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Bond Futures Market in Japan —Its Structure and Some Empirical Tests—

HIROMICHI SHIRAKAWA*

After describing the basic trading mechanisms of Japan's bond futures, this paper firstly analyzes the efficiency of its market based on simple econometric methods with which arbitrage, hedging, and speculation are examined separately. Secondly, how spot bond prices have been affected by the creation of bond futures is discussed from the viewpoint of a change in the conditional variance of the spot price. Empirical results suggest that; 1. Japan's bond market satisfies covered interest parity while its futures market would be inefficient in terms of speculation; 2. Spot bond holders are provided with an effective risk-hedging instrument by the futures; 3. The effect of the bond futures' existence on the spot price variability is ambiguous.

I. Introduction

Deregulation and internationalization of Japan's financial and capital markets are unfolding in various forms. One of the notable moves is a creation of markets[1] in the last two to three years for financial instruments that have not traditionally existed in Japan. The bond futures market is not only the market that was created relatively early (October 1985), but it also attracts attention due to its rapidly expanding trading volume.

The creation of bond futures market in Japan was driven by a general consensus that the market would serve as an essential instrument to reduce the risk of holding bonds due to their price fluctuations and also to provide new profit opportunities under the credit market expansion. Futures trading, including bond transactions, is the "trading with a promise to buy or sell commodities at a predetermined price at a certain time in the future."[2] Trading in the futures market, therefore, can be thought to enable bond holders

* Economist, Institute for Monetary and Economic Studies, Bank of Japan.

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[1]The other recent-created markets are bankers acceptance market (June 1985), short-term government bond market (February 1986), CP market (October 1987) and so forth. It also should be noted that the stock futures trading (June 1987) and the stock index futures trading (September 1988) have started.

[2]This transaction is sometimes considered as the "futures trading in a broad sense" or forward trading which should be separated from the "futures trading in a narrow sense."; the "narrow sense" trading is institutionally authorized to settle by the difference between pre-established price and the price of a reverse trading (either

to hedge against the price risk (change in the value of bonds) while increasing profit opportunities for speculation based on expectations of future bond prices. Thus, the primary role expected to the bond futures market at the time of introduction was to provide instruments for hedging against the price risk and to create new profit opportunities. The second role anticipated was to make long-term interest rates (spot bond prices) more correlated with short-term interest rates since a bond futures market is based on relatively short-term future contracts (minimum period of 9 days to maximum period of 1 year and 3 months). Thirdly, because it is possible for investors to calculate profits or losses of bond trading before completing the transaction, the bond futures market was expected to contribute the expansion of the secondary spot market. And the fourth role believed was to provide information on the bond prices in the future.[3]

This paper provides an evaluation of three basic functions of Japan's bond futures market and also argues the influence of the bond futures market's existence on variability of spot bond prices based on empirical analyses.

In section II, we describe the basic structure of Japan's bond futures market and the various forms of transactions involved. In section III, we examine the efficiency of the transactions such as arbitrage, hedging, and speculation based on recent data. Section IV analyzes the relationship between the futures market and the spot price fluctuations. Lastly, in section V, future issues of Japan's bond market are discussed. The empirical analyses of this paper cover the period of one year starting on November 21, 1986.

The major conclusions obtained from the analyses can be summarized as follows.

(1) Theoretically, when a bond futures market exists in addition to the spot market, an one-period holding return (yield obtained from buying bonds in the spot market at the beginning of a term and at the same time committing to their sales in the futures market at the end of the term) equals the short-term interest rate corresponding to the holding period. This relationship can be referred as so-called "covered interest parity in the bond market."

(2) Our empirical analysis suggests that the "covered interest rate parity" in Japan's bond market holds. In Japan's bond futures market where the right to choose a bond in the spot market for delivery lies in the sellers of futures while the futures are for "standard bond," the "arbitrage transaction" can be done only by trading the spot bond whose holding period yield is the largest (the "bond with the cheapest futures price") of all the "deliverable bonds" in the market. We can see empirically that any attempt of arbitrage transaction which aims to gain a profit without taking a risk cannot be benefited by profit opportunities. In that sense, Japan's bond market is efficient. However, it should be noted that the so-called "Shihyou-Meigara" bonds (such as the 89th issue),

buying back or selling) by the agreed date. Refer to Cox, Ingersoll, and Ross (1981) on an theoretical analysis concerning the difference between forward and futures trading.

[3]Shoken Torihiki Shingikai (1984) also describes the background of creating the bond futures market.

which have the dominating trading volumes in the market, have rarely been used for the arbitrage transactions since their spot prices have been always higher relative to the futures prices. This can be seen as existence of liquidity premiums attributable to their higher marketability, and consequently, it is possible to judge that the actual number of arbitrage transactions has been rather limited.

(3) As for hedging transactions, our empirical result shows that investors, who had been assumed to behave according to a simple hedging strategy, could have covered a large portion (80−90%) of risk in the spot market. The result is also applicable to the "Shihyou-Meigara" (89th issue) because the movement of discrepancy between its price and the futures price has been stable. We can conclude that Japan's bond futures market has satisfactorily been providing a risk-hedging instrument to bond holders.

(4) We can demonstrate that investors, who had acted on the basis of fairly simple speculation rule with an expectation of future prices, could have made profits from the movements of actual future prices. The existence of profit opportunities in speculation also implies that within the estimated period, the futures market had a tendency to move toward one direction.

(5) Some analysts view that the creation of bond futures market will contribute to the stability of spot bond yields because of the availability of hedging transaction and so forth. However, in Japan, since the creation of the futures market, fluctuations in spot bond yields on "Shihyou-Meigara" have instead become larger. One possible answer is that this is due to sensitive reactions of bond market participants against the foreign exchange rates that were very unstable during the estimated period. To concentrate on the effects of bond futures market on the spot yield fluctuation, we need further investigations.

(6) In considering the future of Japan's bond market, issues to be tackled are as follows: (a) price discrimination within the spot market due to the dominant trading volume of the specific issues ("Shihyou-Meigara") which has impeded active arbitrage transactions or stronger correlation between long-term and short-term interest rates and (b) undiversified and small number of participants in the bond futures market, which has occasionally made the bond futures price move toward one direction.

II. Mechanism and Structure of Bond Futures Trading in Japan

Here, we will describe the fundamental mechanism and the typical transactions of Japan's bond futures.[4]

A. Features and Settlement Methods

Japan's bond futures trading has the following two major characteristics.

[4]Refer to Seki (1985) about the structure of Japan's bond futures market.

(1) The "standard bond" (10-year maturity with 6 percent coupon rate or 20-year maturity with 6 percent coupon rate) which actually does not exist in the market while ensuring a continuity and preventing price manipulations is used in transactions. Thus the futures prices pertain to the "standard bonds" and not to the bonds actually traded in the market.

(2) The maturity dates are the 20th of March, June, September and December. Transactions can be made for the nearest one to 15 months ahead which means there are five possible maturity dates.

Since it adopts the "standard bond" system, the relationship between futures and spot in the market is that of one "standard bond" versus many bonds. Thus, as will be explained in section III, it should be noted that it is difficult to analyze the "efficiency of information" of the bond futures market by employing time-series model approaches used for analyzing the forward foreign exchange market.

Also, direct participants to the market are limited to financial institutions and securities firms.

Next, there are two settlement methods in the bond futures: "settlement by difference" and "settlement by delivery." The "settlement by difference" is made by reversing trade (long positions are sold and short positions are bought) between a contracted day and the delivery day which is 9 trading days before the maturity date. One the other hand, the "settlement by delivery" is made by delivering and receiving existing spot bonds against the unsettled futures contract. The investor who has contracted to sell futures receives payments against the delivery of spot bonds on hand, and the investor who has contracted to buy futures makes payments for the spot bonds he receives. The spot bonds used in this transaction should be "deliverable bonds" which are government bonds with a remaining maturity of more than 7-years and less than 11-years on the exchange. The seller of futures has the option to choose among the "deliverable bonds."

