Financial Markets Department Working Paper 01-E-1

Market Participants' Behavior and Pricing Mechanisms in the JGB Markets

-- Analysis of Market Developments from the End of 1998 to 1999 --

Yosuke Shigemi
yousuke.shigemi@boj.or.jp

Sotaro Kato
soutarou.katou@boj.or.jp,

Yutaka Soejima
yutaka.soejima@boj.or.jp

Tokiko Shimizu
tokiko.shimizu@boj.or.jp

FINANCIAL MARKETS DEPARTMENT
BANK OF JAPAN

C.P.O. BOX 30 TOKYO
103-8660

April 19, 2001

Financial Markets Department Working Paper Series 2001-E-1
2001

Market Participants' Behavior and Pricing Mechanisms in the JGB Markets

-- Analysis of Market Developments from the End of 1998 to 1999 --

Yosuke Shigemi
Sotaro Kato
Yutaka Soejima
Tokiko Shimizu

Table of Contents

SUMMARY ..... **III**

1. INTRODUCTION **1**

2. DEVELOPMENTS IN JGB MARKETS SINCE AUTUMN 1998 ..... **2**

2.1 CRISES IN INTERNATIONAL FINANCIAL MARKETS AND THE 'TRUST FUND BUREAU SHOCK' (AUTUMN 1998 TO END-1998) **2**

2.2 CHANGE IN THE CHEAPEST TO DELIVER ISSUE ACCOMPANYING CHANGE OF THE MOST ACTIVE CONTRACT (JUNE 1999) **5**

2.2.1 Large amount of unsettled June 99 contract outstanding ***5***

2.2.2 Change in the CTD issue for June 99 contract: from the JGB 187th issue to the 20-year JGB 2nd issue ***6***

2.2.3 Use of yen-yen swaps as an alternative in response to the decline in the efficiency of hedging with futures ***7***

2.3 TURMOIL IN THE REPO MARKET ACCOMPANYING THE CHANGEOVER IN THE MOST ACTIVE CONTRACT AND THE Y2K PROBLEM (AUGUST 1999) **8**

2.3.1 Change in the most active contract from September 99 to March 00 contract (skipping December 99 contract) ***8***

2.3.2 Turmoil in the repo market prompted by rumors surrounding repo trading over the year- end ***10***

3. MARKET PARTICIPANTS' BEHAVIOR AND MARKET MICRO-STRUCTURE – MAIN FINDINGS OF THE SURVEY **12**

3.1 MARKET MAKERS' BEHAVIOR **12**

(1) Less willingness to take risks, due to the intensification of competition and instability in the financial system in the autumn 1997 and the autumn 1998 ..... ***12***

(2) Decline in hedging efficiency of JGB futures – Hedging by cash or avoiding cash delivery for settlement of futures contracts ***12***

(3) Greater reluctance to take risk in response to higher volatility of daily earnings ***13***

(4) Continually modifying the pricing model ***13***

BOX 2 DECLINE IN HEDGING EFFICIENCY OF JGB FUTURES **14**

BOX 3 INCREASED RISK FOR BASIS TRADING **16**

3.2 INVESTORS' BEHAVIOR **17**

(1) Tendency for investors to prefer current yield ***17***

(2) Instability in repo rate resulting from concentration in market participants' cash bond holdings ***17***

(3) Investors use the options market mainly for speculative trading, rather than for hedging purposes ***18***

3.3 MARKET MICROSTRUCTURE **18**

3.3.1 The repo market ***18***

(1) Long-term repo contracts are not actively traded ***18***

(2) Repo trading as a tool for hedging dealers' cash bond positions ***18***

(3) Difficult to predict which issues will go special ***19***

3.3.2 The cash market ***19***

(1) Lack of procedures to deal with delivery fails ***19***

(2) Only the most recent issues are highly liquid ***19***

(3) Investor behavior distorts the yield curve ***19***

(4) Kink in the yield curve in the seven-year zone ***19***

(5) Issues to be solved in the primary market ***20***

3.3.3 The futures market *20*
(1) Futures market is not strongly tied to the cash market *20*
(2) Effects of lowering the coupon on underlying bonds for futures contracts *20*
4. PRICING METHODS **21**
4.1 SIMULATION OF CASH BOND PRICING **21**
4.1.1 Simulation methods *21*
(1) Estimating prices from movements in the prices of issues with close remaining life *21*
(2) Calculating a theoretical value for CTD issues from futures prices, and estimating prices for other issues based on historical relationship *22*
(3) Estimating the shift in the level of the yield curve from the CTD issue, and then assuming a parallel shift or adjusting with the slope in the swap rate *23*
(4) Pricing based on a fixed swap spread *23*
4.1.2 Simulation results *24*
(1) Estimating prices from movements in prices of issues with close remaining life *24*
(2) Calculating a theoretical value for CTD issues from futures prices, and estimating prices for other issues using historical correlation *24*
(3) Estimating the level of the yield curve from the CTD issue, and then using a parallel shift or slope in the swap curve to adjust *25*
(4) Pricing based on a fixed swap spread *26*
4.1.3 Summary of findings on pricing methods *26*
4.2 EFFECTS OF THE CHARACTERISTICS OF INDIVIDUAL ISSUES ON PRICING **27**
4.2.1Method of analysis *27*
4.2.2 Changes in the gradient of the yield curve *28*
Period I: From November 1998 to early-January 1999 ..... *30*
Period II: From mid-January 1999 to end-February (Chart 4-7-1) *30*
Period III: From early-March 1999 to mid-April 1999 (Chart 4-7-2) *30*
Period IV: From end-May to end-June 1999 (Charts 4-7-3 and 4-7-4) *31*
Period V: From August 10th to early-September 1999 (Charts 4-7-5 and 4-7-6) *32*
Period VI: From early-September to early-October 1999 (Chart 4-7-7) *33*
Period VII: From end-November to end-December 1999 (Chart 4-7-8) *34*
4.2.3 Issue characteristics and their effects *34*
5. CONCLUSION **37**
REFERENCES **38**

Summary

Enhancing market liquidity and efficiency in government bond markets is a central issue which needs to be addressed so as to ensure that the yield curve, which acts as the benchmark for yen interest rate instruments, is smoothly determined and reflects prevailing market prices. An efficient government bond market is indispensable from the standpoint of financial policy operations in order (1) to secure reliable information which reflects market participants' outlook on interest rates, and (2) to carry out smooth market operations using government bonds. However, there are various problems with respect to the government bond markets, related to both market structure and the behavior of market participants, and thus they are vulnerable to stress. The experience of summer 1999, where a widespread decline in market liquidity was observed in the government bond markets prompted in part by a shock which materialized in the repo market, is still fresh in our minds.

In this paper, we explore various developments in Japanese government bond markets, focusing on the connection between the behavior and incentives of market participants and the effect they have had on market liquidity. More specifically, we examine the various problems (pricing difficulties and the impact on earnings, for example) faced by market participants and the accompanying decline in the market making activities, based on quantitative analysis and the results of questionnaire and interviews conducted by the Financial Markets Department.

The key points are as follows.
Macro dynamics and behind-the-scenes working of micro-mechanisms

Macro Dynamics

Concern over the supply and demand of JGBs was mounting between the autumn of 1998 and the end of the year. In December 1998, the long-term interest rate rose by 105bps in one month, marking the highest rise in 20 years. This was prompted in part by the announcements made by leading figures with regard to fund management by the Trust Fund Bureau. The markets were in turmoil in June 1999, when the change in the most active bond futures contract was delayed. Just before the change in the most active contract, there was a sudden switch in the cheapest to deliver issue (hereafter, CTD issue), and the lending rate for the issue rose above 1 percent. In August 1999, the lending rate for the CTD issue rose above 2 percent. This occurred against a backdrop of moves to avoid the super-long (20-year) government bond, which was hampered by poor liquidity, to become the CTD issue, and a decline in the efficiency of the repo market as a result of concerns over the Y2K problem. Thus, the non-arbitrage relationship between the cash, futures, and repo markets and market liquidity deteriorated.

Micro-mechanisms

In the background to the above-mentioned macro dynamics, there was a global tendency among market participants engaged in arbitrage trading to withdraw from the markets, prompted by the near collapse of LTCM in the summer of 1998. As a result of the decline in the ability of market participants to supply market liquidity, structural problems came to the fore once again. The increased pessimism of market participants over the certainty of market developments, due to concerns over the Y2K problem and the liquidity problem in the cash market amplified the vulnerability of JGB markets, such as pricing mechanisms heavily relying on futures and the immature repo market. The costs associated with market making rose, along with a decline in the effectiveness of hedging and an increase in inventory risk. As a result, the market mechanisms which compensate for a decline in market liquidity did not come into play, and market liquidity declined further. The low level of price sensitivity on the part of investors, which had been pointed out for some time, is considered to have been another reason why the liquidity supply mechanism within the market failed to function.

An examination of micro-mechanisms

Under these market developments, many dealers were confronted by the limitations of their pricing methods. The pricing methods employed by the majority of participants are broadly divided into those based on (1) cash prices for similarly dated issues, (2) CTD issue price, calculated from the futures price, and (3) yield information from other markets, such as the swap market. The relative performance of each of these methods differed when the futures and repo markets experienced unstable market conditions between June and September 1999. While the performance of pricing methods based on futures and swaps deteriorated, the performance of a method based on cash prices for similarly dated issues showed relative improvement, which agrees with the views obtained from market participants through our questionnaire.

Furthermore, when considering dealer pricing behavior and investor behavior, it is necessary to give careful thought to bias originating in the characteristics and attributes of individual issues. We thus conducted our analysis using a spline curve to eliminate this bias. While there is only a small element of bias when pricing on-the-run issues which enjoy high liquidity, there is a strong tendency to attach a relatively low price to issues with remaining life close to CTD issues, influenced by futures prices. This induces the tendency for issues with remaining life close to both sides of CTD issues to be priced relatively high. There is also a tendency for low coupon bonds such as the JGB 207th issue to be priced cheaply, reflecting the low level of liquidity.

Issues for further discussion

As a result of the series of studies undertaken for this paper, we observed that in the background to macro-market developments such as an increase in volatility, a deterioration in the non-arbitrage relationship, and a decline in market liquidity, micro mechanisms exists, such as a reduction in positions accompanying difficulties over pricing and hedging by market participants, and a decline in the market making activities. Light is shed on the relationship that the macro-market environment, comprising market prices and market liquidity determined as an aggregation of micro trends among a diversity of market participants, was in its turn influencing the incentives and behavior of market participants.

There are two issues in the JGB market which need to be addressed in the future. First, in attempting to improve the efficiency of JGB markets, as well as creating a more balanced relationship between the cash, futures, and repo markets, it will be necessary to eliminate factors that hinder the liquidity supply function within the market. Second, in monitoring macro-market developments, it is important to enhance our understanding of the interplay with background micro mechanisms, and the factors influencing the functioning of the market. In this regard, it is important to enhance the capacity and organization necessary for conducting appropriate analyses. The aim of these efforts is to contribute to securing information on interest rates which accurately reflects the prevailing market prices, which is indispensable from the standpoint of monetary policy and improving the effectiveness of market operations. It is important that both market participants and the related authorities play an active role in these efforts.

1. Introduction

Enhancing market liquidity and efficiency in the government bond markets is a central issue which needs to be addressed so as to ensure that the yield curve, which acts as the benchmark for yen interest rate instruments, is smoothly determined and reflects prevailing market prices. An efficient government bond market is also necessary from the standpoint of monetary policy operations in order to (1) obtain reliable information regarding the outlook of market participants on interest rates, and (2) to smoothly implement market operations in the government bond market. This view is also shared by central banks of the G10 and Asian countries. The BIS Committee on the Global Financial System [1996b] noted that "there is a consensus that based on recent experience of financial crises, financial markets with high liquidity, particularly government bond markets, are necessary in order to maintain an overall financial system which is robust and efficient".

As the speed and magnitude of changes in cross-border capital flows and expectations of market participants accelerate, market robustness will have to be fortified, so that markets can withstand stress, i.e., to ensure that liquidity is maintained and the price discovery function is robust. Some issues that could be addressed in order to enhance market robustness are noted. These were derived from the result of the analysis undertaken for this paper: (1) improving the functioning of and the balance between the cash bond, futures, and repo markets, (2) removing obstacles to the market-making activities (liquidity supply function), and (3) promoting the close monitoring of market functions.

Long-term interest rates rose from end-1998, and the non-arbitrage relationship between the cash, futures, and repo markets deteriorated in the summer of 1999. These moves were amplified as the liquidity supply capacity of market participants declined against the background of the crises in the international financial markets and ongoing reforms related to the government bond issuing system, the tax system, and trading practices. This series of market developments was triggered by the increase in the sensitivity of market participants to event risk, namely the Y2K problem and the change in the environment surrounding the supply and demand for government bonds, while the tempo of improvement in market efficiency, which had been increasing in the first half of the 1990s, was slowing down.

In this paper, we study the incentives and behavior of market participants which are believed to have contributed to these developments. Fact finding and analyses are based on responses of major JGB market participants to questionnaire and interviews conducted by the Financial Markets Department. We examine the problems faced by market participants, and what sort of issues these problems led to with regard to pricing and earnings risk, and position management. We find that micro-mechanisms, namely a decline in the market-making activities, a reduction in positions accompanying pricing difficulties and market participants' hedging activities, were contributing to macro-market developments, such as an increase in volatility, a deterioration in the non-arbitrage relationship, and a decline in market liquidity. Furthermore, the macro-market environment, where market prices and liquidity are determined through the collective micro actions of the various market participants, was conversely influencing the incentives and behavior of market participants.

The structure of this paper is as follows. First, in Section 2, an overview of market developments from autumn 1998 to end-1999 is outlined, and in Section 3, we examine the behavior of market participants. In Section 4, four typical pricing methods are compared and contrasted by quantitatively analyzing the background to market developments and behavior of participants discussed in Sections 2 and 3. Some key characteristics of issues from the standpoint of pricing identified through this study are also explained. Finally, in Section 5, the findings of this paper and their implications are summarized.

2. Developments in JGB Markets since Autumn 1998

This section looks at events in JGB markets since autumn 1998, especially events leading up to the turmoil in JGB markets, including futures, in summer 1999 and the developments observed in the futures market. Chart 2-1 gives a timeline of the market dynamics during the period.

2.1 Crises in International Financial Markets and the 'Trust Fund Bureau Shock' (autumn 1998 to end-1998)

While the major international financial markets escaped the effects of the crises seen in the emerging markets between July 1997[1] and July 1998, many investors with Russian exposure suffered serious losses when the 'Russian crisis' emerged in summer 1998.[2] As this prompted market participants in all international financial markets to reduce their risk exposure, market liquidity declined.

Against this background, arbitrage opportunities became less likely to be exploited with the decline in the ability of arbitrageurs (arbitrageurs who actively take advantage of arbitrage opportunities) to take risks, as demonstrated by the near collapse of LTCM, or their withdrawal from the market. From summer 1998, in particular, a decline in liquidity and an increase in volatility accompanying the withdrawal of arbitrageurs from the market and reduction in ability to take risks were widely observed in the international financial markets.

The JGB market, influenced by such developments, became more volatile after November 1998. Market participants have become very conscious of a deterioration in supply and demand conditions accompanying an increase in the issuance of JGBs when the supplementary budget is compiled in the autumn of each year. Market conditions continued lackluster toward end-1998, as concerns over JGB supply and demand conditions did not ameliorate and market demand remained weak. At the end of the year, in particular, the JGB market became volatile, with the price limit being triggered in the futures market for the first time since August 10th 1988. This volatility was triggered as selling pressure from investors, which was already mounting in response to rumors of an increase in the issuance of JGBs, might have been compounded by announcements by leading figures indicating that the Trust Fund Bureau would suspend JGB purchases.[3]

Some market participants pointed out that the market's reaction to the 'Trust Fund Bureau shock' might have been amplified owing in part to "changes in the trading system, such as the complete overhaul of the bond futures trading system and the abolition of the suspension system" – these changes were implemented on November 2nd 1998.[4] While these system changes were aimed at

[1] Devaluation of the Thai baht (July 1997).

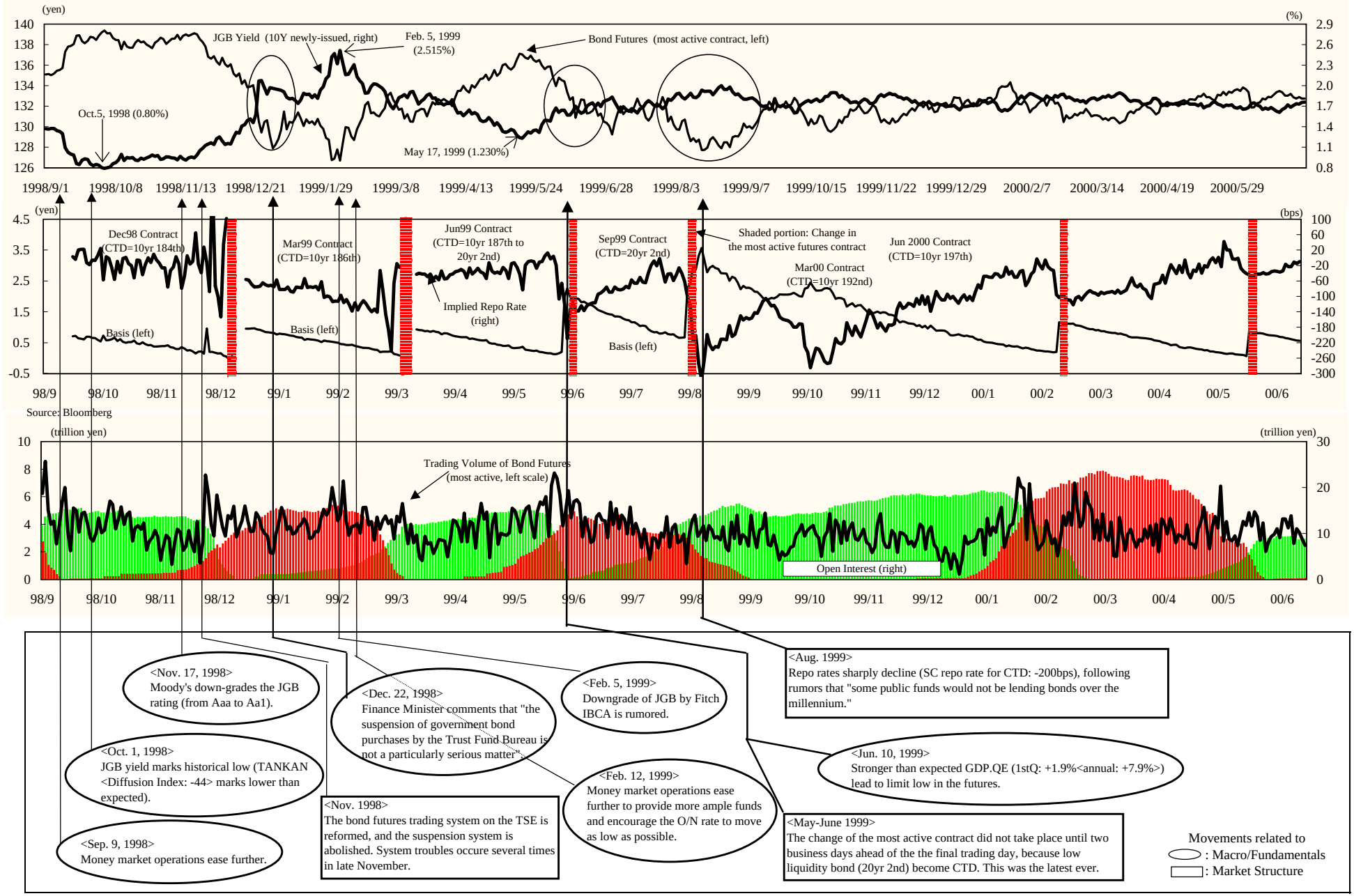
[2] Russia announced a de facto devaluation of the ruble, and a moratorium on the repayment of short-term foreign debt by the private sector (August 1998).

[3] For example, Finance Minister Miyazawa commented that the suspension of government bond purchases by the Trust Fund Bureau was not a particularly serious matter, and Bank of Japan Governor Hayami stated it was not a natural state of affairs for the Bank of Japan to be holding government bonds worth in excess of 50 trillion yen (both of these comments were made on December 21st 1998).

