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Flights-to-Quality: The Effects of Market Volatility on Short Term U.S. Treasury Yields

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FLIGHTS-TO-QUALITY: THE EFFECTS OF MARKET VOLATILITY ON SHORT TERM U.S. TREASURY YIELDS

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Abstract

Flights-to-quality are the sudden, and sometimes irrational, rebalancing of investment portfolios to include more liquid and safer investments during times of uncertainty, high market volatility, or other unusual stock market environments. While previous research has explained flights-to-quality in terms of liquidity needs and credit risk premiums, this paper examines the significant statistical relationship between the VIX Index of implied market volatility and yields on U.S. Treasury bills. I found that the VIX Index explains a significant portion of U.S. Treasury yield variability and that the models become more significant and accurate as the maturity of the Treasuries increases. In terms of mispricing, the one month U.S. Treasury exhibited the largest deviation from the theoretical yield—more than 50%. Also, as the Treasuries' maturities increased, the degree of mispricing decreased; this parallels the tendency to see a steepening yield curve during times of higher implied volatility.

1. Introduction and Overview

Flights-to-quality are the sudden, sometimes irrational, rebalancing of investment portfolios to include more liquid and safe investments (U.S. Treasury Bills) during times of uncertainty, high market volatility, or other unusual stock market environments. As investors demand safer securities, the prices of these investments increase and the corresponding yields (the annual rate of return on the investments) decrease significantly. In the recent subprime lending market fallout, a distinct flight-to-quality was observed in the one month U.S. Treasury bill between August 8, 2007 and August 27, 2007, where the yield on a one month U.S. Treasury bill fell from 5% to nearly 2% in less than a week.

While many factors influence the yields on U.S. government securities, a significant increase in implied market volatility was most likely the underlying trigger of this particular flight-to-quality. The VIX Index of implied volatility[1] was at a four year high during this drop in yields. It is common for investors to seek safe, fixed-income investments when the market is abnormally volatile (VIX Index value of more than 30), but how much variance in short term U.S. government Treasury yields can actually be explained by implied market volatility? A drop in yields from 5% to 2% is hard to justify given only an increase in one index of volatility. Also, if there is a significant effect, which durations experience the greatest change in yields (one month, three month, one year Treasury bills)? How is the entire yield curve[2] affected by flights-to-quality?

The topic of market volatility and flights-to-quality is an interesting and important aspect of empirical financial research. While flights-to-quality have been examined previously, this paper sheds more light on the overall effect of increased market volatility on U.S. Treasury bills and on the dynamics of the U.S. Treasury yield curve during these periods of market uncertainty. The outcomes of the data analysis conducted here provide additional information about the market's often irrational reaction to increased volatility and the underlying causes of investors' flights-to-quality.

The statistical analyses conducted in this study included multivariate regressions which were used to determine the amount of variability in short term U.S. Treasury yields that can be explained by the VIX Index of market volatility and the Federal Funds target rate, a control variable. The initial regression analysis showed that the VIX Index and the Federal Funds rate variables explained approximately 98% of the variability in the yield on the one month U.S. Treasury since October 31, 2001. According to the regression equation, during the flight-to-quality in August, 2007[3], the one month Treasury was mispriced by approximately 53%. The data for the three month and six month Treasuries showed similar but different degrees of yield change during the August flight-to-quality, and significantly different levels of Treasury mispricing.

The statistical strategies used in this study have applications ranging from new trading strategies to economic policy making, adding to existing finance research on the topic. The following section of this article summarizes relevant research and theoretical premises. The remainder of the article provides a more detailed discussion of the research methods findings, and conclusions.

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[1] The ticker symbol for the Chicago Board Options Exchange (CBOE) Volatility Index, which shows the market's expectation of 30-day volatility. It is constructed using the implied volatilities of a wide range of S&P 500 index options. This volatility is meant to be forward looking and is calculated from both calls and puts. The VIX is a widely used measure of market risk and is often referred to as the "investor fear gauge."

[2] A graph tha plots the interest rates, at a set point in time, of fixed-income instruments having equal credit quality, but differing maturity dates.

