Liquidity, Transaction Costs and Risk in JGB Futures Market

皆　木　健　男

Liquidity, Transaction Costs and Risk in JGB Futures Market

Takeo MINAKI[1]

Contents
1．Introduction
2．Measurements of Liquidity and Other Variables
3．Models
4．Data and Microstructure of the JGB Futures Market
5．Empirical Results
6．Conclusion

1．Introduction

This paper presents an examination of that relation of liquidity, transaction costs and risk in the Japanese Government Bond （JGB） Futures market of the Tokyo Stock Exchange （TSE）.

Until now, many studies related to liquidity research have been described in the literature. Research in this field has progressed briskly since Kyle （1985）. The study of latent liquidity is one example. Mahanti and et al. （2008） estimated latent liquidity of corporate bonds as the weighted average efficiency of the investment horizon of a corporate bond holder, and reported that correlation exists that is strong between latent liquidity and transaction cost, or and Spread. Moreover, ILLIQ of Amihud （2002） used for this study is one which are researched briskly. The liquidity in the market is high, which means that an investor's market participation is easy. When liquidity is low, it will be difficult for an investor to carry out market participation. Then, 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.

This paper presents clarification also of the relation between liquidity and transaction costs. An Effective Spread is used as a proxy variable of transaction costs in this paper. It can be said that market participation is easy when a Spread is small. Furthermore, liquidity and risk can be verified. When risk is small, an investor tends to participate in the market. In this paper, risk is measured as the transitory volatility （Ranaldo （2004））.

Another purpose of this paper is to clarify liquidity and the announcement of macro-economic indicators. To date, many studies have verified the announcement effect, specifically examining 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. This paper clarifies the mutual relation of macroeconomic indicator announcement, liquidity, and volatility.

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 increased volatility increases ILLIQ, which is a liquidity index. Liquidity in the market falls when risk increases. Moreover, ILLIQ becomes large as Spreads become large, when liquidity and transaction costs are investigated. Regarding this, when transaction costs increase, liquidity in the market falls. Finally, Spreads become large as volatility increases, when transaction costs and risk are investigated. Effective half Spreads and effective Spreads show the same result. When risk increases, transaction costs go up.

This paper proceeds as follows. Section 2 explains liquidity measurements and other variables used for this study. Section 3 presents models of the empirical framework used for this study. Section 4 explains the data used for analyses and the microstructure of the JGB futures market. Section 5 presents empirical results. Finally, Section 6 concludes this study.

2．Measurements of Liquidity and Other Variables

Liquidity

Many previous studies have described the concept of liquidity and measurements of that in securities market[2]. 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.

ILLIQ in this paper is the averaged 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: ILLIQ computed by the following formula will be so small that the price impact is small. A small ILLIQ signifies that market liquidity is high.

Liquidity measure: ILLIQt

$$ILLIQ_t = \frac{1}{417} \sum_{J=1}^{417} \frac{|R_{t,j}|}{Volume_{t,j}}$$

Rt,j: *j* expresses the one-day data total; *t* expresses the *t*-th in *j*. Therefore, *Rt,j* expresses the return of the JGB futures price of the *t*-th interval in *j*. *Volume t,j*: this expresses the *t*-th Volume in *j* data.

Transaction Costs

O'Hara (1995) defines liquidity as follows. The state in Liquidity is high when trading can be conducted with minimum costs. The minimum costs mean that Spreads are narrow. Furthermore, minimum cost means that volatility is low. Usually Spreads are defined by the difference of the bid-price and ask-price. The following Effective Spread is used for this study[3].

Effective Spread　(St)

$$S_t = |P_t - Q_t| \times 2$$
$$Q_t = (a_t + b_t)/2$$

Therein, St represents an Effective Spread, Pt expresses a contracted price, Qt signifies a middle quote, at denotes Ask-Price, and bt stands for the bid-price. Moreover, in terms of market microstructure, a Spread is interpreted as an investor's transaction cost. The Spread widens, which means that transaction costs become large. In contrast, concomitantly with the Spread narrowing, transaction costs become small.

