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Which Risk Dominates the Bond Yield? Empirical Tests from Market Sentiment Perspective

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Abstract

This paper adopts the Constant Maturity Treasury (CMT) issuance and the Treasury Inflation Protected Securities (TIPS) to strip the general credit risk and liquidity risk of bonds. By reclassifying the reinvestment risk as a type of interest risk, we analyze the yield spread of inflation risk and interest rate risk. As TIPS is free of inflation risk, we focus on the source of its unique major risk: interest rate risk. We employ daily data and Granger causality test and Johansen cointegration test to conclude that market sentiment, measured by the Chicago volatility (VIX) series, affects the yield related to interest rate risk significantly. Such impact is persistent in all different term of maturity over 10 years. However, when inflation risk is present, market sentiment fails to dominate the yield spread.

Keywords: bond yield, interest rate risk, CMT, TIPS, VIX, market sentiment

1. Introduction

The financial academia and industry generally recognize five risks for various types of bonds: interest rate risk, which refers to the price volatility of bond in terms of the change in interest rate; reinvestment risk, which is the risk of failing to reinvest proceeds at the initially higher interest rate; inflation risk, which erodes the intrinsic value of future cash flows; credit risk, which refers to the partial or full loss of future cash flows due to counterparty default; and liquidity risk, which causes the deviation of fair value and realizable value of the bond.

While downgrade risk is sometimes regarded as another source of risk (Ng & Phelps, 2011; Acharya et al., 2013), the factors that trigger downgrade are incorporated in the five types of risks stated above. In addition, reinvestment risk can be regarded as a subset of interest risk to a large extent because of two reasons: first, the volatility of bond price leads to the change of the yield and the uncertainty of reinvestment return; second, reinvestment risk only exists after the bond is sold or matures for zero-coupon bonds and such risk and interest rate risk are homogeneous. Therefore our study recognizes four major risks of bonds: interest rate risk, inflation risk, credit risk, and liquidity risk.

Numerous literatures contribute to the relationship between these risks and the bond yield (Nashikkar et al., 2011; Maltritz & Molchanov, 2013), as risk premium and risk factor is the keystone in modern financial theory. However, few previous studies separate the risks and examine their impacts to bond spread individually. This is mainly due to the difficulty of the separation of risks by their sources, as well as the endogeneity among risks. Our paper attempts to separate the types of risks and identifies their sources by controlling the class of bonds (Haubrich et al., 2012) and we adopt similar strategy. The conclusion of our paper not only helps understand the impacts of various risks to the yield spread but also provides clues for designing bond vehicles for heterogeneous investor risk demand and risk hedging portfolios.

We incorporate two bond classes in this study: Constant Maturity Treasury (CMT) bond and Treasury Inflation Protected Securities (TIPS). Our time series regressions are based on the daily data of 5-year, 7-year, 10-year, 20-year, and 30-year CMT and TIPS. CMT yields are derived from Treasury Bills, Notes, and Bonds and are frequently used by lenders to determine loan rates, especially for the loans with significant prepayment risks. Therefore, CMT is an ideal proxy for both of the on-the-run and off-the-run Treasury series. TIPS is another proxy of the Treasury series that strips the inflation risk. TIPS raisesits par value with inflation, measured by the Consumer Price Index, and guarantees its interest rate being fixed.

As both of the bond classes represent that United States government credit, the solvency concerns from the investors are ignored. For the same reason, the liquidity risk is also regarded as being trivial for these two classes. Thus the significant risk sources for CMT are: interest rate risk, reinvestment risk, and inflation risk. In contrast, the major risk sources for TIPS are only interest rate risk, reinvestment risk.

We also include the daily data of the volatility index (VIX) series in this study. The VIX indices are measures of market sentiment from the investor side. In the previous studies, the main stream of sentiment proxy is the VIX index, for example, Ben-Rephael et al. (2012). The Chicago Board Options Exchange (CBOE) calculates the CBOE Volatility Index (VIX) as the scale of stock market volatility and it is often referred to as the “investor fear gauge”. CBOE first creates the weighted average value of options with a constant maturity of 30 days to expiration. The options are based on market portfolio index option prices and incorporate information from the volatility skewness by setting a wide range of exercise prices. Four market portfolio indices are included: the Standard and Poor’s 100 and 500 index, the Dow Jones Industrial Index, and the NASDAQ returns. VIX is often cited as an indicator of investor panic, as volatility signifies financial turbulence. During financial stress and periods of significant security price drops, VIX increases, and vice versa. We adopt the S&P 500-based VIX index thereafter.

