

Flight to “Futures” during the financial crisis: Deliverability through central counterparties

Takahiro Hattori ^a

Ministry of Finance Japan

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Abstract

This paper evaluates the role of central counterparties (CCPs) in the over-the-counter market during the 2008–2009 financial crisis. Taking advantage of the physical settlement of Japanese Government Bond (JGB) futures, we focus on the institutional linkage between 7-year JGBs and JGB futures, which enable investors to clear their cash bonds through CCPs. To identify the premium on the linkage, we compare 7- and 6-year JGBs, which generate almost the same cash flow except in their linkage to JGB futures, and empirically show that the special premium on the linkage clearly emerged only during the crisis and its premium was significantly related to the actual physical settlements through CCPs.

JEL codes:

Keywords: term structure, financial crisis, central clearing, counterparty risk

^a Corresponding author. Ministry of Finance Japan. 3-1-1 Kasumigaseki, Chiyoda-ku, Tokyo, 100-8940 JAPAN. Tel 81-3-3581-4111. E-mail address: hattori0819@gmail.com.

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 serious counterparty risk. 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 researchers (Bernanke 1990; Loon and Zhong 2014; Bernstein et al. 2017) supported the effectiveness of central clearing, although some researchers (Pirrong 2009; Acharya and Bisin 2014) emphasized the negative aspects of CCPs.

The Japanese Government Bond (JGB) futures market during the financial crisis provides a good example for investigating how investors appreciated the linkage to the JGB futures and the clearing through CCPs during the financial crisis. Our strategy is to 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 or so). Based on the previous literature (such as Krishnamurthy 2002), we compare the yield of 7-year JGBs and the closest-maturity JGBs (6-year JGBs) because these assets generate an almost identical cash flow and have the same institutional features except for the linkage to JGB futures.

To estimate the premium on linkages to JGB futures, the entire term structure is fitted under the specific parametric assumption by Hu et al. (2013) to compute the theoretical implied yield. We take the spread of the theoretical implied yield and the actual yield to compare 7-year sector with 6-year sector. Figure 1 contrasts the actual yield curve for JGB with the theoretical curve just after the failures of Bear Stearns and Lehman Brothers. Figure 1 clearly shows that the high premium for 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.

What was the mechanism behind this additional premium during the financial crisis? We attribute this reason to the deliverability of 7-year JGBs through CCPs. The specific feature of bond futures is that the physical settlement of the 7-year JGBs is institutionally required through the CCPs with a sufficient margin, which mitigates the counterparty risk

drastically. However, investors traded JGBs in the OTC market during the crisis; i.e., these investors recognized the counterparty risk of trading JGBs during the crisis. In reality, Lehman Brother's default caused the accumulation of failed settlements worth several trillion JPY (several hundred billion USD). We empirically show that the special premium on the 7-year JGBs is significantly related to the amount of the physical settlement of JGB futures through CCPs and to the variable of the counterparty risk.

After the financial crisis, several empirical papers have explored the effect of CCPs. Menkveld et al. (2013) used 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) demonstrated that the clearing of credit derivative contracts in 2009 increased asset values. Bernstein et al. (2017) examined 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) showed 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 2007–2008 financial crisis by taking advantage of the linkage between cash bonds and bond futures. The literature has widely explored the postcrisis reform as a historical event; however, we directly focus on the 2007–2008 crisis by empirically showing that investors added the additional premium to the CCPs. This evidence supports the recent financial regulation reforms.

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 2017). Some researches explored the disparity of similar assets, such as the relationship between bonds and notes in the US Treasury market (Musto et al. 2017) and between US Treasury and inflation-swapped Treasury inflation-protected securities during the financial crisis (Fleckenstein et al. 2014).

In addition to the above contributions, we also add the robust result of Hu et al. (2013), who used the case of the second-largest bond market in the world. According to Fontaine and Garcia (2012) and Hu et al. (2013), the yield curve is widely known to contain the

liquidity condition of the capital market. We can interpret the smoothness of the yield curve as a good proxy for the market liquidity, i.e., the “noise” measure. Several applications of the noise measure have been performed (Anand et al. 2013; Filipović and Trolle 2013; Jacobs 2015; Foucault et al. 2016; Trebbi and Xiao 2016; Adrian et al. 2017). We show that the noise measure based on JGBs can track the illiquidity during the financial crisis and other illiquidity events. This measure has a strong relationship with other financial variables, which shows that it also has robust explanatory power for the illiquidity condition.

Fortunately, we can obtain the official database for the individual securities in Japan’s fixed-income securities market. This database contains all of the government bonds issued by the Japanese government, which is in sharp contrast with the US Treasury.¹ This database allows us to release the liquidity data for the economists through our site (<https://sites.google.com/site/hattori0819/data>). In particular, as Vayanos and Wang (2012) noted, the noise measure indicates the aggregate liquidity of the market. Therefore, this measure should be useful not only for financial economists but also for macroeconomists and policy-makers. We consider that releasing the index to the public is an important contribution to the field in the light of recent researches (Lane and Shambaugh 2010; Baker et al. 2016; Schwarz 2017).

The remainder of this paper is organized as follows. Section 2 reviews features of the JGB market and the noise measure proposed by Hu et al. (2012). Section 3 presents the time series properties of the noise measure in Japan and show that this measure can capture the illiquidity event in the Japanese market. Section 4 describes the linkage between the 7-year JGBs and JGB futures and how the 7-year JGBs can be cleared through CCPs. Section 5 reports the results and implications of our empirical analyses, and section 6 concludes.

¹ A public database for fixed-income securities is available, i.e., the Trade Reporting and Compliance Engine (TRACE). However, TRACE does not contain US Treasury data.

