Flight to "Futures" During the Financial Crisis: Deliverability Through Central Counterparties[1]

Takahiro Hattori [a]

Ministry of Finance Japan

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Abstract

Taking advantage of the physical settlement of Japanese government bond (JGB) futures, this paper firstly evaluates the role of central counterparties (CCPs) in the over-the-counter market during the 2008–2009 financial crisis. Our result shows that the special premium on the settlements through CCPs clearly emerged only during the crisis and is significantly related to physical settlements through CCPs. To identify the premium, we compare 7- and 6.75-year JGBs, which generate almost the same cash flow except in their linkage to JGB futures. Our evidence strongly supports the recent financial regulation reforms which mitigate the counterparty risk through CCPs.

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[a] Corresponding author. Ministry of Finance Japan. hattori0819@gmail.com. 3-1-1 Kasumigaseki Chiyoda-ku Tokyo Japan 100-8940. Tel 81-3-3581-4111.

1. Introduction

The financial crisis is often referred to as the crisis in the over-the-counter (OTC) market. After this crisis, investors have recognized the counterparty risk in the OTC market. The recent financial regulation reforms require that standardized derivatives should be cleared through central counterparties (CCPs) while the regulator requires higher capital and margin requirements for noncentrally cleared derivatives. However, despite the apparent advantages of CCPs for practitioners and policy-makers, whether CCPs can improve the market function is still heavily discussed from theoretical and empirical perspectives. Several studies (Bernanke 1990; Loon and Zhong 2014; Bernstein et al. 2017) support the effectiveness of central clearing, although other studies (Pirrong 2009; Acharya and Bisin 2014) note the negative aspects of CCPs.

To add a new insight to these literatures, our paper is the first to evaluate the role of CCPs in the OTC market during the 2008–2009 financial crisis. Exploiting the unique institutional features in Japanese Government Bond (JGB) futures as a laboratory, we investigate whether the investors actually demanded the central clearing during the financial crisis. Our empirical finding indicates that investors imposed the special premium related to the settlement through CCPs only during the financial crisis. In this sense, our evidence supports the recent financial regulation reforms which mitigate the counterparty risk through CCPs.

For identifying how investors appreciated the settlements through CCPs during the financial crisis, we take advantage of the institutional linkage of 7-year JGBs to JGB futures (such as Yu et al. 1996; Hamao and Hoshi 2000; Kikuchi and Shintani 2012); the investors can deliver 7-year JGB, which is called the cheapest-to-deliver (CTD) bonds, through CCPs as long as they take a position of JGB futures. To extract the special

premium of the settlement through CCPs, we compare the yield of 7-year JGBs (CTD bond) with 6.75-year JGBs, which has the closest-maturity to the CTD bond but is not cleared through CCPs. This approach is in line with the previous literatures about the on-the-run premium (See Krishnamurthy 2002) because we compare the assets with an almost identical cash flow except one factor, which is the linkage to CCPs through JGB futures. Figure 1 contrasts the actual yield curve for JGB with the theoretical curve just after the failure of Lehman Brothers. This figure clearly shows that the special premium for the 7-year sector emerged during the crisis and the emergence of this special premium coincided with the timing when investors recognized the counterparty risk in the OTC market.

To attribute this premium to the deliverability of 7-year JGBs through CCPs, we examine whether the investors actually delivered JGBs through CCPs during the financial crisis or not. JGB futures have other functions such as hedging, but investors should avoid the physical delivery of JGBs through reverse trading[2] if they are exposed on the JGB futures for other purposes such as hedging. Our paper empirically shows that the special premium on the linkage to JGB futures is significantly related to the actual amount of JGBs settled through CCPs, which provides strong evidence to support our interpretation.

Investors recognized the counterparty risk of trading JGBs during the crisis. Due to the T+3 settlement cycle in Japan, the trade in JGBs suffered from the relatively larger counterparty risk during the crisis compared to other advanced countries. For example, the default by Lehman Brothers led to the accumulation of failed settlements worth

[2] For example, investors can take long and short positions on the same underlying asset with different delivery months, which is often called trading a calendar spread.

several trillion JPY (several hundred billion USD).

"Squeeze" could be an alternative explanation for this additional premium, where the squeezer attempts to make a profit by restricting the supply of the CTD bond (7-year JGB). However, we rule out the possibility of a squeeze for two reasons. First, the Japanese government has implemented the unique auction called "liquidity enhancement auction," which among advanced countries only exists in the Japanese market. Indeed, Japan can reissue the old JGBs that have structural liquidity shortages or temporary liquidity shortages due to expanding demand such as a squeeze; thus, the investor can directly purchase the CTD bond from the Ministry of Finance even if the squeezer restricts its supply. Our empirical finding indicates that the investors didn't purchase the CTD bond at all from this unique auction during the financial crisis even though they could purchase the CTD bond. This is strong evidence that the squeezer didn't restrict the supply of the CTD bond during this period. Second, we utilize the useful measure of a squeeze which is called Squeeze Potential proposed by Merrick et al. (2005), which also confirms that we cannot find the persistent squeeze during the financial crisis.

After the financial crisis, several empirical papers have explored the effect of CCPs. Menkveld et al. (2013) use data from clearing reform in three Nordic equity markets in 2009 to show that the adoption of CCPs enhances price stability. Loon and Zhong (2013) demonstrate that the clearing of credit derivative contracts in 2009 increased asset values. Bernstein et al. (2017) examine the establishment of a clearinghouse on the New York Stock Exchange (NYSE) in 1892 and showed that the introduction of clearing reduced the annualized volatility of NYSE returns and increased asset values. Using 1892 NYSE data, McSherry et al. (2017) show that multilateral settlement is

advantageous when the financial markets are highly stressed.

Our paper is in line with these empirical studies. The distinct feature of our paper is to focus on the direct effect of the 2008–2009 financial crisis by taking advantage of the linkage between cash bonds and bond futures. The literature has empirically explored the function of CCPs using historical events during the nonfinancial period; however, we directly focus on the 2008–2009 crisis by empirically showing that investors actually demanded the settlement through the CCPs. This evidence supports the recent financial regulation reforms which mitigate the counterparty risk through CCP.

To identify the premium on CCPs during the crisis, our paper takes advantage of assets with similar cash flows. This analysis is related to the on-the-run premium (such as Amihud and Mendelson 1991; Boudoukh and Whitelaw 1993; Krishnamurthy 2002) and the premium on government-guaranteed bonds (such as Longstaff 2004; Schwarz 2018). Some researches explore the disparity of similar assets, such as the relationship between bonds and notes in the US Treasury market (Musto and Schwarz 2018) and between US Treasury and inflation-swapped Treasury inflation-protected securities during the financial crisis (Fleckenstein et al. 2014).

The remainder of this paper is organized as follows. Section 2 describes the linkage between the 7-year JGBs and JGB futures and how the 7-year JGBs can be cleared through CCPs. Section 3 reports the results and implications of our empirical analyses. Section 4 discusses the possibility of squeeze, and section 5 concludes.