Another series of sentiment studies use the BW market sentiment index (Baker & Wurgler, 2006, 2007). The BW index is based on first principal component of six orthogonal sentiment proxies: value-weighted dividend premium, IPO volume, first day returns on IPO, closed-end fund discount, equity share in new issues, and NYSE turnover. A significant amount of literature adopts the BW index as the barometer of market, for example, Stambaugh et al. (2012), and Laborda and Olmo (2013). The BW index is not created from the bond market and hence is not cited in our current study.

Some researches adopt the Index of Consumer Sentiment produced by the University of Michigan Survey Research Center as market sentiment indicator, for instance, Akhtar et al. (2012). However, we do not include this series in the current paper, because this variable contains only one series of monthly data and it is survey based rather than market mechanism based.

In addition, a few previous studies use the assumed mood of investors of market sentiments. Al-Hajieh et al. (2011) examine whether the mood brought by the holy month of Ramadan, a time of celebration and renewal in Muslim countries affects the Islamic Middle Eastern stock markets. Palomino et al. (2009) uses the outcomes of soccer club games as investor moods to test its relation with the stock returns. We do not adopt this method, as there is no unique and consistent event that can persistently generate a time series of quantitative investor sentiment.

Finally, existing studies also propose other measures of sentiments, such as the trading volume-based BSI (Kumar & Lee, 2006), liquidity (Baker & Stein, 2004), psychological evidence (Barberis et al., 1998), IPO underpricing (Hrnjić & Sankaraguruswamy, 2011), and the Tobin’s Q ratio (Grundy & Li, 2010). These measures are incorporated in the BW index as subsets and are not appropriate for bond spread study.

We perform the Granger causality tests and Johansen cointegration tests between the sentiment series and the two bonds series to detect the function of market sentiment to interest rate risk and inflation risk. Our aim is to identify the different possible functions of market sentiment to the inflation risk and interest rate. As the CMT bond yield carries both risks and TIPS is inflation risk free, the difference of the roles of market sentiment play in these bonds can be reasonably regarded as the result of inflation risk.

The paper is organized as follows: section 2 describes the source of data and the observation pool; section 3 provides the regressions equations and the reasoning of conclusion; section 4 reports the econometric results and the analyses; and section 5 concludes.

2. Data

We use daily data of the CMT, TIPS and VIX series in this study. The bond data are from the FRED® Database provided by the Federal Reserve Bank of St. Louis, and the Standard and Poor’s 500 VIX data is from Yahoo! ® Finance. The consumer price index data is from the Bureau of Labor Statistics at the U.S. Department of Labor.The size of the observation pool is described in Table 1.

Yields on Treasury issuances at constant maturity are interpolated by the U.S. Treasury from the on the run yield curve fornon-inflation-adjusted Treasury bonds. This curve presents the closing bid yield levels on liquid Treasury securities in the over-the-counter market. Likewise, yields on inflation-indexed securities at constant maturity are interpolated from the daily yield curve for Treasury inflation protected securities. Both bond series yields are read at fixed maturities, which are 5, 7, 10, 20, and 30 years. Both interpolations are linear-relation based.

Table 1. Variables and time series facts

Series	Start	End	Series	Start	End
5YCMT	1/2/1962	10/29/2013	20YCMT	10/1/1993	10/29/2013
5YTIPS	1/2/2003	10/29/2013	20YTIPS	7/27/2004	10/29/2013
7YCMT	7/1/1969	10/29/2013	30YCMT	2/15/1977	10/29/2013
7YTIPS	1/2/2003	10/29/2013	30YTIPS	2/22/2010	10/29/2013
10YCMT	1/2/1962	10/29/2013	VIX (Adjusted Close)	1/2/1990	10/29/2013
10YTIPS	1/2/2003	10/29/2013	Consumer Price Index	January 1913	September 2013

All the time series are non-seasonal adjusted. As the highest frequency of Consumer Price Index (CPI) available is monthly-based, we linearly interpolate the missing daily values to facilitate the plot in Figure 1. While CPI is not involved in the regressions, we list the index in the following figures to present the relationships in a straightforward way. This figure suggests certain comovement patterns of CMT with inflation. However, we find no such comovements with the TIPS series.

