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## Liquidity in JGB markets - Analysis on the Intraday Bid-Ask Spreads -

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# arket Review

*Liquidity in the Japanese government bond (JGB) market has improved significantly as a result of a series of market reforms implemented since 2000. Market liquidity is a measure of "the level of ease with which trading can be conducted in the market." In order to facilitate trading in the JGB market, or in other words to enhance overall liquidity in the market, it is necessary to have a clear understanding of the changing mechanisms in market liquidity, together with main factors which have an impact on this. Detailed information known as "tick data," which records trading patterns over the course of a day, is a very useful tool when conducting a detailed analysis of market liquidity. Our empirical analysis, based on the intraday bid-ask spread, shows that as is the case in the US Treasury bond market, the longer the remaining maturity, the wider the bid-ask spread. Moreover, we find that wider bid-ask spreads are observed when market prices are volatile. These empirical findings are consistent with the general perception held by market participants.*

### Introduction

The yield on the currently-issued ten-year JGB, which hit the lowest level of 0.44% on June 12 2003, had reached 1.67% on September 3. As this marked a sudden turnaround from a protracted period of extremely low interest rates beginning in 1999, this probably had an effect on market liquidity as well. When interest rates fluctuate dramatically over a short period of time, market participants may need to exercise more caution than usual when showing bid (buying) and ask (selling) prices. Whether or not their bid or ask prices are significantly cheaper or more expensive than prevailing market prices, or whether transaction costs are appropriate prices for liquidity, are key factors to be taken into consideration. In this article, when looking at factors influencing short-term price formations in the JGB market, we focus on movements in the intraday bid-ask spread (i.e., the difference between the buying price and selling price).

### Reforms in the JGB market and improvements in market liquidity

In 2000, the BIS Committee on the Global Financial System published a report<sup>1</sup> on government securities market liquidity that examined three dimensions of market liquidity.

1. The degree of separation between transaction prices and mid-market prices (*tightness*). This is generally measured by the bid-ask spread.
2. The volume of trades possible without affecting prevailing market prices (*depth*). This is measured using market makers' order volume and trade execution volume or changes in prices just after execution.
3. The speed of the restoration of normal market conditions, or the speed at which supply and demand imbalances in order flows can be adjusted (*resiliency*).

Based on these three dimensions, the report concluded that JGB market liquidity was "the lowest among the G7 nations" (Chart 1). In particular, the report notes that when the JGB outstanding volume rises sharply, the cash market is not sufficiently liquid with respect to the volume of securities issued.

**Chart 1: Comparison of basic market liquidity measures (BIS report)**

(Volume outstanding is as of end-1997, other figures are during CY1997)

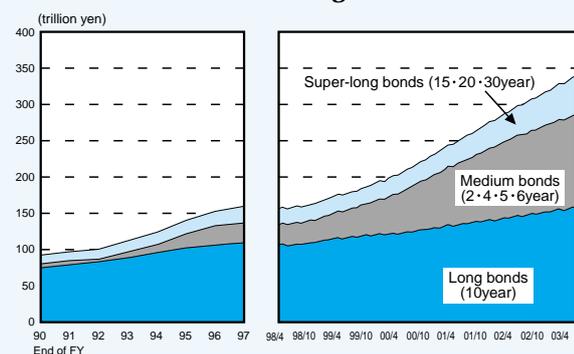
	Canada	Italy	Japan	UK	US	
Bid-ask spread:	2-year	2	3	5	3	1.6
	5-year	5	5	9	4	1.6
	10-year	5	6	7	4	3.1
	30-year	10	14	16	8	3.1
Volume outstanding (a) **	285	1,100	1,919	458	3,457	
Yearly Trading Volume (b) **	3,243	8,419	13,282	3,222	75,901	
Turnover ratio (b)/(a)	21.9	7.7	6.9	7.0	22.0	
Issue size per issue **	6.7	12.3	7.7	18.2	17.5	

\* Units: 1/10,000 of face value (for example, for two-year bonds, this equates to 5 sen for a ¥100 face value. Note that 100sen=1yen).