The reason why Spreads are transaction costs is the following. The investor considers the possibility of dealing with an investor who has information (An information trader, an informed trader), when placing an order (bid-price or ask-price). Therefore, when issuing a selling order, an investor considers the possibility that the information trader will have better information and will take out the limit order at a lower price. Then, if an investor does not take out a limit order at an even lower price, then he cannot trade. Conversely, an investor taking out a buy order can be considered. Because it becomes impossible to trade when an information trader places an order for a higher price, an investor will take out a limit order exceeding it. As described above, a liquidity trader will place an order high (at buying order) or low (at selling order) rather than the price that is being considered. Therefore, Spreads will widen, imposing higher transaction costs.

Transitory Volatility

Volatility, a risk index of dealings, is measured by the standard deviation of returns. If an investor is risk-averse she might like to perform 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. In this paper, the transitory volatility described by Ranaldo (2004) is used . In Ranaldo, the standard deviation is calculated at t-interval using the 20-lag return. Then he uses those as a representation of volatility (*Volat*). This paper adopts the same representation[4].

3．Models

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

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

Hypothesis 1
NH 1: Volatility (transitory volatility) improves liquidity. Increased volatility decreases the liquidity index (ILLIQ).

Model 1

$$ILLIQ_t = a_0 + a_1 Vola_t + e_t$$

As described in this paper, because a risk increases as volatility increases, it is considered that liquidity becomes small: any increase of volatility can be expected to increase ILLIQ.

Hypothesis 2
NH 2: Transaction costs (Spreads) improve liquidity. ILLIQ decreases as Spreads become large.

Model 2

$$ILLIQ_t = b_0 + b_1 S_t + e_t$$

As described in this paper, it is considered that liquidity becomes small as Spreads become large: Spreads will become large; for that reason, liquidity becomes small. If Spreads become large, then ILLIQ can be expected to take a large value.

Hypothesis 3
NH 3: Volatility (transitory volatility) reduces transaction costs (Spreads). Spreads become narrow as volatility increases.

Model 3

$$S_t = c_0 + c_1 Vola_t + e_t$$

As described in this paper, if volatility increases and risk increases, then it is considered that transaction costs become large. If volatility increases, then the Spread can be expected to widen.

Model 4

Robustness Check

$$ILLIQ_t = d_0 + d_1 Vola_t + d_2 S_t + e_t$$

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

Expected Sign Conditions in Relations of Variables

The expected signs of coefficients of models 1–4 are positive, as presented in Table 1.

Table 1. Expected sign conditions in relations of variables

	a_1	b_1	c_1	d_1	d_2
Model 1	+				
Model 2		+			
Model 3			+		
Model 4				+	+

4. Data and Microstructure of the JGB Futures Market

Sample Period

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.

Trading Hours of Data Used for This Study

When the data sample is created for each minute through following three transaction sessions, they will include 417 samples in a single day: morning session, 9:01 a.m. – 10:59 a.m.; afternoon session, 12:31 p.m. – 14:59 p.m.; and evening session, 15:31 p.m. – 17:59 p.m.

There are 244 transactions business days in this study's sample period. The total number of samples is 101,748. Table 2 presents statistics related to each variable.

Table 2. Statistics of respective variables

	ILLIQ	Effective half Spread	Effective Spread	Vola__20
Average	3.1E-05	0.614	1.229	0.000
Standard deviation	2.09E-05	0.505	1.010	0.000
Variance	4.37E-10	0.255	1.020	1.232E-08
Kurtosis	3.524	2009.8	2009.8	48.03
Skewness	1.543	30.75	30.75	4.795
Minimum	4.89E-06	0	0	0
Maximum	0.0001	47.5	95	0.002
Total number of samples	101748	101748	101748	101748

Market Microstructure of JGB Futures

JGB futures data 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 min. When a deal not established during a certain interval and the contracted price is not indicated to book, the contracted price in 1-lag of the interval is used. The JGB futures market has three trading sessions: morning session, 9:00 a.m. – 11:00 a.m.; afternoon session, 12:30 p.m. – 15:00 p.m.; and evening session, 15:30 p.m. – 18:00 p.m.