In Japan 99% of the settlement are made through the "settlement by difference."[5]

B. Major Transactions and Profit-loss Calculations

Bond futures transaction can be divided into the following four types: 1) simple

[5]The transaction costs incurred to the bond futures are as follows:

(1) Commission fee (per par value)
Par value of less than ¥500 million: 0.015%
Par value from ¥500 million to ¥1 billion: 0.010%
Par value frrom ¥1 billion to ¥5 billion: 0.005%
Par value more than ¥5 billion: 0.0025%

(2) Securities transaction tax (per delivery price)
General investors 0.03%
Brokerage firms 0.01%

(3) Admission Charge (per delivery price)
0.01%

delivery transaction; 2) speculation; 3) hedging transaction; 4) arbitrage transaction.

Each type of these transactions will be explained with a specific example of calculating profits and losses (on the assumption of ¥1 billion investment). The definitions of notation used in the formulas are as follows:

Fs	=	Futures selling price
Fb	=	Futures buying price
Ff	=	Futures settlement price
Ps	=	Spot selling price
Pb	=	Spot buying price
R	=	Profit or loss (=P/L)
I	=	Investment
C	=	Coupon rate of a spot bond
r	=	Short-term interest rate
T	=	Holding period.

1. Simple delivery transactions

In this type of transactions, a settlement is made only by "delivery." In the delivery process, conversion factors (CF) which convert prices of "deliverable bonds" into that of "standard bonds" are used.[6]

The basis will be defined as spot price minus futures price * CF ("forward price") where * expresses multiplication.

(P/L Calculation)

$$R=[\{(Ff * CF) + (Fs-Ff)\}/100-1] * I$$

(Transaction example)

Jan. 31, buying the future with the maturity date of June 20 at ¥101.00

June 20, settlement price is ¥99.00

Spot bond to be delivered is 53rd issue with CF of 1.00551

R = [{(99.00 * 1.00551) + (101−99)}/100−1] * ¥1 billion

=profit of ¥15.45 million

2. Speculation

Some investors speculate to earn capital gains from the movement of future prices by taking risks under uncertainty. Speculation is the transaction "settled by difference" in

[6]"Conversion factor" is a ratio between the total of principle plus interests of the "deliverable bond" whose reinvestment rate of coupon income is set as the coupon rate of the "standard bond" at the maturity date and the total of principle plus interests of the "standard bond." This can be expressed in the formula below:

$$CF = \frac{100\,C\,\{\frac{(1+r)^T-1}{r}\} + 100}{100\,(1+r)^T}$$

where C: the coupon rate of the "deliverable bond"

r: the coupon rate (6%) of the "standard bond"

T: remaining period to the maturity of the "deliverable bond."

the futures market. The most important information for speculators is the discrepancies of their contracted prices from the settlement price of that day which are calculated and announced daily by the stock exchange. (Its calculation is called "Nearai.") Speculators adjust their positions according to the unrealized profits and losses revealed by the process of "Nearai."

Factors which enhance the speculative feature of the futures market are the availability of short-selling (short position) with a lower transaction cost and the "capital leverage effect"; investors can make a large amount of transactions only by submitting 3% of par value (¥6 million minimum) as a margin deposit.

(P/L calculation)

$$R=(Fs - Fb)/100 * I$$

(Transaction example)

Speculation (selling futures) expecting future increase in interest rates

Jan. 31, short-selling the future with the maturity date of June 20 at ¥100.00

Feb. 28, re-purchasing the future with the maturity date of June 20 at ¥98.50

$$R = (101.00 - 98.50)/100 * ¥1 \text{ billion} = \text{profit of } ¥25 \text{ million}$$

3. Hedging transactions

Hedging transactions are done to avert price fluctuation risks in the spot market by holding opposite positions in spot and futures and reversing their respective positions simultaneously. As a result, a return can be determined at the time of making contracts. There are two types of hedging: "hedging by selling" to avert the risk of declining price of bonds held or the risk of rising debt cost, and "hedging by buying" to avert the risk of rising price of bonds purchased in the future. The most general case where effective hedging is realized is when futures price and the spot price move in the same direction. However, since the price movement of the spot bonds to be hedged is usually different from that of "standard futures bond" quantitatively, we have to be careful to calculate the "hedging ratio" that is the percentage of futures contract to be sold or bought against the spot. And the ratio showing to what extent the loss of spot transaction is offset by the profit of futures transaction is called the "covering ratio."

(P/L Calculation)

$$R = \{(Fs-Fb) + (Ps-Pb)\}/100 * I$$

(Transaction example)

Hedging by selling the future with the anticipated rise in interest rates (decline in spot bond prices).

⟨Spot Market⟩

Jan. 31, holding 53rd issue at the market price of ¥104.80

Feb. 28, selling 53rd issue at ¥102.40

⟨Futures market⟩

Jan. 31, short-selling the future with the maturity date of June 20 at ¥101.00

Feb. 28, re-purchasing the future with maturity date of June 20 at ¥98.85

$R = \{(102.40-104.80) + (101.00-98.59)\}/100 * ¥1$ billion

$= +¥1$ million

(covering ratio = ¥25 million / ¥24 million = 104.2%)

4. Arbitrage transactions

When there exist price discrepancies between markets, one can attain profits through an arbitrage transaction by buying in the market with a lower price and simultaneously selling in the market with a higher price without involving any risk. Three basic transactions are 1) "spread transaction," 2) "basis transaction" and 3) "arbitrage transaction." In this paper, the "arbitrage transaction" refers to 3), unless qualified otherwise. First of all, "spread transaction" is one type of arbitrage which concentrates on the spread (price difference between two maturity dates on futures) and can be understood as the combination of "settlements by difference" in the futures market. We can also consider the "spread transaction" as the one benefited from a shift of the yield curve.

(P/L Calculation)

$$R = \{(F_{1S}-F_{1b}) + (F_{2S}-F_{2b})\}/100 * I$$

(Transaction example)

—Spread transaction expecting future decrease in the short-term interest rate

Jan. 31, long-term interest rate 5.5%, short-term interest rate 5.6%

Feb. 28, long-term interest rate 6.2%, short-term interest rate 5.7%

Jan. 31, buying the future with the maturity date of June 20 at ¥101.00
short-selling the future with the maturity date of March 20 at ¥102.00

Feb. 28, selling the future with the maturity date of June 20 at ¥98.50
re-purchasing the future with the maturity date of March 20 at ¥98.00

$R = \{(98.50 - 101.00) + (102.00 - 98.00)\}/100 * ¥1$ billion

=profit of ¥15 million (1.5%)

"Basis transaction" or "arbitrage transaction" is the transaction designed to make profits without taking risks by holding opposite positions simultaneously in both futures and spot markets expecting that the existing discrepancy between the actual "basis" or the futures price of the deliverable bonds and their theoretical values should be corrected at a later date. In the "basis transaction," positions are squared before the final trading day (delivery day), while in the "arbitrage transaction" the settlement is done by delivery of a spot bond.

The "theoretical futures price" in the "arbitrage transaction" can be derived as follows assuming no restrictions in both bond markets and the short-term money market. Since one-period holding returns on bonds (neglecting taxes on accrued interests) with the "settlement by delivery" should be equal to the one-period short-term interest rates, the following equation can be obtained:

$$({}_{t+1}F_t * CF^i_t - P^i_t + C^i * T) / P^i_t = r_t * T \quad (1)$$

where ${}_{t+1}F_t$: the one-period ahead futures price at time t
P^i_t : the spot price of bond i at time t
C^i : the coupon rate of bond i
CF^i_t : the conversion factor of bond i at time t
r_t : the one-period short-term interest rate at time t
T : the period until the final transaction date (delivery date).

From the above equation, the "theoretical futures price," ${}_{t+1}\hat{F}_t$ (the arbitrage price corresponding to bond i) can be given as:

$$ {}_{t+1}\hat{F}_t = [P^i_t - (C^i - P^i_t * r_t) * T] / CF^i_t \tag{2} $$

that is,

Theoretical futures price

= {spot price − (coupon receipt − financing cost) × holding period}
÷ (conversion factor).