[3] August 20, 2007–two days after the VIX Index reached a year-to-date high of 30.83. The yield on the one month U.S. Treasury fell from 4.60% to 2.11% in only five trading days (see Appendix 1).

2. Review of literature

Relevant literature can be classified into two areas that are useful for this paper: evidence of the flight-to-quality phenomenon and causes of the flight-to-quality. Each of these is discussed briefly below.

2.1. Evidence of the flight-to-quality

In a paper on stock-bond correlation, Baur and Lucey (2006) find that "there is strong evidence for flight-to-quality" and "there is simultaneous flight-to-quality across countries [...] in several crisis periods." Their paper examined data from eight developed countries which suggest that the flight-to-quality is a pervasive phenomenon in global stock markets.

Underlying reasons for these flights-to-quality have been investigated by Beber, et al. (2006) who find that "in times of market stress, investors chase liquidity, not credit quality" (liquidity is a key determinant of demand for short-term money market securities). The idea of a flight-to-liquidity is further supported by Longstaff (2004) who finds that there is "a large liquidity premium in Treasury bonds, which can be more than 15% of the value of some [...] bonds."

2.2. Causes of the flight-to-quality

As for the effects of volatility on flights-to-quality and flights to liquidity, Vayanos (2004) finds that "during volatile times, assets' liquidity premia increase, investors become more risk averse, assets become more negatively correlated with volatility, assets' pairwise correlations can increase, and illiquid assets' market betas increase." Longstaff also suggests that this premium is caused by consumer confidence, the amount of debt available to investors, and movements to equity and money market mutual funds. This implies that Treasury bonds' popularity has a direct effect on their valuation. In terms of sheer market dynamics, flights-to-quality can be explained by volatility and demand for liquidity. It is still difficult, however, to quantitatively explain such a sudden and irrational short-term demand for investments earning only 2%.

In addition to the liquidity premium suggested in Longstaff (2004), there is also evidence of a credit risk premium inherent in U.S. Treasury yields. Huang (2003) notes that up to 30% of a U.S. Treasury-corporate bond credit spread is attributable to a credit risk premium.

Other than the liquidity and credit premiums suggested in the papers above, little light has been shed on the actual behavioral causes of flights-to-quality. Avery and Zemsky (1998) find that "herd behavior can lead to a significant, short run mispricing" in certain securities. Do investors only exhibit herd behavior with U.S. government securities? What about other fixed-income investments? Why bid for government securities when you can walk to a local bank and open a CD account with a similar risk profile that earns three times as much?

In summary, previous research has concentrated on evidence and causes of flights-to-quality. The study described in this paper adds to the literature by examining more thoroughly the effects of volatility on short term U.S. Treasury yields and the changes in the yield curve that result. In addition, significant and possibly lucrative trading strategies could be developed given the results of the statistical analysis explained below.

3. Sample selection and research method

As previous research has explained flights-to-quality in terms of liquidity needs and credit risk premiums, this paper examined the significant statistical relationship between the VIX Index of implied market volatility and yields on U.S. Treasury bills. I also investigated the effects of flights-to-quality on the positioning of the yield curve and the degree of theoretical mispricing in the Treasuries during flights-to-quality.

To explore these topics, the following data were compiled: historical daily yields for three relevant U.S. Treasury bills (one month, three month, and six month maturities); the corresponding VIX volatility index values, and the target Federal Funds rate. Regression analyzes were then performed to determine the level of variation in the Treasury data explained by the corresponding VIX Index values, or how much of the flight-to-quality phenomenon can be statistically justified by the underlying market volatility. The format of the regression equation is as follows, where $Yield_t$ is the yield for the short term Treasury, VIX_t is the corresponding VIX Index value, c_v is the regression coefficient for the VIX Index variable, $FFRate_t$ is the corresponding Federal Funds target rate, c_f is the coefficient for the Federal Funds variable, and ε is an error term.

$$(1)\quad Yield_t = c_v VIX_t + c_f FFRate_t + \varepsilon$$

Two additional regression analyses were performed using data with the VIX Index values lagged by one and two days, respectively. In the corresponding regression equations, VIX_{t-1} is the one-day lagged VIX Index value and VIX_{t-2} is the two-day lagged VIX Index value.