Moreover, JGB futures trading has adopted two matching methods, known as "ITAYOSE[5]" and "ZARABA[6]". Only the data of intraday trading（ZARABA）are used for this study, thereby removing the influence of the high volume that occurs by ITAYOSE. However, in data of the next intervals, 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 the data in 9:01 a.m. – 10:59 a.m. and 12:31 p.m. – 14:59 p.m. and 15:31 p.m. – 17:59 p.m.

5．Empirical Results

Results of the Relations of Liquidity, Transaction Costs, and Risk

ILLIQ and Risk（Volatility）, Hypothesis 1
NH 1: Volatility（transitory volatility）improves liquidity. Increased volatility makes the liquidity index（ILLIQ）small.

As described in this paper, risk increases as volatility increases, and liquidity is considered to become small: the increase of volatility is expected to increase ILLIQ.

Consequently, Table 3 shows that the coefficient of volatility is positive and significantly so. The increase of volatility increases the ILLIQ. This result demonstrates that liquidity becomes small as risk increases.

Table 3. Model 1 $\quad ILLIQ_t = a_0 + a_1 Vola_t + e_t$

Explained variable, ILLIQ ;

Explanatory variable, Vola_20

	coefficient	Std	P-value
a_0	$2.049\,E{-}05$***	$7.881\,E{-}08$	0
Vola_20	0.097***	0.005	0
Adjusted R^2	0.263		
Total number of samples	101748		

*** is significant at 1% significance level. The number of observations is 101,331. It is impossible to use single-day data（417）to produce a first-order regression model.

ILLIQ and Transaction Costs (Spreads), Hypothesis 2

NH 2: Transaction costs (Spreads) improve liquidity. ILLIQ decreases as Spreads become large.

As described in this paper, liquidity is considered to decrease as Spreads become large: Spreads will become large, and liquidity becomes small. When Spreads become large, ILLIQ can be expected to become a larger value.

Consequently, Table 4 and Table 5 show that the coefficients of Spreads (Effective half Spread and Effective Spread) are positive and significantly so. They show that liquidity becomes small as Spreads become large. This result shows that liquidity becomes small as transaction costs become large.

Table 4. Model 2 $\quad\quad ILLIQ_t = b_0 + b_1 S_t + e_t$

Explained variable, ILLIQ ;

Explanatory variable, Effective half Spread

	coefficient	Std	P - value
b_0	2.546 E -05***	1.008 E -07	0
Effective half Spread	8.998 E -06***	1.267 E -07	0
Adjusted R^2	0.047		
Total number of samples	101748		

*** is significant at 1% significance level. The number of observations is 101,331. It is impossible to use single - day data (417) to produce a first - order regression model.

Table 5. Model 2' $\quad\quad ILLIQ_t = b_0 + b_1 S_t + e_t$

Explained variable, ILLIQ ;

Explanatory variable, Effective Spread

	coefficient	Std	P - value
b'_0	2.546 E -05***	1.008 E -07	0
Effective Spread	4.499 E -06***	6.335 E -08	0
Adjusted R^2	0.0472		
Total number of samples	101748		

*** is significant at 1% significance level. The number of observations is 101,331. It is impossible to use single - day data (417) to produce a first - order regression model.

Transaction Costs (Spreads) and Risk (Volatility), Hypothesis 3

NH3 : Volatility (transitory volatility) makes Transaction Costs (Spreads) small. Spreads

become narrow as volatility increases.

As described in this paper, when volatility increases and risk increases, transaction costs are considered to become large: if volatility increases, then the Spread can be expected to widen.

Consequently, Table 6 and Table 7 show that the coefficient of Volatility is positive and significantly so. Spreads become large when volatility increases. The same can be said of the results of Effective half Spread and Effective Spread. These results show that transaction costs become large as Volatility increases.

Table 6.　Model 3 $$S_t = c_0 + c_1 Vola_t + e_t$$

Explained variable，Effective half Spread；

Explanatory variable，Vola_20

	coefficient	Std	P - value
c_0	0.505***	0.002	0
Vola_20	1005.7***	13.91	0
Adjusted R^2	0.049		
Total number of samples	101748		

*** is significant at 1% significance level. The number of observations is 101,331. It is impossible to use single‐day data（417）to produce a first‐order regression model.

