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DECONTAMINATING FINANCIAL MARKETS

A VAR Framework on the Fed's Efforts to Mitigate Contagion in During the Subprime Credit Crisis

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ABSTRACT

I conduct an empirical investigation on the effects of the Fed's TAF program on the financial market contagion between the ABX indexes and several equity and bond markets during the subprime credit crisis. I find evidence that the contagion effects significantly differ between the periods before and after Fed's TAF program is employed. The results support the hypothesis that the Fed interventions helped mitigate the contagion effects across several markets. ABX returns hold significant predictive power over treasury, corporate bond and equity markets before Fed's TAF program however these contagion effects dissipate for the subsample after the Fed intervenes. These results show that the Fed's actions stabilized the risk and liquidity premia for these markets relieving contagion effects.

Keywords: Contagion, Intervention, Mortgage-backed securities, Liquidity

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CHAPTER 1 Introduction

Financial markets act as a mechanism where funds are channelled from those with surplus funds to those in need of these funds for investments allowing for an efficient allocation of resources. Facilitation of this process is crucial for technological advancement fuelling economic growth. Thus, financial markets also allow for reflection of available information about several of these investments which are then used to discover their prices by the market participants.

However, this mechanism does not always act as perfectly as it is designed to. As prices generally reflect available information accurately sometimes widespread price discoveries occur when the reality is not the same as the general expectation leading to major price shocks. This is what happened in the subprime credit crisis as the realization that cash-flows from Mortgage-Backed Securities (MBSs) were going to be much less than initially anticipated.

As these MBSs were widely popular in the financial markets, their decline in value acted as a catalyst to trigger widespread financial distress, leading to the collapse of several important financial institutions and a global financial crisis. This catalyst acts as a shock to the financial markets which led to a "contagion" between the MBS market and several markets.

The extensive literature about contagion in financial markets defines this phenomenon as an increase between the cross-market linkages after a shock event, thus the subprime credit crisis provides an opportunity to look at the effects of the contagion. The subprime crisis was unprecedented in many ways as also the central banks did not experience a similar shock to the markets before it. Therefore, they intervened in unprecedented ways themselves. The focus of this research is to determine if the Fed helped mitigate the effects of contagion in financial markets with their unconventional interventions.

This paper aims to combine the ideas and methods from several prior literature and provide a greater understanding on the effects of the Fed's actions on the contagion in financial markets during the subprime credit crisis. Namely Wu, (2011) finds that the TAF program by the Fed helped improve liquidity conditions in the interbank markets. Which when combined with the idea from Longstaff, (2010) that the contagion during the subprime credit crisis spread through the liquidity channels, also consistent with the funding-illiquidity mechanism presented by Brunnermeier & Pedersen (2005), provides an opportunity to see if the TAF program by the Fed helped mitigate contagion effects also in the broader financial markets.

To see the effects, I use a VAR framework and test for contagion using Granger causality before and after the Fed employs the TAF program as it is the first unconventional step the Fed took to combat the subprime credit crisis.

The VAR results and Granger causality tests show significant contagion before the Fed interventions across the treasury market, corporate-treasury bond yield spreads along with equity markets. However, after the Fed started to intervene the results changed significantly with contagion properties changing for the 10-year treasury bond yields. More importantly the contagion effects seem to almost fully dissipate for the 2-year treasury bond yields and the corporate-treasury bond yield spreads. Thus, these results suggest that the Fed interventions were successful in its efforts to mitigate contagion in financial markets during the subprime credit crisis.

The paper is structured as follows, the theoretical framework will summarize the previous literature regarding contagion in financial markets and possible channels in which it might occur as well as the possible targets and effects of central bank interventions on contagion. The data section gives detailed information about data sources and structure and properties. The Methodology section explains the VAR framework, the Granger causality tests, and the hypothesis and scope of this research. Then the results section discusses the results and their economic implications. Finally, the conclusion and discussion section give final remarks and possible improvements and ideas for future research.

CHAPTER 2 Theoretical Framework

2.1 Contagion in Financial Markets

The term contagion by itself means “the spreading of a harmful practice”. This is widely used in the context of healthcare, where a disease develops a contagious nature and slowly, or sometimes quickly, becomes the problem of more people around the world. In the context of financial markets “contagion” corresponds to a similar circumstance.

Following Dornbusch et al., (2000) and many others, I will define contagion as a period where there is a significant increase in cross-market linkages after a shock occurs in one market. Which would translate to a situation where a negative shock to a certain debt market would map into subsequent negative returns in the stock market, hence becoming a problem for more people. Contagion in financial markets has been studied extensively in academic research.

2.2 Contagion Channels

2.2.1 Fundamentals Channel

In their paper Dornbusch et al., (2000) highlight that economic and financial linkages between countries become stronger during times of financial distress or shocks. The paper also finds that there can be several factors and channels that can lead to contagion in financial markets across countries. Fundamental channels such as trade and financial linkages where countries who have strong trade ties and common cross-border financial institutions can transmit financial distress through supply chain disruptions or shocks to common creditors which makes obtaining credit more difficult thus leading to contagion in credit markets for these countries.