2. Construction of the Noise Measure

2.1 The Japanese Government Bond (JGB) Market²

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 1 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 2 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 3 compares the reopening issuance between Japan and the US. As for on-the-run JGB 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.

2.2 JGB Data

We use a JSDA database, “Reference Statistical Prices [Yields] for OTC Bond

² In this section, we rely on the Debt Management Reports published by the Ministry of Finance, Japan. Please see these reports for more detail of the JGB market.

Transactions,” which is the public database for Japan’s fixed-income market. Technically, JSDA collects bond quotes from 18 main securities firms daily. These daily quotes include national government bonds, corporate bonds, and municipal bonds. The data cover the average, median, highest, and lowest quotes of each bond issue based on JSDA’s aggregate data. The data are available starting August 1, 2002. Thus, our estimation term is from then until December 30, 2017.

We use the coupon-bearing bond with the nominal and fixed coupon payment, which is a standard fixed-income security. Table 4 shows the summary statistics for the JGB data from the JSDA database, “Reference Statistical Prices [Yields] for OTC Bond Transactions.” For the estimation, the number of the sample was 152.3 on average for each day. The average number of years to maturity is 4.7 years. The yield has decreased from 0.65% (August 2002–December 2006) to 0.47% (January 2013–December 2017).

2.3 Noise Measure

The liquidity measure was constructed based on Hu et al. (2013). As noted in the Introduction, a sufficient capital and ample liquidity condition enables investors to make an arbitrage, which smoothens the curve. However, arbitrage can become difficult with scarce capital and liquidity, which makes the curve noisy. Thus, the smoothness of the yield curve should be a good proxy for the liquidity measure.

For estimation, we follow the method proposed by Hu et al. (2013). First, we estimate the yield curve based on Svensson (1994) by computing the model-implied yield. Second, we construct the noise measure using the dispersion between the actual and model-implied yields.

Svensson (1994) models the forward rate ($f(x)$) for the six parameters according to the following functional form:

$$f(m) = \beta_0 + \beta_1 \exp(-m/\alpha_3) + \beta_2 (-m/\alpha_3) \exp(-m/\alpha_3) + \beta_3 (-m/\tau_1) \exp(-m/\tau_2) \quad (1)$$

where m is the remaining maturity and β_0 , β_1 , β_2 , β_3 , τ_1 , and τ_2 are the parameters to be estimated. This model is an extension of Nelson and Siegel’s (1987)

model. The parameters must satisfy the conditions that $\beta_0 > 0, \beta_0 + \beta_1 > 0, \tau_1 > 0, \tau_2 > 0$.

We can convert the forward-rate model in Eq. (1) into the spot-rate model:

$$y_t(b) = \frac{1}{m} \int_0^m f(s) ds = \beta_0 + \beta_1 \left(\frac{1 - \exp(-m/\alpha_3)}{m/\alpha_3} \right) + \beta_2 \left(\frac{1 - \exp(-\frac{m}{\tau_1})}{\frac{m}{\tau_1}} - \exp(-m/\tau_1) \right) + \beta_4 \left(\frac{1 - \exp(-m/\tau_2)}{m/\tau_2} - \exp(-m/\tau_2) \right) \quad (2)$$

We consider $y_t(b)$ as the theoretical yield and minimize the deviation between the theoretical yield and the actual yield for estimating the parameters (b) based on eq. (2). We construct the yield curve fitting the noise using the model-implied and actual yields (y_t^i), such as:

$$Noise_t = \sqrt{\frac{1}{N_t} \sum_{i=1}^{N_t} [y_t^i - y^i(b)]^2} \quad (3)$$

Based on Hu et al. (2013), we constructed our noise measure to follow two points. First, we use bonds with a maturity between 1 and 10 years in constructing the noise measure. Second, we employ a filter where any bonds four standard deviations away from the model yield are excluded from the construction of the noise measure.

Because our noise measure data were derived from the public JGB market data, we will make it available in our website for application in futures academic research.

3. Time Series Properties of the Noise Measure in Japan

In this section, we confirm that Hu et al. (2013) also provided a robust result using the JGB data. First, we describe the time series of the noise measure. We then discuss the period of the financial crisis and the implementation of quantitative and qualitative easing (QQE).

3.1 Times Series of the Noise Measure in Japan

Figure 2 shows the times series of a yield curve fitting noise. First, this measure

indicates that the illiquidity premium has negative trends. During 2002–2007, the average value of this measure was 1.4 basis points (bps), although the average value had dropped to 1.0 bps in the previous 5 years. During the 2000s, the MOF reformed the JGB market, especially by enhancing its liquidity (e.g., the implementation of reopening). This should contribute to the decreasing trend of the liquidity premium.³ In addition, investors have suffered from the long-run trend of the lower JGB yield, which could decrease the level of illiquidity premium. Second, this figure also shows that this noise measure can capture the famous illiquidity event known as the Value-at-Risk (VaR) shock, the collapse of Bear Stearns and Lehman Brothers, and the implementation of QQE by the Bank of Japan (BOJ). The VaR shock was the famous crash in the JGB market of June 2003, when 10-year JGB yields surged from 0.43% to 1.6% within 3 months.⁴ The liquidity was widely noted to have dropped tremendously during this period. The noise measure can clearly capture this illiquidity event. We will explain in detail about the financial crisis and QQE in the next section.

Table 5 shows the fundamental statistics of the yield curve fitting noise. This table includes the unit root test (ADF and PP tests), which shows that the yield curve fitting noise follows the stationary process.