\*\* Units: US \$1 billion.

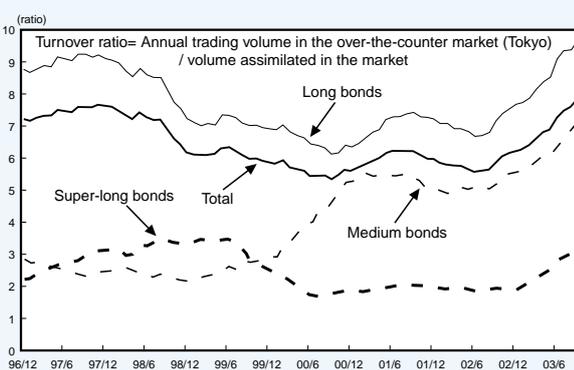
However, since then, JGB market liquidity has been improved through a series of reforms (BOX). For example, the BIS report highlighted the small issue size per issue and concentration of ten-year JGBs in the whole product mix as key constraints on liquidity. To rectify these problems, the issue ratio for medium-term JGBs has risen and modified the concentration of ten-year JGBs (Chart 2). Since FY2001, the integration of the medium-term JGBs to five-year JGBs as a benchmark issue, has led to an increase in the turnover ratio of medium-term JGBs (Chart 3). In addition, the average issue size has risen as a result of an introduction of a re-opening system (Chart 4). Therefore, problems pointed out in the BIS report have been steadily resolved.

**Chart 2: Amount of JGBs outstanding**



\* Interest-bearing bonds assimilated in the market.  
Source: Japan Securities Dealers Association "Securities Industry Information."

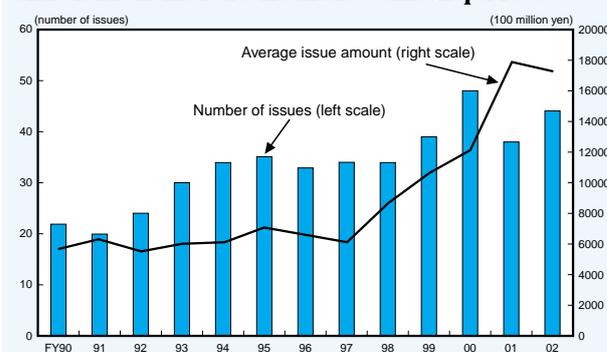
**Chart 3: Turnover ratios of JGBs**



\* Super-long bonds = 30, 20 and 15-year; long = 10 and 6-year; medium = 5, 4 and 2-year  
Source: Japan Securities Dealers Association "Securities Industry Information."

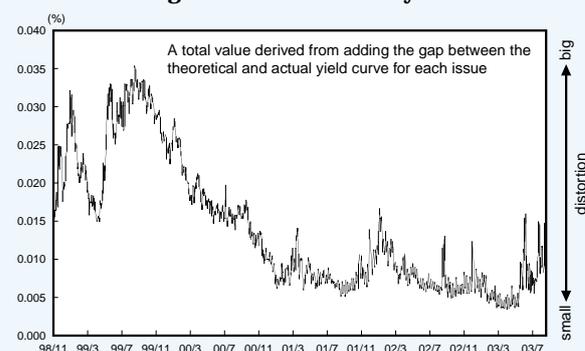
Chart 5 illustrates the improvement in market liquidity in terms of a smoother price formation in the market resulting from market reforms in the primary market, secondary market and payment system. The smoothness of the yield curve shows the degree of price distortion for each issue, and when the distortion is small, this indicates that the price formation mechanism is functioning efficiently. This index also suggests that JGB market liquidity has been consistently improving.

**Chart 4: The number of JGBs and issue amount per issue**



\* Interest-bearing bonds assimilated in the market.  
\* Average issue amount per issue = total amount issued in that financial year / number of issues.  
Source: Japan Securities Dealers Association "Securities Industry Information."

