An analysis of the VIX volatility index on the US treasuries, Specifically during the periods of Quantitative Easing

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Abstract: The main purpose of this paper is to explore the question "Is the VIX index an effective predictor of the 10yr treasury? In particular, how did this relationship change during the periods of QE1, QE2, and QE3?" An empirical analysis of five models is conducted and it is determined the change in VIX is predictive of the change in the 10 year treasury.

1. Introduction

Volatility is a concern of many investors. In turbulent financial times there can be a flight from the equity market to treasury bonds in order to provide greater security, liquidity and guarantee of returns. Calculated as a weighted average of put and call options on the S&P 500 Index, the VIX is considered as a forecasting indicator of the S&P 500 Index's volatility over a one-month period. The dependent variable in this study is the 10 yr Treasury note. The 10-year T-note is the most widely tracked government bond, and it is used as a benchmark for banks and the Treasury market in calculating mortgage rates.

This paper is organized in the following manner: section two is a literature review for papers that have focused on VIX, treasuries, event studies and the stock – bond correlation. Section three is a discussion and historical reference of the key variables that are being used for analysis

including the VIX, treasury market and the monetary policy termed quantitative easing. The relationship between the equity and bond market will also be discussed. Section four is an empirical analysis that consists of five models; an ordinary least squared regression including the change in VIX and the change in the 10yr treasury. The implications of quantitative easing (QE1, QE2, and QE3) on VIX and the 10yr treasury will also be explored. In addition, a model that looks at the interaction of the previous month's VIX on the treasury and potential shocks on each variable. In section five a conclusion is drawn, including a proposal for the next analysis.

2. Literature overview

There appears to be minimal literature that directly looks at VIX and the ten year treasury. The most recent analysis that looked at the interaction of these specific variables was in (Simlai 2010). They investigated whether the persistence of changes in the CBOE volatility index is associated with Treasury Bill (T-bill) yield and common market index, such as S&P 500, during the period of the tremendous stock market growth of the late 1990s. "We examine if the positive information from the market index and the innovations in the predictive variables play any role in explaining the variability of index options. The implied volatility from our model shows that high volatility of index options accompanies falling prices in the market index. Overall, our empirical results demonstrate that there is more downside weakness than upside strength in the predictive power of the market index." The data used was from September 1995 to August 2003, the frequency was weekly, the changes in the 10 year treasury, changes in the VIX and the S&P 500 daily closing figures were included variables. They observe that the GJR-GARCH specification seems to do a better job at forecasting the variation in actual volatility of VIX changes.

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The majority of journal articles focus on the underlying topics in this paper including the correlation between the equities and bond market. This literature confirms the previous knowledge that in turbulent times investors tend to flee the stock market and increase demand for US treasuries. In a study by (*Guo, Zhou, Cheng, & Sornette 2011*) the conclusion is made that "the robust lead of the S&P 500 stock market index with respect to yields of all maturities remains the most important stylized fact unearthed by our study."

The event study methodology is discussed in detail in (*Baur & Rudebusch 2013*) provided the rational for including the indicator variables for quantitative easing in this study. "This methodology focuses on changes in asset prices over tight windows around discrete events. We also employ such a methodology to assess the effects of LSAPs on fixed income markets."

In a paper by (*Markellos & Psychoyios 2013)* they investigate the US treasury market volatility and develop new ways of dealing with the underlying interest rate volatility risk. They use "an innovative approach based on a class of model-free interest rate volatility (VXI) indices we derive from options traded on the CBOE."

3. The model description or core analytical discussion of the main concept

3.1 Basic interaction of equity and bond market.

Traditional financial wisdom has guided investors to allocate their investments amongst stocks and bonds. This advice was given on the premise that these two markets move in opposite directions. This tends to be the historical perception, however the long-term view of the stock and treasury movement can depict otherwise. Certain economic conditions will have investors abandoning the stock market and pursuing bonds, the same holds true in the opposite condition. During periods of economic growth and expansion the bond market might not appear as attractive and have investors pursuing the potentially more lucrative returns of stocks. By

