The Behavior of US Interest Rate Swap Spreads in Global Financial Crisis [☆]

Takayasu　Ito

【SUMMARY】

This paper investigates the impacts of global financial crisis on interest rate swap spreads in US. The asymmetric impacts of global financial crisis on interest rate swap spreads are focused by dividing the whole sample period into four. One sample is a period for normal time. The other samples are for the period of global financial crisis which are divided into three. The default risk measured in Aaa corporate bond is positively incorporated in 2-year and 10-year swap spreads only in the period before the financial crisis. When financial crisis became worse after the collapse of Lehman Brothers, default risk measured both in Aaa and Baa corporate bonds gave negative impact on the swap spread of 10 years. The positive contribution of liquidity premium is more evident in 2-year swap spread after financial crisis surfaced. Especially after the collapse of Lehman Brothers, FRB began to take non-traditional measures. The market participants were uncertain as for the future of monetary policy by FRB. The speculation on the path of monetary policy and the uncertainty of market are considered to cause more volatility in the market. Thus the volatility can be a positive determinant of US swap spreads after the collapse of Lehman Brothers.

Keywords: Financial Crisis, Swap Spread, Default Risk, Liquidity Premium, Monetary Policy
JEL Classifications: E43, E52

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1. INTRODUCTION

This paper investigates the impacts of global financial crisis on interest rate swap spreads in US. The asymmetric impacts of global financial crisis on interest rate swap spreads are focused by dividing the whole sample period into four. One sample is a period for normal time. The other samples are for the period of global financial crisis which are divided into three. It is significant to check the impacts of global financial crisis in various phases because severity of crisis varies from a period to another. So far no analysis has been made for US interest rate swap spreads by dividing the period of financial crisis into three. Thus this paper distinguishes itself from other works.

This paper regards the beginning of global financial crisis as February 8, 2007. The announcement by HSBC Holdings on a previous day that its charge for bad debts would be more than $10.5 billion for 2006 was a surprise. This number was 20 % more than the expectation of financial analysts. The suspicion that subprime loan might be a big problem was disseminated in the financial market on the day. The next stage of global financial crisis was from August 9, 2007 when subsidiaries of BNP Paribas announced the suspension of liquidation from the asset because fair values of ABS related assets were difficult to get under the pressure of market. The final stage of global financial crisis was from September 15, 2008 when Lehman Brothers went bankrupt.

Four determinants of swap spreads - default risk, the slope of yield curve, liquidity premium and volatility - are chosen. As for default risk, two kinds of default risk are used to investigate the sensitivity of swap spreads to Aaa and Baa corporate bond spreads.

An interest rate swap is an agreement between two parties to exchange cash flows in the future. In a typical agreement, two counterparties exchange streams of fixed and floating interest rate payments. Thus fixed interest rate payment can be transformed into floating payment and vice versa. The amount of each floating rate payment is based on a variable rate that has been mutually agreed upon by both counterparties. For example, the floating rate payment could be based on 6 month LIBOR (London Interbank Offered Rate).

The market for interest rate swap has grown exponentially in the 1990's. According to a survey by BIS (Bank for International Settlements), the notional outstanding volume of transactions of interest rate swap amounted to 328,114 billions of US dollars at the end of December 2008[1]. Differences between swap rates and government bond yields of the same maturity are referred to as swap spreads. If the swap and government bond markets are efficiently priced, swap spreads may reveal something about the perception of the systemic

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[1] Statistics are cited from Semiannual OTC derivatives statistics at end-December 2008. For details, see Bank for International Settlements (2009).

risk in the banking sector.

   The remainder of this paper is as follows. Section 2 provides literature review. Section 3 discuses the determinants of swap spread. Section 4 describes data and provides summary statistics. Section 5 presents the framework of the analysis and results. Section 6 concludes.

2. LITERATURE   REVIEW

   As for the analysis of the interest rate swap spreads in US market, previous studies such as Sun et al (1993), Brown et al (1994), Duffie and Huang (1996), Cossin and Pirotte (1997), Minton (1997),Lang et al (1998), Lekkos and Milas (2001), Fehle (2003), Huang and Chen (2007) and Ito(2010) are cited.

   Sun et al (1993) examine the effect of dealers' credit reputations on swap quotations and bid-offer spreads by using quotations from two interest rate swap dealers with different credit ratings (AAA and A). The AAA offer rates are significantly higher than the A offer rates, and the AAA bid rates are significantly lower than the A bid rates. They also document the relation between swap rates and par bond yields estimated from London interbank offered rate (LIBOR) and bid rate (LIBID) data. They identify some of the problems in testing the implications of swap pricing theory.

   Duffie and Huang (1996) present a model for valuing claims subject to default by both contracting parties, such as swaps and forwards. With counterparties of different default risk, the promised cash flows of a swap are discounted by a switching discount rate that, at any given state and time, is equal to the discount rate of the counterparty for whom the swap is currently out of the money (that is, a liability). The impact of credit-risk asymmetry and netting is presented through both theory and numerical examples, which include interest rate and currency swaps.