Although the "theoretical futures prices" exist in as many numbers as the deliverable bonds, the market futures price converges on the cheapest price among them.[7] This is because the sellers of futures have the right to choose among the deliverable bonds and thus the delivery actually occurs only with the bond which offers the most profitable holding period return. Therefore, the "arbitrage transaction," which ensures the so-called "covered interest parity in the bond market," should be thought to be made only when there exists a price discrepancy between the "theoretical futures price" of deliver-

[7]Let's assume that there are two bonds in the spot market (bond A and bond B) and their coupon rates (C), prices (P), conversion factors (CF) and the short-term interest rate (r) are as follows;

	C	P	CF	r
Bond A	7.0%	100.00	1.07	6.0%
Bond B	8.0%	108.00	1.14	

First of all, from equation (2), the "theoretical futures prices" for bonds A and B can be obtained. For bond A, it is ¥92.52 (={100.00−(7.0−100.00×0.06)}/1.07), and for bond B, ¥93.40 (={108.00−(8.0−108.00×0.06)}/1.14). If the actual futures price in the market is equal to the "theoretical futures price" of bond B (¥93.40), one-year holding return on bond A will be 6.94% (={93.40×1.07−100.00+7.0}/100.00), while that on bond B will be 6.00% (={93.40×1.14−108.00+8.0}/108.00) from equation (1). Therefore, when the futures bond is quoted at ¥93.40, the investor can obtain a higher return than the short-term interest rate by buying bond A and selling the future. As the result of this "arbitrage transaction," the futures price will decline until it reaches the "theoretical futures price" of bond A (¥92.52) which equilibrates the holding period return with the short-term interest rate. On the other hand, when the futures price is equal to the "theoretical futures price" of bond A (¥92.50), the holding period return on bond A will be 6.00% and that on bond B will be 5.06%. At a first glance, it seems that financing at a cheaper cost than the market short-term interest rate is possible through selling bond B and buying the future, however, since the buyer of futures cannot nominate a particular bond prior to delivery, the futures price will not consequently be apart from the "theoretical futures price" of bond A. Thus, the futures price in the market converges on the cheapest "theoretical price" of ¥92.52.

able bond with the cheapest futures price and the actual futures price.[8]

(P/L calculation)

Case for "basis transaction"

$$R = \{(Fs-Fb) + (Ps-Pb) + (C-Pb * r) * T\} / 100 * I$$

Case for "arbitrage transaction"

$$R = [\{(Ff * CF) - Pb + (C - Pb * r) * T\} + (F_S - F_f)] / 100 * I$$

(Transaction example for the "basis transaction")

—Overvalued futures and undervalued spot.

June 21, 58th issue with the cheapest futures price of	¥111.00
Price of the future with the maturity date of September 20	¥102.00
Market short-term interest rate	4.6%
Theoretical futures price corresponding to the 58th issue	¥101.57
[= {111.00 − (7.5 − 111.00 * 0.046) * 90/365} / 1.087 calculated from equation (2)]	
Holding period return	6.30%
[= (102.00 * 1.087 − 111.00 + 7.5 * 90/365) / 111.00 × (365/91) calculated from the left hand of equation (1)]	
Basis	¥0.13
[= 111.00 − 102.00 * 1.087]	
Appropriate basis (theoretical value)	¥0.59
[= 111.00 − 101.57 * 1.087]	

As of June 21, the futures price (¥102.00) is above its theoretical price (¥101.57). Accordingly, the basis also exceeds its appropriate value. This situation suggests overvalued futures with undervalued spot where an arbitrage profit can be attained by buying spot and selling futures. A reversing trade is made on August 21.

August 21, 58th issue price	¥111.50
(CF = 1.085)	
Price of the futures with the maturity date of September 20	¥102.40
Basis	¥0.40
Appropriate basis	¥0.20

Then, selling spot and re-purchasing the futures which as a result produces ¥5 million profit.

$$R = \{(102.00 - 102.40) + (111.50 - 111.00) + (7.5 - 111.00 * 0.046) * 61/365\} / 100 * ¥1 \text{ billion} = ¥5 \text{ million}.$$

[8]On the other hand, the "basis transaction," sometimes uses a bond different from the one with the cheapest futures price, but this is considered to be a speculation against short-term basis fluctuation.

Income		Expenditure	
Selling the future	¥102.00	Purchasing the spot	¥111.00
Selling the spot	¥111.50	Repurchasing the futures	¥102.40
Coupon income	¥1.25	Short-term financing cost	¥0.85
(= 7.5 x 61/365)		(= 111 x 0.046 x 61/365)	
	¥214.75		¥214.25

Profit is ¥0.5 (x ¥1 billion)

The P/L calculation of the transaction can also be expressed as the above table.

III. Analysis of Arbitrage, Hedging, and Speculation

We will investigate the performance of Japan's bond futures market by looking at three major transactions.

A. Covered Interest Parity in the Bond Market

Our first interest is the pricing mechanism for the bond futures where bond futures prices should fully reflect all of the available information. After describing briefly the concept of efficiency of the bond futures market, we will examine the "covered interest parity."

1. Market efficiency

In general, when the future (next-period) price of an asset is determined by the expectations of the market participants who use all the information available at the present time, we can refer to that asset market as efficient one in terms of information. The market efficiency in this sense can be evaluated in the form of joint hypothesis with the attitude of market participants toward risk. For example, if the relationship between the one-period ahead futures price and the expected spot price at the one-period ahead can be expressed as

$$ {}_{t+1}F_t = E_t\,[P_{t+1} \mid \Omega_t] \tag{3}$$

where

${}_{t+1}F_t$: the one-period ahead futures price at time t

P_{t+1} : the spot price at time t+1

$E_t\,[\,\cdot\,|\Omega_t]$: the expectations operator conditional on information available at time t, Ω_t,

we are supposed to deal with the joint hypothesis of "efficiency in information" and the risk neutrality, that is the non-existence of risk premium. The combination of equation (3) and (4) below can be considered as the equation for the "uncovered interest parity."[9]

It is well-known that there have been many empirical analyses for the efficiency of

[9]"Uncovered interest parity" is explained as the situation where "the rationally expected holding period

the forward foreign exchange market based on equation (3). However, as for the Japan's bond futures market, it is more desirable that the so-called "covered interest parity", where the one-period holding return on a bond using futures contract equals to the short-term interest rate (expressed as equation (4) below) should be investigated rather than equation (3) because it is not obvious that the "covered interest parity" holds for the newly-created market.

$$({}_{t+1}F_t - P_t + C)/P_t = r_t \tag{4}$$

where

C : the coupon income

r : the one-period short-term interest rate.

As theoretically shown in section II. B and as will be presented in the next section for the actual data, the spot bond which makes the "covered interest parity" hold in the bond market is the "deliverable bond" with the cheapest futures price in the day. Therefore, equation (3) can be written as:

$${}_{t+1}F_t = E_t\,[\min({}_TP^1_{t+1}, {}_TP^2_{t+1}.., {}_TP^n_{t+1}) \mid \Omega_t] \qquad (3)'$$

where

$\min({}_TP_{t+1}, {}_TP_{t+1}.., {}_TP_{t+1})$ expresses the price of bond whose theoretical futures price is minimum among the existing spot bonds at time t+1.

As a result, it is quite difficult to examine the relationship in equation (3)′ with a time series model, and consequently, the evaluation of "efficiency in information" in the Japan's bond futures market will be untouched in this paper.

2. *Analysis of covered interest parity based on data*

Strictly speaking, the examination should be done for the discrepancies[10] between the market futures prices and the "theoretical futures prices" of the "deliverable bonds" with the cheapest futures price since profit opportunities could remain unadjusted at least theoretically for the other "deliverable bonds." However, in the actual market, we cannot deny the possibility that arbitrage transactions are done between the futures and the spot bonds whose "theoretical futures prices" are not significantly apart from the market futures prices. Therefore, we add two "deliverable bonds" to the bonds with the cheapest

returns on all bonds in the market are equal to the short-term interest rate corresponding to the holding period." There are two approaches to verify this relation: one is by examining simultaneously both equations (3) and (4), and the other is checking

$$E_t\,[(P_{t+1} - P_t + C)/P_t|\Omega_t] = r_t \tag{5}$$

without including the futures market explicitly. The latter is equivalent to test the rational expectations model of the term structure, which states that a bond yield is equal to the weighted average of the short-term interest rates (Shirakawa 1987).