[4] A suspension system closely resembling the old system was later reintroduced on June 25th 1999.

improving liquidity and speeding up transactions in the futures market, there were reports that "liquidity in the futures market actually declined following these changes". After the initial reforms, "large-lot market orders were matched with orders on the book immediately and automatically without any notice to market participants, and without cushioning the impact on prices." As a result, "market participants felt that they were more susceptible to prices moving, and an event such as 'the Trust Fund Bureau shock' was more likely to make market prices highly volatile.

Chart 2-1 Key Indicators and Major Events in the JGB Market



2.2 Change in the cheapest to deliver issue accompanying change of the most active contract (June 1999)

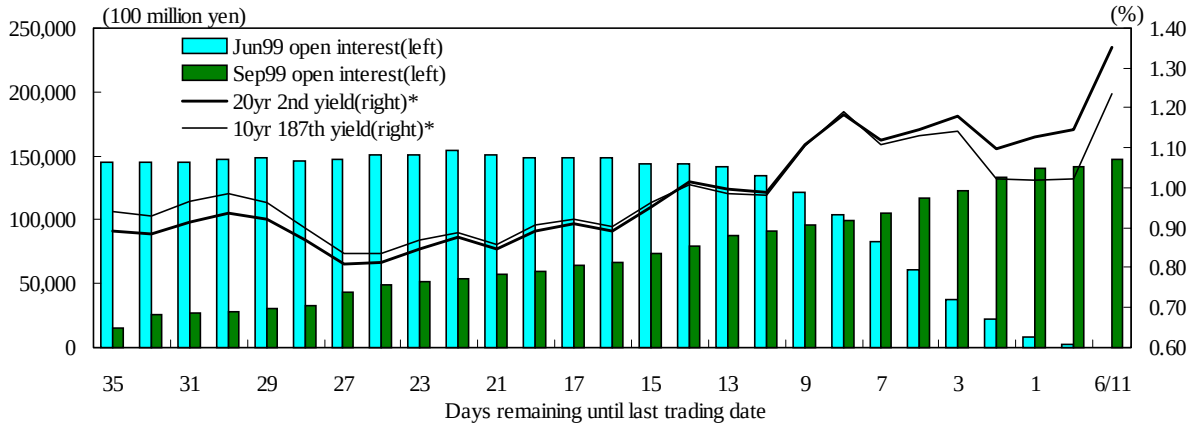
In this section, the developments surrounding the change in the most active contract from *June 99 contract* to *December 99 contract* in June 1999 and the factors behind these developments are explored.

2.2.1 Large amount of unsettled *June 99 contract* outstanding

Market developments

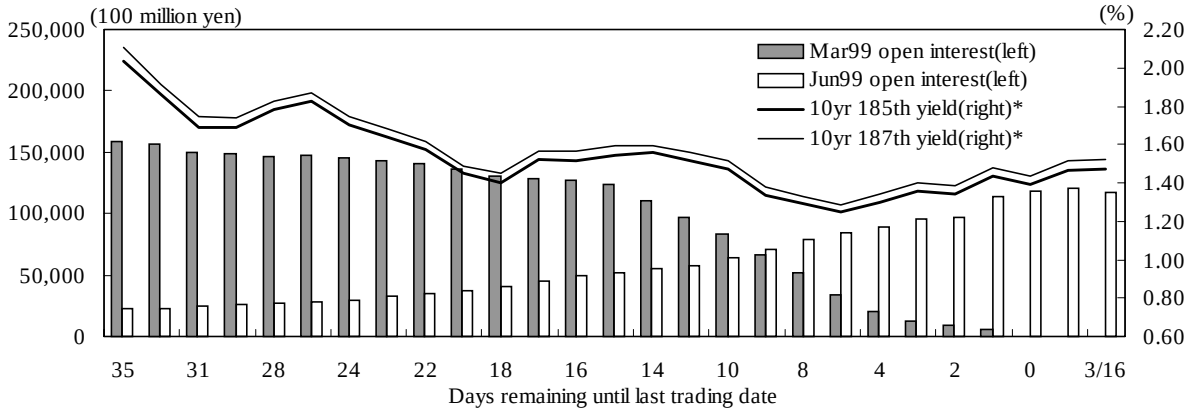
Ordinarily, when a change in the most active contract nears, market participants rollover the contract by buying back the outgoing contract and taking a short position on the next contract. This means that while open interest on the outgoing contract declines, and that on the following contract accumulates. However, this decline was much slower than usual in the case of *June 99 contract*. With only eight business days remaining until the final trading day (June 10th 1999), the amount of open interest was still high at around 15 trillion yen, compared to 8 trillion yen outstanding in CTD issues (Chart 2-2). Because of this slowness in the decline of open interest related to *June 99 contract*, the change in the most active contract did not take place until an unprecedented late two business days prior to the final trading day (June 8th 1999).

Chart 2-2 Open Interest in Futures and CTD Issue Yield Surrounding the Change from *June 99* to *September 99 Contract*



(Note) * CTD issue candidates for *June 99 contract*.

Chart 2-3 Open Interest in Futures and CTD Issue Yield Surrounding the Change from *March 99* to *June 99 contract*



(Note) * CTD issue candidates for *March 99 contract*

Background

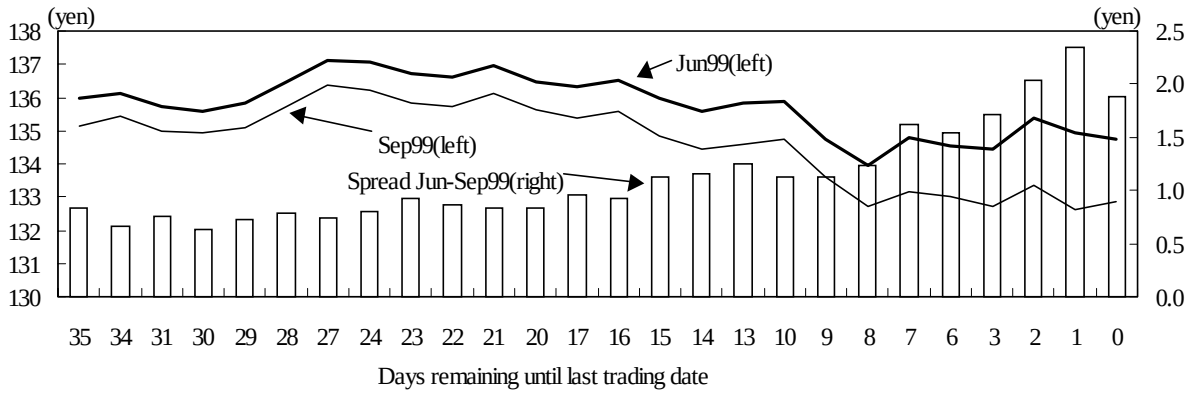
Market participants have pointed to a number of factors which may have caused the open interest on the *June 99 contract* to remain at a high level. These include (1) the rollover to *September 99 contract* was delayed as many investors were hesitant to create a position in it, as its CTD issue was the 20-year JGB 2nd issue. The 20-year JGB 2nd issue is critically small and its liquidity is low,[5] and (2) some market participants noted that the open interest on the June contract might have been intentionally boosted by creating a cross-position in the contract, i.e., buying and selling the issue, so as to put buyback pressure on the JGB 187th issue, which was the CTD issue for *June 99 contract*.

2.2.2 Change in the CTD issue for *June 99 contract*: from the JGB 187th issue to the 20-year JGB 2nd issue

Developments with respect to the CTD issue

The CTD issue for *June 99 contract* was originally the 10-year 187th issue. However, just several days before the change in the most active contract, the 20-year 2nd issue began to look less expensive due to the developments discussed in the previous section,[6] while the 187th issue suddenly became more expensive due to buybacks. Therefore, on June 8th 1999, the CTD issue switched from the 10-year 187th issue to the 20-year 2nd issue. The timing for CTD was unprecedented close to the final trading day. A large volume of short-basis positions had been taken in JGB 187th issue, i.e., taking a short position on 187th issue and long position on the *June contract*. The high liquidity of the 187th issue was regarded as a precondition for taking such large short positions. Therefore, the sudden emergence of delivery options prompted loss-cutting amongst those holding short-basis positions. Consequently, the basis spread suddenly expanded, as did the 'calendar spread' (inter-month spread), the price differential between *June 99* and *September 99 contract* (Chart 2-4).

Chart 2-4 Inter-month Spread Transaction between *June 99* and *September 99 Contract*



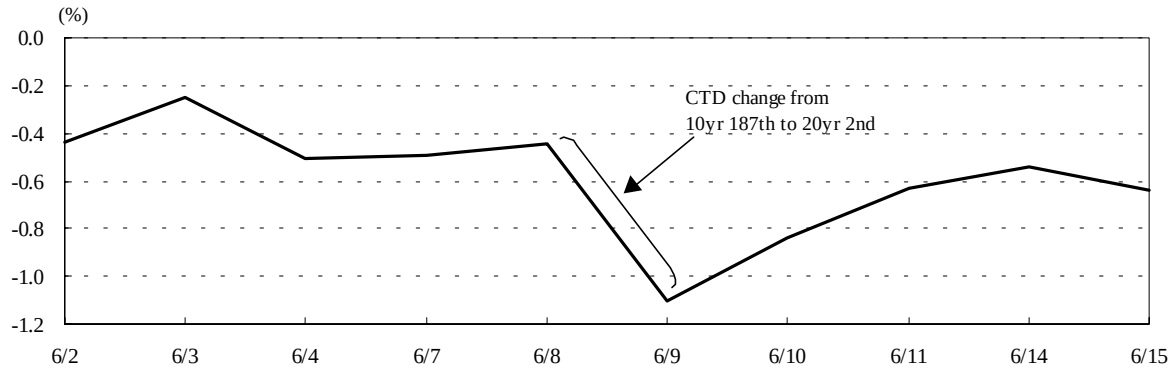
In this way, the 20-year 2nd issue became the CTD issue for *June 99 contract* just before the change in the most active contract. Accompanying this, in the repo market, an increase in borrowing needs

[5] Whereas the average amount of issues allocated to the private sector for long-term JGB with around seven years maturity is approximately 1-3 trillion yen, that for super-long bonds is no more than 400-500 billion yen.

[6] Market participants indicated that the fact that super-long bonds were excluded from deliverable issues for futures contracts settlement on the Tokyo Stock Exchange, as decided on March 16th 1999 and applied to futures contracts from the *March 00 contract* onward and that the 20-year JGB 2nd issue was excluded from the Bank of Japan's JGB purchasing operations offered from June 4th 1999 accelerated the relative cheapness of the 20-year JGB 2nd issue.

prompted the lending rate for the 20-year 2nd issue to rise sharply. This, in turn, caused the SC repo rate, which was already negative,[7] to decline sharply (Chart 2-5).[8]

Chart 2-5 The SC Repo Rate for the 20-year JGB 2nd Issue



Background

The fact that open interest on *June 99 contract* remained at a high level until just before the final trading day, as discussed in the previous section, is also believed to have had a major influence on the changeover in the CTD issue. Open interest on *June 99 contract* remained at around 15 trillion yen until just prior to the final trading day, which was very high in comparison with approximately 8 trillion yen for the CTD issue, namely the JGB 187th issue. As a result, market participants holding short positions on futures gave serious consideration to the risk that they would not be able to deliver the cash bond to settle their futures position,[9] which led to a sudden jump in buying pressure on the JGB 187th issue.

2.2.3 Use of yen-yen swaps as an alternative in response to the decline in the efficiency of hedging with futures

Market developments

Approaching June 10th 1999, the final trading day for *June 99 contract*, in the yen-yen swaps market, swap rates rose sharply in the long-term nine to ten year maturity zone in particular. Although the

[7] There are two types of repo transaction: General Collateral (GC), where the issue is not specified, and Specific Collateral (SC), where a specified cash bond is lent. The repo rate is defined as [repo rate] equal [interest rate minus lending rate for the issue]. When the lending rate rises sharply in response to an increase in borrowing needs for a certain issue, the issue is regarded as become 'special'. Under the current interest rate environment, the lending rate charged on the cash bond tends to exceed the interest rate (interest rate < lending rate for the cash bond) for SC trading where specified issues have become special and SC repo rates are constantly negative.

[8] Market participants also noted, as background to the growing needs for borrowing following the change in the CTD issue, the difference in the treatment of taxable and non-taxable bonds in the cash delivery of futures contracts. On the Tokyo Stock Exchange, when a cash delivery is made, if the buy-side requires a bond which is taxable and the short side cannot deliver a cash bond which is taxable, then the sell-side has to deliver a non-taxable bond for the same price as a taxable bond. As the income tax for the interest rate is subtracted from accrued interest in this case, the taxable bond is cheaper by the tax amount. Ordinarily, the effects of this are negligible because accrued interest does not exist, owing to the interest payment for the CTD issue being the same as the settlement day for futures. For *June 99 contract*, however, the fact that the 20-year JGB 2nd issue had a high coupon (5.7 percent) and the income tax on this interest was not negligible at roughly 0.29 yen for every 100 yen may have prompted futures buybacks.

[9] As the open interest on *June 99 contract* remained at a high level until the final trading day, there was a greater possibility that a sizeable amount of futures contracts would be settled by the physical delivery of the CTD issue.

spread for JGBs temporarily shrank to around 35bps on June 5th 1999, it subsequently expanded again to roughly 45bps. The average spread during January to March 1999 was generally just under 30bps. In addition, while swap rates in the medium-term zone temporarily rose following the preliminary January to March GDP announcement on June 10th 1999,[10] in part reflecting the relatively limited liquidity in comparison with bond futures, they subsequently declined rapidly.

Background

Some investors and dealers chose to avoid using futures as a means of hedging their bond portfolios or trading positions because there was concern over the settlement of *June 99 contract*, as well as the *September 99* and *December 99 contracts* for which there was concern over the possibility of a short squeeze. This stimulated moves to switch part of their bond futures investments into swaps.

Market participants point out, though, that as (1) counterparty risk for both sides is reflected in interest rates and as (2) market liquidity is low and it is difficult to handle large-lot orders, the efficiency of hedging with swaps is limited.

2.3 Turmoil in the repo market accompanying the changeover in the most active contract and the Y2K problem (August 1999)

In August 1999, an unprecedented contract changeover took place, with the most active futures contract changing from *September 99 contract* to *March 00 contract*, bypassing *December 99 contract*. Following this, sparked by rumors that "public funds would not be engaged in repo transactions (lending bonds) over the year-end because of concerns over the Y2K problem", SC repo rates, starting with CTD issues, dropped for a wide range of issues, and reached lower than minus 200bps. Under these conditions, liquidity in the JGB cash market suddenly contracted, as many market-makers managing their risks on a daily basis wound-down their positions to cut losses.[11]

2.3.1 Change in the most active contract from *September 99* to *March 00 contract* (skipping *December 99 contract*)

Market Developments

September 99 and *December 99 contracts* were hampered by their reduced efficiency as a means of hedging and also liquidity problems, because market participants did not show much interest in them since the CTD issue was the relatively illiquid 20-year bond.[12] However, 20-year bonds have become ineligible as deliverable issues for futures settlement from *March 00 contract*. Therefore, in an unprecedented move, on August 9th 1999, the most active contract shifted from *September 99* to *March 00 contract* (final trading day, March 9th 2000). This was unprecedented in two ways. First, it was much earlier than would ordinarily be expected, and second, *December 99 contract* was bypassed. However, no consensus among market participants was reached with regard to the price for *March 00 contract* even after this switch in the most active contract, due to the difficulties in calculating fair value as shown below. As a result, the basis, which is the difference between cash and futures prices, continued to fluctuate.

[10] The announced GDP figure was 7.9 percent year on year, which greatly exceeded expectations. Prior to the official release of the figure, the most bullish forecast in the market was about 2.0 percent.

[11] Companies may set in-house rules, for example, that long or short positions which are exposed to risk should be closed almost automatically when expected losses on bond transactions for a certain department or dealer reach a pre-determined level, in order to avoid a further accumulation of losses.

[12] Relatively illiquid 20-year JGBs were deliverable against *September* (the changeover from *June* to *September contract* took place on June 8th) and *December contracts* (the 20-year JGB 2nd issue was the CTD issue). This made these futures contracts less attractive to market participants as "they were not best suited for hedging purposes because of concern over physical delivery at settlement".

Background

The instability in the bond futures market at the time is attributable to two points:

a) In calculating the fair value of futures and the repo rate, for which there is a non-arbitrage relationship with futures, is an important indicator. It is, however, difficult to create a long-term repo extending over seven months, such as that from September 1999 to March 2000 so as to create an arbitrage position with the futures contract at the time, because transactions in the repo market are mostly short term (Box 1).

b) The term from September 1999 to March 2000 included the 1999 year-end, which coincided with the period when concern over the Y2K problem, heightened.

The demand for cash bond purchases among large institutional investors such as insurers, public funds, and city banks that needed a sound investment vehicle and collateral to manage their portfolios, remained strong. However, their purchases were concentrated on on-the-run issues (the most recently launched issues) which had more liquidity in comparison with off-the-run issues and could easily be sold whenever the need arose, and on JGB 192nd and 193rd issues, which were the CTD issues for *March 00 contract*.

Institutional investors were purchasing cash bonds on the one hand, and selling large volumes of futures on the other in order to hedge against the risk of a rise in interest rates. Therefore, the CTD issue looked relatively cheap compared with the issues with similar remaining life. Investors, then, increased buying pressure on the CTD issue because of its cheapness, and so short positions were created among dealers. However, as investors did not actually sell the CTD issue, the basis between cash and futures prices expanded, the repo rate rose, and dealers took steps to cut their losses. The behavior of dealers up to this point, that is building short positions in cash bonds and long positions in futures, may have been, in part, a reflection of their overconfidence in the efficiencies of markets. (1) Dealers did not foresee much concern regarding the liquidity of JGB 192nd and 193rd issues from the standpoint of amount issued (1.3 trillion yen and 3.0 trillion yen, respectively), and (2) they expected liquidity and hedging efficiency to improve after the changeover to *March 00 contract* albeit the period to settlement was long at seven months, and thus believed that the next change in the most active contract would not pose a problem.

Few repo dealers tried to exploit the arbitrage opportunities between the implied repo rate for CTD issues (JGB 192nd and 193rd issue)[13] and the actual repo rate through relative value trading. This arbitrage opportunity stemmed from the expansion in basis as cash bonds became relatively expensive with an increase in the specific cash bond purchasing needs of institutional investors as described above, and as futures became relatively cheap. Such arbitrage activity was not sufficient to make market movements less volatile, e.g., lead to a reduction in basis.

