

Chapter 16

An Applied Approach to Valuation of Securitized Balance Sheet Assets Based on Monte Carlo Simulation with Special Reference to Turkish Finance Sector

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Abstract In this study, the Monte Carlo Simulation method is used in mortgage-backed security asset pool calculations. By simulating different combinations of input variables affecting the mortgage-backed securities asset pool, the future earnings, the total amount of interest, and the minimum and maximum values of the amount of total interest to be distributed are estimated. Six different scenarios were used in the assessment of the asset pool. At the end of the simulation obtained for the scenarios, the minimum, and maximum earnings, total amount of interest and total amounts to be distributed obtained from the asset pool that have been estimated. In conclusion, the Monte Carlo Simulation method is effective in evaluating the mortgage-backed securities asset pool.

Key Words: Mortgage-Backed Securities, Balance sheet, Asset Pool, Monte Carlo Simulation

16.1 Introduction

Nowadays, the globalization process has enabled different nations to rapidly reach technological developments and innovations in any field. Financial globalization has enabled the free movement of finance among countries and increased capital movements. Therefore, the globalization of financial markets has caused the financial instruments used in the markets to expand and diversify. In particular, the mortgage-based securitization process has gained influence in the world financial markets recently.

Mortgage-based securitization (MBS), the asset pool created by collecting mortgage-backed loans of various types, rates, and maturities to their customers in a pool, and the sale of this pool to other securities issuing institutions and the securitization of this pool by the purchasing

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institution. Mortgage backed loans, one of the bank balance sheet assets, are also one of the most important instruments of securitization. It is observed that mortgage-backed loans and mortgage bonds are used as a widespread and increasingly growing funding instrument. Mortgage-based securities constitute the second most important source of funds in bank balance sheets after deposits. Unlike the USA, the majority of Institutions operating in the EU Mortgage Markets consist of various types of banks. As mortgage loans are kept on bank balance sheets, mortgage-based markets and mortgage-based securities are directly affected by Basel II regulations (Aksoy, 2006:94-95). With Basel II criteria, the risk weight of mortgage-backed loans has been reduced in parallel with the decrease in risk weighting in other balance sheet assets. This has had the effect of decreasing the loan / funding cost, increasing the loan volume and consequently reducing the minimum capital requirement of credit institutions (Aksoy, 2007:84-85).

The mortgage financing system, which is frequently used in the USA and developed countries, basically operates as follows: Mortgage housing finance institutions usually provide funds by selling their mortgage-backed loans in the second-hand market or by issuing securities based on these mortgage loans. Thanks to this method, liquidity is created for mortgage loans and the integration and deepening of mortgage and capital markets is ensured (Aksoy, 2005:188-189). Expressed as the transaction of selling papers to investors, MBS has a long history in financial markets. MBS transaction is generally based on the housing finance system. This type of securitization is widely used, especially in developed countries. The success of the system depends on the success of the organization funding the system. The increment of MBS investments in recent years in both in Turkey and the world are remarkable. Investors demand for such securities is increasing. The reason for this is that they are government-supported and reliable investments. In the MBS system, by collecting the mortgaged housing loans in an asset pool, various classes of securities are issued based on the cash flows that include the principal and interest payments of the loans. MBS are securities backed by an asset pool. In the MBS transaction used by the public and private sectors, at the time of issuance, even if the cash flow subject to issuance is partially available or not available, securities can be issued from now based on future cash flows. In this transaction, the terms of the assets in the asset pool are not similar. Loans consisting of different maturities and interest rates constitute the asset pool. The selection of loans to be found in the asset pool in the MBS transaction is made according to the expected returns and risks. Risk calculation is based on deviations in expected returns. Calculation of return depends on how much the risks of receivables can be eliminated. Changes in interest, restructuring, early repayment of the loan and non-payment of the loan pose risks to the cash flows in the asset pool. Therefore, the risk will be eliminated with the least negativity by taking precautions against possible risks that may occur. For this, it is important to be able to estimate the minimum and maximum values of the yield that can be obtained. By analyzing the different situations that may occur in the asset pool, the minimum and maximum return of the pool can be estimated, and the losses that may occur in the face of the risks that may occur can be determined and thus the negative effects that may be encountered in the event of the risk can be minimized.

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and maximum return of the pool can be estimated, and the losses that may occur in the face of the risks that may occur can be determined and thus the negative effects that may be encountered in the event of the risk can be minimized. The minimum and maximum return of the pool can be estimated by analyzing the different situations that may occur in the asset pool, and the losses that may occur in the face of the risks can be determined, thus the negative effects that may be encountered in the event of the risk can be minimized. MBS asset pool cash flow is based on the interest and principal payments of the mortgage loans that make up the pool. Since these cash flows are long term, their realization as predicted over time involves some concern. To minimize this concern in terms of the asset pool, it is necessary to ensure that the calculations made for the future are as close to the truth as possible. Different methods continue to be developed to obtain correct estimates and take correct decisions in MBS issues. One of these methods is Monte Carlo Simulation (MCS) that the essence of the simulation is based on the principle of obtaining different combinations for output variables by giving random distribution to input variables. Thus, the MBS asset pool is a method used for the analysis of uncertain situations that cash flows may face in the future. In this study, calculations are made by considering six different scenarios for the MBS asset pool cash flows, and the calculation results are compared with the MCS estimates. The minimum and maximum returns, total interest amount and total amounts to be distributed are estimated from the asset pool with MCS. Consequently, it was concluded that the MCS method useful in the evaluation of MBS.

