.018)	(0.015)	(0.015)	(0.016)
2[0]*$Dummy_{t+1}^{U}.S.$	-0.027	-0.028	-0.033	-0.017	**-0.032****	**-0.039*****	-0.02
	(0.026)	(0.024)	(0.022)	(0.018)	(0.015)	(0.015)	(0.016)
2[1]*$Dummy_{t+2}^{U}.S.$	-0.027	-0.027	-0.022	-0.013	-0.004	0.001	0.015
	(0.026)	(0.024)	(0.022)	(0.018)	(0.015)	(0.015)	(0.016) [b]
Observations	1,452	1,452	1,452	1,452	1,452	1,452	1,452

Note: Standard errors are in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. *For brevity, regressions of constant term and control variables are not shown in the table.*

Table 16. Regression of Indian Bond Yields Changes on U.S. QE Announcements Interaction terms

2[4]*Independent Variable(s)	Dependent Variable(s)						
	3 Months	6 Months	1 Year	2 Years	3 Years	5 Years	10 Years
2[1]*$Dummy_t^{U.S.}$	0.004	-0.017	-0.015	0.002	-0.021	-0.02	-0.003 [t]
	(0.028)	(0.025)	(0.023)	(0.019)	(0.016)	(0.015)	(0.017)
2[0]*$Dummy_{t+1}^{U.S.}$	-0.028	-0.03	-0.04	-0.028	-0.028	**-0.032***	-0.014
	(0.030)	(0.027)	(0.025)	(0.021)	(0.017)	(0.016)	(0.018)
2[0]*$Dummy_{t+2}^{U.S.}$	-0.03	-0.028	-0.018	-0.008	5.71E-05	**0.027***	**0.033***
	(0.029)	(0.026)	(0.024)	(0.020)	(0.016)	(0.016)	(0.017)
2[0]*$\Delta y_t^{U.S.}$	-0.002	-0.011	0.011	0.036	0.047	0.036	0.013
	(0.051)	(0.045)	(0.043)	(0.035)	(0.029)	(0.028)	(0.030)
2[0]*$\Delta y_{t-1}^{U.S.}$	0.031	0.054	0.044	**0.118*****	**0.074****	**0.122*****	**0.091*****
	(0.051)	(0.045)	(0.043)	(0.035)	(0.029)	(0.028)	(0.030)
2[0]*$Dummy_t^{U.S.} * \Delta y_t^{U.S.}$	-0.076	-0.229	0.01	-0.042	-0.093	0.072	0.019
	(0.188)	(0.169)	(0.158)	(0.131)	(0.109)	(0.104)	(0.112)
2[0]*$Dummy_{t+1}^{U.S.} * \Delta y_t^{U.S.}$	-0.112	-0.14	-0.056	-0.228	-0.062	-0.175	-0.093
	(0.299)	(0.267)	(0.251)	(0.208)	(0.173)	(0.165)	(0.179)
2[0]*$Dummy_{t+2}^{U.S.} * \Delta y_t^{U.S.}$	0.2	0.099	0.013	-0.019	0.015	**0.535***	0.297
	(0.502)	(0.449)	(0.422)	(0.349)	(0.290)	(0.278)	(0.300)
2[0]*$Dummy_t^{U.S.} * \Delta y_{t-1}^{U.S.}$	-0.079	0.063	**0.770***	**0.555***	**0.918*****	**0.439***	0.303
	(0.473)	(0.423)	(0.397)	(0.329)	(0.274)	(0.262)	(0.283)
2[0]*$Dummy_{t+1}^{U.S.} * \Delta y_{t-1}^{U.S.}$	0.01	-0.01	-0.153	-0.202	0.005	0.106	0.086
	(0.185)	(0.166)	(0.156)	(0.129)	(0.107)	(0.102)	(0.111)
2[1]*$Dummy_{t+2}^{U.S.} * \Delta y_{t-1}^{U.S.}$	-0.204	-0.121	0.079	0.033	0.019	**0.467*****	**0.302***
	(0.297)	(0.266)	(0.250)	(0.207)	(0.172)	(0.164)	(0.178) [b]
Observations	1,452	1,452	1,452	1,452	1,452	1,452	1,452

Note: Standard errors are in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. *For brevity, regressions of constant term and control variables are not shown in the table.*