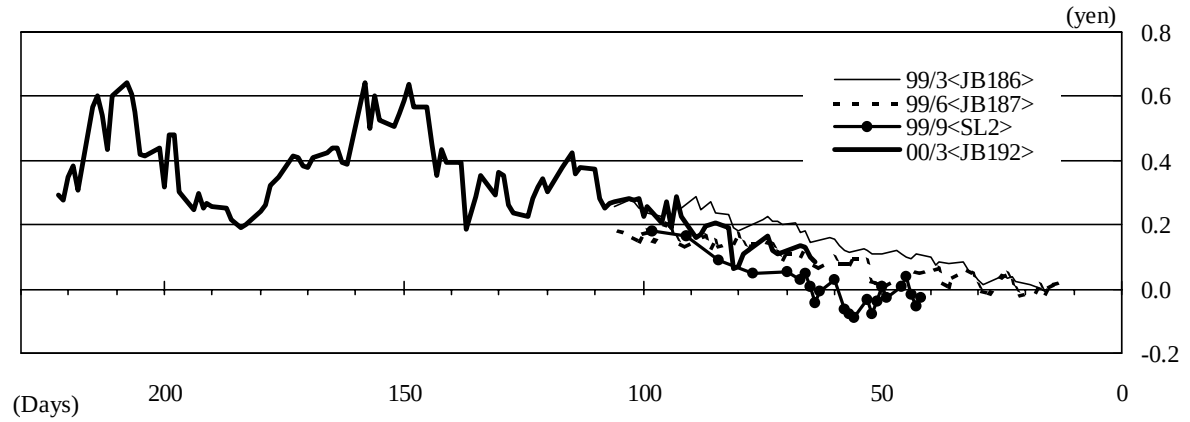
Box 1 Influence of *December 99 contract* being skipped on the CTD issue for *March 00 contract*

The futures market plays a key role in price formation in the cash bond market. The CTD issue, which moves in close relation to futures, provides a strong link between the two markets. The price differential between futures and the CTD issue (CTD net basis: CTD forward price minus futures price times CTD conversion factor) is an important indicator when gauging the relative cheapness of cash bonds and futures. It is also used to measure the efficiency of hedging through the conversion factor (hereafter CF), and to assess arbitrage opportunities using repos. Net basis for the CTD issue converges on zero on the settlement day for futures contracts. In other words, the forward price (on the settlement day this conforms with the cash bond price) and the delivery price (final settlement

[13] 'Cash and carry' is a popular arbitrage in government bond markets. It entails taking a long position in cash bonds and short position in futures. A 'Cash and carry' position matched with repos becomes profitable when the actual repo rate is not the same as the implied repo rate; a theoretical repo rate calculated assuming a non-arbitrage condition, where arbitrage opportunities do not exist. Arbitrage with repos involves delivery risk, which materializes when the CTD issue changes.

price times CTD CF[14]) become the same. Under the current market environment, net basis usually takes on a positive value and approaches zero as time passes. In the case of *March 00 contract*, as the period until the settlement day was longer than usual, the net basis started at a higher level than usual (Box Chart 1). Since market participants had no pervious experience in dealing with a most active futures contract that had more than six-months remaining life, and there was not such a long term repo rate to determine the appropriate CTD spot rate, the net basis became very volatile.

Box Chart 1 Developments in CTD issues' net basis for four futures contracts



Note: For the net basis for 10-year 186th and 187th issues, the GC rate is used to calculate the forward prices instead of the SC rate. As such, their figures are slightly higher than those for the 20-year issue and 10-year 192nd issue, for which the SC rate for CTD issues has been used.

2.3.2 Turmoil in the repo market prompted by rumors surrounding repo trading over the year-end

Market developments

Before mid-August 1999, many market participants had created short positions in cash bonds, assuming that large institutional investors, such as insurance firms and public funds would continue repo trading (bond lending) as normal. However, following rumors that surfaced around August 12th 1999 that "some public funds would not be lending bonds over the millennium", market participants became concerned that "public funds in general would not be effecting repos that extended over the year-end". The market was already nervous regarding market liquidity for bond futures when *March 00 contract* had become the most active contract, and thus these rumors fueled concern about the cash bond market overall. Such concern accelerated moves to close existing positions (described below), causing sudden changes in both futures prices and repo rates.

Background

The following two factors have been highlighted as having contributed to the instability in the repo market.

a) Dealers who had created short-basis positions as described in the previous section closed their positions (by buying back cash bonds, selling futures) in response to the rapid expansion in basis, leading to a further expansion in basis. In this way, a chain of events was triggered where implied repo rates, which were already negative, fell further (a sudden rise in the cash bond lending rate) and cash bond prices rose sharply.[15]

[14] This calculation does not include accrued interest for the period when the futures contract had been bought, which needs to be added to this to make it strictly accurate.

[15] At first, cash bond prices rose and SC repo rates fell sharply, centering on JGB 192nd and 193rd issues, which were the CTD issues for *March 00 contract*. With time, though, the fall in SC repo rates spread to on-the-run issues. See Section 4.2.2, period V.

b) At the same time, some repo dealers who had built up short positions in repos (the long-term lending of cash bonds) were faced with a situation where they had to cut losses under the loss-cut rules as losses expanded due to the sharp fall in repo rates (a sudden expansion in basis means that cash bonds become relatively more expensive and futures relatively cheaper). Dealers were forced to rapidly close existing repo short positions which contributed to further declines in repo rates.

3. Market Participants' Behavior and Market Micro-structure – Main Findings of the Survey

Both the downward trend of market liquidity since 1998 and also the stress in JGB markets which started with a shock in the repo market in mid-August 1999, stemmed from and in turn stimulated various behavior of market participants reflecting their different incentives. Defining the relationship between observed market dynamics and participants' behavior is by no means easy. In this section, we examine market participants' behavior and market micro-structure which greatly affected market dynamics during this period, based on the findings of our survey and interviews.

3.1 Market makers' behavior

The fall in market liquidity since 1998 is partly attributable to a decline in market makers' ability to supply liquidity to JGB markets. The smooth price formation and increase in liquidity in JGB markets seen in the mid-1990s were supported in part by aggressive entry into the market by internationally active investors as well as market makers targeting room for arbitrage, including hedge funds. It was observed that such investors and market makers tended to withdraw from the markets in the aftermath of the series of international financial crises triggered by the near collapse of LTCM. Their withdrawal shed light on the structural problem of JGB markets, that is, there were not various market participants taking advantage of the arbitrage opportunity which potentially existed in the markets, contributing to making the market efficient. The Y2K problem amplified further structural problems. That is, the unstable expectations of market participants due to the Y2K problem enlarged distortions in cash market, price formation with an overemphasis on futures, and the immature repo market. The enlarged distortions increased hedging and inventory risk (i.e., the costs associated with market making), resulting in a further decline in market liquidity. The following four types of behavior exhibited by market makers were the keys to this process.

(1) Less willingness to take risks, due to the intensification of competition and instability in the financial system in the autumn 1997 and the autumn 1998.

A series of financial system reform laws were implemented in April 1993, which, for example, permitted financial institutions to undertake both banking and broking operations. Following this, between June 1993 and November 1994 in particular, bank-affiliated stockbrokers moved into the bond market, and the subsequent increase in the number of market participants contributed to intensified competition. As a result of this increased competition, coupled with the blow dealt to earnings by the plunge in the market at the end of 1998, the willingness of domestic market makers to take risks sharply contracted. In addition, the number of arbitrageurs, e.g., arbitrage-related hedge funds, aggressively taking risks on 'market anomaly' markedly decreased. This reflected a severe impairment of their capacity following the Russian crisis, as demonstrated by the near collapse of LTCM. The turmoil in JGB markets in August 1999 made market participants limit their JGB market exposure even when a sharp decline in SC repo rates (which were already negative) presented them with opportunity to generate profits. Therefore, arbitrage opportunities continued for a while, resulting in an inefficient market where fair prices based on arbitrage conditions could not be found.

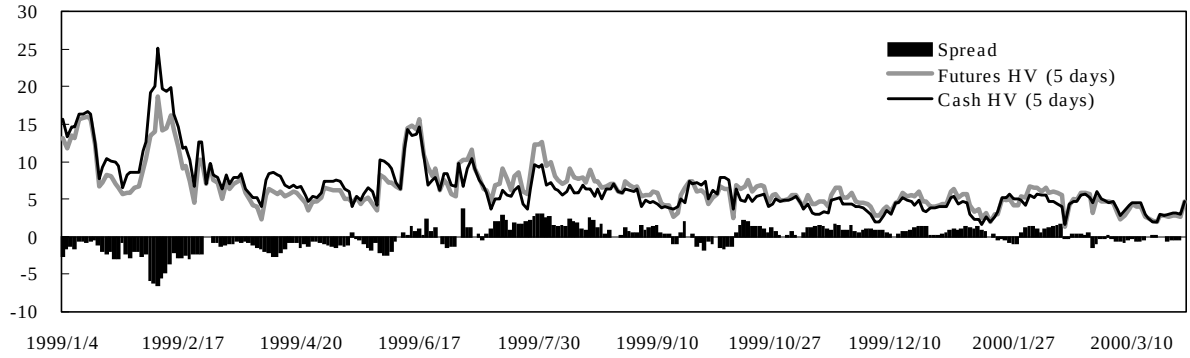
(2) Decline in hedging efficiency of JGB futures – Hedging by cash or avoiding cash delivery for settlement of futures contracts

Many market participants pointed out that "from *June 99 contract*, for which the super-long bond was one of the deliverable issues for futures settlement, the non-arbitrage conditions and interrelation between cash and futures deteriorated, and the hedging efficiency of JGB futures declined." Accompanying this, a growing number of market participants found that "profits and losses management made it difficult to inflate positions due to the increase in hedging errors". Market participants as a whole showed an increasing tendency to sharply reduce their cash and futures positions. It was also pointed out by some that "due to the deteriorating non-arbitrage relationship between cash and futures, the daily fluctuation in the cash and futures yield spread was approximately

three times greater than before the summer of 1998 (i.e., the risk was three times greater for a position of the same size)" (see Chart 3-1, and Box 2).

Reflecting the decline in hedging efficiency, some market participants "hedged their cash bonds not by futures but by cash bonds with close remaining life", and laid down an internal rule that "in principle, physical delivery for futures settlements would be avoided".[16]

Chart 3-1 Historical Volatility for Cash and Futures



Note: In this chart, the historical volatility of a cash bond (HV cash) refers to that of a 10-year on-the-run bond. Historical volatility of futures (HV futures) refers to that of the CTD issue with seven-year remaining life. In the case the yield curves for both cash and futures show a parallel shift (move in the same direction and magnitude), the volatility of seven and ten-year yields must be the same. However, the higher coupon for futures at 6 percent makes the duration for futures shorter than the ten-year on-the-run issue. Therefore, the price volatility of futures is usually less than that of 10-year bonds. This was not the case in the market from June 1999 when the relationship was reversed, and this situation continued until the end of the year.

(3) Greater reluctance to take risk in response to higher volatility of daily earnings

Before 1998, futures prices moved with relative stability in relation to CTD issues because a large number of players participated in the market. However, due to factors including the decline in arbitrageurs discussed in point (1) above, market liquidity declined and volatility increased, leading to a further decline in the number of market participants. Thus, a vicious circle emerged. Consequently, distortions in prices were not corrected, and there was an increasing tendency for even a small shock to create an excessive trend in one direction. Some market participants revealed that "even when clear arbitrage opportunities existed, they chose not to take a position as the daily fluctuations in earnings marked to the market were too large." In the background to this behavior, many foreign participants laid down an internal rule that "investment decisions should be carried out based on [expected earnings from a position] divided by [the standard deviation of daily earnings generated through that position], and when this was excessively low for certain transactions (high denominator, in other words high daily earnings fluctuations), no matter how high a profit these transactions might yield (high numerator), they should refrain from trading". In the case of *March 00 contract*, one market participant responded that "they could most likely earn 100 million yen in March next year if they sold, but that they could not sell because they could not afford temporary losses of 100 million or 200 million yen that might be incurred on a daily basis when mark-to-market evaluation is used" (Box 3).

(4) Continually modifying the pricing model

As a decline in liquidity in the JGB cash market was noted as discussed in the previous sections, many market makers indicated that "most methods they had been using to estimate theoretical yield curves became inappropriate." That is to say, they perceived "wide disparities in investor appetite according

[16] The performance analysis of the various pricing methods in Section 4.1 gives quantitative evidence of such behavior.

to the attributes of individual issues, such as the coupon rate and degree of liquidity", and therefore, "price differentials emerged due to disparities in supply and demand for individual issues".

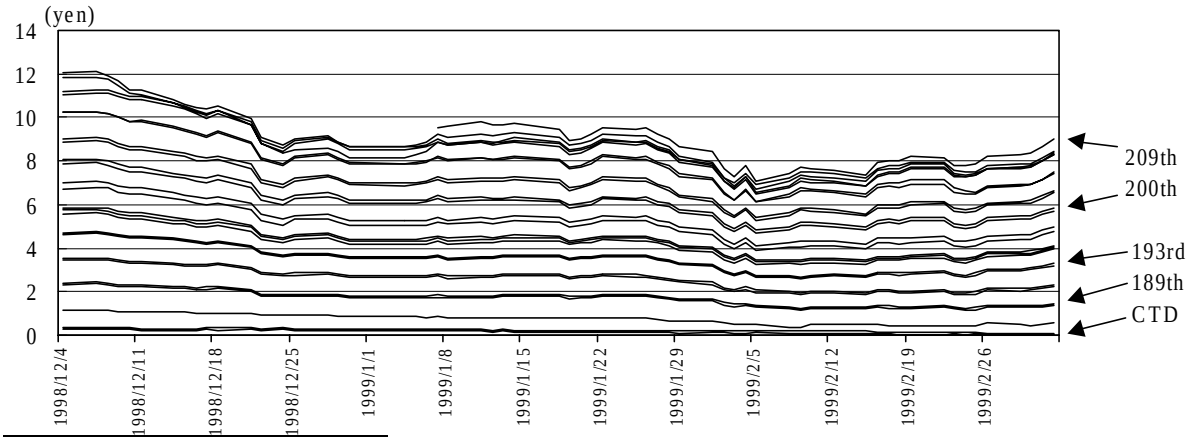
Dealers typically carry out daily transactions based on a pricing model which reflects the attributes of individual issues using price data which prevailed in the inter-dealer market. Each company follows its own pricing model. However, when the arbitrage relationship between individual issues and between markets becomes unstable, the performance of these models also becomes unstable. Therefore, a large number of participants responded that they make continuous revisions, by, for example "ascertaining the most influential factor at the time, and incorporating it into the model". (See Section 4 on pricing methods for a more detailed discussion).

Box 2 Decline in hedging efficiency of JGB futures

The volatile movements in CTD net basis as seen in Box 1 also had a negative impact on price stability of other issues and on their hedging efficiency. As the relationship between futures and CTD issues became unstable, the relationship of futures and other cash bonds, which are linked with CTD issues through the yield curve, also became unstable. Thus, hedging cash bonds using futures became increasingly unreliable. When using the conversion factor (CF) to hedge cash bonds, it is assumed that the basis will not fluctuate.[17] In reality, the basis does change, and therefore CF hedging entails basis risk. Usually, basis fluctuations are influenced mainly by changes in the slope of the yield curve or changes in the overall yield, but for *March 00 contract*, fluctuations in the basis for CTD issues had a major impact on basis fluctuations across all issues (Box Charts 2-1 and 2-2).

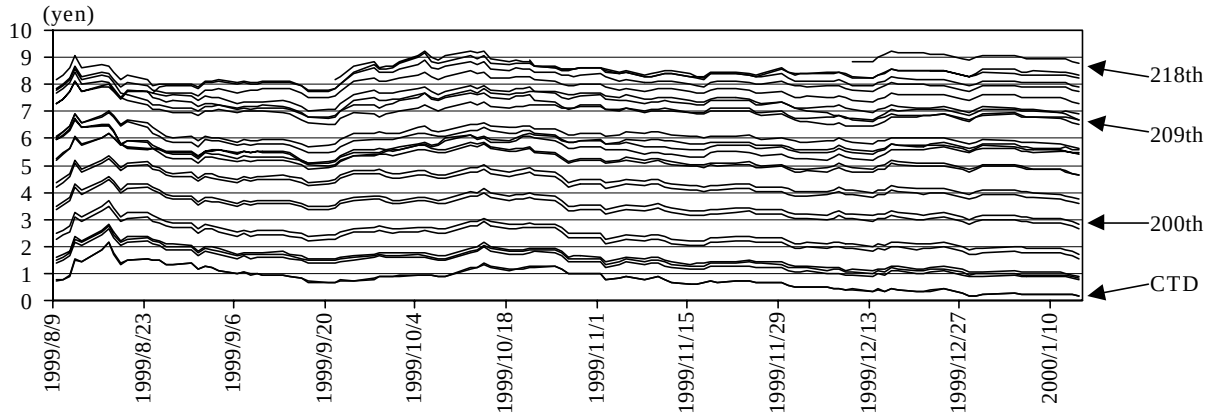
Looking at *March 99 contract* as an example of what usually happens, the net basis for CTD issues was extremely low in comparison with other issues' net basis. In addition, any fluctuations in the basis for the CTD issue had a very limited impact on other issues' bases. Net basis fluctuations were essentially determined by the shape of the yield curve, which steepened until February 1999 and flattened out in February, and the level of yield. Box Charts 2-3 and 2-4 show the factors behind net basis fluctuations. The effects of each factor on CTD net basis fluctuations are given in detail in this chart. For example, while yield curve factors exerted the greatest influence on basis fluctuations in January 1999, the CTD issue basis factor only had a limited effect. In contrast, in September 1999, both CTD issue basis and price level factors had a major impact. In addition, changes in the yield curve had different degrees of influence on adjacent issues, although such influences are usually equal. The factors behind this include the decrease in liquidity in the cash bond market and the unstable relationship between cash bonds and futures, which are likely to have caused the cash bond yield to diverge from the theoretical yield. This phenomenon can also be observed in the decline in spline fitness discussed later in Section 4.2 (Chart 4-6).

Box Chart 2-1 Net Basis Movement for *March 99 Contract* (deliverable 10-year bonds for futures settlement: CTD issue was the JGB 186th issue)



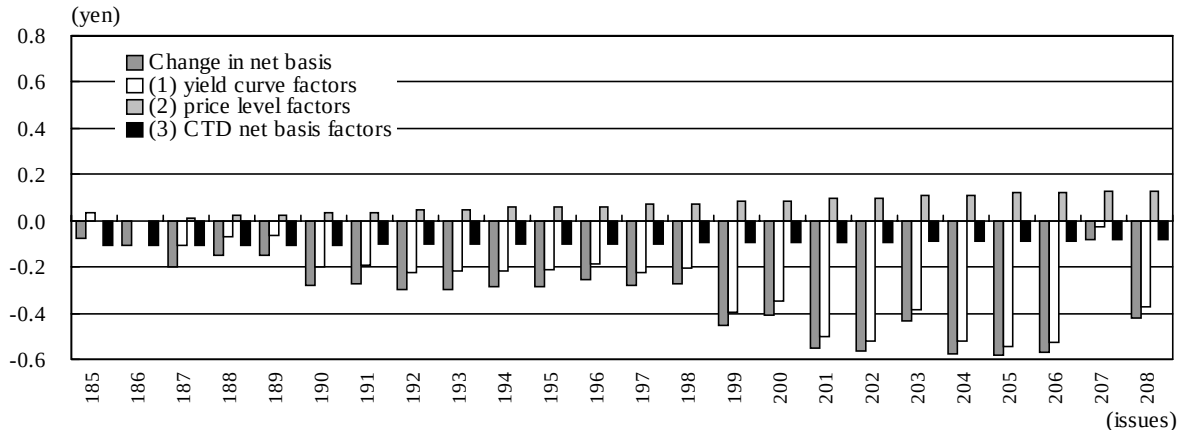
[17] There are other hedging techniques, including duration ratios and regression analysis.

Box Chart 2-2 Net Basis Movement for *March 00 Contract* (deliverable 10-year bonds for futures settlement: CTD issues were the JGB 192nd and 193rd issues)

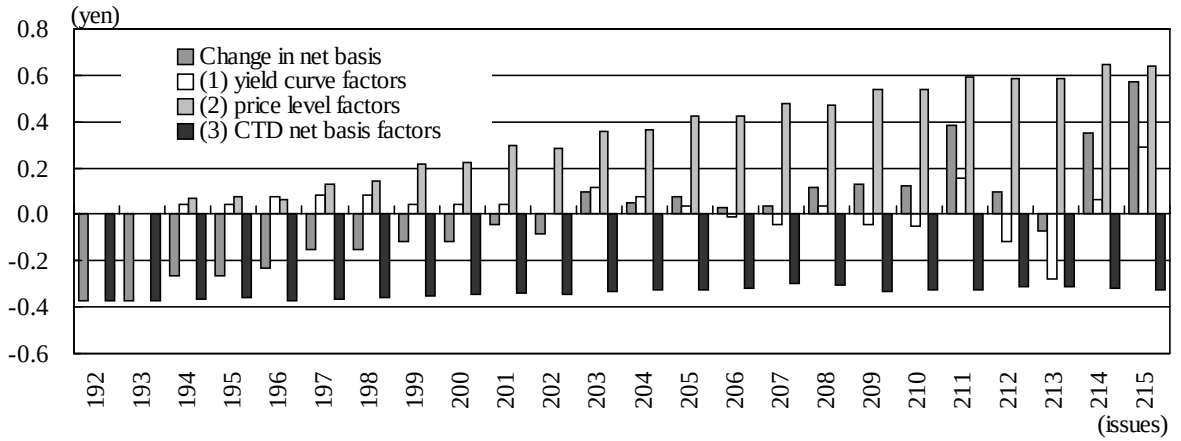


Note: The GC rate is used in the forward price calculation in the net basis equation, and so for issues on special, net basis is slightly on the high side.