3.2 Illiquidity During the Financial Crisis

In this section, we describe the movement of the noise measure during the global financial crisis in detail. Figure 3 shows the noise measure from June 2007 to June 2009. According to this measure, illiquidity increased sharply after the failures of Bear Stearns and Lehman Brothers. After the failure of Lehman Brothers, central banks implemented policies, including lowering the interest rate, the Troubled Asset Relief Program (TARP), mortgage-backed securities purchases. On December 2008, the illiquidity increased again although the illiquidity premium gradually shrank and stabilized after 2009, which was the same trend shown by the US Treasury's noise measure as computed by Hu et al. (2013).

³ Tomida (2001) noted that the JGB yield curve in the 1990s was very noisy because of market regulation and a lack of institutions supporting liquidity, although the curve became relatively smoother in 2000.

⁴ See Sakiyama and Yamada (2016) for details of the VaR shock.

3.3 Illiquidity During the Implementation of QQE

The BOJ introduced its QQE policy in April 2013 with the aim of achieving a 2% inflation rate as measured by the consumer price index as soon as possible. Since then, the BOJ has conducted money market operations to increase the monetary base by about 80 trillion yen annually. In January 2016, the BOJ introduced its QQE with a Negative Interest Rate policy by applying a negative interest rate of minus 10 bps to the current accounts held by financial institutions at the BOJ. Subsequently, the BOJ introduced its QQE with the Yield Curve Control (YCC) policy in September 2016, which controls the yield curve through market operations. Because the BOJ purchases almost 100% of JGBs in terms of their issuance, market participants and the International Monetary Fund pointed out that the market liquidity decreased after the implementation of QQE.

Figure 4 shows the time series of the noise measure from January 2013 to December 2017, which demonstrates that the illiquidity premium increased sharply just after the implementation of QQE policies. During April 2013 to May 2013, the JGB yield also increased sharply (the 10-year JGB yield jumped from 0.3% to 1.0%) and market participants during this period argued for liquidity impairment because the BOJ purchases all of the issuance of JGBs, which is consistent with the noise measure. On the one hand, Figure 4 suggests that the sharp increase in the interest rate induced the temporary illiquidity. For example, the JGB market in January 2015 and January 2017 suffered from a fall; these events coincided with the timing of the increased noise measured. In particular, the BOJ conducted a fixed-rate purchase operation in February 2017 to stabilize the JGB market; this operation followed the YCC policy (Hattori 2017a). On March 2017, the BOJ changed the open market operation by preannouncing the schedule, which stabilized the fluctuation of the JGB yield (Hattori 2017b) and the noise measure. On the other hand, Figure 4 shows the negative trend of the illiquidity premium, which implies that even when the illiquidity jumped temporarily, the long-run trend of the illiquidity premium was reduced.

3.4 The Relationship Between Noise Measure and Other Financial Variables

In this section, we investigate the relationship between the noise measure and other financial variables. We use financial variables related to the (i) fixed-income market, (ii)

stock market, (iii) credit market, and (iv) other liquidity measures. For this purpose, we regress the noise measure on the following variables: (i) Term Premium, bond volatility (BondVol); (ii) stock return (StockReturn), Volatility Index (VIX); (iii) Ted spread, Bond Credit Index; and (iv) bid-ask spread (BidAskSpread), the spread of Japanese government-guaranteed bonds (GovGuaranteed).

For (i), i.e., the fixed-income market variables, we use the term premium computed as the spread of 10- and 1-year JGB yields and use the bond volatility computed as the historical volatility of 5-year JGB yields using a rolling window of 21 business days. For (ii), i.e., the stock market variable, we use the stock return computed as the return of the Tokyo stock price index (TOPIX) and use the Volatility Index Japan (VXJ) computed by the Center for Mathematical Modeling and Data Science as a VIX. For (iii), i.e., the credit market variable, we use the Ted spread computed as the spread of 3-month JPY LIBOR and 3-month T-bill rate and use the Bond Credit Index as the T-spread of the NOMURA Bond Price Index. For (iv), i.e., the market liquidity variables, we use the bid-ask spread of 10-year on-the run JGBs and the spread of the 5-year Japanese government-guaranteed bonds and 5-year JGBs.⁵

Table 7 shows the estimation results. Most of the variables are significant at 5% except for the stock return and Bond Credit Index, although these variables are also significant at 10%. In addition, our results also indicate that the sign of the coefficient is expected. The liquidity premium should have a positive effect on the term premium and volatility, and the credit spread should be positively correlated. In addition, it should also have a negative effect on the stock return, which is consistent with our estimates.

4. 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 was 7 years and the correlation of 7-

⁵ We use the data of the spread of Japanese government-guaranteed bonds and JGBs from August 2002 to January 2016, which was just before the BOJ implemented QQE with a negative yield. See Hattori (2017c) for more detail.

year JGB yields and JGB futures was amazingly high. Second, for computing the special premium, we compare the deviation of 7- and 6-year sector from the theoretical yield based on Hu et al. (2013) and show that the special premium emerged suddenly during the financial crisis.

4.1 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 well-known feature of bond futures is the physical settlement of the actual bonds. The buyers and sellers of bond futures deliver cash bonds to the deliverable basket through CCPs. The sellers have an incentive to deliver the cheapest cash bond in the basket, i.e., CTD bonds. Thus, the seller and buyers of bond futures deliver the CTD bonds through the CCPs.⁶ This is sharp contrast to equity futures; i.e., the cash settlement.

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 8 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 5 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

⁶ See Burghardt and Belton (2005) for the detail for the computation of CTD.

of the maturity was 7.15 years).⁷ 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 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.⁸ Needless to say, JGB futures sellers choose JGBs in the deliverable basket (JGBs with more than 7 years to less than 11 years), but it is costly for sellers to select JGBs that are not the CTD.