[10]More simply, it is possible to discuss this in terms of whether the basis spreads from zero, ignoring the time until the maturity date.

futures prices to analyze the discrepancies between the market and theoretical futures prices. To see whether the profit opportunity for the "arbitrage" remains unadjusted, the discrepancy for each bond will be checked if it lies within the boundary of transaction costs which is set to be ¥0.5 per ¥100 as a broad sense.[11] This boundary takes the following factors into account in addition to the transaction costs in a strict sense (see footnote 5).

(1) There can be about ¥0.3 of difference in the "theoretical futures price" for each bond when there is about 0.5% of rate discrepancy in the short-term interest rates employed. (In general the "Gensaki" rate is used, but the weighted average rate including CD rate or MMC rate can also be used.)

(2) There are some minor technical factors which make the market futures price and the "theoretical futures price" differ; the difference in the trading hours between the spot and futures markets,[12] or a forecast error of the short-term interest rate at the delivery dates.

From equation (2), the discrepancy between the market futures price and "theoretical futures price" can be given as follows (t and i are omitted);

$$
\begin{aligned}
F-\hat{F} &= \{(F * CF - P) + (C - P * r)T\}/CF \\
&= \{-B + (C - P * r)T\}/CF \qquad (6)
\end{aligned}
$$

where B is basis.

In the case when the market futures price is above (or below) the "theoretical futures price", it is possible to judge that the spot price is undervalued (or overvalued) relative to its corresponding forward price.

In the following figures, the movements of the discrepancies for the 89th issue ("Shihyou Meigara"), 73rd issue and the bonds with the cheapest futures prices are plotted for each maturity date[13] together with the broadly defined boundary of transaction costs; the discrepancies (the market futures price minus the theoretical futures prices) are denoted as D1 for the 89th issue, D2 for the 73rd issue and D3 for the bonds with the cheapest futures prices.

Table 1 shows the sampling averages (E), standard deviations (S), maximum values (MA), minimum values (MI) and the Durbin-Watson statistics (DW) for D1, D2, and D3.

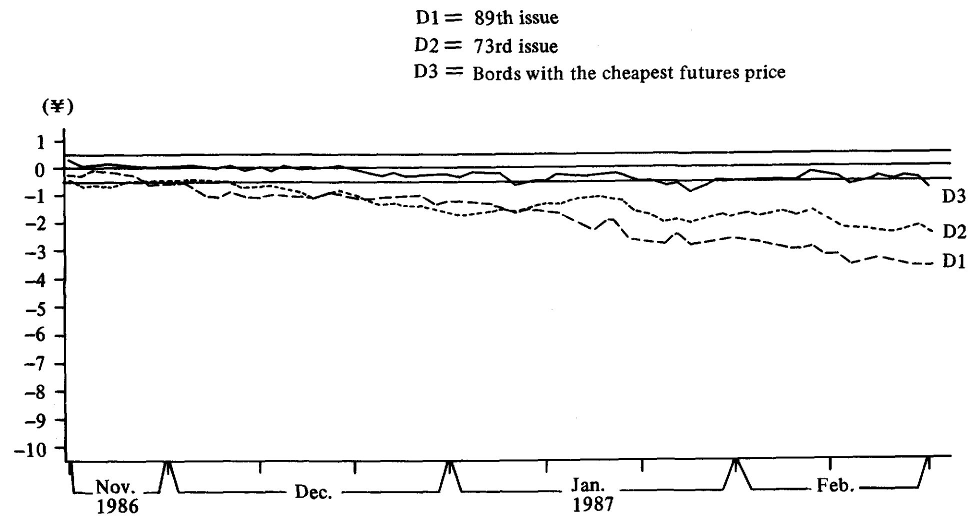
[11]In addition, we are sometimes required to test the auto-correlation in the profit opportunity for the arbitrage. However, for this point we just calculate the Durbin-Watson statistics as references and will not examine in detail.

[12]Futures transactions are limited during the trading hours of the Tokyo Stock Exchange (9am—11am, 1pm—3pm), while the trading hours for spot transactions are characterized by those (8:40am—11:15am, 0:40pm—5pm) of BB trading (trading between securities firms via Nippon Sogo Shoken as the broker). Thus, in the futures trading, it is necessary to predict not only the real time spot prices but also prices in the spot markets after the futures market is closed.

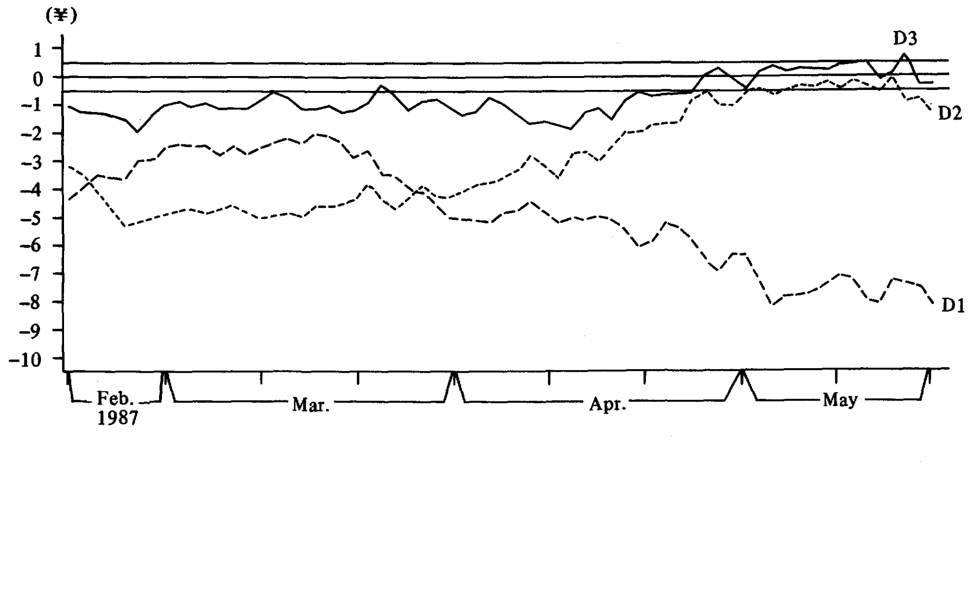
[13]The transaction volume for each maturity date concentrates on four to one months prior to the date.

Figure 1. Profit Opportunities for Arbitrage – Discrepancies between the market futures price and theoretical future prices

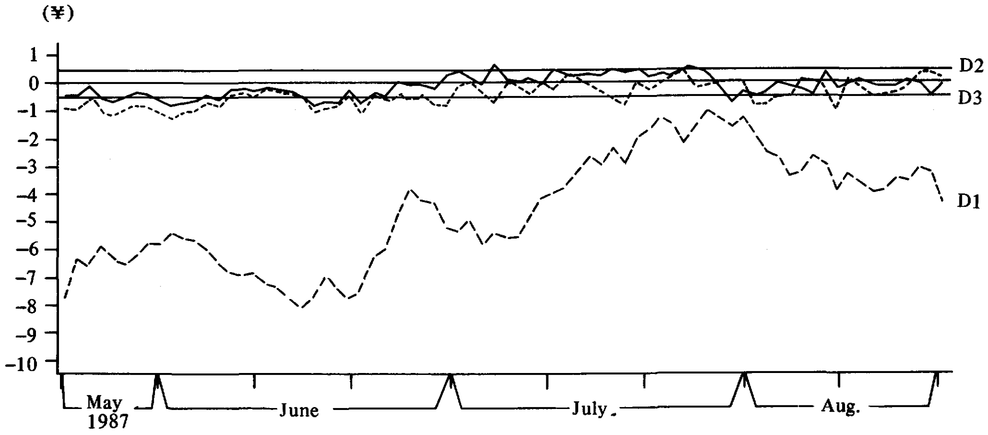
(1) Maturity date of March 20, 1987
(Nov. 21, 1986 – Feb. 20, 1987)