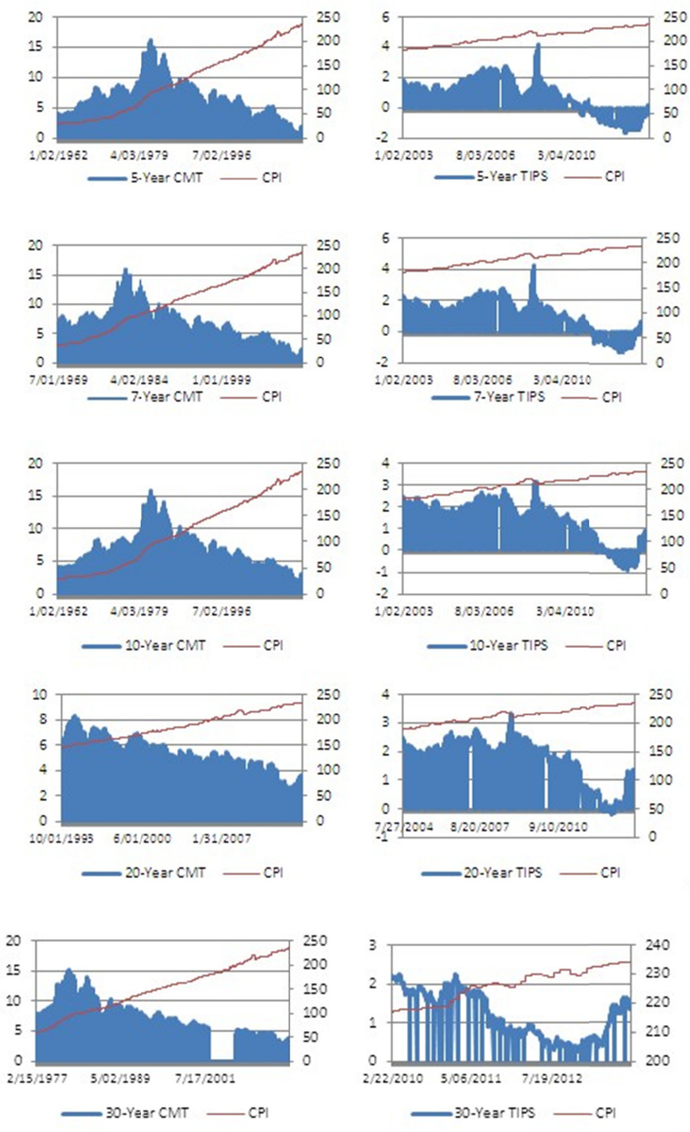

Figure 1. Constant maturity bonds, inflation protection bonds, and inflation from 1962 to 2013

3. Methodology

We first follow the standard Augmented Dickey-Fuller (ADF) test procedure to examine the unit root issue. Then we proceed to perform the Granger causality tests and Johansen cointegration tests between the sentiment series and the two bonds series to detect the function of market sentiment to interest rate risk, reinvestment risk, and inflation risk. In other words, the tests examine different possible functions of market sentiment to the inflation risk and interest rate. The results can fall into the following four categories:

First, if market sentiment, represented by VIX, plays a vital role in determining the yield spread for TIPS rather than CMT, aggregate bond yield is dominated by inflation risk instead of investor optimism or pessimism. Second, if VIX significantly affects the yield spread for CMT but not TIPS, bond yield is more likely to be mispriced, as the driving factors of TIPS should be nested by those of CMT. Third, if VIX determines both of the spreads for CMT and TIPS, inflation has no role in bond market, *i.e.*, inflation risk should not generate the corresponding risk premium. In this scenario, the pricing of Treasury series is the process of implementing investor sentiments. Fourth, if VIX does not result in any change in terms of the spreads of CMT and TIPS, the market is perfectly rational and investor sentiment does not lead to the change in demand of bonds, risk, or liquidity.

We also perform the cointegration tests and Granger causality tests among the series of CMT and TIPS bonds with heterogeneous maturities to examine the yield spread contagion and the indirect impacts of risks. The reason for this further step is to detect the endogenous factors embedded in bond yields to identify the exogenous role of inflation risk as well as market sentiment. In other words, we use this step as a robustness check of the effect of inflation risk in terms of the CMT bond.

