

Feature Article: Asset-Backed Securities

Effects of Valuation Model on RMBS Investment

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Residential mortgage-backed Housing Loan Corporation securities (RMBS) carry a conditional prepayment option which straight bonds do not. Therefore, investors need some common yardsticks to assess indicators in relation to such securities. In general, such assessment requires a conditional prepayment model and an interest rate model; however, employing them without a good understanding of characteristics specific to each makes it difficult to effectively carry out investment estimation and risk assessment. In this context, this study conducts assessment in relation to the characteristics of RMBS on the condition that the assessment procedure considered is practical from the viewpoint of investors.

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1. Introduction

The Housing Loan Corporation first launched RMBS (based on mortgages on housing loans extended) in the form of bonds in March 2001. As of end-March 2003, the value of RMBS on the market had reached 1 trillion yen and they have been adopted as one of the securities composing the main domestic bond index; therefore, their importance as an object of investment is considered to increase. It is recognized that for many in the nation to acquire good quality housing, steady progress of the RMBS market is important, and investors in the RMBS market should understand this social aspect.

Housing Loan Corporation customers holding mortgages have the right to effect conditional prepayment. Hence, from an investor's point of view, final cash flow generated by the related RMBS is not necessarily fixed. To take into account this characteristic and while simultaneously expanding the traditional measures such as yield-to-maturity (or spreads versus government bonds), remaining life, and modified duration, measures such as option-adjusted spreads (OAS), weighted average life (WAL), and effective duration have been devised. Nowadays, it is common for bonds with a particular characteristic to be compared with a straight bond using the same measure. However, a measure reflecting a particular characteristic that impacts assumed cash flow is dependent on the model used and assumptions.

Using RMBS bond data collected by Mizuho Trust and Banking¹, a simple comparison was made for WAL², OAS, and spreads³ compared with the rate of government bonds (diagrams 1, 2, and 3). These diagrams provide a clear understanding that the level of each measure and changing situation differ greatly⁴. Anyway, each firm would calculate the measures based on price of his own⁵. In this regard, Diagram 4 specifies the relation of price and OAS in regard to several bonds. In view of this diagram, even if there is no great difference in price, considerable divergence in OAS is seen. This analysis indicates that such measures as WAL and OAS are dependent on the model used for their derivation.

At the same time, the model used cannot be perfect even if it is very sophisticated; therefore, it is difficult to achieve a proper judgment without sufficient understanding of the characteristics and limitations of the model used. Advanced studies from this viewpoint include those that consider the relation between the transition of a

¹ Data was obtained for three companies for which sufficient information was available. These data do not necessarily reflect the general viewpoint of the authors or market players.

² Each of the three companies has its own conditional prepayment rate model that fluctuates in line with the future interest rate. Company A assumes the realization of the implied spot rate and Company C assumes consistency of the interest rate. Company B's assumption is unknown.

³ All three firms define these as a certain spread between the yield-to-maturity of assumed cash flow and government bonds with respect to WAL. The yield-to-maturity for Company B and C is semi-annual. Company A's is unknown

⁴ For example, WAL of Company A is positioned at a considerably higher level than the other two companies. Company A and C posted the maximum OAS level in September 2003, and Company B in December 2003.

⁵ As well as the price difference, the delivery date of Company A is set after three business days (T+3) whereas the other two companies set delivery date for the next business day after a coupon payment date the following month.

conditional prepayment rate and MBS price change such as that by Waldman [1992]. On the other hand, Babbel and Zenios [1992] analyzed the effects on OAS caused by interest rate model parameter variations. In addition, the effect on MBS price valuation caused by parameter variations of models is considered in the study of Kariya, Ushiyama and Pliska [2002]. As a result of establishing an assessment procedure that might be practical from the viewpoint of investors, this study identifies specific effects on the characteristics of RMBS caused by parameter transition of the model employed. The assessment of attributes in regard to RMBS is considered below based on the conditional prepayment and interest rate models described, and then assessment procedures are given.