(2) That of June 20, 1987
(Feb. 23, 1987 – May 20, 1987)



(3) That of September 20, 1987
(May 21, 1987 – Aug. 22, 1987)



(4) That of December 20, 1987
(Aug. 24, 1987 – Nov. 20, 1987)

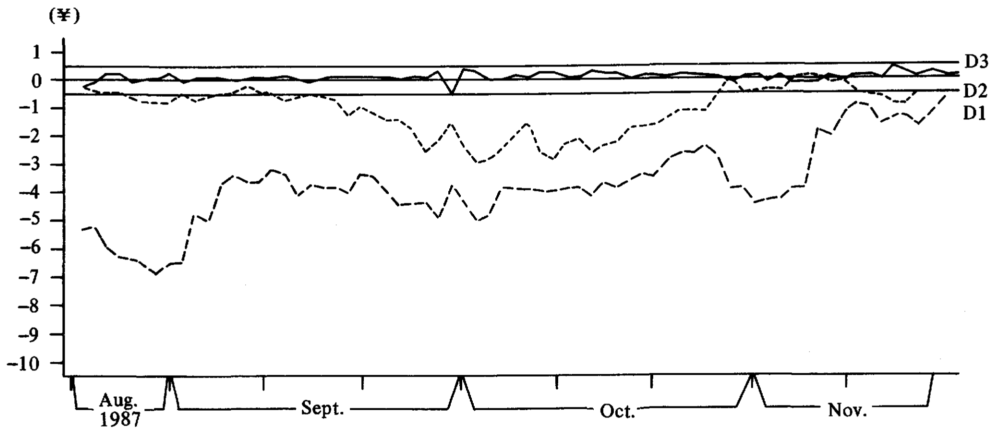


Table 1. Statistics on Profit Opportunities for Arbitrage

		D1	D2	D3
	E	−1.778	−1.340	−0.251
	S	1.047	0.594	0.267
Mar. 20	MA	−0.128	−0.411	0.290
	MI	−3.570	−2.447	−0.930
	DW	0.008	0.008	0.156
	E	−4.881	−2.965	−0.794
	S	1.936	1.732	0.644
June 20	MA	−2.036	−0.090	0.700
	MI	−8.276	−5.271	−1.980
	DW	0.006	0.010	0.108
	E	−4.579	−0.387	−0.113
	S	2.003	0.430	0.382
Sept. 20	MA	−1.001	0.473	0.720
	MI	−8.149	−1.272	−0.810
	DW	0.012	0.388	0.536
	E	−3.796	−1.119	0.025
	S	1.399	0.833	0.145
Dec. 20	MA	−0.885	0.059	0.370
	MI	−6.915	−2.986	−0.580
	DW	0.019	0.061	2.014

Note: The first column shows maturity dates.

From Figure 1 and Table 1, the following conclusions can be pointed out:
(1) The disrepancy for the bonds with the cheapest futures prices (D3) has been within the boundary except for some period in the maturity date of June 20. It means that in Japan's bond futures market, the profit opportunities for the "arbitrage transactions" did not exist for the most period and therefore, we can judge that the "covered interest parity" has been holding. (It should be noted that in the recent period the discrepancy lay in the strictly-defined boundary.) During the first half of the period whose maturity date was June 20, the expectation of interest rate declining can be thought to have caused larger dicrepancies in addition to the insufficient supply of spot bonds in the market which might give futures-sellers a hard time with finding an appropriate "deliverable bond."
(2) For the 73rd issue, there is the possibility of having been involved in the "arbitrage transactions" in some period (the case for the maturity date of September 20), while for the 89th issue it is unlikely that "arbitrage transactions" were made throughout the period because its spot prices had been considerably higher than its corresponding forward prices for most of the case. That is, although in the Japan's bond market the "covered

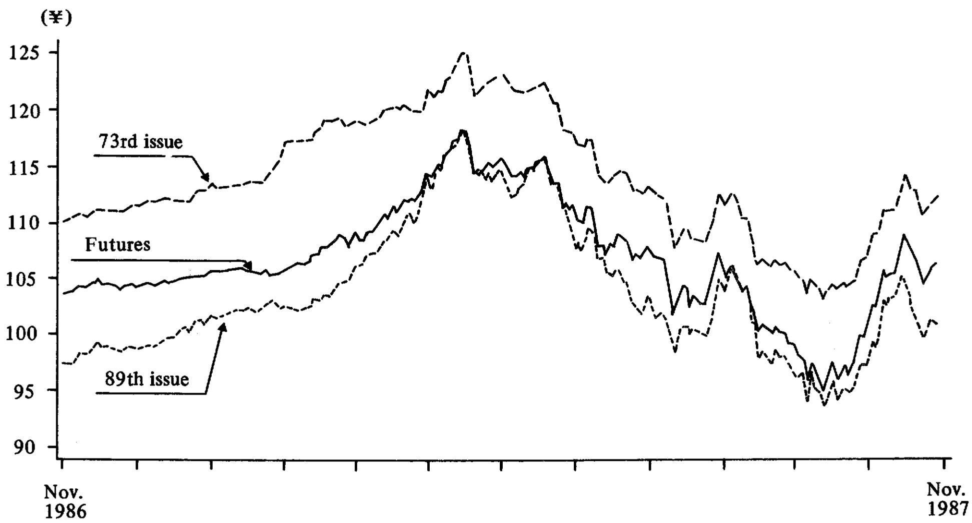
interest parity" cannot be rejected as we have shown in (1) above, the number of actual "arbitrage transactions" can be judged to have been very limited since the "Shihyou Meigara" with dominant trading volume has not been the target of the transactions. One possible reason for the price discrimination between the "Shihyou Meigara" and the rest is that a kind of liquidity premium is added to the spot price of the "Shihyou Meigara."[14]

B. Analysis of Hedging and Covering Ratios

1. *Methods*

The bond futures market provides the instrument to hedge interest rate risks for risk

Figure 2. Spot and Futures Prices



[14]The proportions of trading the "Shihyou Meigara" to the total government bond trading in over-the-counter market are as follows:

(%)

	78th issue	89th issue	105th issue
Sept. 1986	97.7	0.7	
Oct. 1986	91.5	4.0	
Nov. 1986	33.6	42.6	
Dec. 1986	1.1	85.8	
Jan. – Mar. 1987	–	82.5	
Apr. – June 1987	–	87.1	
July – Sept. 1987	–	95.7	
Oct. 1987	–	95.8	
Nov. 1987	–	81.2	12.3
Dec. 1987	–	3.8	88.1

averse investors. Such function of the bond futures market plays an important role in promoting the development of the secondary and primary bond markets as well as the overall investment activities in the economy. In this section, to what extent investors could have hedged the spot market risks through the bond futures market will be examined. It will be useful to look at the recent movements of spot bonds prices and the futures price which are plotted in Figure 2 before the analysis based on data. It is obvious from the figure that the spot and futures prices show similar movements although differences in their price levels can be recognized. Therefore, we are allowed to infer that a certain amount of spot market risks might have been reduced through hedging with futures transactions from the *ex post* point of view.