The pre-requisite of the tests is the unit root test, which measures the degree of integration of the time series. The regression function is:

$$\Delta y_t = \alpha + \beta t + \gamma y_{t-1} + \delta_1 \Delta y_{t-1} + \cdots + \delta_{p-1} \Delta y_{t-p+1} + \varepsilon_t \quad (1)$$

The null hypothesis is $\gamma = 0$, i.e., the series has a unit root. The alternative hypothesis is $\gamma < 0$, or the series is stationary. We report the results in Table 1. Following the random walk test is the Granger causality test, which is adopted to measure the mutual impact between market sentiment and bond yield. For a bivariate linear autoregressive model with pairwise variables $X_1$and X_2, the test regression is:

$$X_1(t) = \sum_{j=1}^{P} A_{11,j} X_1(t-j) + \sum_{j=1}^{P} A_{12,j} X_2(t-j) + E_1(t) \quad (2)$$

$$X_2(t) = \sum_{j=1}^{P} A_{21,j} X_1(t-j) + \sum_{j=1}^{P} A_{22,j} X_2(t-j) + E_2(t) \quad (3)$$

P in the regression equations is the maximum number of lags included, and the matrix A is the plain vanilla VAR coefficients. $E.(t)$ is the regression residual. If the variance of $E.(t)$ is improved by adding X_1or X_2, it implies that X_1 or X_2 Granger causes X_2 or X_1. The way to detect such improvement is by testing whether, for example, the coefficients carried by A_{12} are jointly different from zero. If the null hypothesis of $A_{12} = 0$is rejected significantly by the F test, X_2 Granger causes X_1. We use the Bayesian Information Criterion (BIC) to determine the number of lags. The results are presented in Table 3 and 5. We also perform the cointegration tests between the bond series and sentiment series to identify the comovement pattern of the bond market and investor expectation. The procedure is based on the Vector Error Correlation Model (VECM) and it follows the results of the unit root tests. For the pairwise cointegration test, the regression is: for a VAR of order p:

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + B x_t + \epsilon_t \quad (4)$$

Where y_t is a k-vector of non-stationary I(1) variables, x_t is a d-vector of deterministic variable, and the error term is a vector of innovations. Using the first-order difference form, the VAR can be rewritten as:

$$\Delta y_t = \Pi \mathrm{y}_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta \mathrm{y}_{t-i} + \mathrm{Bx}_t + \epsilon_t, \text{ where } \Pi = \sum_{i=1}^{p} A_i - I, and\ \Gamma_i = -\sum_{j=i+1}^{p} A_j \quad (5)$$

If the coefficient matrix Π has reduced rank r<k, then there exists $k \times r$ matrices α and β each with rank r such that $\Pi = \alpha\beta'\ and\ \beta' y_t$ is I(0). r is the number of cointegrating relations, or the rank. The results are exhibited in Table 4 and 6.

4. Results and Discussion

The results of the two groups of tests are highly consistent. Table 3 suggests that market sentiment significantly affects the inflation-adjusted yield of Treasury (TIPS) issues but not the constant maturity treasury series (CMT). When a bond incorporates the inflation risk, the impact of market sentiment has a limit role in terms of the yield spread of bonds. Therefore it is plausible to conclude that interest risk dominates the bond yields when inflation risk is absent; however, inflation risk dominates the yields when it is present. Inflation risk overrides interest risk, and the latter is significantly affected by investor sentiment. The counter-direction causality does not hold: neither inflation risk nor interest risk has strong impact on investor sentiment.

Specifically, other than the anomaly of the causality from VIX to 10-year CMT bond, the VIX series fails to Granger cause the CMT series significantly at 5% level. Such anomaly is reasonable as the 10-year CMT is particularly cited for the setting of mortgage rate and primary rate. At 1% level, VIX has no impact on the yield of CMT. In contrast, the VIX series strongly affects the TIPS bonds at almost all levels of maturity, as reported in Table 3. Such comparison leads to the conclusion that market sentiment only dominates the interest risk when an asset is inflation risk free.

The unit root test procedure is the standard Augmented Dickey-Fuller test and the regression is described by Equation (1). We use MacKinnon (1996) one-sided p-values as the indicator of significance level. The null hypothesis is the time series is not stationary, i.e., the variable has a unit root.