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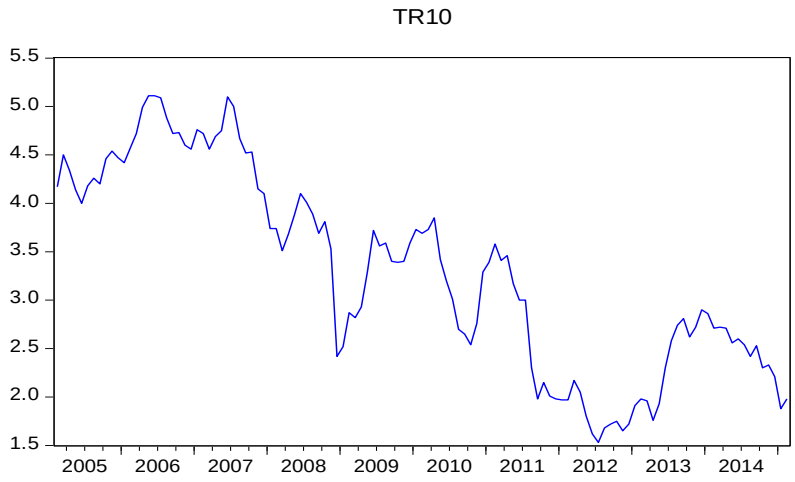
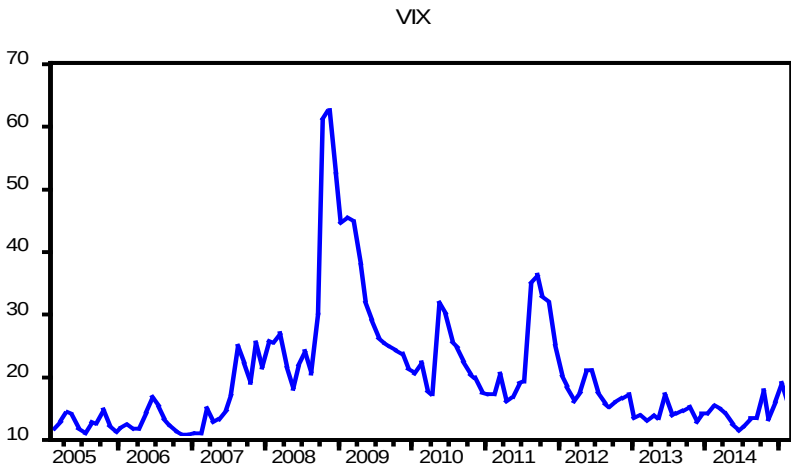
allocating to both in a portfolio, a tumble in stocks would be offset by rising bond prices. While that hasn't taken place over the last few months, bonds and stocks can still balance each other out because bond market returns tend to be less volatile than stock market returns. The financial crisis of 2008 has caused the markets to perform in inconsistent ways and the interactions and co movements that were known to exist have not completely realigned to pre-crisis behavior. The graphs below shows the 10 year treasury yield and the VIX over the 2005 – 2015 periods analyzed in this study.





3.2 History of VIX:

VIX was introduced by the CBOE in 1993 and revised in 2003. It is often referred to as the "fear" index. The VIX is quoted in percentage points and translates, roughly, to the expected movement (with the assumption of a 68% likelihood i.e. one standard deviation) in the S&P 500 index over the next 30-day period, which is then annualized. The VIX is a measure of a perceived market risk in either direction.

3.4 The period of quantitative easing. The role of event studies.

The most high-profile form of unconventional monetary policy has been Quantitative Easing (QE). The phrase was first applied to Japan as it dealt with the bursting of a real estate bubble and the deflationary pressures that followed in the 1990s. The hope was that by targeting a high enough level of reserves, eventually this would spill over into lending into the broader economy, helping drive asset prices up and removes deflationary forces. The central banks of the US, the Euro area and the UK have all followed Japan in adopting policies that have led to substantial increases in their balance sheets, although there are significant differences both amongst themselves and with Japan in terms of how they have implemented QE and other unconventional policies. The Bank of England has overwhelmingly bought UK government bonds from the non-bank private sector through its QE operations; the Fed has bought US Treasuries but also large quantities of agency debt and agency-backed mortgage backed securities. This period of quantitative easing had a significant impact on the financial markets; the inclusion of these indicator variables seemed relevant in the formation of this study.