$$(2)\quad Yield_t = c_v VIX_{t-1} + c_f FFRate_t + \varepsilon$$

$$(3)\quad Yield_t = c_v VIX_{t-2} + c_f FFRate_t + \varepsilon$$

Market data were compiled from Bloomberg Professional (an integrated financial platform that streams together price and trading data, financials, news, and economic statistics). Given the six year range of the data, "generic" Treasury yields were used. Generic yields are derived from the synthetic yield history that is created by piecing together observed closing yields for benchmark bills of a given maturity. Such derived yields provide a more useful and seamless data set.

After determining the correlation between the VIX Index and Treasury yields, I used the regression equations to determine theoretical yields for each U.S. Treasury (based on the given Federal Funds target rate and the VIX Index value) and compared these to the actual yields during the August 2007 flight-to-quality. This gave an approximate estimate for the mispricing of the Treasury bills during the period shortly after the spike in market volatility.

4. Findings

4.1. Relevant statistical findings

This study used multivariate regression to determine the amount of variability in short term U.S. Treasury yields that could be explained by the VIX Index of market volatility and the Federal Funds target rate. The results of univariate, bivariate, and multivariate analyses are summarized below and presented in Table 1.

4.2. Strong correlation between Federal Funds target rate and U.S. Treasury yields affects study

The correlation between the Federal Funds target rate and each of the U.S. Treasury yields is strong—approximately 99% for each maturity (one month, three month, and six month). To account for this collinearity, regressions were recalculated using the VIX Index as the only independent variable. Further, a specific data set in which the Federal Funds rate remained unchanged at 5.25%[4] was used to account for the variability in the Federal Funds rate and its effects on Treasury yields,. This regression showed a more realistic adjusted R^2 value while maintaining significance (F value of nearly zero).

4.3. Significant mispricing in one and three month U.S. Treasuries during flights-to-quality

After determining a regression equations using both the VIX Index and Federal Funds target rate as independent variables, I used historical trading data from an August flight-to-quality to estimate approximately the theoretical yield on the U.S. Treasuries, given that day's VIX Index value and Federal Funds rate. I then compared this value with the actual close, to determine roughly the amount of mispricing due to the underlying flight-to-quality. Put another way, I determined what the Treasury should have closed at and compared it to its actual closing yield. This analysis showed strong mispricing in the one and three month U.S. Treasury yields—53% and 29% overpriced, respectively (see Tables 2 and 3). The six month Treasury was actually *underpriced* (true yield was higher than the theoretical) by only 1% (see Table 4).

This mispricing result can be explained by the direct relationship between implied volatility and the slope of the yield curve. As volatility increases, there is downward pressure on the yields of Treasuries with shorter maturities. Since the yield curve steepens in response to this increase in volatility, short maturity bills are mispriced more considerably more than longer term notes and bills. The small underpricing in the six month yield is most likely insignificant, and does not represent a considerable deviation from the theoretical yield (as in the one and three month bills).

4.4. Regression significance increases as U.S. Treasury maturity increases

For all three U.S. Treasuries, both regression analyses (with and without Federal Funds target rate) exhibited significance. However, as the maturity increased, there were

Table 1: Descriptive statistics and correlations

Panel A: Descriptive statistics

	VIX Index	Fed Funds Target Rate	1 Month Treasury	3 Month Treasury	6 Month Treasury
Mean	18.0200	2.8226	2.6068	2.7112	2.8573
Standard Error	0.1760	0.0428	0.0398	0.0404	0.0410
Median	16.0200	2.0000	1.8870	2.0120	2.1720
Mode	11.9800	5.2500	0.8650	0.9270	1.0320
Standard Deviation	6.8271	1.6621	1.5423	1.5691	1.5906
Sample Variance	46.6089	2.7627	2.3788	2.4620	2.5300
Kurtosis	1.2122	-1.5054	-1.3902	-1.5023	-1.5632
Skewness	1.2912	0.4114	0.4439	0.3589	0.2839
Range	35.1900	4.2500	4.5350	4.3700	4.5120
Minimum	9.8900	1.0000	0.7120	0.8050	0.8060
Maximum	45.0800	5.2500	5.2470	5.1750	5.3180
Sum	27120.1100	4248.0000	3923.2980	4080.4100	4300.2490
Count	1505	1505	1505	1505	1505

