The change of liquidity in the life cycle of Japanese government securities*

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Abstract

The paper empirically examines the effect of deviation from par value and remaining life of individual 10-year JGBs on their turnover ratio, a proxy for liquidity. First, the paper shows that there is no clear relationship between turnover ratio and deviation from par-value. Second, the effect of remaining life on turnover ratio is non-linear. Third, the remaining life elasticity of turnover ratio for ex-benchmark issues and that for non-benchmark issues are different, especially for issues with about 3 and 4 years remaining in life and those with 7 years remaining. According to interviews with market participants, relationships with other financial instruments functioning similarly to government securities may cause non-linear changes in the liquidity of government securities as their remaining life decreases. In addition, there is a market disposition which distinguishes ex-benchmark issues from non-benchmark issues.

Key words: Turnover ratio, life cycle of securities, ex-benchmark issue, Japanese government securities market

* The views expressed in this paper are solely those of the author and do not necessarily represent the view of the Bank of Japan.

1. Introduction

The aim of this paper is to shed light on changes in market liquidity for individual issues of Japanese government securities. As mentioned in *Miyanoya, Inoue and Higo* (1999), it is widely recognised that the liquidity of Japanese government securities varies due to characteristics of the securities, e.g. maturity, listed/unlisted on the exchange, treatment of taxation and accounting, and other factors. Previous research in this field has mainly focused on the relationship between the liquidity of issues – especially benchmark issues[1] – and price differences,[2] but has not examined changes in liquidity. In light of the issuance cycle of U.S. government securities, *Keane* (1996) reveals that repo rates for recently issued Treasury notes rise and fall in a regular pattern in accordance with the Treasury auction cycle. However, it is not clear how the liquidity of individual government securities changes in their life cycle from issuance to redemption. This is a point to consider when examining the determinants of liquidity in the government securities market.

In this paper, the liquidity of individual issues of 10-year Japanese government bonds (JGBs) is measured by a traditional indicator, turnover ratio (ratio of trading volume per day to net outstanding amount)[3] in one of the inter-dealer markets. This paper examines two factors expected to affect the turnover ratio of individual 10-year JGBs: deviation from par value and remaining life. Regarding the deviation from par value, investors using historical cost accounting seem to avoid buying over-par bonds. Regarding the effect of remaining life on turnover ratio, buy-and-hold strategies may decrease the turnover ratio of issues as their remaining life become shorter. As there is no reason to assume a linear effect, we first estimate both the linear regression model and the non-linear model using dummy variables for remaining life, and then choose the statistically preferred of the two models based on a standard statistical test. Comparison of the two results sheds some light on the determinants of liquidity in the government securities market.

The paper is organised as follows. Section 2 characterises the data used in the analyses and the calculation process for turnover ratio, and provides results from a preliminary test of the analyses. Section 3 tests some hypotheses on the turnover ratio of 10-year JGBs. Section 4 discusses implications obtained from the analyses, and Section 5 suggests possible areas for further study.

2. Data

2.1 Description of data

2.1.1 Turnover ratio

Turnover ratio is the ratio of trading volume of each 10-year JGB through the Japan Bond Trading Co., the largest inter-dealer broker in Japan,[4] to net outstanding amount of each issue. Net outstanding amount of each 10-year JGB is calculated on a daily basis, by subtracting the amount of outright

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1 Note that Japan's definition of "benchmark" issue differs from other countries. In Japan, whether an issue is regarded as benchmark depends mainly on its issue size but not on whether it is most recently issued or not. Fifteen issues have been designated benchmark issues in the government securities market. For details on benchmark issues, see Appendix.

2 See *Boundoukh and Whitelaw* (1993) and *Fukuta* (1995).

3 Although it is better to use bid-ask spread, depth of order, market impact, and resiliency of price to measure liquidity, such indicators are not always available for individual 10-year JGBs.

4 The Japan Bond Trading Co. is one of seven inter-dealer brokers, holding an 18.6 percent share in the OTC market for government securities as of 1997. For details on the cash inter-dealer broker market, see *Miyanoya, Inoue and Higo* (1997).

purchases by the Bank of Japan and the Trust Fund Bureau of the Ministry of Finance from total amount issued. Note that the Bank of Japan and the Trust Fund Bureau of the Ministry of Finance periodically purchase bonds from market participants and seldom sell.[5] This decreases the effective outstanding amount of issues in the market. Because the daily data seem to be erratic, quarterly averages of daily data from the third quarter, 1995 to the second quarter, 1998 are used in the study.

In the analyses to follow, data for the benchmark issue is omitted. This is because the turnover ratio of the benchmark issue is substantially higher than those of other issues (see table in footnote[6]), and there are just 12 observations for benchmark issues in the data set while there are 784 observations for non-benchmark issues and 81 observations for ex-benchmark issues. This leads to technical difficulties in conducting a regression analysis. For an alternative analysis of benchmark issues, see Appendix.

2.1.2 Remaining life, deviation from par-value

Average remaining life and deviation from par-value for each 10-year JGB is calculated on a quarterly basis.

2.2 Preliminary analysis of trading volume

Turnover ratio is a useful proxy for liquidity of individual issues because it is a standardised measurement that compares liquidity of issues for different net outstanding amounts. However, the appropriateness of the turnover ratio is questionable because the relationship between trading volume and net outstanding amount is assumed to be linear when turnover ratio is used. It may be possible to assume that turnover ratio is related to net outstanding amount, i.e. trading volume is affected by the squared net outstanding amount. In this case, it would be best to avoid using turnover ratio as a dependent variable in regression models. This is because technical difficulties occur if net outstanding amount is used as one of the independent variables on the right side of an equation while it is also used to calculate dependent variable on the left side. The following regression is conducted to test whether trading volume is affected by squared net outstanding amount.

(1) $$T_{it} = \rho_0 + \rho_1 V_{it} + \rho_2 V_{it}^2 + \tau_{it} ,$$

where T is the trading volume per day, ρ_0 is a constant variable, V is the net outstanding amount, τ_{it} is the independent identically distributed error term, ρ_1 and ρ_2 are parameters to be estimated, subscript i denotes individual issues, and subscript t denotes the period measured in terms of quarters. If turnover ratio is affected by net outstanding amount, ρ_2 takes a positive or negative value.

The regression results are summarised in columns (a) and (b) of Table 1. In column (a), the coefficient for net outstanding amount is 0.0040 (t-value 13.796). The F-value test of the null hypothesis, given that the parameters of the constant and remaining life are zero, takes a value of 498.641, which is

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5 The total amount of 10-year JGBs that the Bank of Japan and the Trust Fund Bureau of the Ministry of Finance purchased in the market from the third quarter, 1995 to the second quarter, 1998 is 17,964 billion-yen, and the amount they sold is zero.