**Chart 5: Increasing smoothness of the JGB yield curve**



\* Theoretical yield is calculated by applying a spline interpolation function to market yield data (excluding bonds with remaining maturities of less than a year).  
Source: Bank of Japan.

## Characteristics of the bid-ask spread

- tends to be wider with longer the remaining maturity

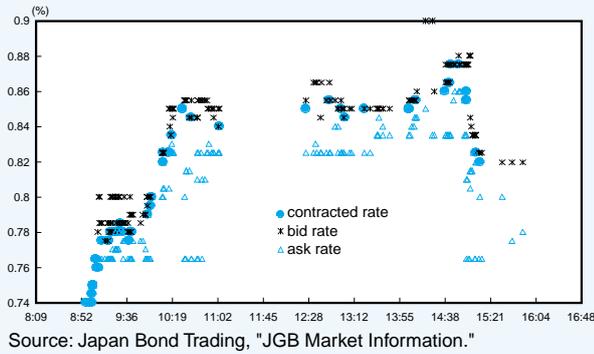
In order to empirically analyze the impact of liquidity on transaction costs, it is necessary to use transaction records known as "tick data"<sup>2,3</sup> (Chart 6). There are few previous analyses of JGB market liquidity using tick data partly due to data constraints. Below we present the results of our analysis using tick data from April 2002 to September 2003.

Looking at descriptive statistics for bid-ask spreads classified by original maturities, we can observe a positive correlation between the original maturity and bid-ask spread in the JGB market (Chart 7). This also applies to the case of the US<sup>4</sup>.

It should be noted that each maturity zone has issues for a variety of remaining maturities. Among the ten-year bonds, there is a clear correlation between the remaining maturity and bid-ask spread (Chart 8).

The main factors affecting market participants' bid and ask prices include transaction volume, price

**Chart 6: An example of tick data  
(June 30 2003, 10-year bond issue No.250)**



**Chart 7: Bid-ask spread by original maturities**

	Average	Median	Standard Deviation
2-year bonds	0.8	0.6	0.4
5-year bonds	0.9	0.8	0.6
10-year bonds	1.1	0.9	1.5
20-year bonds	1.4	1.2	1.7
30-year bonds	2.7	2.1	2.3

\* For 2-year JGBs, the figures exclude bonds with a remaining maturity of less than a year.

**Chart 8: Average bid-ask spread by remaining maturity**

Remaining maturity	2-5 years	5-7 years	7-10 years
10-year bonds	0.88	0.92	1.17

fluctuation risk, and market participants' risk appetite (i.e., degree of risk aversion). The mechanism is as follows: Suppose that prices are volatile in a market. This makes it more difficult for dealers to predict whether the bid and ask prices shown are appropriate considering the closing prices on that day or prevailing market prices. This leads to more cautious bid and ask prices than in a normal period and consequently the bid-ask spread widens.

To verify this point, as an indicator of price fluctuation risk, we conduct a panel analysis using interest rate volatility (Chart 9). Assuming that the bid-ask spread is correlated with interest rate levels, we have added interest rates to the explanatory variables in one of our models.

These results reveal that both interest rate levels and volatility significantly impact the bid-ask spread. In short, the bid-ask spread tends to be larger for higher and more volatile interest rates. For the sample period, from April 2002 to July 2003, the pattern that emerged was the longer the remaining maturity, the higher the interest rate and volatility<sup>5</sup>, and therefore the longer the remaining maturity, the greater the bid-ask spread.

