

## **Liquidity in Japanese Government Bond Futures Market**

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### **ABSTRACT**

This paper presents an examination of the relations among liquidity, transaction costs and risk and an investigation of macroeconomic indicator announcements effects on liquidity in the Japanese Government Bond (JGB) Futures market of the Tokyo Stock Exchange (TSE). Results reveal that increased volatility enlarges ILLIQ, a liquidity index. Results show that liquidity falls when risk increases in the JGB Futures market. Moreover, ILLIQ increases as the effective half spread (EHS), representing transaction costs, widens. These results suggest that the liquidity falls when transaction costs become large. Finally, results of macroeconomic indicator announcements significantly affect liquidity. ILLIQ decreases along with announcements of macroeconomic indicators. These results indicate the possibility that liquidity increases in the JGB Futures market because of macroeconomic indicator announcements.

*JEL Classifications:* G14, G12

*Key words:* liquidity; transaction costs; risk; macroeconomic announcements

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## I. INTRODUCTION

This paper presents an examination of the relation of liquidity, transaction costs, and risk, and describes an investigation of macroeconomic indicator announcement effects on liquidity in the Japanese Government Bond (JGB) Futures market of the Tokyo Stock Exchange (TSE).

Currently, JGB amounts are reaching 789 trillion yen as of the end of FY2011. If Financing Bills and Borrowings are included, then the government's fund-raising debt has reached 960 trillion yen (Debt Management Report 2012, Financial Bureau, Ministry of Finance). Government debt is 55.6 trillion in FY2002. It is 703 trillion, given the addition of Financing Bills and Borrowings to that total. In addition, an increase of approximately 260 trillion has taken place over the past 10 years. Because of the great amounts of issuance of JGB, JGB prices have become unstable, and the evaluation of Japan's financial markets has fallen. Taken together, these factors might exert a major impact on the Japanese economy.

To date, many studies related to liquidity research have been described in the literature. Market liquidity is high, which means that an investor's market participation is easy. When liquidity is low, it is difficult for an investor to undertake market participation<sup>1</sup>. Research in this field has progressed briskly since that of Kyle (1985). The study of latent liquidity is one example. Mahanti and et al. (2008) estimated the latent liquidity of corporate bonds as the weighted average efficiency of the investment horizon of a corporate bond holder, and reported that strong correlation exists between latent liquidity and transaction costs, and the bid-ask spread. Moreover, ILLIQ, explained by Amihud (2002) and used for this study, is investigated frequently.

This paper presents clarification also of the relation between liquidity and transaction costs. Liquidity and risk can be verified. When risk is low, an investor tends to participate in the market. Herein, risk is measured as the transitory volatility (Ranaldo (2004)). The effective half spread (EHS) is used as a proxy variable for transaction costs in this paper. Market participation can be regarded as easy when EHS is small.

Another purpose of this paper is to clarify the relation between liquidity and the announcements of macroeconomic indicators. This paper presents an investigation of whether liquidity changes on event days when macroeconomic indicators are announced in the JGB Futures market of the TSE. To date, many studies have verified the announcement effects, specifically examining the effects on volatility. They analyze market efficiency. For example, Arshanapalli et al. (2006), Wang, Wang, and Liu (2005), and Ederington and Lee (2001) investigated whether a difference would have occurred in return volatility when macroeconomic indicators are announced. However, these studies analyze market other than JGB. This paper is focused on JGB Futures in TSE and clarifies the mutual relation of macroeconomic indicator announcements, liquidity, transaction costs, and risk.

Consequently, the following relations can be shown: relations between liquidity, transaction costs, and risk in the JGB Futures market. An investigation of the relation between liquidity and risk reveals that an increase of volatility enlarges the ILLIQ, which is a liquidity index. The liquidity in the market falls when risk increases. Moreover, the ILLIQ becomes large as the EHS becomes large, when the liquidity and transaction costs are investigated. Regarding this, when transaction costs increase,

liquidity in the market falls.