Diagram 1

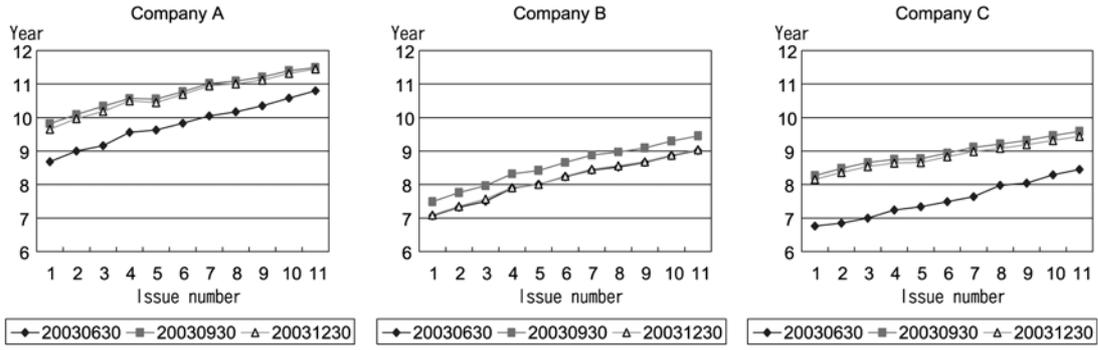


Diagram 2

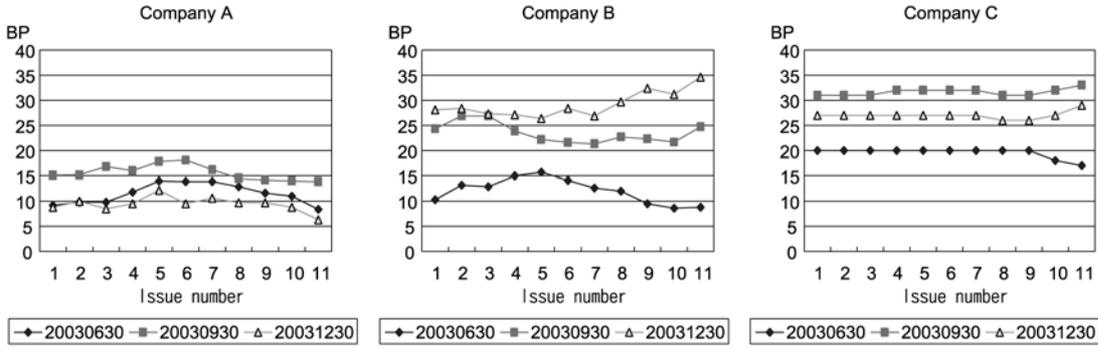


Diagram 3

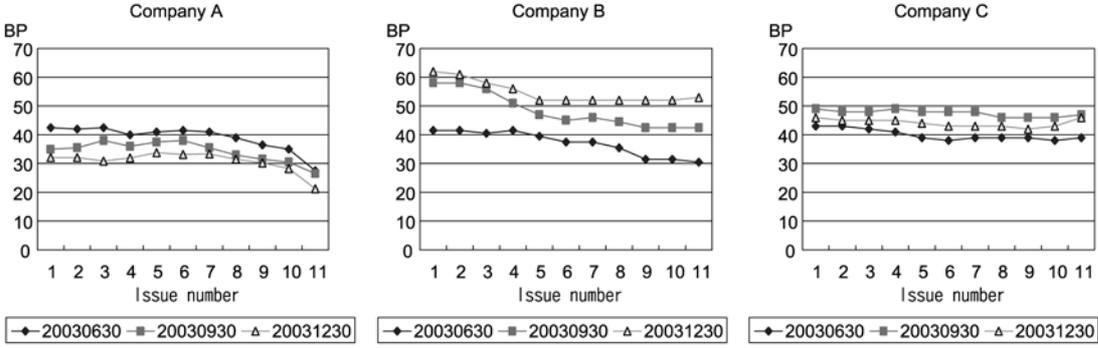
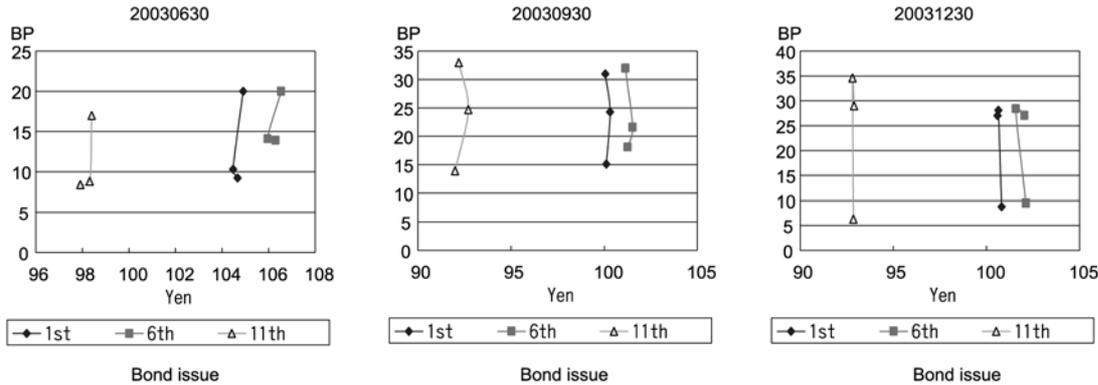