**Chart 9: Factors affecting the bid-ask spread**

$$\text{Model 1: } y_{it} = \alpha_i + \beta_1 r_{it} + \beta_2 \text{vol}_{it} + \varepsilon_{it}$$

Explanatory variable	Coefficient	Standard error	t-value
Interest rate	0.003	0.0005	7.4
Volatility	0.026	0.0042	6.2
Constant (average)			
2-5 years remaining	0.009	Adjusted R-squared	0.1
5-7 years remaining	0.006		
7-10 years remaining	0.008		

$$\text{Model 2: } y_{it} = \alpha_i + \beta_3 \text{vol}_{it} + \eta_{it}$$

Explanatory variable	Coefficient	Standard error	t-value
Volatility	0.027	0.0042	6.4
Constant (average)			
2-5 years remaining	0.010	Adjusted R-squared	0.1
5-7 years remaining	0.008		
7-10 years remaining	0.011		

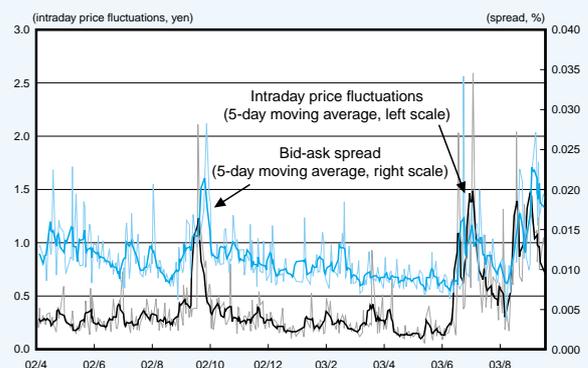
\* Here,  $i$  = each of the 10-year bonds,  $y$  = bid-ask spread,  $r$  = interest rate for each bond,  $\text{vol}$  = historical volatility (based on 20 business days). Sample period is April 4 2002 to July 25 2003 (8468 samples). In order to look at the effects for each remaining maturity, we create three zones (2-5 years, 5-7 years and 7-10 years), and exclude those bonds that moved from one zone to another during the sample period (for example, bonds with a remaining maturity of six years as of April 2002). For our analysis we use a fixed effect model assuming individual effects for each bond (i.e., every constant is different). Heteroskedasticity and autocorrelation consistent covariance are employed for standard errors.

Source: Japan Bond Trading "JGB Market Information."

## The bid-ask spread widens when the market becomes more volatile

We would like to present an example of the relationship between bid-ask spreads and fluctuations in market prices. First, as shown in Chart 10, in the autumn of 2002 and summer of 2003, when the 10-year JGB auction was under-subscribed and interest rates fluctuated widely, there were dramatic increases in bid-ask spreads.<sup>6</sup>

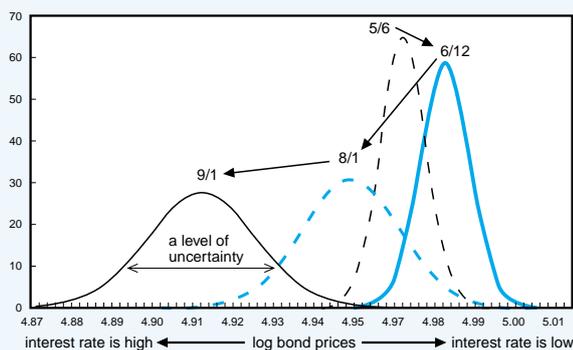
**Chart 10: Bid-ask spread and intraday price fluctuations**



\* We use scaled intraday price fluctuations for 10-year bond futures in the cheapest-to-deliver (CTD) issue. The bid-ask spread is the average of all ten-year bonds.  
Source: Nikkei QUICK Information Technology, Japan Bond Trading "JGB Market Information."

Chart 11 shows the risk of future price fluctuations measured by implied probability distributions for short-term interest rates computed from 10-year JGB future option prices. The fatness of each distribution's tail represents the level of uncertainty with regards to future interest rate movements. According to this chart, in the early May, when the bid-ask spread was both low and stable, the tail of the distributions was narrow. However, from June onwards, when the bid-ask spread widened, the tails of the distributions expanded. This indicates that when market participants' expected range for future interest rates widens, the bid-ask spread also expands.