6 Turnover ratio of benchmark issue and average of other issues, %

Period	1995		1996				1997				1998	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Benchmark issue	5.9	8.0	4.3	6.0	5.9	10.0	6.8	6.7	4.8	7.7	4.7	2.9
Others (average)	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2

rejected at the 1% significance level. In column (b), the squared net outstanding amount is added to the explanatory variables used in column (a). Note that the coefficient for net outstanding amount in column (b) is 0.0047 (t-value 8.930), which seems virtually unchanged from the result in column (a). The coefficient for squared net outstanding amount takes a value of –2.74E-08 and t-value is 1.234, which is statistically insignificant at the 5% level. The F-test value testing the model in column (b) against the model in column (a) is 1.519, which is insignificant at the 5% level. The results suggest that we cannot safely conclude that the squared net outstanding amount affects trading volume, and it is not inappropriate to use turnover ratio as a standardised proxy for liquidity.

In addition to the above regressions, in column (c) of Table 1, the dummy variable for ex-benchmark issues replaces the squared net outstanding amount of the set of regression in column (b). The coefficient for the ex-benchmark dummy takes a positive value of 11.9300 and t-value is 2.719, which is statistically significant at the 1% level. The F-test value testing the model in column (c) against the model in column (a) is 11.615, which is also significant at the 1%. The results indicate that trading volume is affected by whether the issue is ex-benchmark or not. Hence in the following analyses, the data is separated into two segments: ex-benchmark issues and non-benchmark issues.

2.3 Brief observation

Before moving on to detailed analyses of the relationship between remaining life and deviation from par value and turnover ratio, it would be useful to take a brief look at the data. The data for actual turnover ratio for the second quarter, 1998 is plotted according to the remaining life of issues in Figure 1. Figure 1 reveals the following points.

The turnover ratio for non-benchmark issues ranges from zero to 2.5%. It takes its highest value with 10 years of life remaining and then quickly falls as remaining life decreases. It seems to increase slightly with around 7 years of life remaining.

The turnover ratio for ex-benchmark issues, which is not included in non-benchmark issues, is somewhat higher than that for non-benchmark issues from 4 to 6 years of life remaining.

Figure 1 suggests that patterns in turnover ratio for ex-benchmark issues and non-benchmark issues differ. The following section will test this observation through regression analysis. As mentioned above, regression tests are conducted on two data sets: ex-benchmark issues and non-benchmark issues.

Data on actual turnover ratio for the second quarter, 1998 are plotted according to deviation from par-value in Figure 2. It seems that deviation from par value is inversely related to turnover ratio.

3. Statistical models and regression results

3.1 The regression model

The statistical models used in the following analyses are equations (2) and (3):

(2)
$$\left(\frac{T}{V}\right)_{it} = \beta_0 + \beta_1 (RL)_{it} + \beta_2 (DPAR)_{it} + TD_t \vec{\beta}_3 + \varepsilon_{it} ,$$

(3)
$$\left(\frac{T}{V}\right)_{it} = \gamma_0 + Z\vec{\gamma}_1 + \gamma_2 (DPAR)_{it} + TD_t \vec{\gamma}_3 + \omega_{it} ,$$

where *(T/V)* is the turnover ratio (trading volume per day/net outstanding amount), β_0 and γ_0 are constant variables, *RL* is the remaining life, *Z* is the vector of dummy variables for remaining life, *DPAR* is the deviation from par value, *TD* is the vector of time dummy variables for each quarter, ε_{it} and ω_{it} are independent identically distributed error terms, β_1, β_2, $\bar{\beta}_3$, $\bar{\gamma}_1$, γ_2, and $\bar{\gamma}_3$ are parameters to be estimated, subscript *i* shows individual issues, and subscript *t* denotes the period measured in terms of quarters. We will use two equations, and decide which equation is appropriate for the data using the J-test.[7] The hypotheses to be examined are as follows:

Remaining life (RL): If investors who use buy-and-hold strategies constantly purchase bonds, the tradable amount of the issues in the inter-dealer market may steadily decrease as the issues' life remaining decreases. Therefore, parameter β_1 is expected to be positive.

Remaining life dummy (Z): Investors may prefer trading issues with specific amounts of life remaining to hedge market risks of their assets/liabilities which have specific duration. If this affects dealers' behavior and increases the turnover ratio in the inter-dealer market at certain points of remaining life, the relationship between turnover ratio and remaining life may not be linear. Therefore, in equation (3), *RL* of equation (2) is replaced by *Z*, the vector of dummy variables for remaining life divided in units of half-years. The most appropriate of the two possible regression sets is determined using the J-test. The non-linear model, equation (3), rather than the linear model, is expected to be the statistically preferred model, because the change in turnover ratio with respect to remaining life seems to be non-linear in Figure 1.

Deviation from par value (DPAR): In Japan, it is said that financial institutions and investors using historical cost accounting tend to avoid buying over-par bonds because they would have to report losses at redemption or amortise losses.[8] This may decrease the demand for over-par bonds, and parameters β_2 and γ_2 are therefore expected to be negative.

Time dummy (DT): *DT* is the time dummy which takes a value of one in each period from the third quarter, 1995 to the second quarter, 1998. *DT* is expected to absorb aggregate shocks, such as activity in all securities markets, changes in the Japan Bond Trading Co.'s share in the inter-dealer markets, or fluctuations in the business cycle.

3.2 Basic results using non-benchmark data

To examine the hypotheses, turnover ratio is first regressed on the constant and the remaining life, and on the constant and the remaining life dummy variables. Then, using the J-test, a statistically appropriate model is selected. The sample period is from the third quarter, 1995 to the second quarter, 1998. The coefficient for remaining life is expected to be positive in the former regression set. In comparing the two models, the latter regression set is expected to be more appropriate.

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7 The J-test is one of the non-nested tests for linear regression models. Consider the following two linear regression models:

M_1: $y = W_1\bar{\eta}_1 + u_1,\ u_1 \sim N(0, \sigma_1^2)$

M_2: $y = W_2\bar{\eta}_2 + u_2,\ u_2 \sim N(0, \sigma_2^2)$

The tests of M_1 against M_2 and M_2 against M_1 are based on the t-values of λ and θ in the following "artificial" OLS regressions, respectively.

$$y = W_1\bar{\eta}_1 + \lambda(W_2\hat{\eta}_2) + v_1$$
$$y = W_2\bar{\eta}_2 + \theta(W_1\hat{\eta}_1) + v_2$$

8 Some reasons organisations may avoid reporting amortisation losses are (a) certain public entities, e.g. insurance cooperatives for government institutions, have internal rules prohibiting the purchase of securities which lead to redemption losses, and (b) smaller local financial institutions with limited staffs may not like carrying the administrative costs of accounting for amortisation losses.

The regression results are summarised in columns (a) and (b) of Table 2. In column (a), the coefficient for remaining life takes a positive value of 0.0493 (t-value 12.084) and the sign of the coefficient meets our expectations. The F-value test of the null hypothesis, given that the parameters of the constant and remaining life are zero, takes a value of 322.382, which is rejected at the 1% significance level. In column (b), the F-value is 66.553, which is also larger than the critical value at 1%.