Panel B: Correlation matrix

	VIX Index	Fed Funds Target Rate	1 Month Treasury	3 Month Treasury	6 Month Treasury
VIX Index	1				
Fed Funds Target Rate	-0.4591	1			
1 Month Treasury	-0.4803	0.9870	1		
3 Month Treasury	-0.5083	0.9910	0.9957	1	
6 Month Treasury	-0.5381	0.9869	0.9885	0.9974	1

Panel C: Controlled correlation matrix

	VIX Index	1 Month Treasury	3 Month Treasury	6 Month Treasury
VIX Index	1			
1 Month Treasury	-0.6140	1		
3 Month Treasury	-0.7368	0.8985	1	
6 Month Treasury	-0.7492	0.7951	0.9556	1

Figure 1 shows the descriptive statistics and correlations for the five variables used in the study Panels A and B cover a period from October 31st 2001 to October 31st 2007 while Panel C includes only data from June 29th to September 17th; this controls for the Federal Funds rate as it remained at 5.25% over the period.

[4] The Federal Funds rate was unchanged at 5.25% from June 29, 2006 to September 17, 2007.

Table 2: One month U.S. Treasury regression analysis

	FFRate and VIX Index (1)	VIX Index (2)	VIX Index$_{t-1}$ (3)	VIX Index$_{t-2}$ (4)
Intercept	0.2033*	5.6372*	5.691*	5.7123*
	(7.4947)	(90.1104)	(93.4950)	(94.4152)
c_v (VIX)	-0.0078*	-0.0563*	-0.0601*	-0.0617*
	(-7.5204)	(-13.5406)	(-14.8296)	(-15.2781)
c_f (FFRate)	0.9012*	-	-	-
	(212.0522)	-	-	-
Significance F	0	5.4520×10^{-33}	8.7707×10^{-38}	1.8127×10^{-39}
Adjusted R^2	0.9751	0.3749	0.4186	0.4333
N	1505	305	305	305

*Indicates statistical significance at the 0.05 level

Table 2 shows the results of the regression analyses performed using one month U.S. Treasury data. Column (1) summarizes the regression analysis calculated using both the VIX Index values and Federal Funds target rate as independent variables over the period of October 31, 2001 to October 31, 2007. Column (2) summarizes the regression analysis calculated using the VIX Index values as the sole independent variable. This regression only includes data from June 29, 2006 to September 17, 2007 to control for the Federal Funds target rate as it remained at 5.25% over the period. Columns (3) and (4) summarize the regressions calculated using only lagged VIX Index values from June 29, 2006 to September 17, 2007 (to control for the Federal Funds target rate) as the independent variable. The VIX Index values for these regressions were lagged one and two days, respectively. *t*-statistics are in parentheses.

Table 3: Three month U.S. Treasury regression analysis

	FFRate and VIX Index (1)	VIX Index (2)	VIX Index$_{t-1}$ (3)	VIX Index$_{t-2}$ (4)
Intercept	0.4329*	5.6139*	5.6453*	5.6625*
	(20.6639)	(144.2953)	(150.2182)	(153.1091)
c_v (VIX)	-0.0155*	-0.0490*	-0.0513*	-0.0526*
	(-19.4262)	(-18.9693)	(-20.4968)	(-21.3006)
c_f (FFRate)	0.9062*	-	-	-
	(276.1704)	-	-	-
Significance F	0	1.9406×10^{-53}	3.5163×10^{-59}	3.5583×10^{-62}
Adjusted R^2	0.9857	0.5414	0.5796	0.5983
N	1505	305	305	305