**Chart 11: Implied probability distributions from 10-year JGB future option prices**



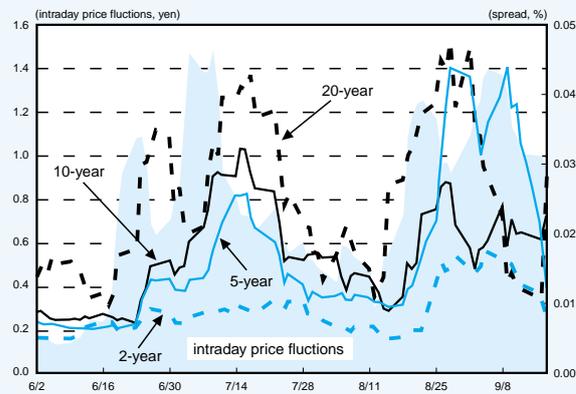
\* These distributions are calculated using techniques from P. Soderlind and L.E.O. Svensson, [1997], "New Techniques to Extract Market Expectations from Financial Instruments," *Journal of Monetary Economics*, vol.40 (2), pp.383-429.  
Source: Bank of Japan.

Furthermore, in looking at trends in bid-ask spreads by original maturity, from mid-June, the bid-ask spread for the current issues of 10-year and 20-year bonds expanded (Chart 12). From mid-August to September, in the medium-term zone, the bid-ask spread for 2-year bond current issues also widened and the spread for 5-year bond current issues exceeded that for 10-year bond current issues. In order to look at market price fluctuations for each term over this period, Chart 13 shows the term structure of forward rates. This shows that while from mid-June onwards, forward rates mainly for the long-term zone rose, forward rates for the medium-term zone also rose from August. Consequently, these results suggest that the bid-ask spreads expanded for maturity zones where market prices fluctuated widely.

When volatility rises, for example in June 2003, turnover increases (Chart 14). Despite this increased turnover, some market participants have upheld the view that "the JGB market is illiquid." This can stem from the fact that "the bid-ask spread is wider than

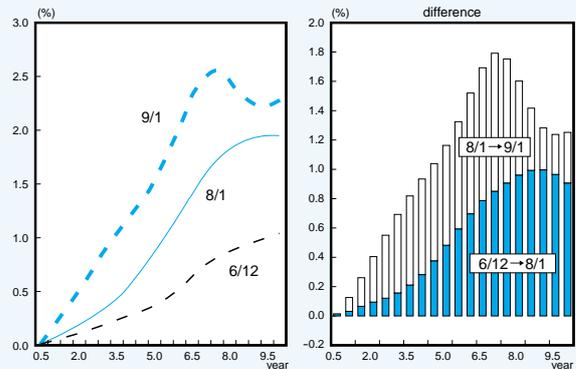
usual when participants want to make a transaction." There is a tendency to believe that the greater the turnover, the more active the trading, and the greater the liquidity. However, as market liquidity is gauged in terms of transaction costs, in some situations, turnover alone does not draw the full picture.

**Chart 12: Trends in bid-ask spread according to original maturity**



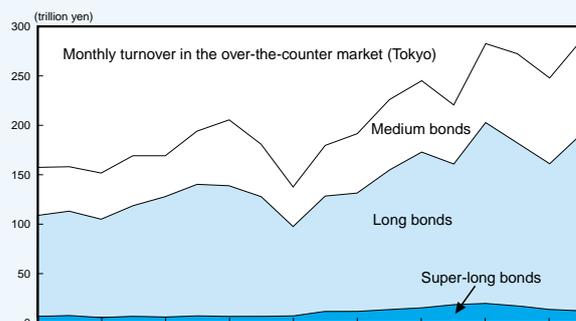
\* All series are 5-business day later moving averages. All bonds are on-the-run.  
Source: Nikkei QUICK Information Technology, Japan Bond Trading "JGB Market Information."

**Chart 13: Changes in term structure of forward rates**



\* The forward rates show current expectations for future short-term interest rates. For example, the 2-year forward rates show the expected level of short-term interest rates two years from now.  
Source: Bank of Japan.