Table 7.　Model 3' $$S_t = c_0 + c_1 Vola_t + e_t$$

Explained variable，Effective Spread；

Explanatory variable，Vola_20

	coefficient	Std	P - value
c'_0	1.01***	0.004	0
Vola_20	2011.4***	27.82	0
Adjusted R^2	0.049		
Total number of samples	101748		

*** is significant at 1% significance level. The number of observations is 101,331. It is impossible to use single‐day data（417）to produce a first‐order regression model.

Robustness Check

Although Spreads and Volatility are used simultaneously in this model, the question of whether the result has consistency can be confirmed using model 4.

Table 8 and Table 9 show that the result has consistency with the results of other mod-

els for Spreads and Volatility. The coefficients of Spreads are positive and significantly so. Moreover, ILLIQ becomes larger as Spreads will widen, so liquidity will decrease. The coefficient of Volatility is positive and significantly so. Results show that ILLIQ becomes larger as Volatility increases, so the liquidity becomes lower.

Table 8. Model 4 $\quad ILLIQ_t = d_0 + d_1 Vola_t + d_2 S_t + e_t$

Explained variable, ILLIQ ;

Explanatory variable, Vola__20 and Effective half Spread

	coefficient	Std	P - value
d_0	1.820E-05***	9.692E-08	0
Vola_20	0.092***	0.001	0
Effective half Spread	4.528E-06***	1.134E-07	0
Adjusted R^2	0.274		
Total number of samples	101748		

*** is significant at 1% significance level. The number of observations is 101,331. It is impossible to use single - day data（417）to produce a first - order regression model.

Table 9. Model 4' $\quad ILLIQ_t = d_0 + d_1 Vola_t + d_2 S_t + e_t$

Explained variable, ILLIQ ;

Explanatory variable, Vola__20 and Effective Spread

	coefficient	Std	P - value
d'_0	1.820E-05***	9.692E-08	0
Vola_20	0.092***	0.001	0
Effective Spread	2.264E-06***	5.671E-08	0
Adjusted R^2	0.274		
Total number of samples	101748		

*** is significant at 1% significance level. The number of observations is 101,331. It is impossible to use single - day data（417）to produce a first - order regression model.

6 . Conclusion

This paper presented an examination of the relations among liquidity, transaction costs, and risk in the Japanese Government Bond（JGB）Futures market of the Tokyo Stock Exchange（TSE）.

Consequently, results revealed the following relations, which are the relations between liquidity, transaction costs, and risk in the JGB futures market. Investigation of the relation between liquidity and risk revealed that increased volatility increases ILLIQ, which is a liquidity index. Liquidity in the market decreases when risk increases. Moreover, results show that ILLIQ increases as a Spread will widen, when liquidity and transaction costs were investigated. Regarding this, when transaction costs become large, liquidity in the

market falls. Finally, results show that Spreads become large as volatility increases, when the transaction costs and the risk were investigated. Regarding this, Effective half Spreads and Effective Spreads yield the same result. Transaction costs will increase concomitantly with risk.

[1] Faculty of Economics, Hokusei Gakuen University. This paper reports results of a study that has been supported financially by Grants-in-Aid for Scientific Research（Kamae, Akimori, Minaki Scientific Research（C）22530319）.

[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）, Mahanti et al.（2008）.

[3] Effective half spreads are also used in this paper. The transaction cost is usually measured using the bid-ask spread. However, when that measure is used, the transaction costs of the investor who orders the bid and the investor who orders the ask are calculated twice, as a "round-trip transaction".

[4] To check robustness, the volatility of lag [of 10 terms] and 30 terms and 50 terms is also calculated and analyzed in this paper.

[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 adapted ITAYOSE. At the opening, all quotes（orders）before the contract price are recorded in the order book. They are considered to be simultaneous orders. Each is matched from the highest price order with a high priority level（price priority principle）. Moreover, the 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 under price 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.

