NOMURA

NOMURA-BPI MBS Reference Book

CROSS-ASSET

Global Markets Research

31 March 2025

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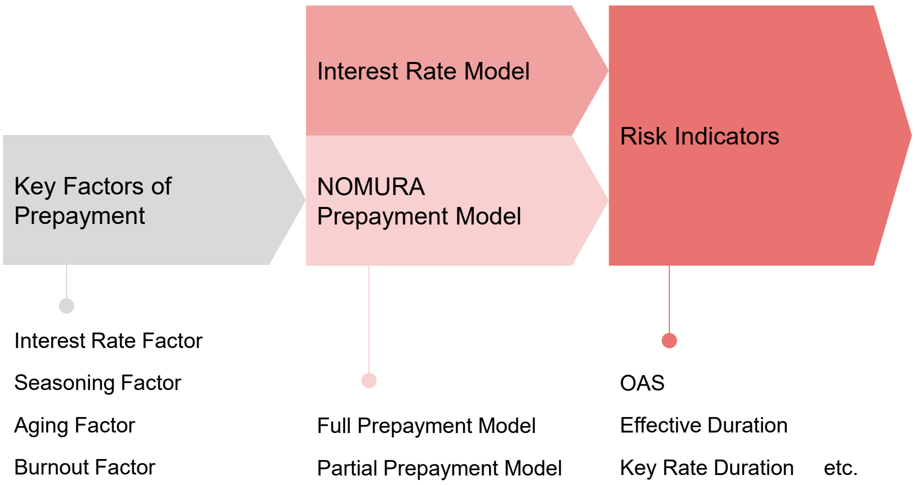
Outline

This article summarizes the calculation methods for risk indicators and total return index of MBS for the NOMURA-BPI.

MBS are fixed-rate bonds backed by residential mortgages, structured as pass-through securities where investors receive principal and interest payments from underlying loans. As a result, MBS are subject to prepayment risks arising from events such as prolonged delinquencies in the underlying mortgages, changes in repayment schedules, or modifications to loan terms. Consequently, MBS are characterized by the uncertainty of future cash flow. To account for these factors in calculating risk indicators and total return index, this article introduces NOMURA Prepayment Model (the prepayment model and the cancellation rate estimation model) used in the NOMURA-BPI.



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Contents

1. What are JHF MBS?

One of the sectors that constitute the NOMURA-BPI (Nomura Bond Performance Index) is MBS (Mortgage-Backed Securities). In March 2001, the first issuance of loan-backed securities by the Japan Housing Finance Agency (hereinafter, JHF MBS) took place, and starting from April 2003, these securities began to be included in the NOMURA-BPI as part of a newly established sector classification, the MBS sector. As of March 2025, only JHF MBS are classified under the MBS sector.

JHF MBS are fixed-rate securities backed by mortgages on residential property. They are pass-through MBS, in which an issuer collects monthly repayments from loan borrowers and then passes on a proportionate share of the collected principal and interest to the investor. The borrower's principal repaid monthly is not repaid in accordance with the schedule determined at the start of the loan; generally, the loan is prepaid ahead of schedule (prepayment). With JHF MBS being a pass-through MBS, this unscheduled cash flow is passed through to the investor. This makes JHF MBS fixed income securities that do not define future cash flow.

Thus, portfolio indicators including compound yields and duration cannot be computed as they are for ordinary fixed-coupon bonds. It is thus necessary to project future prepayments and calculate the risk indicators based on the projected cash flow. Prepayment projection method is an extremely important point in calculating risk indicators.

The speed of prepayment is usually shown using single monthly mortality (SMM) or conditional prepayment rate (CPR). In the following formula, SMM is the rate of prepayment per month and is expressed in monthly terms. CPR is this rate in annualized terms.

$$SMM[\%] = \frac{monthly\ prepayment\ amount}{previous\ month's\ principal\ balance - scheduled\ principal\ payment} \times 100$$

$$CPR[\%] = 100 - \left(1 - \frac{SMM[\%]}{100}\right)^{12} \times 100$$

When analyzing JHF MBS, 'Prepayment Model' is constructed to forecast of these two indicators.

A prepayment model is developed to project SMM or CPR when analyzing MBS. Also, when long-term loan delinquency, changes in loan terms and the like occur in the underlying collateral pool, these loans would be replaced with healthy loans for some JHF MBS— monthly MBS issued before March 2007 and S-series MBS[1]. For monthly MBS issued from April 2007, these loans are removed from the collateral pool, and JHF MBS investors are repaid for the amount equivalent to the removed loans. Since this repayment has the same effect on cash flow as prepayment, the probability of long-term delinquency, changes in loan terms and the like must also be projected (a cancellation model) for monthly JHF MBS issued since April 2007.

Another attribute that must be watched is the cleanup call clause. According to this, if the balance of a JHF MBS falls below 10% of the balance at issuance, the JHF can make an early repayment of the said MBS. Risk indicators related to JHF MBS are computed with the assumption that clean up calls will be made the month after JHF MBS balances fall below 10% of issuance balance.

[1] JHF MBS includes the regularly issued 'Monthly Bonds', as well as the irregularly issued 'S-Series Bonds' and 'T-Series Bonds'. S-Series bonds were issued between 2005 and 2009. Similarly, T-Series Bonds were issued between 2018 and 2021.

After prepayment trends are summarized below, NOMURA Prepayment Model (prepayment model and cancellation model) used in the NOMURA-BPI is introduced. The calculation methods of risk indicators and investment return indicators are then explained. Changes in the models that have been used for JHF MBS are shown in Fig. 1.

Fig. 1 Changes in Models

April 2003	JHF MBS included in NOMURA-BPI for first time (NOMURA Prepayment Model introduced)
April 2007	Cancellation Model introduced
April 2011	NOMURA Prepayment Model revised (burnout Introduced)
March 2016	Started to use an interest rate model that corresponds with negative interest rates

Source: NFRC

2. Prepayment behavior

There are several different reasons for prepayment of JHF MBS, or rather prepayment of the residential mortgages that serve as collateral of the JHF MBS. Residential mortgage holders can prepay not only the entire outstanding balance of the loan all at once (full prepayment), but they can also prepay a portion of the outstanding balance (partial prepayment). Typical reasons for both types of prepayments are:

Full prepayment: Refinancing, housing turnover, etc.

Partial prepayment: Prepayment with surplus funds, etc.

There are several factors that could lead to prepayment, and they are believed to have multiple effects. We discuss the factors affecting full prepayment and partial prepayment below using historical loan redemption data (static data) released by the JHF.