4. Empirical evidence

Monthly data was obtained from FRED from February 2005 to February 2015. The dummy variables were created from December 1, 2008 to September 1, 2010 for QE1, October 1, 2010 to July 1, 2012 for QE2 and August 1, 2012 to November 1, 2014 for QE3. Appendix A details

the announcements/statement regarding the implementation of the periods of quantitative easing. It was determined that the monthly data for both VIX and the 10 year treasury is non-stationary; therefore the monthly change for both variables was used. There are five models for analysis.

4.1 Empirical Analysis: Key Statistics and Discussion of Models

	Ind. Var	Coeff	t-stat	p-value	R-squared	DW	AIC	Schwarz
1. OLS	C	-.018	-.908	.366	.032	1.559	-.205	-.158
	D(VIX)	-.009	-1.981	.050				
2. OLS With QE	C	-.010	-.318	.751	.053	1.571	-.177	-.060
	D(VIX)	-.009	-2.102	.038				
	QE1	-.047	-.822	.413				
	QE2	-.042	-.764	.446				
	QE3	.037	.717	.475				
3. Lag	C	-.020	-.837	.404	.126	2.043	-.286	-.192
	D(VIX)	-.012	-2.807	.006				
	AR(1)	-.270	-1.202	.232				
	MA(1)	.592	3.152	.002				
4.GARCH	C	-.012		.596	.003	1.563	-.247	-.131
	D(VIX)	-.017		.000				
	C	.009		.266				
	RESID (-1)^2	.241		.030				
	GARCH(-1)	.572		.028				
5.VAR	D(VIX)				.173		5.894	6.156
	D(TR10)				.287		-.350	-.087

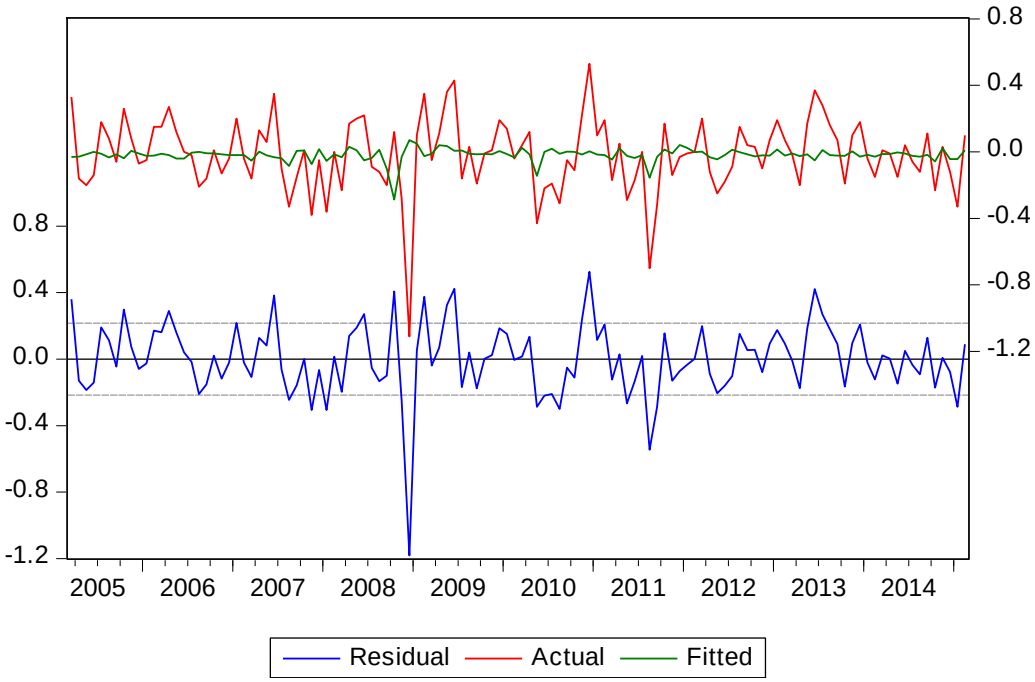
Model 1~

$$\Delta Y_t = \mathrm{B}_0 + \mathrm{B}_1 \Delta X + \varepsilon_t$$

Model 1 is an ordinary least squared model with one predictor variable. In Model 1, the negative coefficient suggests that when the change in VIX increases by one unit, the change in the 10 year treasury decreases by .009. However the change in VIX is barely statistically significant. The