Diagram 4 Relationship Between Bond Price and Option-adjusted Spreads (OAS)



2. Conditional Prepayment Rate Model

2.1 Advanced studies

Concepts in advanced studies are generally classified into 1) methods modeling past behavior in relation to conditional prepayment using statistical techniques, 2) methods explaining and applying an assessment theory for the prepayment option, and 3) methods estimating an implied conditional prepayment rate that is priced in the current market price.

A typical example of modeling past behavior in relation to conditional prepayment using a statistical technique includes that by Schwartz and Torous [1989]. Schwartz and Torous [1989] applied a proportional hazard model (life-time analysis for a conditional prepayment rate) and analyzed prices of US MBS using a term structure model of interest rates. In addition, Ichijo and Moridaira [2001] analyzed Japanese housing loan data using a proportional hazard model and also explained the variables used for a conditional prepayment model.

A typical example of modeling past behavior in relation to conditional prepayment while applying an assessment theory includes that by Stanton [1995]. Stanton [1995] analyzed prices of US MBS using an interest rate model. His method recognizes past behavior in relation to conditional prepayment as an interest rate option and considers the housing loan pool of collateral for MBS in the US as the collective of options having various strike prices. In addition, Kariya, Ushiyama and Pliska [2002] proposes this method to analyze prices of RMBS to consider the fluctuation in housing prices while applying an assessment theory for the prepayment option.

A typical example of estimating an implied conditional prepayment rate inherent in the current market price includes the model proposed by Cheyette [1993]. Here, something that defines the kind of conditional prepayment rate model is initially determined, then necessary parameters are determined in conformity with market price. This method is similar to implied volatility being derived from market price in the Black-Scholes model; meanwhile, this method is also employed to estimate a conditional prepayment rate that the market discounts in the assessment period.

Ichijo [2003] attempted to mix a proportional hazard model and an assessment model. An example studied by Yamamoto and Zenios [1993] of an attempt to model a conditional prepayment rate using the neural network method in addition to the aforementioned three methods is given in this report.

In the meantime, any attempt to model a conditional prepayment rate is really just the same as “modeling complicated human behavior”; therefore, the result of such an attempt is likely to be affected by various national identities and social systems. Advanced studies that have been referred to were mainly based on examples in the US; on the other hand, various studies, such as the method used by Ichijo and Moridaira

[2003], concerning behavior in relation to conditional prepayment, have been made in Japan. These various studies include examples by Yamagishi, Hatayama and Kakuma [2002] that use a conditional prepayment rate model considering the seasonal influences specific to Japan such as bonus payments and changes that occur each fiscal year. In addition, Katsumata [2002] and Tokaku [2003] attempted to perform modeling focusing on the different patterns of behavior between total redemption and partial redemption in Japan.

2.2 Our approach

Almost all the studies that have been referred to have employed detailed data in regard to each loan as original data and have modified them appropriately. From the viewpoint of such entities as issuing organizations that set issuing conditions and securities companies engaged in composing the securities, this approach is taken as a matter of course. However, from the viewpoint of investors who attempt to find the most significant meaning with regard to the final cash flow generated by the securities, this approach is not necessarily essential⁶. For this reason, we adopted the approach of Kataoka and Tamura [2003] which assumes *a priori* explaining variables and a function for a conditional prepayment rate (based on principal studies) and then estimates the parameters considering the practical conditional prepayment rate of each disclosed bond (practical CPR)⁷.

2.3 Conditional prepayment rate model

The main reasons that loan debtors implement conditional prepayment are as follows: 1) to ease the interest burden as a result of refinancing a lower interest housing loan rather than the current housing loan; 2) to sell house; and 3) by obtaining excess cash. In fact, considering the model of a conditional prepayment rate to be obtained in a concrete manner from advanced studies, it will generally specify the ability to explain behavior in relation to conditional prepayment as a result of properly adapting such factors as elapsed time⁸, interest rate incentive “*i*” ($=r_t - r_0$)⁹, and seasonality.

Given this factor, in this case, assuming that a conditional prepayment rate can be explained by two variables, such as elapsed time and interest rate incentive¹⁰, parameters were estimated using the data in regard to an actual conditional prepayment rate of the outstanding RMBS obtained using the homepage of the Housing Loan Corporation.