Table 17. Regression on Expected Yield Changes on U.S. QE Announcements

2[4]*Independent Variable(s)	Dependent Variable(s)						
	3 Months	6 Months	1 Year	2 Years	3 Years	5 Years	10 Years
2[1]*$Dummy_t^{U.S.}$	0.003	0.004	0.005	0.009	0.01	0.012	0.011 [t]
	(0.018)	(0.018)	(0.016)	(0.017)	(0.016)	(0.016)	(0.016)
2[0]*$Dummy_{t+1}^{U.S.}$	-0.012	-0.012	-0.013	-0.017	-0.019	-0.022	**-0.026***
	(0.018)	(0.018)	(0.016)	(0.017)	(0.016)	(0.016)	(0.016)
2[1]*$Dummy_{t+2}^{U.S.}$	-0.025	-0.026	-0.024	**-0.028***	**-0.029***	**-0.030***	**-0.030***
	(0.018)	(0.018)	(0.016)	(0.016)	(0.016)	(0.016)	(0.016) [b]
Observations	1,452	1,452	1,452	1,452	1,452	1,452	1,452

*Note: Standard errors are in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. For brevity, regressions of constant term and control variables are not shown in the table.*

Table 18. Regression of Expected Yield Changes on U.S. QE Announcements Interaction terms

2[4]*Independent Variable(s)	Dependent Variable(s)						
	3 Months	6 Months	1 Year	2 Years	3 Years	5 Years	10 Years
2[1]*$Dummy_t^{U.S.}$	-0.004	-0.004	-0.002	-0.001	-0.006	0.001	0.005 [t]
	(0.020)	(0.019)	(0.017)	(0.018)	(0.017)	(0.017)	(0.017)
2[0]*$Dummy_{t+1}^{U.S.}$	-0.008	-0.01	-0.012	-0.02	-0.024	-0.029	**-0.034***
	(0.021)	(0.020)	(0.018)	(0.019)	(0.018)	(0.018)	(0.018)
2[0]*$Dummy_{t+2}^{U.S.}$	-0.029	-0.03	-0.028	**-0.031***	**-0.031***	**-0.031***	**-0.029***
	(0.020)	(0.020)	(0.017)	(0.018)	(0.018)	(0.017)	(0.017)
2[0]*$\Delta y_t^{U.S.}$	0.011	0.012	0.012	0.017	0.02	0.023	0.027
	(0.036)	(0.035)	(0.031)	(0.032)	(0.031)	(0.031)	(0.030)
2[0]*$\Delta y_{t-1}^{U.S.}$	-0.003	0.001	0.006	0.019	0.029	0.042	**0.062****
	(0.036)	(0.035)	(0.031)	(0.032)	(0.031)	(0.031)	(0.030)
2[0]*$Dummy_t^{U.S.} * \Delta y_t^{U.S.}$	-0.172	-0.185	-0.185	**-0.233***	**-0.249****	**-0.263****	**-0.259****
	(0.133)	(0.129)	(0.115)	(0.119)	(0.116)	(0.114)	(0.112)
2[0]*$Dummy_{t+1}^{U.S.} * \Delta y_t^{U.S.}$	0.13	0.102	0.058	-0.0089	-0.051	-0.1	-0.139
	(0.211)	(0.206)	(0.182)	(0.189)	(0.184)	(0.181)	(0.178)
2[0]*$Dummy_{t+2}^{U.S.} * \Delta y_t^{U.S.}$	0.039	0.041	0.041	0.053	0.062	0.077	0.105
	(0.354)	(0.346)	(0.306)	(0.317)	(0.310)	(0.305)	(0.300)
2[0]*$Dummy_t^{U.S.} * \Delta y_{t-1}^{U.S.}$	-0.122	-0.0921	-0.0451	0.0347	0.0879	0.155	0.23
	(0.334)	(0.325)	(0.289)	(0.299)	(0.292)	(0.287)	(0.283)
2[0]*$Dummy_{t+1}^{U.S.} * \Delta y_{t-1}^{U.S.}$	-0.016	-0.03	-0.045	-0.085	-0.106	-0.127	-0.138
	(0.131)	(0.127)	(0.113)	(0.117)	(0.114)	(0.112)	(0.111)
2[1]*$Dummy_{t+2}^{U.S.} * \Delta y_{t-1}^{U.S.}$	-0.145	-0.146	-0.134	-0.142	-0.136	-0.123	-0.089
	(0.210)	(0.205)	(0.181)	(0.188)	(0.184)	(0.180)	(0.177) [b]
Observations	1,452	1,452	1,452	1,452	1,452	1,452	1,452