low R-squared value shows that the VIX only explains 3.2 percent of the variance in the 10yr treasury. In **Figure 1/Model 1**, the fitted values are not mirroring the actual. This is a poor model evidence by the low R-squared.

Figure 1/Model 1



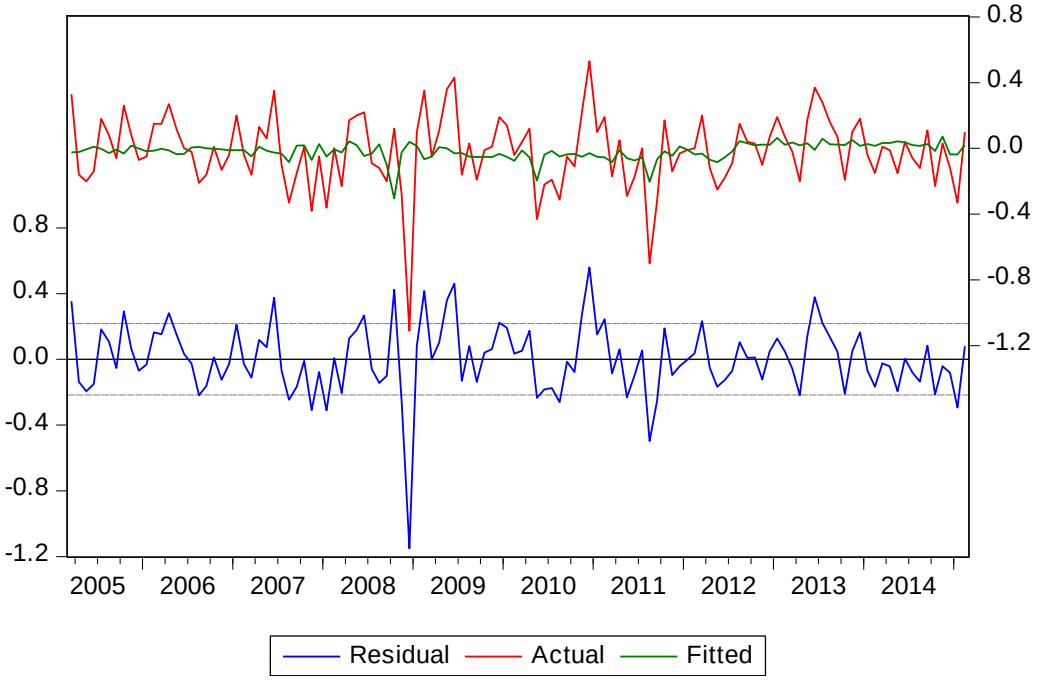
Model 2~

$$\Delta Y_t \ = \beta_0 \ + \ \beta_1 \Delta X_{1t} + \ \beta_2 \, X_2 \ + \ \beta_3 X_3 + \ \beta_4 X_4 + \ \varepsilon_t$$

Model 2 is an ordinary least squared model including the change in VIX and three indicator variables for each period of the quantitative easing policy. The indicator variables were created using the following dates: December 1, 2008 to September 1, 2010 for QE1 (β_2), October 1, 2010 to July 1, 2012 for QE2 (β_3) and August 1, 2012 to November 1, 2014 for QE3 (β_4). (See Appendix 1 for the particular announcements.) The change in VIX remained a statistically

significant variable. The indicator variables are not statistically significant; however the inclusion of the three indicator variables has slightly improved the R-Squared. The DW is slightly improved. The AIC and Schwarz are lower than Model 1. In **Figure 2/Model 2**, the fitted is still not mirroring the actual and the residuals are not trending.