Table 2. The results of unit root tests of CMT, TIPS, and market sentiment series

Variable	t-Statistics	P Value	Variable	t-Statistics	P Value
5YCMT	-0.653867	0.8561	20YCMT	-1.2125	0.6714
5YTIPS	-1.611305	0.4766	20YTIPS	-1.48077	0.5434
7YCMT	-0.332914	0.9177	30YCMT	-0.33535	0.9173
7YTIPS	-1.589715	0.4877	30YTIPS	-1.65733	0.4527
10YCMT	-0.781504	0.8237	VIX	-3.79704	0.0030
10YTIPS	-1.537665	0.5144			

We use a pairwise Granger causality method. The procedure is described in Equation (2) and (3). The columns of variable description indicate the direction of causality. The null hypothesis is the absence of causality. For example, as the p value of VIX to 5YTIPS rejects the null hypothesis, VIX Granger causes 5YTIPS.

Table 3. Granger causality between bonds and market sentiment

Variable	F-Statistics	P Value	Variable	F-Statistics	P Value
VIX to 5YCMT	1.74096	0.1380	5YCMT to VIX	0.78207	0.5366
VIX to 5YTIPS	12.5603	0.0000	5YTIPS to VIX	1.48201	0.2050
VIX to 7YCMT	2.05712	0.0837	7YCMT to VIX	0.57092	0.6838
VIX to 7YTIPS	13.9747	0.0000	7YTIPS to VIX	1.33649	0.2540
VIX to 10YCMT	2.95977	0.0187	10YCMT to VIX	0.64643	0.6294
VIX to 10YTIPS	11.3345	0.0000	10YTIPS to VIX	1.52184	0.1931
VIX to 20YCMT	1.53499	0.1892	20YCMT to VIX	0.36016	0.8371
VIX to 20YTIPS	6.24568	0.0001	20YTIPS to VIX	0.97185	0.4217
VIX to 30YCMT	2.46608	0.0429	30YCMT to VIX	1.12719	0.3417
VIX to 30YTIPS	2.20233	0.0671	30YTIPS to VIX	1.40852	0.2293

The cointegration test follows the Johansen procedure as described in Equation (5). For the three options of data trend: no trend, linear trend, and quadratic trend, this paper assumes that the data trend is absent. However, we do not exclude the intercept of the time series regression. This table hence reports results with two test settings: no intercept no trend, and intercept no trend. We adopt two criteria for the number of cointegration relationships: trace method, and maximum eigenvalue method. The results reported in this table are the number of significant cointegration relationships between the pairwise variables. The critical values are based on MacKinnon-Haug-Michelis (1999), all at 0.05 levels.

Table 4. Cointegration between bonds and market sentiment

	No intercept no trend	Intercept no trend		No intercept no trend	Intercept no trend
Series: 5YCMT VIX			Series: 10YTIPS VIX		
Trace	1	1	Trace	0	0
Maximum Eigenvalue	1	1	Maximum Eigenvalue	0	0
Series: 5YTIPS VIX			Series: 20YCMT VIX		
Trace	0	1	Trace	1	1
Maximum Eigenvalue	0	1	Maximum Eigenvalue	1	1
Series: 7YCMT VIX			Series: 20YTIPS VIX		
Trace	1	1	Trace	0	0
Maximum Eigenvalue	1	1	Maximum Eigenvalue	0	0
Series: 7YTIPS VIX			Series: 30YCMT VIX		
Trace	0	0	Trace	1	1
Maximum Eigenvalue	0	1	Maximum Eigenvalue	1	1
Series: 10YCMT VIX			Series: 30YTIPS VIX		
Trace	1	1	Trace	0	0
Maximum Eigenvalue	1	1	Maximum Eigenvalue	0	0

The regression method is described in Table 3. A significant rejection ($p<0.05$) of the null hypothesis implies the existence of causality.

Table 5. Granger causality of cmt and tips yields in the u.s. market from 1962 to 2013