2 The Relationship Between JGB Futures and JGBs

In this section, we consider the relationship between JGBs and JGB futures and empirically show that investors put the additional premium on JGBs with linkages to the

JGB futures market during the crisis. First, we describe the basic feature of JGB futures and the relationship between 7-year JGBs and the cheapest-to-deliver (CTD) bonds. We empirically indicate that the maturity of CTD bonds is 7 years. Second, we briefly describe the institutional feature of JGB market. Third, for computing the special premium of 7-year JGB, we compare the yield spread of 6.75- and 7-year and show that the special premium emerged suddenly during the financial crisis.

2.1 JGB Futures and 7-Year JGBs

JGB futures are derivative products that provide contractors with opportunities for buying or selling JGBs on a specified date at a predetermined price. The basic concept is the same as US Treasury futures: i.e., the foundation of JGB futures are standardized bonds that are set with a coupon rate and a maturity listed in the Japan Exchange Group (JPX). A certain amount of the margin (collateral) is required when investors take the position of the JGB futures.[3]

A well-known feature of bond futures is the physical settlement of the cash bonds. The buyers and sellers of bond futures deliver cash bonds through CCPs. The sellers have an incentive to deliver the cheapest cash bonds among the deliverable basket, i.e., CTD bonds. Thus, the sellers and buyers of bond futures deliver the CTD bonds through the CCPs.[4] The sellers could choose non-CTD bonds as long as the bond is chosen among the deliverable basket, but it is costly for sellers to select non-CTD bonds. This is in sharp contrast to equity futures, i.e., the cash settlement.

Notably, contractors can deliver CTD bonds, but they do not have to choose physical

[3] Please see the Japan Securities Clearing Corporation (JSCC) website for details on calculating margin requirements (https://www.jpx.co.jp/jscc/en/cash/futures/marginsystem/rpf.html).
[4] See Burghardt and Belton (2005) for details on the computation of CTD.

settlement. In particular, if investors have different purposes such as hedging, they may choose the reversing trading to bring their net position back to zero. Investors normally use the futures not for delivery through CCPs, but for other purposes. Therefore, most contracts are offset prior to the contract expiration to avoid physical delivery.

The distinct feature of JGB futures compared with US Treasury futures is that only single futures (10-year JGB futures) have been traded in the JGB market (several bond futures have been traded in the US bond market). This enables us to identify the different effects of the futures on JGBs. Table 1 shows the basic information of 10-year JGB futures. Under the rule of 10 year-JGB futures, the JGBs with more than 7 years and less than 11 years are eligible for delivery. Under the current system of JGB futures, it is widely well recognized that the shortest maturity bonds (7-year JGBs) in the deliverable basket basically become the CTD bonds (Yu et al. 1996; Hamano and Hoshi 2000; Kikuchi and Shintani 2012). More concretely, the sellers (buyers) of JGB futures basically deliver (receive) the 7-year JGBs on the delivery dates. For instance, Kikuchi and Shintani (2012) note that the "maturity of the cheapest-to-deliver of the JGB futures is around 7 years."

This was also true during the financial crisis. Figure 2 shows the daily time series of the years to maturity of CTD bonds from January 2007 to December 2009, which demonstrates that the years to maturity of CTD bonds were around 7 years (the average of the maturity was 7.15 years).[5] In addition, the tight linkage of JGB futures and 7-year JGBs creates a high correlation between them. The correlation between the prices of JGB futures and 7-year JGBs during 2007–2009 is 0.98. However, the

[5] We select the minimum implied repo rate of JGBs among the deliverable basket using Bloomberg data. The settlement of JGBs and the delivery months for JGB futures are set on March, June, September, and December; therefore, the years to maturity for CTD bonds jump every 3 months.

correlation between the prices of JGB futures and 2-year, 5-year, and 10-year yields only amounts to 0.81, 0.92, and 0.97, respectively.[6]

2.2 JGB Market and Description of Data

The JGB market is one of the largest bond markets in the world. At the end of 2017, the outstanding value of JGBs was 9,008 billion USD. Table 2 compares the G7 countries in terms of outstanding value, which shows that the JGB market is the second largest next to the US bonds market.

The JGB market has similar features to the government bond markets of other advanced countries, including the US Treasury market. In terms of the primary market, the Ministry of Finance, Japan (MOF) regularly issues JGBs. Table 3 compares the bond types between Japan and the US. Currently issued JGBs can be classified into six categories: short-term (1-year) bonds; medium-term (2- and 5-year) bonds; long-term (10-year) bonds; super long-term (more than 10-year) bonds; inflation-indexed (10-year) bonds; and JGBs for retail investors (i.e., 3-year fixed rate, 5-year fixed rate, and 10-year floating-rate bonds). JGBs are principally issued in public offerings on market-based issue terms and the majority are issued by competitive auction. For secure and stable issuance and enhanced liquidity, the so-called "primary dealer system" was introduced in 2004 and is similarly designed to those in the US and major European countries.

To enhance market liquidity, the immediate reopening rule was introduced. Table 4 compares the reopening issuance between Japan and the US. As for on-the-run JGB

[6] For computing the correlation, we use the JGB yield and take the negative value because the yield and price move in opposite ways.

issues, Japan has adopted reopening for 20–40 years and inflation-indexed JGB issues in principle and 10-year JGB issues unless their yield fluctuates widely. Thus, Japan has tried to maintain and enhance liquidity by securing a sufficiently outstanding value for each issue.

In the secondary market, the predominant transaction for JGBs is OTC trade. To ensure fair and smooth OTC bond transactions, the Japan Securities Dealers Association's (JSDA) self-regulatory regulations require each securities company to maintain the fairness of the transaction by acting at a proper price according to a set of internal rules.

We use the JGB data from Bloomberg, which provides the closing price of the security level data.

2.3 Comparison Between 6.75- and 7-Year JGBs: Premium of CTD bond

There is no other institutional feature that makes 7-year JGBs special except for their linkage with JGB futures.[7] We consider this as an ideal situation for extracting the premium on linkages to futures because the comparison between the CTD bond and the closest-maturity non CTD bonds enables us to estimate the additional premium of the CTD bond. We select the closest-maturity non CTD bonds as 6.75-year JGBs because 6.75-year JGBs have an almost identical cash flow as 7-year JGBs and should be affected by the market condition in the same ways, but 6.75-year JGBs are not in the deliverable basket (which includes more than 7- and less than 11-year JGBs) in JGB futures. Because the redemption date of JGB is March, June, September or December,

[7] Unlike the US Treasury, the MOF has not issued 7-year JGBs; therefore, 7-year JGBs are always off-the-run.

6.75 year JGB is the bond which is the closest to 7-year JGB and is not included in the deliverable basket. Thus, the premium on 7-year JGBs compared with 6.75-year JGBs only comes from their linkage to JGB futures.