Figure 2/Model 2



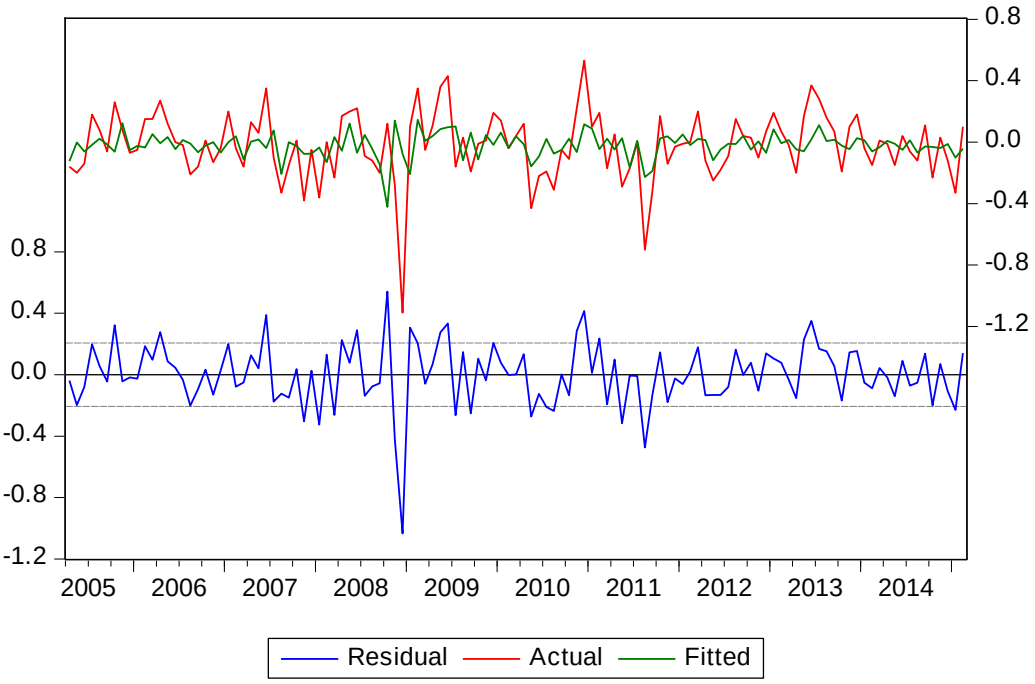
Model 3 ~

$$\Delta Y_t = \beta_o + \beta_1 \Delta X_1 + \phi_1 Y_{t-1} + \Theta_1 E_{t-1}$$

Model 3 is an autoregressive model. Initially the model included the moving average one and two and autoregressive one and two. When the second lag was removed the first became significant. The Durbin-Watson is higher at 2.043. The AIC and Schwarz criterion are both also higher than the previous models. The R-squared value of .126 shows that the first lagged VIX explains 12.6 percent of the variance in the 10yr treasury. In **Figure 3/Model 3** the fitted does a

better job capturing the actual. In addition, the residuals are scattered around 0, with no discernible pattern.