How do risk averse investors choose the optimal "hedging ratio"? And how much of risks in the spot market can be reduced under such optimal "hedging ratio"? Let us consider the case where an investor holding one spot bond makes a hedging transaction. The major interest of the investor would be to minimize the fluctuation or variance of the return after the transaction or to minimize the expected value of risks not reduced by the transaction. Assuming that the spot and futures prices are in a linear relationship, the spot price at time t is P_t, the futures price is F_t and the "hedging ratio" is α, such hedging strategy can be expressed as the following minimization problem (ignoring the transaction costs).

$$\min_{\alpha} E = \{(P_{t+1} - P_t) - \alpha(F_{t+1} - F_t)\}^2 \tag{7}$$

Replacing $(P_{t+1}-P_t)$ by Y_t and $(F_{t+1}-F_t)$ by X_t, we can get the optimal "hedging ratio" α by estimating $Y_t=\alpha X_t+u_t$, using the least squares method. And the "covering ratio" $\gamma(\alpha)$ which is the proportion of reduced risk to the total risk of the spot price fluctuation and is expressed as equation (8) below can be given as the estimated coefficient of determination.[15]

$$\gamma(\alpha) = \frac{VAR(Y_t) - VAR(U_t)}{VAR(Y_t)} \tag{8}$$

(VAR: variance)

2. *Empirical results*

Tables 2 and 3 provide the estimated values of "hedging ratios"and "covering ratios" for the 89th and the 73rd issues.[16] We assume that the hedging period of time t to time t+1 is to be set one, two and three weeks. Conclusions obtained from the tables are summarized as follows:

(1) Hedging transactions employing such strategy have been successful in reducing substantial proportion (80−95%) of risks in the spot market. The reason why the "covering ratios" for the 89th issue are also high is that the liquidity premium added to the 89th

[15] See Ederington (1979) for a further discussion.

[16] We do not think much of the statistical significances of optimal hedging ratio.

Table 2. Empirical Results on Hedging Transactions Using the 89th Issue

		Optimal Hedging Ratio	Covering Ratio
Mar. 20	A	1.638	0.776
	B	2.064	0.914
	C	2.182	0.959
June 20	A	1.116	0.801
	B	1.289	0.909
	C	1.357	0.961
Sept. 20	A	1.014	0.705
	B	1.134	0.803
	C	1.257	0.898
Dec. 20	A	1.009	0.840
	B	0.929	0.917
	C	0.881	0.949

Table 3. Empirical Results on Hedging Transactions Using the 73rd Issue

		Optimal Hedging Ratio	Covering Ratio
Mar. 20	A	0.750	0.358
	B	1.199	0.701
	C	1.359	0.792
June 20	A	0.711	0.767
	B	0.617	0.805
	C	0.544	0.876
Sept. 20	A	0.981	0.946
	B	1.067	0.975
	C	1.124	0.989
Dec. 20	A	0.833	0.959
	B	0.816	0.976
	C	0.815	0.990

Note: A . . . . . Case for one-week hedging period
B . . . . . Case for two-week hedging period
C . . . . . Case for three-week hedging period

issue can be considered as a sluggish one that hardly fluctuates in the short term.
(2) The longer the hedging period is, the higher the "covering ratio" becomes.
(3) While the optimal "hedging ratios" are mostly found in the vicinity of 1.0, the figures for the 89th issue are higher than those for the 73rd issue, which indicates that the price variability was greater for the 89th issue in the spot market.

It should be noted that the above analysis deals with the "in sample" data analysis; calculating the optimal "hedging and covering ratios" simultaneously for all given samples. Therefore, it is useful to conduct "out of sample" tests which calculate the "covering ratios" of some period under the optimal "hedging ratios" estimated on the past data. Our "out of sample" tests where the optimal "hedging ratios" estimated in the first month of each case are used to estimate the "covering ratios" of the rest of period show that under the same hedging strategy, investors should have reduced almost the same proportion of risks as obtained from the "in sample" data analysis for the cases of one-week hedging period.[17]

C. Returns on Speculation

Next, we are going to analyze the "speculative efficiency" of Japan's bond futures market by looking at the time-series data of returns on speculation. The hypothesis to be examined is that there should be no systematic profit opportunity in speculation which is equivalent to the zero ex-post expected return on speculation under risk neutrality of investors. In the process of analysis, we can evaluate whether the profit opportunity involving risks remains unadjusted or not. One approach to test that hypothesis is to employ the following ARMA (2, 2) model:

$$\pi_t = \mu + \alpha_1\pi_{t-1} + \alpha_2\pi_{t-2} + \beta_1 e_{t-1} + \beta_2 e_{t-2} + e_t \tag{9}$$

where π_t represents one-period speculative return which equals to $(F_{t+1}-F_t)$.

The null hypothesis here is that the estimated parameters of α_1, α_2, β_2, β_2 are all zero and simultaneously that of μ is less than the reasonable transaction costs. If the null hypothesis is rejected, then there should be the profit opportunities remained in speculation since the rejection of null hypothesis means that the speculative returns are generated systematically and their expected value is not zero. Furthermore, if the estimated value for μ is significantly large, we cannot reject the possibility that a continuous profit opportunity has existed in speculation.

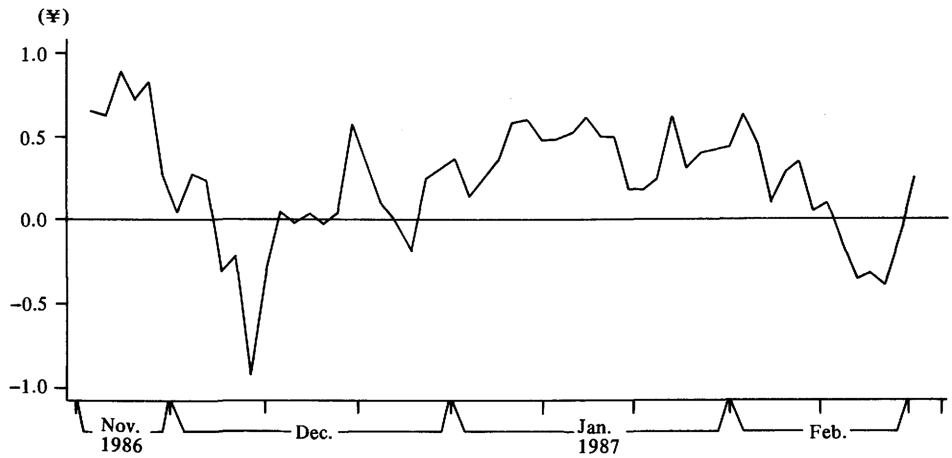
In this paper, we assume that the speculation period (from time t through time t+1)

[17]The covering ratios obtained from the "out of sample" tests.

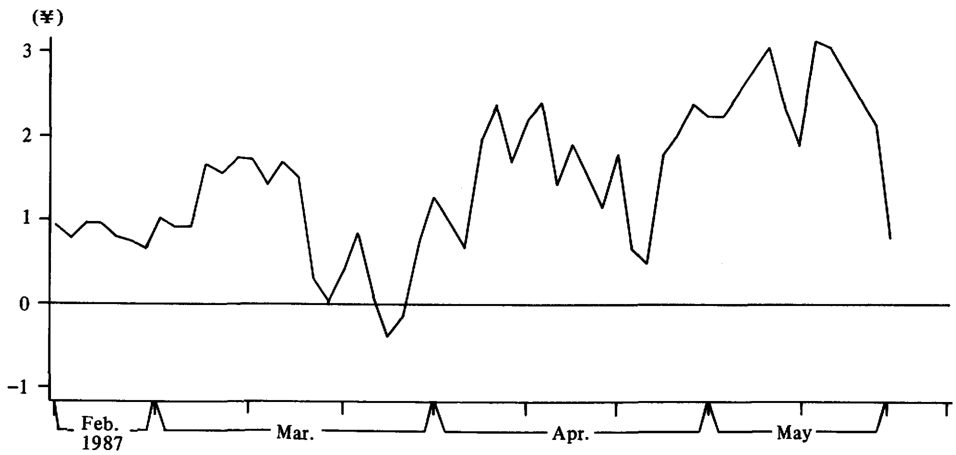
	Mar. 20	June 20	Sept. 20	Dec. 20
89th issue	0.725	0.812	0.717	0.842
73rd issue	0.369	0.776	0.929	0.989