For estimating the CTD premium, we take the yield spread of the 6.75- and 7-year JGB while this idea is in line with the on-the-run premium (Amihud and Mendelson 1991; Boudoukh and Whitelaw 1993; Krishnamurthy 2002), which compares the similar maturity bond for extracting the illiquidity premium by taking advantage of the fact that investors concentrate their trading on on-the-run government bonds. In our case, we compare off-the-run government bonds with similar maturity, but with and without the linkage to JGB futures to extract the value of the linkage.

Figure 3 shows the time series of yield spread of the 6.75- and 7-year JGB, which indicates that the spread started to widen during the financial crisis. In September 2008, the spread jumped drastically from about 0% to 0.1%, which is when Lehman Brothers in turn collapsed. After late 2009, the spread decreased and disappeared. Table 6 compares the yield spread of the 6.75 and 7-year sectors. During 2006–2007 and 2009–2011, the spread was around ▲2 bps. On the other hand, during 2008, the spread in this sector was 0.02, which is the positive value.

3. Deliverability of CTD Bonds Through CCPs and the Counterparty Risk of JGBs During the Financial Crisis

In the previous section, we empirically demonstrate that the special premium on the 7-year sector emerged only during the financial crisis. Why did this happen? Because we compare 6.75-year JGBs with 7-year JGBs, which have almost the same cash flow, the only difference comes from the institutional aspect of the linkage to JGB futures,

which enables investors to settle through CCPs at a predetermined time. This suggests that this premium should come from the premium of the settlement through CCPs. To confirm that investors preferred central clearing during the crisis, we show the empirical evidence that the 7-year JGBs' special premium is significantly related to the actual settlement through CCPs.

3.1 The Relationship Between the 7-Year Premium and the Counterparty Risk

According to Ghamami and Glasserman (2017), CCPs aim to reduce the contagion effects in the OTC derivatives market while lowering counterparty risk in part through margin requirements (collateral). The contractors of JGB Futures deliver the CTD bond through Japan's central clearing, the Japan Securities Clearing Corporation (JSCC). JSCC received European Securities and Markets Authority recognition as a third-country CCP.

As with the US Treasury, JGBs are traded on the OTC market. However, the CTD bonds among JGBs can be cleared through CCPs because investors can take advantage of JGB futures for delivering the CTD bonds through the CCPs. Table 7 shows the institutional difference between CTD (7-year JGBs) and non-CTD (e.g., 6.75-year JGBs) bonds in terms of their deliverability through the CCPs. For example, when the investor holds a CTD bond, the investor can sell the CTD bond by shorting the JGB futures, which enables the investor to deliver the CTD bond to the counterparty through a CCP. However, if investors do not hold a non-CTD bond (which does not link with JGB futures such as a 6.75-year JGB), investors holding the JGBs must enter the OTC market to sell it. The investor may suffer from counterparty risk during this process.

It should be emphasized that the investors who already held the CTD bond can settle

it through a CCP, which drastically mitigates the settlement risk. Some investors who trade CTD and futures could suffer from a certain amount of settlement risk during the financial crisis. However, the important point is that the CTDs should already be held by other investors; therefore, the CTD should provide them with an option to settle it through a CCP.

3.2 The Counterparty Risk in JGB Market during the Financial Crisis

During the crisis, the counterparty risk of trading JGBs was perceived strongly in the OTC market. Due to the T+3 settlement cycle in Japan, the counterparty risk also included the risk of failure to deliver securities on the scheduled date, which is called a "settlement fail." Figure 4 shows that settlement fails surged in September 2008, when Lehman Brother's default on its settlement obligations caused the accumulation of settlement fails for several days. According to the BOJ (2010), it is estimated that JGBs and other securities transactions worth several trillion JPY to which Lehman Brothers was a counterparty were suspended from settlement because of Lehman Brother's bankruptcy.

During the financial crisis, the JGB could be cleared through a CCP, called the Japan Government Bond Clearing Corporation (JGBCC), which is the former name of JSCC.[8] However, more than 60% of JGB market transactions were not cleared in the clearing house, according to a BOJ survey (see BOJ 2010).

[8] According to the BOJ (2010), JGBCC replaces the contract between two parties to a JGB trade with two contracts: i.e., one between JGBCC and the buyer and one between JGBCC and the seller. Cash and securities positions between JGBCC and participants are netted and settled on a DVP basis using BOJ-NET.

3.3 The Empirical Evidence

In section 4.1, we confirm the institutional relationship between the 7-year special premium and the actual bonds delivered through the JGBs. However, bond futures could include several functions such as a tool for hedging. In addition, the squeezer could attempt to make a profit by restricting the supply of the CTD. Therefore, we use the data of the actual amount of JGBs delivered through the JSCC to detect the relationship between the 7-year special premium and deliverability through CCPs. If the financial crisis encourages investors to require central clearing through the JSCC, then the amount of JGBs delivered through JSCC should increase during the crisis. However, if investors use the JGB futures for other purposes, such as hedging, they should avoid physical settlement. For example, investors choose reverse trading strategies to bring their net position back to zero.

Figure 5 shows the actual amount of JGBs that were delivered through the JGB futures (this amount of JGB was actually cleared through CCPs). The contract months of JGB futures are set on March, June, September, and December; thus, the frequency of this data is quarterly. The data is obtained from Bloomberg. During 2008, the amount of the delivered JGBs in September 2008 jumped to 2.1 trillion JPY (19 billion USD), which is more than 7 times compared with the previous years, providing empirical evidence that investors actually increased the settlement through CCPs during the crisis.

We examine this connection by simple regression as follow:

$$\text{Special Premium}_t = \beta_0 + \beta_1 \text{Delivered}_t + \beta_2 \text{Control}_t + \varepsilon_t \quad (1)$$

,where Special Premium_t indicates the special premium of CTD bond (7-year

sector's premium), $\mathrm{Delivered}_t$ is the amount of JGBs delivered through CCPs, $\mathrm{Control}_t$ is control variables, and ε_t is an error term.

Table 8 reports the estimation results when we regress the 7-year sector's premium on the amount of JGBs delivered through CCPs. We use the data from August 2002 to March 2013, which is the period just before the Bank of Japan started to implement the Quantitative and Qualitative Policy. This table demonstrates that the actual amount of the delivered JGBs has a positively significant relationship with the special premium on JGBs in the 7-year sector with 5% significant level. This empirical evidence supports the statement that the investors required the central clearing process during the financial crisis.

We also report the estimation results with the control variable, which is the bid-ask spread of JGB futures. This variable is included because the special premium in the 7-year sector could stem from the changes in the market liquidity of JGB futures during the crisis. Table 8 also includes the estimation results with the control variable and we confirm that the actual amount of the delivered JGBs still has a positively significant relationship with the special premium on JGBs even if we include the control variable.

In addition, to check whether the premium on the 7-year sector could be related to the counterparty risk, we regress the 7-year sector's premium on the proxy variable of the counterparty risk. We use LIBOR-OIS spread as the proxy of the counterparty risk. This measure contains the short-term default risk of the financial institution, which is widely used as the proxy of the counterparty risk by several researchers (such as Taylor and Williams 2008; Baba and Packer 2009). Table 9 shows the result of the estimation, which clearly shows that the spread is significantly related to the variables of counterparty risk.