Box Chart 2-3 Breakdown of Factors behind Changes in the Net Basis (*March 99 contract*, in January 1999)



Box Chart 2-4 Breakdown of Factors behind Changes in Net Basis (*March 00 contract*, in September 1999)



Note: In the factor breakdown, total differential calculus was applied to net basis $NB(i)$, where (i) denotes a certain issue. Using this, the change in cash bond prices $dS(i)$ (where $S(i)$ represents cash bond prices for a certain issue) was replaced by the product of the changes in yield-to-maturity $dr(i)$, modified duration $(\partial S(i)/\partial r(i))$, and price $(S(i))$. This leaves factors related to (1) changes in carrying cost (change in repo

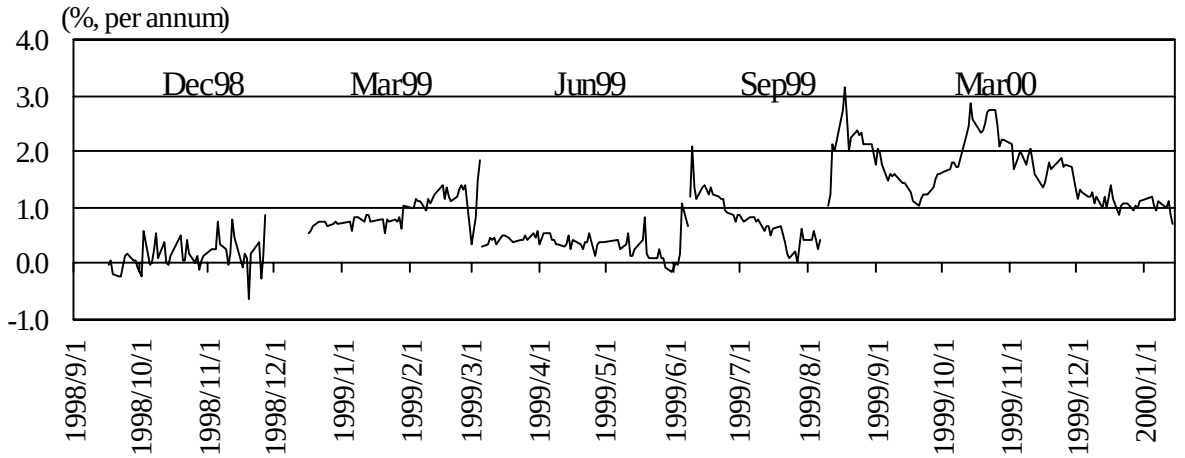
rate and effect of time) and (2) tracking errors for the convexity portion. These are included in *others*(*i*). Effects of price (yield) level factors are measured using CTD as a comparison point. The formula is as below. The first term (first underlined part) corresponds to yield curve factors, the second term (second underlined part) to price level factors, and the third term (third underlined part) to effects of changes in CTD net basis.

$$dNB(i) = \{\partial S(i)/\partial r(i)\} * \underline{(dr(i)-dr(CTD))}$$
$$+ [\{\partial S(i)/\partial r(i)\}/\{\partial S(CTD)/\partial r(CTD)\} - CF(i)/CF(CTD)] * \underline{dS(CTD)}$$
$$+ CF(i)/CF(CTD) * \underline{dNB(CTD)}$$
$$+ others(i)$$

Box 3 Increased risk for basis trading

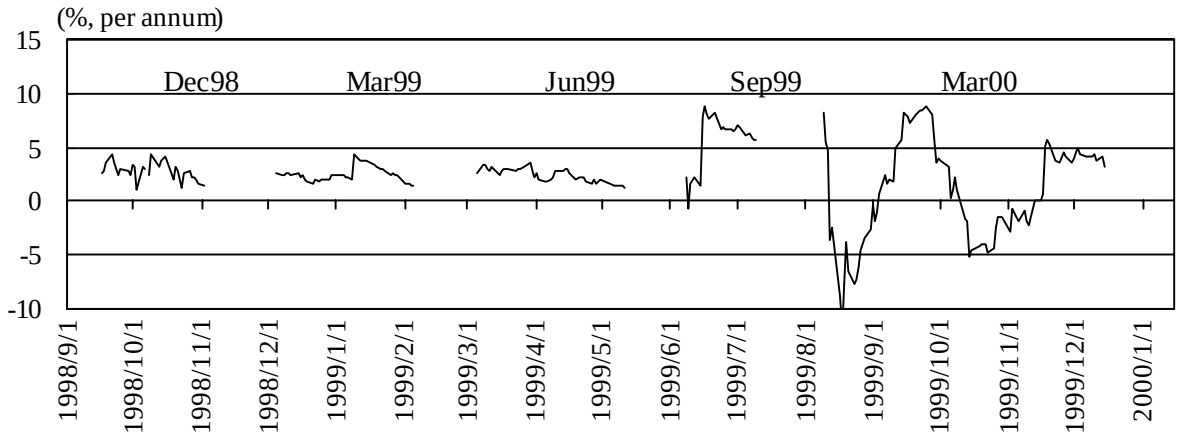
Short basis trading for CTD issues (combination of short position on cash bonds and long positions on futures) synthetically produces the same cash flow and cash bond transfer as repo trading.[18] Therefore, short basis is often used in arbitrage transactions with repos. As net basis starts positive and converges on zero, it is relatively easy to generate positive returns with a short basis trading. Box Chart 3-1 shows the rate of return for the term when short basis position was maintained until the settlement date for the futures contract. Although volatility in the rate of return is high, taking such a short basis position seems profitable at first glance, as the rate of return is also high. However, calculating the rate of return over a one-month period reveals that the volatility in the rate of return rose considerably from June (Box Chart 3-2). This means that the market value of the short basis trading was more volatile than indicated from the rate of return for the full period until the settlement date. The averages and volatility for the rate of return as shown in Box Chart 3-3, also indicates that the level of risk in relation to return was conspicuously high for *March 00 contract*, when looking at the rate of return over a one-month period. Such volatility in the returns of short-basis trading implies an increase in losses in the period. This led to the closing of positions to contain losses (loss-cutting), which, in turn, led to a reduction in arbitrage trading.

Box Chart 3-1 Rate of Return on Short Basis Positions for the Full Period (when positions are closed through physical delivery)

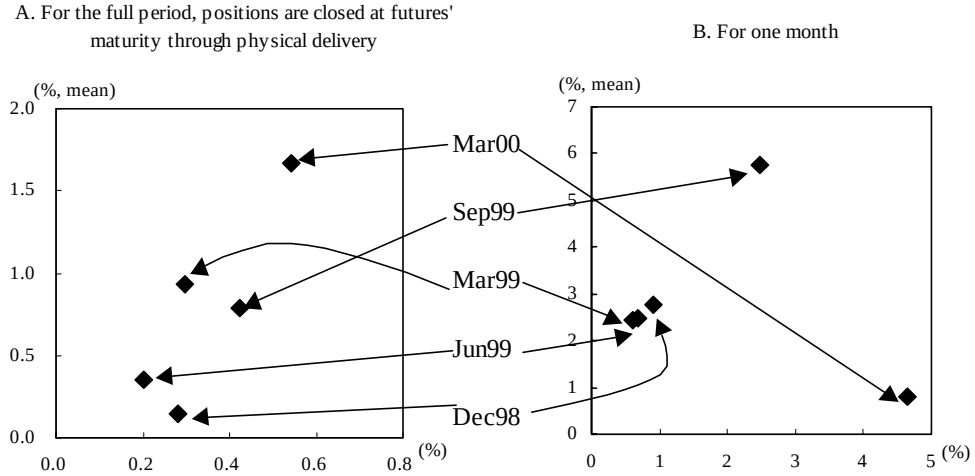


[18] Considering the possibility of a change in the CTD issue, a premium is added to short basis trading. This premium arises from the delivery risk that the issue delivered will be different to the issue which was borrowed through a repo transaction and sold in the cash bond market. In the current interest rate environment and long-term JGB futures scheme, delivery risk is low and is generally not taken into consideration.

Box Chart 3-2 Rate of Return on Short Basis Positions for One Month



Box Chart 3-3 Mean and Variance in Rate of Return on Short Basis Positions



3.2 Investors' Behavior

While market movements were volatile as discussed in the previous section, the behavior of Japanese investors was fundamentally unchanged. This is believed to have been another factor contributing to the decline in market liquidity and efficiency. On the other hand, as dealers experienced higher risks on earnings as aforementioned, they began to charge higher transaction costs to investors. This has contributed to an increase, albeit gradual, in the level of price responsiveness in investor behavior. Three typical investor behavior patterns are identified.

(1) Tendency for investors to prefer current yield

Reflecting such factors as the current accounting system, institutional investors tend to emphasize the current yield. However, investors are gradually moving to market price based decision-making as dealers have a greater tendency to add transaction costs to prices they charge investors reflecting increasing balance sheet constraints.

(2) Instability in repo rate resulting from concentration in market participants' cash bond holdings

Cash bonds held by investors, including financial institutions, tend to be focused on certain issues. In addition, many of these investors are conservative with regard to lending bonds in the repo market, or have internal limitations on their dealings with regard to repo transactions. As such, liquidity in the

repo market is not to satisfy the demands of dealers to obtain cash bonds to cover their futures short positions, for example.

In addition, some market participants indicate that ”arbitrage efficiencies in the market are eroded by the fact that many investors do not apply ’mark-to-market’ accounting to manage their profits and losses in repo transactions, and thus do not unwind their positions by borrowing cash bonds even when the value of the bonds which they have lent falls sharply” and also that "such investors do not take note of arbitrage opportunities to begin with”. On the other hand, dealers tend to close their short positions when the value of cash bonds that they have lent declines, as stop-loss rules come into play. If many dealers close their positions at the same time (as seen in the mid-August 1999, referred to in 2.3.2), repo market conditions could become excessively volatile given present insufficient liquidity.

(3) Investors use the options market mainly for speculative trading, rather than for hedging purposes

Many investors do not use JGB-related options trading for speculative reasons at present, and few institutional investors use it as a means of hedging.

3.3 Market microstructure

Each market has a distinct microstructure borne out of its history. In this section, the focus is on microstructure which induced turmoil in the market and changed after market turmoil.

3.3.1 The repo market

(1) Long-term repo contracts are not actively traded

Long-term contracts, for example three-month contracts, are not often traded in the repo market. Some market participants noted that in the formation of rates for long-term repo contracts, the cut-off rate for Bank of Japan’s repo operations acts as a kind of benchmark. As a result, if, as discussed in Section 2.3.1, the period to the next settlement day for the most active futures contract is extended to seven months, then the price discovery in the repo market suddenly deteriorates. After experiencing market turmoil, long-term trading is gradually picking up. This is contributing to greater diversification in the futures market, with, for example, trading in *June 01 contract* increasing from mid-January 2000.

(2) Repo trading as a tool for hedging dealers' cash bond positions

The repo market is still, more than anything else, a tool used by dealers to cover cash bond positions created as a result of cash bond trading ’Repo books’, which are actively traded among investors in the US, for example, are still in relatively limited use in the Japanese market. ’Repo books’ involve a combination of repo and reverse repo transactions. ’Matched book’ trading is the most popular, where funds procured at a low rate of interest by offering issues which have gone special and have high lending rates are simultaneously invested in instruments carrying high interest rates in a reverse repo transaction. The reasons why matched book trading has not been widely adopted in the Japanese market include the lack of clear rules and practices for delivery fails[19] and the limited entry of

[19] In regard to fails, the Japan Securities Dealers Association published “The Guideline for Real Time Gross Settlement of Government Securities Transactions” (“The Guideline”) in December 2000, in preparation for the Bank of Japan’s introduction of real time gross settlement (RTGS) at the beginning of 2001. Guidelines concerning fails in “The Guideline” consist of (1) definition of a fail, (2) good-faith effort to resolve a fail, (3) conditions to guidelines concerning a fail, (4) policy regarding costs incurred under a fail, (5) application of a fail based on establishment of a cut-off time, and (6) policy regarding payments and receipts in the case of internet payment and redemption prior to the resolution of a fail. At the time of the study in 1999, however, no rules existed for fails, defined as “a situation whereby a party

investors into the repo market. Liquidity in the repo market is expected to improve once the appropriate market environment has been put in place e.g., once market rules have been laid down.

(3) Difficult to predict which issues will go special

One further reason why 'matched book' trading discussed under (2) above has failed to become active in the Japanese market is that, "in general, it is difficult to predict whether a particular issue will go special". If it were easy to predict whether a particular cash bond would go special, then it would be possible for dealers to make sure profits through 'matched book' trading. However, there are many factors determining whether an issue will go special, including the volume of the issue held by investors, the volume of the issue in circulation in the market, and investor investment trends. As such, the risks involved are high, and it is difficult for dealers to take on a large position. Meanwhile, in the US, issues with the potential to go special are usually limited to on-the-run issues and the two preceding issues.

3.3.2 The cash market

(1) Lack of procedures to deal with delivery fails

As there are no rules and practices to deal with cash bond delivery fails as of end-1999, "some investors aim to cause a squeeze on certain issues". They "tie up an excessive amount of an issue by intentionally buying a large quantity of a specified issue and not provide it in the repo market (causing lending rates to rise)". In such cases, market participants who hold short positions in the issues that are not available in the market because of the squeeze may be forced to unwind their positions. This could, for example, lead to wider bid-ask spreads in trades between dealers and greater fluctuations in market prices.

(2) Only the most recent issues are highly liquid

The majority of dealers concede that "only on-the-run 10-year bonds and recent issues have enough liquidity for over the counter transactions". Most dealers consider the liquidity for CTD issues and surrounding issues to be insufficient.

(3) Investor behavior distorts the yield curve

As some investors only trade specific issues (market participants frequently point to public funds in this connection), striking differences in yield are created even for neighboring issues with almost the same remaining life and coupon. These distortions in the yield curve are often left uncorrected due to the absence of arbitrageurs.

(4) Kink in the yield curve in the seven-year zone

The yield curve is currently showing a kink at around the seven-year zone, which contains the CTD issues. The rates in the zone below seven years show a relatively strong correlation with swap rates; and the rates in the shorter maturity zone show a strong correlation with interest rate futures rates. Recently, the medium-term zone, which covers issues with around five-years maturity, has been sensitive to trends in the economy and financial policy, reflecting market participants' outlook on interest rates, for example (the same is true for the US). This is attributable to active trading in the medium-term zone, reflecting a pick-up in demand from both market participants who want to buy and issuers who want to sell, as for example the government's greater emphasis on shorter term borrowing.

---

receiving government securities has not received delivery of the relevant securities from the delivering party after the end of the settlement date".

(5) Issues to be solved in the primary market

Supply and demand conditions are currently unstable owing to various factors. For example, by amount, a large share of issues is concentrated in long-term bonds. Each issue amount is small, and varies from issue to issue. As a result, distortions in the yield curve are amplified.

To contribute to increasing market liquidity, reopen was introduced since March 2001 issue of 10-year government bonds.

3.3.3 The futures market

(1) Futures market is not strongly tied to the cash market

Some market participants noted that liquidity in the futures market is high in comparison with the cash and repo markets. This could also mean that the JGB markets are "over-dependent on futures, which offer relatively high liquidity and superiority in terms of price discovery". In normal market conditions, both markets are linked by one or two CTD issues. However, when the JGB market is under stress how fragile this link is becomes evident.

(2) Effects of lowering the coupon on underlying bonds for futures contracts

There are two views concerning lowering of the coupon on issues underlying futures contracts. First, it is simpler for dealers to explain payoffs to customers, for example, when the CTD issues are fixed and there is no need to be concerned over delivery options. The lowering of the coupon may also be contributing to adding liquidity to the cash bond market, as there is less likelihood of a squeeze, accompanying an expansion in the number of candidates for CTD issues.

4. Pricing Methods

In this section, the methods chosen by market participants when setting prices for JGB cash bond issues will be examined through simulations based mainly on market participants' responses to questionnaire and interview questions. Then, using spline curve analysis, the degree of consistency in JGB prices under stress will be explored.[20]

4.1 Simulation of cash bond pricing

A simulation of cash bond pricing is conducted based on the assumption that "the prices observed in the market are a true reflection of market participants' pricing behavior". If the prices estimated through a particular pricing method in the simulation match the actual prices observed in the market, then it is highly likely that market participants are using this pricing method when trading. Therefore, it would be possible to identify the pricing methods that market participants have adopted under certain market conditions and for each issue. Specifically, the performance of each pricing method, as revealed through responses to questionnaire and interviews, is compared over time and for individual issues to examine which pricing methods were most likely applied under certain market conditions, and for each issue.

The main methods of pricing that were identified through market participants' responses to questionnaire and interview questions can be divided into four categories as explained below.

(1) Where it is possible to observe changes in the price of bond issues with remaining life close to the bond to be priced, then these price movements from the previous day are referred to in pricing the bond.

(2) As it is difficult to observe net basis (or repo rates) on a real time-basis in the market, an estimate is made using certain assumptions (for example, net basis is unchanged from the previous day). Using this estimated net basis, the CTD issue price is estimated from the futures price available on a real time basis. Prices of issues other than CTD issues are priced using the historical correlation between the price movements of each issue and the CTD issue.

(3) The CTD issue price is calculated from the futures price using an assumed net basis figure for that day, as in (2). Then, based on this calculated CTD issue price, the prices of issues other than CTD issues are set a) assuming a parallel shift in the yield curve, or b) constructing a yield curve using swap or three-month interest rate futures data, which are relatively easy to obtain.

(4) Each bond issue is priced using the spread between the rates for which real-time price information is available such as the three-month interest rate futures or the swap rate.

4.1.1 Simulation methods

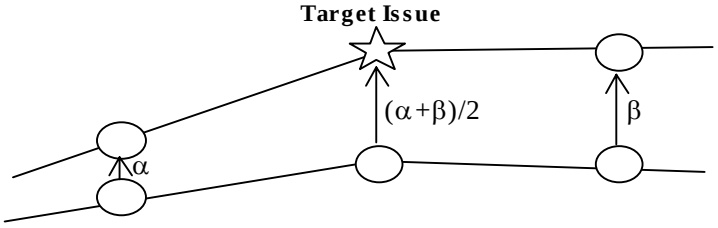
The following four algorithms, simplifying the pricing methods described above, are used to simulate dealers' pricing methods.

(1) Estimating prices from movements in the prices of issues with close remaining life

An error factor is added to the actual change in the yield from the previous day for the third issue on both sides (hereafter referred to as reference issues) of a particular issue to be priced (target issue) so

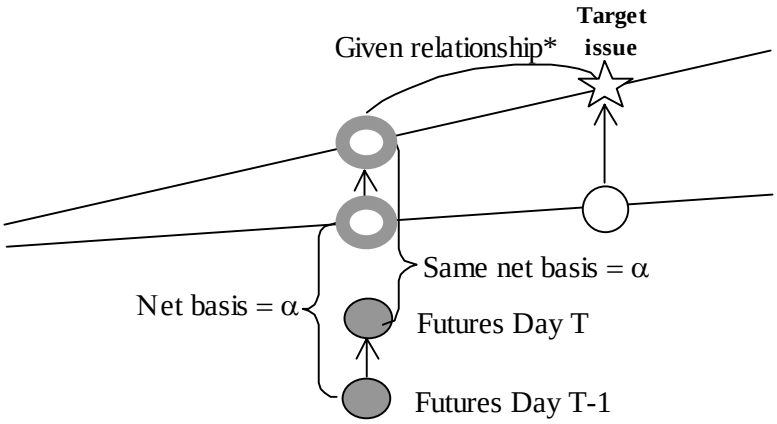
[20] Data for closing prices on the Japan Bond Trading Co., Ltd., a specialized brokers' broker (BB) market, are used.

as to estimate the yield change from the previous day for the reference issues.[21] An estimate of the change in yield from the previous day for the target issue is then derived by averaging the figures for the reference issues. When the target issue is at an extreme end of the yield curve, and there is no reference issue on both sides of it, then at the short end it is excluded from the estimation targets, and at the long end the prices of on-the-run issues are used as reference issues.[22]



(2) Calculating a theoretical value for CTD issues from futures prices, and estimating prices for other issues based on historical relationship

A theoretical value is calculated for the CTD issue, assuming that the net basis is unchanged from the previous day, using futures prices, which can usually be obtained in the market.[23] Then, for issues other than the CTD issue, the price movement for the day is estimated assuming that the correlation in price movements with the CTD issue for day T-2 to day T-1 is maintained for day T-1 to day T. For example, if the CTD issue rises by 5bps between day T-2 and day T-1, and the target issue rises by 4bps during the same period, then if the theoretical CTD issue price for T is 3bps higher than the price on day T-1, the price of the target issue is estimated as being 2bps (3bps plus 4bps minus 5bps) higher than on the previous day.