4.2 Comparison Between 6- and 7-Year JGBs

There is no other institutional feature that makes 7-year JGBs special except for their linkage with JGB futures.⁹ We consider this as an ideal situation for extracting the premium on linkages to futures because 6- and 7-year JGB yields have an almost identical cash flow and should be affected by the market condition in the same ways, but 6-year JGBs are not in the deliverable basket (which includes more than 7- and less than 11-year JGBs) in JGB futures, while 7-year JGBs and CTD bonds are in the deliverable basket. Thus, the premium on 7-year JGBs compared with 6-year JGBs only comes from their linkage to JGB futures.

For estimating the 7-year JGBs' special premium, we construct the noise measure from the 6- and 7-year sector, and take the spread of the noise measure.¹⁰ The model-implied yield curve is estimated using the whole sample (1–10 years), but the noise of 7-year sector is constructed by the residual of the estimates from more than 7- and less than 8-year JGBs, while the noise of 6-year sector is constructed from more than 6- and less than 7-year JGBs. The spread of the 6–7-year sector' noise contains information about the 7-year JGBs' deviation from the theoretically implied yield over the 6-year JGBs'

⁷ We select the minimum implied repo rate of JGBs among the deliverable basket using Bloomberg data. The settlement of JGBs and the delivery months of JGB futures are set on March, June, September, and December; therefore, the years to maturity of CTD jump every 3 months (i.e., T+3).

⁸ For computing the correlation, we use the JGB yield and take the negative value because the yield and price move in opposite ways.

⁹ Unlike the US Treasury, the MOF has not issued 7-year JGBs; therefore, 7-year JGBs are always off-the-run.

¹⁰ The reason why we set the range for constructing the sector noise such as more than 7 years to less than 8 years stems from the fact that investors in JGB futures can choose JGBs with longer maturity, such as 7.5-year JGBs if the JGBs are in the deliverable basket, although it is relatively costly to select non-CTD.

deviation, which enables us to interpret the additional premium on the linkage to JGB futures.

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. In addition, we compute the deviation from the theoretically implied yield for evaluating whether 7-year JGBs have the special premium or not.

Figure 7 shows the time series of 6- and 7-year sector' noise and their spreads, which indicates that the spread between the 6- and 7-year sector started to widen during the financial crisis. In March 2008, the spread jumped drastically, which is when Bear Stearns collapsed, and peaked at September 2008, which is when Lehman Brothers in turn collapsed. After late 2009, the spread decreased and disappeared.

Table 9 compares the 6- and 7-year sector' noise. During 2006–2007 and 2010–2011, the noise level was around 1 bps, with a deviation of less than 0.5 bps. On the other hand, during 2008–2009, the noise in these sectors jumped because of the illiquidity during the turmoil of the financial crisis, although the noise of the 7-year JGBs sector increased to be larger than the noise of the 6-year sector. In particular, during 2008, the noise of the 7-year sector was more than 4 times as much as that of the 6-year sector.

To consider whether only 7-year sector' noise included the special premium or not, we also evaluate the 8-year sector' noise, which is in the deliverable basket but is far from the CTD. Figure 8 shows the time series of 7- and 8-year sector' noise and their spread, which shows similar trends to Figure 7. Table 9 also includes the comparison of 7- and 8-year sector, which shows that the difference during 2008 increased by 4.2 bps, although the difference during 2006–2007 and 2010–2011 was less than 0.5 bps. This evidence provides the robust results of the special premium of 7-year sector' noise.

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

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

In the previous section, we empirically demonstrated that the special premium on the 7-year sector emerged during the financial crisis. Why did this happen? The only institutional aspect of the linkage to JGB futures is the deliverability of JGBs through the Japan Securities Clearing Corporation (JSCC), which is a CCP in Japan. 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). JSCC was equipped with these functions and received European Securities and Markets Authority (ESMA) recognition as a third-country CCP.

As with the US Treasury, JGBs are traded on the OTC market and basically cleared in CCPs. However, because JGB futures are the product of delivering JGBs in their specific baskets at certain dates, the CTD among JGBs can be cleared through the CCP.¹¹ Table 10 shows the difference between CTD (7-year JGBs) and non-CTD (e.g., 6-year JGBs) bonds in terms of their deliverability through the CCPs. If the investor holds a CTD bond, the investor can settle the CTD through a CCP by having a position in JGB futures. 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-year JGB), investors holding the JGBs must enter the OTC market to sell it. This process suffers from counterparty risk.

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 6 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. Moreover, it is estimated that JGBs and other securities transactions

¹¹ Please see the following JSCC website for further details:
<https://www.jpx.co.jp/jsccl/en/cash/futures/marginsystem/rpf.html>.

worth several trillion JPY to which Lehman Brothers was a counterparty were suspended from settlement because of Lehman Brother's bankruptcy.

5.2 The Empirical Evidence

Figure 8 shows the actual amount of JGBs that were delivered through the JSCC. 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. We report the estimation result when we regress the 7-year sector's premium on the amount of the delivered JGBs in Table 11. Table 11 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.

In addition, to check whether the premium on the 7-year sector could be related to the counterparty risk, we regress the premium on the 7-year sector 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 12 shows the result of the estimation, which clearly shows that the spread is significantly related to the variables of counterparty risk.

6. 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- 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, and 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 a theoretical and empirical perspective,

but no study has explored the effect of CCPs during the 2008–2009 financial crisis, which policy-makers and practitioners really need to understand. Our result empirically shows that investors actually preferred the central clearing during the financial crisis. The recent financial regulation reform attempts to foster the trade of OTC derivatives to be cleared through CCPs. Our results provide empirical justification for this preference.

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Table 1 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 2 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-Indexed Bonds (10-year)	Inflation-Indexed Bonds(5-year, 10year, 30year), Floating Rate Bonds(2-year)

Source: Ministry of Finance Japan

Table 3 Reopening Issuances in Japan and U.S.