3.4 Why did the Special Premium Emerge in the JGB Market Compared with the US Treasury Market

It is natural to ask why the 7-year special premium emerged only in the JGB market but not in the US Treasury market. Musto and Schwarz (2018) provide the daily yield curve in US Treasury market on their website, which shows the disparity between bonds, i.e., the Treasury bonds issued with 30 years to maturity, and notes, i.e., all other coupon-paying Treasury bonds in the US Treasury market, although there was no special premium from the linkage to the futures market during the crisis in the US market.

There are at least two reasons for the above. First, the settlement cycle of the JGB market was much longer than in other advanced countries, such as the US, suggesting that the counterparty risk in the JGB market was much more serious than the risk in the US Treasury market during the crisis. In particular, the cash bond contains the settlement risk in terms of the counterparty risk. The BOJ (2010) defines the settlement risk by multiplying the outstanding value of unsettled transitions by the duration to settlement. Table 10 shows the settlement cycles in major countries in 2009, indicating that outright settlement cycles of JGBs required T+3 days during the crisis, which is 2 days longer than that in the US market (T+1 days). This suggests that the counterparty risk of JGBs should be three times as high as that of the US Treasury in terms of duration to settlement. In fact, because Lehman Brothers was the primary dealer in the JGB market and bid in JGBs auctions before the collapse, the default of Lehman Brothers caused a huge accumulation of settlement failures during the crisis. In September 2008, Ministry of Finance Japan was unable to issue a further 288.5 billion

yen ($2.7 billion) in government bonds because Lehman Brothers had failed to pay.[9]

Second, there have only been single bond futures in the JGB market, which is in sharp contrast to the US Treasury market. This market practice in the JGB market provides an exclusive premium of linkage to the futures market (7-year JGBs). However, the US Treasury futures are available for a wide range of the tenors: 2-year, 5-year, 10-year, and 30-year. With these multiple bond futures, the deliverable bucket of US Treasury futures covers almost all US Treasury bonds. This market practice should mitigate the exclusive premium of the deliverability through CCPs.

4. The Possibility of Squeeze?

There could be an alternative explanation for the special premium of CTD bond which is characterized as a squeeze. However, we rule out the possibility of the squeeze for two ways. First, we describe Liquidity Enhancement Auction, which is very unique to Japan and this prevents a squeeze institutionally. Second, we use the useful measure called Squeeze Proposed by Merrick et al. (2005).

4.1 Special JGB auction for preventing squeeze: Liquidity Enhancement Auction

From April 2006, the Japanese government implemented the unique "liquidity enhancement auction," which among advanced countries only exists in the Japanese market. Through liquidity enhancement auctions, Japan can reissue the old JGBs that have structural liquidity shortages or temporary liquidity shortages due to expanding

[9] See Reuters for further detail (https://www.reuters.com/article/financial-lehman-japan/lehman-failure-prevents-y288-5-bln-jgb-issuance-idUST11999320080922).

demand such as a squeeze.[10] This means that even if the squeezer attempts to make a profit by restricting the supply of the CTD, investors can ask the Ministry of Finance to issue the squeezed bonds. Therefore, this mechanism drastically mitigates the possibility of squeeze.

Figure 6 shows the amount of Liquidity Enhancement Auction conducted by the Ministry of Finance from 2007 to 2009, which suggests the investors could purchase "potentially squeezed bonds" by 10 billion JPY every month. However, the investors did not request to purchase the CTD bond during the financial crisis. Table 11 describes the result of Liquidity Enhancement Auction from July 2008 to October 2008, which clearly shows the investors did not require the CTD bond even though they could purchase the CTD bond. During this period, the amount of the CTD bond which the investors required was only 0.2% among the total issuance from Liquidity Enhancement Auction.

4.2 Potential Squeeze proposed by Merrick et al. (2005).

Second, we empirically rule out the possibility of the squeeze, using Squeeze Potential proposed by Merrick et al. (2005). Merrick et al. (2005) define Squeeze Potential as the difference between "forward price with squeeze" and "forward price with no squeeze". In actual computation, Merrick et al. (2005) compare the price of the futures contract to its full-squeeze and no-squeeze values, which is derived from the values of the first-and the second-cheapest deliverable bonds (the relatively unattractive second choice). Following this idea, we compute the squeeze potential as the yield

[10] The yield-spread-competitive auction under the conventional method for JGB Market Special Participants is used for Liquidity Enhancement Auctions. See MOF (2017) for the detail of liquidity enhancement auction.

spread of the CTD and the bond of the relatively unattractive second choice among the deliverable basket, which is 7.25 year JGBs.

Figure 7 shows the squeeze potential, which shows there is no evidence that the squeeze potential drastically increased during the financial crisis, compared with the other period. To control the squeeze potential, we include this variable as the control variable in eq. (1). Table 12 shows the estimation results when we regress the CTD premium on the amount of JGBs delivered through CCPs with the control of the squeeze potential and the proxy of liquidity premium. This table confirms that the actual amount of the delivered JGBs still has a positively significant relationship with the special premium on JGBs with 5% significant level.

In addition, we will empirically show the relationship between the 7-year special premium and the actual bonds delivered through the JGBs. If the squeezer attempts to make a profit by restricting the supply of the CTD, investors should avoid physical settlement (they could easily cancel out their position by taking the opposite position). However, our data indicate that physical settlement sharply increased during the financial crisis, which is also strong evidence that investors actually demanded settlement through the CCPs.

5. Conclusion

This paper presents the effect of CCPs using the JGB market during the financial crisis. The unique feature of this paper is that we take advantage of the difference between 6.75- and 7-year JGBs that generate almost identical cash flows, except in their linkage to JGB futures. We empirically show that the special premium on 7-year JGBs emerged only during the financial crisis, which provides empirical evidence that

investors put a special premium on the linkage to the JGB futures market. Moreover, we note that the only institutional feature of linkage to the JGB futures market is about the deliverability of JGBs through the CCPs, which decreases the counterparty risk. To provide empirical support, we show the tight connection between the actual amount of delivered JGBs and the special premium.

Our conclusion complements the existing literature and has huge policy implications. Several studies in the literature support CCPs from theoretical and empirical perspectives, but no study has explored the direct effect of CCPs during the 2008–2009 financial crisis, which policy-makers and practitioners really need to understand. Our result empirically shows that investors preferred the central clearing process during the financial crisis for mitigating the counterparty risk. The recent financial regulation reform attempts to foster the trade of OTC derivatives to be cleared through CCPs. Our results provide empirical justification for the recent reform of the financial regulation.

References

[1]. Acharya, V.V., Bisin, A. 2014. Counterparty risk externality: centralized versus over-the-counter markets. Journal of Economic Theory 149, 153–82.

[2]. Amihud, Y., Mendelson, H., 1991. Liquidity, maturity, and the yields on U.S. Treasury securities. Journal of Finance 46(4), 31–53.