2.1 Key factors of full prepayment

2.1.1 Interest rates factor

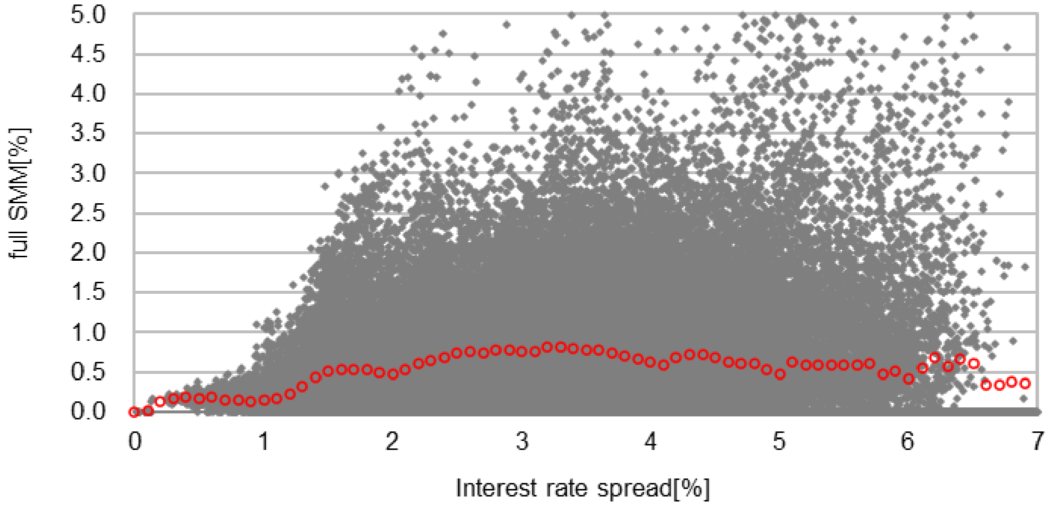
In Fig. 2, the spread between the Weighted Average Coupon (WAC) of the collateral loans at the end of the loan repayment month and the 5Yr JGB par yield[2] as of end month three months earlier (hereafter, interest rate spread) is the X-axis, while the Y-axis is the SMM of full prepayment (hereafter, full SMM). The red circles show the average of full SMM at each interest rate spread level. (The following figures in this section show the same.)

This figure shows that when interest rate spreads are 3% or less, full SMM tends to rise as market interest rates decline (interest rate spreads widen), and conversely, as market interest rates rise (interest rate spreads narrow), full SMM tends to decline. This is considered to show that when market interest rates fall after the loan is made, mortgage rates also fall and financially-rational refinancing is more likely to occur. When interest rate spreads are at 4% or more, full SMM tends to decline slightly; this is thought to be from the impact of the burnout, as described below.

[2] The reference point for 5Yr JGB par yield was selected after applying various different points to the prepayment model, selecting the most appropriate point, and then using the month-end value for the point three months earlier. Such a time lag is thought to occur because there is a slight time lag between changes in market interest rates and changes in refinancing mortgage rates by banks and other financial institutions; because some time is required between banks and other financial institutions changing the mortgage rates, the borrower considering the new rates and preparing the necessary materials, and the refinancing bank processing the application; and also because applications must be submitted to JHF by one month prior to the prepayment.

Fig. 2 SMM of Full Prepayment: Interest Rate Factor

(Using data through end-Dec. 2024)



Source: Compiled by NFRC from Japan Housing Finance Agency data

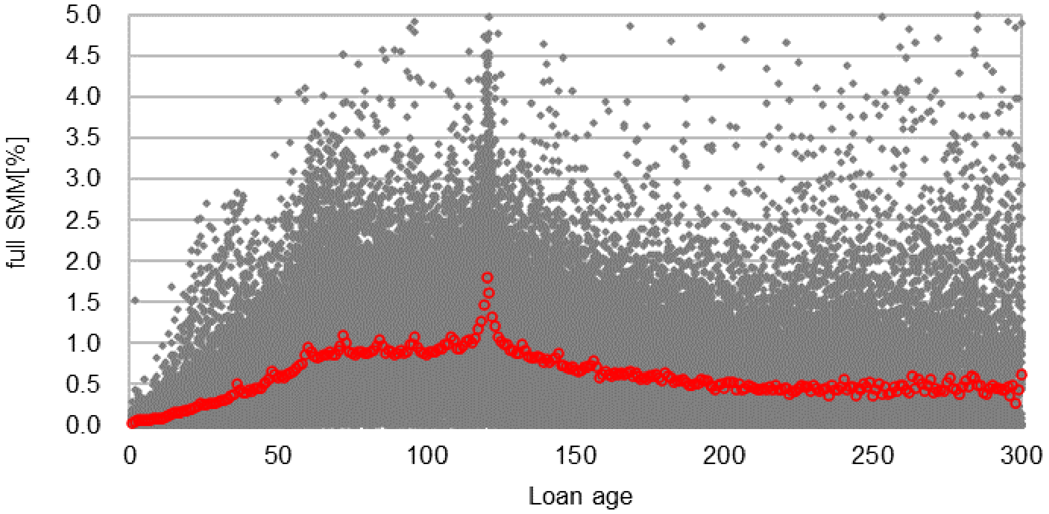
Note: Interest rate spread = WAC - 5Yr JGB par yield at the month-end value for the point three months earlier

2.1.2 Aging factor

Fig. 3 shows the linkage between the loan age and full SMM. Full SMM gradually rises for some time after the loan commences, remains steady as the loan age approaches more than 70 months, then peaks at approximately 120 months. Thereafter, full SMM tends to gradually decline. The tendency of full SMM to be low at the initial loan start, then the ratio rising to a certain level as the loan age increases, is thought to be due to qualitative reasons like 1) there is little need to change residences soon after purchasing a home; and 2) refinancing is unlikely soon after beginning repayment as long as interest rates do not fall dramatically. Further, full SMM peaking at 120 months is thought to be due to borrowers whose loan interest rates re-set at a higher rate 10 years after beginning loan repayments trying to repay their loans in advance as much as possible before the higher mortgage rates begin.

Fig. 3 SMM of Full Prepayment: Aging Factor

(Using data through end-Dec. 2024)



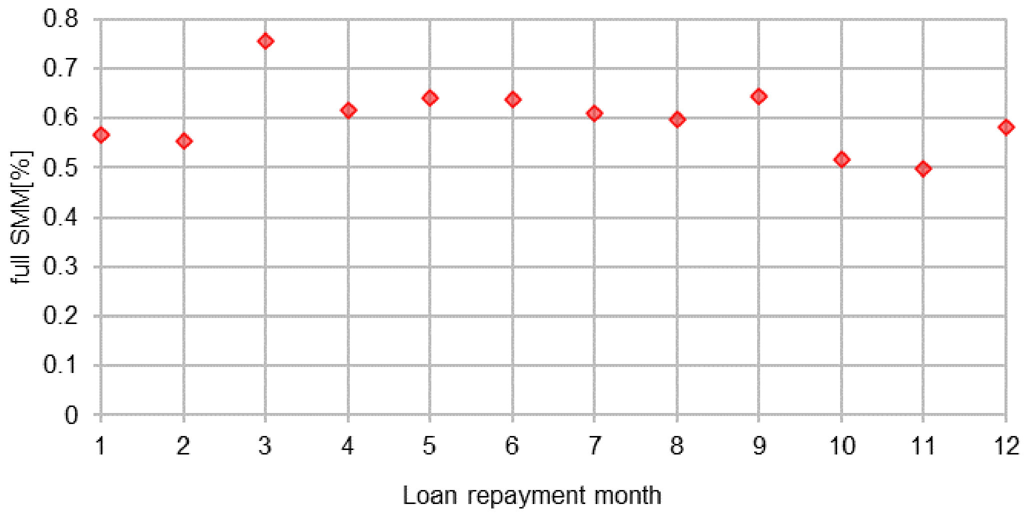
Source: Compiled by NFRC from Japan Housing Finance Agency data

The decline in full SMM after 120 months is considered to be due to fewer borrowers in the loan pool actively trying to prepay their loans because the borrowers sensitive to interest rate changes or with surplus funds have paid off their loans in full. Thus, part of the decline in full SMM is likely due not to the aging factor, but rather to the burnout described below.

2.1.3 Seasonality factor

Fig. 4 shows average full SMM values by number of loan payment months. This figure shows that full SMM tends to rise in March and be low in January, February, October, and November. This is thought to be because March is the end of the fiscal year in Japan, and full prepayments because of changes in residence are more likely to occur in March than in other months.