*Note: Standard errors are in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. For brevity, regressions of constant term and control variables are not shown in the table.*

Table 19. Regression of Risk Premia Changes on U.S. QE Announcements

2[4]*Independent Variable(s)	Dependent Variable(s)						
	3 Months	6 Months	1 Year	2 Years	3 Years	5 Years	10 Years
2[1]*$Dummy_t$	0.001	0.001	-0.0005	0.007	-0.009	**-0.022***	-0.022 [t]
	(0.004)	(0.006)	(0.014)	(0.013)	(0.012)	(0.012)	(0.015)
2[0]*$Dummy_{t+1}$	0.0003	-0.003	-0.013	0.009	-0.006	-0.011	0.011
	(0.004)	(0.006)	(0.014)	(0.013)	(0.012)	(0.012)	(0.015)
2[1]*$Dummy_{t+2}$	8.43E-05	0.001	0.001	0.014	0.012	0.009	**0.027***
	(0.004)	(0.006)	(0.014)	(0.013)	(0.012)	(0.012)	(0.015) [b]
Observations	1,452	1,452	1,452	1,452	1,452	1,452	1,452

*Note: Standard errors are in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. For brevity, regressions of constant term and control variables are not shown in the table.*

Table 20. Regression of Risk Premia Changes on U.S. QE Announcements Interaction terms

2[4]*Independent Variable(s)	Dependent Variable(s)						
	3 Months	6 Months	1 Year	2 Years	3 Years	5 Years	10 Years
2[1]*$Dummy_t^{U.S.}$	0.001	-0.001	0.004	0.011	-0.003	-0.011	-0.004 [t]
	(0.004)	(0.006)	(0.014)	(0.014)	(0.013)	(0.013)	(0.016)
2[0]*$Dummy_{t+1}^{U.S.}$	-0.002	-0.006	-0.018	0.003	-0.001	-0.002	**0.034****
	(0.005)	(0.006)	(0.015)	(0.014)	(0.014)	(0.014)	(0.017)
2[0]*$Dummy_{t+2}^{U.S.}$	0.0006	0.002	0.007	0.018	0.017	0.022	**0.033****
	(0.005)	(0.006)	(0.015)	(0.014)	(0.013)	(0.013)	(0.016)
2[0]*$\Delta y_t^{U.S.}$	0.004	-0.001	0.007	0.01	0.003	-0.008	-0.008
	(0.008)	(0.011)	(0.026)	(0.025)	(0.023)	(0.023)	(0.028)
2[0]*$\Delta y_{t-1}^{U.S.}$	**0.017****	**0.019***	0.012	**0.059****	0.034	**0.039***	-0.006
	(0.008)	(0.011)	(0.026)	(0.025)	(0.023)	(0.023)	(0.029)
2[0]*$Dummy_t^{U.S.} * \Delta y_t^{U.S.}$	0.005	-0.059	0.065	0.055	0.094	**0.236*****	**0.357*****
	(0.032)	(0.042)	(0.098)	(0.092)	(0.086)	(0.087)	(0.106)
2[0]*$Dummy_{t+1}^{U.S.} * \Delta y_t^{U.S.}$	**-0.115****	-0.011	-0.138	-0.188	0.069	-0.0705	**0.397****
	(0.051)	(0.067)	(0.156)	(0.146)	(0.138)	(0.139)	(0.169)
2[0]*$Dummy_{t+2} * \Delta y_t^{U.S.}$	0.0209	0.054	-0.034	-0.004	0.0202	0.238	-0.046
	(0.086)	(0.114)	(0.263)	(0.246)	(0.232)	(0.234)	(0.284)
2[0]*$Dummy_t^{U.S.} * \Delta y_{t-1}^{U.S.}$	-0.085	0.057	**0.655*****	-0.032	0.085	0.001	-0.169
	(0.081)	(0.107)	(0.247)	(0.232)	(0.219)	(0.221)	(0.267)
2[0]*$Dummy_{t+1}^{U.S.} * \Delta y_{t-1}^{U.S.}$	0.001	-0.061	-0.025	-0.066	0.016	**0.182****	**0.203***
	(0.031)	(0.042)	(0.096)	(0.090)	(0.085)	(0.086)	(0.105)
2[1]*$Dummy_{t+2}^{U.S.} * \Delta y_{t-1}^{U.S.}$	-0.012	0.008	0.178	0.05	0.113	**0.231***	0.202
	(0.051)	(0.067)	(0.155)	(0.146)	(0.137)	(0.139)	(0.168) [b]
Observations	1,452	1,452	1,452	1,452	1,452	1,452	1,452