**Chart 14: Trends in turnover**



\* Super-long bonds = 30, 20 and 15-year; long bonds = 10 and 6-year; medium bonds = 5, 4, and 2-year.  
Source: Japan Securities Dealers Association "Securities Industry Information."

## [BOX] Recent Reforms in the JGB market

### ▼ Primary market

#### Variety of products and maturities

1994 Issuance of 6-year JGBs  
 1999 Issuance of 1-year TBs  
 Issuance of 30-year JGBs  
 2000 Issuance of 5-year JGBs  
 Issuance of 15-year floating rate bonds  
 2001 Integration of mid-term government securities (4 to 6 year JGBs) into 5-year JGBs  
 2003 Introduction of STRIPS (separate trading of registered interest and principal of securities) for government securities  
 Issuance of bonds for individuals  
 2004 Issuance of 10-year inflation-indexed bonds (scheduled)

#### Review of issue procedures

[Reduction of syndicate group underwriting (10-year JGBs)]  
 1989 Introduction of partial competitive bidding (share 40%)  
 1990 Expansion of the competitive bidding limit (share 60%)  
 2002 Further expansion of competitive bidding limit (share 75%)  
 2003 Further expansion of competitive bidding limit (share 80%)  
 [Re-opening system]  
 2001 Introduction of re-opening system [FB issuance]  
 1999 Adoption of public auctions for FB issuance  
 2000 Adoption of fully public auctions

#### Improvement of bidding procedures

1991 Introduction of same-day announcement of bidding results  
 1999 Introduction of prior announcement of auction calendar and issue amount  
 2000~02 Time of announcement of bidding results brought forward  
 2003 Reduction in days between auction and issue dates

### ▼ Secondary market

#### Creation of new markets and transactions

[Futures and options markets]  
 1985 Creation of JGB futures market  
 1989 Creation of JGB options market  
 [Repo market]  
 1989 Introduction of securities lending ←  
 1996 Full-scale commencement of securities lending transactions against cash collateral ←  
 2001 Introduction of repurchase agreement  
 [Outright market]  
 2003 Commencement of buy-backs by the Ministry of Finance  
 ✎ Establishment of guidelines relating to WI (When-Issued) trading of JGBs (scheduled to be implemented in 2004)  
 [Electronic trading system]  
 2000 Introduction of electronic trading systems ←

#### Easing of restrictions on the trading front

1984 Lifting of the ban on bank dealing  
 1987 Lifting of the ban on short sales by securities houses  
 1989 Lifting of the ban on short sales by banks  
 1996 Removal of interest rate regulations of securities lending against cash collateral  
 1998 Introduction of Proprietary Trading Systems (PTS)

### ▼ Taxation

#### Relating to non-resident

1992 Lifting of taxes on profits from TB redemptions for foreign institutions  
 1999 Exemption of withholding taxes on interest from JGBs held by foreign investors  
 2001 Exemption of withholding taxes on interest from JGBs held by foreign investors through global custodians  
 2002 Exemption of taxes on interests from cross-border repo transactions earned by foreign financial institutions

#### General

1999 Abolition of Securities Transaction Tax and Exchange Tax  
 ✎ Exemption of withholding taxes on redemption profits on TBs and FBs  
 2003 Exemption of withholding taxes on JGB interest for domestic corporations (capital in excess of ¥100 million)

### ▼ Settlement system and practices

#### Settlement system

1980 Creation of transfer book-entry settlement system  
 1990 BOJ-NET JGB services came into operation  
 1994 JGB DVP system came into operation  
 2001 Introduction of BOJ-NET real time gross settlement (RTGS) →  
 2002 Introduction of RTGS for issuance of JGBs  
 2003 "The Law concerning Book-Entry Transfer of Corporate Bonds, etc" took effect  
 Establishment of Japan Government Bond Clearing Corporation

#### Settlement practices

1987 Introduction of "Gotoubi" settlement \*  
 1996 Introduction of T+7 rolling settlement  
 1997 Introduction of T+3 rolling settlement  
 2001 Establishment of "The Japanese Government Securities Guidelines for Real Time Gross Settlement" (market practices)  
 \* A market practice where JGB transactions are settled within 10 business days after trades are contracted, on the fifth, 10th, 15th, 20th, 25th, and the last day of each month. The word "Gotoubi" means every fifth and tenth day of the month.