Furthermore, results show significant effects of macroeconomic indicator announcements on liquidity. In fact, ILLIQ decreases along with macroeconomic indicator announcements. These results show that liquidity increases in the JGB Futures market.

Even using volatility, EHS, and macroeconomic indicator announcements simultaneously in the model, the result was confirmed to have consistency with other models.

This paper proceeds as follows. Section II explains liquidity measurements and other variables used for this study. Section III presents models of the empirical framework used for this study. Section IV explains the samples used for analyses and the microstructure of the JGB Futures market. Section V presents empirical results. Finally, Section VI concludes this study.

## II. MEASUREMENTS OF LIQUIDITY AND OTHER VARIABLES

### A. Liquidity

Many previous reports have described the concept of liquidity and measurements of it in securities market<sup>2</sup>. Therefore, in this paper, the liquidity index (ILLIQ) proposed by Amihud (2002) is used. The ILLIQ advocated by Amihud is a liquidity index showing the influence (Price impact), that it has on the stock price per trading value unit. This price impact becomes small as liquidity increases.

The value of ILLIQ used in this paper is the average value per day. The absolute value of a return per minute is divided by the volume at the interval. This also expresses the rate of change of the market price to volume of JGB Futures. In other words, the ILLIQ computed using the following formula will be so small that the price impact is small. A small ILLIQ value signifies that market liquidity is high.

Liquidity measure: ILLIQ<sub>t</sub>

$$ILLIQ_t = \frac{1}{I} \sum_{i=1}^I \frac{|R_{t,i,j}|}{Volume_{t,i,j}}$$

In that equation,  $R_{t,i,j}$ :  $j$  represents the  $j^{\text{th}}$  day in the sample period;  $i$  denotes the  $i^{\text{th}}$  data on the  $j^{\text{th}}$  day;  $t$  signifies the  $t^{\text{th}}$  sample in all numbers of samples. Therefore,  $R_{t,i,j}$  expresses the return of the JGB Futures price of the  $t^{\text{th}}$  interval in all numbers of samples.  $Volume_{t,i,j}$  expresses the  $t^{\text{th}}$  volume in all numbers of samples.

### B. Transaction Costs

O'Hara (1995) defines liquidity as follows. The state of liquidity is high when trading can be conducted with minimum cost. The minimum cost means that a bid-ask spread is extremely narrow. Furthermore, minimum cost means that volatility is low. Usually a bid-ask spread is defined by the difference of the bid-price and ask-price.

In terms of the market microstructure, the bid-ask spread is interpreted as an

investor's transaction costs. If the spread widens, the transaction costs become large. In contrast, concomitantly with the spread narrowing, transaction costs become small.

As described above, the transaction cost is usually measured using a bid-ask spread. However, when the measure is used, the transaction costs of the investor who orders the bid and those of the investor who orders the ask are calculated twice, as a "round-trip transaction". Therefore, in this paper, the effective half spread (EHS) is adopted. The following EHS is used<sup>3</sup>:

Transaction cost measure: effective half spread (EHS<sub>t</sub>)

$$\begin{aligned} \text{EHS}_t &= |P_t - Q_t| \\ Q_t &= (a_t + b_t) / 2 \end{aligned}$$

Therein,  $P_t$  expresses a contracted price,  $Q_t$  signifies a middle quote,  $a_t$  denotes the ask-price, and  $b_t$  stands for the bid-price.

### C. Risk

Volatility, a risk index of dealings, is measured by the standard deviation of returns. A risk-averse investor might like to conduct dealings at trading hours when volatility is low. Liquidity is low at the time when volatility increases and liquidity is high at the time when volatility decreases.

As described in this paper, the transitory volatility described by Rinaldo (2004) is used. Rinaldo calculates the standard deviation for the  $t$ -interval using the 20-lag return. Then he uses those as a representation of volatility ( $\text{Vola}_t$ ). This paper adopts the same representation<sup>4</sup>.