[3]. Baba, N., Packer, F., 2009. From turmoil to crisis: dislocation in the FX swap market before and after the failure of Lehman Brothers. Journal of International Money and Finance 28(8), 1350–1374.

[4]. Bank of Japan. 2010. Payment and Settlement Systems Report 2009 Response to the Global Financial Crisis and Initiatives to Effect Improvements. Payment and Settlement Systems Department Bank of Japan.

[5]. Bernanke, B., 1990. Clearing and settlement during the crash. Review of Financial Studies 3(1), 133–151.

[6]. Bernstein, A., Hughson, E., Weidenmier, M. 2017. Counterparty Risk and the Establishment of the NYSE Clearinghouse. Journal of Political Economy, forthcoming.

[7]. Boudoukh, J., Whitelaw, R. 1993. Liquidity as a choice variable: A lesson from the Japanese government bond market. Review of Financial Studies 6(2), 265–292.

[8]. Burghardt, G., Belton, T. 2005. The Treasury Bond Basis: An in-Depth Analysis for Hedgers, Speculators, and Arbitrageurs. McGraw-Hill Library of Investment and Finance.

[9]. Fleckenstein, M., Longstaff, F., Lustig, H. The TIPS-Treasury Bond Puzzle. The Journal of Finance 69(5), 2151–2197.

[10]. Ghamami, S., Glasserman, P. 2017. Does OTC derivatives reform incentivize central clearing? Journal of Financial Intermediation 32, 76–87.

[11]. Hamao, Y., Hoshi, T. Bank-Owned Security Subsidiaries in Japan: Evidence after the 1993 Financial System Reform. Finance, Governance, and Competitiveness in Japan (Japan Business and Economics Series), Oxford University Press.

[12]. Jordan, B., Jordan, S. 1996. Salomon brothers and the May 1991 Treasury auction: Analysis of a market corner. Journal of Banking and Finance 20, 25–40.

[13]. Kikuchi, K., Shintani, K., 2012. Comparative Analysis of Zero Coupon Yield Curve Estimation Methods Using JGB Price Data. Monetary and Economic Studies 30.

[14]. Krishnamurthy, A. 2002. The Bond/Old-Bond Spread. Journal of Financial Economics. 66(2-3), 463–506.

[15]. Longstaff, F.A., 2004. The flight-to-liquidity premium in U.S. treasury bond prices. Journal of Business 77(3), 511–526.

[16]. Loon, Y.C., Zhong, Z.K., 2014. The impact of central clearing on counter- party risk, liquidity, and trading: evidence from the credit default swap market. Journal of Financial Economics 112(1), 91–115.

[17]. McSherry, B., Wilson, B., Mcandrews, J. 2017. Net Settlement and Counterparty Risk: Evidence from the Formation of the New York Stock Exchange Clearing House in 1892. Journal of Money, Credit and Banking 49(6), 1273–1298.

[18]. Menkveld, A., Pagnotta, E., Zoican, M. 2013. Does Central Clearing Affect Price Stability? Evidence from Nordic Equity Markets. Working Paper.

[19]. Merrick, J., Naik, Y., Yadav, P. 2005. Strategic trading behavior and price distortion in a manipulated market: anatomy of a squeeze. Journal of Financial Economics 77, 171–218.

[20]. Ministry of Finance, Japan. 2017. Debt Management Report 2017.

[21]. Musto, N., Schwarz, K. 2018. Notes on Bonds: Illiquidity Feedback During the Financial Crisis. Review of Financial Studies, 31(8), 2983–3018.

[22]. Nelson, C., Siegel, A. 1987. Parsimonious Modeling of Yield Curve. The Journal of Business, 60(4), 473–489.

[23]. Pirrong, C., 2009. The economics of clearing in derivatives markets: netting, asymmetric information, and the sharing of default risks through a central counterparty. Unpublished working paper. University of Houston, Houston, TX.

[24]. Schwarz, K., 2018. Mind the Gap: Disentangling Credit and Liquidity in Risk Spreads. Review of Finance, forthcoming.

[25]. Svensson, L.E.O., 1994. Estimating and interpreting forward rates: Sweden 1992–1994. Unpublished working paper 4871. National Bureau of Economic Research, Cambridge, MA.

[26]. Taylor, J., Williams, J. 2008. A Black Swan in the Money Market. NBER Working Paper No. 13943.

[27]. Yu, S., Theobald, M., Cadle, J. 1996. Quality Options and Hedging in Japanese Government Bond Futures Markets. Financial Engineering and the Japanese Markets 3, 171–193.

Table 1 The concept of 10-year JGB futures

	10-year JGB Futures
Contract	Standardized 6%, 10-year JGB
Opening Date	19-Oct-85
Deliverable Grade	Interest-bearing 10-year JGBs with 7 years or more but less than 11 years.
Contract Months	3 months in the March quarterly cycle (March, June, September and December)
Last Trading Day	5th business day prior to each delivery date (20th day of each contract month, move-down the date when it is not the business day). Trading for the new contract month begins on the business day following the last trading day
Contract Unit	100 million yen face value

Source: Japan Exchange Group

Table 2 The outstanding of the government bond in the end of 2016

	Countries	Outstanding
1	United States	17,011
2	Japan	9,008
3	China	3,332
4	United Kingdom	2,504
5	Italy	1,975
6	France	1,921
7	Germany	1,715
8	Canada	1,136
9	Spain	993
10	Australia	576

Notes: This table show the total debt securities issued by the general government

Source: BIS

Table 3 Bonds Types in Japan and U.S.

	Japan	U.S.
Short-term	About 2-month, 3-month, 6-month, 1-year	4-week, 13-week, 26-week, 52-week
Medium-term	2-year, 5-year	2-year, 3-year, 5-year, 7-year
Long-term	10-year	10-year
Super-Long-term	20-year, 30-year, 40-year	30-year
Others	Inflation-Inexed Bonds (10-year)	Inflation-Indexed Bonds(5-year, 10year, 30year), Floating Rate Bonds(2-year)

Source: Ministry of Finance Japan

Table 4 Reopening Issuances in Japan and U.S.