Note that the models estimated in column (a) and column (b) are non-nested models. Therefore, in order to compare the statistical performance of these models, it is necessary to conduct the J-test. First, test statistic J_a for the J-test is 8.709. This tests the null hypothesis that the parameter for fitted values by the regression set in column (b) artificially nested into the regression set in column (a) is zero. The null hypothesis is rejected at the 1% significance level. Test statistic J_b , which is estimated by the reverse procedures of J_a , takes a value of 3.541 and the null hypothesis is also rejected at the 1% significance level. Therefore, we cannot decide which of the two models is best.

In columns (c) and (d) of Table 2, deviation from par-value is added to the explanatory variables in columns (a) and (b), respectively. The coefficient for deviation from par value is expected to be negative. In column (c), note that the coefficient for remaining life is 0.0438 (t-value 13.777), which seems virtually unchanged from the result in column (a), and the coefficient for deviation from par value takes a negative value of –0.0097 (t-value 6.865), whose sign meets our expectation. The value of F-test statistics testing the model estimated in column (c) against the null hypothesis of the model in column (a) is 67.762, which is statistically significant at the 1% level. In column (d), the coefficient for deviation from par-value is -0.0058 (t-value 4.496), whose sign meets our expectation. The F-test value for testing the model in column (d) against the model in column (b) is 12.939, which is statistically significant at the 1% level. Overall evidence in columns (c) and (d) suggests that deviation from par value is inversely related to turnover ratio.

In columns (e) and (f) of Table 2, the time dummy variable which takes a value of one in each period from the third quarter, 1995 to the second quarter, 1998 is added to the explanatory variables in columns (c) and (d), respectively. In column (e), note that the coefficient for remaining life is 0.0433 (t-value 12.437), which seems unchanged from the result in column (c). The F-value becomes 34.590, which is statistically significant at the 1% level. The F-test value for testing the model in column (e) against the model in column (c) is 2.244, which is statistically significant at the 5% level. In column (f), the F-value takes a value of 44.525, which is statistically significant at the 1% level. Note that the F-test value for testing the model in column (f) against the model in column (d) is 2.595, which is statistically significant at the 1% level. It is safe to conclude that the qualitative nature of our analysis is insensitive to the time dummy variable.

The estimated turnover ratio of the remaining life in column (e) and the estimated coefficients[9] for remaining life dummy variables in column (f) are summarised in Figure 3. Note that the shape of the plots of estimated coefficients for remaining life dummy variable is similar to the actual turnover ratio of non-benchmark issues shown in Figure 1. However, the rise around 7 years, which is not distinct in Figure 1, becomes distinct in Figure 3.

3.3 Results using ex-benchmark data

In analysing data of ex-benchmark issues, the procedure used in the Section 3.2 is also used for data on ex-benchmark issues. Turnover ratio is first regressed on the constant and the remaining life, and on the constant and the remaining life dummy variable. Next, using the J-test, we determine which of the two regression sets is most appropriate. Then, possible explanatory variables are added one by one to the appropriate regression set. Note that the sample period is the same for ex-benchmark and

[9] The constant in column (f) in Table 2 consists of the estimated turnover ratio when both the remaining life dummy variable and the time dummy variable are zero. Since they cannot be separated, Figure 3 shows estimated coefficients, not estimated turnover ratio, for the remaining life dummy variables in column (f).

non-benchmark data, but the former data set does not include the data for issues with over 8.5 years of life remaining, because ex-benchmarks were benchmark issues at that point.

The results of the first and second regressions are summarised in columns (a) and (b) of Table 3, respectively. In column (a), the coefficient for remaining life is 0.0389 (t-value 4.277), whose sign meets our expectation. The F-value for testing the null hypothesis, given that the constant and remaining life are zero, takes a value of 10.999, which is rejected at the 1% significance level. In column (b), the F-value is 8.248, which is also larger than the critical value at 1%. The test statistic J_a for the J-test is 8.077. Therefore, the null hypothesis, the parameter for fitted values by the regression set in column (b) artificially nested into the regression set in column (a) is zero, is rejected at the 1% significance level. The test statistic J_b , which is estimated by reverse procedures of J_a , takes a value of 0.932 and the null hypothesis is not rejected at the 5% significance level. The result of the J-test suggests that the set of explanatory variables in column (b) is more appropriate than that used in column (a), which meets our expectation of remaining life's effect on turnover ratio.

In column (c) of Table 3, deviation from par value is added to the explanatory variables used in column (b). The coefficient for deviation from par value is expected to be negative. In column (c), however, the coefficient for deviation from par value takes a positive value of 0.0115 (t-value 1.217), whose sign does not meet our expectation. The value of F-test statistics testing the model estimated in column (c) against the model in column (a) is 2.153, which is not rejected at the 5% significance level. Evidence in column (c) suggests that we cannot conclude that deviation from par value is inversely related to the turnover ratio.

In column (d) of Table 3, the time dummy variable is added to the explanatory variables used in the model in column (b). Note that the value of F-test statistics testing the model in column (d) against the model in column (b) is 0.902, which is statistically insignificant at the 5% level. Overall evidence in columns (c) and (d) suggests that the regression set in column (b) is chosen as the best model among the four regression sets.

The estimated coefficients for the remaining life dummy variables in column (b) are summarised in Figure 4. Note that the shape of plotted coefficients for remaining life dummy variables looks significantly different from that of column (f) of Table 2 for non-benchmark data, which is summarised in Figure 3. Observe spikes at around 3 and 4 years of remaining life, which are not observed in Figure 3.

3.4 Consistency between the two data sets

As ex-benchmark data lacks issues with over 8.5 years of remaining life, comparing the regression results for non-benchmark and ex-benchmark issues might be misleading. Therefore, the same regression analysis is conducted once again using the data set for non-benchmark issues with a remaining life of 8.5 years or less.

The regression results for turnover ratio on the constant and the remaining life and on the constant and the remaining life dummy variable are summarised in columns (a) and (b) of Table 4. In column (a), the coefficient for remaining life is 0.0236 (t-value 15.100), whose sign meets our expectation. The F-value of column (a) takes a value of 224.103, which exceeds the critical value at 1%. In column (b) the F-value is 20.480, which also exceeds the critical value at 1%. The test statistic J_a for the J-test is 7.789. Therefore, the null hypothesis, the parameter on fitted values by the regression set in column (b) artificially nested into the regression set in column (a) is zero, is rejected at the 1% significance level. The test statistic J_b , which is estimated by reverse procedures of J_a , takes a value of 1.712 and the null hypothesis is not rejected at the 5% significance level. The result of the J-test suggests that the regression set in column (b) is more appropriate than that in column (a).

In column (c) of Table 4, the time dummy variables are added to the explanatory variables in column (b). In column (c), the value of F-test statistics testing the model estimated in column (c) against the model in column (b) is 10.621, which exceeds the 1% significance level. It is safe to conclude from this that the time dummy variable can be added to the explanatory variables.

In column (d) of Table 4, deviation from par value is added to the explanatory variables in column (c). In column (d), the coefficient for deviation from par value takes a negative value of –0.0019 whose sign meets our expectation. However, the t-value of the coefficient is 1.790; the null hypothesis that the coefficient for deviation from par value is zero or positive is not rejected at the 1% significance level. The value of F-test statistics testing the model estimated in column (d) against the model in column (c) is 3.588, which is less than the 5% significance level. The results shown in column (d) do not allow a conclusion that deviation from par-value is inversely related to the turnover ratio.