   Brown et al (1994) analyze US swap spreads to find that 1) short- term, 1-, and 3-year swaps are priced differently from longer-term, 5-, 7-, and 10-year swaps; and 2) the pricing dynamics for all five swap maturities changed substantially during the period spanning January 1985 to May 1991. Cossin and Pirotte (1997) conduct empirical analysis on transaction data and show support for the presence of credit risk in swap spreads. Credit ratings appear to be a significant factor affecting swap spreads not only for their pooled sample but for IRS and for CS separately as well. In IRS, the credit rating impact on prices seems to come largely at the detriment of the non-rated companies.

   Lang et al (1998) argue that an interest rate swap, as a non-redundant security, creates surplus which will be shared by swap counterparties to compensate their risks in swaps. Analyzing the time series impacts of the changes of risks of swap counterparties on swap

spreads, they conclude that both lower and higher rating bond spreads have positive impacts on swap spreads.

Lekkos and Milas (2001) assess the ability of the factors proposed in previous research to account for the stochastic evolution of the term structure of the U.S. and U.K. swap spreads. Using as factor proxies the level, volatility, and slope of the zerocoupon government yield curve as well as the Treasury-bill–London Interbank Offer Rate (LIBOR) spread and the corporate bond spread, they identify a procyclical behavior for the short-maturity U.S. swap spreads and a countercyclical behavior for longer maturity U.S. swap spreads. Liquidity and corporate bond spreads are also significant, but their importance varies with maturity.

Minton (1997) directly tests the analogy between short-term swaps and Eurodollar strips and finds that fair-value short-term swap rates exist in the Eurodollar future market. However, proxies for differential probability of counterparty default are statistically significant determinants of the difference between OTC swap rates and swap rates derived from Eurodollar futures prices for maturities of three and four years.

Fehle (2003) analyzes 2- year and 5-year swap spreads in 7 countries (US, UK, Japan, Germany, France, Spain and Netherland). They conclude that corporate bond spread, LIBOR spread and slope of the yield curve are components of swap spreads.

Huang and Chen (2007) analyze the asymmetric impacts of various economic shocks on swap spreads under distinct Fed monetary policy regimes. The results indicate that (a) during periods of aggressive interest rate reductions, slope of the Treasury term structure accounts for a sizeable share of the swap spread variance although default shock is also a major player. (b) On the other hand, liquidity premium is the only contributor to the 2-year swap spread variance in monetary tightening cycles. (c) The impact of default risk varies across both monetary cycles and swap maturities. (d) The effect of interest rate volatility is generally more evident in loosening monetary regimes.

Ito (2010) analyzes impacts of financial crisis on interest rate swap spreads by dividing the whole sample period into two. First period (Sample A) is from January 3, 2005 through February 7, 2007. Second period (Sample B) is from February 8, 2007 through March 12, 2009. First period includes relatively calm market. Second period includes financial crisis. The default risk measured both in Aaa and Baa corporate bonds are negatively incorporated in the period of financial crisis. The slope is positively incorporated in short and long term maturities in the period of financial crisis. The liquidity premium is positively incorporated in short and long term maturities in normal period and only in short term maturity in the period of financial crisis. The volatility is a positive determinant of US swap spreads in the period of financial crisis.

On the other hand, the number of previous studies analyzing the market other than US is small. Castagnetti (2004) analyzes the interest rate swap spreads in Germany. Hmano (1997), Eom et al (2000), Ito (2007) focus on the swap spreads in Japanese market. Hamano (1997) focuses not on credit risk but on market factors such as TED spread and finds that swap spreads reflect TED spread and longer term swap spreads are less influenced by TED spread. On the other hand, Eom et al (2000) focuses on the credit risk and concludes that yen swap spread is significantly related to proxies for the long term credit risk factor.

Ito (2007) investigates the determinants of interest rate swap spreads in Japan. Four determinants of swap spreads - TED spread, corporate bond spread, interest rate and the slope of yield curve from July 12, 1995 through January 31, 2005- are chosen. The swap spreads of 2 years through 4 years are mostly influenced by TED spread, interest rate and slope. The swap spread of 5 years is mostly decided by corporate bond spread and slope. The swap spreads of 7 years and 10 years are mostly affected by corporate bond spread. Ito(2011) investigates the asymmetric impacts of global financial crisis on Japanese interest rate swap spreads by dividing the whole sample period into four.　Volatility is a positive contributor to swap spreads of 2-years and 5- years. Default risk is negatively incorporated in 10-year swap spread after the Lehman shock of September 15, 2008. It is presumed that the functions of price discovery were lost.

So far no other previous works focused upon interest rate swap spread in the period of financial crisis by dividing the period into four- a normal period and three periods of financial crisis. Ito (2010) divides the sample into two – a normal period and a crisis period. This paper will be the first one to analyze US interest rate swap spreads by dividing the period of financial crisis into three. Thus asymmetrical impacts of global financial crisis in various phases on interest rate swap spreads in US can be examined.