⁶ The Housing Loan Corporation commenced the disclosure of each housing loan from November 2003.

⁷ This concept enables us to find similarities in thinking when estimating a conditional prepayment rate (CPR) that is inherent in the market price in that the “sharing of open information” is utilized properly, while putting an empirical base to a statistical model.

⁸ Studies using elapsed months after starting point of a loan (or issue of securities) have mainly been performed.

⁹ The differential between the current fixed interest rate on a housing loan, “*r*0”, and the interest rate on a housing loan, “*r*1”, where a financing contract is newly fixed at point “*t*” after implementing financing.

¹⁰ Seasonality is an important element in explaining a conditional prepayment rate. However, almost all the effects are supposed to be set off in the process of calculating the current value of cash flow accumulated over 30 years. For this reason, we adopted a simpler model.

Specifically, a conditional prepayment rate, C_t , was formulated as follows:

$$C_t = \min(T_t \cdot I_t, 1) \quad - (1)$$

where “ T_t ” is the function of elapsed month “ t ” after bond issuance and “ I_t ” is the function of interest rate incentive “ i_t .”

In the first place, as for “ T_t ,” the same functional type as the model of a conditional prepayment rate of the “PSA” type was assumed¹¹ (where a conditional prepayment rate increases in proportion with elapsed months before reaching “ η ,” and after reaching “ η ” it remains constant.)

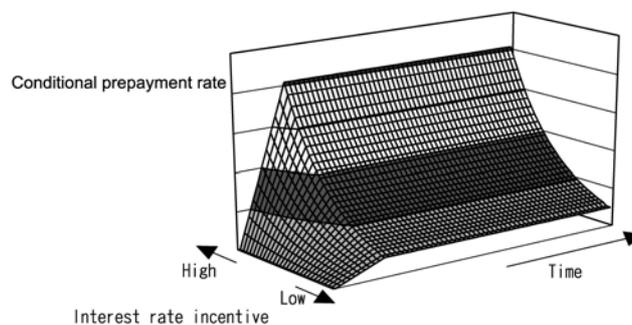
$$T_t = \begin{cases} \alpha_0 + \alpha_1 t & (t < \eta) \\ \alpha_0 + \alpha_1 \eta & (t \geq \eta) \end{cases} \quad - (2)$$

On the other hand, interest rate incentive “ i_t ,” a differential between the current borrowing rate of interest and the refinancing interest rate, is defined as the remaining balance of the par rate of a 5-year government bond after deduction of weighted-average coupons (WAC). “ I_t ” was defined as an exponential function using advanced studies as a reference such as 1) where the interest rate incentive increases as a result of the decrease in the par rate of government bonds, conditional prepayment increases, and 2) where the interest rate incentive increases, the increase in conditional prepayment rate is accelerated.

$$\begin{aligned} i_t &= r_t - WAC \\ I_t &= \exp(\beta \cdot i_t) \end{aligned} \quad - (3)$$

In this case, “ β ” is the time lag. “ $\beta = 2$ ” was assumed in advance. Diagram 5 shows a conditional prepayment rate model. The estimation results (= tallying between an actual CRP model and a model CRP) are indicated in diagrams 6 and 7).

Diagram 5 Image of a Conditional Prepayment Rate Model



¹¹ According to the results of both domestic and foreign studies, the number of months necessary for saturation (number of months to attain a certain conditional prepayment rate) is supposed to be 30 to 60 months. However, the effect of burnout is not taken into consideration.

Diagram 6 Actual CPR and Model CPR (1st bond issue)

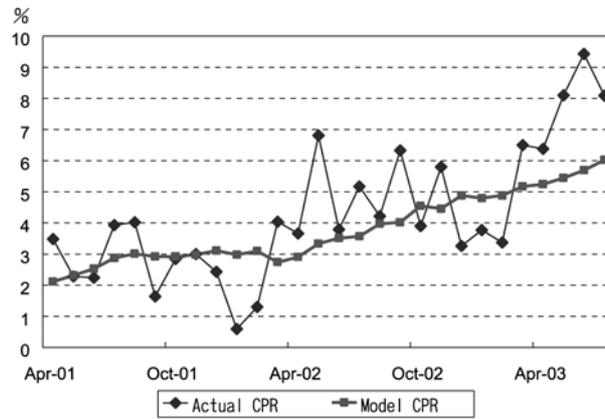
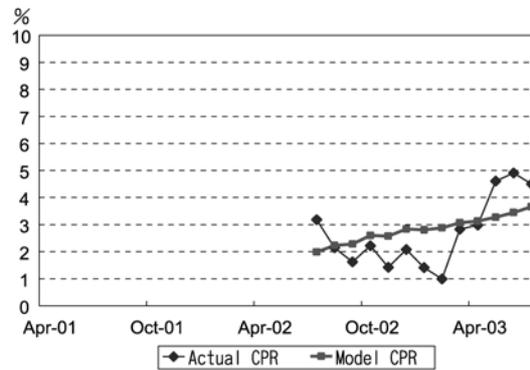