Overall evidence in columns (c) and (d) suggests that the regression set in column (c) is the best model among these four regression sets. The estimated coefficients for the remaining life dummy variables of the model in column (c) of Table 4 and ones in column (b) of Table 3 are summarised in Figure 5. The shapes of the two plotted lines significantly differ. Note that the plots of coefficients estimated using ex-benchmark data are almost the same with these of non-benchmark data at points where less than 2 years of life remain, and are very close to ones of non-benchmark at points where around 6 and 7 years of life remain. However, the former has spikes at around 3 and 4 years of remaining life, which are not observed in the latter.

3.5 Summary of results

A summary of this paper's findings is outlined below.

It was assumed that investors using historical cost accounting avoid buying over-par bonds because they would have to report losses at redemption or amortise losses. Therefore, the coefficient for deviation from par value was expected to be negative. The hypothesis is supported by the data set using whole non-benchmark issues. However, once data for the issues with over 8.5 years of life remaining was dropped, the statistical significance of the estimated parameters decreased. Moreover, the data set for the ex-benchmark does not confirm the hypothesis. Therefore, one cannot conclude that there is an inverse relationship between deviation from par-value and turnover ratio holding remaining life constant, based on the data set used in the study.

The effect of remaining life on turnover ratio for the data from all non-benchmark issues could be either linear or non-linear. However, once the focus is limited to issues with 8.5 years or less of remaining life, both non-benchmark data and ex-benchmark data support the view that the relationship between remaining life and turnover ratio is non-linear. In looking at the estimated coefficients for remaining life dummy variables, there is a rise in non-benchmark issues and a fall in ex-benchmark issues at around 7 years of remaining life, and there are spikes for only ex-benchmark issues at around 3 and 4 years of remaining life. The two shapes of plotted coefficients for non-benchmark issues and for ex-benchmark issues significantly differ.

3.6 Possible explanations for differences in the remaining life coefficients

According to interviews with dealers in the government securities market, possible explanations regarding the apparent differences in the estimated coefficients for remaining life dummy variables using non-benchmark data and ex-benchmark data (shown in Figure 5) are as follows:

- While estimated coefficients for remaining life dummy variables using non-benchmark data rise with about 7 years of life remaining, those of ex-benchmark data fall at the same point in Figure 5. The relationship between the cash bond market and the bond futures market may account for these opposite movements. As mentioned in *Miyanoya, Inoue and Higo* (1999), the 10-year JGB market is a future-driven market, mainly because the transaction costs for futures contracts are lower than those for cash bonds. There are two possible ways that long-term bond futures contracts affect the turnover ratio of cash bonds. One way is through arbitrage between the futures contract and its cheapest-to-deliver issue.[10] Usually, an issue with 7 years of life remaining at the expiration date of the futures contract becomes the cheapest-to-deliver issue, and whether the issue is ex-benchmark or non-benchmark is irrelevant. This effect may increase turnover ratio of both ex-benchmark and non-benchmark issues as their remaining life decreases and approaches 7 years. The second way is through the substitution effect of the futures contract as a tool for hedging interest rate risk. This may decrease the turnover ratio of cash bonds when their remaining life is around 7 years. Let us suppose that the substitution effect is stronger for liquid issues than non-liquid issues. If this is true, the following may occur:

(a) The substitution effect is stronger than the arbitrage effect for ex-benchmark issues, and leads to a decrease in the turnover ratio of ex-benchmark issues.

(b) The arbitrage effect is stronger than the substitution effect for non-benchmark issues and leads to an increase in the turnover ratio of non-benchmark issues.

The asymmetry of those two effects for the ex-benchmark issues and non-benchmark issues may be a possible explanation for the different shapes of plotted coefficients on time dummy variables for the data of ex-benchmark issues and non-benchmark issues with about 7 years of life remaining.

- Regarding the significant difference between estimated coefficients using ex-benchmark data and those using non-benchmark data at points with around 3 and 4 years of life remaining, a possible explanation is that there is no appropriate tool for hedging interest rate risks near these points other than cash bonds. Some dealers suggest that an interest rate risk of less than 2 years can generally be hedged by short-term interest rate futures contracts and an interest rate risk of longer than 5 years can be roughly hedged by long-bond futures contracts. Credit risks can be avoided in the futures market as in the government securities market, and the transaction costs of these instruments are lower than those of cash bonds.[11] However, instruments other than cash government bonds cannot be used to hedge an interest rate risk of about 3 or 4 years.[12] Dealers prefer ex-benchmark issues to non-benchmark issues, as tools to hedge interest rate risk of 3 and 4 years. Their reasons are as follows:

  (a) Indication data or orders for ex-benchmark issues are available on the screens of vendors or inter-dealer brokers. Accordingly, price information for ex-benchmark issues is more accessible than that of non-benchmark issues.

  (b) Investors who adopt historical cost accounting are more likely to sell ex-benchmark issues, because the book values of these issues are closer to market values than the book values of non-benchmark issues held for a longer period, and sellers do not have to report large capital gains/losses. The supply of ex-benchmark issues in the secondary market exceeds the supply of non-benchmark issues.

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10 The deliverable issues for the long-term bond future are 10 and 20-year JGBs with a remaining life of between 7 and 11 years.

11 Swap contracts seem to be used to hedge interest rate risks. However, some dealers note that swap contracts entail credit risks, and therefore do not play the same role as cash government bonds.

12 Mid-term futures contracts, whose cheapest-to-deliver issue is usually an issue with 3 years of remaining life, seem appropriate for hedging an interest rate risk of 3 or 4 years. However, mid-term futures are rarely traded, probably because the notional coupon of the futures is set at 6%, which is substantially higher than the actual yields of deliverable issues, and because it is possible to incur large losses during squeeze for the cheapest-to-deliver issue. While trading volume of long-term futures contracts was 1,180 trillion-yen in 1997, that of mid-term futures contracts was only 12 trillion-yen in the same year.

4. Implications

The regression results indicate that in general, the turnover ratio of 10-year JGBs in an inter-dealer market decreases as their remaining life decreases. However, the relationship between turnover ratio and remaining life is non-linear, and the patterns of estimated coefficients for time dummy variables for ex-benchmark issues and non-benchmark issues differ, especially at points with around 3 and 4 years of life remaining and with 7 years of life remaining. Although empirical evidence presented in this paper does not determine what causes changes in turnover ratio, interviews with market participants suggest that relationships with other financial instruments may cause changes in the turnover ratio of 10-year JGBs through dealers' hedging activities. The fall in plotted coefficients for ex-benchmark issues with around 7 years of life remaining in Figure 5 may indicate a liquidity shift from ex-benchmark issues to futures contracts. The rise in plots with around 3 and 4 years of life remaining may suggest that liquidity of ex-benchmark issues resurges even if they are hardly new issues. Liquidity may come and go between ex-benchmark issues and alternative instruments as the remaining life of issues decreases.