3. DETERMINANTS OF SWAP SPREAD

a. Liquidity Premium

For instance, during periods of weak economy, treasury bonds are considered to be more liquid, and swaps thus command a larger liquidity premium. Liquidity effect may be absent in the aggregate data, but can be arguably pronounced under certain market conditions. Hamano (1997),Minton (1997), Brown et al (1994), Eom et al (2000), Lekkos and Milas (2001) check the influence of TED spread .

First, a case in which floating rate and fixed rate are swapped based on the yield curve of government bond is described in the equation (1).

$$\frac{f_1}{(1+R_1)} + \frac{E(f_2)}{(1+R_2)^2} + \cdots + \frac{E(f_n)}{(1+R_n)^n} = \frac{C}{(1+R_1)} + \frac{C}{(1+R_2)^2} + \cdots + \frac{C}{(1+R_n)^n} \tag{1}$$

$E(\ )$ is an operator indicating expectation, C is a coupon, f_n is a floating rate, R_n is a fixed rate of government bond.

In equation (1), floating rate and fixed rate are swapped on the condition that there is no credit risk. Present values of both floating rate and fixed rate get equal. Here exchange of cash flows is presupposed to happen once a year.

In the case of swap transaction, floating rate is Euro dollar, for example, LIBOR which is usually higher than short-term government bill. Thus fixed side results in higher rates. Here the difference between Euro dollar rate, for example, LIBOR (London Interbank Offered Rate) and short-term Treasury Bill is defined as TED spread. Swap rate and TED spread are in the relationship as described in the equation (2).

$$\frac{f_1 + TED_1}{(1+R_1)} + \frac{E(f_2 + TED_2)}{(1+R_2)^2} + \cdots + \frac{E(f_n + TED_n)}{(1+R_n)^n} = \frac{C+SS}{(1+R_1)} + \frac{C+SS}{(1+R_2)^2} + \cdots + \frac{C+SS}{(1+R_n)^n} \tag{2}$$

TED_n is TED spread, SS is swap spread.

Equation (2) can be rewritten into equation (3) to show that swap spread is a weighted average of present and future TED spreads.

$$\frac{TED_1}{(1+R_1)} + \frac{E(TED_2)}{(1+R_2)^2} + \cdots + \frac{E(TED_n)}{(1+R_n)^n} = SS\left(\frac{1}{(1+R_1)} + \frac{1}{(1+R_2)^2} + \cdots + \frac{1}{(1+R_n)^n}\right) \tag{3}$$

In addition to liquidity premium, default risk, slope of yield curve and volatility are considered to be determinants of interest rate swap spread in previous studies.

b. Default Risk

According to Minton (1997), Brown et al (1994), Eom et al (2000), Lekkos and Milas (2001), the default risk in swaps can be proxied with the information from the corporate bond market. Any such proxy is imperfect as mentioned in the previous studies because the characteristics of swap and corporate bond are not totally comparable. Nevertheless, since swap default spreads are unobservable, the difference between the yield on a portfolio of corporate bonds and the yield on an equivalent government bond can be used as a proxy for the default premium.

c. Slope of Yield Curve and Volatility

Following the Sorensen and Bollier (1994) framework, in which the slope of the term structure and interest rate volatility determine the value of the option to default, these two variables are incorporated into empirical model. It is notable that the impacts of the yield curve and interest rate volatility on swap spreads may not be symmetrical under various market conditions.

According to Alworth (1993), the impact of the slope of the term structure on swap spreads could be either positive or negative. When the yield curve is upward sloping, the fixed payer (floating receiver) is exposed to higher counterparty risk due to higher default risk exposure associated with the higher future floating payments. A lower fixed swap rate will compensate for this increased risk. Swap spreads are thus expected to be negatively related to the slope of the term structure.

On the other hand, expected default premium should be higher at the time of recession and financial instability. In this case, swap spreads are expected to be positively related to the slope of the term structure. Increasing interest rate volatility is often associated with economic uncertainty, as such, it is expected to positively influence swap spreads. Similarly, as Huang and Chen (2007) describe, swap spreads may be more responsive to the shape of yield curve during periods of a steep yield curve due to the "flight to quality" concern.

Eom et al (2000) find that swap spreads are negatively related to the slope of the term structure. Huang and Chen (2007) and Ito(2010) use slope of yield curve and volatility. They calculate volatility of 2-year US Treasury note by using EGARCH model.

4. DATA

About four years of daily data ranging from January 3, 2006 through August 27, 2009 are chosen. These data are quoted from the Federal Reserve Statistical Release (H.15). The whole sample is divided into four depending upon the aspects of financial crisis. As Huang and Chen (2007) mention, aggregating time series data over different market condition produces results that are in favor of finding no impact of economic shocks on swap spreads because asymmetrical impacts may cancel out over different aspects of global financial crisis..