	Japan	U.S.
On-the-run Issues	・5-year ・10-year ・20-year ・30-year ・40-year ・inflation-indexed bonds	・10-year ・30-year ・inflation-indexed bonds
Without reopening	・2-year	・2-year ・3-year ・5-year ・7-year

Notes: In Japan, reopening issuances only in case nominal coupon is the same as the that of previous issues

Source: Ministry of Finance Japan

Table 5 Descriptive statistics of the yield spread of 6.75 and 7-year JGBs

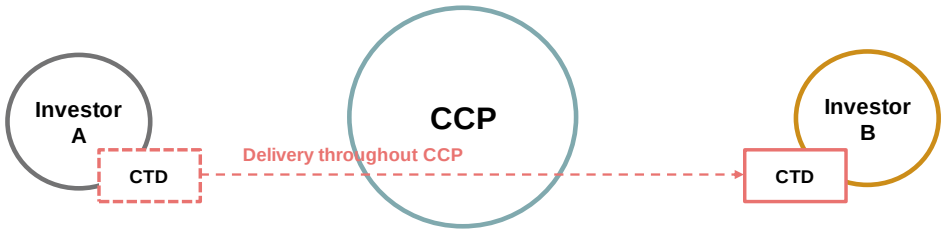
Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis	Num of Obs
-0.03	-0.03	0.21	-0.09	0.03	2.28	13.06	2743

Table 6 Yield spread of 6.75- and 7-year JGBs in each year

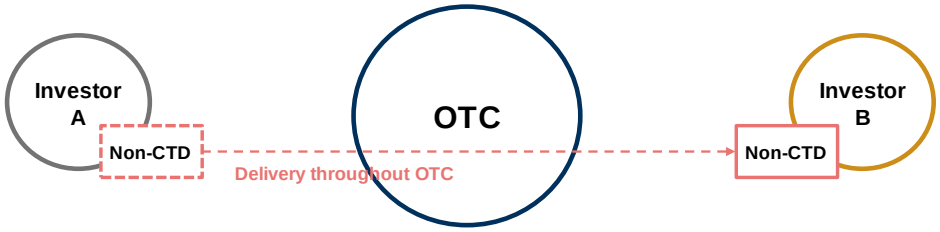
	2006	2007	2008	2009	2010	2011
6.75-year	1.500	1.391	1.122	0.893	0.655	0.654
7-year	1.524	1.409	1.098	0.916	0.695	0.684
Difference	-0.023	-0.018	0.024	-0.023	-0.040	-0.030

Table 7 The settlement of CTD and non-CTD with and without linking to JGB futures

1. CTD (7-year JGB) with JGB Futures



2. Non CTD (non 7-year JGB) without JGB Futures



Notes: "CTD" is the Cheapest to Deliver, which has a linkage with 7-year JGBs. "Non-CTD" is the JGBs that are not CTD bonds, such as 6.75-year JGBs. CCP stands for central counterparty and OTC is over-the-counter.

Table 8 The estimation results

	(1)	(2)
Delivery	0.022**	0.018***
	(0.010)	(0.005)
bid ask spread		1.644***
		(0.454)
R-squared	0.180	0.279
Observations	43	43

Notes: This table shows the estimation results. The dependent variable is the yield spread of the 6.75- and 7-year sectors. The independent variable is the amount of JGBs delivered through JGB futures, bid-ask spread of JGB futures, constant, and trend. Also reported are the OLS regression coefficients. The robust standard error with Newey–West is in parentheses (*** p<0.01, ** p<0.05). The data were produced daily from August 2002 to March 2013.

Table 9 The estimation results

LIBOR-OIS	0.113***
	(0.004)
R-squared	0.394
Observations	1470

Notes: This table shows the estimation results. The dependent variable is the yield spread of the 6,75- and 7-year sectors. The independent variable is the 3-month LIBOR OIS spread, constant, and trend. Also reported are the OLS regression coefficients. The robust standard error with Newey–West is in parentheses (*** p<0.01, ** p<0.05). The data were produced daily from January 2006 to December 2011.

Table 10 Settlement Cycles in Major Countries in 2009

	Japan	US	UK	Germany
Government Bond Outright	T+3	T+1	T+0	T+2
(Repo)	(T+2)	(T+0)	(T+0)	(T+1)

Source: Bank of Japan (2010)

Table 11 Result of Liquidity Enhancement Auction during the financial crisis

Name	Auction Date	Amount of issuance	Year to Maturity	Name	Auction Date	Amount of issuance	Year to Maturity
10 year bond 258	2008/7/11	249	5.7	20 year bond 71	2008/9/4	9	15.8
10 year bond 260	2008/7/11	280	5.9	20 year bond 81	2008/9/4	31	17.0
10 year bond 272	2008/7/11	5	7.2	20 year bond 82	2008/9/4	40	17.0
10 year bond 273	2008/7/11	5	7.2	20 year bond 84	2008/9/4	20	17.3
10 year bond 274	2008/7/11	30	7.4	20 year bond 85	2008/9/4	90	17.5
10 year bond 276	2008/7/11	30	7.4	20 year bond 86	2008/9/4	35	17.5
10 year bond 277	2008/7/11	10	7.7	20 year bond 92	2008/9/4	10	18.3
10 year bond 278	2008/7/11	10	7.7	30 year bond 1	2008/9/4	4	21.0
10 year bond 279	2008/7/11	10	7.7	30 year bond 9	2008/9/4	3	24.3
20 year bond 43	2008/7/11	16	11.2	30 year bond 10	2008/9/4	9	24.5
20 year bond 44	2008/7/11	120	11.7	30 year bond 13	2008/9/4	10	25.3
20 year bond 45	2008/7/11	18	11.7	30 year bond 21	2008/9/4	20	27.3
20 year bond 46	2008/7/11	135	12.0	30 year bond 25	2008/9/4	384	28.3
20 year bond 47	2008/7/11	37	12.2	20 year bond 45	2008/10/10	33	11.4
20 year bond 52	2008/7/11	3	13.2	20 year bond 57	2008/10/10	194	13.7
20 year bond 53	2008/7/11	1	13.5	20 year bond 58	2008/10/10	194	14.0
20 year bond 54	2008/7/11	40	13.5	20 year bond 61	2008/10/10	44	14.4
20 year bond 67	2008/8/8	2	15.6	20 year bond 62	2008/10/10	129	14.7
20 year bond 69	2008/8/8	7	15.6	20 year bond 63	2008/10/10	120	14.7
20 year bond 70	2008/8/8	1	15.9	20 year bond 64	2008/10/10	286	15.0
20 year bond 72	2008/8/8	2	16.1	20 year bond 67	2008/10/10	100	15.4
20 year bond 81	2008/8/8	20	17.1	20 year bond 69	2008/10/10	234	15.4
20 year bond 82	2008/8/8	5	17.1	20 year bond 70	2008/10/10	35	15.7
20 year bond 83	2008/8/8	197	17.4	20 year bond 76	2008/10/10	3	16.4
20 year bond 84	2008/8/8	15	17.4	20 year bond 83	2008/10/10	136	17.2
20 year bond 85	2008/8/8	727	17.6	20 year bond 84	2008/10/10	40	17.2
20 year bond 86	2008/8/8	15	17.6	20 year bond 85	2008/10/10	260	17.4
30 year bond 21	2008/8/8	7	23.8	30 year bond 10	2008/10/10	100	24.4
20 year bond 67	2008/9/4	285	15.5	30 year bond 13	2008/10/10	30	25.2
20 year bond 69	2008/9/4	49	15.5	30 year bond 25	2008/10/10	60	28.2

Note: Cheapest to Delivered is highlighted.