In inter-dealer markets, dealers may need vehicles to deal with "pure" interest rate risks over the wide range of maturities. Government bonds and futures contracts are regarded as virtually credit risk-free and have traits which make them natural choices as hedging tools for "pure" interest rate risks. For each maturity, the dealers select the most suitable instrument among fungible instruments, considering transaction costs and other factors. Such dealer activity may explain the non-linear changes in liquidity of 10-year JGBs observed in the study. In addition, market disposition which distinguishes ex-benchmark issues from non-benchmark issues may play a role in the selection process.

In conclusion, liquidity of government securities may be affected by factors, such as their characteristics, fungibility with other instruments, and market disposition, and these factors must be considered when designing the structure of government securities, especially in areas of maturity, transaction costs, and issuance system.

5. Possible areas of future study

Please note that dealers prefer ex-benchmark issues to non-benchmark issues as tools to hedge interest rate risks. This is because price information is abundant and book values are closer to market values for ex-benchmark issues. This in turn, may stem from the fact that these issues are actively traded in the market. If the reasons that dealers point out are true, their preference for ex-benchmark issues may be self-enforcing. Accordingly, it might be a good idea to investigate the mechanism for selecting a "benchmark" issue in the Japanese government securities markets: the mechanism for selecting particular issues as benchmark issues seems to be the origin of the self-enforcing mechanism for ex-benchmark issues. This suggests that areas for future study may include a Probit model analysis – which is appropriate in analysing binary data – for becoming a "benchmark" issue using issue size, lag from issuance of the previous benchmark issue, and other factors as independent variables.

Appendix

The benchmark cycle in the JGS market

It is technically difficult to conduct the same regression analysis as shown in the text, using data on benchmark issues, because there are just 12 observations in the data set. Therefore, in this appendix, the characteristics of benchmark issues are explained separately.

First, Table A-1 summarises the key features of benchmark issues including issue size, starting date of the benchmark period, and the remaining life at the starting date and the ending date. The first benchmark issue, the #53 issue, was designated in August 1983, when Japanese commercial banks were preparing to start dealing government securities in the secondary markets from July 1984; until then, only securities companies had been allowed to deal in the secondary market for government securities. Since the #53 issue, fourteen issues have been designated as benchmark issues.[13] In Table A-1, several features of benchmark issues are pointed out.

- It seems that issue size for benchmarks has been gradually growing. The issue size of the #182 issue is the largest of the fourteen ex-benchmark issues.
- While benchmark period, where issues are regarded as benchmark, ranges from 0.5 to 1.5 years for the other thirteen ex-benchmark issues, that of the #182 issue is 2.6 years and substantially longer.
- Regarding remaining life at the starting date of the benchmark period, ten out of fifteen ex-benchmark/present benchmark issues became benchmark when their remaining life was 9.5 or 9.6 years.
- Regarding remaining life at the ending date of the benchmark period, that of the #182 issue is 7.1 years while remaining life the other thirteen ex-benchmark issues ranges from 7.6 to 9.1 years.

Compared with the other ex-benchmark issues, some notable characteristics of the previous benchmark, the #182 issue, are largest issue size, longest benchmark period, and shortest remaining life at the ending date of its benchmark period.

Because the total outstanding amount of 10-year JGBs has been increasing,[14] it may be inappropriate to compare the absolute issue size of JGBs to assess their characteristics. The absolute issue sizes and relative issue sizes (ratio of issue size to average issue size of previous five issues and subsequent five issues) for each 10-year JGB are shown in Figure A-1. It seems that the relative issue size better indicates whether the issue is likely to be benchmark than the absolute issue size does. Except for the present benchmark, #203 issue, the 2.0 level for relative issue size ratio seems to be the borderline at which a certain issue becomes a benchmark issue or not.

Figure A-2 shows the turnover of benchmark issues in an inter-dealer broker, the Japan Bond Trading Co., from January 1991 to June 1998. Some features of the market as seen in Figure A-2 are as follows:

- Turnover of benchmark issues dramatically increases immediately after these issues become benchmark and quickly falls when the benchmark issue changes to the next one.

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[13] There is no official rule for selecting benchmark issues.

[14] The total outstanding amount of 10-year JGBs increased from 71 trillion-yen as of August 1983 to 192 trillion-yen as of June 1998.

- In general, turnover of benchmark issues is declining. In June 1998, the turnover of the #182 issue was only 2.9%, which is one nineteenth of the peak turnover of the #129 issue.

The declining trend in the turnover of benchmark issues may be explained by the increasing popularity of the so-called “curve trades” strategy: investors/dealers buy issues that seem cheaper and sell issues that seems more expensive than the prices calculated using a theoretical yield curve. The development of the JGB repo market may also have made it easier to trade issues other than benchmark issues. With regard to the historically low turnover of the #182 issue, the substitution effect by long-bond futures mentioned in the text may offer an explanation. The remaining life of the #182 issue was 7.3 years as of June 1998, and the issue was one of the cheapest-to-deliver issues for September 1998 futures contracts.

References

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Fukuta, Yuichi: "The Benchmark Issue Premium in the Japanese Government Bond Market," *Japan and the World Economy* 7 (3), 1995, 291-307.

Keane, Frank: "Repo Rate Patterns for New Treasury Notes," *Current Issues in Economics and Finance* 2 (10), Federal Reserve Bank of New York, 1996.

Miyanoya, Atsushi, Hirotaka Inoue and Hideaki Higo: "Microstructure and liquidity in the Japanese government securities market" Working Paper Series released by Financial Markets Department, No. 99-J-1, 1999

Table 1
Estimation results of 10-year JGBs other than benchmark issue

Dependent variable: trading volume (billion-yen)

	(a) [1]	(b) [1]	(c) [1]
Constant	-11.9250	-15.5166	-11.1946
	(5.686)**	(6.663)**	(5.109)**
Net outstanding amount	0.0040	0.0047	0.0038
	(13.796)**	(8.930)**	(11.915)**
Squared net outstanding amount	NO	-2.74E-08	NO
		(1.234)	
Ex-benchmark dummy variable	NO	NO	11.9300
			(2.719)**
Standard error	28.697	28.689	28.523
Residual SS	710,717	709,467	701,268
$\bar{R}^2$	0.365	0.366	0.373
F-value	498.641**	250.230**	258.195**
	F(1,863)	F(2,862)	F(2,862)
F-test	NO	1.519 [2]	11.615** [3]
		F(1,862)	F(1,862)
Number of observations	865	865	865

1: t-value is calculated by standard deviation estimated by the White method.
2: (a) vs. (b)
3: (a) vs. (c)
* and ** denote significance at 5% and 1% levels, respectively.
Estimation is by the OLS method.