Fig. 4 SMM of Full Prepayment: Seasonality Factor
(Using data through end-Dec. 2024)



Source: Compiled by NFRC from Japan Housing Finance Agency data

2.1.4 Burnout factor

Residential mortgage borrowers have many different repayment behaviors, but borrowers more sensitive to changes in interest rates are probably most likely to drop out of the pool of borrowers due to prepayment. Therefore, it is said that the more the pool has experienced low interest rates, the more the pool loses the sensitivity to low interest rates. This is called the burnout.

What sorts of explanatory variables should be used in including burnout in the model? Several possibilities come to mind, but here we use cumulative incentive as an explanatory variable for burnout, as defined below, based on our viewpoint that more burnout is thought to occur the longer the loan pool has experienced stronger incentives to refinance[3].

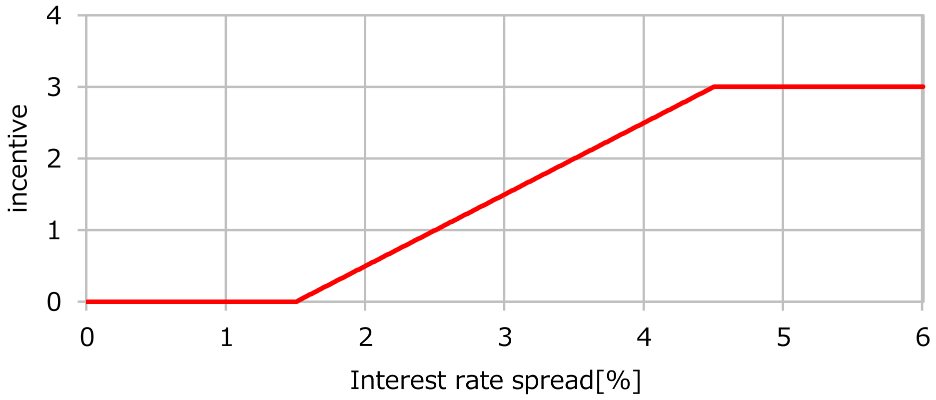
[3] WAC history from the start of the loan is needed to calculate cumulative incentive. Because observation of historical loan redemption data began in May 1996, WAC was not observed at initial loan start for pools with loans that commenced prior to that. Therefore, cumulative incentive for such pools is calculated assuming that the oldest WAC data has been constant from the start of the loan. This assumption is thought to be appropriate because WAC does not change much as long as the applied interest rate has not changed for loans in the pool. However, because historical loan redemption date includes loans with interest rates that reset higher 10 years after commencement, only WAC after interest rate re-set is observed for loans that began prior to May 1986. Data for loans that began before May 1986 is not used because WAC after interest rate re-sets

$$cumulative\ incentive_t = \sum_{n=1}^{t-1} incentive_n$$

$$incentive_n = \min\{\max\{spread_n - threshold,\ 0\},\ upper\_bound\}$$

Here, n represents the number of months since the loan begins, t is the number of months data is observed since the loan begins. $Spread_n$ is the interest rate spread, an explanatory function for interest rate factor, at each point. $Incentive_n$ is a simple expression of how much full prepayment incentive exists in a given month due to interest rates. For example, the linkage with the interest rate spread is shown in Fig. 5 for a threshold = 1.5 and upper_bound = 3.0.

Fig. 5 Incentive Function (threshold = 1.5 and upper_bound = 3.0)



Source: NFRC

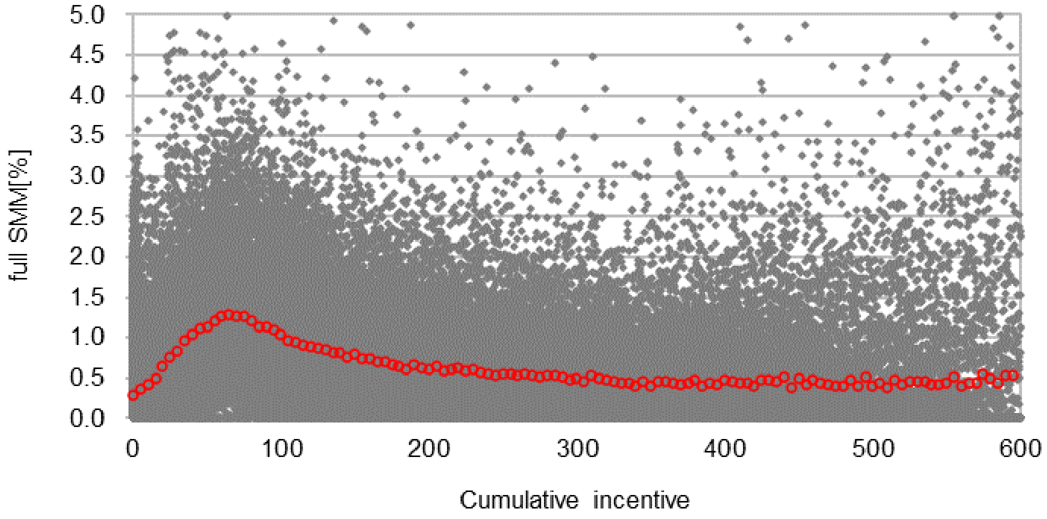
Note: Interest rate spread = WAC - 5Yr JGB par yield at the month-end value for the point three months earlier

This function is defined by the trend of the interest rate factor described above and may be considered as a simple version of the interest rate factor function f in the prepayment model below. Once the interest rate spread is a certain size, even if it widens further, incentive to prepay is not likely to rise much more; conversely, when an interest rate spread shrinks to a certain degree, the incentive to prepay approaches zero. The cumulative value of incentive, or cumulative incentive, can be considered to show how much the relevant pool has been incentivized to make full prepayment from when the loan began to the month before the loan repayment month.

Fig. 6 shows the linkage between cumulative incentive and full SMM when threshold =1.5 and upper_bound = 3.0. Full SMM tends to rise when cumulative incentive is up to around 70, then tends to gradually decline once cumulative incentive exceeds 70. The initial rise in full SMM is thought to correspond to the rise in the seasoning factor through about the 70th month, and the decline in full SMM is thought to be a reflection of the burnout factor once cumulative incentive exceeds 70.

cannot be considered to have remained the same.

Fig. 6 SMM of Full Prepayment: Burnout Factor
(Using data through end-Dec. 2024)



Source: Compiled by NFRC from Japan Housing Finance Agency data

2.1.5 Other factors

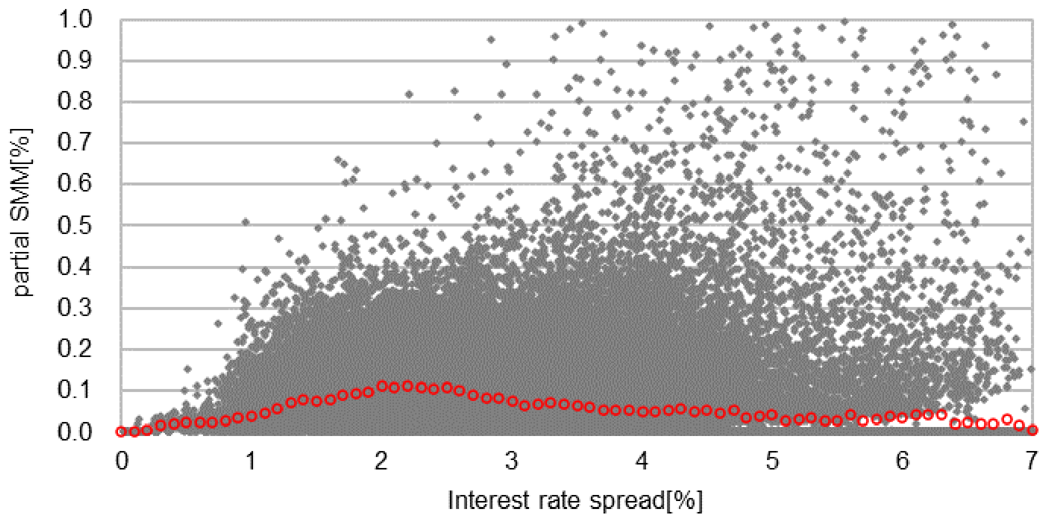
In addition to those discussed above, various other factors are believed to impact full prepayment. These include real estate values and regionalism, as well as changes in social system.