### D. Macroeconomic Indicator Announcements

This paper presents consideration of 12 different macroeconomic indicator announcements that provide a characterization of the macroeconomic. Macroeconomic indicator announcements are the following: Bank of Japan's Quarterly Economic Survey (Tankan), Consumer Price Index (CPI), Corporate Goods Price Index (CGPI), Family Income and Expenditure Survey, GDP, Industrial Produce Index (IIP), Machinery Orders, Money Supply, New Residence Starts (New Dwellings Started), Trade Balance (Trade Statistic), Trade Payment, and Unemployment Rate.

This study's sample period has 244 transaction business days. There are 77 days on which macroeconomic indicators were announced. Table 1 presents the statistics related to respective variables.

## III. MODELS

As described in this paper, the relations of liquidity, transaction costs, and risk are verified. This paper clarifies the respective relations of the ILLIQ, EHS, and volatility. This section explains each variable and the models used for this study.

The validation methodology of the relations among the liquidity, transaction costs, risk and the event effect is explained. This paper clarifies the following hypotheses.

**Table 1**  
Statistics of respective variables

Series	Mean	Std. Error	Minimum	Maximum
ILLIQ	0.000031	0.000021	0.000005	0.000145
VOLA20	0.000109	0.000111	0	0.002192
EHS	0.607560	0.346371	0	5
MEA	0.311475	0.463099	0	1

Note. MEA represents a dummy variable that takes 1 on announcement day and takes 0 on others.

### HYPOTHESIS 1

H1: Risk (transitory volatility) decreases liquidity. An increase of volatility enlarges ILLIQ.

$$\text{ILLIQ}_t = a_0 + a_1 \text{Vola}_t + e_t \quad (\text{Model 1})$$

As described herein, because risk increases as volatility increases, the liquidity is considered to become low. Increased volatility can be expected to enlarge the value of ILLIQ.

### HYPOTHESIS 2

H2: Transaction costs (EHS) decrease liquidity. ILLIQ increases as EHS becomes large.

$$\text{ILLIQ}_t = b_0 + b_1 \text{EHS}_t + e_t \quad (\text{Model 2})$$

Liquidity becomes low as EHS becomes large. For that reason, as transaction cost becomes large, liquidity becomes low. If EHS becomes large, then ILLIQ can be expected to take a large value.

### HYPOTHESIS 3

H3: Macroeconomic indicator announcements decrease or increase liquidity.

$$\text{ILLIQ}_t = c_0 + c_1 \text{MEA}_t + e_t \quad (\text{Model 3})$$

Therein,  $\text{MEA}_t$  represents a dummy variable, which takes 1 on announcement day and takes 0 on others. It is considered that the liquidity becomes low or high when macroeconomic indicators are announced. If the announcement is a surprise one for investors, then liquidity might be low. The investors' expectation was out. Therefore, the risk is becoming high. However, if the announcement is not a surprise, then liquidity might be high. The investors' expectation is fulfilled. Therefore, the risk becomes low.

**HYPOTHESIS 4**

H4: Risk (transitory volatility) reduces liquidity even if it is considered that the macroeconomic indicator announcements affect the model simultaneously.

$$\text{ILLIQ}_t = d_0 + d_1 \text{Vola}_t + d_2 \text{MEA}_t + e_t \quad (\text{Model 4})$$

This model is obtained by adding the announcement effects to model 1.

**HYPOTHESIS 5**

H5: Transaction costs (EHS) reduce liquidity, even if macroeconomic indicator announcement effects are considered in the model simultaneously.

$$\text{ILLIQ}_t = f_0 + f_1 \text{EHS}_t + f_2 \text{MEA}_t + e_t \quad (\text{Model 5})$$

This model is obtained by adding the announcement effects to model 2.

**HYPOTHESIS 6**

H6: Risk (transitory volatility) reduces liquidity. An increase of volatility enlarges ILLIQ, even if EHS is considered in the model simultaneously.

$$\text{ILLIQ}_t = g_0 + g_1 \text{Vola}_t + g_2 \text{EHS}_t + e_t \quad (\text{Model 6})$$

Although volatility and EHS are used simultaneously in this model, it can be confirmed whether the result has consistency among various cases.