*Indicates statistical significance at the 0.05 level

Table 3 shows the results of the regression analyses performed using three month U.S. Treasury data. Column (1) summarizes the regression analysis calculated using both the VIX Index values and Federal Funds target rate as independent variables over the period of October 31, 2001 to October 31, 2007. Column (2) summarizes the regression analysis calculated using the VIX Index values as the sole independent variable. This regression only includes data from June 29, 2006 to September 17, 2007 to control for the Federal Funds target rate as it remained at 5.25% over the period. Columns (3) and (4) summarize the regressions calculated using only lagged VIX Index values from June 29, 2006 to September 17, 2007 (to control for the Federal Funds target rate) as the independent variable. The VIX Index values for these regressions were lagged one and two days, respectively. t-statistics are in parentheses.

proportional increases in significance (F values closer to zero) as well as increases in the adjusted R^2 values. Accordingly, the six month Treasury regression showed the most significance while also explaining the most variability in the Treasury yields that could be attributed to the corresponding VIX Index values (see Table 4). Given the six month Treasury's relatively low degree of mispricing, the result of a more accurate and significant model is not unexpected.

4.5. Regression significance increases when VIX Index values are lagged

For all three U.S. Treasuries, regression analyses using lagged VIX Index values showed higher adjusted R^2 values and lower significance F values, indicating more accurate models. The one month Treasury regression showed the highest increase in adjusted R^2 from lagging the VIX Index by two days—a nearly six percentage point increase. This result suggests that U.S. Treasury yields require at least one day to price in the effects of higher VIX Index values (this of

Table 4: Six month U.S. Treasury regression analysis

	FFRate and VIX Index (1)	VIX Index (2)	VIX Index$_{t-1}$ (3)	VIX Index$_{t-2}$ (4)
Intercept	0.7772*	5.5903*	5.6047*	5.6160*
	(33.8087)	(182.3036)	(184.7627)	(186.9325)
c_v (VIX)	-0.0251*	-0.0401*	-0.0412*	-0.0421*
	(-28.6255)	(-19.6869)	(-20.3801)	(-20.9577)
c_f (FFRate)	0.8971*	-	-	-
	(249.1773)	-	-	-
Significance F	0	3.8305×10^{-56}	9.6044×10^{-59}	6.7001×10^{-61}
Adjusted R^2	0.9832	0.5598	0.5768	0.5904
N	1505	305	305	305

*Indicates statistical significance at the 0.05 level

Table 4 shows the results of the regression analyses performed using six month U.S. Treasury data. Column (1) summarizes the regression analysis calculated using both the VIX Index values and Federal Funds target rate as independent variables over the period of October 31, 2001 to October 31, 2007. Column (2) summarizes the regression analysis calculated using the VIX Index values as the sole independent variable. This regression only includes data from June 29, 2006 to September 17, 2007 to control for the Federal Funds target rate as it remained at 5.25% over the period. Columns (3) and (4) summarize the regressions calculated using only lagged VIX Index values from June 29, 2006 to September 17, 2007 (to control for the Federal Funds target rate) as the independent variable. The VIX Index values for these regressions were lagged one and two days, respectively. t-statistics are in parentheses.

course, requires the assumption that markets are not perfectly efficient).

5. Conclusion

This study examined the amount of variability in short term U.S. Treasury yields that can be explained by the VIX Index of implied market volatility. Twelve regression analyses were performed using the one, three, and six month generic U.S. Treasury yields as dependent variables and the corresponding VIX Index values and Federal Funds target rate as independent variables. To improve the accuracy of the study, models were created both including and excluding the Federal Funds target rate. This process addressed the collinearity between the Treasuries and Federal Funds rate. Models with lagged VIX Index values were also created.

The models showed a significant level of mispricing in the one and three month yields during the August flight-to-quality (see Figure 1). Due to the proportional relationship between the slope of the yield curve and implied volatility, this result is not unexpected. The sheer degree of mispricing in the one month Treasury (more than 50%), however, is both an unexpected and interesting result (see Table 5).