	Japan	U.S.
On-the-run Issues	• 5-year	
	• 10-year	
	• 20-year	• 10-year
	• 30-year	• 30-year
	• 40-year	• inflation-indexed bonds
Without reopening	• inflation-indexed bonds	
		• 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 4 Summary Statistics of JGB data from “Japan Securities Dealers Association”

	Number of Bond	Coupon	Yield	Price	Year to maturity
	average				
2006-2007	157.6	1.98%	0.65%	106.0	4.7
2008-2012	154.7	1.76%	0.65%	104.7	4.5
2003-2017	144.7	1.26%	0.06%	105.9	4.8
All	152.3	1.67%	0.47%	105.4	4.7
	median				
2006-2007	157	1.40%	0.55%	102.4	4.2
2008-2012	155	1.40%	0.61%	102.3	4.0
2003-2017	145	1.30%	0.04%	104.7	4.4
All	153	1.40%	0.32%	103.0	4.2

Notes: The bonds with maturity from 1-year to 10-year is used for the estimation and the construction of Noise. The number of Bonds is the average and median of each day's bonds.

Source: JSDA

Table 5 Descriptive statistics of the yield curve fitting noise

Mean	Median	Max	Min	Std. Dev.	Skewness	Kurtosis	Num of Obs
1.3	1.2	5.5	0.3	0.6	2.2	9.9	3,783

Notes: This table provides descriptive statistics for the noise measure proposed by Hu et al. (2013).

Table 6 Unit root test

ADF	PP	Num of Obs
-3.34	-4.55	3,783
(0.01)	(0.00)	

Notes: This table provides the unit root test results for the noise measure proposed by Hu et al. (2013). The intercept is included in this test. P-values are shown in parentheses.

Table 7 Estimation Results

	coefficient	t-statistics	R ²	Num of Obs
TermPremium	0.452	11.844	0.081	3783
BondVol	27.623	11.807	0.266	3783
StockReturn	-2.060	-1.845	0.002	3783
VIX	0.038	12.126	0.317	3783
Ted Spread	2.895	8.334	0.255	3783
Bond Credit	0.004	1.709	0.012	3783
BidAskSpread	0.549	10.889	0.162	3783
GovGuaranteed	0.132	8.419	0.287	3309

Note: This table show the estimation results. The dependent variable is the yield curve fitting noise. The independent variables are Term Premium, Bond Vol, StockReturn, VIX, Ted Spread, Bond Credit, BidAskSpread, and GovGuaranteed. Term Premium is the spread of 1- and 10-year JGB rates, BondVol is the historical volatility of 5-year JGB yield using a rolling window of 21 business days, StockReturn is TOPIX's return, VXJ is the VIX used, Ted spread is the spread of 3-month LIBOR and 3-month T-bill rate, and Bond Credit is the T-spread of NOMURA Bond Price Index, BidAskSpread is the bid-ask spread of on-the-run JGBs, and GovGuaranteed is the spread of 5-year Japanese government-guaranteed bonds and 5-year JGBs. Also reported are the OLS regression coefficients with Newey–West t-statistics and adjusted R-squared. The data were produced daily from August 2002 to December 2017.

Table 8 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

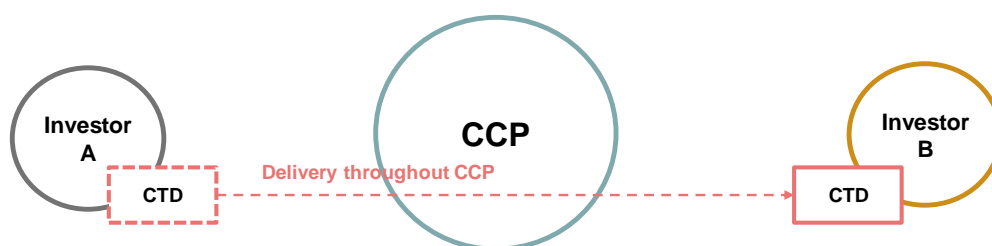
Source: JPX

Table 9 Noise of 6-year sector and 7-year JGB in each year

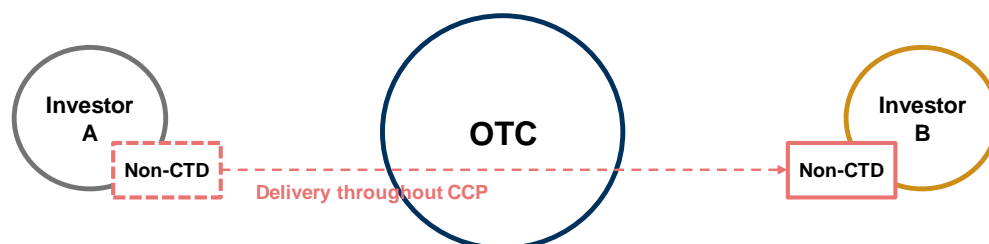
	2006	2007	2008	2009	2010	2011
Comparison between 7-6 year sector						
7-year sector	1.3	1.1	6.6	3.1	0.9	1.0
6-year sector	0.9	0.8	1.5	2.2	1.3	0.8
Difference	0.4	0.3	5.1	1.0	-0.3	0.2
Comparison between 7-8 year sector						
7-year sector	1.3	1.1	6.6	3.1	0.9	1.0
8-year sector	1.3	0.9	2.4	1.1	0.8	1.1
Difference	0.1	0.3	4.2	2.0	0.1	-0.1

Table 10: 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



Note: “CTD” is the Cheapest to Deliver, which has the linkage with 7-year JGB. “Non-CTD” is the JGBs which is not CTD such as 6-year JGBs. CCP stands for central counterparty and OTC is over-the-counter.