Diagram 7 Actual CPR and Model CPR (6th bond issue)



3. Interest rate model¹²

In this study, a 3-factor CIR model was selected from among the equilibrium models. The two main reasons the equilibrium model was adopted instead of an arbitrage-free model that is generally used by securities companies are that, firstly, investors need to determine whether it is undervalued or overvalued from the long-term point of view, and secondly, therefore, continuity of the adopted model is important¹³.

The concrete model is as follows:

$$dF = c(m - F)dt + \sqrt{F}dZ \quad - (4)$$

$$r = a^T F \quad - (5)$$

¹² A detailed explanation of the interest rate model is omitted because of space limitations.

¹³ See Tuckman (1995) for reference for comparing the equilibrium model and the arbitrage-free model.

In this case, “r” indicates a short-term interest rate. “F,” “m,” “Z,” and “a” represent a three-dimensional, vertical vector, where “F” = factor (variable), “m” = regression level (parameter), “Z” = three-dimensional independent Wiener process (variable), and “a” = coefficient vector to transform from factor to short-term interest rate (parameter). Moreover, each symbol such as “c,” “v,” and the square root of “F” represents a 3×3 matrix; in particular, “v” and the square root of “F” represent a diagonal matrix where “C” = factor regression velocity (parameter), “v” = volatility (parameter), and the square root of “F” = factor (variable).

In addition, the spot rate S (T) for remaining period T can be described as follows¹⁴:

$$S(T) = \frac{A(T)}{T} + \sum_{i=1}^3 \frac{B_i(T)}{T} F_i \quad - (6)$$

where A (T) and Bi (T) are functions of T and parameters.

4. Assessment of RMBS (Residential Mortgage-backed Housing Loan Corporation Securities)

4.1 Assessment Procedure

As indicated above, because conditional prepayment rate changes are affected by future interest rates, it follows that the cash flow of RMBS can be determined. In this regard, in order to assess RMBS, the future interest rate is given for a conditional prepayment rate model in some way. The methods below are considered to obtain the future interest rate.

- One that assumes the current spot rate curve will remain in the future as well.
- One that assumes the future current spot rate curve inherent in the current spot rate curve (=implied spot rate curve) will be put into practice.
- One that generates several kinds of interest rate paths in the future, using a method such as the Monte Carlo simulation.

The third method, i.e. the Monte Carlo simulation method, is adopted in this study. The specific procedures for assessment are generally as follows:

- 1) As a result of generating three-dimensional normal randoms, stream of factors are generated by assigning them to “dZ” in Formula 4¹⁵

¹⁴ It is notable that the theoretical spot rate given by the equilibrium model sometimes deviates widely from the spot rate for the market (Diagram 9). The theoretical curve coincides with the market curve in the arbitrage-free model.

- 2) As a result of assigning the stream of factors to Formula 6 obtained by 1), the par rate of 5-year government bonds and the 1-month interest rate are calculated at each point in time (the 10th of each month).
- 3) The interest rate incentive is calculated by deducting the WAC of each bond from the par rate of 5-year government bonds¹⁶. As a result of calculating a conditional prepayment rate for each bond by assigning the interest rate incentive obtained and the months elapsed, cash flow is determined¹⁷.
- 4) WAL (weighted average life) is calculated by extracting that part of principal from cash flow obtained in 3).
- 5) On the other hand, together with OAS in addition to the 1-month interest rate obtained in 2), a deflator from the beginning point of assessment is calculated.
- 6) The value of assessment on each path corresponds to the sum of cash flow calculated in 3) divided by deflators at each point calculated in 5).

Meanwhile, OAS is calculated by performing a convergent calculation so that the average value of an assessment on each path corresponds to the market price. In addition, the number of path occurrences was set at 500 times.