2.2 Key factors of Partial prepayment

2.2.1 Interest rates factor

In Fig. 7, the spread between the Weighted Average Coupon (WAC) of the loan balance at the end of the loan repayment month and the 5Yr JGB par yield as of end month three months earlier (hereafter, interest rate spread) is the X-axis, while the Y-axis is the SMM of partial prepayment (hereafter, partial SMM).

Fig. 7 SMM of Partial Prepayment: Interest Rate Factor
(Using data through end-Dec. 2024)



Source: Compiled by NFRC from Japan Housing Finance Agency data

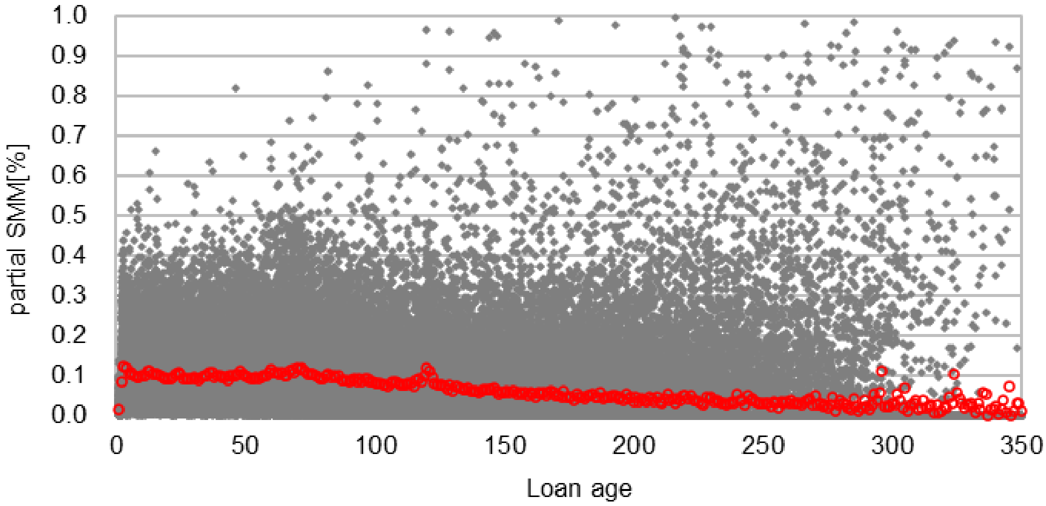
Note: Interest rate spread = WAC - 5Yr JGB par yield at the month-end value for the point three months earlier

Note that the amount of partial prepayment is on average smaller than the amount of full prepayment, and the scale marks on the Y-axis are one decimal point smaller those for full SMM. This figure does not clearly show a linkage between interest rate spread and partial SMM. Even considering the ten-fold difference with full SMM, partial SMM can be considered to have a roughly constant linkage with interest rate spread.

2.2.2 Aging factor

Fig. 8 shows the linkage between the loan age and partial SMM. The figure shows that partial SMM is high from immediately after the loan commences, and then tends to gradually decline after the 70th month. There appear to be several borrowers who use surplus cash in hand to make partial prepayments from an early stage in order to alleviate future interest rate payments by reducing the loan balance. Together with the full SMM trend shown in Fig. 3, most prepayments immediately after repayments begin are partial prepayments, and thereafter the ratio of full prepayment tends to rise.

Fig. 8 Partial Prepayment Rate: Aging Factor
(Using data through end-Dec. 2024)

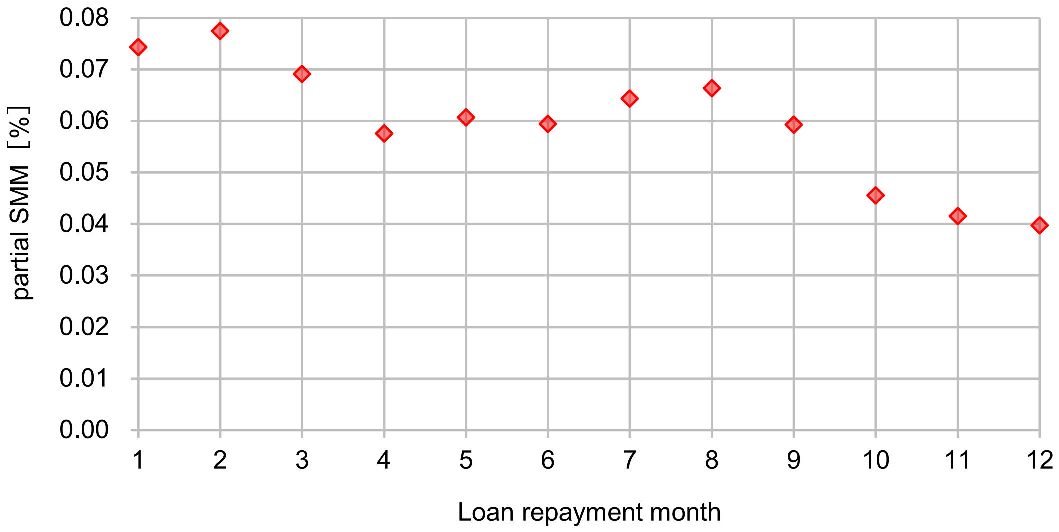


Source: Compiled by NFRC from Japan Housing Finance Agency data

2.2.3 Seasonality factor

Fig. 9 shows average partial SMM figures for each loan payment month.

Fig. 9 Partial Prepayment Rate: Seasonality factor
(Using data through end-Dec. 2024)



Source: Compiled by NFRC from Japan Housing Finance Agency data

This figure shows that partial SMM tends to be high early in the year and low at the end of the year, and that partial SMM tends to increase in January, February, July, and August. This is believed to be because the size of the residential mortgage tax credit is determined based on the loan balance at the end of the year, so this acts as an incentive to pay down loans early in the year rather than at year's end. Many borrowers make partial advance payments on their mortgages with cash on hand following the distribution of bonuses.

2.2.4 Other factors

In addition to the factor discussed herein, various others are believed to impact partial prepayment. These include real estate values and regionalism, as well as changes in social system.

3. NOMURA Prepayment Model

3.1 Prepayment Model

In order to analyze the returns and risks of JHF MBS, the speed with which mortgage borrowers prepay their loans must be projected. The Prepayment Model models this behavior. Below is a description of the current NOMURA Prepayment Model used starting from the April 2011 portfolio.

