

On the Determination of Convenience on Japanese Government Bonds¹

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Yuichi FUKUTA, Osaka University
Makoto SAITO, Hitotsubashi University
Shingo TAKAGI, Hokkaido University

Abstract: This paper explores the extent to which the market valuation of Japanese government bonds (JGBs) deviates from the present values of corresponding coupons and redemption, and how such deviation depends on possible sources of convenience (specialness) associated with time-dependent components as well as issue-specific characteristics. Using market prices of long-term JGBs traded for the period between November 1995 and December 2001, this paper demonstrates empirically that common factors among issues were largely influenced by wide differences in cheapness to deliver among deliverable issues as a result of a large deviation of a hypothetical rate (6%) from market yields (far below 2%). Such an effect of cheapness to deliver weakened after a failure to deliver was allowed in 2001. In addition, we find evidence for the ‘flight to liquidity phenomenon’ in 1997 and 1998, as well as massive capital flows into long-term instruments in 2000 and 2001. On the other hand, issue-specific differences in issue sizes and coupon rates had at most marginal effects on convenience. Unlike in the US government bond market, convenience was not found in on-the-run issues up to 2000.

Keywords: convenience, specialness, cheapest to deliver, on-the-run issues.

JEL classification: G13, G18

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1. Introduction

In government bond markets, some issues are discounted less relative to other issues, although they have similar fundamentals. That is, government bonds with particular characteristics may bear convenience or specialness. There may be several reasons for this phenomenon, including market practices, institutional factors, accounting practices, and tax schemes on investors.

This paper presents a simple econometric framework to investigate empirically possible sources of convenience associated with Japanese government bonds (JGBs) traded for the period between November 1995 and December 2001. More concretely, we compare the market price of JGBs with the present values of coupons and redemption based on the term structure of interest rate swap rates. Because interest swap rates are usually higher than yields on JGBs, the market price of JGBs generally dominates the present value based on the term structure of interest rate swap contracts.² Such a difference between the market price and the present value is common among various issues of JGBs, and amounts to a **market-wide effect**.

In addition to the market-wide effects, swap spreads often differ substantially among different issues even if two JGBs yield fairly similar present values of coupons and redemption, thereby suggesting the presence of **issue-specific** convenience. In the US government bond market, convenience is often associated with on-the-run issues. Duffie (1996) derives specialness from repo markets based on the arbitrage relationship between a general collateral contract and a special collateral contract backed by on-the-run issues.³ Using data on US government bonds, Jordan and Jordan (1997) find that the source of convenience in on-the-run issues is related to tightness in Treasury auctions and the distribution of the ownership of on-the-run issues. Cherian, Jacquier, and Jarrow (2004) associate the seasonal movement of convenience of on-the-run issues with the practice of when-issued markets (forward markets opening prior to auctions).⁴ Krishnamurthy (2002) finds the preference of

² Existing literature attributes premiums of interest rate swaps over government bonds (often called swap spreads) to several fundamental sources. For example, Longstaff and Schwartz (1995) find that counterparty default risks embedded in swap spreads are empirically small. Duffie and Singleton (1997) estimate the defaultable bond rates implicit in the swap market. Duffie and Singleton (1999) parameterize liquidity factors in modeling term structures of defaultable bonds. Duffie (1996) suggests the presence of the convenience yield to holding Treasuries relative to offshore money market instruments. Collin-Dufresne and Solnik (2001) relate the spread between corporate yields and swap rates to the market expectations about credit conditions. Liu, Longstaff, and Mandell (2006) find that swap spreads are driven by liquidity factors and default components. Feldhütter and Lando (2007) demonstrate that the convenience yield is most responsible for the determination of swap spreads.

³ As an alternative way to model convenience of government bonds, Grinblatt (2001) treats convenience needs as an exogenous stochastic process in deriving term structures of swap spreads. He (2001) models the term structures of swap spreads in consideration of TED spreads (spreads of Eurodollar rates over Treasury bill rates), changes in demand and supply for government bonds, and convenience yields to holding government bonds.

⁴ During preauction periods, speculators with expectations of price decreases may short to-be-auctioned securities in a when-issued market (a sort of forward market), while they attempt to hedge their position by buying existing on-the-run issues as close substitutes. During postauction periods, on the other hand, dealers who sold too much of to-be-auctioned securities to their customers in a when-issued market attempt to cover their positions in the secondary market for newly issued (now on-the-run) securities. In a more serious case, a short squeeze may occur at settlement after the auction. Such behavior of market participants during preauction and postauction periods may

investors to hold liquid assets has some effects on the convenience of on-the-run issues. Goldreich, Hanke, and Nath (2005) and Strebulaev (2002) demonstrate that US convenience yields are related to the difference in the remaining future liquidity in on-the-run issues and off-the-run issues. Graveline and McBrady (2006) present evidence that on-the-run specialness results from the demands of market intermediaries for hedging the interest rate risk in their inventories. Using German data, Buraschi and Menini (2002) show that the time-varying volatility of repo specialness has an important role in explaining the movement of convenience.

Boudoukh and Whitelaw (1991) find that convenience on benchmark issues existed in the JGB market up to the beginning of the 1990s.⁵ They also point out the convenience caused by the preference for higher coupon issues, because insurance companies can pay dividends only out of income and not by using capital gains.⁶ Shigemi *et al.* (2001) describe the convenience of the cheapest issues to deliver for JGB futures, referring to the stressful events that happened between 1998 and 1999. Baba and Inamura (2004) demonstrate that on-the-run issues and the cheapest issues to deliver contain convenience yields in Japanese repo markets. None of the previous studies, however, empirically investigates possible sources of convenience of JGBs in a systematic manner.