4.2 Reassessment of each company

First, in combination with the assessment using our model, we attempt to consider WAL obtained irrespective of price. Rising interest rates reduce the conditional prepayment rate in the process of diminishing the interest rate incentive, which leads to the prolongation of WAL. For example, observations were selected from end-June, end-September, and end-December 2003. For periods from June to September, the yield curve (= spot rate curve) steepened; however, for December, it stayed (Diagram 8). As expected, for periods from June to September, WAL at each company gained almost the same amount, and it thus remained at the same level as that in September till December (Diagram 10)¹⁸. On the other hand,

¹⁵ To be exact, discretization is observed after rewriting Formula 4 to the relational expression in regard to the risk neutral measure. As a result of discretization, the value of the factor is dependent on a path so that it is liable to result in a minus value. However, where simulation is implemented, such restrictions that prevent it from resulting in a minus value are imposed.

¹⁶ The rising loan interest rate after 11 years have passed is taken into consideration in the process of adjusting the interest rate incentive for each security.

¹⁷ It is assumed that the Housing Loan Corporation implemented a clean-up call (= the option for the remaining balance to be repayable in a lump sum where the balance of the principal loan amount is less than 10% of the initial loan).

¹⁸ WAL (weighted average life) of Company B is exceptional so that (the absolute value of) the variation value to be identified from June to September and the variation value to be identified from September to December is at much the same level; therefore, the model of a conditional prepayment rate provided by this company is unique. For this reason, it is not referred to further when comparing WAL.

considering the level of WAL, our assessment and that of Company A is the same, while that of Company C is lower¹⁹. Assuming that there is not a large difference in the conditional prepayment rate model, this difference is considered to coincide with the assumption of Company C that the yield curve will not move. In other words, with an upward spot rate curve, the implied spot rate curve tends to stay at a higher level; therefore, it is deemed that the assumption of Company A that the implied spot rate will be put into practice results in a low estimated conditional prepayment rate²⁰. Using WAL as a measure for the remaining period of a straight bond is common; however, as mentioned, it is fundamentally essential that investors have sufficient understanding of the kind of assumption that has been implemented to obtain WAL in the calculation.

Diagram 8 Change in Yield Curve

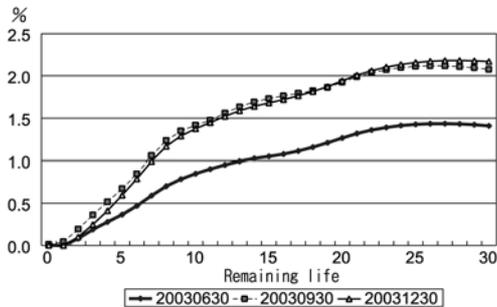
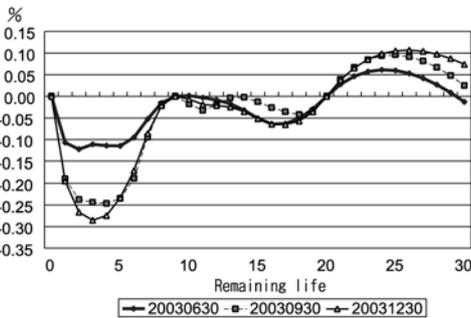


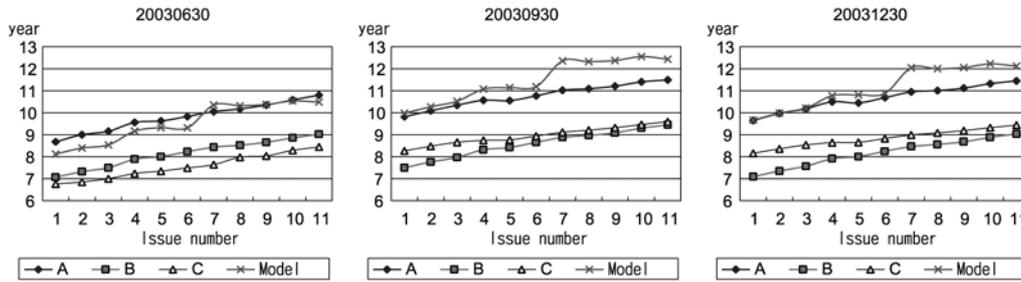
Diagram 9 Deviation Between Theoretical Curve and Market Curve



¹⁹ After September, it is observed that WAL obtained by our study outweighs that obtained by Company A. This is probably because estimated cash flow in our study has a tendency to be prolonged as a result of deviation between the theoretical curve and market curve widening for the remaining period up to 10 years (Diagram 9). In addition, it is thought that the large difference between the 6th bond issuance and the 7th bond issuance is attributable to the difference that coincides with the effect of the rising loan interest rate after 11 years have passed (refer to footnote 16).