The NOMURA Prepayment Model, the prepayment model used to calculate risk indicators in the NOMURA-BPI, gives more weight to stability, consistency, and usability[4], and full SMM and partial SMM are each modeled, as shown below. Each parameter value uses the latest data[5] and is estimated monthly. However, the two parameters used in calculating interest yield incentive (threshold and upper_bound) are assigned as follows: threshold=1.5 and upper_bound=3.0.

$$SMM[\%] = \text{full } SMM[\%] + \text{partial } SMM[\%]$$

$$\text{full } SMM_t[\%] = f(wac_t - r_{t-3},\ burnout_t) \times g^{full}(age_t) \times h^{full}(month_t)$$

$$\text{partial } SMM_t[\%] = g^{partial}(age_t) \times h^{partial}(month_t)$$

wac_t: loan balance weighted average mortgage rate as of month-end of loan repayment month

r_{t-3}: 5Yr JGB par yield as of month-end of payment month

$burnout_t$: $\sum_{n=1}^{t-1} incentive_n$ (= cumulative $incentive_t$)

$incentive_n$: $\min\{\max\{wac_n - r_{n-3} - threshold,\ 0\},\ upper\_bound\}\ (\geq 0)$

age_t: number of months elapsed since loan commences

$month_t$: loan repayment month (1, 2, …, 12)

4 'Stability' is weighted more to limit changes in risk indicators when the model parameter is renewed. Also, 'Consistency' is important because the model must some extent be consistent with public data released by JHF so that it does not diverge too much from market direction. 'Usability' is also a consideration because the model must not become too complex in meeting these conditions.

5 Parameters are estimated monthly using data updated by JHF, Historical Loan Redemption Data. (Data is available from the data vendor. See http://www.jhf.go.jp/english/mbs_screen.html for vendor information.)

3.1.2 Model of Full SMM

Full SMM is shown by the product of interest rate factor function f, aging factor function g^{full}, and seasonality function h^{full} and burnout is also included by making interest rate factor function dependent not only on the interest rate spread but also cumulative incentive (the explanatory variable for burnout). Real estate values, one of the Other Factors given, are not considered because gathering data and projecting future values is rather difficult. Also, regionalism is not addressed because there are few borrowers in the loan pool with data by region, and the dispersion of observed SMM is wide; thus, for ease, these factors are not considered.

Interest rate function f

$$f(wac_t - r_{t-3}, burnout_t) = \alpha_0 + \alpha_1 \times (1 - e^{-\Omega}) \times b(burnout_t)$$
$$\Omega = \exp\{\beta_0 + \beta_1 \times (wac_t - r_{t-3})\}$$
$$b(x) = \frac{1}{1 + (\gamma_0 x)^{\gamma_1}}$$

Interest rate function f has six parameters, $\alpha_0, \alpha_1, \beta_0, \beta_1, \gamma_0$ and γ_1, all of which are nonnegative, except for β_0. This is a function where as $wac_t - r_{t-3}$ approaches α_0 as it becomes sufficiently small, and $wac_t - r_{t-3}$ approaches $\alpha_0 + \alpha_1 \times b(burnout)$ as it becomes sufficiently large. Also, function b, which reflects burnout, is a function that declines from 1 toward 0 as x rises.

Please note that cumulative incentive is the cumulative value of incentives from when the loan commences, not from when the JHF MBS is issued. Cumulative incentive is 0 at the time of issuance for recent monthly JHF MBS because loans are securitized immediately after contract. However, issues like S-series JHF MBS and monthly JHF MBS issued in the past which did not have weighted average loan age of 0 at the time of issuance, basically do not have cumulative incentive at the time of issuance of 0[6].

Aging factor function g^{full}

$$g^{full}(age_t) = \min\left[\frac{age_t}{\tau}, 1\right]$$

Full SMM aging factor function g fullg^{full} has one parameter $\tau > 0$. In $0 < age < \tau$, it increases at a constant rate from 0 to 1, and thereafter remains flat. It is the same form as the PSJ model[7].

Seasonality function h^{full}

$$h^{full}(month_t) = h^{full}_{month}$$

Full SMM seasonality function h^{full} has 12 parameters $(m = 1, \ldots, 12)$, and $h^{full}_{10} = 1$. Fig. 10 shows each function for full prepayment using observed parameters based on data released through the end of Dec. 2024. Function f shows the condition for when cumulative incentive is 0.

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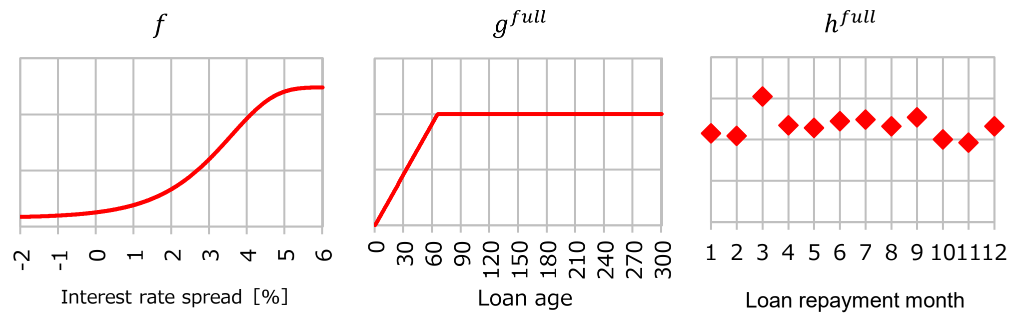
[6] Cumulative incentive at the time of loan issuance is calculated by adding interest rate incentive from when weighted average loan age is 0. So, the WAC prior to issuance is needed. Since mortgage rate is constant until it steps up at a certain timing decided in the contract, WAC can be calculated when all loans in the collateral pool have not stepped up at the time of issuance, assuming that WAC at the time of issuance is observed from before issuance. Pre-issue WAC is estimated using historical loan redemption data for collateral pools with loans whose mortgage rates have stepped up after issuance, like JHF S-Series Bond since the No. 13 issue.

[7] The Prepayment Standard Japan (PSJ) model is a prepayment model introduced by the Japan Securities Dealers Association as a simple model showing Japanese RMBS prepayment. For further information, see the JSDA website(https://www.jsda.or.jp/en/activities/research-studies/psj/index.html).

Fig. 10 Functions for Full Prepayment

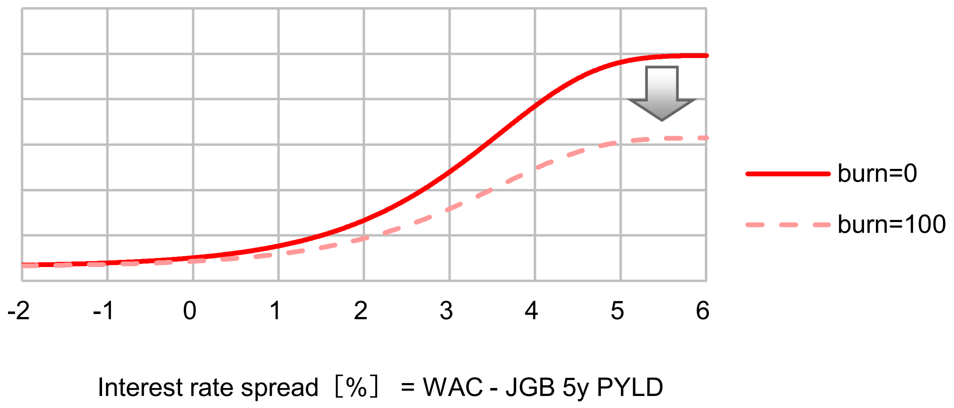


Source: NFRC

Note: Interest rate spread = WAC - 5Yr JGB par yield at the month-end value for the point three months earlier

Here we will touch upon the impact of the burnout included in the interest rate factor function f. Function f in the model is a function where, as the cumulative incentive increases, the upper limit value (the value approached as the interest rate spread widens sufficiently) falls. Fig. 11 shows the interest rate function f when the cumulative incentive is 0 and 100. As cumulative incentive figure thus increases, function f does not increase much even as the interest rate spread widens, so the rise of full SMM is limited. Thus, the degree of sensitivity to the interest rate spread decreases.