An empirical investigation of the JGB market during the period between 1995 and 2001 may offer several alternative explanations for the generation of mechanisms for convenience of government bonds for the following reasons. Firstly, because it is only recently (in 2004) that when-issued markets were introduced in the JGB market, there might have been no special demand for on-the-run issues in preauction and postauction periods prior to the introduction of when-issued markets in 2004. In other words, on-the-run issues may not have been highly priced.

Secondly, the Japanese government started to drastically reform government bonds from the year 2000. Major reforms included the introduction of the primary dealer system and the reopening system.⁷ Reflecting the immature nature of the JGB market, the contract clauses of JGBs issued before the late 1990s differed substantially among issues in terms of issue volume, issue prices, and coupon rates. In our investigation, such wide differences in issue-specific characteristics help us to identify issue-specific effects on convenience.

Thirdly, as a result of a unique policy adopted by the Tokyo Stock Exchange, a yield on the hypothetical contract with 10-year maturity, which is traded as an underlying bond in the JGB futures market, has been fixed at 6% per annum up to now, although annual yields on JGBs have been well below 2% since 1997. Consequently, issues with shorter duration among deliverable issues were extremely convenient relative to other issues in terms of cheapness to deliver at maturity, and they were indeed traded with large premiums. Accordingly, the degree of cheapness to deliver

generate strong demand for on-the-run issues, thereby yielding convenience in these issues.

⁵ The benchmark JGB issues were supposed to be more liquid than other JGBs. For example, No. 119 of the JGB, the benchmark issue in April 1990, occupied more than 97% of the entire trading in JGBs during the month. Boudoukh and Whitelaw (1993) construct a theoretical model to explain the presence of the benchmark issue.

⁶ This rule was abolished in 1996.

⁷ The Ministry of Finance (2006) discusses recent reforms of the JGB market.

may be another important source of convenience of JGBs, as pointed out by Shigemi *et al.* (2001) and Baba and Inamura (2004). In addition, because a failure to deliver was not allowed at all up to the end of 2000, the effect of cheapness to deliver might have strengthened.

Fourthly, in the relationship to interest rate swap markets, the above sample period contains the periods in which there was a large-scale fund shift from non-JGB markets to JGB markets during the financial crisis in 1997 and 1998. These incidents would allow us successfully to identify market-wide effects associated with ‘flight to liquidity’ phenomena. On the other hand, the swap market has been subject to strong demand for long-term fixed rates (relative to floating rates) from speculators with expectations of further decreases in long-term JGB rates, since the Bank of Japan implemented the so-called zero-interest-rate policy in 1999. Consequently, swap spreads have been close to zero, or even negative, because of speculative transactions. Accordingly, it is possible to identify the wide effect of strong demand for long-term instruments in 2000 and 2001.

In the rest of this paper, Section 2 describes how to construct a data set, while Section 3 presents estimation results for time-dependent and issue-specific effects on swap spreads. Section 4 offers conclusions.

2. Data Construction and Estimation Procedures

2-1. Construction of convenience on JGB

The presence of issue-specific convenience of JGBs makes it impossible to derive a unique term structure of interest rates as a benchmark because two bonds with the identical present value may be valued differently by the pricing impact of issue-specific convenience. Thus, this paper adopts a benchmark spot rate curve from an alternative market, or the yen-denominated interest rate swap market.

More concretely, we construct term structures of interest rates based on the average rate of offers and bids quoted by *Yagi Euro*, one of the major dealers in the interest rate swap market in Japan. From a database compiled by *Nomura Research Institute*, we can obtain daily time series of swap rates of one year, two years, three years, four years, five years, six years, seven years, eight years, nine years, 10 years, 11 years, 12 years, 15 years, and 20 years. We make a linear interpolation to compute an interest rate of a midpoint between these observed maturities.⁸ In addition, interest rates with shorter than one-year maturity are represented by the linear interpolation between one-year rates and one-week offshore rates, the latter of which have been well below 0.5% per annum and close to zero since the mid-1995.

A coupon (C) on JGB is paid twice per year, while a face amount is standardized at 100 yen. Suppose that coupons are paid T times up to maturity, and that a time length up to maturity is equal to $m(\tau)$ at each point of coupon payment τ

⁸ Firstly, we compute swap rates of 13 years, 14 years, and years from 16 to 19 by a linear interpolation of the observed data. Next, we construct a daily spot rate of the same maturity as the swap rate by using the bootstrapping method discussed by Tuckman (2002) and others. Finally, we interpolate a spot rate of a midpoint between these maturities.

($\tau = 1, 2, 3, \dots, T$). Then, the present value of a particular bond (NP) computes from:

$$NP = \sum_{\tau=1}^T \frac{C}{(1 + s_{m(\tau)})^{m(\tau)}} + \frac{100}{(1 + s_{m(T)})^{m(T)}}, \quad (1)$$

where s_j denotes a spot rate with j maturity.