Table 2
Estimation results of non-benchmark 10-year JGBs

Dependent variable: turnover ratio (trading volume per day/net outstanding amount, %)

	(a) [1]	(b) [1]	(c) [1]	(d) [1]	(e) [1]	(f) [1]
Constant	-0.0613 (3.579)**	0.0233 (7.000)**	0.0904 (7.810)**	0.0301 (6.066)**	0.147159 (6.070)**	0.0833 (3.241)**
Remaining life	0.0493 (12.084)**	No	0.0438 (13.777)**	No	0.0433 (12.437)** (see Figure3)	No
Remaining life dummy variable	No	Yes	No	Yes	No	Yes (see Figure3)
Deviation from par-value	No	No	-0.0097 (6.865)**	-0.0058 (4.496)**	-0.0104 (7.305)**	-0.0077 (5.191)**
Time dummy variable	No	No	No	No	Yes	Yes
Standard error	0.199	0.144	0.191	0.143	0.189	0.142
Residual SS	30.890	15.895	28.424	15.630	27.541	15.057
$\bar{R}^2$	0.291	0.626	0.347	0.632	0.358	0.640
F-value	322.382** F(1,782)	66.553** F(20,763)	208.833** F(2,781)	64.992** F(21,762)	34.590** F(13,770)	44.525** F(32,751)
F-test	No	No	67.762** [3] F(1,781)	12.939** [4] F(1,762)	2.244* [5] F(11,770)	2.595** [6] F(11,751)
J-test [2]	J_a: 8.709** J_b: 3.541**		No	No	No	No
Number of observations	784	784	784	784	784	784

1: t-value is calculated by standard deviation estimated by the White method.
2: (a) vs. (b)
3: (a) vs. (c)
4: (b) vs. (d)
5: (c) vs. (e)
6: (d) vs. (f)
* and ** denote significance at 5% and 1% levels, respectively.
Estimation is by the OLS method.

Table 3
Estimation results of ex-benchmark 10-year JGBs

Dependent variable: turnover ratio (trading volume per day/net outstanding amount, %)

	(a) [1]	(b) [1]	(c) [1]	(d) [1]
Constant	0.1937 (3.518)**	0.0450 (3.000)**	0.0344 (1.570)	0.1220 (0.933)
Remaining life	0.0389 (4.277)**	No	No	No
Remaining life dummy variable	No	Yes (see Figure4)	Yes	Yes
Deviation from par-value	No	No	0.0115 (1.217)	No
Time dummy variable	No	No	No	Yes
Standard error	0.244	0.165	0.164	0.167
Residual SS	4.700	1.749	1.691	1.473
$\bar{R}^2$	0.111	0.592	0.599	0.585
F-value	10.999** F(1,79)	8.248** F(16,64)	8.029** F(17,63)	5.172** F(27,53)
F-test	No	No	2.153 [3] F(1,63)	0.902 [4] F(11,53)
J-test [2]	J_a: 8.077** J_b: 0.932		No	No
Number of observations	81	81	81	81

1: t-value is calculated by standard deviation estimated by the White method.
2: (a) vs. (b)
3: (b) vs. (c)
4: (b) vs. (d)
* and ** denote significance at 5% and 1% levels, respectively.
Estimation is by the OLS method.

Table 4
Re-estimation results of non-benchmark 10-year JGBs
(data of issues with 8.5 years or less of remaining life)

Dependent variable: turnover ratio (trading volume per day/net outstanding amount, %)

	(a) [1]	(b) [1]	(c) [1]	(d) [1]
Constant	0.0426 (6.272)**	0.0233 (7.000)**	0.151127 (7.019)**	0.1495 (7.107)**
Remaining life	0.0236 (15.100)**	No	No	No
Remaining life dummy variable	No	Yes	Yes (see Figure5)	Yes
Deviation from par-value	No	No	No	-0.0019 (1.790)*
Time dummy variable	No	No	Yes	Yes
Standard error	0.085	0.081	0.075	0.075
Residual SS	4.658	4.127	3.468	3.448
$\bar{R}^2$	0.258	0.327	0.424	0.427
F-value	224.103** F(1,641)	20.480** F(16,626)	18.515** F(27,615)	18.057** F(28,614)
F-test	No	No	10.621** [3] F(11,615)	3.588 [4] F(1,614)
J-test [2]	J_a: 7.789** J_b: 1.712		No	No
Number of observations	643	643	643	643

1: t-value is calculated by standard deviation estimated by the White method.
2: (a) vs. (b)
3: (b) vs. (c)
4: (c) vs. (d)
* and ** denote significance at 5% and 1% levels, respectively.
Estimation is by the OLS method.

Table A-1
Properties of benchmark issues

Issue	Issue size (billion yen)	Starting date of benchmark period	Length of benchmark period (years)	Remaining life at the starting date (years)	Remaining life at the ending date (years)
#53	1,800	31-Aug-83	1.0	9.4	8.4
#59	1,600	16-Aug-84	0.8	9.3	8.6
#68	1,450	24-May-85	0.6	9.6	9.0
#78	1,300	27-Dec-85	0.9	9.6	8.7
#89	2,708	19-Nov-86	1.0	9.6	8.6
#105	1,500	26-Nov-87	1.0	10.1	9.0
#111	2,000	9-Dec-88	1.0	9.5	8.5
#119	1,852	6-Dec-89	1.2	9.5	8.4
#129	2,300	13-Feb-91	1.5	9.1	7.6
#145	3,200	27-Aug-92	1.2	9.6	8.3
#157	2,400	26-Nov-93	0.5	9.6	9.1
#164	2,000	30-May-94	0.7	9.6	8.8
#174	3,000	24-Feb-95	1.0	9.6	8.6
Average of above issues	2,085	----	0.95	9.55	8.58
Maximum of above issues	3,200	----	1.50	10.10	9.10
Minimum of above issues	1,300	----	0.50	9.10	7.60
Previous benchmark #182	3,200	28-Feb-96	2.6	9.6	7.0
Present benchmark #203	2,200	22-Sep-98	---	9.7	---

Figure 1
Turnover ratio of 10-year JGBs according to remaining life
(average in 98Q2)