2.2.2 Information and Behavioural Channels

Information and behavioral channels also play a role in contagion across financial markets. In their study King & Wadhwani, (1990) focus primarily on information channels and their role in spreading contagion. They highlight that markets are linked with information channels and when shocks happen to a certain market it affects other markets not solely based on fundamentals but also through information channels. Their study also emphasizes the effect of the behavioral aspects where a shock to one market propagates negative sentiment to another market through investor expectation that this shock provides new information about returns across different markets.

2.2.3 Liquidity Channel

Liquidity can also play a role in spreading contagion across financial markets. Liquidity shocks to a certain market may lead to an overall liquidity shortage across different markets thus leading to increased cross-market linkages based on liquidity. Allen & Gale, (2000), using their model, highlight how interbank connections can spread liquidity shocks across different regions. They show that when

banks establish claims where one would provide liquidity to another in times of distress, these claims can lead other banks to sell assets or call in loans to meet the liquidity demand. In that case, this leads to difficulties in obtaining credit or liquidity for the other bank who also relies on the interbank claims for liquidity. Thus, the initial shock propagates between other regions and hence leads to contagion in financial markets. However interbank markets are not the only cause of liquidity contagion, Kodres & Pritsker, (2002) find that negative shocks to one market, also amplified by leveraged positions, lead investors to manage their liquidity by selling assets in unrelated markets to balance their portfolios and meet liquidity demands from their leveraged positions. They find empirical evidence that this rebalancing leads to significant contagion effects across different markets. Their model also shows that even smaller shocks can lead to significant rebalancing as investors manage their risk preferences and thus leading to contagion effects across many different markets.

2.2.4 Risk-premia Channel

Tied to liquidity contagion channel, Acharya & Pedersen, (2005) developed a Liquidity Adjusted Capital Asset Pricing Model (LCAPM) where a security's required return does not only depend on its relative risk to the market but also on its liquidity. In their model illiquid securities have higher risk premia compared to more liquid assets to compensate for potential liquidity risk. When negative liquidity shocks hit one financial market, investors in other markets also demand higher returns, as liquidity risk premia increases, to hold illiquid assets. This then leads to changes in the equilibrium risk premia implying that asset returns in distressed markets may hold predictive power over other assets in different markets. In a major distress event, this contagion can spread throughout the whole economy. Longstaff, (2010) claims that an increase in risk-premia for assets in a certain market impacts the distribution of future asset returns in other markets, thus creating a feedback effect which may introduce predictability in asset return time series.

2.3 Contagion in the subprime credit crisis

The subprime credit crisis which then developed into the global financial crisis provides an almost textbook example of a major distress event where liquidity shocks influence the equilibrium risk premia across many markets. Bouwman et al., (2012) found well documented changes in risk-premia across the US Treasury bond market. Longstaff, (2010) claims that liquidity shocks in the subprime Mortgage-Backed Securities (MBS) market had significant spill over effects over other markets across the economy. During the subprime crisis, investors generally moved from illiquid assets which were increasingly riskier because of the liquidity shortages to more liquid and traditionally safer assets which is consistent with flight-to-quality and flight-to liquidity patterns. Therefore, it is reasonable to take liquidity and risk-premia channels as the main channels for contagion during the subprime credit crisis.

2.4 Fed interventions and possible effects

2.4.1 TAF Program

During the subprime credit crisis banks faced severe liquidity shortages and they became in severe need of short-term funding. However, since the interbank lending market became distressed the traditional mechanisms to obtain these funds were impaired. The Fed offered a discounted funding window however borrowing using this channel was deemed as a way of showing "financial weakness", so banks were reluctant to use this channel. As a result, the Fed came up with what is called the Term Auction Facility, more commonly known as TAF on the 21st of December 2007. Where the Fed conducted regularly scheduled auctions where the financial depositories who were eligible could bid for term funds using a wide range of collateral. Typically, short-term funds were given through TAF and it provided urgent liquidity to the market and relieved stress on the interbank market. The interest rate for these loans was determined by an auction system, as the name suggests, which reflected the market conditions effectively.