The tendency for model accuracy to improve as the Treasury maturity increases is another interesting result of the analysis. Examining the flight-to-quality in August, though, shows a less volatile market for the six month Treasury (Figure 1). This smoother data set is most likely the reason for the more significant model. Regression models using data lagged by one and two days respectively explained a higher percentage of variability in the Treasury yields that could be explained by the VIX Index values. Models with lagged data also exhibited more significance (lower F values).

The analyses used in this study examined the dynamics of short term U.S. Treasury yields during flights-to-quality.

Figure 1. August 2007 flight-to-quality

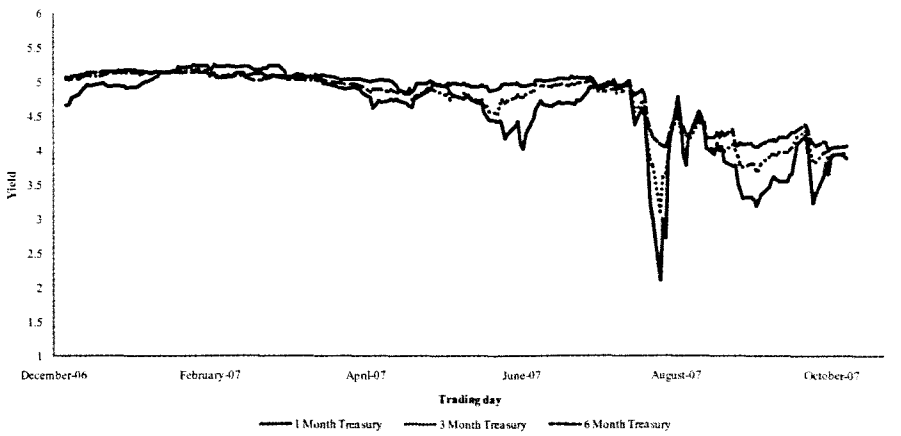

Table 5: Determination of fight-to-quality mispricing using regression equations

	Regression equation	Theoretical yield	Actual yield	Percent mispriced
One month U.S. Treasury	$Y_{Treasury} = -0.0078x_V + 0.9012x_F$	4.53%	2.11%	-53.45%
Three month U.S. Treasury	$Y_{Treasury} = -0.0155x_V + 0.9062x_F$	4.35%	3.09%	-28.88%
Six month U.S. Treasury	$Y_{Treasury} = -0.0251x_V + 0.8971x_F$	4.05%	4.09%	0.88%

Table 5 shows the mispricing of U.S. Treasuries on August 20th 2007 due to a flight-to-quality. Using the regression equations that included both the Federal Funds and VIX Index variables, theoretical yields were calcuated and compared to the actual yield.

The statistical results show interesting levels of mispricing and various degrees of quality and significance among the three different maturities. The models created in this analysis can be adapted to complement trading strategies and will add to the existing (and limited) research on the statistical effects of volatility on flights-to-quality.

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Mentor Comments:

Dr. Craig Rennie draws attention to the independence of Craig Cox's work and its importance in contributing to our understanding of stock market volatility.

Craig Cox's undergraduate honors thesis titled "Flights to Quality: The Effects of Market Volatility on Short Term U.S. Treasury Yields" addresses a research topic of great interest not previously addressed in Finance. Market volatility and associated flights to quality via short-term U.S. Treasury securities is of great interest to Finance academics and practitioners. Artificially low yields and correspondingly high prices appear inconsistent with market efficiency. However, a growing body of behavioral Finance literature suggests investors often overreact to news and market volatility through excessive buying or selling of securities. The effects of stock market volatility, reflected in the relatively new VIX index, on U.S. Treasury yields and the U.S. bond market, have not previously been studied. Craig shows that stock market volatility, as measured by the VIX index, helps explain volatility in U.S. Treasury yields and thus prices. In fact, he documents mispricings of as much as 50% during periods of high stock market volatility. These results are some of the first to explain changes in U.S. Treasury yield changes associated with flights to quality following increases in stock market volatility. They represent a material contribution to the body of knowledge in the field of Finance.

Craig's research is original, and he selected his topic completely independently. His thesis "Flights to Quality: The Effects of Market Volatility on Short Term U.S. Treasury Yields" is one of the very best undergraduate research papers that I have seen.