The above-computed present value of a particular bond is comparable to its market price adjusted by accrued interest payments (hereafter, denoted by P). In this paper, we regard a deviation of an accrued interest-adjusted market price of a particular JGB from its present value NP as the approximated convenience. In the sense that the thus-approximated convenience on JGBs increases with an increase in swap rates relative to JGB rates, the above convenience translates a swap spread (swap rates minus JGB yields with the same maturity) into a difference in prices between swap contracts and JGB contracts.

We can define the approximated convenience in two ways: a difference in levels between market prices and the present value ($P - NP$), or a difference in logarithmic levels between the two ($\ln P - \ln NP$). We here adopt estimation results based on the latter definition, because the pattern in estimation results does not at all depend on the choice between the two definitions.

The Japanese government issues two types of long-term bonds, that is, 10-year and 20-year JGBs.⁹ We extract the daily time series of market prices of 10-year and 20-year JGBs from a database compiled by *Nomura Research Institute*. This database records the daily time series of reference prices provided by the *Japan Securities Dealers Association* as well as close market prices based on transactions in the stock exchanges of Tokyo, Osaka, or Nagoya, where JGBs are traded most actively.¹⁰ In JGB markets, small-amount transactions occur mainly in these exchanges, while large-amount transactions are conducted in dealers' markets.

As discussed in the introduction, our investigation focuses on the sample period between November 1995 and December 2001. In addition, we concentrate an analysis mainly on 10-year and 20-year JGBs with longer than seven-year maturity, because JGBs with such maturities can serve as deliverable issues in the JGB futures market and collaterals in the repo market, and convenience may arise for such JGBs for these reasons. Thus, the sample covers 10-year JGBs issued in the year 1992 or after, and 20-year JGBs issued in the year 1986 or after.¹¹ Consequently, our data set includes 122 issues with 42,012 observations for 10-year JGBs, and 69 issues with 58,351 observations for 20-year JGBs.

⁹ The Ministry of Finance (2006) reports the Japanese government has issued other types of bonds, such as 15-year and 30-year JGBs, in recent periods.

¹⁰ In addition, government and corporate bonds trade on OTC markets in Japan. The *Japan Securities Dealers Association* reports the average quotes of bid and ask prices for about 4,500 bond issues on a daily basis.

¹¹ The first issue of 20-year JGBs was placed privately in September 1983. The data set we use for this study includes the 20-year JGBs that were issued publicly after October 1986.

For sample periods, we choose not only a full sample period, but also three subsample periods between 1995 and 1997, 1998 and 2000, and 2001. The second subsample includes the period in which demand for liquid or safe assets was extremely strong, while a failure to deliver occurs in the third subsample period. The average yields with 10-year maturity in the first subsample, second subsample, and third subsample are 2.59%, 1.59%, and 1.33%, respectively.¹² In contrast, the hypothetical rate with a 10-year maturity in the JGB futures transaction is 6%. Such a large difference in rates between actual yields and the hypothetical rate causes convenience of the cheapest issues in the second and third subsamples.

2-2 Estimation procedures: Time-dependent factors and issue-specific factors (The first-step estimation to identify time-dependent factors)

We execute two-step procedures separately in estimating time-dependent and issue-specific effects on convenience. In the first step, the logarithmic convenience or $\ln P - \ln NP$ is regressed on time-dependent factors as well as issue-specific dummy variables (the latter of which capture fixed effects). We compute robust standard errors of estimates using the Huber–White method by allowing for possible heteroskedasticity and serial correlation within the same issue,¹³ while we do not consider any possible correlation among different issues. A major reason for this estimation strategy is that because of using high-frequency data, serial correlation within the same issue may be more important than cross-sectional correlation among different issues after controlling for market-wide effects.

We specify time-dependent factors as follows. Firstly, monthly dummy variables can capture market-wide effects on convenience, while dummy variables associated with the duration (the average remaining periods up to maturity) can identify term structures of convenience.¹⁴ Note that while the period up to maturity is longer than seven years, the duration may become well shorter than seven years by partially reflecting the duration of high coupon rates.

Secondly, we adopt dummy variables for the number of days after the issue to examine whether any convenience was attached to on-the-run issues. That is, dummy variables are constructed for up to one month after the issue, from one through two months, and from two through three months.

Thirdly, convenience may be related to the practices of the JGB futures market. In the Tokyo Stock Exchange, JGB futures are settled on the 20th of March, June, September, and December.¹⁵ As a settlement day approaches, demand for JGBs from investors with short positions in JGB futures may become strong, and consequently convenience may arise. To capture this effect on convenience, we construct a dummy

¹² These statistics are from NEEDS-Financial Quest database.

¹³ See Arellano (1987) for reference.

¹⁴ As we use a benchmark spot rate curve computed from the swap market, the market-wide shocks may be mitigated in the case that these shocks occur in both the JGB market and the swap market. However, this mitigation seems weak because, as discussed in the introduction, existing literature finds that swap spreads contain various components related to a convenience yield, a swap-specific factor, and a credit risk.