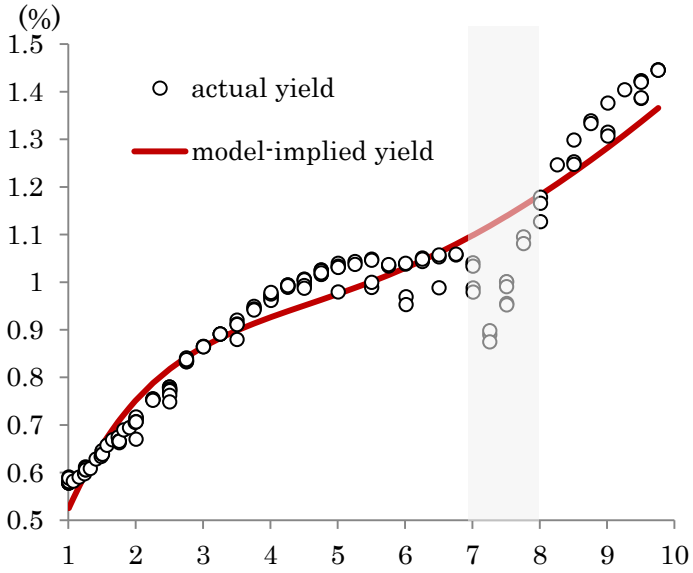
Source: Ministry of Finance, Japan

Table 12 The estimation results

	(1)	(2)
Delivery	0.011**	0.013***
	(0.005)	(0.004)
Potential Squeeze	-0.930***	-0.543***
	(0.177)	(0.135)
bid ask spread		1.193**
		(0.497)
R-squared	0.477	0.617
Observations	43	43

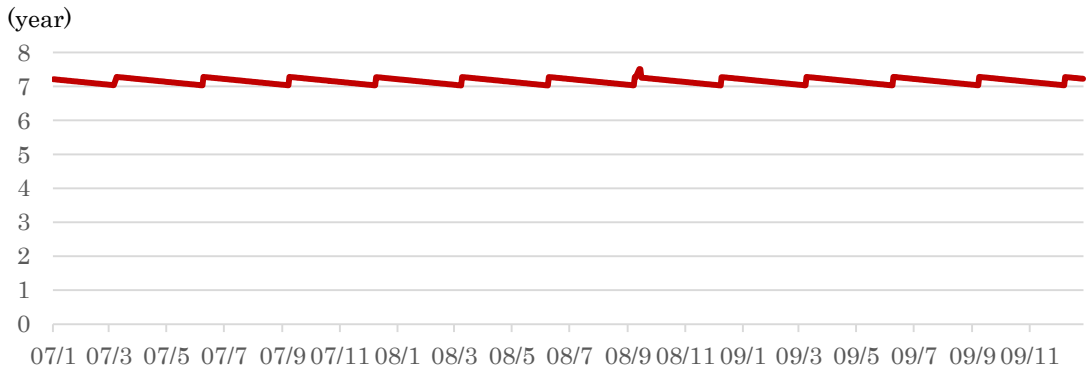
Notes: This table shows the estimation results. The dependent variable is the yield spread of the 6.75- and 7-year sectors. The independent variable is the amount of JGBs delivered through JGB futures, bid-ask spread of JGB futures, constant, and trend. Also reported are the OLS regression coefficients. The robust standard error with Newey–West is in parentheses (*** p<0.01, ** p<0.05). The data were produced daily from August 2002 to March 2013.

Figure 1 The term structure of the JGB yield just after the failure of Lehman Brothers



Notes: The figure shows the term structure of JGB yields just after the failure of Lehman Brothers, which was on September 16, 2008. The model-implied yield was based on Svensson (1994). The highlighted zone is a 7-year zone (more than 7 and less than 8 years), which is highly connected to JGB futures.

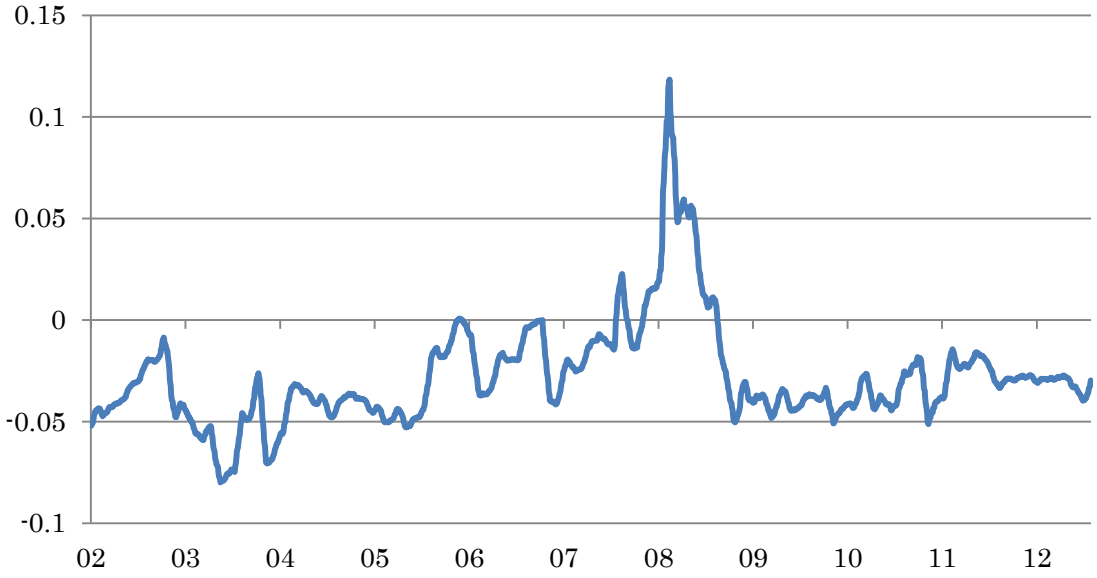
Figure 2 The maturity of Cheapest to Deliver (CTD) in JGB futures from January 2007 to December 2009



Notes: This graph shows the CTD of 10-year JGB futures. The CTD is chosen from the JGBs which have more than 7-year to less than 11-year in the maturity. The CTD is computed based on the coupon rates, prices, and years to maturity.