²⁰ The path of the short-term interest rate generated by Monte Carlo simulation is almost consistent with an instantaneous forward rate curve; therefore, WAL provided by our study is almost consistent with WAL provided by Company A where it is assumed that the same conditional prepayment rate model is used.

Diagram10 Comparison of Weighted Average Life (WAL)



Next, the study considers OAS that plays an important role in comparing relative value among several securities. As for the three points stated previously, OAS provided by each company and OAS estimated by our study based on the price provided by each company were compared (Diagram 11).

First, it is understandable that OAS estimated by our study is far higher than that provided by each company²¹, the main reason probably being the different interest rate models used. It is believed that from among arbitrage-free models each company employs a logarithm model²²; however, such a model tends to generate an extremely high interest rate path^{23,24}. Therefore, in a path environment where conditional prepayment does not occur often as a result of remaining relatively high above a certain interest rate level, deflators provided by each company are likely to have larger values than those provided by us. This analysis assumes price as a given value; therefore, the result obtained by our calculation tends to show OAS as a relatively large value. These differences are so important that it is presumed that, for example, judgment by employing our OAS is different from that by employing OAS of Company A where RMBS are compared with government bonds.

Another characteristic is that spread differentials among securities were relatively larger in our assessment. As shown in Diagram 11, the spread differential among securities stays generally within the range of approximately 5bps. On the other hand, maximum spread differentials obtained by our reassessment reaches approximately 20bps (Diagram 11)²⁵. This indicates that employing a different model could have different results, even if it is a comparison with securities in the RBMS sector.

²¹ Adjustment provided by Company A is not performed in the estimation (refer to footnote 5).

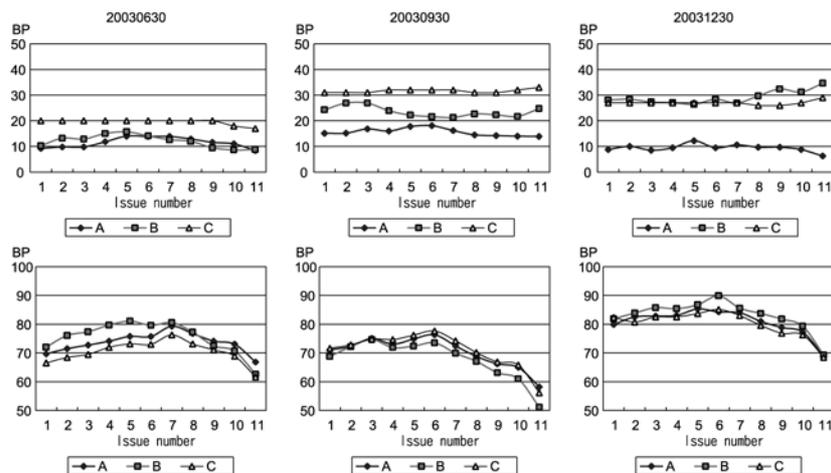
²² Assessed based on materials provided by each company.

²³ Each company generates an interest rate path where they calculate OAS.

²⁴ Refer to Ho and Goodman [2003], etc.

²⁵ The low OAS rate of the 11th bond issue is outstanding; refer to footnote 27.

Diagram 11 Comparison of OAS (Original: 1st order; Our estimation: 2nd order)



4.3 Effect of modeling a conditional prepayment rate

This section studies the effect where modeling a conditional prepayment rate overestimates or underestimates the practical conditional prepayment rate. First, to explain the accuracy of the conditional prepayment rate employed, the difference between practical CPR and model CPR was 0.0% on average and 1.2% with standard deviation. Average practical CRP was 3.0%; therefore, the effect of multiplying “ C_t ,” i.e., an output of the model by 0.5-1.5 times to be used as a target [i.e., “ $(3.0 \pm 1.2) \div 3.0 = 1.0 \pm 0.4$,”] was observed.

Diagram 12 shows the plotting of WAL (a horizontal axis) and OAS (a vertical axis) for each security where the multiplying power in each output of the modeling of a conditional prepayment rate is changed on the assumption that the price of securities is constant as of September 30, 2003. The shortening of WAL and the expansion of OAS were observed in line with the increase in multiplying power in each output²⁶. The following points were noted.

- The variation of WAL is generally four years or less. This implies that WAL varies for roughly half a year even though the bias of the model of a conditional prepayment rate stays within the range of 10% to 20%.