* Difference between change in CTD from T-2 to T-1 and change in target from T-2 to T-1
= Difference between change in CTD from T-1 to T and change in target from T-1 to T

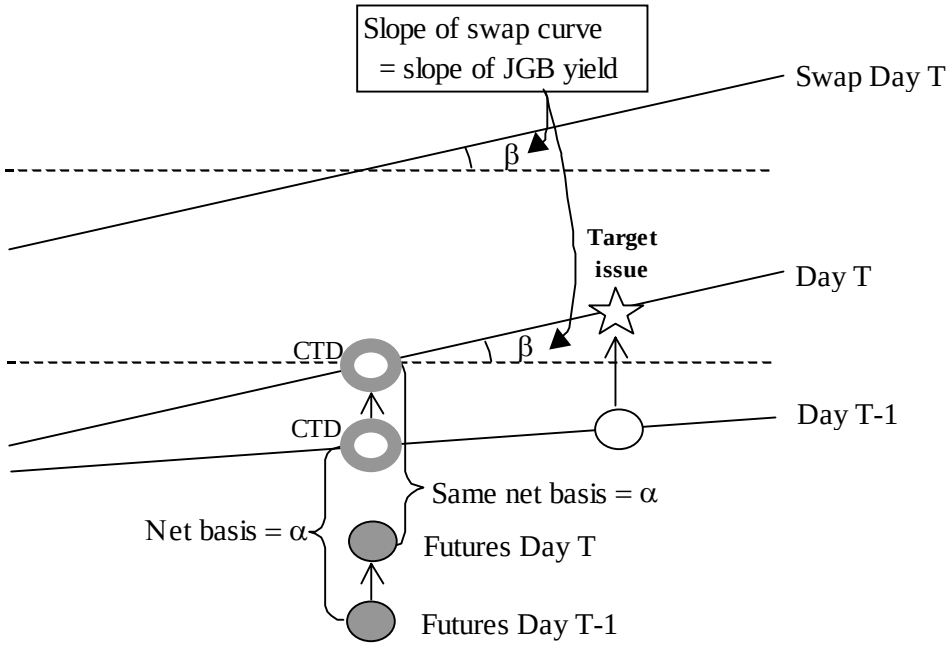
[21] Ordinarily, issues with a high outstanding amount, such as former benchmark issues or combined fungible issues offer greater liquidity than other issues. Price information on such bonds is generally easier to obtain in the market. In the 10-year bond market, these account for roughly one in every five issues, so the reference issues are set as the three issues on both sides of the target issue in the simulation. Furthermore, the actual price information derived in the market takes the form of bid-ask information, and so, in the simulation, prices are extracted randomly (uniform distribution) from within the bid-ask spread. With reference to Inoue [1999], 0.075 yen for a face value of 100 yen is used as a parameter for the bid-ask spread.

[22] This is because at the long end of the yield curve, the bid-ask information for on-the-run issues, which are the most liquid cash bonds, can be obtained.

[23] Data from Nikko Salomon Smith Barney's futures interest arbitrage table is used for net basis. It is not easy to observe repo rate movements in the market. Nevertheless, the pricing algorithms used in the simulations in this Working Paper incorporate changes in market repo rates, because this has a major

(3) Estimating the shift in the level of the yield curve from the CTD issue, and then assuming a parallel shift or adjusting with the slope in the swap rate

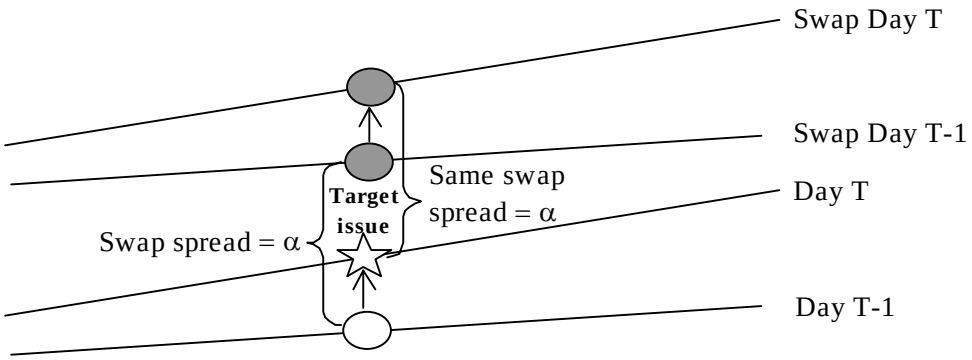
An estimate of the CTD issue price is arrived at using a net basis and the futures price in the same way as in method (2). For issues other than the CTD issue, two methods are tried using the CTD issue price as the pivot point. Specifically a) implementing a parallel shift compared with the previous day for the yield curve, and b) using the slope of the swap yield curve to estimate changes in the yield compared with the previous day. While method a) is simple, it ignores changes in the slope of the yield curve, and therefore the further an issue is away from the CTD issue, the worse the fit. To mitigate this problem, method b) employs the swap rate, for which real-time bid-ask information is usually available in the market, so that changes in the slope of the yield curve can be reflected. In the simulation, the movement in the target issue price is estimated by first estimating the spline curves for one- to ten-year swap rates. Then, slope information is obtained as the difference between the "swap rate with the same remaining life with CTD" and the "swap rate for a issue with same remaining life as target issue".



(4) Pricing based on a fixed swap spread

Prices are estimated for each target issue assuming that the swap spread does not change from the previous day. In the simulation, the yield for that day is estimated by adding the change in the rate of swap with the same remaining life as the target issue, as obtained through spline interpolation, to the previous day's price for the target issue.

influence on the functioning of the market, as seen in the turmoil in the markets in summer 1999. That is to say, in the actual simulation program, [gross basis] - [net basis], which is equivalent to the cost of carrying, is reduced in line with the decline in the number of days remaining until the futures settlement day. Through this, gross basis for day T is calculated, assuming that net basis does not change from day T-1, and from this the cash bond price is derived from gross basis and the futures price. Net basis changes day by day in line with fluctuations in market repo rates, but as there is currently no effective way of estimating repo rates on a real time basis for issues which have gone special, these were set as unchanged from the previous day.



4.1.2 Simulation results

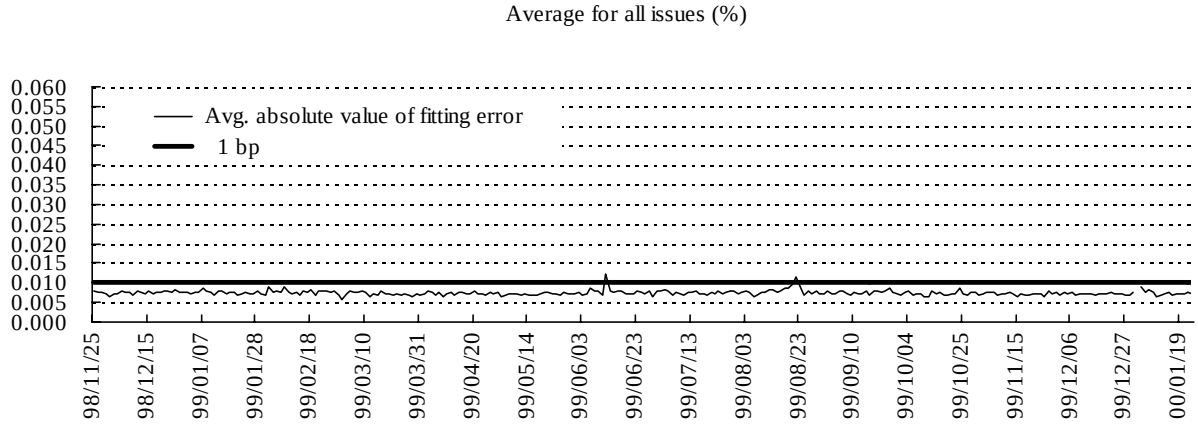
The absolute value of the fitting error between actual market prices and estimated prices for each issue based on the algorithms for methods (1) to (4) above, for each business day between November 24th 1998 and January 24th 2000, are shown in Charts 4-1 to 4-4. These charts also show the averages of the absolute value of the fitting errors for all issues in order to show the fit over the yield curves.

(1) Estimating prices from movements in prices of issues with close remaining life

In the simulation using the third closest issues with remaining life shorter than and longer than the target issue as reference issues and adding in an error factor, stable results were obtained. The average fitting error for all issues remained at around 0.7-0.8bps.

By remaining life zones, the performance of this method deteriorated in relation to the JGB 207th issue, the 208th, and 213th issues with low coupons, as well as issues with close remaining life to the CTD issue from end-1998 to around February 1999, and around May 1999, for example, when selling pressure for futures used for hedging mounted accompanying warnings of a price drop. The fit was also not good in the June to August 1999 period when the repo market was in a state of turmoil.

Chart 4-1 Pricing using price movements for third issues on either side of the target issue

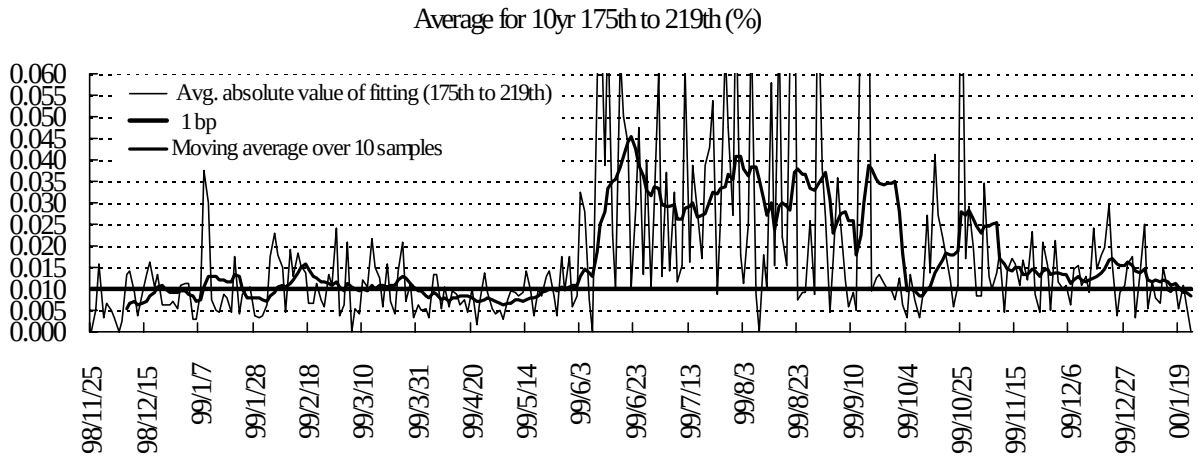


(2) Calculating a theoretical value for CTD issues from futures prices, and estimating prices for other issues using historical correlation

Stable results were obtained for this pricing method up until the beginning of June 1999 when prices became volatile with the unexpected change in the CTD issue. The average fitting error for issues from 175th (with remaining life of four to five years) and longer are evaluated for fit. The shorter term issues, which are far from the CTD issue, are excluded because of a significant decline in performance. Before June 1999, the average fitting error moved at around 1bp, indicating that even with a simple algorithm such as this, it is possible to explain market prices with a fair degree of precision. However, around June to September 1999, there was an extreme deterioration in fit,

suggesting that this method of pricing was deemed unfit for practical use and had not been used in the market. By issue, a large fitting error was noted for all remaining life zones, indicating that the prerequisite for this method of pricing, namely 'a link between futures and CTD issues', collapsed.

Chart 4-2 Pricing using relationship with CTD issues (provided net basis is unchanged)

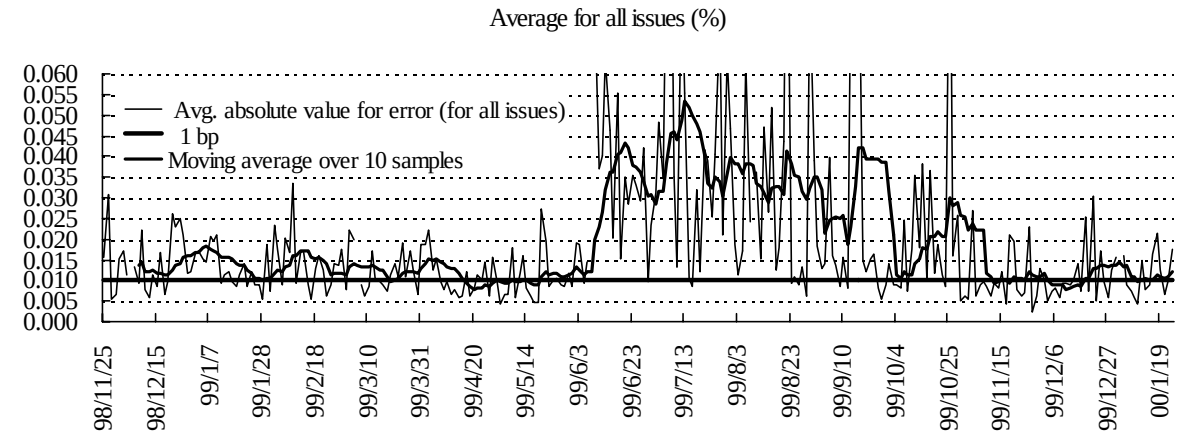


(3) Estimating the level of the yield curve from the CTD issue, and then using a parallel shift or slope in the swap curve to adjust

Using algorithm a), which assumes a parallel shift in the yield curve, performance deteriorated sharply the farther an issue was away from the CTD issue for the period when the slope of the curve changed significantly, namely from the end-1998 to around February 1999. So in b), information on the slope of the yield using the swap yield curve was incorporated. Until May 1999, the average fitting error for all issues remained at just over 1bp, indicative of a reasonable performance. But in June to September 1999, when the relationship between the cash and futures markets became unstable, performance deteriorated sharply, as was the case with method (2), because the estimated price of the CTD issue itself became unreliable.

Whereas with method (2), pricing was based on a one-on- one interrelation between a CTD issue or a futures contract and the issue being priced, under this method, the CTD issue is only used to estimate the level of the yield curve. Slope information is obtained from the swap market. For this reason, while this method shows inferior performance in comparison with method (2) for issues in the seven-year remaining life zone where the CTD issue link and influence is strong, the performance of method (3) is superior for issues in the short remaining life zone, which are far removed from the CTD issue, and therefore the relationship is weak.

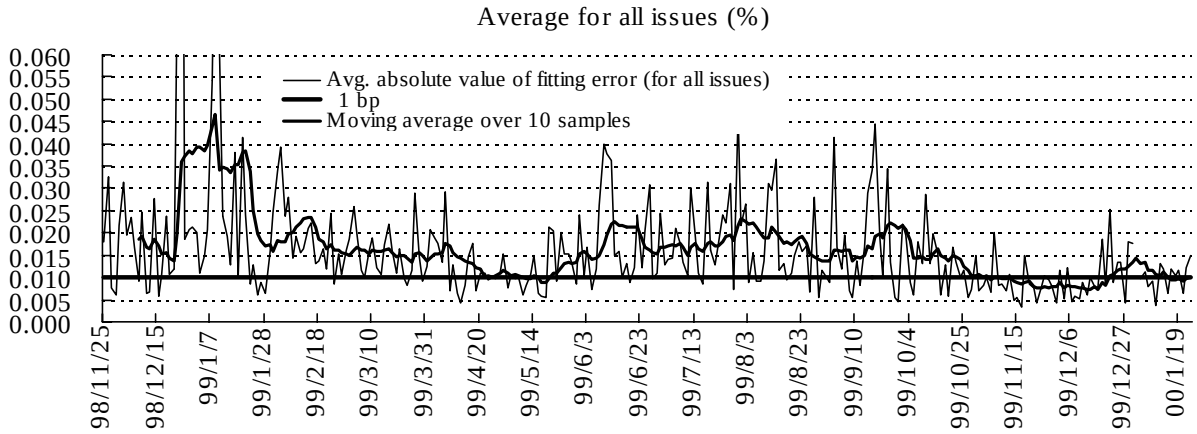
Chart 4-3 Pricing Using Relationship with Swap Curve (with no changes in net basis)



(4) Pricing based on a fixed swap spread

This method of pricing, which does not use information from futures and is based only on swaps, shows a relatively strong performance for issues with short remaining life zone. This indicates the possibility that pricing in the zone covering issues with remaining life of up to around three years is based on swap information. On the other hand, there is quite a large fitting error for issues with a medium to long remaining life until around September 1999. This indicates that market participants were most likely not referring to swap rates in pricing JGB cash issues outside of the short remaining life zone.[24] The average fitting error for all issues was 1-2bps, indicating that this method had an inferior performance to those using futures prices. Around end- 1998 in particular, when swap spreads became unstable reflecting the sudden changes in market prices, the average fitting error for all issues reached approximately 3bps. However, for the June-September 1999 period, when the performance of the methods using futures market information showed a marked deterioration, the performance of method (4) did not deteriorate noticeably.

Chart 4-4 Pricing Assuming Fixed Swap Spreads



4.1.3 Summary of findings on pricing methods

For pricing methods (1) to (4) described above, Chart 4-5 shows which arrived at an estimated price closest to the actual market price for each issue and contract date. From these results, it is possible to identify the following developments, which are in line with the points made by market participants in Section 3 of this paper.

a)For the period up to June 1999, pricing method (1), which is based on cash bonds alone, is performed relatively poorly. On the other hand, methods (2) and (3), which use futures prices, performed well in relation to issues with longer remaining life, centered on the seven-year zone. Method (4), which uses swap market information, did well for relation to issues with short remaining life.

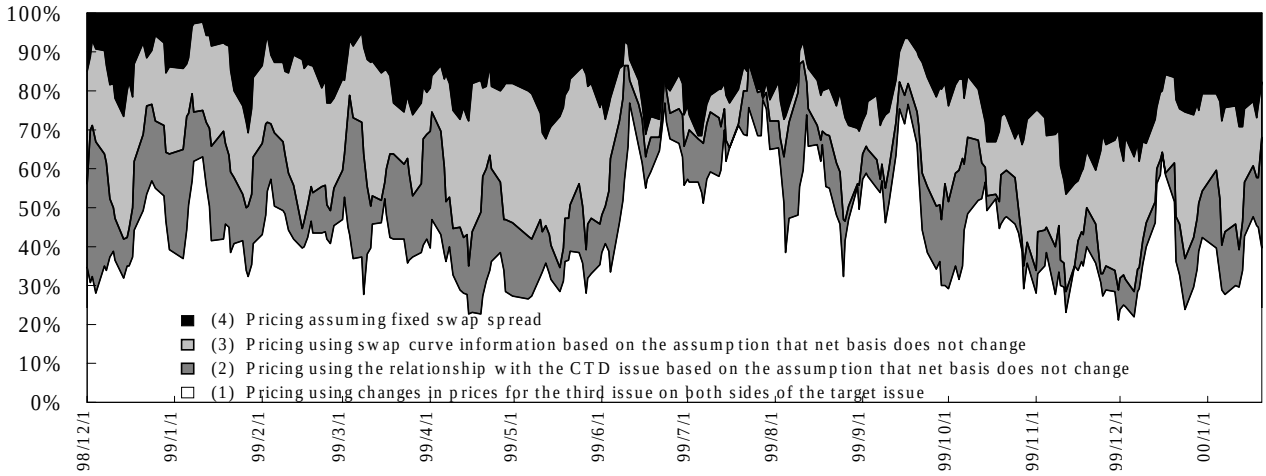
b)For the June-September 1999 period, as the performance of methods (2) to (4) deteriorated, the relative performance of method (1) improved.

c)For the period from October 1999, the performance of methods (2) to (4) improved again. Due to the volatility in the repo market between June and September 1999, market participants temporarily

[24] While performance has been improving since October 1999, it is difficult to say whether this means that market participants are paying more attention to swap rates when pricing bonds, or whether it is the result of stable market prices.

abandoned the pricing methods based on futures and swaps which they had been using until then, but began using these methods again as stability returned.