2.4.2 Possible Effects of Fed Interventions on Contagion

This research is focused on curing financial contagion and how the Federal Reserve system aided the financial sector with unconventional interventions. Since the main drivers of the contagion are liquidity and risk-premia channels, the Fed's actions to provide liquidity to generally financially sound, but distressed because of short-term liquidity shocks, financial institutions are going to be focused on. Wu, (2011) shows that during the subprime credit crisis liquidity premiums and counterparty default risk premiums surged to unprecedented levels. Wu, (2011) also found that The Fed's Term Auction Facility helped relieve the liquidity distress on the interbank markets and therefore helped cure, although not all, some of the contagion in the financial markets. As, it would be "too good to be true" that the TAF alone could undo all the damage done to the financial markets and the whole economy in such brief time and action frames. Wu, (2011) primarily focuses on the interbank markets and concludes that the TAF program acted as a critical measure to relieve pressure on the liquidity stress in the financial sector. When combined with the idea which Longstaff (2010) finds, that the main channel that led to contagion during the subprime credit crisis was the liquidity channel, by showing that the subprime credit crisis led to significant changes on liquidity, funding and trading activity patterns. It could be reasonable to combine the ideas of the two papers and see whether the TAF program was also successful in mitigating the contagion effects for the broader financial markets including the treasury, corporate bond and the equity markets.

Based on previous literature about contagion in financial markets and the effects of Federal Reserve interventions, namely the TAF program, this research aims to find that the returns of the subprime mortgage-backed securities that have significant predictive power over (granger cause) asset returns

from equity and bond markets during the subprime credit crisis, will not have significant predictive power over (granger cause) the same assets after the TAF program has been employed.

CHAPTER 3 Data

3.1 The ABX indexes:

In order to investigate the contagion between the subprime MBS market and other bond and equity markets I will be using the ABX index weekly returns as the MBS market returns as Longstaff (2010). ABX indexes are maintained by the Markit Group and consist of different tranches based on their credit ratings. The "ABX.HE.AAA.06-1" is the AAA tranche of the ABX indexes, "HE" stands for home-equity loans, AAA is the initial credit rating of the specific tranche and 06-1 means that this index is constructed from the securities that have been issued in the second half of 2005 (the previous six months from the 06-1 which means the first half of 2006). Similarly, ABX.HE.AA.06-1, ABX.HE.A.06-1, ABX.HE.BBB.06-1 and ABX.HE.BBB-.06-1 are the tranches with different ratings with the rest indicating the same information. Each index is a simple average of the prices for 20 Collateralized Debt Obligations (CDOs), which are essentially MBSs, prices are quoted based on a 100USD nominal position. The data is taken from IHS Markit and contains daily quotations from 01/2006 until 05/2010. Then from the daily price quotations, weekly returns were calculated from Wednesday price quotes (Thursday prices were used for when markets were closed on a Wednesday) starting from 28/02/2007 as it marks the beginning of the subprime credit crisis according to the Federal Reserve Bank of St. Louis' Financial Crisis Timeline and until the end of 2008 as the focus of this research is the immediate effect of the Fed interventions.

3.2 Treasury yields:

To test the contagion on treasury bond markets I used market yields on US 10-year and 2-year treasury securities with constant maturities. The Wednesday levels of the yields are then subtracted from each other and multiplied by 100 to get weekly changes by basis points so that an increase from 2.50 to 2.75 would translate into a 25 basis-point increase in the yields. Both 10-year and 2-year data is taken from FRED St. Louis Fed. The timeframe is again from 28/02/2007 until the end of 2008.

3.3 Treasury Corporate bond spreads:

I used the Moody's Seasoned Aaa and Baa Corporate Bond Yields Relative to Yield on 10-Year Treasury Constant Maturity as the spread between corporate and treasury bond yields. Similarly to the treasury yields the changes are calculated by subtracting Wednesday levels of the spreads and multiplying by 100 to get weekly changes by basis points. Data is again taken from FRED St. Louis Fed. The timeframe is again from 28/02/2007 until the end of 2008.

3.4 Equity Markets:

As equity market data I use returns on the S&P 500 index. The Wednesday closing prices are used to calculate weekly returns. I obtained the data from the Bloomberg system. The period is again from 28/02/2007 until the end of 2008. For the equity market volatility, I use weekly changes of the VIX

which is similarly calculated as the S&P 500. I obtained VIX data from the Chicago Board Options Exchange's (CBOE) website. The period is again from 28/02/2007 until the end of 2008.

3.5 TAF intervention:

The timing of the TAF interventions have been taken from the Fed's website.

Variables		Before Intervetions					After First Intervention				
		N	Mean	Std Dev	Min	Max	N	Mean	Std Dev	Min	Max
ABX Tranches	AAA	43	-0,002	0,012	-0,051	0,039	54	-0,002	0,035	-0,149	0,122
	AA	43	-0,003	0,026	-0,097	0,071	54	-0,015	0,067	-0,263	0,116
	A	43	-0,009	0,067	-0,199	0,242	54	-0,026	0,089	-0,192	0,211
	BBB	43	-0,019	0,085	-0,330	0,214	54	-0,030	0,075	-0,228	0,087
	BBB-	43	-0,023	0,072	-0,271	0,162	54	-0,028	0,068	-0,236	0,056
10-Year Treasury Yield		43	-1,465	10,505	-28,000	23,000	54	-3,351	19,486	-49,000	39,000
2-Year Treasury Yield		43	-3,953	15,699	-58,000	20,000	54	-4,370	20,739	-58,000	39,000
Aaa Corporate-Treasury Spread		43	1,698	5,882	-9,000	21,000	54	1,944	10,603	-19,000	36,000
Baa Corporate-Treasury Spread		43	2,326	7,230	-9,000	25,000	54	6,074	16,444	-21,000	66,000
S&P 500		43	0,0004	0,020	-0,049	0,035	54	-0,009	0,045	-0,192	0,120
VIX		43	0,030	0,164	-0,294	0,512	54	0,021	0,142	-0,260	0,477