Panel A: Granger Causality among Constant Maturity Treasury Bonds with Heterogeneous Terms								
Variable	F-Statistics	P Value	Variable	F-Statistics	P Value	Variable	F-Statistics	P Value
5YCMT to 7YCMT	8.0201	0.0000	7YCMT to 30YCMT	1.2843	0.2736	20YCMT to 10YCMT	2.6375	0.0323
5YCMT to 10YCMT	6.0628	0.0001	10YCMT to 5YCMT	1.7283	0.1406	20YCMT to 30YCMT	0.9740	0.4204
5YCMT to 20YCMT	1.4926	0.2016	10YCMT to 7YCMT	6.6707	0.0000	30YCMT to 5YCMT	0.7093	0.5855
5YCMT to 30YCMT	0.5018	0.7345	10YCMT to 20YCMT	3.1026	0.0146	30YCMT to 7YCMT	1.8290	0.1202
7YCMT to 5YCMT	0.7810	0.5373	10YCMT to 30YCMT	2.9084	0.0204	30YCMT to 10YCMT	0.5821	0.6756
7YCMT to 10YCMT	5.1820	0.0004	20YCMT to 5YCMT	1.7904	0.1278	30YCMT to 20YCMT	0.6567	0.6221
7YCMT to 20YCMT	1.7415	0.1379	20YCMT to 7YCMT	2.1423	0.0730			
Panel B: Granger Causality among Treasury Inflation Protected Securities with Heterogeneous Terms								
Variable	F-Statistics	P Value	Variable	F-Statistics	P Value	Variable	F-Statistics	P Value
5YTIPS to 7YTIPS	5.4143	0.0002	7YTIPS to 30YTIPS	1.8537	0.1167	20YTIPS to 10YTIPS	5.9873	0.0001
5YTIPS to 10YTIPS	1.7166	0.1435	10YTIPS to 5YTIPS	3.6514	0.0057	20YTIPS to 30YTIPS	0.4004	0.8085
5YTIPS to 20YTIPS	7.2265	0.0000	10YTIPS to 7YTIPS	3.7498	0.0048	30YTIPS to 5YTIPS	3.8785	0.0040
5YTIPS to 30YTIPS	1.2068	0.3064	10YTIPS to 20YTIPS	6.7540	0.0000	30YTIPS to 7YTIPS	1.9797	0.0957
7YTIPS to 5YTIPS	2.6701	0.0307	10YTIPS to 30YTIPS	1.6644	0.1563	30YTIPS to 10YTIPS	2.6379	0.0329
7YTIPS to 10YTIPS	1.3501	0.2490	20YTIPS to 5YTIPS	4.9950	0.0005	30YTIPS to 20YTIPS	2.1902	0.0684
7YTIPS to 20YTIPS	8.7548	0.0000	20YTIPS to 7YTIPS	3.8870	0.0038			
Panel C: Granger Causality from Constant Maturity Treasury to Treasury Inflation Protected Securities								
Variable	F-Statistics	P Value	Variable	F-Statistics	P Value	Variable	F-Statistics	P Value
5YCMT to 5YTIPS	11.3460	0.0000	7YCMT to 30YTIPS	0.3719	0.8288	20YCMT to 20YTIPS	9.6783	0.0000
5YCMT to 7YTIPS	4.5911	0.0011	10YCMT to 5YTIPS	16.2662	0.0000	20YCMT to 30YTIPS	1.1054	0.3528
5YCMT to 10YTIPS	6.4878	0.0000	10YCMT to 7YTIPS	7.7026	0.0000	30YCMT to 5YTIPS	20.5155	0.0000
5YCMT to 20YTIPS	3.6160	0.0061	10YCMT to 10YTIPS	9.2319	0.0000	30YCMT to 7YTIPS	12.1693	0.0000
5YCMT to 30YTIPS	0.2848	0.8879	10YCMT to 20YTIPS	5.2095	0.0004	30YCMT to 10YTIPS	13.8666	0.0000
7YCMT to 5YTIPS	14.2023	0.0000	10YCMT to 30YTIPS	0.5346	0.7104	30YCMT to 20YTIPS	9.7780	0.0000

7YCMT to 7YTIPS	5.9923	0.0001	20YCMT to 5YTIPS	19.0561	0.0000	30YCMT to 30YTIPS	0.9639	0.4265
7YCMT to 10YTIPS	7.2824	0.0000	20YCMT to 7YTIPS	10.8656	0.0000			
7YCMT to 20YTIPS	3.5785	0.0065	20YCMT to 10YTIPS	12.4736	0.0000			
Panel D: Granger Causality from Treasury Inflation Protected Securities to Constant Maturity Treasury								
Variable	F-Statistics	P Value	Variable	F-Statistics	P Value	Variable	F-Statistics	P Value
5YTIPS to 5YCMT	2.7010	0.0291	7YTIPS to 30YCMT	1.0209	0.3952	20YTIPS to 20YCMT	0.2988	0.8788
5YTIPS to 7YCMT	2.0108	0.0904	10YTIPS to 5YCMT	1.5687	0.1799	20YTIPS to 30YCMT	0.4991	0.7365
5YTIPS to 10YCMT	1.6465	0.1599	10YTIPS to 7YCMT	1.6525	0.1584	30YTIPS to 5YCMT	1.8443	0.1184
5YTIPS to 20YCMT	1.5580	0.1829	10YTIPS to 10YCMT	1.2152	0.3022	30YTIPS to 7YCMT	2.0679	0.0832
5YTIPS to 30YCMT	0.8197	0.5125	10YTIPS to 20YCMT	0.5074	0.7303	30YTIPS to 10YCMT	1.4747	0.2080
7YTIPS to 5YCMT	2.4920	0.0413	10YTIPS to 30YCMT	0.3419	0.8498	30YTIPS to 20YCMT	0.8149	0.5158
7YTIPS to 7YCMT	2.4727	0.0426	20YTIPS to 5YCMT	0.9645	0.4258	30YTIPS to 30YCMT	1.1587	0.3278
7YTIPS to 10YCMT	2.2812	0.0584	20YTIPS to 7YCMT	0.9631	0.4266			
7YTIPS to 20YCMT	1.4477	0.2157	20YTIPS to 10YCMT	0.4345	0.7838			