**HYPOTHESIS 7**

H7: Risk (transitory volatility) decreases liquidity. An increase of volatility enlarges ILLIQ, even if EHS and MEA are considered in the model simultaneously.

$$\text{ILLIQ}_t = h_0 + h_1 \text{Vola}_t + h_2 \text{EHS}_t + h_3 \text{MEA}_t + e_t \quad (\text{Model 7})$$

Although volatility, EHS, and macroeconomic indicator announcement effects are used simultaneously in this model, it can be confirmed whether the result has consistency among various cases or not.

The expected sign conditions of the coefficients of the models 1–7 are presented in Table 2.

**Table 2**  
Expected sign conditions of the coefficient of variables

	$a_1$	$b_1$	$c_1$	$d_1$	$d_2$	$f_1$	$f_2$	$g_1$	$g_2$	$h_1$	$h_2$	$h_3$
Model 1	+											
Model 2		+										
Model 3			$\pm$									
Model 4				+	$\pm$							
Model 5						+	$\pm$					
Model 6								+	+			
Model 7										+	+	$\pm$

#### IV. DATA SAMPLE AND MICROSTRUCTURE OF THE JGB FUTURES MARKET

##### A. Data Sample

The sample period used for this study is April 2, 2003 – March 31, 2004. The transactions business days in this sample period constitute 244 days. JGB Futures data samples were extracted from "Nikkei NEEDS" (Tick Saiken Sakimono Option). This paper creates sample data for the contract price, volume, and quote price in units of 1 minute.

When a deal is not established during a certain interval and the contracted price is not marked to book, the contracted price in 1-lag of the interval is used. When the data sample is created for each minute through following three transaction sessions, they include 417 samples in a single day. The total number of samples is 101,748.

##### B. Market Microstructure of JGB Futures

The JGB Futures market has three trading sessions: the morning session, 9:00–11:00 a.m.; the afternoon session, 12:30–15:00 p.m.; and the evening session, 15:30–18:00 p.m.

Moreover, JGB Futures trading has adopted two matching methods, known as "ITAYOSE<sup>5</sup>" and "ZARABA<sup>6</sup>". Only intraday trading (ZARABA) data are used for this study, thereby removing the influence of the high volume that occurs by ITAYOSE. Furthermore, ITAYOSE might not necessarily be conducted. For this study, the following data are removed: 9:00, 11:00, 12:00, 12:30, 15:00, 15:30, and 18:00. Then, this paper uses data in the morning session (9:01–10:59 a.m.) and afternoon session (12:31–14:59 p.m.) and the evening session (15:31–17:59 p.m.)

#### V. EMPIRICAL RESULTS

This paper verifies the liquidity of JGB Futures in TSE with the seven models. The results are presented in this section.

### A. Liquidity and Risk: Model 1

The model 1 hypothesis is the following: Volatility decreases liquidity. An increase of volatility makes the ILLIQ value larger.

Table 3 shows that the coefficient of volatility is positive and significantly so. The increase of volatility increases ILLIQ. This result demonstrates that the liquidity becomes lower as risk increases. As described previously in this paper, risk increases as volatility increases, and liquidity is regarded as becoming lower.

**Table 3**  
Result of model 1

Dependent Variable ILLIQ		
Variable	Coefficients	t-Statistics
1. Constant	2.05E-05*	260.015
2. Vola 20	0.097*	190.373
Adj. $R^2$	0.263	
Durbin–Watson	0.014	

Note: \*denotes significance at 1%

### B. Liquidity and Transaction Costs: Model 2

The model 2 hypothesis is the following: an increase of transaction costs decreases liquidity. The ILLIQ increases as the EHS becomes large.

Consequently, Table 4 shows that the coefficient of the EHS is positive and significantly so. As described previously in this paper, when the EHS becomes large, the ILLIQ can be expected to become a larger value. It shows that liquidity becomes lower as the EHS becomes large. This result shows that liquidity becomes lower as transaction costs become large.