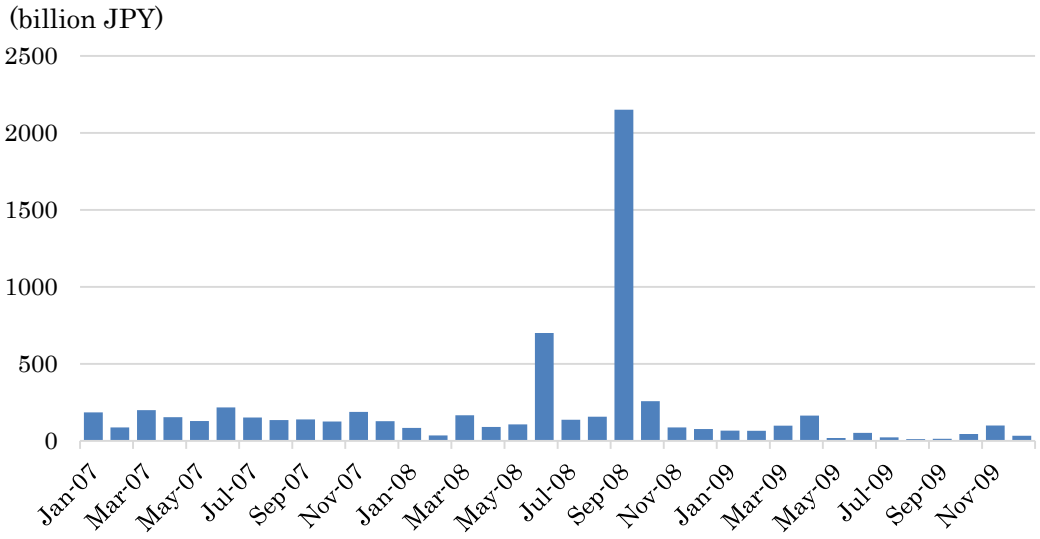
Source: Bloomberg

Figure 3 The time series of the yield spread of 6.75- and 7-year JGBs



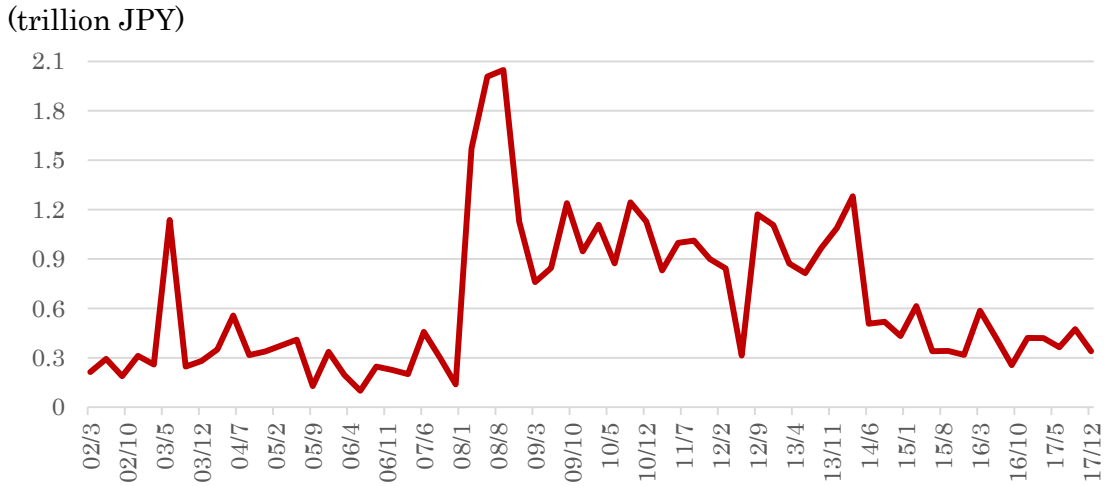
Notes: This graph shows the spread of 6.75- and 7-year JGB with 1 month moving average.

Figure 4 Settlement Fails in the JGB Market



Source: JSCC

Figure 5 The amount of the JGB delivered through the JSCC



Notes: The amount of JGBs delivered through JSCC is computed as the open interests in the last trading day in each delivery month.

Figure 6 The amount of the issuance of JGB through Liquidity Enhancement Auction

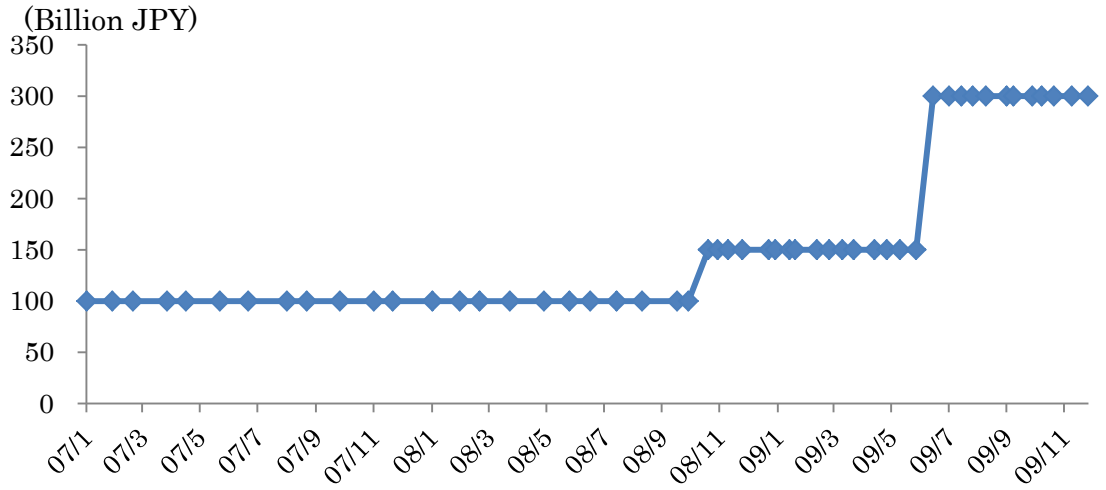
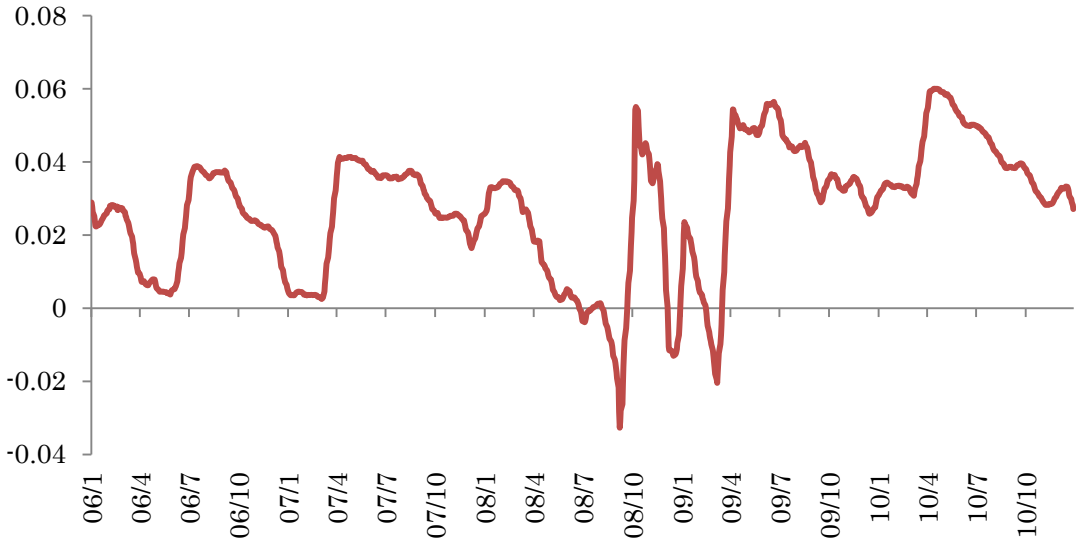


Figure 7 Squeeze Potential



Note: This figure shows Squeeze Potential proposed by Merrick et al. (2005). In this figure, Squeeze Potential is computed as the spread of 7-year JGBs and 7.25 JGBs with 1-month moving average.