### ▼ Others

#### Improving transparency of pricing and market information

2000 Start of public announcement of aggregate repo rate statistics by the Bank of Japan  
 2001 Start of public announcement of the Bank of Japan's Issue-by-Issue Holdings of JGBs by Amount Outstanding  
 2000~02 Measures to improve the reliability of Reference Prices (Yields) for OTC Bond Transactions, published by the Japan Securities Dealers Association

#### Dialogue with the market

2000 Inauguration of the Meeting on the JGB Market by the MoF  
 2002 Inauguration of the Meeting of the JGB Investors by the MoF

## Conclusion

Smooth price discovery in the JGB market is prerequisite for robust functioning of the financial market as a whole. In addition to price formation based on expectations for long-term economic trends, the smoothness with which each individual transaction can be carried out also has a significant impact on price discovery in the JGB market. In order to make transactions even smoother, we need to enhance the functioning of the market based on a clear understanding of market liquidity.

Market liquidity analysis using tick data given in this article sheds light on the current condition of transaction costs in the JGB markets and provides a useful tool in further understanding the changing mechanisms in market liquidity. However, as there are various indicators to assess liquidity in the market, we need to carefully examine the consistency between these indicators and also their relationship with related factors such as interest rates and their volatility, remaining maturity and original maturity. The Financial Markets Department will continue to analyze this area, which provides useful viewpoints for market reforms in practice as well as infrastructure to enhance market liquidity.

<sup>1</sup> BIS Committee on the Global Financial System, "Market Liquidity: Research Findings and Selected Policy Implications," March 2000.

<sup>2</sup> Japan Bond Trading Co., Ltd. "JGB Market Information," includes executed information and quoted information. Quoted information is comprised of best bid and best offer (simple interest), as well as time of occurrence/change, security code, bond name and delivery date.

<sup>3</sup> The Federal Reserve Bank of New York, which carries out pioneering research in this field, is continuously publishing reports on liquidity in the US Treasury market using tick data. Its most recent analysis of this subject is Michael J. Fleming, "Measuring Treasury Market Liquidity," Federal Reserve Bank of New York, *Economic Policy Review*, September 2003.

<sup>4</sup> In the US Treasury market, there is a positive correlation between the bid-ask spread and remaining maturity (Fleming (2003)).

	Average	Median	Standard Deviation
2-years	0.21	0.20	0.03
5-years	0.39	0.37	0.10
10-years	0.78	0.73	0.20

\* Unit = 1/32 point. 1 point = 1%.

<sup>5</sup> Average interest rate and average volatility for each zone during the sample period (April 4 2002 to July 25 2003) are as follows:

Remaining maturity	2-5 years	5-7 years	7-10 years
Interest rates	0.21	0.49	0.84
Volatility	0.018	0.033	0.042

<sup>6</sup> Analyzing the relationship between bid-ask spreads and fluctuations in market prices using the Granger causality test reveals a relationship where "after fluctuations in intraday prices become more volatile, the bid-ask spread subsequently widens."

(Reference) The Granger causality test

Null hypothesis (H <sub>0</sub> )	F value	p value
Intraday price fluctuations doesn't Granger cause bid-ask spread	15.8*	0.00
Bid-ask spread doesn't Granger cause intraday price fluctuations	1.4	0.26

Sample period is April 1 2002 to August 14 2003. \* denotes statistical significance at 1% level. For each variable, stationarity is verified using the ADF test. The lag used for the presumptions is three business days.

Source: Japan Bond Trading "JGB Market Information," Nikkei QUICK Information Technology, Bank of Japan

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