**Table 4**  
Result of model 2

Dependent Variable ILLIQ		
Variable	Coefficients	t-Statistics
1. Constant	1.99E-05*	157.985
2. EHS	1.82E-05*	100.811
Adj. $R^2$	0.091	
Durbin–Watson	0.099	

Note: \*denotes significance at 1%

### C. Liquidity and Macroeconomic Indicator Announcements: Model 3

The model 3 hypothesis is the following: Macroeconomic indicator announcements decrease or increase liquidity.

Results show that the liquidity becomes high when macroeconomic indicators are announced. From Table 5, this is shown significantly. The macroeconomic indicator announcements are no surprise. Therefore, it is considered that the liquidity becomes high. In other words, because it was reasonable to expect investors, then the risk is lowered.

**Table 5**  
Result of model 3

Dependent Variable ILLIQ		
Variable	Coefficients	t-Statistics
1. Constant	3.13E-05*	396.433
2. MEA	-1.02E-06*	-7.239
Adj. $R^2$	0.001	
Durbin-Watson	0.000	

Note: \*denotes significance at 1%

#### D. Liquidity, Risk and Macroeconomic Indicator Announcements: Model 4

The model 4 hypothesis is the following: Risk reduces the liquidity, even if the macroeconomic indicator announcements effects are considered in the model simultaneously.

Consequently, Table 6 shows that the coefficient of volatility is positive and significant, as in Model 1. The increased volatility raises the value of ILLIQ. This result demonstrates that liquidity becomes lower as the risk increases. Moreover, the liquidity is considered to become high when macroeconomic indicators are announced, as in Model 3. These results are consistent among models.

**Table 6**  
Result of model 4

Dependent Variable ILLIQ		
Variable	Coefficients	t-Statistics
1. Constant	2.02E-05*	152.034
2. EHS	1.82E-05*	100.803
3. MEA	-9.65E-07*	-7.149
Adj. $R^2$	0.091	
Durbin-Watson	0.099	

Note: \*denotes significance at 1%

#### E. Liquidity, Transaction Costs and Macroeconomic Indicator Announcements: Model 5

The model 5 hypothesis is the following: Transaction costs reduce liquidity, even if macroeconomic indicator announcement effects are considered simultaneously in the model.

Consequently, Table 7 shows that the coefficient of EHS is positive and significant as in Model 2. When EHS becomes large, ILLIQ can be expected to become a larger value, even if the model controlled the announcement effects simultaneously. This result shows that the liquidity becomes lower as transaction costs become large. Moreover, it is considered that as liquidity becomes high when macroeconomic indicators are announced as in Model 3. These results are consistent among models.

**Table 7**  
Result of model 5  
Dependent Variable ILLIQ

Variable	Coefficients	t-Statistics
1. Constant	2.08E-05*	238.617
2. Vola 20	0.097*	190.480
3. MEA	-1.11E-06*	-9.103
Adj. $R^2$	0.263	
Durbin-Watson	0.014	

Note: \*denotes significance at 1%

#### F. Liquidity, Risk and Transaction Costs: Model 6

The model 6 hypothesis is the following: increased volatility reduces liquidity. An increase of volatility enlarges ILLIQ, even if EHS is considered simultaneously in the model.

Although volatility and EHS are used simultaneously in this model, the question of whether the result has consistency can be settled using model 1 and model 2.

Table 8 shows that the result has consistency with other results of model 1 (Table 3) and model 2 (Table 4). The coefficient of volatility is positive and significant. Results show that ILLIQ becomes larger as volatility increases. Therefore, liquidity becomes lower. Moreover, the EHS coefficient is positive and significant. ILLIQ becomes larger as EHS widens, so liquidity will decrease.

**Table 8**  
Result of model 6  
Dependent Variable ILLIQ

Variable	Coefficients	t-Statistics
1. Constant	1.34E-05*	115.546
2. Vola 20	0.089*	178.318
3. EHS	1.30E-05*	80.984
Adj. $R^2$	0.307	
Durbin-Watson	0.080	

Note: \*denotes significance at 1%

#### G. Liquidity, Risk, Transaction Costs and Macroeconomic Indicator Announcements: Model 7

The model 7 hypothesis is the following: an increase of volatility increases ILLIQ, even if EHS and MEA are considered in the model simultaneously. Although volatility, EHS and macroeconomic indicator announcement effects are used simultaneously in this model, the question of whether the result has consistency can be confirmed using model 6.