The cointegration test follows the Johansen procedure as described in Equation (5). For the same reason stated in Table 4, this table reports results with the test settings of no intercept no trend and intercept no trend, and with the criteria settings of trace method and maximum eigenvalue method. The results reported in this table are the number of significant cointegration relationships between the pairwise variables. The critical values are based on MacKinnon-Haug-Michelis (1999), all at 0.05 levels.

Table 6. Cointegrationof CMT and TIPS yields in the U.S. market from 1962 to 2013

No intercept no trend		Intercept no trend	No intercept no trend		Intercept no trend	No intercept no trend		Intercept no trend
Series: 5YCMT 5YTIPS			Series: 5YTIPS 20YCMT			Series: 7YTIPS 30YTIPS		
Trace	0	0	Trace	0	0	Trace	0	0
MaximumEigenvalue	0	0	Maximum Eigenvalue	0	0	Maximum Eigenvalue	0	0
Series: 5YCMT 7YCMT			Series: 5YTIPS 20YTIPS			Series: 10YCMT 10YTIPS		
Trace	1	1	Trace	0	0	Trace	0	0
Maximum Eigenvalue	1	1	Maximum Eigenvalue	0	0	Maximum Eigenvalue	0	0
Series: 5YCMT 7YTIPS			Series: 5YTIPS 30YCMT			Series: 10YCMT 20YCMT		
Trace	0	0	Trace	0	0	Trace	0	0
Maximum Eigenvalue	0	0	Maximum Eigenvalue	0	0	Maximum Eigenvalue	0	0
Series: 5YCMT 5YTIPS			Series: 5YTIPS 30YTIPS			Series: 10YCMT 20YTIPS		
Trace	0	0	Trace	0	0	Trace	0	0
Maximum Eigenvalue	0	0	Maximum Eigenvalue	0	0	Maximum Eigenvalue	0	0
Series: 5YCMT 7YCMT			Series: 7YCMT 7YTIPS			Series: 10YCMT 30YCMT		
Trace	1	1	Trace	0	0	Trace	0	0
Maximum Eigenvalue	1	1	Maximum Eigenvalue	0	0	Maximum Eigenvalue	0	0
Series: 5YCMT 7YTIPS			Series: 7YCMT 10YCMT			Series: 10YCMT 30YTIPS		
Trace	0	0	Trace	1	1	Trace	0	0
Maximum Eigenvalue	0	0	Maximum Eigenvalue	1	1	Maximum Eigenvalue	0	0