¹⁵ On national holidays, JGB futures are settled on the next business day.

variable associated with the number of days up to the nearest settlement of JGB futures.¹⁶

As mentioned in the introduction, yields on long-term JGBs were far below yields on the hypothetical contract traded in the JGB futures market (6%) during the second half of 1990s, and especially after the end of the 1990s, and there emerged substantial convenience for issues with shorter duration in terms of cheapness to deliver at settlement among different issues. We thus construct dummy variables associated with the first, second, and third cheapest issues to deliver according to the length of duration of each issue. Up to February 1999, all of the first, second, and third cheapest issues to deliver belonged to 10-year JGBs. However, 20-year JGBs were the second cheapest to deliver for the period between March 12, 1999, and June 10, 1999, and the first cheapest for the period between June 11, 1999, and December 9, 1999. From the year 2000, 20-year JGBs were excluded from a list of deliverable issues of the long-term JGB futures of the Tokyo Stock Exchange.¹⁷

(The second step estimation to identify issue-specific factors)

In the second step of the estimation procedure, the fixed effects estimated in the first step (estimated coefficients on issue-specific dummy variables) are regressed on issue-specific factors, while a fixed effect of one particular issue is regarded as a zero constant term.¹⁸ Possible issue-specific factors include logarithmic issue volume, a difference between issue prices and par prices (100 yen), and coupon rates. As Tables 1-1, 1-2, and 1-3 show, there are wide varieties in terms of issue volume, issue prices, and coupon rates among 10-year JGBs as a result of the premature nature of the JGB market. Similarly, Tables 2-1, 2-2, and 2-3 demonstrate large variations with respect to these aspects among 20-year JGBs.

We have some remarks on the three issue-specific explanatory variables. Firstly, transaction volume may generate opposite effects on convenience. On the one hand, large issue volume enhances market liquidity, thereby attaching liquidity premiums to issues with large volume. On the other hand, large issue volume lowers scarcity of convenience attached to issues with large volume, thereby lowering convenience on such issues.

Secondly, unless both financial and nonfinancial institutions adopt amortization methods in tax accounting, differences between issue prices and par prices are calculated as capital gains or losses at maturity. Such institutions may have aversion toward an issue whose issue price is largely different from its par price in order to avoid one-time losses (gains) at maturity, and to smooth tax obligations on capital income. Obviously, once amortization methods have been adopted, deviations of issue prices do not matter for tax smoothing.¹⁹

Thirdly, life insurance companies preferred issues with high coupons because

¹⁶ We adopt the effect of more than 60 days up to the nearest settlement as a baseline.

¹⁷ A major reason for this exclusion is that, given rather small issue amounts, 20-year JGB trades tended to be subject to speculative transactions once they became the cheapest to deliver.

¹⁸ More concretely, a baseline contract is the 10-year JGB issued on August 20, 1998, or April 21, 1997, and the 20-year JGB issued on January 20, 1994.

¹⁹ Amortization methods began in 2000.

they had to pay insurance claims from only income gains on their bond portfolios under some governmental regulations. If this preference of life insurance companies existed and affected JGB prices, such preference for a particular contract form may be registered in observed convenience on issues with high coupons.

3. Estimation Results

(Effects of time-dependent components)

In Tables 3-1 (10-year JGBs) and 3-2 (20-year JGBs), we report estimation results concerning time-dependent effects on convenience. Among JGBs issued within three months, the computed convenience of either 10-year or 20-year JGBs did not change significantly except for the year 2001. That is, unlike in the US government bond market, convenience did not emerge for on-the-run issues. One possible reason for this finding is that when-issued markets, which may be one of the major sources of convenience of government bonds in the US, did not exist in the JGB market before 2004. One puzzling finding is that convenience emerges in on-the-run issues for both 10-year and 20-year JGBs in the estimation based on the year 2001.²⁰

On the other hand, convenience arose for the first through third cheapest issues to deliver (CTD) among 10-year JGBs. According to the full sample estimation, the first CTD was higher by 0.18%, while the second and third CTDs were higher by 0.08%. The effect of CTD on convenience was the most serious for the subsample period between 1998 and 2000; the first (second) CTD was higher by 0.23% (0.15%).

The large deviation of a hypothetical contract rate for JGB futures from market rates after 1998 might have caused a great demand for cheap issues to deliver. Hence, in this period, estimated coefficients on CTDs became significantly large. However, since the introduction of a failure to deliver may weaken the demand for cheap issues, we obtained smaller coefficients on CTDs in 2001 than between 1998 and 2000.

Although the number of observations is rather limited, as mentioned before, convenience attached to the second cheapest issue to deliver among 20-year JGBs. One possible reason for a negative coefficient on the first cheapest to deliver among 20-year JGBs is that, although one 20-year issue became the first from June 1999, 20-year issues were expected to be excluded from a list of deliverable issues of the JGB futures. Indeed, the list has excluded them since the year 2000.

As shown in Table 3-1, the estimated coefficients on the dummy variables up to 50 days through 10 days before the nearest settlement date are significantly positive for the subsample period between 1998 and 2000, when CTDs yielded significant convenience. This estimation may reflect the fact that JGB futures trading due on the nearest settlement date is quite active up to 10 days before the nearest settlement, and that the main transactions are switched to those due on the second nearest settlement when the remaining periods are shorter than 10 days. According to the 2001 estimation, however, convenience did not increase at all even if the settlement date approached. This change in patterns may be a result of allowance for failures to

²⁰ Baba and Inamura (2004) also demonstrate that on-the-run issues had positive convenience during 2001.

deliver in 2001.