First period (Sample A) is from January 3, 2006 through February 7, 2007. Second period (Sample B) is from February 8, 2007 through August 8, 2007. Third period (Sample C) is from August 9, 2007 through September 14, 2008. Fourth period (Sample D) is from September 15, 2008 through August 27,2009. Sample A is a calm market. Sample B is a relatively calm market in comparison with Sample C and Sample D. But the potential risk of sub-prime loan issue began to be recognized in Sample B. Samples C

and D are in the middle of financial crisis[2]. Especially the degree of crisis deepened after the collapse of Lehman Brothers in Sample D.

a. US Interest Rate Swap Spread

  US interest rate swap rate minus US government bond yield in the corresponding maturity is defined as swap spread. SS2 is 2- year swap spread. SS10 is 10 - year swap spread. The movements of swap spreads in 2 years and 10 years in whole sample period are shown in Figure 1. The descriptive statistics of swap spreads in each sample period are provided in Table 1.
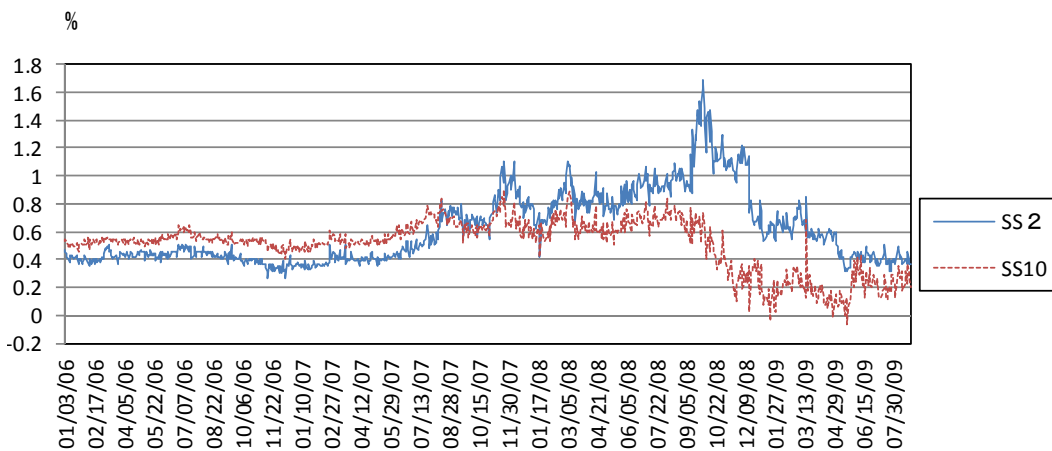

Figure 1 Swap spread
Whole sample period from January 3, 2006 through August 27, 2009.
SS2 = 2 - year swap spread, SS10 = 10 - year swap spread

b. Determinants of Swap Spread

Liquidity Premium

  Liquidity premium is defined as TED spread between 6- month Eurodollar rate and 6 month TB (Treasury Bill).

Default Risk

  Default risk is defined as yield spread between corporate bond issued and 10-year US Treasury note yield. Corporate bond spread is considered to represent default risk. Two kinds of corporate bond are used for the analysis. They are Moody's seasoned Aaa corporate bond and Baa corporate bond. According to Moody's Investors Service, Aaa corporate bonds are judged to be of the highest quality, with minimal credit risk. Baa corporate bonds are subject to moderate default risk. They are considered medium-grade and as such may possess certain speculative characteristics.

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[2] As for the phases of global financial crisis, see section 1.

Table 1.Descriptive statistics of swap spreads

Variable	Average	SD	Min	Max	Median
Sample A					
SS2	0.409	0.046	0.270	0.510	0.415
SS10	0.528	0.038	0.400	0.640	0.530
Sample B					
SS2	0.434	0.058	0.350	0.650	0.420
SS10	0.573	0.070	0.480	0.790	0.540
Sample C					
SS2	0.823	0.126	0.420	1.110	0.820
SS10	0.663	0.075	0.420	0.900	0.660
Sample D					
SS2	0.707	0.330	0.320	1.690	0.600
SS10	0.265	0.161	-0.060	0.770	0.230

Notes : Sample A = from January 3, 2006 through February 7, 2007.

Sample B = from February 8, 2007 through August 8, 2007.

Sample C = from August 9, 2007 through September 12, 2008.

Sample D = from September 15, 2008 through August 27, 2009.

SS2 = 2 - year swap spread, SS10 = 10 - year swap spread

The correlation of Aaa and Baa corporate bond spreads in each sample period is shown in Table 2. During a normal time the correlation between these two is relatively low. But during financial crisis the correlation is high. This fact indicates that when credit risk increased, Aaa corporate bond became more sensitive to default risk together with Baa corporate bond.

Table 2.Correlation of default risk

Variables	Correlation Coefficient
Sample A	
AAA－BAA	0.728
Sample B	
AAA－BAA	0.875
Sample C	
AAA－BAA	0.971
Sample D	
AAA－BAA	0.961

Notes : Sample A = from January 3, 2006 through February 7, 2007.

Sample B = from February 8, 2007 through August 8, 2007.

Sample C = from August 9, 2007 through September 12, 2008.

Sample D = from September 15, 2008 through August 27, 2009.

AAA = Aaa corporate bond spread, BAA = Baa corporate bond spread

Slope of Yield Curve

Slope of yield curve is defined as the differential between 2 - year and 10 - year US Treasury note yields as in Huang and Chen (2007).