Table 11 The result of estimation

	coefficient	t-statistics	R ²	Num of Obs
Delivery	1.441	2.319	0.290	62

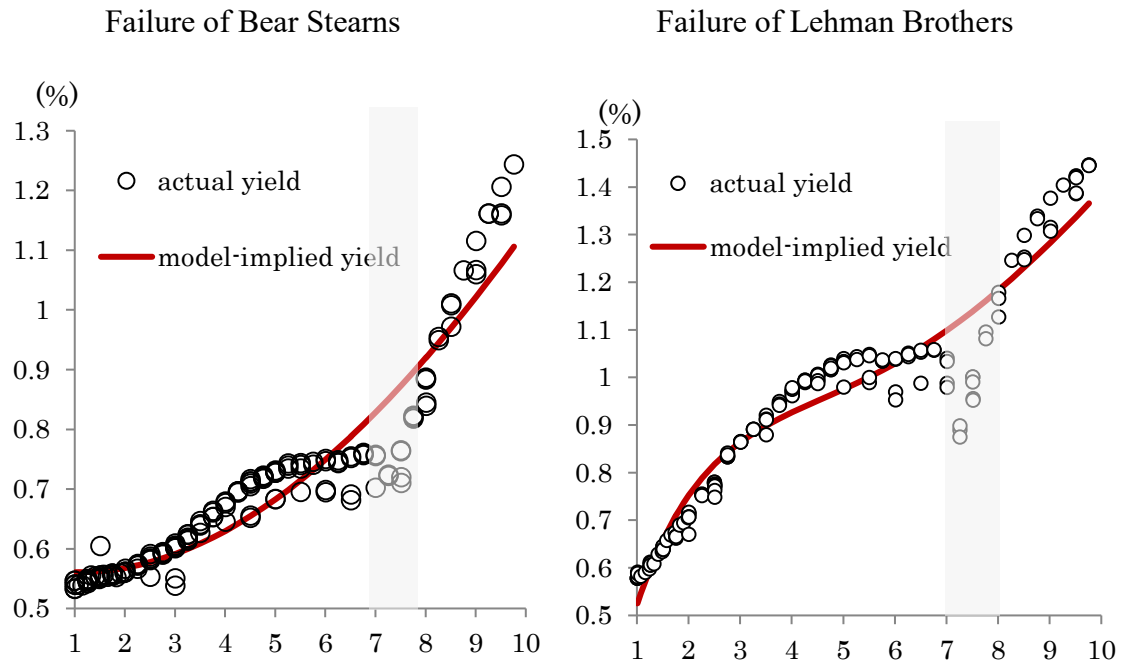
Note: This table shows the estimation results. The dependent variable is the average spread of 6- and 7-year sector noise. The independent variable is the amount of JGBs delivered through JGB futures, constant, and trend. Also reported are the OLS regression coefficients with Newey–West t-statistics and adjusted R-squared. The data were produced daily from August 2002 to December 2017.

Table 12 The results of estimation

	coefficient	t-statistics	R ²	Num of Obs
LIBOR-OIS	7.296	10.222	0.515	3783

Note: This table shows the estimation results. The dependent variable is the spread of 6- and 7-year sector noises. The independent variable is the 3-month LIBOR OIS spread, constant, and trend. Also reported are the OLS regression coefficients with Newey–West t-statistics and adjusted R-squared. The data were produced daily from January 2006 to December 2011.

Figure 1 The term structure of the JGB yield during the financial crisis



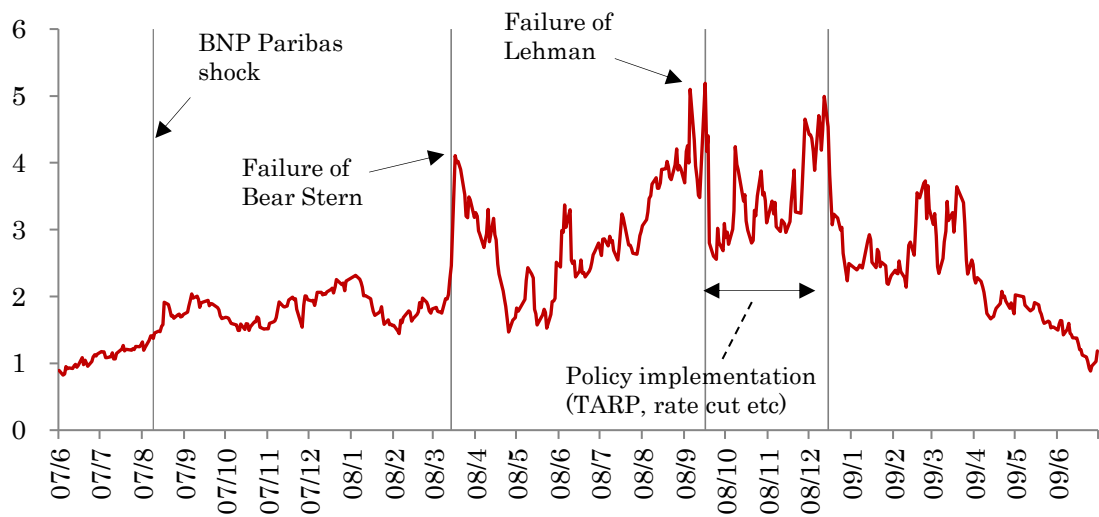
Note: The figure shows the term structure of JGB yields during the financial crisis. The left panel is for March 17, 2008 and the right panel is for September 16, 2008, which is the next business day of the event. The model-implied yield was based on Svensson (1994). The highlighted zone is a 7-year zone (more than 7 and less than 8 years), which is highly connected to JGB futures.