Fig. 11 Interest Rate Factor Function f



Source: NFRC

Note: Interest rate spread = WAC - 5Yr JGB par yield at the month-end value for the point three months earlier

3.1.2 Model of Partial SMM

Partial SMM does not address the interest rate factor because the effect of interest rates does not appear clearly. Thus, partial SMM is a product of aging factor function $g^{partial}$ and seasonality function $h^{partial}$.

Interest rate function $g^{partial}$

$$g^{partial}(age_t) = k_0 + \frac{k_1 - k_0}{t_0 - 1}\{\min(age_t,\ t_0) - 1\} + \frac{k_2 - k_1}{t_2 - t_1} \times \max(\min(age_t,\ t_2) - t_1,\ 0)$$

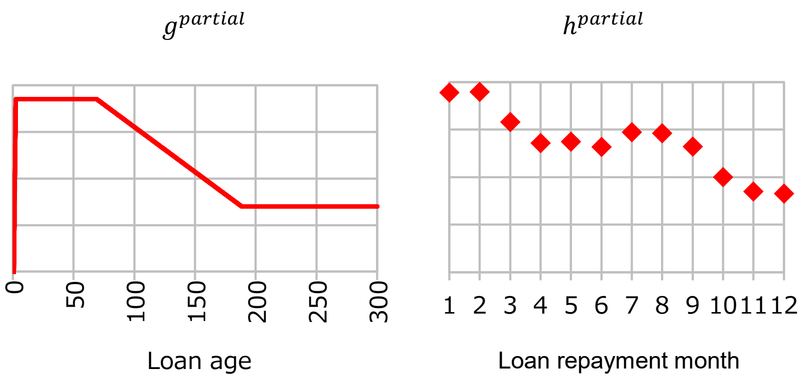
Partial SMM aging factor function $g^{partial}$ includes six parameters $k_i (i = 0,1,2)$, $t_i (i = 0,1,2)$, where $k_i > 0\ (i = 0,1,2)$, $1 < t_0 < t_1 < t_2$.

Seasonality function $h^{partial}$

$$h^{partial}(month_t) = h^{partial}_{month}$$

Partial SMM seasonality function $h^{partial}$ includes 12 parameters $(m = 1, \dots, 12)$, and $h^{partial}_{10} = 1$. Fig. 12 shows each factor function for partial prepayment using observed parameters based on data released through the end of Dec. 2024.

Fig. 12 Functions for Partial Prepayment



Source: NFRC

3.2 Cancellation model

For monthly JHF MBS issued after April 2007, the cancellation model is used to project not only prepayment rate, but also the occurrence of extended delinquency and changes in financing terms for residential mortgages.

This model classifies cancellations as either cancellation due to extended delinquency or cancellation due to other than extended delinquency, and these two categories are modeled as follows. Please note that both model cancellation rates are annualized rates. Note that cancellation rates are modeled with the addition of some qualitative analysis, as data does not show trends as clearly as it does for prepayment rates.

Cancellation due to extended delinquency rate estimation function d [%]

$$d(t) = \begin{cases} \theta_0 \min(X,\ t) & (t \le Y) \\ \theta_0 X + \theta_1 \min(t - Y,\ Z - Y) & (Y < t) \end{cases}$$

Includes five parameters X, Y, Z and $\theta_i (i = 0{,}1)$, where $0 < X < Y < Z$.

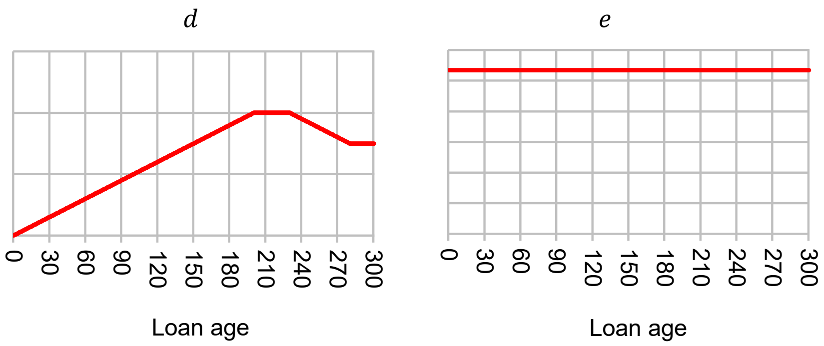
Cancellation not due to extended delinquency estimation function e [%]

$$e(t) = u$$

Includes one parameter u.

Fig. 13 plots each function based on parameters applied in Dec. 2024.

Fig. 13 Functions for Partial Prepayment



Source: NFRC

3.3 Calculating future cash flow

At the time of JHF MBS issuance, the initially scheduled balance ratio after monthly payments is released as Scheduled Factors, and updated figures (Rescheduled Factors) considering repayment progress are released every six months. These figures do not consider future prepayments nor cancellations, but the projected cash flow can be determined based on risk factors calculations, reflecting projected prepayment rates and cancellation rates with models.

Residential mortgages—the collateral of MBS—have varied characteristics and repayment periods and applied interest rates differ depending on the borrowers. Therefore, even if the same amount is repaid in advance, the impact on future cash flow differs, depending on how borrowers made prepayments (full prepayments or partial prepayments. In case of partial prepayments, shorten the period or reduce the repayment amount). However, it is realistically impossible to fully reflect the individual characteristics of these borrowers, so we have calculated repayment schedules based on the assumption that there are many such borrowers.

Under such assumptions, the effects of projected full SMM and cancellation rates can be assessed by reducing the amount of cash flow proportionally at each point in the future in calculating projected cash flow. Considering that, for partial SMM, many partial prepayments shorten the loan term, and the calculation to some extent reflects the term shortening effect. In particular, the calculation of partial SMM is based upon the assumption that the projected principal balance declines by an equal amount at each future point during the shortened payment period.

4. Calculating risk indicators and the investment return index

4.1 Calculating risk indicators

Concepts like compound yield and modified duration, used for normal fixed income bonds, do not apply directly to JHF MBS, whose future cash flow is uncertain. Detailed calculation methods of each risk indicator for JHF MBS are shown below. Please note that the risk indicators are values that depend on the prepayment model.

4.1.1 Compound yield, modified duration, weighted average life[8], etc.

In the prepayment model, the SMM at any point in time can be shown once one future interest rate path is determined. We therefore consider the forward rate implied from the current yield curve as the future interest rate path and determine future cash flow. Compound yield, modified duration, and weighted average life (WAL) can then be calculated. The calculation steps are outlined below.

1. Determine the forward interest rate path in the future assuming that the forward rate implied from yield curve on the day of calculation will be realized.
2. Calculate the SMM at each point in the future using input variables interest rate (calculated from 1), WAC, cumulative incentive, loan age, and seasonality (what month).
3. Calculate future cash flow from the SMM (from 2) and scheduled factors.
4. Calculate compound yield, duration, modified duration, convexity, and WAL from future cash flow (in 3) and using the same calculation methods as with ordinary fixed-coupon bonds[9].