Figure 3. Fluctuation in Speculative Returns

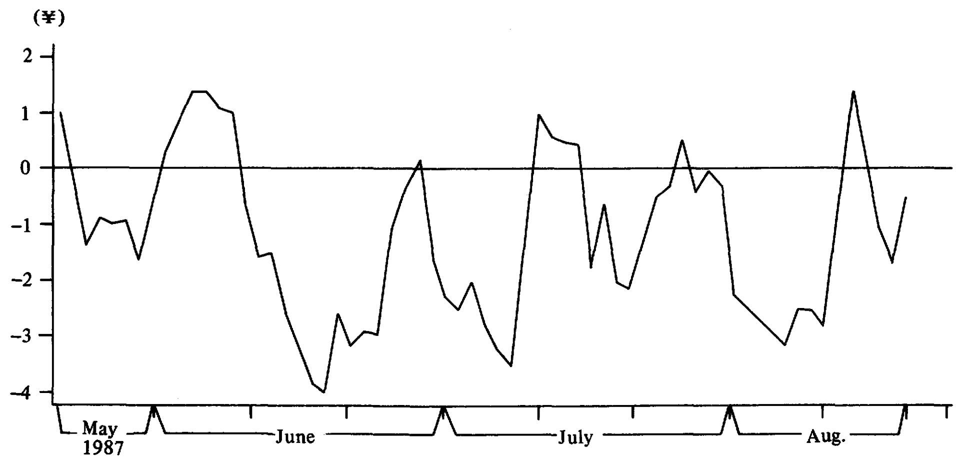
(1) Maturity date of March 20, 1987
(Nov. 21, 1986 – Feb. 20, 1987)



(2) That of June 20, 1987
(Feb. 23, 1987 – May 20, 1987)



(3) That of September 20, 1987
(May 21, 1987 – Aug. 20, 1987)



(4) That of December 20, 1987
(Aug. 24, 1987 – Nov. 20, 1987)

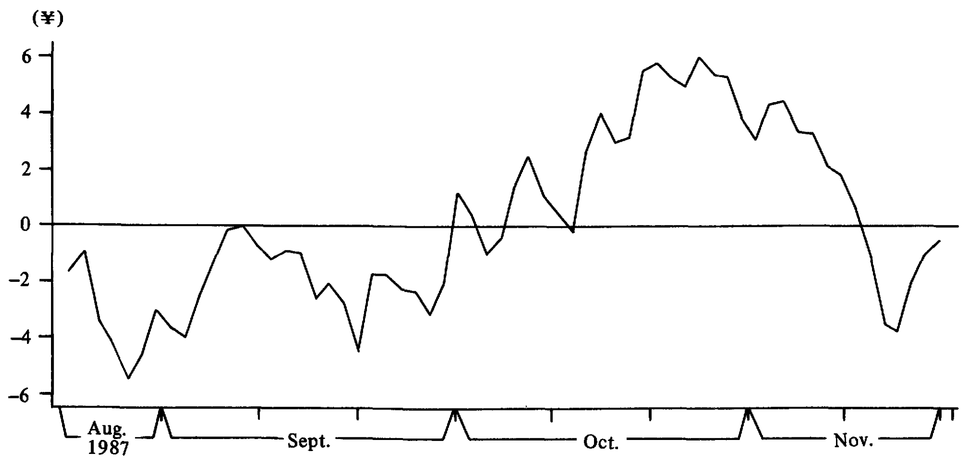


Table 4. Results of ARMA Model Estimation

	α_1	α_2	β_1	β_2	μ	W
Mar. 20	0.829 (2.00)	0.813 (1.20)	0.135 (0.00)	0.865 (0.00)	0.265 (4.05)	0.000
June 20	1.824 (16.04)	−0.848 (−7.56)	0.756 (0.01)	0.244 (0.01)	1.240 (5.69)	0.007
Sept. 20	0.790 (4.37)	0.647 (3.40)	−0.321 (−1.17)	0.646 (3.40)	−1.023 (−2.67)	0.042
Dec. 20	1.339 (4.22)	0.037 (0.08)	0.229 (0.01)	0.771 (0.04)	−0.695 (−0.59)	0.010

Note: 1. t - values in parentheses.
2. W is the probability obtained from the Lyung – Box statistics with which the hypothesis that the error is white noise is rejected. The first column expresses the settlement dates.
3. The first column expresses the maturity dates.

is one week and that the transaction is always made by "buying on day t and selling on day t+7 operating days." The fluctuation in speculative returns is given in Figure 3 and estimated results of the above model are given in Table 4.

According to the Table 4, the estimated values for α_1, α_2, and μ are significant in almost all cases while those for β_1 and β_2 are rarely significant. Therefore, it can be inferred that speculators could have made profits if they had successfully employed the speculative strategy like ARMA (2, 2) model where they use the information such as past returns or forecast errors. We are allowed to conclude that the possibility that the speculative opportunity in Japan's bond futures market remains unadjusted and that it is inefficient market in terms of speculation cannot be rejected, if we assume the risk neutrality of investors.

IV. Futures Market and Spot Price Volatility

It is interesting to analyze the relationship between the creation of bond futures market and variability of spot bond prices. Before getting into the empirical analyses, we will briefly overview the general concepts about the relationship.

A. General Concepts

The arguments that the futures market contributes the stability of its spot market have more frequently been recognized than those which look at the negative side.[18] The

[18]It has been theoretically proved that the bond futures market contributes the stability of spot prices through the optimization behavior of rational investors by Kiyokawa (1986). For a more detail, see the appendix and for references, see Kawai (1984) and Turnovsky (1979).

latter argument is based on the concept that the futures market is quite often exposed to the speculation and its volatility is easily transferred to the spot market, while the former argument focuses on the followings:
(1) It is not plausible to assume that the participants in the futures market are always acting inefficiently to make its price movement more volatile than that in the spot market. (2) The trading pressure to the spot market can be transferred to the futures market through the hedging transactions. (3) Since the futures prices function as additional information available to the market participants, an unanticipated movement in the spot prices will become smaller. In addition, there are two characteristics to reinforce the argument in Japan's bond futures market. At first, because intensively-traded "Shihyou Meigaras" are not involved in the arbitrage transaction as we have seen, price movements in the futures market are not constantly transferred to the spot market. And secondly, with the limitation of trading hours etc., the bond futures market in Japan has been reacting passively to the movement of spot prices and it can be thought that the futures market rarely causes the fluctuation in the spot market.

B. Volatility of Spot Bond Yields

Past empirical researches which analyzed the effects of futures market on the spot price fluctuations fail to consider the other factors which might have influenced the spot price movements by simply looking at the ex-post futures price fluctuations or futures transaction volumes with the spot prices.[19] This paper employs an improved method to analyze the spot bond price fluctuations since the creation of the bond futures market.

1. Conditional variances

In the traditional method, analysts have compared sample variances of spot prices between before and after the creation of the futures market. However, this method cannot distinguish the pure effects of the futures market from the other factors affecting the spot prices; that are changes in the parameters of dependent variables or in variables themselves in a spot price model. In other words, if for example, the sample variance of a spot bond price is estimated to become smaller after the creation of a futures market, it might not be due to the existence of the futures market, but rather, it could be brought by the fact that the short-term interest rate becomes stable. Such an argument can be seen from the comparison between the unconditional and conditional variance of spot price under a most simplified model as follows:

$$\begin{aligned} R_t &= \alpha R_{t-1} + \varepsilon_t \\ &\quad \varepsilon_t \sim \mathrm{i.i.d}(0,\ \sigma_\varepsilon^2) \\ &\quad 0<\alpha<1 \end{aligned} \tag{10}$$

where R_t is a stochastic spot price.

[19]For past analyses, refer to Bortz (1984), Figlewski (1981), *et. al.*

From equation (10) we get:

$$R_t = \sum_{s=0}^{\infty} \alpha^s \varepsilon_{t-s} \tag{11}$$

and therefore, the unconditional variance (sample variance) can be expressed:

$$\sigma^2 (R_t) = \sigma_\varepsilon^2 / (1 - \alpha^2).$$

The conditional variance based on the information available at time t, on the other hand, can be given as:

$$\sigma^2 (R_t \mid \Omega_t) = \sigma_\varepsilon^2.$$

It is obvious from the above that the unconditional variance of spot price depends on the parameter (α) of equation (10) while the conditional variance is the variance of the random shock (forecast error) in equation (10).