Volatility

Yield volatility calculated by EGARCH model is defined as volatility[3]. The 2- year US Treasury note yield is used for the calculation as in Huang and Chen (2007) and Ito (2010).

The descriptive statistics of determinants of swap spreads in each sample period are provided in Table 3. The movements of determinants of swap spread in the entire sample are shown in Figure 2. In Sample A and Sample B Sample, the determinants of swap spread are not so volatile. But in Sample C and Sample D, they get volatile a lot. Especially in Sample D, strong shocks are observed after the collapse of Lehman Brothers.

Table 3.Descriptive statistics of determinats of swap spreads

Variable	Average	SD	Min	Max	Median
Sample A					
AAA	0.783	0.061	0.630	0.900	0.780
BAA	1.678	0.061	1.550	1.840	1.680
SLOPE	-0.032	0.087	-0.190	0.210	-0.040
TED	0.456	0.047	0.340	0.570	0.450
VOLA	0.203	0.050	0.118	0.336	0.197
Sample B					
AAA	0.734	0.062	0.640	0.990	0.720
BAA	1.655	0.083	1.530	1.890	1.640
SLOPE	0.046	0.109	-0.140	0.260	0.020
TED	0.513	0.082	0.390	0.720	0.520
VOLA	0.248	0.082	0.115	0.443	0.242
Sample C					
AAA	1.564	0.275	1.010	2.130	1.640
BAA	2.792	0.510	1.870	3.500	3.010
SLOPE	1.214	0.465	0.300	2.090	1.390
TED	1.290	0.246	0.700	1.980	1.290
VOLA	0.870	0.229	0.394	1.469	0.823
Sample D					
AAA	2.299	0.343	1.520	3.000	2.400
BAA	4.829	0.988	2.850	6.160	5.240
SLOPE	2.117	0.356	1.270	2.760	2.050
TED	2.103	0.995	0.640	4.680	2.000
VOLA	0.713	0.479	0.264	2.290	0.450

Notes : Sample A = from January 3, 2006 through February 7, 2007.
Sample B = from February 8, 2007 through August 8, 2007.
Sample C = from August 9, 2007 through September 12, 2008.
Sample D = from September 15, 2008 through August 27, 2009.
AAA = Aaa corporate bond spread, BAA = Baa corporate bond spread
TED = TED Spread, SLOPE = Slope of yield curve, VOLA = Volatility

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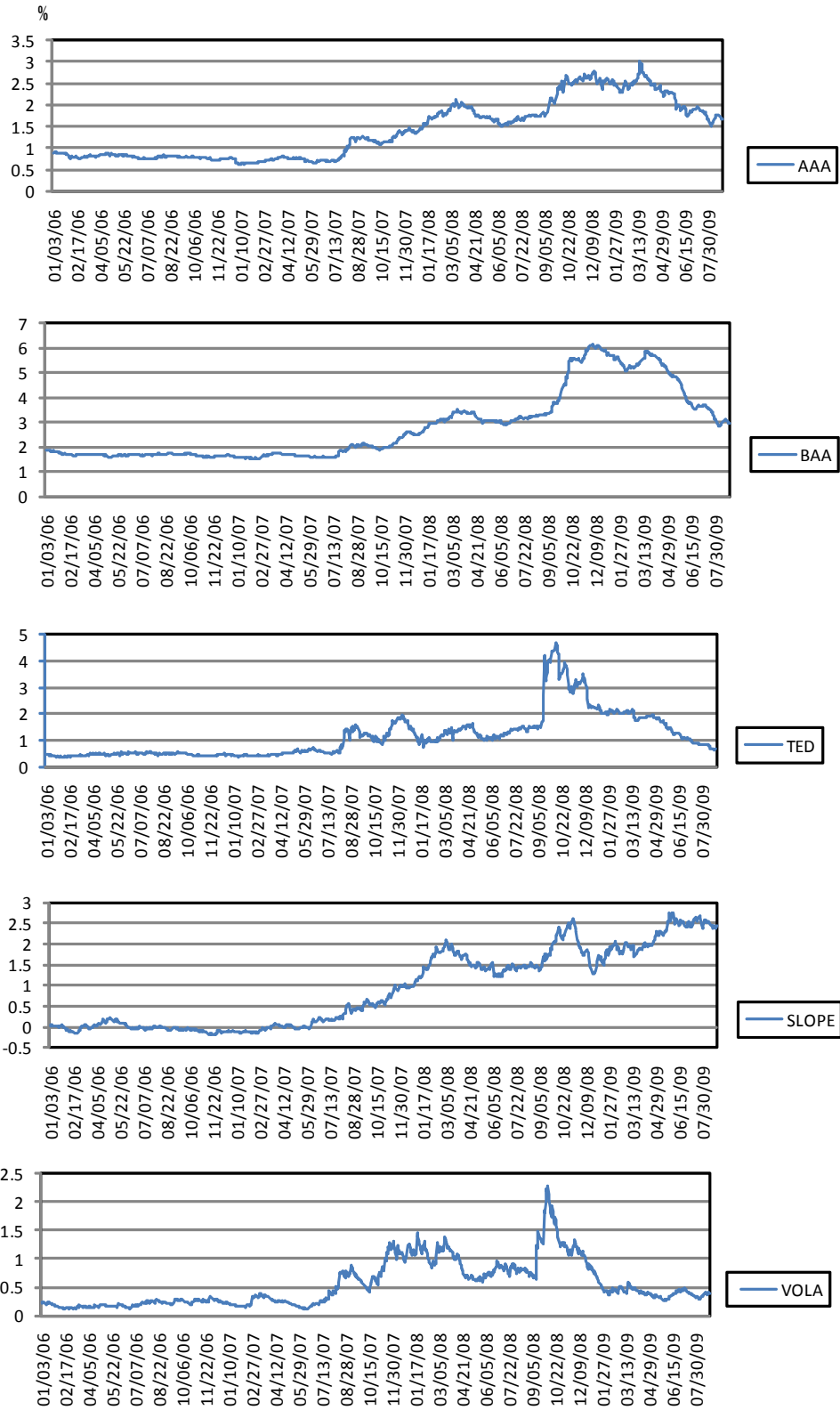[3]   See Nelson (1991) as for EGARCH model.