Table1: Summary statistics[1]

[1] Table 1 denotes the summary statistics for each variable. ABX tranches are the weekly return on each differently rated ABX tranche so AAA stands for the AAA rated ABX tranche, AA for the AA rated and so on. 10-Year and 2-Year treasury yields are the weekly basis point changes in the 10-year and 2-year treasury market yields with constant maturities. Aaa-Baa Corporate-Treasury Spreads are the weekly basis point changes Moody's Seasoned Aaa and Baa Corporate Bond Yields Relative to Yield on 10-Year Treasury with Constant Maturity S&P 500 and VIX stand for the S&P 500 weekly returns and VIX weekly changes.

CHAPTER 4 Method

To determine if Fed's interventions helped cure the contagion in the financial markets during the subprime credit crisis, I need to identify time periods where contagion can be tested. For this I will be splitting my sample from 21.12.2007 which is the introduction of the Term Auction Facility which can be regarded as the first unconventional step the Fed took to combat the subprime credit crisis. I will be applying the VAR framework to each of these sub-samples to see if contagion effects are different between the two samples.

To empirically test whether Fed's actions helped cure the contagion I will be testing if the cross-market linkages changed after the interventions using a Vector Autoregression (VAR) framework and then testing for Granger-causality as Longstaff, (2010) to estimate the relation between MBS and other market returns separately for the period preceding the intervention, which would be from 28/02/2007 until 21/12/2007, and for the period during which the Fed intervened with the TAF until the end of 2008 Limiting the scope at the end of 2008 allows me to isolate the effects of the interventions better as the general recovery of the markets will not be considered with this sampling.

My dependent variables are weekly changes in the 10-year and 2-year treasury yields, weekly changes in corporate-treasury bond yield spreads, S&P 500 index weekly returns and VIX volatility index weekly returns. My independent variables are weekly returns of ABX tranches with different ratings (from AAA to BBB-). Based on the AIC criteria, I determined my optimal lag-length to be 4 weeks. Which would specify the VAR system as follows,

$$Y_t = \alpha + \sum_{k=1}^{4} \beta_k \, Y_{t-1} + \sum_{k=1}^{4} \gamma_k \, ABX_{t-k} + \varepsilon_t \,^{2}$$

I apply the VAR framework separately to each specific dependent variable and estimate the VAR for all the different rating tranches separately. I do the same steps for both of my samples before and after interventions. Then I conduct Granger causality tests on each VAR framework to estimate if the weekly returns of the ABX tranches hold predictive power over (Granger cause) the weekly returns of the dependent variables. Then I conduct robustness tests to ensure the stability of the VAR system by ensuring all roots lie within the unit circle for each VAR framework.

After the Granger causality tests are done, I will compare these tests for the sample before interventions and after the first intervention aiming to determine whether the ABX index returns hold predictive power

[2] This VAR system is almost identical to the one used in Longstaff (2010) as the framework is almost the same except for the period focused which also depends on the scope of the study.

(or granger cause) other market returns. This VAR framework and my subsampling is aimed at determining if the Fed helped cure the contagion across different markets.

CHAPTER 5 Results & Discussion

The results of the VAR framework and subsequent Granger causality tests are reported as can be seen from Table-2. As a preliminary interpretation of the results, it can be said that for the period before the first TAF intervention, ABX index returns for different tranches have significantly impacted the returns for several treasury and equity markets, however after the first intervention these impacts are very limited compared to the period before.

In Table-2 below I show the γ_k coefficients of the VARs for each of the dependent variables on each tranche of the ABX indexes, the p-values from the Granger causality tests along with the R^2 values from each of the VARs. On the table, γ_k coefficients represent the lagged effects of each ABX tranche on the subsequent dependent variables, γ_1 shows the estimate with a one-week lag, γ_2 shows the estimate with a two-week lag and so on. The dependent variables (Y) and the ABX index returns are used as detailed in the data and methodology sections.