As for term structures of convenience, convenience was the highest at the six–seven-year duration of 10-year JGBs. This result may be interpreted as a consequence of arbitrage between the issues with CTD (shortest duration) and those with relatively short duration. In the 2001 estimation, convenience arose also for nine- to 10-year durations, perhaps a result of arbitrage with the issues with on-the-run premiums. On the other hand, 20-year JGBs yielded complicated term structures. Convenience was almost increasing up to the 10-year duration, declined toward the 14-year duration then increased substantially again. One interesting finding is that although 20-year JGBs are not in a list of deliverable issues for JGB futures from 2000, the issue with a rather short duration still carried significant convenience in the 2001 estimation.

Based on the full sample estimation, Figure 1-1 depicts the time series of estimated coefficients on monthly dummies with a 95% confidence interval for 10-year JGBs. Figure 1-2 draws them for 20-year JGBs. According to Figures 1-1 and 1-2, market-wide effects captured by monthly dummies were quite stable up to the third quarter of 1997, and have increased gradually since then. However, the estimated aggregate effect declined substantially towards April 1999, and has moved up again since then. These patterns in the estimated time effect indicate that the financial crises between the late 1997 and the end of 1998 had an impact on JGB convenience. In other words, massive funds flew into JGB markets from other long-term financial instruments as part of a ‘flight to liquidity’ phenomenon. A substantial decline in convenience seems to result from the zero-interest-rate policy implemented by the Bank of Japan in February 1999. Such a policy impact was temporary; it bounded back again toward late 1999 partly because of market participants’ concerns about the year 2000 problem.

The estimated market-wide effect has, however, declined gradually since late 1999. During this period, the swap market was subject to strong demand for long-term fixed rates (relative to floating rates) from speculators with expectations of further decreases in long-term JGB rates since the Bank of Japan implemented its so-called zero-interest-rate policy in 1999. Consequently, swap spreads have been close to zero, or even negative because of speculative transactions.

(Effects of issue-specific components)

Tables 4-1 and 4-2 report the estimation results on issue-specific effects. Because fixed effects (coefficients on issue-specific dummy variables) are unidentifiable for one or all issues, the sample for the second step estimation is 121 issues (122 minus 1) for 10-year JGBs, and 68 issues (69 minus 1) for 20-year JGBs.

The estimated coefficient on issue volume is not significant in most cases of 10-year and 20-year JGBs, when coupon rates are included as an explanatory variable. With coupon rates excluded from explanatory variables, estimated coefficients are significantly positive in some cases. These results suggest that the improving effect of market liquidity may compete with the deteriorating effect of convenience scarcity.

The estimated coefficients on differences between issue prices and par prices indicate that there is a tendency for aversion toward not over-par issues, but under-par issues. That is, investors seemed to avoid one-time capital gains at maturity from

under-par issues. A significant negative coefficient on coupon rates is contrary to the prediction mentioned before. A high-coupon preference of life insurance companies did not at all register in convenience.²¹ One caveat of the significant coefficients on coupon rates is that they may pick up time effects because coupon rates declined on newer issues.

4. Conclusions

Given the above estimation results, we can evaluate possible impacts of the recent reform of the JGB market that occurred from the early 2000s. Given negative or positive coefficients on issue sizes, the reopening system and auction for an enhanced-liquidity system may smooth cross-issue differences in convenience by integrating new issues with existing issues at similar sizes. If the introduction of when-issued markets generates additional demand for on-the-run issues, then convenience may arise for on-the-run issues, as in the US government bond market.

One of the most important implications from the estimation results is that the Tokyo Stock Exchange and the Japanese government have not removed the major source of cross-issue differences in convenience of JGBs by bringing yields on the hypothetical 10-year contract (currently 6%) for the JGB futures in line with market yields on long-term JGBs (below 2%). Without narrowing such a wedge, there always emerges strong demand for deliverable issues with the shortest duration, and such demand becomes stronger as the settlement day approaches. While the estimation results indicate that allowance for failures to deliver in 2001 worked to mitigate the above effect on convenience to some extent, there was still significant convenience on CTD issues.

The presence of convenience on particular issues may invite speculators as convenience-seekers into JGB markets. In addition, it is next to impossible to derive unique term structures of JGB yields, once JGB pricing strongly reflects such convenience. In reforming the JGB market, it is necessary to implement a major target such that JGBs may not be influenced by the above factors responsible for issue-specific convenience.

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²¹ Fukuta (1998) also reports the absence of high coupon preferences.

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Table 1-1: The Number of Observations by Issue Volume for 10-Year JGBs with Longer Than 7 Year Maturity

Amount Issued	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	total
less than 800 bn yen	29	759									788
800 bn to 1000 bn yen		556	3034	3605	2978	5356	1049				16578
1000 bn to 1200 bn yen				769	421		2050				3240
1200 bn to 2000 bn yen	29	278	398		616	1841	1657	5364	2499	955	13637
more than 2000 bn yen		151	461	1236	1837		1850	1005	960	269	7769
total	58	1744	3893	5610	5852	7197	6606	6369	3459	1224	42012

Table 1-2: The Number of Observations by Issue Pices for 10-Year JGBs with Longer Than 7 Year Maturity

Issue Prices	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	total
less than 99 yen			335								335
99 yen to 99.5 yen			398	136	836			666			2036
99.5 yen to 100 yen		216	1444		2481	780	1692	1106			7719
100 yen to 100.5 yen	58	302	983	1287	2535	2543	1043	1227	268	201	10447
100.5 yen to 101 yen		860	335	2065		3874	3129	2040	2536	1023	15862
larger than 101 yen		366	398	2122			742	1330	655		5613
total	58	1744	3893	5610	5852	7197	6606	6369	3459	1224	42012