*Note: Standard errors are in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. For brevity, regressions of constant term and control variables are not shown in the table.*

Table 21. Quantitative Easing (QE) Event Dates

QE	Date	Information
QE2	3-Nov-10	The announcement to purchase of $600 billion of Treasury securities by the end of the second quarter of 2011 by Fed. Reserve.
QE2	22-Jun-11	FOMC statement released, to end QE2 in one month.
QE2	13-Jul-11	The Fed. Reserve indicated to ease monetary policy further if economic growth and inflation slow much more.â€
OT (1)	21-Sep-11	Operation Twist involves redeployment of $ 400 bn Federal Assets.
OT (1)	20-Jun-12	Operation Twist ended.
QE3	12-Dec-12	Fed. Reserve announces the beginning of QE3.
2[2]*QE3	2[2]*18-Sep-13	FOMC stated to reduce the pace of its asset [t] purchases from $40 billion to$35 billion per month, and purchase longer-term Treasury securities from $45 billion to $40 billion per month. [b]
QE3	18-Dec-13	The reduction in monthly bond buying to $75 billion from $85 billion announced by Fed. Reserve.
2[2]*QE3	2[2]*29-Jan-14	The reduction in monthly bond purchases from $75 billion to [t] $65 billion announced by Fed. Reserve. [b]

Source: U.S. Federal Reserve Board Home page and Neely (2010). FOMC = Federal Open Market Committee, GSE = government-sponsored enterprises, MBS = mortgage-backed securities.

APPENDIX(B)