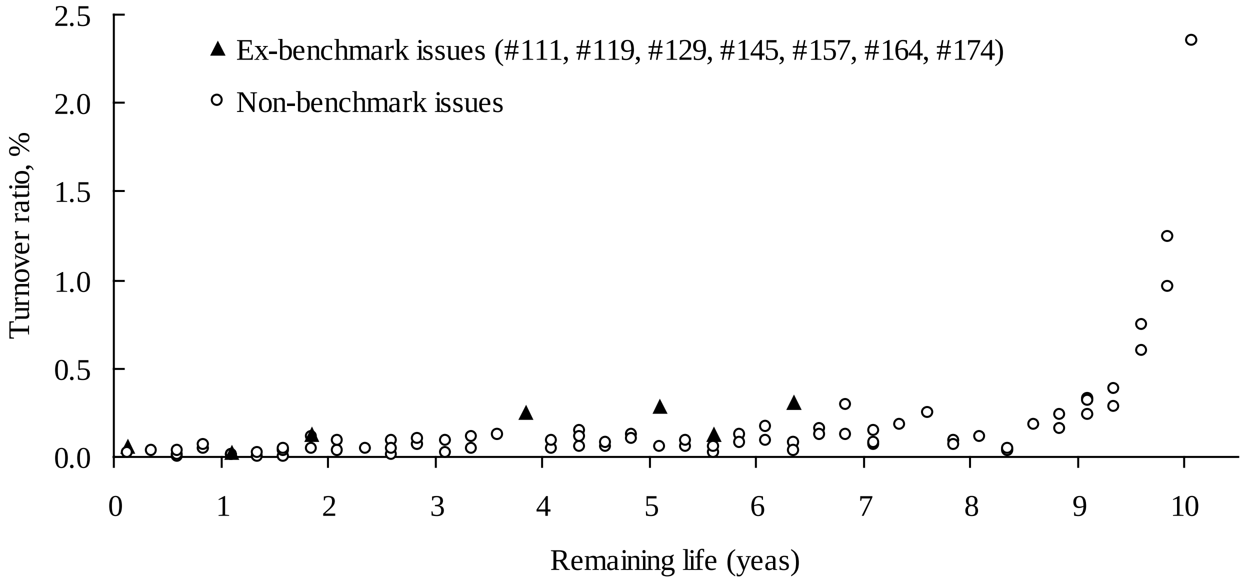


Figure 2
Turnover ratio of 10-year JGBs according to deviations from par-value
(average in 98Q2)

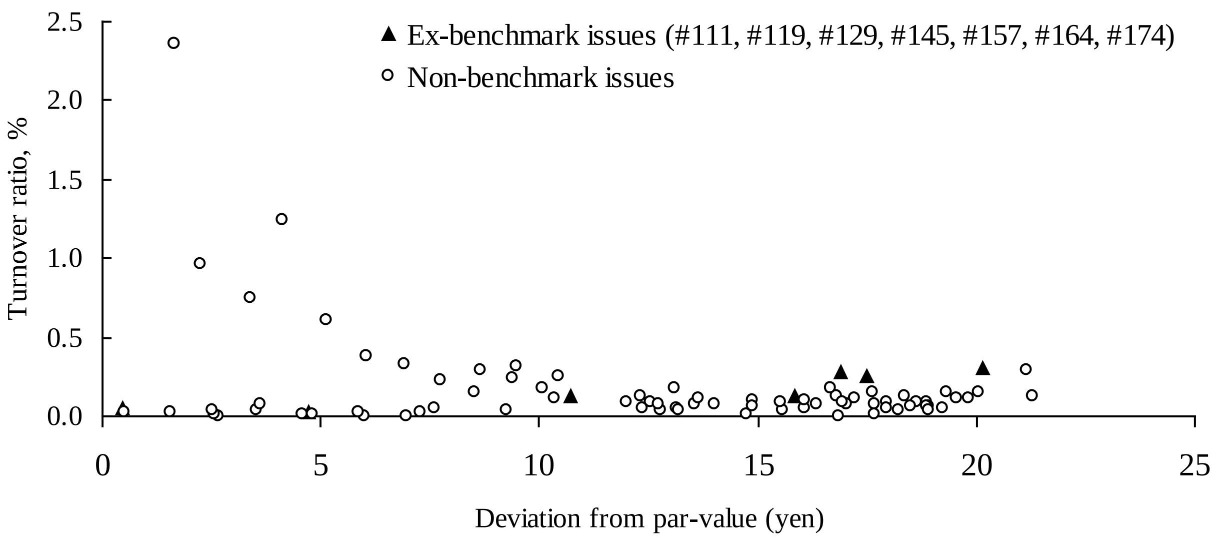


Figure 3

Estimated turnover ratio using a linear model and estimated coefficients for remaining life dummy variables using a non-linear model (non-benchmark JGBs)

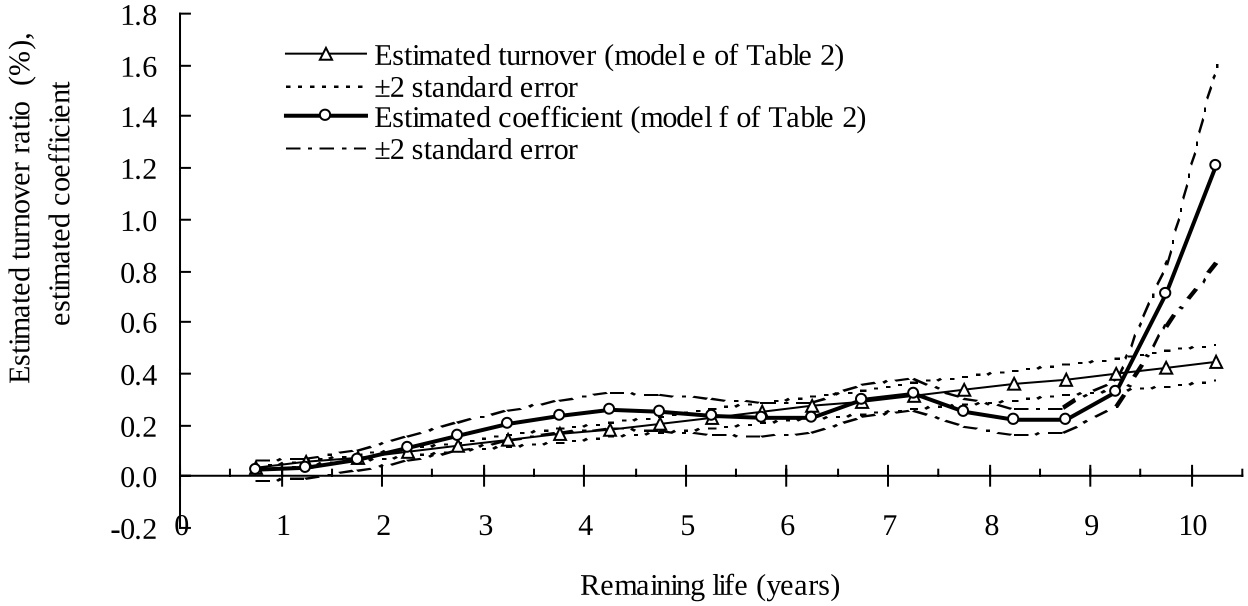


Figure 4

Estimated coefficients for remaining life dummy variables of ex-benchmark 10-year JGBs (model b of Table 3)