Series: 5YCMT 10YCMT			Series: 7YCMT 10YTIPS			Series: 10YTIPS 20YCMT		
Trace	1	0	Trace	0	0	Trace	0	0
Maximum			Maximum			Maximum		
Eigenvalue	1	1	Eigenvalue	0	0	Eigenvalue	0	0
Series: 5YCMT 10YTIPS			Series: 7YCMT 20YCMT			Series: 10YTIPS 20YTIPS		
Trace	0	0	Trace	0	0	Trace	0	0
Maximum			Maximum			Maximum		
Eigenvalue	0	0	Eigenvalue	0	0	Eigenvalue	0	0
Series: 5YCMT 20YCMT			Series: 7YCMT 20YTIPS			Series: 10YTIPS 30YCMT		
Trace	0	0	Trace	0	0	Trace	0	0
Maximum			Maximum			Maximum		
Eigenvalue	0	0	Eigenvalue	0	0	Eigenvalue	0	0
Series: 5YCMT 20YTIPS			Series: 7YCMT 30YCMT			Series: 10YTIPS 30YTIPS		
Trace	0	0	Trace	0	0	Trace	0	0
Maximum			Maximum			Maximum		
Eigenvalue	0	0	Eigenvalue	0	0	Eigenvalue	0	0
Series: 5YCMT 30YCMT			Series: 7YCMT 30YTIPS			Series: 20YCMT 20YTIPS		
Trace	0	0	Trace	0	0	Trace	0	0
Maximum			Maximum			Maximum		
Eigenvalue	0	0	Eigenvalue	0	0	Eigenvalue	0	0
Series: 5YCMT 30YTIPS			Series: 7YTIPS 10YCMT			Series: 20YCMT 30YCMT		
Trace	0	0	Trace	0	0	Trace	0	0
Maximum			Maximum			Maximum		
Eigenvalue	0	0	Eigenvalue	0	0	Eigenvalue	0	0
Series: 5YTIPS 7YCMT			Series: 7YTIPS 10YTIPS			Series: 20YCMT 30YTIPS		
Trace	0	0	Trace	0	0	Trace	0	0
Maximum			Maximum			Maximum		
Eigenvalue	0	0	Eigenvalue	0	0	Eigenvalue	0	0
Series:5YTIPS7YTIPS			Series: 7YTIPS 20YCMT			Series: 20YTIPS 30YCMT		
Trace	0	0	Trace	0	0	Trace	0	0
Maximum			Maximum			Maximum		
Eigenvalue	0	0	Eigenvalue	0	0	Eigenvalue	0	0
Series: 5YTIPS 10YCMT			Series: 7YTIPS 20YTIPS			Series: 20YTIPS 30YTIPS		
Trace	0	0	Trace	0	0	Trace	0	0
Maximum			Maximum			Maximum		
Eigenvalue	0	0	Eigenvalue	0	0	Eigenvalue	0	0
Series: 5YTIPS 10YTIPS			Series: 7YTIPS 30YCMT			Series: 30YTIPS 30YCMT		
Trace	0	0	Trace	0	0	Trace	0	0
Maximum			Maximum			Maximum		
Eigenvalue	0	0	Eigenvalue	0	0	Eigenvalue	0	0

5. Concluding Remarks

In this paper, we first categorize the five risk factors of bond premium: interest rate, reinvestment, inflation, credit, liquidity risk. By adopting the constant maturity bond (CMT) and treasury inflation protection security (TIPS) in the time series study, we restrict the reinvestment, credit, and liquidity risk premium. We attempt to examine the source and impact of the interest rate risk and inflation risk to CMT yield spread, and the interest risk to TIPS yield spread.Our time series regressions are based on the daily data of 5-year, 7-year, 10-year, 20-year, and 30-year CMT and TIPS from 1962 to 2013. We also include the daily data of the volatility index (VIX) series as measures of market sentiment from the investor side.

We find that when a bond incorporates the inflation risk, the impact of market sentiment has a limit role on the yield spread of the bond. Interest rate risk dominates the bond yields when inflation risk is absent; however, inflation risk dominates the yields when it is present. Inflation risk overrides interest rate risk, and the latter is significantly affected by investor sentiment. In contrast, bond risks do not affect investor sentiment. The cointegration regressions also suggest the limited role of market sentiment in the long run to the interest rate risk, and the existence of other unknown risk loadings for long term TIPS, when inflation risk does not present.

In addition, this paper attempts to detect the endogenous risk loadings of CMT and TIPS. The endogenous risk factors of CMT are more significant in the short and mid-term bonds; and that of TIPS are significant in all terms of maturities. This supports the conclusion of the existence of idiosyncratic risk component of TIPS. Such unique risk premium is persistent and contagious in the same bond class, yet is absent for CMT. The yield of CMT significantly leads to the change of the yield of TIPS, inflation risk dominates interest rate risk to a large extent. Market sentiment leads to the fluctuation of TIPS yield, yet the contagion ceases. There is a firewall between CMT and TIPS that prevents the spread CMT from being priced by market fear.

In the further study, we plan to explore the impact of market sentiment and inflation risk on the other risk loadings, mainly credit risk and liquidity risk. The primary preparation for the next step is to identify bond instruments that carry one type of risk but is free for another. Such single asset class does not exist in the market and we plan to assemble an arbitrage-free portfolio that mimics the risk and yield pattern. This has the similar motivation and function with our choice of CMT and TIPS in this current paper

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