Figure 2 Movement of determinants of swap spread

Whole sample period from January 3, 2006 through August 27, 2009.

AAA = Aaa corporate bond spread, TED = TED Spread

SLOPE = Slope of yield curve, VOLA = Volatility

5. FRAMEWORK OF ANALYSIS AND RESULT

Here how to analyze the determinants of interest rate swap spread is indicated. First OLS is used to estimate equation (4). Aaa corporate bond spread is used for default risk. The serial correlations and heteroscedasticity of ε_t are adjusted by the method by Newey and West (1987). The lag periods of twelve are used. The analysis for each sample period is conducted. The results are shown in Table 4.

$$spread_t = \alpha + \beta_1 AAA_t + \beta_2 SLOPE_t + \beta_3 TED_t + \beta_4 VOLA_t + \varepsilon_t \qquad (4)$$

AAA = Aaa corporate bond spread, SLOPE = slope of yield curve,
TED = TED spread, VOLA = volatility

First, analysis on Sample A is conducted. As for Aaa corporate bond spread, the positive coefficients of 2- year and 10-year spreads are significant at 1 % levels respectively. As for slope, the positive coefficient of 2- year spread is significant at 5 % level. The negative coefficient of 10- year spread is significant at 1 % level. As for TED spread, the positive coefficients of 2 year and 10-year spreads are significant at 1 % level. As for volatility, the negative coefficients of 2 - year and 10-year spreads are significant at 1 % level.

Next, analysis on Sample B is conducted. As for Aaa corporate bond spread, the negative coefficients of 2- year and 10- year spread are not significant within 5% level. As for slope, the positive coefficients of 2- year and 10 –year spread are significant at 1 % level. As for TED spread, the positive coefficients of 2-year and 10-year spreads are not significant within 5 % level. As for volatility, the positive coefficient of 2 -year spread is significant at 5 % level.

Next, analysis on Sample C is conducted. As for Aaa corporate bond spread, the negative coefficient of 2- year spread is significant at 1 % levels. The negative coefficient of 10- year spread is not significant within 5 % level. As for slope, the positive coefficient of 2- year spread is significant at 1 % level. The negative coefficient of 10- year spread is not significant within 5 % level. As for TED spread, the positive coefficients of 2 year and 10-year spreads are significant at 1 % level. As for volatility, the negative coefficient of 2-year spread is significant at 5 % level. The negative coefficient of 10-year spread is not significant within 5 % level.

Finally, analysis on Sample D is conducted. As for Aaa corporate bond spread, the negative coefficient of 10- year spread is significant at 1 % levels. The negative coefficient of 2- year spread is not significant within 5 % level. As for slope, the negative coefficients of 2- year and 10-year spreads are not significant within 5 % level. As for TED spread, the positive coefficients of 2 year and 10-year spreads are significant at 1 % level. As for volatility, the positive coefficient of 2-year and 10- year spreads are significant at 1 % level.

Table 4.Result of regression analysis

	α	β1(AAA)	β2(SLOPE)	β3(TED)	β4(VOLA)	R^2	SER
Sample A							
SS2	0.092	0.209	0.090	0.480	-0.305	0.613	0.029
	(0.048)	(4.888)***	(2.298)**	(6.764)***	(-3.672)***		
SS10	0.219	0.191	-0.121	0.486	-0.327	0.426	0.029
	(3.879)***	(3.066)***	(-3.566)***	(5.833)***	(-3.798)***		
Sample B							
SS2	0.446	-0.154	0.401	0.070	0.184	0.643	0.035
	(6.695)***	(-1.401)	(8.592)***	(0.862)	(2.218)**		
SS10	0.564	-0.147	0.467	0.100	0.180	0.619	0.044
	(4.322)***	(-0.917)	(6.207)***	(0.719)	(1.110)		
Sample C							
SS2	0.604	-0.352	0.356	0.347	-0.126	0.612	0.079
	(4.991)***	(-2.690)***	(5.036)***	(8.581)***	(-2.317)**		
SS10	0.660	-0.119	0.076	0.099	-0.036	0.086	0.072
	(7.481)***	(-1.005)	(-1.050)	(2.687)***	(-0.707)		
Sample D							
SS2	0.362	-0.093	-0.037	0.231	0.215	0.900	0.105
	(1.166)	(-1.165)	(-0.507)	(7.472)***	(3.178)***		
SS10	0.770	-0.264	-0.074	0.077	0.136	0.555	0.108
	(3.031)***	(-3.084)***	(-1.365)	(2.490)**	(2.612)***		