Chart 4-5 Performance Comparison of the Various Pricing Methods



Note: The pricing method that showed the best fit with the actual market prices for each period and for each issue was determined, and its share was plotted.

4.2 Effects of the characteristics of individual issues on pricing

The focus in 4.1 was on analyzing which pricing method market participants used under different market conditions and maturity brackets. In addition to pricing methods, it is necessary to consider biases stemming from the characteristics of individual issues when issues are actually priced. Such issue characteristics are examined using spline curve analysis in the following sections.

4.2.1Method of analysis

Spline curves of discount factors are estimated using the Vasicek-Fong [1982] method,[25] where discount factors on spline curves with respect to maturity are derived through regression analysis. The yields for each issue are compared with the yields obtained from estimated spline curves. It is possible to consider the fitting error for each issue as stemming mainly from the characteristics of the individual issues if only issues with high liquidity that are relatively unaffected by the holding behavior of market participants (hereafter referred to as benchmarks for each remaining life zone) are used in estimating spline curves.[26] In addition, the sum of squared residuals (SSR) with regard to estimated prices and market prices for all issues could be taken as an indicator of distortions in the shape of the yield curve as a whole.

In the estimation method as described above, the assumptions are that i) issue characteristics have no influence on the prices of benchmarks for each remaining life zone, and ii) the prices of benchmarks for each remaining life zone contain sufficient information to represent the yield curve as a whole. However, when there are major kinks in the yield curve, for example, it may not be possible to plot the yield curve with sufficient accuracy using only the information contained in the prices of these benchmarks for each remaining life zone. For this reason, to accurately interpret the results of

[25] Knot points have been set in two places, at three years and seven years. The results do not change much when they are set in three places, at three, five, and seven years.

[26] Based on information obtained from market participants through the questionnaire and from monitoring activities the following issues are used in the analysis: JGB 144th, 145th, 151st, 153rd, 157th, 164th, 170th, 174th, 182nd, 190th, 200th, 203rd, 204th, and 214th, and the on-the-run issue for the day the calculations were made. The JGB 187th issue, which boasted high liquidity as a result of its being an amalgamation of three issues, is excluded as it was the CTD issue for *June 99 contract*. However, the results are almost the same for calculations including the JGB 187th issue and those excluding this issue.

analysis, the spline curve for all issues should also be calculated, to be used in checking whether the estimates using benchmarks for each remaining life zone provide a satisfactory expression of the yield curve.

4.2.2 Changes in the gradient of the yield curve

The calculation results are examined in chronological order below (see Chart 4-6-1, the errors for all issues are shown in Chart 4-9[27]).

Chart 4-6-1 shows chronological changes in SSR for estimates using benchmarks for each remaining life zone (zone benchmarks) and estimates using all issues. Charts 4-6-2 and 4-6-3 provide a breakdown of contribution made by each zone benchmark to SSR. According to Charts 4-6-2 and 4-6-3, issues with low coupons such as the JGB 207th, 208th, 212th, and 213th were significant contributing factors in periods IV, V, and VI marked on Chart 4-6-1. Meanwhile, when distortions in the shape of the yield curve were small, such as from end-June to beginning of August 1999, issues close to the CTD issue, such as those between the 180th and 200th, contributed largely to the SSR. These may reflect that under normal conditions, issues with remaining life close to the CTD issue tend to become cheap due to the influence of investors selling futures to hedge their positions, but when the spline curve is pushed downwards with stress such as a tightening in the repo market, the errors in the estimation for low coupon issues in the 9 to 10-year zone tend to become larger.

[27] Charts for 4-9 are attached at the end of this paper.

Chart 4-6-1 Developments in Spline SSR (Sum of Squared Residuals)

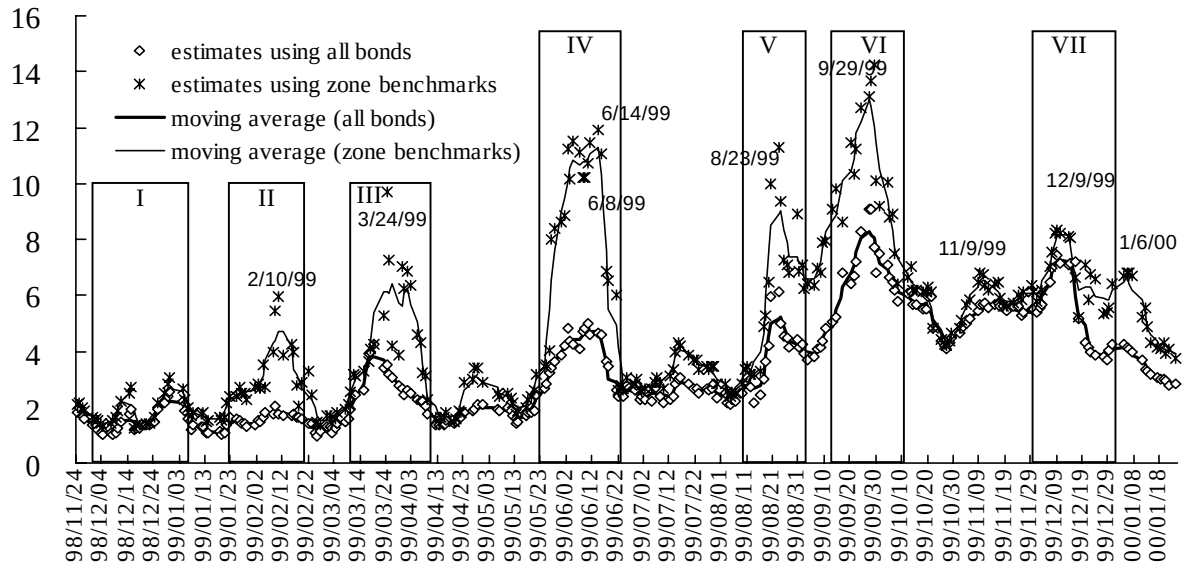


Chart 4-6-2 Breakdown of SSR (for all bonds) by Zone Benchmarks

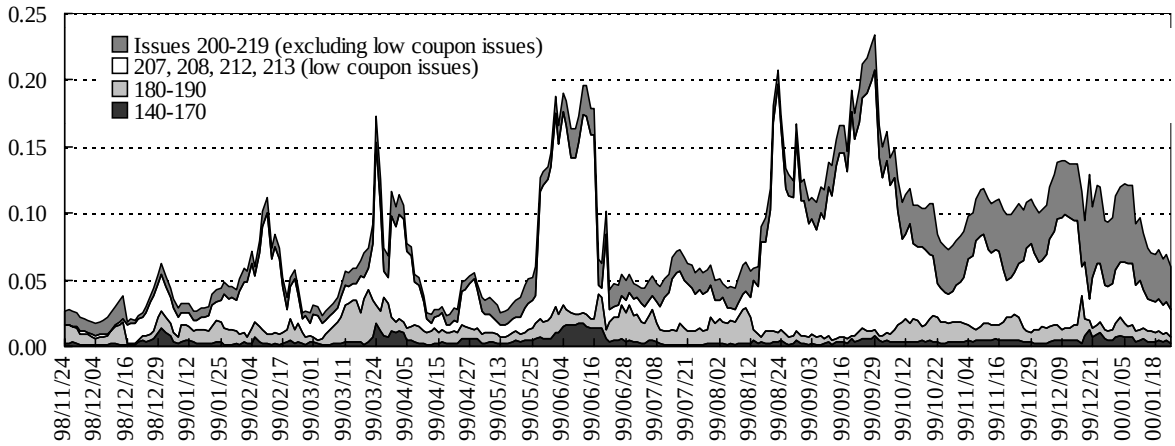
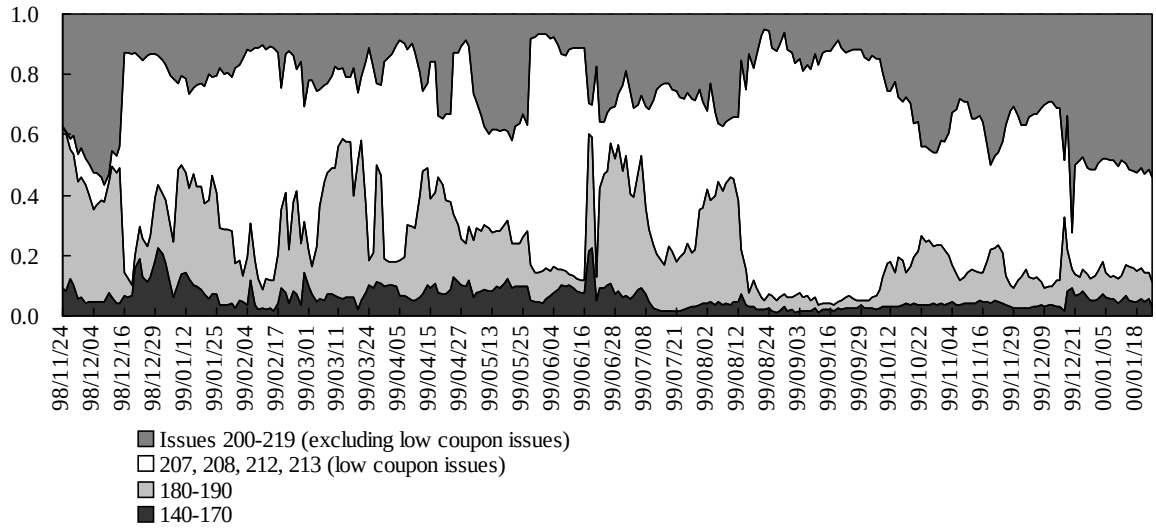


Chart 4-6-3 Breakdown of Contribution by Zone Benchmarks (weight)



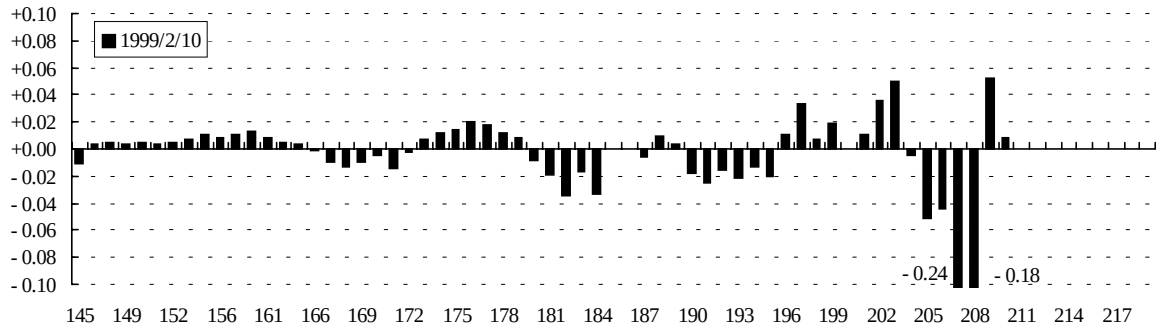
Period I: From November 1998 to early-January 1999

Although market prices between end-1998 and beginning of 1999 were quite volatile (Trust Fund Bureau shock), fluctuations in SSR were relatively small, and there was hardly any difference in SSR between the estimates based on benchmarks for each remaining life zones and on all issues. This indicates that while fluctuations in market prices caused some distortions in the yield curve, they were relatively small, and that information related to the shape of the yield curve had been almost fully incorporated in the benchmarks for each remaining life zone.

Period II: From mid-January 1999 to end-February (Chart 4-7-1)

Prices in the bond market fell sharply toward end-January reflecting announcement of an increase in the issuance of ten-year bonds and concern over the downgrading of JGB credit ratings. This led to increased pressure to sell futures (*March 99 contract*, the CTD issue being the JGB 186th issue) and issues with remaining life of ten years for hedging purposes. The SSR for benchmarks for each remaining life zone rose sharply, largely due to the fact that issues with remaining life of seven years (JGB 180th to roughly 195th issues) and ten years (JGB 200th to 210th issues) became relatively cheap. On the other hand, the SSR for all issues remained relatively stable. This can be interpreted to mean that the influence of price movements in these issues had already been incorporated into the estimate based on all issues, because as issues with remaining life close to the CTD issue and issues with remaining life of ten years became cheaper, close issues also smoothly became relatively cheap. Meanwhile, JGB 207th and 208th issues became markedly cheaper, but the extent to which they did so was less than when large distortions were noted in the yield curve as in period VI, discussed later.

Chart 4-7-1 Yield Deviations (fitting error from the spline curve) <February 10th 1999>



Period III: From early-March 1999 to mid-April 1999 (Chart 4-7-2)

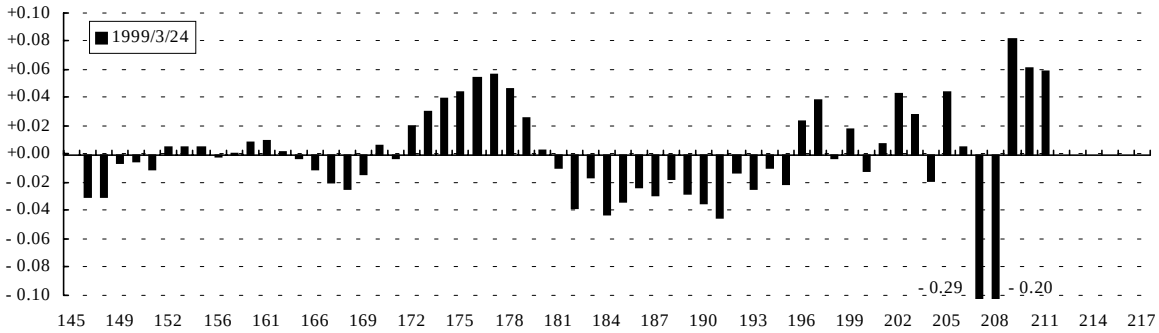
The bond market was relatively stable in this period. The SSR rose, reflecting the changeover in the most active futures contract (on March 4th, the June contract took over from the *March 99 contract*, and the CTD issue changed from the JGB 186th issue to the 187th issue). In contrast to the situation between the mid-January and end-February, the SSR for all issues also increased. Issues with close remaining life to the CTD issue became cheaper than in mid-January to end-February period and the distortion in the yield curve was larger. This suggests that the change in the most active futures contract is more likely to create distortions in the yield curve than market volatility.

Looking at the situation by issue, while issues with remaining life of seven years became cheaper, those in the shorter remaining life zone between the 170th to 180th issues became relatively expensive as a result of an upward pull on the spline curve as issues in the seven-year remaining life zone became cheaper.[28] On the other hand, this reaction did not extend to remaining life zones beyond

[28] This suggests that information on issues with remaining life close to the CTD issue has been partially reflected in the pricing of benchmark issues in each maturity bracket, and even if a spline curve is estimated using benchmark issues alone, the characteristics of individual issues do not completely disappear.

seven years, reflecting the large number of benchmarks for the remaining life zone included in the nine to ten years zone.

Chart 4-7-2 Yield Deviations (fitting error from the spline curve) <March 24th 1999>



Period IV: From end-May to end-June 1999 (Charts 4-7-3 and 4-7-4)

A marked increase was noted in the distortions in the yield curve in this period for a number of reasons, including the following. First, as bond prices turned to decline on concerns over a deterioration in supply and demand conditions accompanying the increased issuance of JGBs and stronger than expected January to March GDP figures, market participants increasingly sold futures to hedge their cash bond positions. Second, although the June futures contract was approaching final settlement, the switch to the September contract did not proceed as it should, as its CTD issue was the relatively illiquid and unpopular 20-year JGB 2nd issue. The SSR using zone benchmarks increased by a greater amount than in beginning of March to mid-April period, and the SSR for all issues also rose.

By issue, while the JGB 187th issue, which was the CTD issue, temporarily became cheaper at end-May in response to selling pressure on futures for hedging (Chart 4-7-3), it rapidly became expensive on June 8th (Chart 4-7-4). The same pattern is also observed for the JGB 188th and 189th issues. On the other hand, issues with shorter remaining life closest to these issues, the 180th to 186th, which were not deliverable issues, also became cheaper but did not become expensive after that. The influence of these developments extended to issues in the still shorter remaining life zone, like the 160th to 180th, contrasting to the situation in beginning of March to mid-April period when only issues with seven years maturity became cheaper. A shortage of CTD issues in the market in addition to the usual cheapening of issues with remaining life of around seven years was behind this. In more detail, 170th to 180th issues became relatively expensive considering the relative cheapness of issues numbered 180th to 190th, which in turn prompted issues numbered 160th to 170th to become cheaper. Meanwhile, 192nd and 193rd issues, which were the CTD issues for *March 00 contract*, were already becoming cheaper in June (Chart 4-9), indicating that market participants, particularly investors, had bypassed the *December 99 contract* and were engaged in selling the *March00 contract* for hedging.

Chart 4-7-3 Yield Deviations (fitting error from the spline curve) <May 20th 1999>

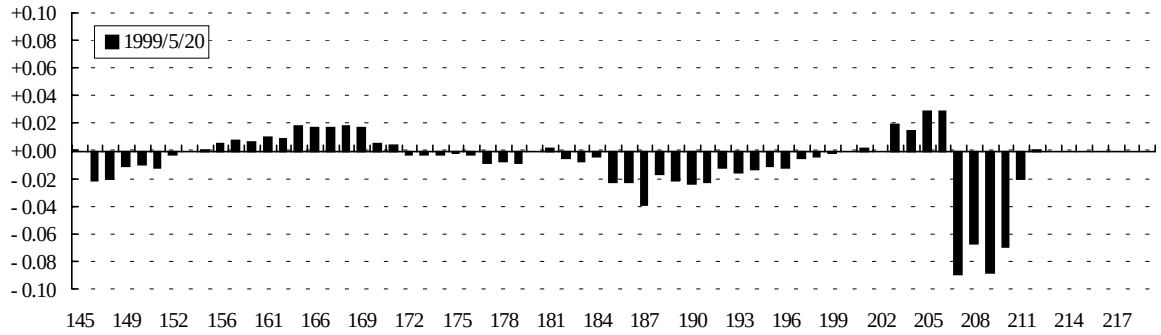
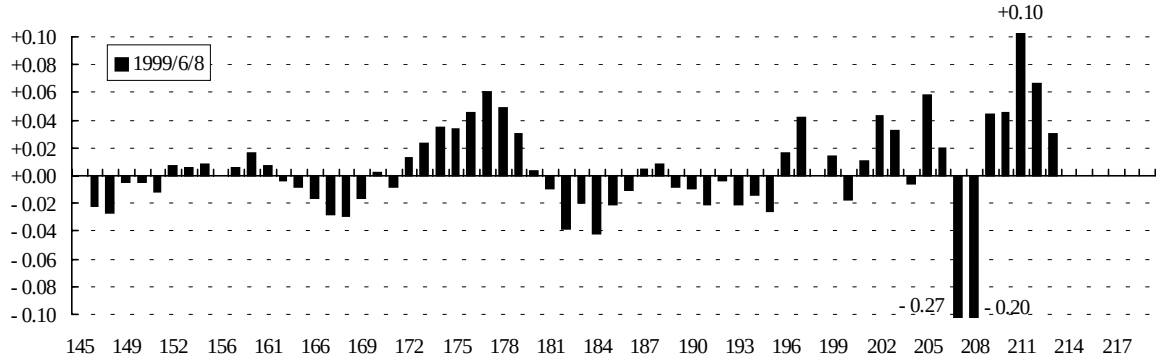


Chart 4-7-4 Yield Deviations (fitting error from the spline curve) <June 8th 1999>



Period V: From August 10th to early-September 1999 (Charts 4-7-5 and 4-7-6)

Following the change in the most active contract at the beginning of August (from *September 99* to *March 00 contract*, with the CTD issue changing from the 20-year JGB 2nd issue to 10-year JGB 192nd and 193rd issues), concern over the possible shortage of certain issues in the market towards the end of the year intensified. This was prompted by rumors that "some investors would not be lending CTD issues for *March 00 contract* in the repo market due to concern over the Y2K problem". Therefore, distortions in the yield curve were noted in the second half of August.