4.1.2 Option Adjusted Spread (OAS)

Compound yield, modified duration, and WAL were determined using a calculation to determine future cash flow. However, future cash flow will differ depending on future interest rate trajectories, and the calculation results for these indicators should vary accordingly. In particular, for risk indicators like duration and convexity, future interest rate changes are fundamentally significant, and metrics that take these impacts into account are even more important. Additionally, the T-Spread (the spread versus JGB yield), which is reported in the NOMURA-BPI as a return indicator, cannot be easily evaluated like an ordinary fixed coupon bond because of the optionality embedded in JHF MBS. Given these, the option adjusted spread (OAS) concept is used for valuation. In order to evaluate such sensitivity to interest rates embedded in JHF MBS, an interest rate model must be used with the prepayment model.

Future interest rate movements must be modeled in order to develop a model to determine SMM depending on future interest rate changes. In the NOMURA-BPI, one factor model with the mean reversion of the short rate $r(t)$. Specifically, the short rate is determined based on stochastic differential equation below.

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[8] The concept weighted average life, rather than term to maturity, is often used for the period principal remains in cases when the principal is partially repaid before maturity, as with JHF MBS. In keeping with market practice, NOMURA-BPI used weighted average life for term to maturity of JHF MBS and releases this as one portfolio indicator. Note that the term to maturity inclusion criteria uses years remaining until final repayment, rather than weighted average life.

[9] For further information, see the document 'NOMURA-BPI Index rulebook 7. Definition of NOMURA-BPI indicators (http://qr.nomuraholdings.com/en/bpi/index.html)'.

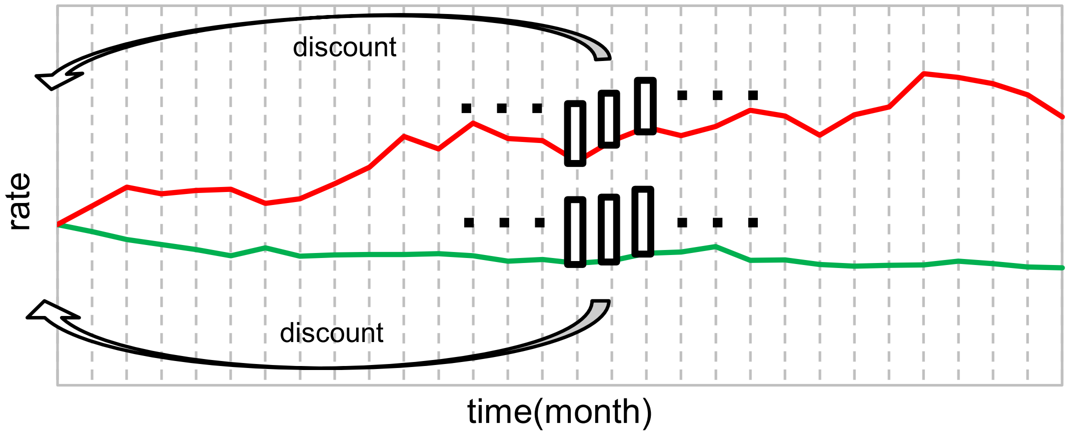
$$dr(t) = \big(\theta(t) - \phi(t)r(t)\big)dt + \sigma(t)dz(t)$$

Here, $\theta(t)/\phi(t)$ is the mean reversion level, $\phi(t)$ is the speed of mean reversion, $\sigma(t)$ is volatility, and $z(t)$ is the standard Brownian motion. The parameters $\theta(t), \phi(t)$ and $\sigma(t)$ are estimated using market discount rate and swaption volatility as input data. The JGB discount rate calculated using the Nomura par yield model is used as the market discount rate.

OAS is calculated using this interest rate model and prepayment model[10].

1. Generate multiple future interest rate paths using the interest rate model.
2. Calculate reference interest rates (5Yr par yield) at points in the future for each interest rate path in (1), and then cash flow using the prepayment model. The values for each interest rate path are calculated by adding present values of cash flows which are discounted with the interest rate plus constant spread δ.
3. The theoretical value of JHF MBS is determined by averaging the values of the interest rate paths calculated in (2).
4. OAS is derived by seeking δ where the values calculated in (3) match JHF MBS market value (including accrued interest).

Fig. 14 Calculating Value for Each Interest Rate Path (conceptual diagram)



Source: NFRC

For JHF MBS, OAS is announced as the T-Spread. When calculating the T-spread for sub-indices that include JHF MBS as well as the NOMURA-BPI, the OAS is the weighted average according to market value, just as with the T-Spread for fixed-coupon bonds.

[10] This method is called Monte Carlo Simulation and is generally used to value instruments with path dependency (future cash flow depends on interest rates path). The NOMURA Prepayment Model used through March 2011 used a calculation method using an interest rate tree, but path dependency has increased since the burnout has been introduced with the change in models. Subsequently, the Monte Carlo Simulation was adopted.

4.1.3 Effective Duration, Effective Convexity

Effective duration and effective convexity are calculated as shown below. Here, we assume a fixed value for the OAS as calculated above and calculate effective duration and effective convexity defined as the price sensitivity to changes in the yield curve upward and downward.

1. Generate interest rate paths in the same way as OAS calculation based on the spot rate curve obtained by raising or lowering the market spot rate curve by Δr.
2. Calculate the fair value using the same method as OAS calculation steps 2) and 3) for each tree with OAS calculated above as constant δ.
3. Calculate effective duration using the formula below from market price and two values calculated in step 2).

$$effective\ duration = \frac{P(-\Delta r) - P(+\Delta r)}{2P(0)\Delta r}$$

$$effective\ convexity = \frac{P(-\Delta r) + P(+\Delta r) - 2P(0)}{P(0)(\Delta r)^2}$$

$P(-\Delta r)$: Value when the spot rate curve has been moved down by Δr

$P(+\Delta r)$: Value when the spot rate curve has been moved up by Δr

$P(0)$: Market price (market price plus accrued interest)

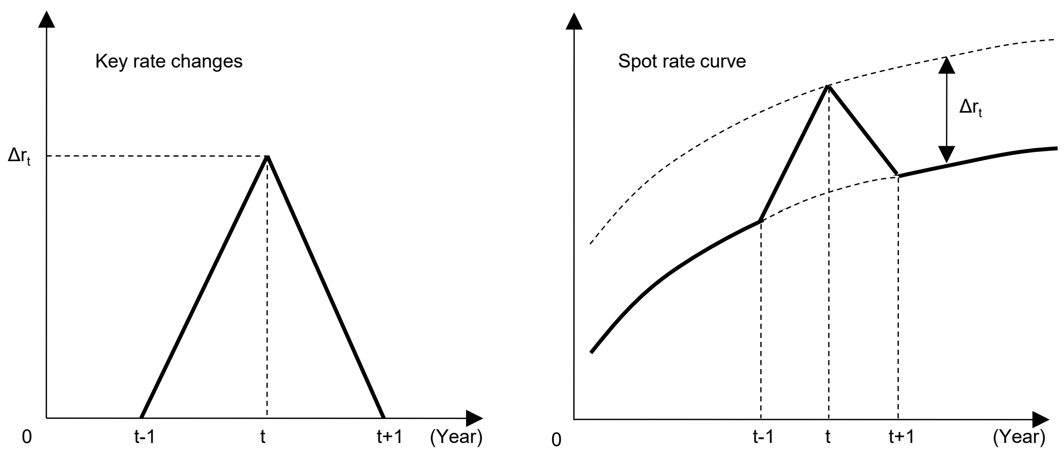
Δr : Margin that moves the spot rate curve

4.1.4 Key Rate Duration

While effective duration shows the sensitivity to changes in spot rates across the curve, key rate duration is the sensitivity to changes in interest rate in specific ranges of the curve. MBS cash flow is dispersed across a wide range of terms to maturity, and effective duration alone cannot address interest rate risk completely. Therefore, key rate duration, a more precise gauge of risk, is necessary.