Focusing on VARs on each dependent variable it can be seen from Table-2 that for the 10-year treasury yields each of the tranches except for the AA tranche have a relatively significant predictive ability. ABX returns granger cause changes in the 10-year treasury with 1% significance for BBB and BBB- tranches, 5% for the A and 10% for the AAA tranches. Also, several individual γ_k coefficients are significant especially for the BBB and BBB- tranches before the first intervention. When looking at the period after the first intervention, AAA and AA tranches now have more significant predictive abilities. This might be because investors moved away from the higher rated securities driven by a flight-to-quality towards the later parts of the crisis as risks with these higher rated securities became more apparent as Liu et al., (2019). So even though the Fed intervened the movement from these higher rated MBSs towards long-term treasury assets appear to have still led to contagion. This is consistent with the significant positive relationship between the individual γ_k coefficients and the treasury yields. This relationship shows that as the higher rated ABXs declined in value the 10-year treasury yields decreased as these bonds became more expensive, reinforcing the flight-to-quality pattern.

However, this continuity in contagion is not apparent for the 2-year treasury yields. For the period before the first intervention all the ABX tranches have predictive power over the 2-year treasury yields with the Granger p-values all being significant to the 1% level as well as individual γ_k coefficients with ABX returns significantly effecting 2-year treasury yields for 1 to 3 weeks ahead. After the first interventions none of the tranches have any significant predictive power. Also, none of the individual γ_k coefficients are significant for this time period. The same flight-to-quality cannot be observed with the 2-year yields as their shorter maturities did not provide the same type of long-term safety as the longer term 10-year treasuries did but rather shorter-term safety consistent with the findings of Liu et al., (2019). Since the

actions of the Fed, namely the TAF, provided short term relief to the market, shorter maturity treasuries were not as highly demanded as that of longer-term maturities. Therefore, led to the mitigation of this contagion as additional short-term safety was not as highly demanded as that of longer-term maturities. So, the shorter-term yields were stabilized more quickly as Mamun et al., (2010) which shows that the actions of the Fed resulted in the mitigation of the contagion for shorter-term treasury yields.

Moving to the corporate-treasury bond spreads, contagion effects can be seen before the first intervention as all the ABX tranches have Granger causality p-values that are significant to the 5% level, with most of them being to the 1% level. The exceptions are the AAA tranche for the Aaa rated corporate-treasury bond spread and the AA tranche for the Baa rated corporate-treasury bond spread. This contagion occurs as the decline in value of the MBSs leads to the increase in perceived risk premium with the corporate bond market as Longstaff, (2010). This can also be seen from Table-2 as the individual γ_k coefficients are significant for the 3-week lag and have a negative sign. This shows that as the value of the ABX indexes decline, the spreads widen. The period after the first intervention shows no contagion effects as none of the granger causality results are significant. This is because as the Fed started utilizing the TAF it provided short-term liquidity and funding to the markets which reduced the liquidity and credit risk-premia thus stabilizing the corporate bond market consistent with the findings of Hrung & Seligman, (2011). Thus, it can be said that the Fed interventions again helped stabilize the markets and mitigate contagion.

Shifting the focus to the equity markets, contagion can again be observed between the MBS market and the S&P 500 before the interventions. As, all tranches of the ABX indexes show significant granger causality p-values to the 1% levels. Along with several individual γ_k coefficients show a positive significant relationship between the ABX and S&500 returns as far as three weeks out. So, it can be said that the decline in the ABX indexes lead to subsequent declines in the equity markets before the Fed interventions. This makes economic sense as financial and non-financial firms were investors in the MBS market, so declines in that market would lead to declines in equity prices of the firms holding said assets. After the interventions however, it can be seen that the contagion effects were limited to the higher rated tranches of the ABX indexes, with significant p-values for the granger causality tests for the AAA and AA rated tranches. This is because the financial aid provided by the Fed was limited to the firms who were inherently financially sound and could put up collateral for these loans, however not all firms were in such conditions. Also, since equity markets are not recognized as the safest markets lead to a flight-to-quality, these selloffs also distressed the equity markets for longer periods as per the findings of Longstaff, (2010).