²⁶ It is as a matter of course that WAL tends to be shortened (or to be prolonged) in line with an overweighting assessment (an underweighting assessment) of a conditional prepayment rate. Meanwhile, it is generally considered that OAS expands (contracts) for the following reason. Where a conditional prepayment rate is overweighted, the cash flow from principal diminishes without any change in deflators; therefore, as a general rule, it is supposed to lead to a rise in stock price. However, as a result of the assumption that the price of securities is constant in this analysis, OAS is supposed to increase. Meanwhile, the main reason for the widely different condition in the fluctuation of each security is likely to be caused by the difference in coupon rate. For example, with two kinds of security where the expiration date, the assumed amortization rate, and WAC are identical, but coupon rates are different, the security with the lower coupon rate exhibits a larger rise in cash flow compared with previous cash flow. For this reason, it is supposed to display a greater rise in price (expanding degree of OAS in this analysis). In fact, OAS of the 11th bond issue that carries an extremely low coupon rate fluctuates markedly compared to others.

- The difference between securities is not observed to greatly affect WAL; however, the effect on OAS is never uniform.

As a matter of course, the model of a conditional prepayment rate has a great effect on the assessment of RBMS. In addition, as pointed out, particular attention is required in that the degree of effect on each security is dependent on each attribute so that it is sometimes very different.

Diagram 12 Effect on OAS and WAL Caused by Overweighting/underweighting Assessment of a Conditional Prepayment Rate (as of September 30, 2003)

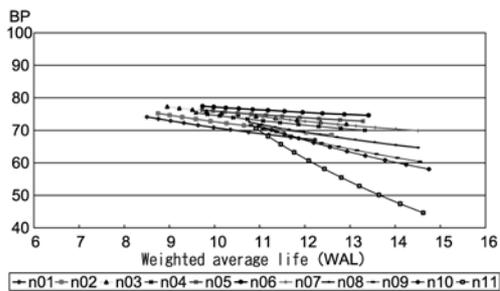
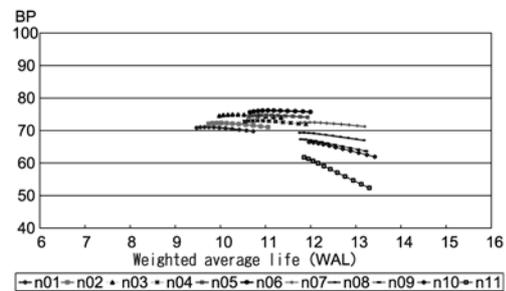


Diagram 13 Effect on OAS and WAL Caused by Overweighting/underweighting Assessment of Interest Rate Volatility as of September 30, 2003



4.4 Effect of interest rate models

The effect when volatility is overvalued/undervalued among the parameters of the interest rate model is considered²⁷. Diagram 13 shows the plotting of WAL (horizontal axis) and OAS (vertical axis) in each security where volatility among the parameters of the interest rate model is changed from 0.5 to 1.5 times as a target on the assumption that the price of securities is constant as of September 30, 2003. This result shows that OAS reaches a ceiling when the increase in volatility exceeds a certain level; however, it is understandable that the result in Diagram 13 is similar to that in Diagram 12. Given that an interest rate model determines interest rate incentives and deflators, this result implies that the effect of the change in cash flow due to interest rate incentives outweighs the effect of the change in deflators²⁸. These points also help identify the importance of modeling a conditional prepayment rate (and the assumption in regard to interest rate incentives that are used).

²⁷ The interest rate models employed in this study are four parameters, i.e., regression level, conversion coefficient, regression velocity, and volatility. Among them, regression velocity and volatility are the most important. However, the change in regression velocity changes the yield curve dramatically; therefore, the validity of the assumption that the price of securities remains unchanged largely loses ground. So we focused on volatility.

²⁸ The result is likely to change as it is dependent on the interest rate level and the interest rate model used; therefore, over generalization of the results of this study should be avoided.

5. Conclusion

As we have shown, the indicators regarding attributes (OAS, WAL and so on) are highly dependent on the relevant model. In consequence, there are many problems where the indicators related to attributes announced by each organization are used too readily without understanding the introduced premise in the case of investment judgment and risk management. Institutional investors are required to compare and study assessment using various models, while being fully aware of 1) the content of the models used in the market, and 2) popularity of each model in the market. In addition, even if they have their own model, they should consider investment judgment and risk management methodologies by comparing with models proposed by other companies, but without having blind trust in them. For additional reference, it is important to improve analytical methods from the standpoint of both the issuing side and the investment side, as well as to disclose achievements stemming from improvements in analytical methods. This will promote an in-depth understanding of RMBS for market participants, consequently contributing to development of the RMBS market.

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