Table 1-3: The Number of Observations by Coupon Rates for 10-Year JGBs with Longer Than 7 Year Maturity

Coupon Rates	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	total
less than 1%							924				924
1% to 2%						881	4923	6369	3459	1224	16856
2% to 3%				1750	1642	6316	759				10467
3% to 4%		556	1068	2698	4210						8532
4% to 5%	58	1188	2825	1162							5233
5% to 6%											
6% to 7%											
larger than 7%											
total	58	1744	3893	5610	5852	7197	6606	6369	3459	1224	42012

Table 2-1: The Number of Observations by Issue Volume for 20-Year JGBs with Longer Than 7 Year Maturity

Amount Issued	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	total
less than 800 bn yen		3717	5729	1514	3028	6056	4541	4542	3028	6323	4296	4536	1933	1449	1589	413	52694
800 bn to 1000 bn yen				1514					1514				808			186	4022
1000 bn to 1200 bn yen	1072																1072
1200 bn to 2000 bn yen													563				563
more than 2000 bn yen																	
total	1072	3717	5729	3028	3028	6056	4541	4542	4542	6323	4296	4536	2741	2012	1589	599	58351

Table 2-2: The Number of Observations by Issue Prices for 20-Year JGBs with Longer Than 7 Year Maturity

Issue Prices	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	total
less than 99 yen		2518	1448	3028		1514				1514	1399			729			12150
99 yen to 99.5 yen	1072		2962			1514					171					341	6060
99.5 yen to 100 yen		1199				3028	4541	1514	1514	1693	1438	2326	1835		914		20002
100 yen to 100.5 yen			1319		1514			1514	1514	1602		1042	906	665		16	10092
100.5 yen to 101 yen					1514			1514	1514	1514	1288	1168		618	675	56	8347
larger than 101 yen									1514							186	1700
total	1072	3717	5729	3028	3028	6056	4541	4542	4542	6323	4296	4536	2741	2012	1589	599	58351

Table 2-3: The Number of Observations by Coupon Rates for 20-Year JGBs with Longer Than 7 Year Maturity

Coupon Rates	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	total
less than 1%													793			289	1082
1% to 2%																	8069
2% to 3%												2210	1948	2012	1589	310	9917
3% to 4%										3295	4296	2326					16273
4% to 5%		1199	2962	3028				1514	4542	3028							13926
5% to 6%	1072	2518	2767				4541	3028									7570
6% to 7%					1514	6056											1514
larger than 7%					1514												1514
total	1072	3717	5729	3028	3028	6056	4541	4542	4542	6323	4296	4536	2741	2012	1589	599	58351

Table 3-1: Estimation Results of Time-Dependent Components: 10-year JGBs

explanatory variables	1995-2001	1995-1997	1998-2000	2001
duration				
5 to 6 years	0.00010 (0.00054)	0.00012 (0.00062)		
6 to 7 years	0.00080* (0.00018)	0.00078* (0.00026)	0.00082* (0.00027)	0.00175* (0.00033)
7 to 8 years	baseline	baseline	baseline	baseline
8 to 9 years	-0.00023 (0.00024)	0.00064 (0.00048)	-0.00040 (0.00027)	0.00064 (0.00046)
9 to 10 years	0.00094 (0.00049)	0.00037 (0.00051)	-0.00029 (0.00057)	0.00218* (0.00067)
10 to 11 years				
11 to 12 years				
12 to 13 years				
13 to 14 years				
14 to 15 years				
15 to 16 years				
16 to 17 years				
cheapest-to-deliver				
1st CTD	0.00178* (0.00043)	0.00114 (0.00064)	0.00226* (0.00063)	0.00149* (0.00056)
2nd CTD	0.00080* (0.00037)	0.00025 (0.00068)	0.00152* (0.00048)	0.00090* (0.00034)
3rd CTD	0.00083* (0.00032)	0.00061 (0.00045)	0.00093* (0.00033)	0.00122* (0.00032)
the dummy variables of days up to the nearest settlement of futures				
1 to 10 days	-0.00020* (0.00005)	0.00002 (0.00009)	-0.00026* (0.00007)	-0.00066* (0.00009)
11 to 20 days	-0.00006 (0.00007)	-0.00027* (0.00009)	0.00035* (0.00010)	-0.00094* (0.00012)
21 to 30 days	0.00057* (0.00008)	0.00005 (0.00008)	0.00140* (0.00013)	-0.00102* (0.00011)
31 to 40 days	0.00077* (0.00008)	-0.00006 (0.00006)	0.00133* (0.00013)	0.00050* (0.00011)
41 to 50 days	0.00079* (0.00010)	0.00033* (0.00007)	0.00092* (0.00018)	0.00086* (0.00011)
51 to 60 days	0.00012* (0.00005)	0.00048* (0.00006)	0.00005 (0.00008)	-0.00039* (0.00006)
the number of days after the issue				
0 to 1months	0.00001 (0.00049)	0.00049 (0.00044)	0.00028 (0.00091)	0.00159 (0.00087)
1 to 2 months	0.00014 (0.00039)	0.00040 (0.00037)	0.00045 (0.00073)	0.00141 (0.00080)
2 to 3 months	0.00022 (0.00028)	0.00031 (0.00030)	0.00037 (0.00047)	0.00117* (0.00047)
adjusted R square	0.9837	0.9835	0.9887	0.9225
the number of observations	42012	14698	20324	6990

Notes: a. Standard errors of the estimators are in parentheses.
b. * indicates that the coefficient is significant at the 5% level.