Figure 3/Model 3



Model 4 ~

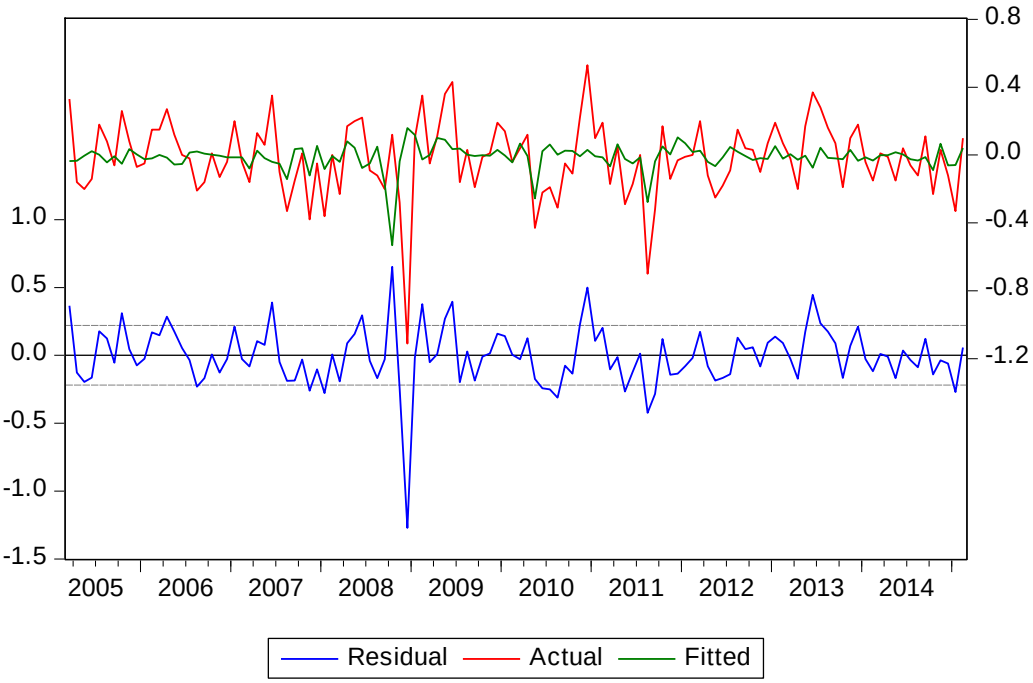
$$\Omega_{it}\left|\Delta Y_t = \beta_0 + \beta_1 \Delta X_t + \varepsilon_t\right. \quad \text{model for mean}$$

$$\sigma_t^2 = \gamma_0 + \gamma_1 \varepsilon_{t-1}^2 + \gamma_2 \sigma_{t-1}^2 + \varepsilon_t^{'} \quad \text{model for variance}$$

Model 4 is a GARCH model that tries to model the volatility in the 10yr treasury. GARCH (-1), 57% of the previous months variance carries over to this month's variance, 24% of last month's variance carries over to this month. In this model the change in VIX is significant. The R-squared is low at .003. The Durbin Watson is 1.563 and the AIC and Schwartz is not an improvement over the previous model. In addition, the GED parameter is less than 2 indicating

possible tail risks. In **Figure 4/ Model 4** the fitted is still not mirroring the actual and the residuals are not trending.

Figure 4/Model 4



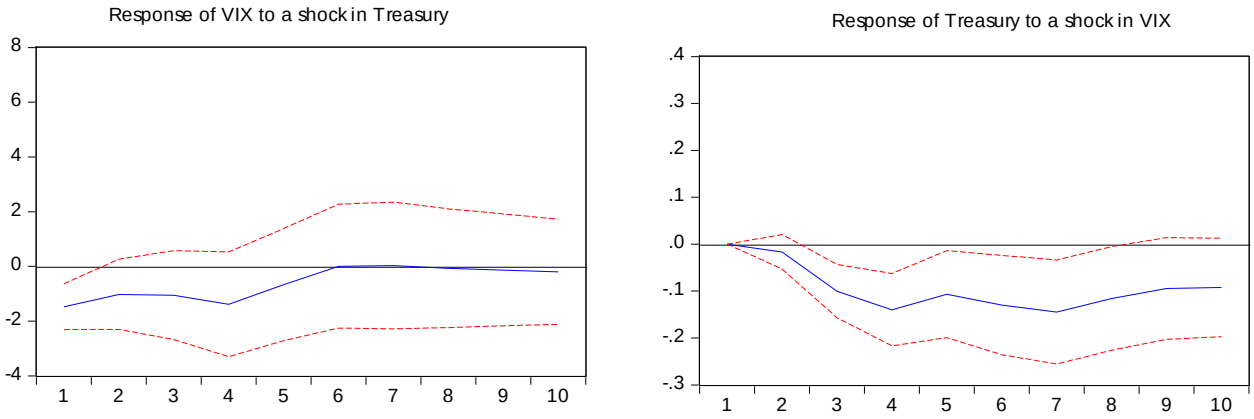
Model 5 ~

$$Y_t = c_1 + \alpha_{11}Y_{t-1} + \alpha_{12}Y_{t-2} + \ldots + \alpha_{15}Y_{t-5} + \beta_{11}X_{t-1} + \beta_{12}X_{t-2} + \ldots + \beta_{15}X_{t-5} + \varepsilon_{1t}$$

$$X_t = c_2 + \alpha_{21}Y_{t-1} + \alpha_{22}Y_{t-2} + \ldots + \alpha_{25}Y_{t-5} + \beta_{21}X_{t-1} + \beta_{22}X_{t-2} + \ldots + \beta_{25}X_{t-5} + \varepsilon_{2t}$$