As we have seen, when we consider volatility of a variable as the variability independent of variables in the model as in the case that we should analyze pure effects of a futures market, it is more appropriate to use the conditional variance.

2. *Empirical results*

In the previous discussion, a spot price is assumed to follow the simple AR model. In the following empirical analyses, however, we assume that the daily spot bond yield Y_t is determined by the yesterday's call rate (CL_{t-1}), foreign exchange rate (EX_{t-1}) and U.S. bond yield (Y^*_{t-1}) as follows:

$$Y_t = a + \alpha \cdot CL_{t-1} + \beta \cdot EX_{t-1} + \gamma \cdot Y^*_{t-1} + \varepsilon_t. \tag{12}$$
$$\varepsilon_t \sim \text{i.i.d}(0, \text{var}(\varepsilon_t))$$

It is also supposed that variables affecting spot bond yields remain unchanged between before and after the creation of futures market. If all the series of variables are stationary, the unconditional variance ($VAR(Y_t)$) of the spot bond yield Y_t is given as:

$$\begin{aligned} VAR(Y_t) = {} & \alpha^2 VAR(CL_{t-1}) + \beta^2 VAR(EX_{t-1}) \\ & + \gamma^2 VAR(Y^*_{t-1}) \\ & + 2\alpha\beta COV(CL_{t-1}, EX_{t-1}) \\ & + 2\beta\gamma COV(EX_{t-1}, Y^*_{t-1}) \\ & + 2\alpha\gamma COV(CL_{t-1}, Y^*_{t-1}) \\ & + VAR(\varepsilon_t) \end{aligned} \tag{13}$$

(VAR: variance, COV: co-variance)

while the conditional variance ($VAR(Y_t|\Omega_t)$ is given as:

$$VAR(Y_t \mid \Omega_t) = VAR(\varepsilon_t). \tag{14}$$

As mentioned in 1. above, what we are interested in is the conditional variance, which can be estimated as the variance of the forecast errors in equation (12). It should be noted

Table 5. Fluctuations in Variables Before and After the Futures Market Created

	Before	After
"Shihyou Meigara" Yield	0.060 (53rd issue) 0.078 (59th issue)	0.109 (78th issue) 0.272 (89th issue)
Call Rate	0.130	0.131
Foreign Exchange Rate	0.800	1.400
U.S. Government Bond Yield	0.173	0.170
Futures Yield	–	0.210
Money Supply Growth (%)	1.459	2.954

Notes: 1. Means of unconditional standard deviation of each month.
2. The estimated period is Oct. 1, 1984 – June 29, 1985 for before the introduction except for the 53rd issue (Jan. 4, 1984 – Sept. 29, 1984) and Nov. 1, 1986 – Nov. 20, 1987 for after the introduction except the 78th issue (Feb. 1986 – Oct. 31, 1986).
3. Call rate is for unconditional ones. Foreign exchange is spot, final quotation (logarithmic value x 100). As for the U.S. government bonds, 30-years bond for the before and 10-year bond for the after.
4. Money supply (M_2 + CD) growth rate is seasonally adjusted annual rate over the previous period.

Table 6. Conditional Variance and Parameter Estimates of the Model Before and After the Futures Market Created

		Before	After
Conditional Standard Deviation		0.009	0.011
Call Rate	$(\hat{\alpha})$	0.005 (0.054)	0.003 (0.093)
Foreign Exchange	$(\hat{\beta})$	6.725 (0.954)	16.383 (1.428)
U.S. Government Bond Yields	$(\hat{\gamma})$	0.007 (0.042)	0.009 (0.093)
Coefficient of Determination		0.966	0.986
Degree of Freedom		253	353

Notes: 1. The conditional standard deviation here is a mean value of each month.
2. For the parameters of the model in equation (12), the squared means of estimated value for each month are provided. Means of the standard error in parentheses.

that we assume the structure of model is unchanged during each month. Table 5 gives the unconditional standard deviation of each variable for both the period before and after the futures market was created. Table 6 provides the conditional standard deviation of the spot bond yield (random shock standard deviation) as well as the squared means of estimated parameters $\hat{\alpha}$, $\hat{\beta}$ and $\hat{\gamma}$ in order to assess the impact of the parameters of explanatory variables on the unconditional variance of the spot bond yield.

The following conclusion can be obtained by the empirical results.

(1) The increase in the unconditional standard deviation of "Shihyou Meigara" yield, that is considered as the increased variability of the spot market, can be the result of

greater fluctuation in the foreign exchange rate as well as more sensitive reaction of the bond market to the foreign exchange rate; the estimated parameter of foreign exchange in the model has risen. Although the volatility (conditional standard deviation) of the yield also shows a slight increase after the creation of the futures market, the increase is not statistically significant.
(2) Although not specifically considered in the model of equation (12), the long-term monetary relaxation with increased variability of money supply growth rates probably accelerated the speculative transactions of "Shihyou Meigara" which brought greater fluctuations in their yields.[20]
(3) Fluctuation in the futures yield (0.210) is smaller than that of "Shihyou Meigara" (89th issue) yield (0.272).
(4) From the above (1) through (3), it is not clear whether the existence of the futures market itself triggered an increase in the volatility of spot bond yields.

V. Conclusion—Issues in Japan's Bond Market

Based on the results of our analyses, we can summarize the future issues to be tackled in the bond markets of Japan.
(1) Although we can see Japan's bond market as efficient from the viewpoint of the "arbitrage transaction," we cannot help hesitating to evaluate its futures market as a well-constructed bridge between the short-term money market and the long-term bond market because "Shihyou Meigaras" traded in a dominant volume have not been the target of "arbitrage transaction." For expanding the transaction volume of "arbitrage," it is essential to stimulate the trading inside the spot market not to concentrate on "Shihyou Meigara" by correcting a sort of market segmentation brought by extremely high premium attached to "Shihyou Meigara."
(2) The result that the existence of profit opportunity in the speculation cannot be rejected would be consistent with the investors' uniform trading behavior or a one-direction movement of futures prices. It will be needed to diversify the market participants and to increase the number of investors in order to improve such a situation and to make a more stable bond market.

This paper provides the ambiguous answer to the question of effects of futures market on the spot price movement, and it is obvious that we need further analyses.

Appendix

Kiyokawa(1987) shows how the fluctuation in spot prices becomes more stabilized after the creation of a futures market based on the following theoretical frame work;

[20]In connection with this point, see Shirakawa (1987).

(a) Investors in the bond market rationally expect the prices; the forecast error at the present time is uncorrelated with the past information.

(b) First, the optimizing behavior of a risk averse investor determines the equilibrium spot price without the futures market.

(c) Then, optimizing behaviors of an arbitrator and a hedger determine the spot and futures prices which clear both the spot and futures markets.

(d) Using the results obtained from (b) and (c), the variability of the spot price without the futures market is compared with that with the futures market.

Here we show just the results of (d); for more detail see Kiyokawa (1986). Let the conditional variance of spot price in the absence of futures market be σ^2, while that in the existence of futures market be σ^2_w, and the variance of random disturbances be σ^2_v, then we get:

$$\sigma^2 = 1/\delta^2 \cdot \sigma^2_v \qquad (\delta = f_1(\alpha, d)>0,\ f'_1(\alpha)<0,\quad f'_1(d)<0)$$
$$\sigma^2_w = 1/(\delta+\eta)^2 \cdot \sigma^2_v\ (\eta = f_2(\gamma, d)>0,\quad f'_2(\gamma)<0,\ f'_2(d)<0)$$

where

α : a value of constant absolute risk averse for investors involved only in spot transactions

d : variance of the discrepancy between the equilibrium spot prices and the market spot prices

γ : a value of absolute risk averse for hedgers.

Because η is positive, the relationship $\sigma^2>\sigma^2_w$ can obviously be gotten which means that the existence of a futures market contributes to stability of the conditional variance of spot price.

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