Table 3-2: Estimation Results of Time-Dependent Components: 20-year JGBs

explanatory variables	1995-2001	1995-1997	1998-2000	2001
duration				
5 to 6 years	-0.00917* (0.00156)		-0.00556* (0.00174)	0.00952* (0.00185)
6 to 7 years	-0.00449* (0.00137)		-0.00356* (0.00069)	0.00898* (0.00088)
7 to 8 years	baseline	baseline	baseline	baseline
8 to 9 years	0.00471* (0.00105)	0.00145* (0.00029)	0.00200 (0.00107)	-0.00481* (0.00090)
9 to 10 years	0.00587* (0.00132)	0.00350* (0.00081)	0.00094 (0.00156)	-0.00743* (0.00181)
10 to 11 years	0.00577* (0.00160)	0.00501* (0.00112)	-0.00036 (0.00205)	-0.00891* (0.00262)
11 to 12 years	0.00477* (0.00215)	0.00336* (0.00159)	-0.00071 (0.00243)	-0.00960* (0.00364)
12 to 13 years	0.00387 (0.00261)	0.00027 (0.00230)	-0.00211 (0.00290)	-0.00700 (0.00458)
13 to 14 years	0.00396 (0.00301)	0.00141 (0.00286)	-0.00314 (0.00347)	-0.00571 (0.00539)
14 to 15 years	0.00727* (0.00330)	0.00149 (0.00302)	-0.00105 (0.00427)	-0.00125 (0.00627)
15 to 16 years	0.01212* (0.00385)	0.00461 (0.00323)	0.00214 (0.00478)	0.00625 (0.00732)
16 to 17 years	0.01843* (0.00434)		0.00545 (0.00592)	0.01448 (0.00792)
17 to 18 years	0.04151* (0.00469)		0.02916* (0.00678)	
cheapest-to-deliver				
1st CTD	-0.00537* (0.00126)		-0.00062 (0.00045)	
2nd CTD	0.00573* (0.00121)		0.01010* (0.00070)	
3rd CTD				
the dummy variables of days up to the nearest settlement of futures				
1 to 10 days	-0.00137* (0.00008)	-0.00161* (0.00012)	-0.00153* (0.00013)	-0.00111* (0.00016)
11 to 20 days	-0.00113* (0.00009)	-0.00240* (0.00011)	-0.00056* (0.00016)	-0.00124* (0.00022)
21 to 30 days	0.00026* (0.00009)	-0.00084* (0.00014)	0.00132* (0.00014)	-0.00150* (0.00019)
31 to 40 days	0.00038* (0.00008)	-0.00084* (0.00014)	0.00082* (0.00010)	0.00044* (0.00016)
41 to 50 days	0.00014 (0.00008)	-0.00021 (0.00016)	-0.00006 (0.00012)	0.00063* (0.00014)
51 to 60 days	-0.00008 (0.00006)	0.00064* (0.00008)	-0.00006 (0.00009)	-0.00156* (0.00025)
the number of days after the issue				
0 to 1months	0.00101 (0.00169)	0.00468* (0.00223)	-0.00252 (0.00286)	0.00857* (0.00151)
1 to 2 months	0.00176 (0.00141)	0.00376* (0.00171)	0.00076 (0.00287)	0.00403* (0.00192)
2 to 3 months	0.00139 (0.00135)	0.00318* (0.00162)	-0.00070 (0.00247)	0.00610* (0.00211)
adjusted R square	0.9491	0.9286	0.9673	0.9229
the number of observations	58351	17509	30187	10655

Notes: a. Standard errors of the estimators are in parentheses.
b. * indicates that the coefficient is significant at the 5% level.

Table 4-1: Estimation Results of Fixed Components: 10-year JGBs

explanatory variables	1995-2001	1995-1997	1998-2000	2001
issue size	0.00112 (0.00099)	-0.00120* (0.00041)	-0.00008 (0.00206)	-0.00128 (0.00082)
issue price - 100 (if positive)	-0.00007 (0.00105)	-0.00062 (0.00044)	0.00115 (0.00228)	0.00130 (0.00088)
issue price - 100 (if negative)	0.00293 (0.00167)	0.00211* (0.00069)	-0.00112 (0.00445)	-0.00256 (0.00152)
coupon rate	-0.00892* (0.00044)	-0.00460* (0.00023)	-0.01094* (0.00116)	0.00167 (0.00104)
constant term	-0.01080 (0.02149)	0.03571* (0.00875)	0.01862 (0.04382)	0.02376 (0.01709)
adjusted R square	0.836	0.876	0.665	0.210
number of observations	121	62	69	41

Notes: a. Standard errors of the estimators are in parentheses.

b. * indicates that the coefficient is significant at the 5% level.

explanatory variables	1995-2001	1995-1997	1998-2000	2001
issue size	0.01028* (0.00232)	-0.00104 (0.00131)	0.00416 (0.00405)	-0.00149 (0.00087)
issue price - 100 (if positive)	0.00135 (0.00294)	-0.00016 (0.00111)	0.00182 (0.00459)	0.00115 (0.00094)
issue price - 100 (if negative)	0.00887* (0.00361)	0.00225* (0.00114)	0.00690 (0.01171)	-0.00286* (0.00138)
constant term	-0.22692* (0.04861)	0.01649 (0.02744)	-0.09468 (0.08504)	0.03106 (0.01880)
adjusted R square	0.200	0.032	0.039	0.146
number of observations	121	62	69	41

Notes: a. Standard errors of the estimators are in parentheses.

b. * indicates that the coefficient is significant at the 5% level.