Y	ABX Tranche	Before Interventions						After First Intervention					
		$\gamma 1$	$\gamma 2$	$\gamma 3$	$\gamma 4$	Granger causality p-values	R^2	$\gamma 1$	$\gamma 2$	$\gamma 3$	$\gamma 4$	Granger causality p-values	R^2
	AAA	125,763	467,556**	59,746	-70,607	0,079*	0,234	52,754	190,415***	44,325	113,005	0,039**	0,276
	AA	12,539	141,801	85,802	56,412	0,137	0,211	42,312	117,327***	16,618	55,586	0,006***	0,326
10-Year	A	50,286*	30,235	68,794**	27,918	0,028**	0,273	27,242	54,970*	-21,022	43,453	0,153	0,232
Treasury	BBB	56,340***	36,389*	55,633**	38,564	0,006***	0,320	56,550*	79,175**	-47,053	20,831	0,017**	0,298
Yield	BBB-	71,263***	43,187*	70,366***	55,010**	0,001***	0,374	46,069	76,064**	-35,527	34,941	0,09*	0,250
	AAA	551,879**	781,451***	359,185	-276,985	0,005***	0,402	0,770	77,991	-28,396	95,887	0,493	0,130
	AA	217,771**	178,388**	253,423**	-38,356	0,004***	0,412	-24,472	32,718	-16,668	61,825	0,572	0,542
2-Year	A	103,769***	50,128*	165,960***	8,879	0,000***	0,522	-31,506	41,218	-40,010	47,110	0,382	0,142
Treasury	BBB	94,499***	49,447**	134,677***	50,964	0,000***	0,525	-20,772	41,870	-18,109	5,909	0,889	0,091
Yield	BBB-	100,389***	30,688	149,060***	93,352***	0,000***	0,565	-31,525	28,863	-16,214	31,494	0,848	0,096
	AAA	111,172	-158,911	-253,400**	78,396	0,041**	0,323	-44,746	-48,965	0,907	9,595	0,706	0,246
Aaa	AA	-42,932	-47,991	-139,045**	63,508	0,003***	0,396	-32,363	0,315	15,866	6,299	0,547	0,259
Corporate-	A	-2,648	-26,542**	-77,585***	24,574	0,000***	0,601	-4,271	7,016	3,319	-7,583	0,976	0,221
Treasury	BBB	9,790	-15,024	-45,438***	3,603	0,000***	0,461	-21,668	-5,956	11,798	-0,541	0,772	0,241
Spread	BBB-	7,401	-3,222	-52,658***	-4,552	0,000***	0,448	-19,082	-4,755	14,313	-8,502	0,858	0,234
	AAA	-10,411	-370,954***	-295,963**	42,972	0,001***	0,463	-58,851	-43,422	94,628	46,573	0,575	0,213
Baa	AA	26,693	-74,876*	-120,020***	15,143	0,011**	0,415	-15,750	6,729	57,223*	10,369	0,527	0,217
Corporate-	A	-13,897	-39,212***	-90,104***	-23,348	0,000***	0,572	25,899	-7,774	41,139	-13,293	0,448	0,225
Treasury	BBB	-9,131	-29,497***	-62,741***	-29,523*	0,000***	0,531	-19,339	-10,686	38,068	5,532	0,723	0,200
Spread	BBB-	-11,684	-21,203	-65,021***	-32,830**	0,000***	0,515	-34,345	-3,288	48,408	3,672	0,571	0,213
	AAA	1,183***	0,584*	-0,258	0,619*	0,000***	0,388	0,391**	-0,239	-0,300	0,220	0,028**	0,248
	AA	0,370***	0,214*	-0,007	0,340***	0,002***	0,330	0,188**	-0,179**	-0,157*	0,149	0,005***	0,297
	A	0,131***	0,063	0,126**	0,204***	0,000***	0,479	0,074	-0,114	-0,030	0,062	0,371	0,157
	BBB	0,131***	0,023	0,069**	0,165***	0,000***	0,536	0,181**	-0,133	-0,012	-0,006	0,240	0,176
S&P 500	BBB-	0,122***	0,050	0,057	0,147***	0,000***	0,393	0,243**	-0,141	-0,064	-0,004	0,100	0,208
	AAA	-3,839	-0,316	2,396	1,111	0,435	0,292	0,941	-0,350	0,329	0,482	0,405	0,131
	AA	-2,159**	-0,810	-0,540	-0,237	0,209	0,324	0,576*	-0,007	0,293	-0,100	0,306	0,144
	A	-1,002***	-0,344	-1,256***	-0,242	0,005***	0,438	0,42*	-0,137	0,199	-0,173	0,433	0,128
	BBB	-0,502*	-0,010	-0,658**	-0,124	0,153	0,337	-0,085	-0,100	0,317	-0,202	0,822	0,089
VIX	BBB-	-0,394	-0,092	-0,592**	-0,167	0,300	0,309	0,018	0,040	0,202	-0,038	0,968	0,071

Table-2: VAR framework results [3]

[3] Table-2 shows the VAR estimation results for each dependent Y variable on each ABX tranche as well as the p-values for the subsequent Granger causality tests. ABX tranches represent weekly returns for each tranches of the ABX indexes. AAA stand for the AAA rated ABX tranches, AA for the AA rated ABX tranches and so on. 10-Year and 2-Year treasury yields are the weekly basis point changes in the 10-year and 2-year treasury market yields with constant maturities. Aaa-Baa Corporate-Treasury Spreads are the weekly basis point changes Moody's Seasoned Aaa and Baa Corporate Bond Yields Relative to Yield on 10-Year Treasury with Constant Maturity S&P 500 and VIX stand for the S&P 500 weekly returns and VIX weekly changes. The sample period is between 28/02/2007 and 31/12/2008. The sample is split from 21/12/2007 so that "before intervention" is the subsample from 28/02/2007 until 21/12/2007. "After First Intervention" is the subsample from 22/12/2007 until 31/12/2008. *** denotes significance at the 1% level, ** on the 5% level and * on the 10% level.