Table 9 shows that the result has consistency with results of model 6 (Table 8). The coefficient of volatility is positive and significant. Results show that ILLIQ becomes larger as volatility increases, so liquidity becomes lower. Moreover, the

coefficient of the EHS is positive and significant. Actually, ILLIQ becomes larger as EHS widens, so liquidity will decrease. Finally, the coefficient of the MEA is negative and significant. ILLIQ becomes smaller when macroeconomic indicators are announced, so liquidity will increase. These results are consistent among models.

**Table 9**  
Result of model 7

Dependent Variable ILLIQ		
Variable	Coefficients	t-Statistics
1. Constant	1.37E-05*	112.867
2. Vola 20	0.089*	178.425
3. EHS	1.30E-05*	80.968
4. MEA	-1.06E-06*	-8.976
Adj. $R^2$	0.308	
Durbin-Watson	0.080	

Note: \*denotes significance at 1%

## VI. CONCLUSION

This paper presented an examination of the relation of liquidity, transaction costs, and risk and an investigation the macroeconomic indicator announcements affect liquidity in the JGB Futures market of the TSE.

Consequently, results revealed the following relations, which are relations among liquidity, transaction costs, and risk in the JGB Futures market. An investigation of the relation between liquidity and risk revealed that increased volatility enlarges ILLIQ. Liquidity in the market falls when risk increases. Moreover, ILLIQ becomes large as EHS becomes larger, when liquidity and transaction costs are investigated. Regarding this, when transaction costs increase, liquidity in the market falls.

Furthermore, macroeconomic indicator announcements affect liquidity, as shown by significance in all models used for this study. ILLIQ decreases along with macroeconomic indicator announcements. These results underscore the possibility that liquidity might increase in the JGB Futures market by macroeconomic indicator announcements.

Even if volatility, EHS, and macroeconomic indicator announcements are used simultaneously in the model, the result was confirmed to be consistent with those of other models.

## ENDNOTES

1. The liquidity definition is checked again here. As O'Hara (1995) shows, the state in which trade can be conducted at the minimum cost is a high-liquidity state. Transaction costs become small, and liquidity will improve.
2. For instance, Garman (1976), Copeland and Galai (1983), Glosten and Milgrom (1985), Easley and O'Hara (1987), Amihud and Mendelson (1987, 1991a,b), Admati and Pfleiderer (1988), Subrahmanyam (1991), Stoll and Whaley (1990),

- and Huang and Stoll (1994, 1996), and Mahanti et al. (2008).
3. Effective Spread was also used for this study. The results were the same. This paper therefore omits those analyses.
  4. To check robustness, the volatility of lag of 10 terms, 30 terms, and 50 terms is also calculated and analyzed in this paper. These results were the same. Therefore, this paper omits them.
  5. The Itayose is used mainly to determine the opening and closing prices of each trading session. The method is used when the market opens and when the market closes. YORITUKI and HIKE (a total of six times) in the morning session (9:00, 11:00), afternoon session (12:30, 15:00) and evening session (15:30, 18:00) have adopted ITAYOSE. At the opening, all quotes (orders) before the contract price are recorded in the order book. They are regarded as simultaneous orders. Each is matched from the highest price order with a high priority level (price priority principle). Moreover, prices that match quantitatively are decided. The chosen price is assumed to be a single contract price. The bargain (transaction) is concluded with the decided price.
  6. The Zaraba method is used during trading sessions to match orders continuously underprice priority and time-precedence principles. This is a method used during transaction times other than opening or closing. After the opening price is decided, this Zaraba method is used until the closing price is decided. Each contract is concluded individually on a first-come-first-served basis during the transaction session; many contract prices are decided continuously.

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