Table 4-2: Estimation Results of Fixed Components: 20-year JGBs

explanatory variables	1995-2001	1995-1997	1998-2000	2001
issue size	0.00019 (0.00112)	0.00108 (0.00191)	-0.00290* (0.00102)	-0.00095 (0.00454)
issue price - 100 (if positive)	-0.00007 (0.00174)	0.00241 (0.00233)	0.00220 (0.00161)	-0.00085 (0.00422)
issue price - 100 (if negative)	0.00034 (0.00042)	-0.00088 (0.00057)	0.00145* (0.00053)	0.00517* (0.00258)
coupon rate	-0.00182* (0.00030)	-0.00258* (0.00033)	-0.00531* (0.00035)	-0.00169 (0.00099)
constant term	0.00400 (0.02290)	-0.01048 (0.03837)	0.08072* (0.02074)	0.02022 (0.09240)
adjusted R square	0.432	0.598	0.867	0.240
number of observations	68	46	51	48

Notes: a. Standard errors of the estimators are in parentheses.

b. * indicates that the coefficient is significant at the 5% level.

explanatory variables	1995-2001	1995-1997	1998-2000	2001
issue size	0.00336* (0.00130)	0.00184 (0.00189)	0.00801* (0.00318)	0.00349 (0.00311)
issue price - 100 (if positive)	0.00085 (0.00188)	0.00481 (0.00300)	0.00389 (0.00438)	-0.00019 (0.00417)
issue price - 100 (if negative)	0.00109* (0.00051)	-0.00070 (0.00056)	0.00421* (0.00113)	0.00619* (0.00234)
constant term	-0.06617* (0.02574)	-0.03773 (0.03745)	-0.15866* (0.06299)	-0.07506 (0.06136)
adjusted R square	0.121	0.105	0.247	0.192
number of observations	68	46	51	48

Notes: a. Standard errors of the estimators are in parentheses.

b. * indicates that the coefficient is significant at the 5% level.

Figure 1-1: Time Effects of 10-Year JGBs

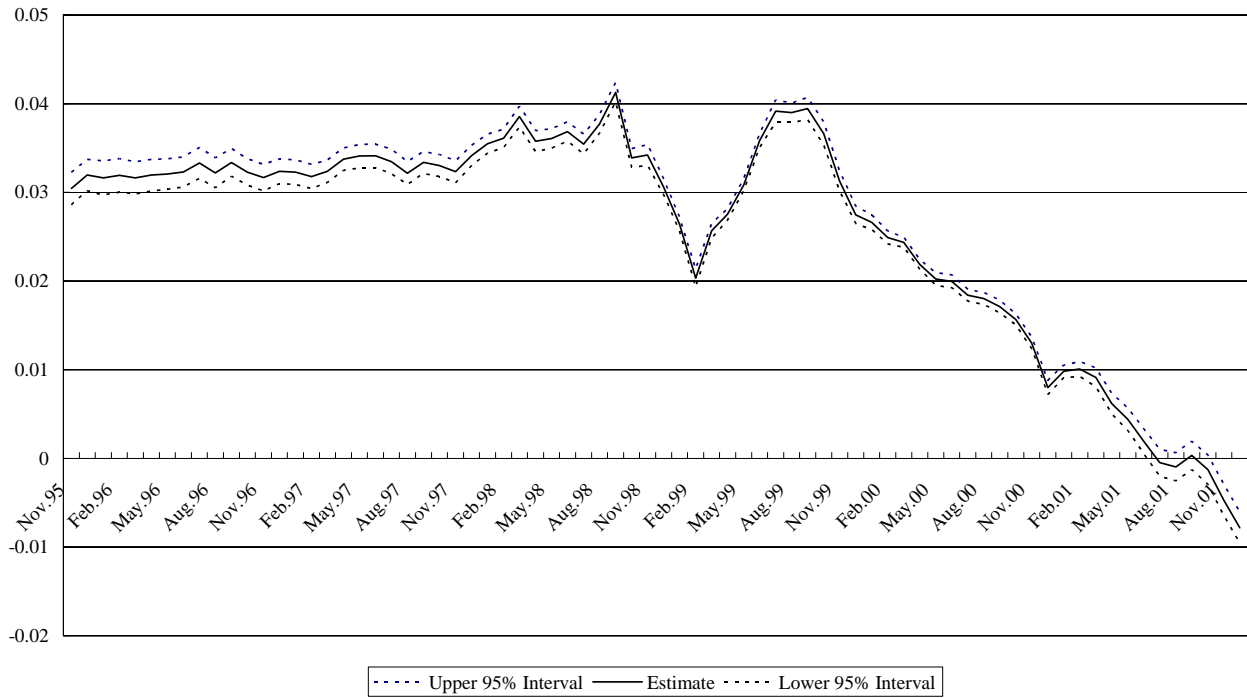


Figure 1-2: Time Effects of 20-Year JGBs