Looking for contagion in the equity markets' volatility the VIX was used to test for and contagion between MBS markets and equity markets' volatility. Although the A rated tranche shows significant granger causality to the 1% level the rest of the tranches are not statistically significant. This might be the result of the methodology behind the VIX itself. The VIX is calculated using the implied volatilities of the S&P 500 index options, since investors use the options markets as a hedge against market risk the general sharp movements of the VIX might not be dependent of the contagion mechanisms of the boarder market. There is also no significant predictive ability of ABX returns for the VIX after the interventions as well.

Overall, it can be seen by the results of the VAR framework, the subsequent granger causality tests and the relevant prior relevant research that the Fed generally helped mitigate the effects of the contagion observed in the financial markets after the subprime credit crisis. This confirms the idea that as Wu, (2011) shows the TAF helped relieve the liquidity strains in the interbank markets which led to the mitigation of the contagion that spread from the MBS market to broader financial markets that, as Longstaff (2010) found, through liquidity and risk-premia channels.

CHAPTER 6 Conclusion

The subprime credit crisis led to an unprecedented shock for the financial markets. While Mortgage-Backed Securities seemed like safer instruments that had relatively good credit ratings throughout the financial markets prior to the financial crisis. Bad lending practices, inaccurate ratings and several other factors turned them into toxic assets by the end of it. Which led to the demise of many financial institutions and heavy global financial distress.

Since these MBSs were deemed as safer instruments while offering relatively good returns they became a widespread option for the whole financial sector. However, after their values started declining because several of these MBSs started to default they led to widespread contagion in the financial sector. This unprecedented distress led central banks and policymakers to take unprecedented action to prevent widespread financial collapse.

This research aimed at looking at the actions of the Fed to determine whether their actions helped mitigate the effects of the contagion in financial markets. Using a VAR framework and Granger causality tests the effects of this contagion could be seen between different tranches of the ABX index, which was used as an indicator for the MBS market, and several financial markets including the treasury, corporate bond and equity markets.

The VAR framework suggests that the subprime crisis led to significant contagion between the ABX indexes and the 10-year and 2-year treasury yields, the spread between Aaa-Baa rated corporate bond yields and the S&P 500. Also, limited contagion to the VIX as well prior to any Fed intervention specific for the subprime credit crisis. The results more importantly show that after the Fed started to intervene specifically to mitigate the effects of the subprime credit crisis, the contagion effects observed were largely mitigated with the biggest effect seen at the 2-year treasury yields and the corporate-treasury bond yield spreads. Although relatively more limited, the effect of these interventions could be seen throughout the equity markets and 10-year treasuries as well. Finally, it can be said that the Fed succeeded in mitigating the contagion effects from the MBS market to several other markets after the subprime credit crisis.

This research could be improved with data from global markets as it was limited to the US markets. Also, data from interbank markets can be taken to see the effects of the international central bank interventions on interbank funding markets. The reason behind this contagion could be that large financial institutions are marginal investors in many markets and a shock to their balance sheets may propagate in the markets they are marginal investors in. An intermediary based pricing kernel could be constructed specifically for this period and the balance sheet variables of these financial intermediaries

can be used to test for contagion. This way the effect of the TAF loans that Fed gave during the period could be observed more specifically for contagion. However, this would require an extensive database of the balance sheets of these financial intermediaries.

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APPENDIX Tables

Table-1: Summary Statistics

Variables		Before Intervetions					After First Intervention				
		N	Mean	Std Dev	Min	Max	N	Mean	Std Dev	Min	Max
ABX Tranches	AAA	43	-0,002	0,012	-0,051	0,039	54	-0,002	0,035	-0,149	0,122
	AA	43	-0,003	0,026	-0,097	0,071	54	-0,015	0,067	-0,263	0,116
	A	43	-0,009	0,067	-0,199	0,242	54	-0,026	0,089	-0,192	0,211
	BBB	43	-0,019	0,085	-0,330	0,214	54	-0,030	0,075	-0,228	0,087
	BBB-	43	-0,023	0,072	-0,271	0,162	54	-0,028	0,068	-0,236	0,056
10-Year Treasury Yield		43	-1,465	10,505	-28,000	23,000	54	-3,351	19,486	-49,000	39,000
2-Year Treasury Yield		43	-3,953	15,699	-58,000	20,000	54	-4,370	20,739	-58,000	39,000
Aaa Corporate-Treasury Spread		43	1,698	5,882	-9,000	21,000	54	1,944	10,603	-19,000	36,000
Baa Corporate-Treasury Spread		43	2,326	7,230	-9,000	25,000	54	6,074	16,444	-21,000	66,000
S&P 500		43	0,0004	0,020	-0,049	0,035	54	-0,009	0,045	-0,192	0,120
VIX		43	0,030	0,164	-0,294	0,512	54	0,021	0,142	-0,260	0,477