Model 5 is a vector auto regression with impulse responses. In this VAR estimation, the most reliable lagged explanatory variable for the difference in treasury is its own first-lag. The accumulated response of the 10yr treasury to a shock in VIX is evident at first and then the reaction smoothes out. A negative response of the 10yr treasury to a shock in the change in the VIX index is most pronounced at the four month lag.

Figure 5/Model 5



5. Conclusions / Further areas of research

One conclusion of this analysis is that implied stock volatility may be a valuable variable for financial applications that need to interpret and predict stock and bond market co-movements. Based the empirical analysis conducted; across models the change in VIX was predictive of the change in treasury. The model examination determined that in model 3, including the autoregressive and moving average provided the most accurate results.

Further analysis of this topic might include looking at both positive and negative shocks on the VIX and that impact on the treasury. In addition the QE periods could still provide valuable information on the interaction between the variables when the observation period is extended or the data frequency is increased. The further research on the topic of volatility in both equities and treasuries can provide investors and advisors with more of a framework to navigate the unchartered territory of the post crisis financial markets.

Appendix:

Appendix A:
Key dates/announcements made by the Federal Reserve

Date	Program	Event
11/25/2008	**QE1**	**FOMC statement –** LSAPs announced: Fed will purchase $100 billion in GSE debt and $500 billion in MBS.
12/1/2008	**QE1**	**Bernanke speech –** First suggestion of extending QE to Treasuries.
12/16/2008	**QE1**	**FOMC statement –** First suggestion of extending QE to Treasuries by FOMC.
10/15/2010	**QE2**	**Bernanke speech –** Bernanke reiterates that Fed stands ready to further ease policy.
11/3/2010	**QE2**	**FOMC statement –** QE2 announced. Fed will purchase $600 billion in Treasuries.
8/22/12	**QE3**	**FOMC minutes released –** FOMC members "judged that additional monetary accommodation would likely be warranted fairly soon…."
9/13/2012	**QE3**	**FOMC statement –** QE3 announced: The Fed will purchase $40 billion of MBS per month as long as "the outlook for the labor market does not improve substantially…in the context of price stability."
12/12/12	**QE3**	**FOMC statement –** QE3 expanded: The Fed will continue to purchase $45 billion of long-term Treasuries per month but will no longer sterilize purchases through the sale of short term treasuries.

References:

Bauer, Michael D, Rudebusch, Glenn D. (2013) *The Signaling Channel for Federal Reserve Bond Purchases.* Federal Reserve Bank of San Francisco Working Paper Series. (2011-2021).

Faugere, Christophe. (August 1, 2013) *The Fear Premium and Daily Comovements of the S&P 500 E/P ratio and Treasury Yields before and during the 2008 Financial Crisis*. Financial Markets, Institutions and Instruments.

Guo K, Zhou W-X, Cheng S-W, Sornette D (2011) *The US Stock Market Leads the Federal Funds Rate and Treasury Bond Yields.* PLoS ONE 6(8): e22794. doi:10.1371/journal.pone.0022794

Johnson, Nicholas, Naik, Vasant, Page, Sebastien, Pedersen, Niels, Sapra, Steve. (November 2013) *The Stock-Bond Correlation. PIMCO Quantitative Research.*

Markellos, Raphael. Psychoyios, Dimitris. *Interest Rate Volatility and Risk Management: Evidence from CBOE Treasury Options.* (August 1, 2013). Available at SSRN: http://ssrn.com/abstract=1585744 or http://dx.doi.org/10.2139/ssrn.1585744

Stivers, Chris, Sun, Licheng. (March 2002) *Stock Market Uncertainty and the Realtion between Stock and Bond Returns.* Federal Reserve Bank of Atlanta.