Issues with close to seven-year remaining life, particularly JGB 192nd and 193rd issues, had become cheaper from around end-June 1999 due to selling pressure on futures that were held to hedge cash bond positions, but this trend was reversed in just one week (August 11th to 17th) with a tightening of supply and demand conditions in the repo market (Charts 4-7-5 and 4-7-6). Issues with shorter remaining life than those in the CTD issues zone were not as affected as in end- May to end-June period. This may have been because the supply and demand conditions became tight for a wide range of issues (whereas in end-May to end-June period, it was only those JGBs around the 187th issue which became in short supply) due to the turmoil in the repo market as a whole, and therefore no major distortions in the yield curve appeared, unlike in the end-May to end-June period. Between August 11th and 17th, due to the shortage of issues with remaining life close to the CTD issue, the spline curve was pushed downwards, and as a result, the JGB 207th and 208th issues, which were unpopular because of their low coupons, became markedly cheaper (Charts 4-7-5 and 4-7-6).

Chart 4-7-5 Yield Deviations (fitting error from the spline curve) <August 11th 1999>

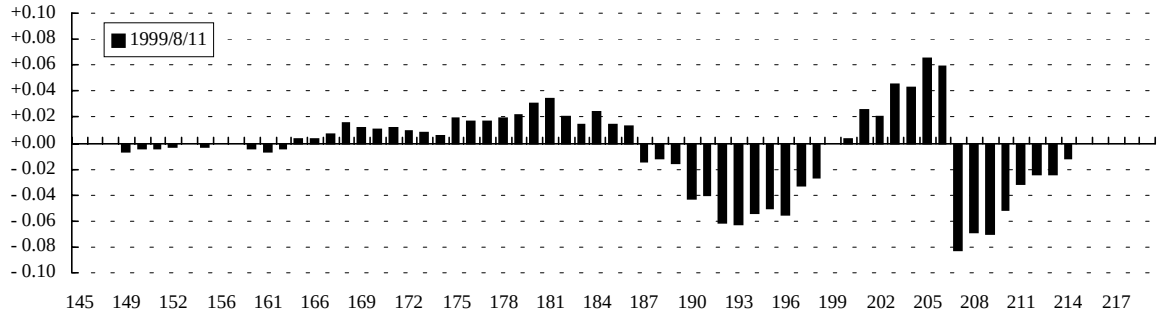
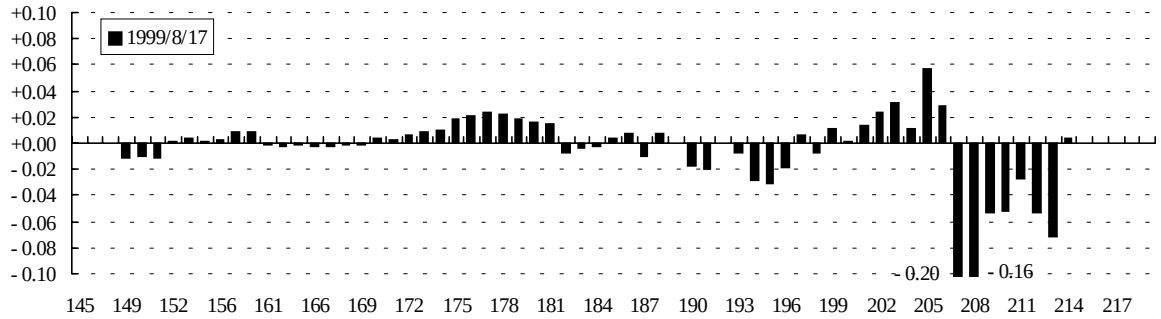


Chart 4-7-6 Yield Deviations (fitting error from the spline curve) <August 17th 1999>

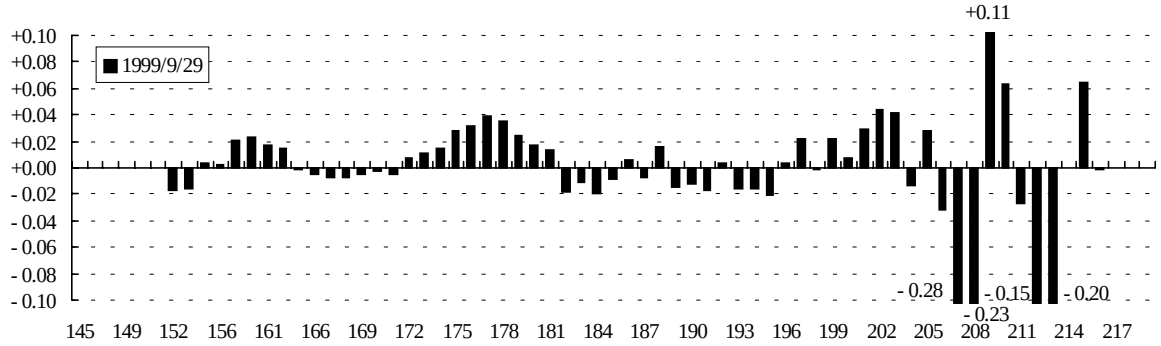


Period VI: From early-September to early-October 1999 (Chart 4-7-7)

Towards the end of September 1999, it is highly likely that the SSR rose as a result of the decline in market liquidity at the end of the first half of fiscal 1999 partly because the turmoil in the repo market continued. Dealers who had incurred losses due to the turmoil in the markets since June 1999 were reluctant to take positions in the market to correct the distortions in the yield curve. Consequently, the supply and demand conditions for individual issues became more clearly reflected in inter-dealer market prices.

Fitting error for issues in the seven-year remaining-life zone followed a similar pattern to that during the period of turmoil in the repo market in mid-August, demonstrating the influence exerted by the turmoil in the market. Some issues, including 200th to 205th, and 209th and 210th, became relatively expensive as a result of continuous buying by some investors. Meanwhile, issues with low coupons, such as 207th, 208th, and 213th, became markedly cheaper. These developments illustrate how prices varied according to issue in the interdealer market. Furthermore, the tightening of supply and demand conditions for issues with ten-year remaining life and selling pressure on seven-year remaining life zone issues for hedging caused a flattening in the yield curve between the remaining life of seven and ten years. This caused the shorter remaining-life zone issues, as those between the 170th and 180th, to become relatively expensive.

Chart 4-7-7 Yield deviations of issues (fitting error from the spline curve) <September 29th 1999>

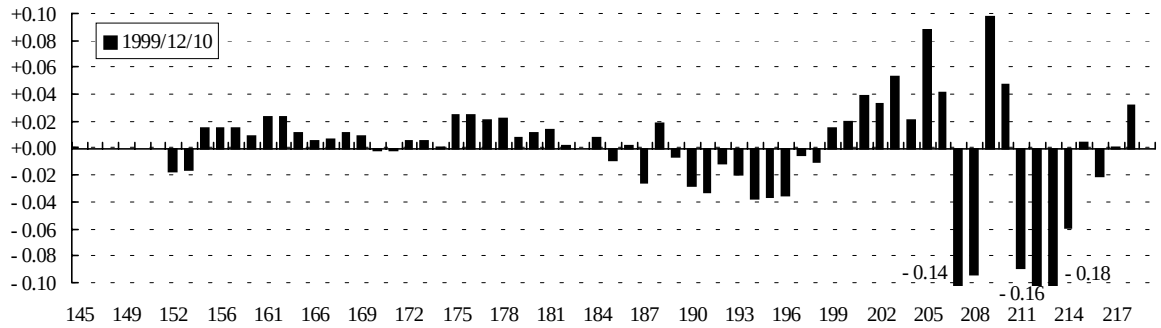


Period VII: From end-November to end-December 1999 (Chart 4-7-8)

While the effects of the turmoil in the repo market gradually wore off between end-November and end-December 1999, the SSR remained at a high level influenced by the announcement of July-September GDP figures on December 6th and the announcement of JGB issuance plans for fiscal 2000 on December 19th, and participants deciding to refrain from trading due to concern over the Y2K problem.

Compared with August and end-September 1999, issues in the seven-year remaining life zone followed their usual route of becoming cheaper in this period, reflecting selling pressure on futures to hedge cash bond positions accompanying fluctuations in market prices. Individual issues with nine-to ten-year remaining life, however, did not follow their usual course but showed differing movement from issue to issue.

Chart 4-7-8 Yield Deviations (fitting error from the spline curve) <December 10th 1999>



4.2.3 Issue characteristics and their effects

Issues are classified according to their characteristics observed throughout the period in the study, using the average and the standard deviation of the fitting error from the estimated spline value (Chart 4-8). Following are some findings regarding issue characteristics and their influence on market developments.

- For issues with short remaining life, the average fitting error is 1bp, as is the standard deviation. This indicates that pricing is being carried out relatively smoothly in this zone.

- Standard deviation is larger than in the shorter remaining life zone for issues in the CTD issue zone. This is because these issues are somewhat cheap influenced by selling pressure on futures to hedge

cash bond positions, and the extent of this cheapness fluctuates in accordance with degree of selling pressure on futures and repo market conditions.

- Issues with remaining life on both sides of the CTD issue zone tend to become relatively expensive in reaction to the CTD issue becoming cheaper. This tendency is more pronounced for issues with six- to seven-year remaining life than for those with eight- to nine-year remaining life, which include a large number of zone benchmarks and therefore are less likely to deviate from the spline curve. As the reason behind the fitting error in these zones is a reactionary expensiveness to the cheapening of issues in the CTD issue zone, standard deviation is at roughly the same level as for the CTD issue zone.

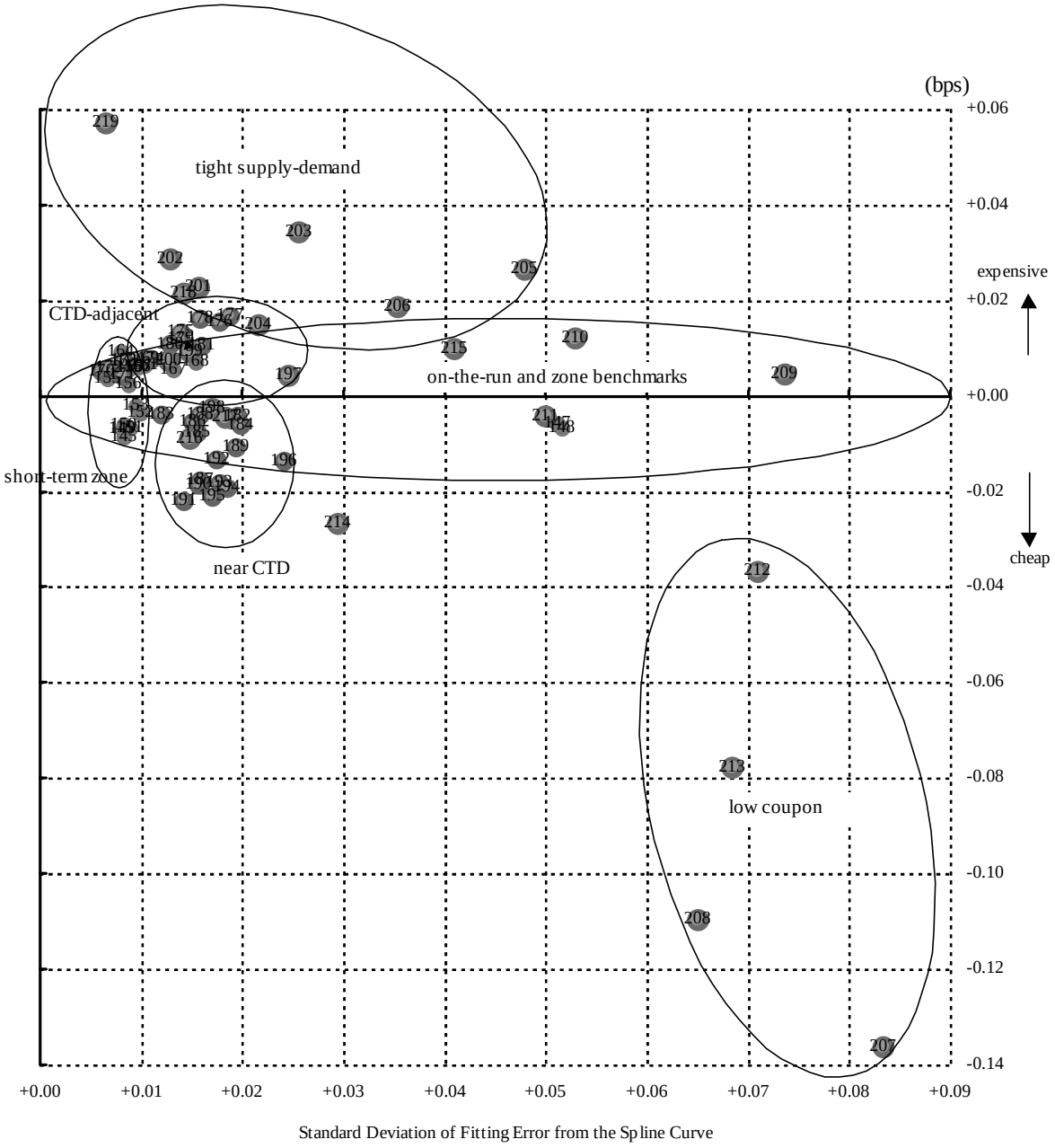
- JGBs between 200th and 205th issues were relatively expensive due to some investors aggressively purchasing them from end of the first half of 1999. This tendency was only noted for limited periods across the time span in the study, however, and the standard deviation for some issues is large.

- The standard deviations for issues such as 207th, 208th, and 213th issues are large as these issues are cheap because of their low coupon for which demand is low, and also as demand for these issues falls even more when market liquidity shrinks.

- As on-the-run issues (this applies to the 207th to 217th issues during the period under review) boast high liquidity, the average fitting error for these issues is low. However, large deviations from the spline curve may appear, reflecting such characteristics as differences in coupon, when the next issue is issued. For example, the 209th issue with a coupon of 2.0 percent and the 210th issue with a coupon of 1.9 percent became relatively expensive when the 216th issue with a coupon of 1.7 percent was issued. This may, in turn, lead to large standard deviations.[29]

[29] On-the-run issues are treated as zone benchmarks until the next issue is newly issued, and therefore the deviation from the spline curve may be biased towards being smaller than actual in the calculation.

Chart 4-8 Mean and Standard Deviation of Fitting Errors from the Spline Curve



5. Conclusion

In this paper, we have attempted to examine the various developments which have been observed in the JGB markets from end-1998 to end-1999, focusing on market developments during this period and the behavior of market participants. We will close this report by presenting some issues for further study, noting the implications from the findings of our analysis.

First, in order to make JGB markets highly efficient and robust, enhancements should be made in both the primary and secondary markets as well as the futures and repo markets. Furthermore, the improvements should not disturb but rather strengthen the balance between the cash, futures, and repo markets. As the developments observed in the period when market efficiency deteriorated show, market robustness may be enhanced if, when a shock occurs in the market, the effects can be dispersed among the markets and absorbed, or absorbed in two of the three markets, so that even if efficiency in one of the markets declines it can be offset by the other two markets. Various measures are already being promoted to improve liquidity in the cash bond primary market and to improve the product design of futures, but efforts to improve liquidity in the repo market which links these markets are also required.

The second issue which needs to be addressed involves improving monitoring capabilities in relation to market liquidity. As the developments during the market turmoil show, market liquidity dries up when market participants lose confidence in market liquidity, and distortions in price formation occur. It is, though, impossible to prevent shocks all together, and shocks usually appear in different forms. As such, the best that can be done is to nurture the appropriate monitoring capabilities to be able to grasp market conditions accurately at any given time, so that timely and effective responses and counter-measures can be taken. In this regard, understanding the mechanisms of market liquidity, such as who the providers of market liquidity are in each market, and what causes market liquidity to be particularly important for certain market players and when, is crucial. Such monitoring capability is valuable not only for each market participant but also essential for the central bank. It is hoped that the potential tools to deepen the quantitative understanding of markets, such as pricing methods and risk profile analyses introduced in this paper, will also contribute to enhancing monitoring capabilities.

References

Bank for International Settlements, “How should we design deep and liquid markets? The case of government securities (CGFS Issues Recommendations for the Design of Liquid Markets)”, Committee on the Global Financial System, November 1999, http://www.bis.org.

Bank for International Settlements, “Market Liquidity: Research Findings and Selected Policy Implications”, Committee on the Global Financial System, May 1999, http://www.bis.org.

Inoue, Hirotaka “The Structure of Japanese Government Securities Market: Characteristics of the Japanese Market from a Market Liquidity Perspective” Bank of Japan Financial Markets Department Working Paper Series, 99-J-2, May 1999, http://www.boj.or.jp (in Japanese).

Vasicek, Oldrich A. and Gifford H. Fong, ”Term Structure Estimation Using Exponential Splines”, *Journal of Finance*, Vol.38, 1982, pp339-48.

Chart 4-9-1 Standard Deviation of Fitting Errors from the Spline Curve (150th-159th issues)

(Note: For all charts under Chart 4-9-1 to 4-9-7, issues not charted are reopened issues.)

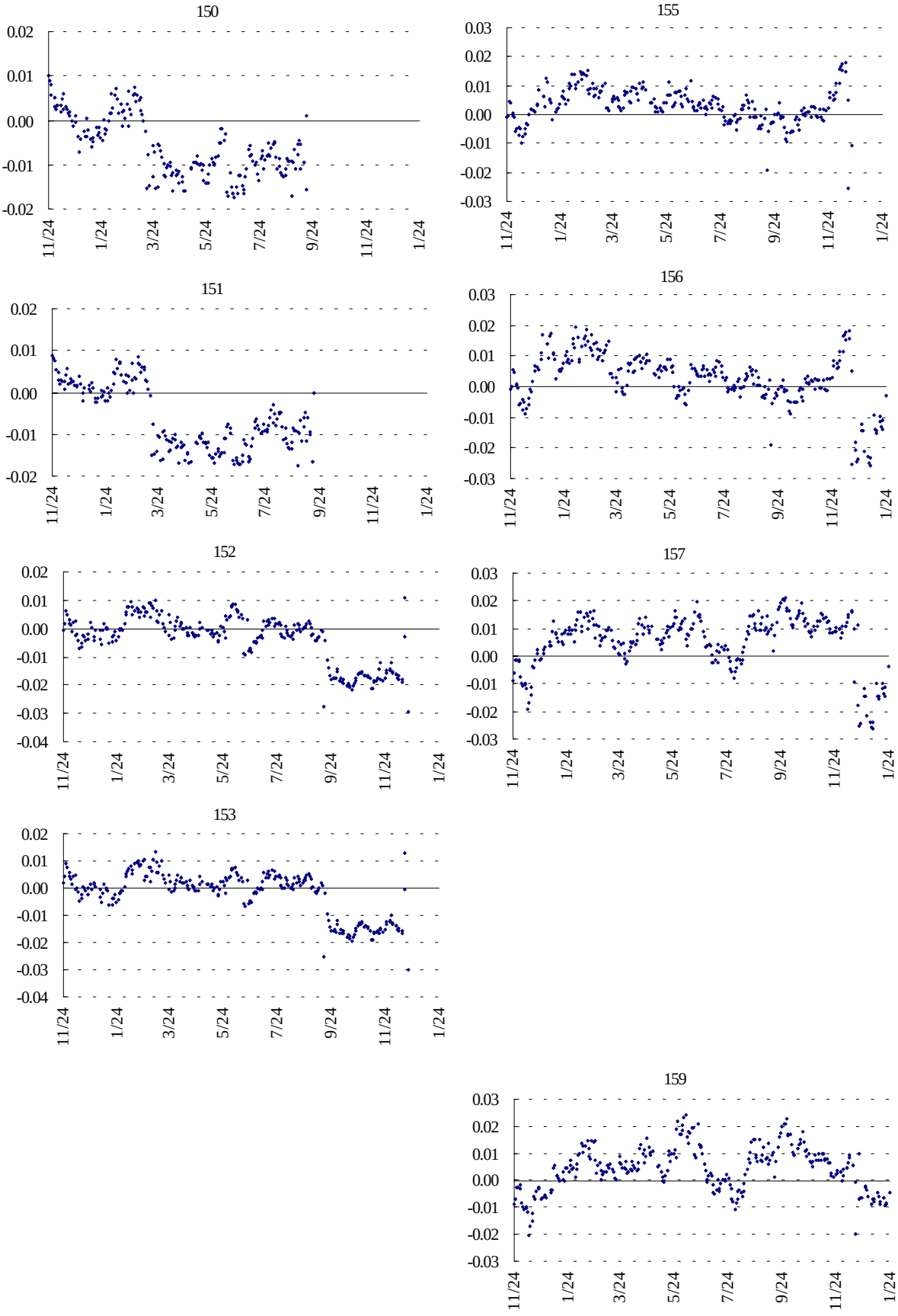


Chart 4-9-2 Standard Deviation of Fitting Errors from the Spline Curve (160th-169th issues)