For the MBS sector, a total of 30 key rates are set with one-year intervals between year 0 and year 29, and the sensitivity is measured for each key rate. Each key rate moves up or down as illustrated in Fig. 15, and the key rate duration is calculated using the same method as for effective duration.

Fig. 15 Changes in Key Rate and Spot Rate Curve (conceptual diagram)



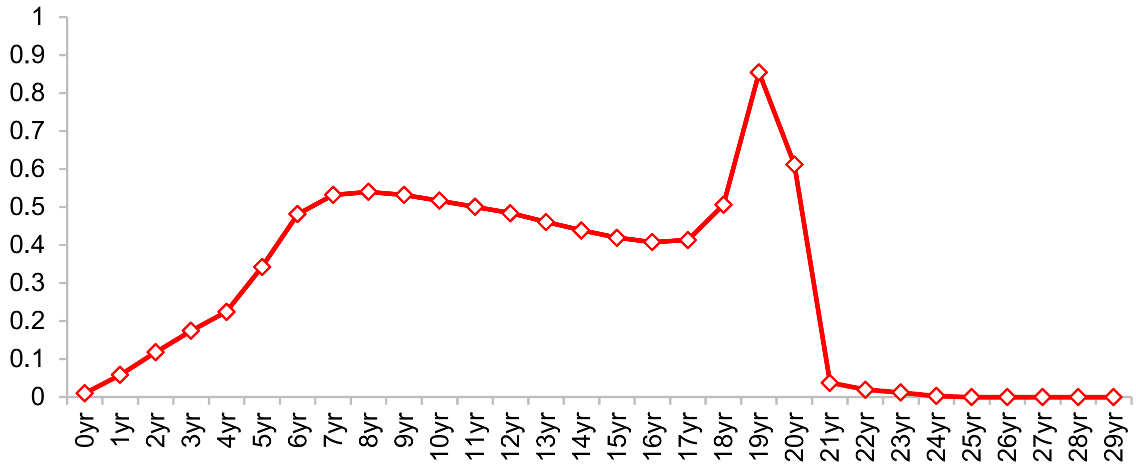
Source: NFRC

$$Year\ t\ key\ rate\ duration = \frac{P(-\Delta r_t) - P(+\Delta r_t)}{2P(0)\Delta r_t}$$

$P(-\Delta r_t)$	:	Price at which year *t* key rate moves down as in figure
$P(+\Delta r_t)$	:	Price at which year *t* key rate moves up as in figure
$P(0)$	:	Market price (market price plus accrued interest)
Δr_t	:	Margin that moves year *t* key rate

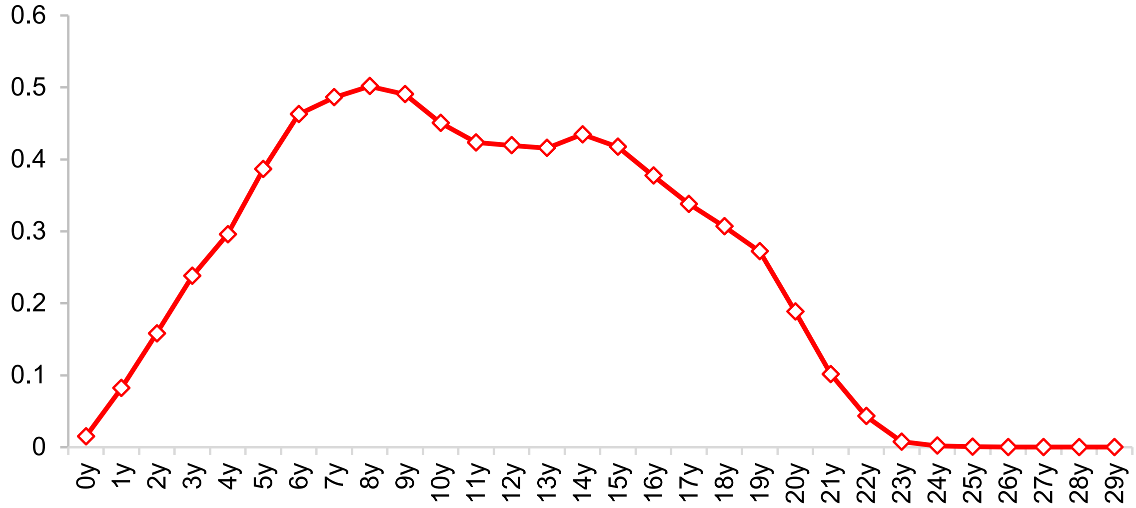
Fig. 16 shows the key rate durations of JHF MBS #170 (effective duration 8.66 as of Dec 30, 2024). The JHF MBS differs from bullet redemptions as MBS key rate duration has measurable values for many ranges other than maturity. This reflects the difference between the MBS projected cash flow and the cash flow of fixed-coupon bonds, whose principal is redeemed only when it matures (bullet maturity). Additionally, Fig. 17 presents the key rate durations of the NOMURA-BPI MBS sector.

Fig. 16 Key Rate Durations: JHF MBS #170 (end-Dec. 2024)



Source: NFRC

Fig. 17 Key Rate Durations: BPI MBS (end-Dec. 2024)



Source: NFRC

4.2 Calculating the investment return index

The investment return index and investment return rate for JHF MBS are calculated using the same method as in the NOMURA-BPI. However, the factor (expected outstanding balance after monthly principal repayment the following month) released every month on the 25th (or immediately preceding business day if the 25th is not a business day) by the Japan Housing Finance Agency must be treated carefully. It goes without saying that the outstanding balance including accrued interest on the day of calculation and the last day of the previous month is determined, regardless of whether the repayment amount for the following month has been determined or not. Therefore, the actual repayment made in the following month does not affect the calculation of the investment return rate. Note that return indices such as compound yield and risk indicators such as duration are calculated considering the determined cash flow after it is released.

$$MVLt_{(today)} = TA \times F_{(today)} \times \frac{P_{(today)}}{100} \qquad MVLt_{(e.l.m.)} = TA \times F_0 \times \frac{P_{(e.l.m.)}}{100}$$

$$CF_{(e.l.m.,\ today)} = \begin{cases} 0 & \text{(Prior to payment date)} \\ TA \times F_0 \times \dfrac{C}{1200} + TA \times (F_0 - F_1) & \text{(After payment date)} \end{cases}$$

$$F_{(today)} = \begin{cases} F_0 & \text{(Prior to payment date)} \\ F_1 & \text{(After payment date)} \end{cases}$$

$MVLt_{(today)}$	:	Total market value of index portfolio including accrued interest, today
$CF_{(e.l.m.,\ today)}$	:	Total income gains and redemptions paid from end of previous month through today
TA	:	Issue par amount
C	:	Coupon (%)
F_1	:	Current month actual factor (released 25th of previous month)
F_0	:	Previous month actual factor (released 25th, two months before)
$P_{(today)}$	:	Unit price including current day interest
$P_{(e.l.m.)}$	:	Unit price including previous month-end interest

Disclaimer

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Registration Number: Director-General of the Kanto Local Financial Bureau (Finance & Commerce) Registration No.451

Membership: Japan Investment Advisers Association No. 011-00961