Reference

Admati, A., and P. Pfleiderer [1988] "A Theory of Intraday Trading Patterns," *Review of Financial Studies* 1, 3-40.

Amihud,Y., and H. Mendelson [1987] "Trading Mechanisms and Stock Returns: An Empirical Investigation," *Journal of Finance* 42, 533-553.

Amihud,Y., and H. Mendelson [1991a] "Market Microstructure and Price Discovery on the Tokyo Stock Exchange," in Japanese Financial Market Research edited by W. T. Ziemba. 169-196.

Amihud,Y., and H. Mendelson [1991b] "Volatility, Efficiency, and Trading: Evidence from the Japanese Stock Market," *Journal of Finance* 46, 1765-1789.

Amihud, Y. [2002] "Illiquidity and Stock Returns: Cross-section and Time-series Effects,"*Journal of Financial Markets*, Vol.5, 31-56.

Arshanapalli, B., d'Ouville E., Fabozzi, F., & Switzer, L. [2006] "Macroeconomic news effects on conditional volatilities in the bond and stock markets," *Applied Financial Economics*, 16, 377-384.

Copeland, T., and D. Galai [1983] "Information Effects on the Bid-Ask Spread," *Journal of Finance*

38, 1457–1469.

Ederington, L., & Lee, J. [2001] "Intraday Volatility in Interest-Rate and Foreign-Exchange Markets: ARCH, Announcement, and Seasonality Effects," The *Journal of Futures Markets*, 21, 517–552.

Easley, D., and O'Hara, M. [1987] "Price, Trading Size, and Information in Securities Markets," *Jorunal of Financial Economics* 19, 69–90.

Glosten, L., and P. Milgrom [1985] "Bid, Ask and Transaction Prices in a Specialist Market with Heterogeneously Informed Traders," *Journal of Financial Economics* 14, 465–474.

Graman,M.B. [1976] "Market microstructure," *Journal of Financial Economics* 3, 257–275.

Huang, R., and Stoll, H [1994] "Market Microstructure and Stock Return Predictions," *The Review of Financial Studies* 7, 179–213.

Huang, R., and Stoll, H [1996] "Dealer versus auction markets: A paired comparison of execution costs on NASDAQ and the NYSE," *Journal of Financial Economics* 41, 313–357.

Kyle, A [1985] "Continuous Auctions and Insider Trading," *Econometrica*, Vol.53, No.6,1315–1335.

Mahanti S, A. Nashikkar, M Subrahmanyam, G. Chacko, and G Mallik [2008] "Latent Liquidity: A new measure of liquidity, with an application to corporate bonds,"*Journal of Financial Economics*, Vol.88, 272–298.

O'Hara, M [1996] Market Microstructure Theory, Blackwell Publishers.

Ronaldo, A [2004] "Order aggressiveness in limit order book markets," *Journal of Financial Markets*, 7, 53–74.

Stoll,H. R. and R. E. Whaley [1990] "Stock Market Structure and Volatility," *Review of Financial Studies* 3, 37–71.

Subrahmanyam, A [1991] "Risk Aversion, Market Liquidity, and Price Efficiency," *Review of Financial Studies* 4, 417–442.

Wang, P., Wang, P., & Liu, A [2005] "Stock Return Volatility and Trading Volume: Evidence from the Chinese Stock Market," *Journal of Chinese Economic and Business Studies* 3(1), 39–54.

[Abstract]

Liquidity, Transaction Costs and Risk in JGB Futures Market

Takeo MINAKI

This paper presents an examination of the relations that prevail among liquidity, transaction costs and risk in the Japanese Government Bond（JGB）Futures market of the Tokyo Stock Exchange（TSE）. Consequently, the following relations are presented as results: relations among 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 increases ILLIQ, which is a liquidity index. Results show that liquidity in the market falls when risk increases. Moreover, ILLIQ increases as Spreads widen, when liquidity and transaction costs are investigated. Regarding this, when transaction costs become large, liquidity in the market falls. Finally, Spreads become large as volatility increases when transaction costs and risk are investigated. Regarding this, Effective half Spreads or Effective Spreads also yield the same result. These analyses show that the transaction costs will increase as risk increases.