Table-2: VAR Estimation Results

Y	ABX Tranche	Before Interventions						After First Intervention					
		$\gamma 1$	$\gamma 2$	$\gamma 3$	$\gamma 4$	Granger causality p-values	R^2	$\gamma 1$	$\gamma 2$	$\gamma 3$	$\gamma 4$	Granger causality p-values	R^2
	AAA	125,763	467,556**	59,746	-70,607	0,079*	0,234	52,754	190,415***	44,325	113,005	0,039**	0,276
	AA	12,539	141,801	85,802	56,412	0,137	0,211	42,312	117,327***	16,618	55,586	0,006***	0,326
10-Year	A	50,286*	30,235	68,794**	27,918	0,028**	0,273	27,242	54,970*	-21,022	43,453	0,153	0,232
Treasury	BBB	56,340***	36,389*	55,633**	38,564	0,006***	0,320	56,550*	79,175**	-47,053	20,831	0,017**	0,298
Yield	BBB-	71,263***	43,187*	70,366***	55,010**	0,001***	0,374	46,069	76,064**	-35,527	34,941	0,09*	0,250
	AAA	551,879**	781,451***	359,185	-276,985	0,005***	0,402	0,770	77,991	-28,396	95,887	0,493	0,130
	AA	217,771**	178,388**	253,423**	-38,356	0,004***	0,412	-24,472	32,718	-16,668	61,825	0,572	0,542
2-Year	A	103,769***	50,128*	165,960***	8,879	0,000***	0,522	-31,506	41,218	-40,010	47,110	0,382	0,142
Treasury	BBB	94,499***	49,447**	134,677***	50,964	0,000***	0,525	-20,772	41,870	-18,109	5,909	0,889	0,091
Yield	BBB-	100,389***	30,688	149,060***	93,352***	0,000***	0,565	-31,525	28,863	-16,214	31,494	0,848	0,096
	AAA	111,172	-158,911	-253,400**	78,396	0,041**	0,323	-44,746	-48,965	0,907	9,595	0,706	0,246
Aaa	AA	-42,932	-47,991	-139,045**	63,508	0,003***	0,396	-32,363	0,315	15,866	6,299	0,547	0,259
Corporate-	A	-2,648	-26,542**	-77,585***	24,574	0,000***	0,601	-4,271	7,016	3,319	-7,583	0,976	0,221
Treasury	BBB	9,790	-15,024	-45,438***	3,603	0,000***	0,461	-21,668	-5,956	11,798	-0,541	0,772	0,241
Spread	BBB-	7,401	-3,222	-52,658***	-4,552	0,000***	0,448	-19,082	-4,755	14,313	-8,502	0,858	0,234
	AAA	-10,411	-370,954***	-295,963**	42,972	0,001***	0,463	-58,851	-43,422	94,628	46,573	0,575	0,213
Baa	AA	26,693	-74,876*	-120,020***	15,143	0,011**	0,415	-15,750	6,729	57,223*	10,369	0,527	0,217
Corporate-	A	-13,897	-39,212***	-90,104***	-23,348	0,000***	0,572	25,899	-7,774	41,139	-13,293	0,448	0,225
Treasury	BBB	-9,131	-29,497***	-62,741***	-29,523*	0,000***	0,531	-19,339	-10,686	38,068	5,532	0,723	0,200
Spread	BBB-	-11,684	-21,203	-65,021***	-32,830**	0,000***	0,515	-34,345	-3,288	48,408	3,672	0,571	0,213
	AAA	1,183***	0,584*	-0,258	0,619*	0,000***	0,388	0,391**	-0,239	-0,300	0,220	0,028**	0,248
	AA	0,370***	0,214*	-0,007	0,340***	0,002***	0,330	0,188**	-0,179**	-0,157*	0,149	0,005***	0,297
	A	0,131***	0,063	0,126**	0,204***	0,000***	0,479	0,074	-0,114	-0,030	0,062	0,371	0,157
	BBB	0,131***	0,023	0,069**	0,165***	0,000***	0,536	0,181**	-0,133	-0,012	-0,006	0,240	0,176
S&P 500	BBB-	0,122***	0,050	0,057	0,147***	0,000***	0,393	0,243**	-0,141	-0,064	-0,004	0,100	0,208
	AAA	-3,839	-0,316	2,396	1,111	0,435	0,292	0,941	-0,350	0,329	0,482	0,405	0,131
	AA	-2,159**	-0,810	-0,540	-0,237	0,209	0,324	0,576*	-0,007	0,293	-0,100	0,306	0,144
	A	-1,002***	-0,344	-1,256***	-0,242	0,005***	0,438	0,42*	-0,137	0,199	-0,173	0,433	0,128
	BBB	-0,502*	-0,010	-0,658**	-0,124	0,153	0,337	-0,085	-0,100	0,317	-0,202	0,822	0,089
VIX	BBB-	-0,394	-0,092	-0,592**	-0,167	0,300	0,309	0,018	0,040	0,202	-0,038	0,968	0,071