Indian Bond Yield Curves & Event Study Graphs

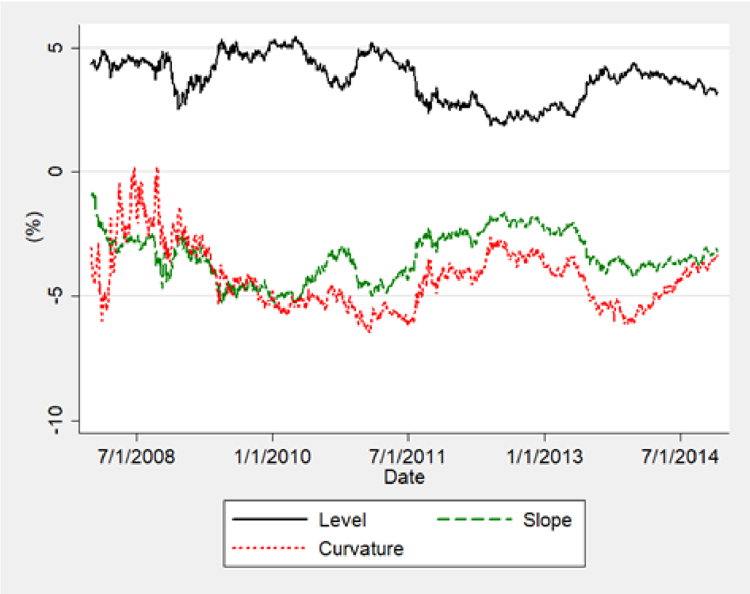

Fig. 7. Level, Slope, and Curvature of US Bond Yields

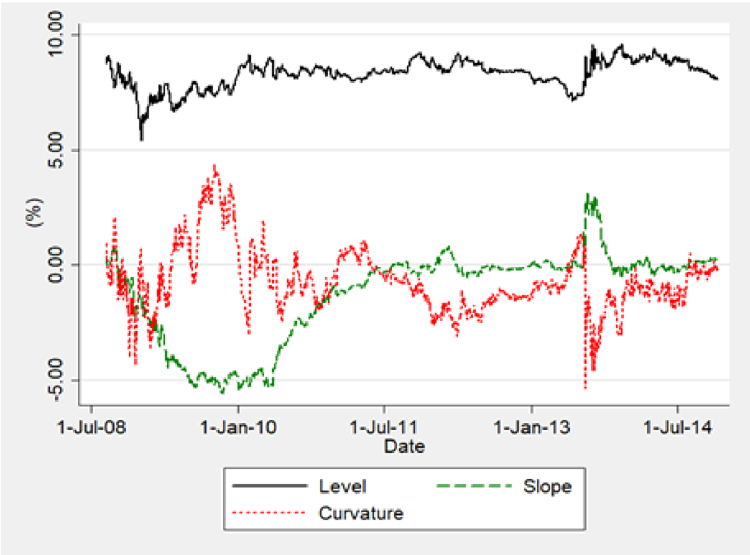

Fig. 8. Level, Slope, and Curvature of Indian Bond Yields

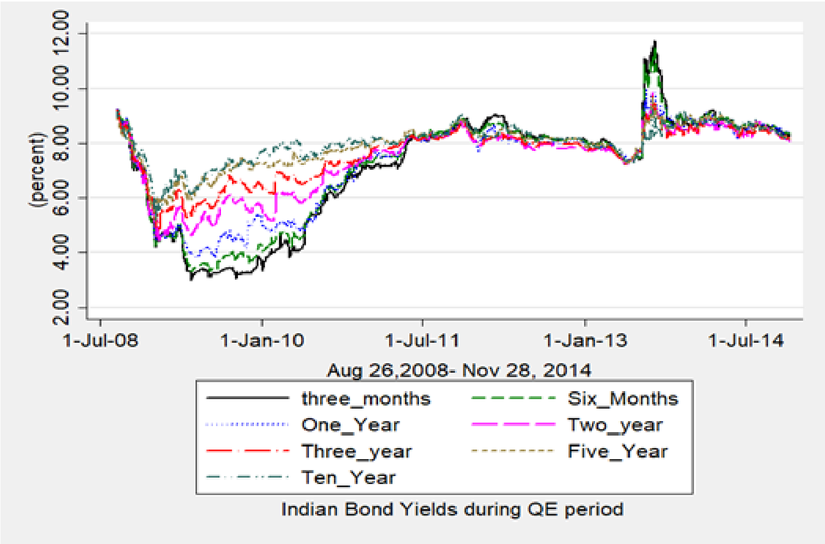

Fig. 9. Indian Treasury Yields during QE Periods

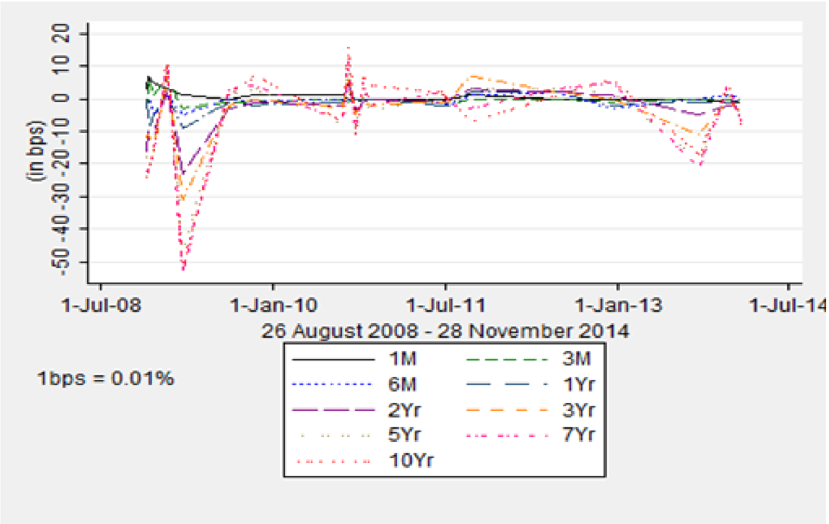