Figure 2 The time series of the yield curve fitting



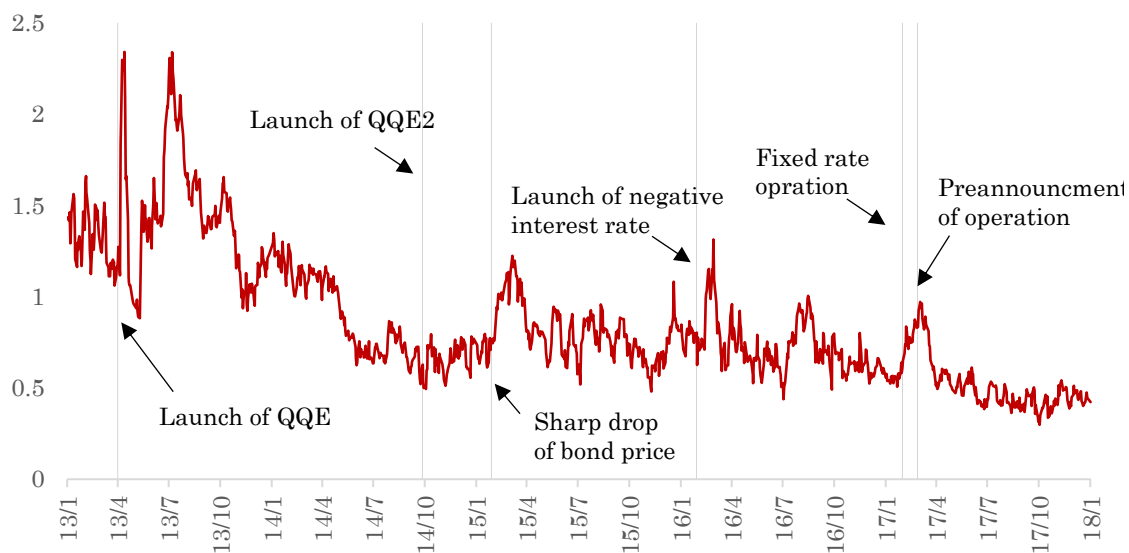
Note: The graph shows the yield curve fitting noise from August 2002 to December 2017.

Figure 3 The time series of the yield curve fitting noise during the financial crisis



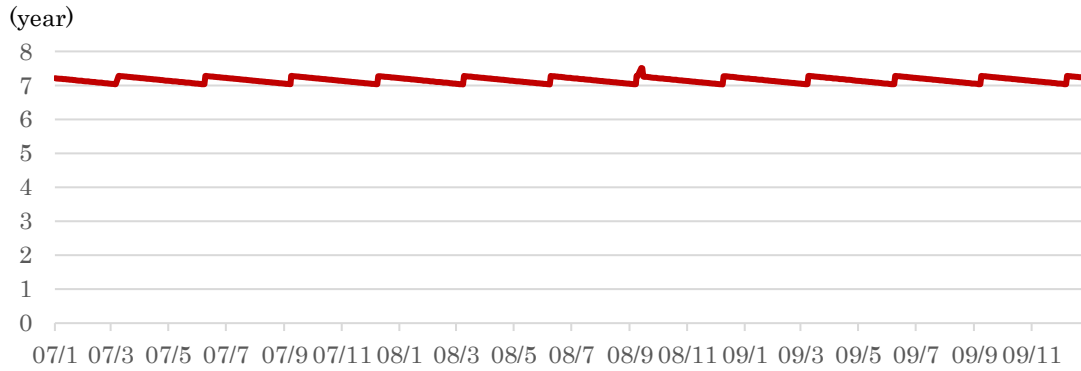
Note: The graph shows the yield curve fitting noise from June 2007 to June 2009.

Table 4 The time series of the yield curve fitting noise after QQE



Note: The graph shows the yield curve fitting noise from January 2013 to December 2017.

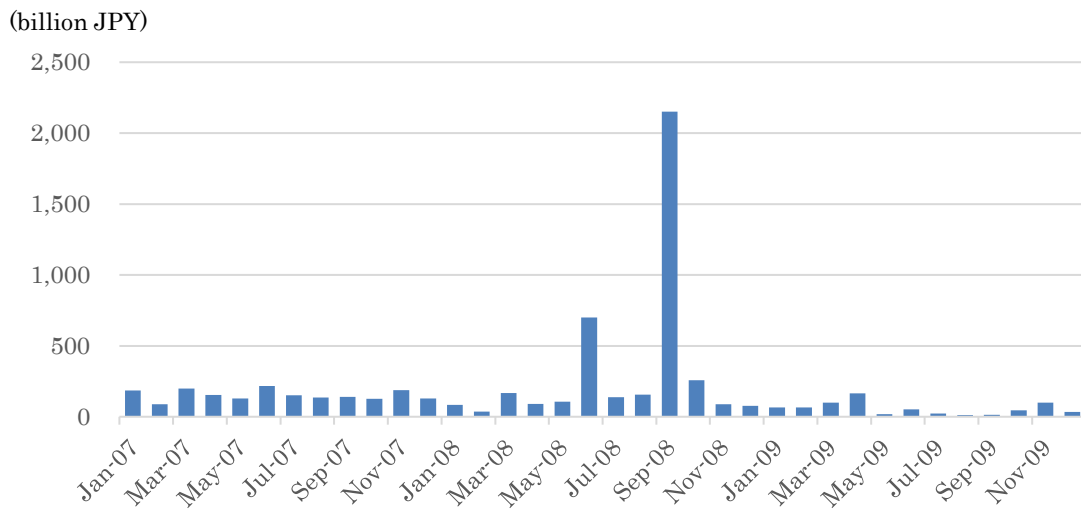
Figure 5 The maturity of Cheapest to Deliver (CTD) in JGB futures from January 2007 to December 2009



Note: 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 6 Settlement Fails in the JGB Market