Notes : Values in the parenthesis are t statistics.
***,** indicates significance at 1 % and 5 % levels respectively.
The serial correlation and heteroscedasticity of errors are adjusted by the method by Newey and West (1987).
AAA = Aaa corporate bond spread, SLOPE = Slope of yield curve, TED = TED spread, VOLA = Volatility

Next, OLS is used to estimate equation (5). Baa corporate bond spread is used for default risk. The serial correlation and heteroscedasticity of ε_t are also adjusted by the method by Newey and West (1987). The lag periods of twelve are used. The analysis for each sample period is conducted. The results are shown in Table 5.

$$spread_t = \alpha + \beta_1 BAA_t + \beta_2 SLOPE_t + \beta_3 TED_t + \beta_4 VOLA_t + \varepsilon_t \qquad (5)$$

BAA = Baa corporate bond spread, SLOPE = slope of yield curve,
TED = TED spread, VOLA = volatility

First, analysis on Sample A is conducted. As for Baa corporate bond spread, the positive coefficient of 2- year spread is significant at 1 % level. The positive coefficient of 10- year spread is not significant within 5 % level. As for slope, the positive coefficient of 2- year

spread is significant at 5 % level. The negative coefficient of 10- year spread is not significant within 5% level. As for TED spread, the positive coefficients of 2 year and 10-year spreads are significant at 1 % level. The coefficient of 10- year spread is larger than 2-year spread. As for volatility, the negative coefficients of 2 - year and 10-year spreads are significant at 5 % level.

Next, analysis on Sample B is conducted. As for Baa bond spread, the negative coefficient of 10- year spread is significant within 1% level. The negative coefficient of 2 - year spread is not significant within 5 % level. As for slope, the positive coefficients of 2- year and 10-year spread are significant at 1 % level. As for TED spread, the positive coefficient of 2-year spread and the negative coefficient of 10-year spread are not significant within 5 % level. As for volatility, the positive coefficient of 10 -year spread is significant at 1 % level. The positive coefficient of 2- year spread is not significant within 5 % level.

Next, analysis on Sample C is conducted. As for Baa corporate bond spread, the positive coefficient of 2- year spread ant the negative coefficient of 10-year spread are not significant within 5 % level. As for slope, the positive coefficients of 2- year and 10-year spread are not significant within 5 % level. As for TED spread, the positive coefficients of 2 year and 10-year spreads are significant at 1 % and 5 % levels respectively. The coefficient of 2- year spread is larger than 10-year spread. As for volatility, the negative coefficients of 2-year and 5-year spreads are not significant within 5 % level.

Finally, analysis on Sample D is conducted. As for Baa corporate bond spread, the negative coefficient of 10-year spread is significant at 1 % level. The negative coefficient of 2- year spread is not significant within 5 % level. As for slope, the negative coefficient of 10-year spread is significant at 5 % level. The negative coefficient of 2- year spread is not significant within 5 % level. As for TED spread, the positive coefficient of 2 year-spread is significant at 1 % level. The positive coefficient of 10-year spread is not significant within 5 % level. As for volatility, the positive coefficient of 2 year-spread is significant at 1 % level. The positive coefficient of 10-year spread is not significant within 5 % level.

6. CONCLUDING REMARKS

This paper investigates the impacts of global financial crisis on interest rate swap spreads in US. The asymmetric impacts of global financial crisis on interest rate swap spreads are focused by dividing the whole sample period into four. One sample is a period for normal time. The other samples are for the period of global financial crisis which are divided into three. It is significant to check the impacts of global financial crisis in various phases

because severity of crisis varies from a period to another.

Daily data ranging from January 3, 2006 through August 27, 2009 are chosen. The whole sample is divided into four depending upon the aspects of financial crisis. First period (Sample A) is from January 3, 2006 through February 7, 2007. Second period (Sample B) is from February 8, 2007 through August 8, 2009. Third period (Sample C) is from August 9, 2009 through September 14, 2008. Fourth period (Sample D) is from September 15,2008 through August 27,2009. First period includes relatively calm market. The periods from second through fourth includes financial crisis. Four determinants of swap spreads – default risk, the slope of yield curve, TED spread and volatility - are chosen. As for default risk, two kinds of default risk are used to investigate the sensitivity of swap spreads to Aaa and Baa corporate bond spreads.