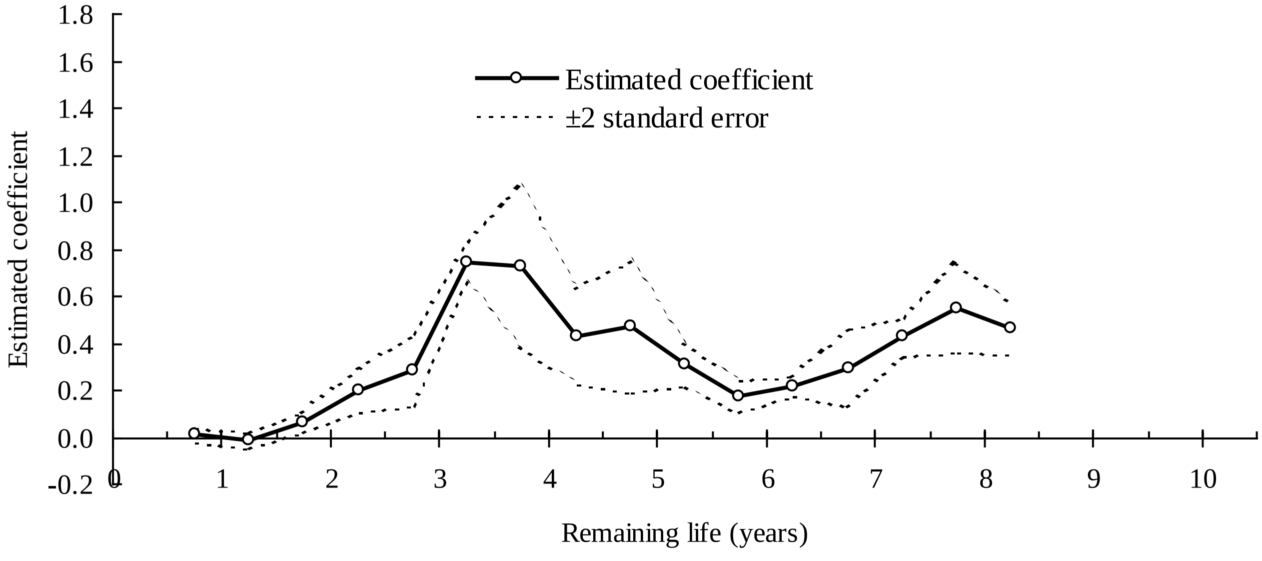
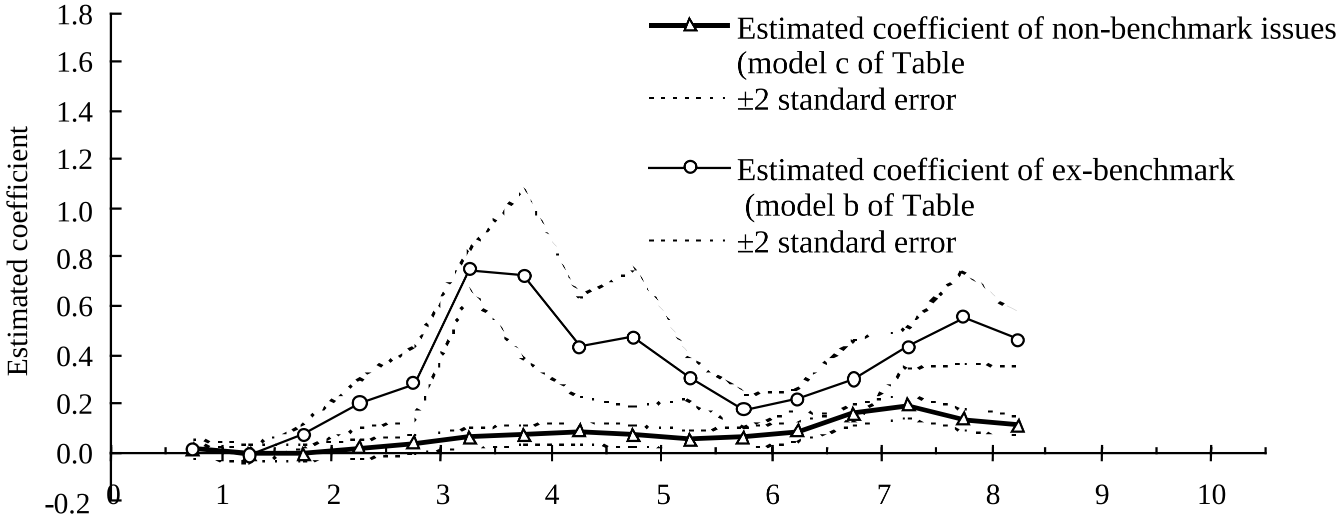


Figure 5

Estimated coefficients for remaining life dummy variables of ex-benchmark and non-benchmark 10-year JGBs

(with 8.5 years or less of remaining life)



Equation for non-benchmark issues: $E(T/V) = 0.151 + Z\gamma_1 + TD_t\gamma_3$

Equation for ex-benchmark issues: $E(T/V) = 0.045 + Z\gamma_1$

Figure A-1
Absolute and relative issue size of 10-year JGBs

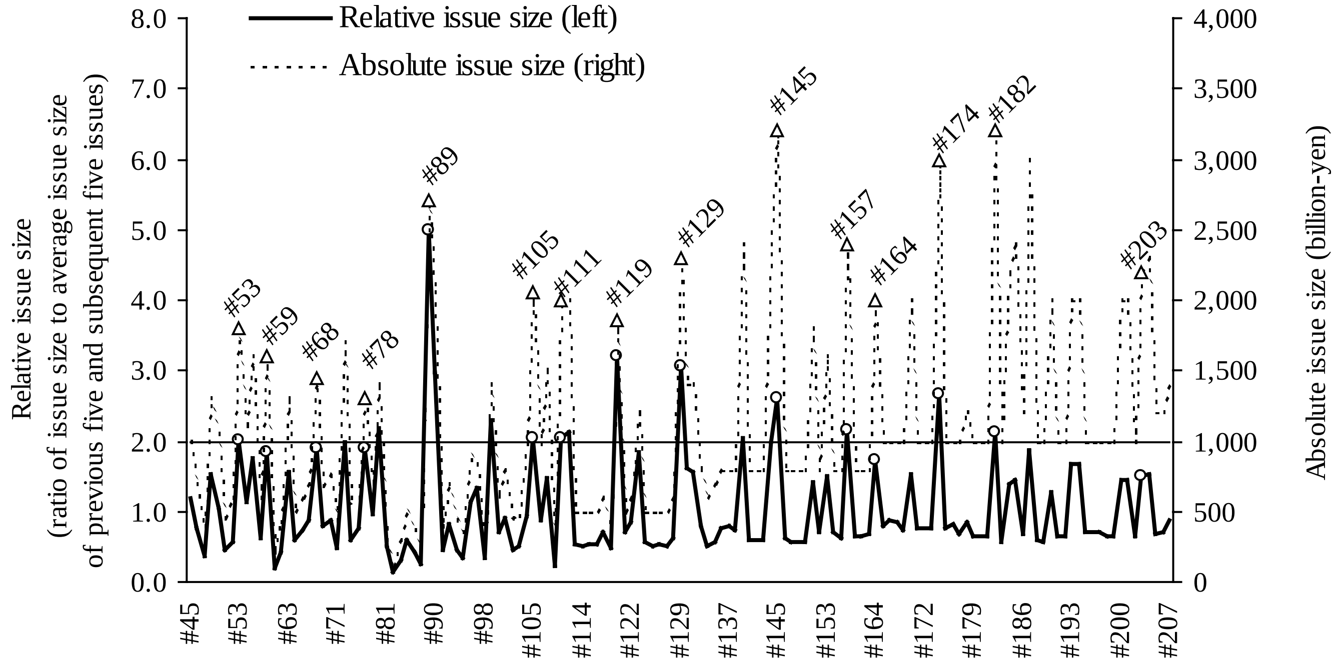


Figure A-2
Turnover ratio of benchmark issues (January 1991-June 1998)