Source: JSCC

Figure 7 The time series of noise measure: 7-year sector and 6-year sector

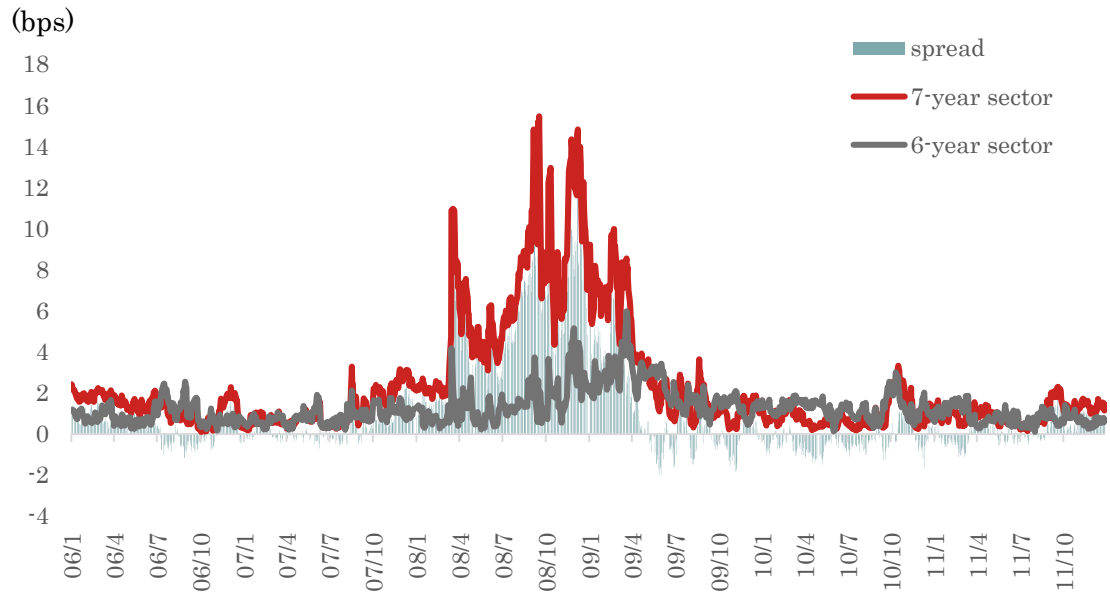


Figure 8 The time series of noise measure: 7-year sector and 8-year sector

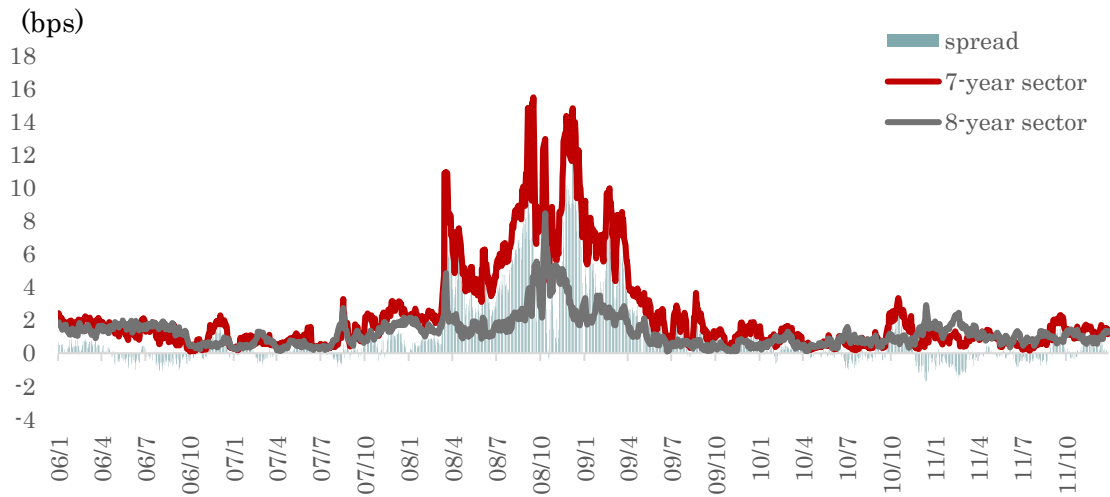
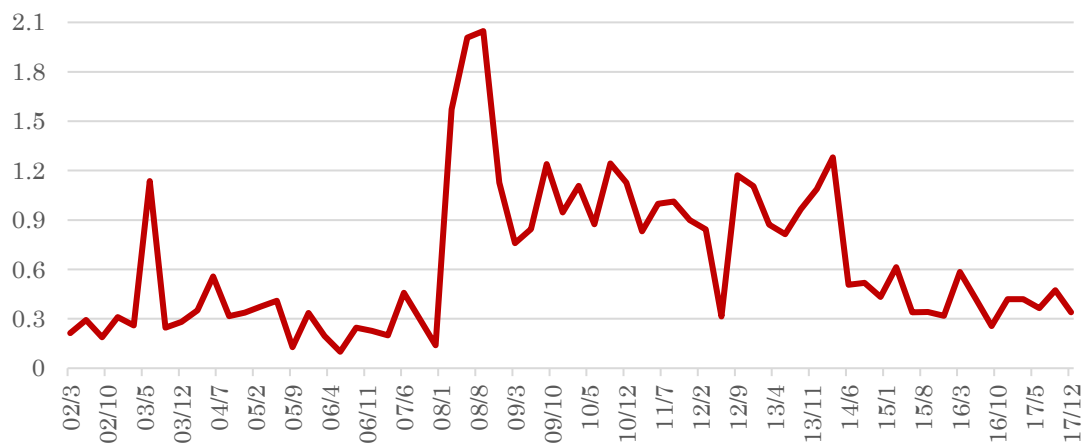


Figure 9 The amount of the JGB delivered through the JSCC

(trillion JPY)



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