Fig. 10. U.S Treasury Yields Following QE Announcements

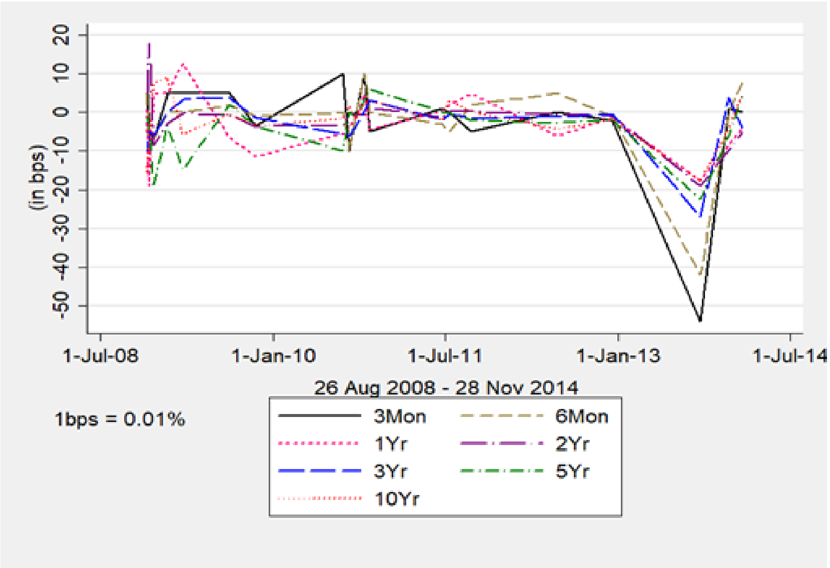

Fig. 11. Indian Treasury Yields One-Day after QE Announcements

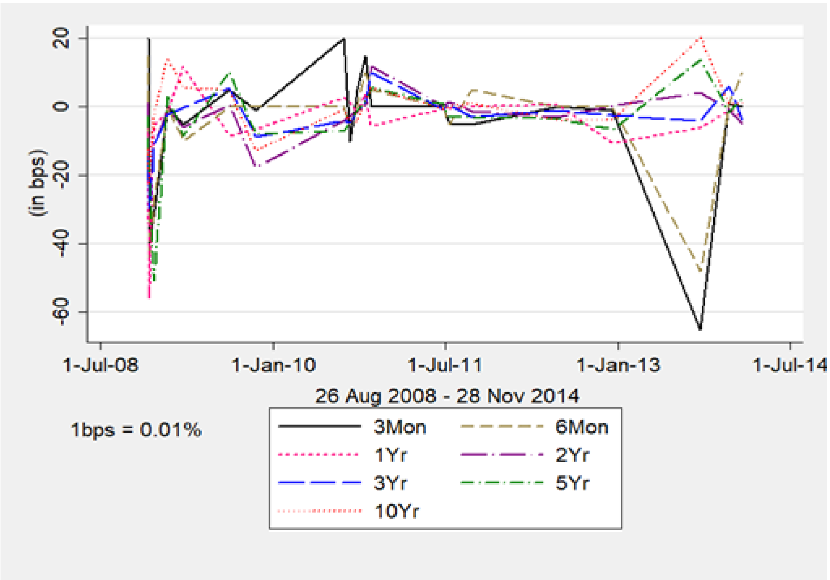

Fig. 12. Indian Treasury Yields Two-Day after QE Announcements

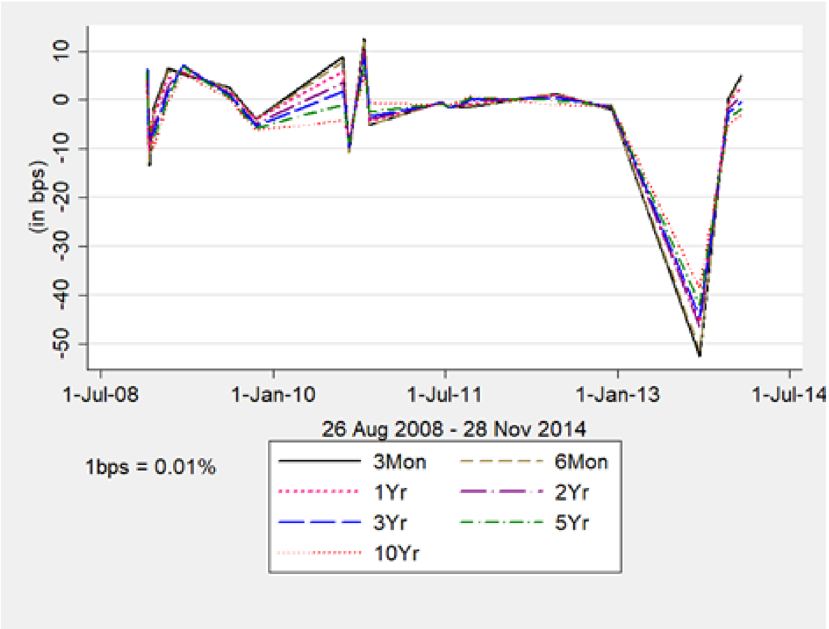

Fig. 13. Indian Expected Yields One-Day after QE Announcements