Table 5.Result of regression analysis

	α	β1(BAA)	β2(SLOPE)	β3(TED)	β4(VOLA)	R^2	SER
Sample A							
SS2	-0.037	0.180	0.166	0.458	-0.294	0.631	0.028
	(-0.463)	(4.441)***	(4.715)**	(6.524)***	(-3.386)***		
SS10	0.200	0.105	-0.038	0.464	-0.306	0.411	0.029
	(1.888)	(1.818)	(-1.307)	(5.500)***	(-3.316)***		
Sample B							
SS2	0.536	-0.135	0.386	0.091	0.228	0.642	0.035
	(3.650)***	(-1.090)	(7.190)***	(0.902)	(1.903)		
SS10	0.755	-0.451	0.239	-0.034	3.759	0.704	0.093
	(15.708)***	(-8.657)***	(5.437)***	(-1.656)	(5.910)***		
Sample C							
SS2	0.302	0.029	0.122	0.301	-0.110	0.574	0.082
	(-2.797)	(0.342)	(1.310)	(5.078)***	(-1.690)		
SS10	0.661	-0.070	0.085	0.109	-0.053	0.091	0.072
	(6.393)***	(-0.939)	(0.957)	(2.471)**	(-0.947)		
Sample D							
SS2	0.367	-0.041	-0.050	0.242	0.191	0.902	0.104
	(1.511)	(-1.651)	(-0.737)	(7.979)***	(2.652)***		
SS10	0.742	-0.110	-0.100	0.101	0.079	0.618	0.100
	(4.530)***	(-7.230)***	(-1.996)**	(0.357)	(1.592)		

Notes : Values in the parenthesis are t statistics.
***,** indicates significance at 1 % and 5 % levels respectively.
The serial correlation and heteroscedasticity of errors are adjusted by the method by Newey and West (1987).
BAA = Baa corporate bond spread, SLOPE = Slope of yield curve, TED = TED spread, VOLA = Volatility

The default risk measured in Aaa corporate bond is positively incorporated in 2-year and 10-year swap spreads only in Sample A. The default risk measured in Baa corporate bond is positively incorporated in 2- year swap spread only in Sample A. The correlation coefficient of Aaa and Baa corporate bond spreads is 0.728 in Sample A. On the other hand, the correlation coefficients of Aaa and Baa corporate bond spreads are 0.875 in Sample B, 0.971 in Sample C and 0.961 in Sample C. Thus the quality of default risks in Aaa and Baa corporate bonds are considered to have got similar as the financial crisis deepened.

Theoretically swap transaction involves default risk in banking sector, which means that positive impact of default risk on swap spread is logical. The result of this paper indicates that when default risk measured in Aaa corporate bond increased, swap spread expanded in normal period. But when the extent of financial crisis deepened, especially after the collapse of Lehman Brothers, default risks measured both in Aaa and Baa corporate bonds gave negative impact on the swap spread of 10 years. The fact that 10-year swap spread became negative indicates that the function of price discovery in the market might have been lowered in financial shocks because theoretically credit risk of banking sector cannot be lower than that of US Government.

The following implications are based on the analysis when Aaa corporate bond spread is used as default risk. The slope is positively incorporated in 2-year spread in Sample A, Sample B and Sample C. As for 10-year spread, the slope is negatively incorporated in Sample A and is positively incorporated in Sample B. The slope is small in Sample A and Sample B. The averages of slope in Sample A and Sample B are -0.032 and 0.046, which means that yield curves are almost flat in Sample A and Sample B. The average of slope in Sample C is 1.214, which means that yield curve is upward. The 2-year swap spread is considered to be positively responsive to slope because of the higher risk premium of Treasury notes in financial crisis.

The liquidity premium is positively incorporated both in 2- year and 10 - year swap spreads in Sample A, Sample C and Sample D. The averages of TED spreads in Sample C and Sample D are 1.290 and 2.103 respectively in comparison with the averages in Sample A and Sample B, 0.456 and 0.513. These facts indicate that liquidity became more serious issue as the degree of financial crisis deepened.

The volatility is positively incorporated in the spreads of 2-years and 10-years in Sample D. FRB started to change monetary policy from September 18, 2007. Afterwards FRB continued to ease monetary policy. Especially after the collapse of Lehman Brothers, FRB began to take non-traditional measures such as CPFF (Commercial Paper Funding Facility) in addition to lowering the operating target of federal fund rate to 0.0% through 0.25% on

December 16, 2008 to mitigate the shocks in the market[4]. The market participants were uncertain as for the future of monetary policy by FRB. The speculation on the path of monetary policy and the uncertainty of market are considered to cause more volatility in the market. Thus the volatility can be a positive determinant of US swap spreads in Sample D.

  The impacts of global financial crisis on financial markets can be investigated in various aspects. Further research of the analysis as for the impacts of global financial crisis on financial markets are to be expected.

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[4] The Federal Reserve Board announced the creation of the Commercial Paper Funding Facility (CPFF), a facility that will complement the Federal Reserve's existing credit facilities to help provide liquidity to term funding markets.

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