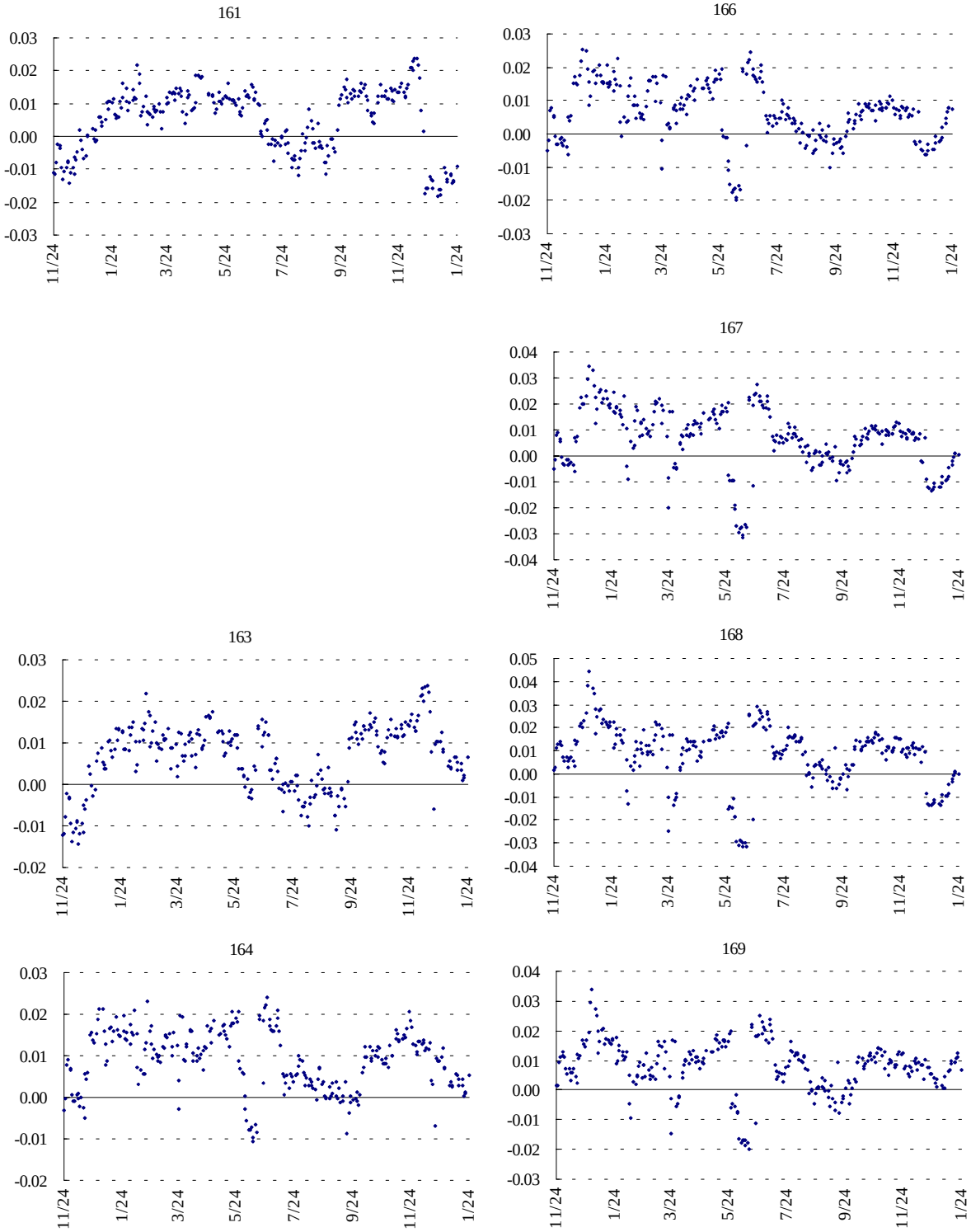


Chart 4-9-3 Standard Deviation of Fitting Errors from the Spline Curve (170th-179th issues)

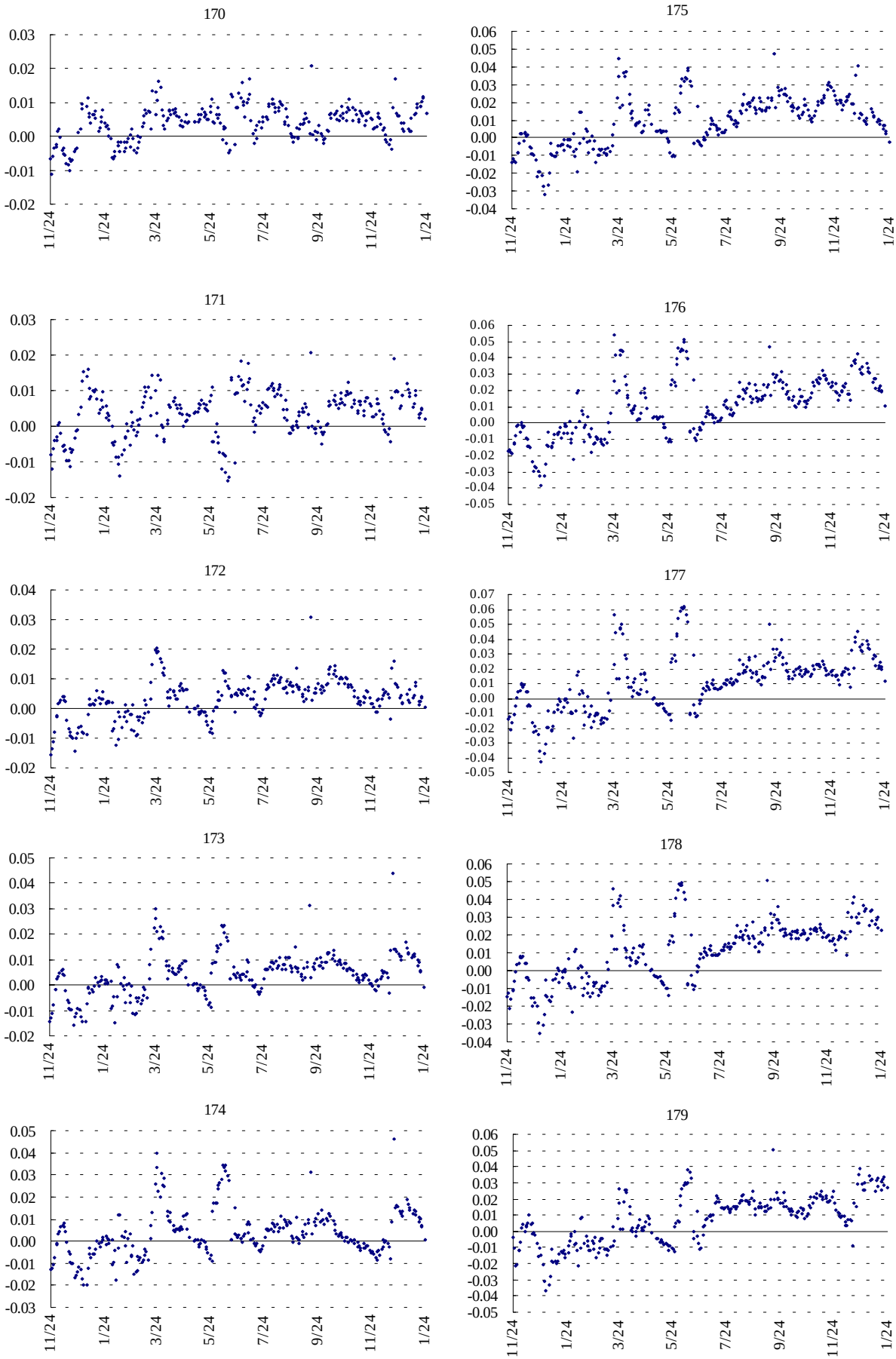


Chart 4-9-4 Standard Deviation of Fitting Errors from the Spline Curve (180th-189th issues)

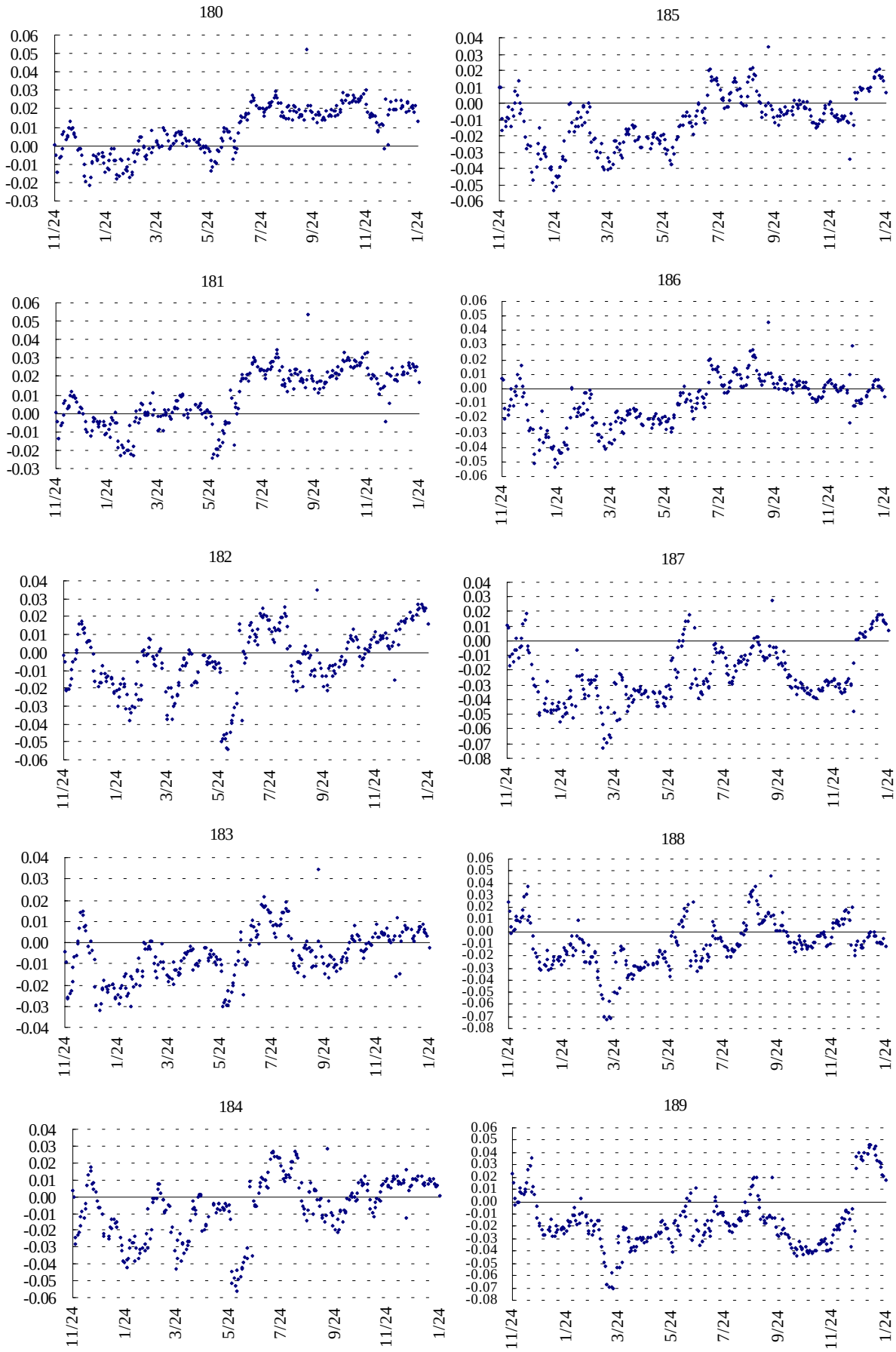


Chart 4-9-5 Standard Deviation of Fitting Errors from the Spline Curve (190th-199th issues)

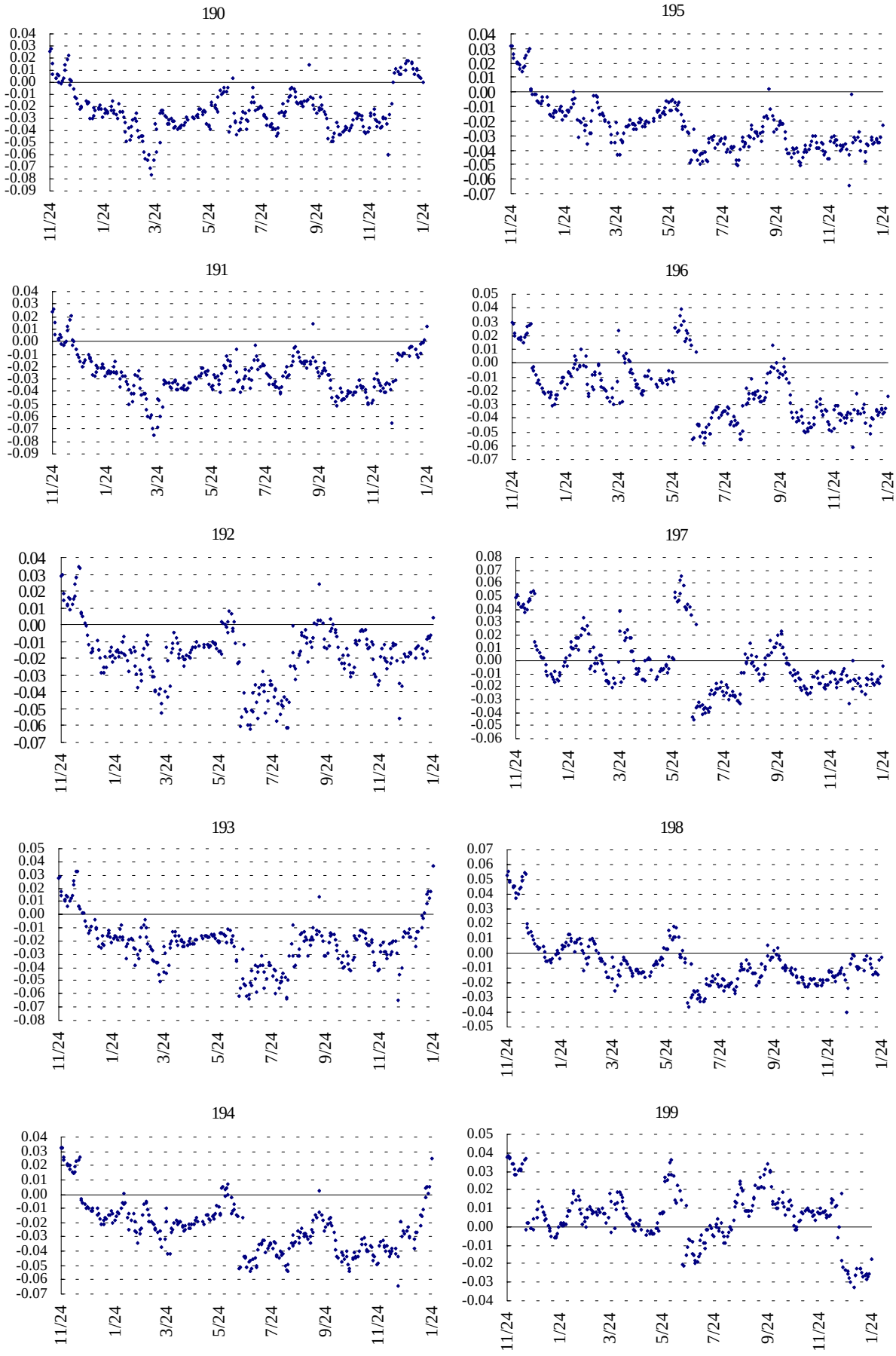


Chart 4-9-6 Standard Deviation of Fitting Errors from the Spline Curve (200th-209th issues)

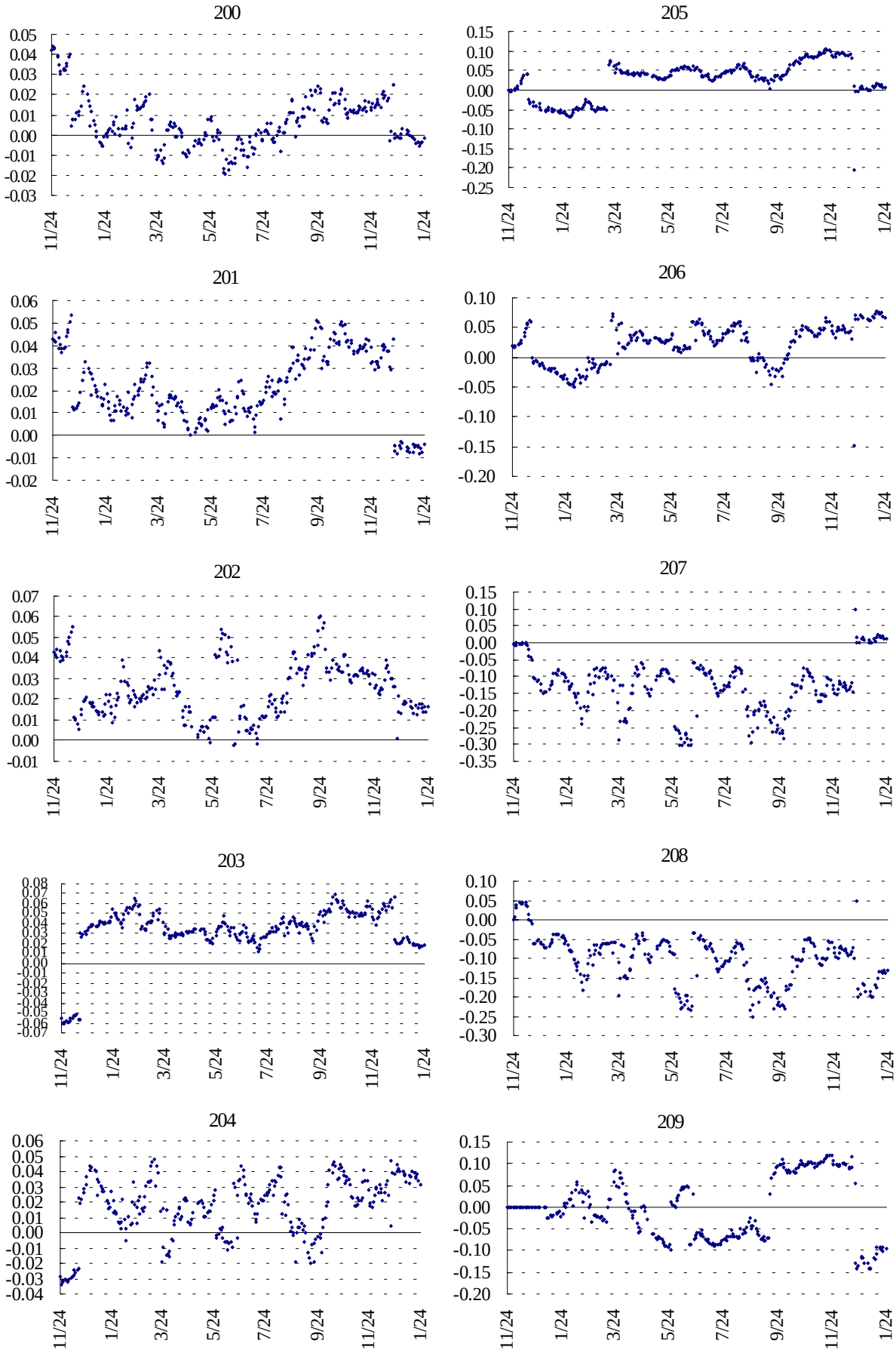


Chart 4-9-7 Standard Deviation of Fitting Errors from the Spline Curve (210th-219th issues)