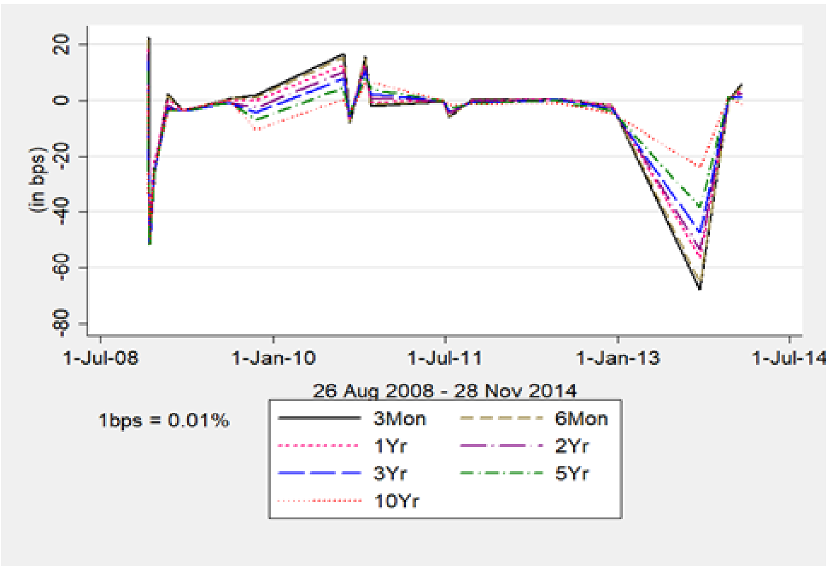

Fig. 14. Indian Expected Yields Two-Day after QE Announcements

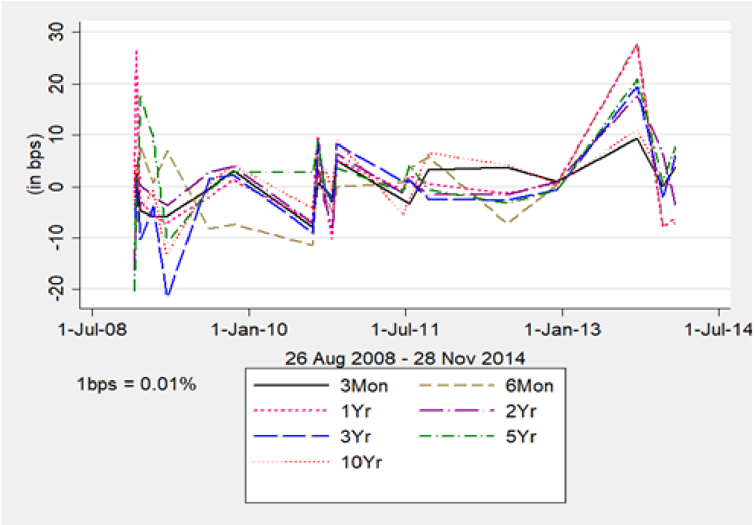

Fig. 15. Indian Risk premia One-Day after QE Announcements

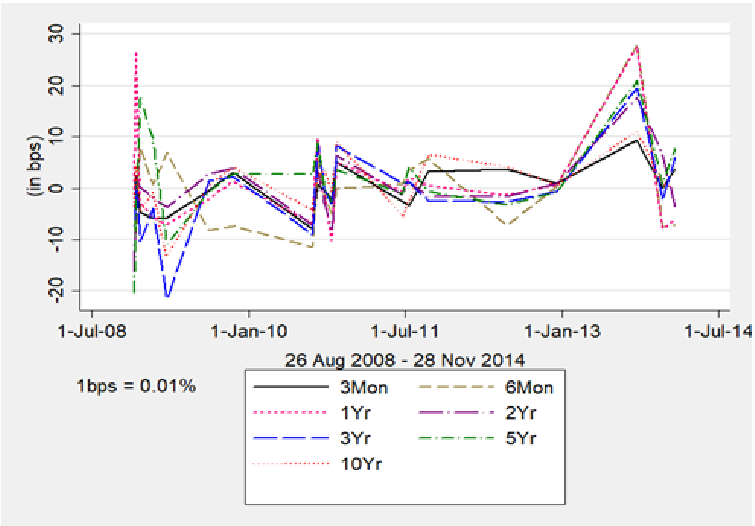

Fig. 16. Indian Risk Premia Two-Day after QE Announcements

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