16.2 Literature

Mortgages have cash flows over their lifetime, which means they are a mix of short-term, medium-term, and long-term periods. Cash flows continue throughout the maturity of mortgage-backed securities (Sakarya and Yıldırım, 2017: 51). Although the interest in MBS is increasing day by day, studies on MCS for this purpose are not yet in the desired number. McConnell and Singh (1993) have been able to create tools that meet the needs of specific clients of investors with different maturity preferences by restructuring the MBS asset pool cash flows. Algebraic equations were formed in the created asset pool cash flow calculations and they used MCS in the solution of these equations.

Zenios (1996) analyzed the level, structure, and history of interest rates, market perception of future interest rates, total and disposable consumer income values with MCS, and estimated interest rates at monthly intervals for thirty years as variables of the MBS asset pool. Akesson and Lehoczky (2000) analyzed a pool of various asset types and stated that early repayment has negative effects on cash flows. Borrowers can prepay mortgages for a variety of reasons. In the event of early repayment, the lender loses the foreseen interest payments. In such a situation, if interest rates change in the future, there is a concern about the cash flow of the asset pool (Acheampong, 2003). This concern makes mortgage-backed securities risky.

In the face of this concern, MCS has been an appropriate method for evaluating future cash flows. Besides, the long-term nature of MBSs also creates concern in cash flow (Goncharov et al., 2007). The long-term cash flows of the pool could be predicted with Monte Carlo Simulation (Green, 2013). Also, pools contain secured mortgage obligations. This is another

reason for concern. In this case, Davidson and Levin (2014) suggested that the MCS method is convenient.

It has been observed that the MCS method is a preferred method for evaluating different interest rates of the pool, as it provides an opportunity to examine a wide spectrum (Fabozzi etc., 2007). Thus, it is understood that the history of interest rates is significant, and it is a suitable method for valuing interest rate sensitive instruments Lutzenkirchen (2014) analyzed the loans in the asset pool subject to securitization with MCS and obtained estimation results for different combinations. It has also been applied in pricing complex instruments such as mortgage-backed securities (MBS) (Pang et al., 2015).

The strength of MCS is not only the analysis of concern situations but also its strong path dependency and high dimensionality. The Road dependency term describes the set of possibilities that the change in interest rates to be high, medium, and low over time will follow. The change in interest rates reveals different paths that were unknown at the beginning but may occur in the future. However, the simulation may take a long time to achieve convergence in the evaluation of all roads. (2015)

It has been clearly understood from the above explanations MCS is a convenient and common method to be used in the analysis of MBS pools because it is random and path-dependent. MCS is used for this reason in this study to estimate the asset pool minimum and maximum return, total interest income and total interest amount to be distributed (to be paid on the security to be issued).

16.3 Asset Pool of Securitized Assets Backed by Mortgages

In a narrow sense, securitization can be defined as the lending institution sells its receivables arising from the loan and the financing of the loan by the investors who purchase the securities issued based on this receivable. With this method, credit institutions that reduce the risky assets in their balance sheets are able to fulfill the equity adequacy requirements more easily. In narrow definition, it is meant the process of converting the illiquid assets of savings institutions (banks) and other intermediaries into securities by packaging. The most prominent example of securitization in a narrow sense is mortgage and asset-backed securities (Aksoy, 1998:17).

The rate of return provided by mortgage-backed asset issues is a significant factor for both investors and securities issuers. While making securitization based on mortgage loans, the price calculations of the securities to be issued should be performed most realistically. In this respect, the stage of creating an asset pool is of great importance. The structure of the asset pool depends on the interest, capital, and early repayment of the loans (Fabozzi and Mann, 2010: 124).

Debt receivables in asset pools may have different interests and maturity structures. This can prevent a significant reduction in asset pool revenues in the event of any early repayment, structuring and non-repayment of the loan. Thus, asset pool cash flow estimates can be more easily predicted. This should be taken into account when making estimates of asset pool cash flows in terms of maturity risk since the payment of mortgage-backed debt receivables (loans) is likely to be non-payment (default) in the first years. The type of loans (fixed or variable rate),

maturity structure, risk, and priorities of capital-interest payments may differ. In such a case, MBS issues should be made by considering the status of the asset pool.

While creating MBS asset pools, attention must be paid to ensure that the interest and maturity structures of the loans in the pool are free from risks such as non-repayment and early repayment of the loan. The low-risk asset pool will provide high returns. When calculating the interest (return) to be applied to the securities to be issued from MBS assets, it will be appropriate to determine the lowest mortgage loan in the pool.

When the head institution transfers the mortgage-backed asset pool to the special purpose institution, all the claims and rights regarding the asset pool pass to the special purpose institution. The structure of the asset pool is extremely significant for both the institution that will issue the security and the investor who will buy the security. The securities to be issued based on the asset pool must be reliable and profitable. The securities to be issued may vary according to the nature of the rights to be provided to their owners (Kravitt, 2013:1; Simkovic, 2013:216).

16.4. Research Methodology

16.4.1. Analysis Method: Monte-Carlo Simulation.

The main purpose of the research is to accurately determine the future return, total interest amount, interest amounts to be distributed (the amount of interest applied to the security to be issued) using the MCS method of the mortgage-backed asset pool, and to provide the institutions that will issue the securities with an idea about the decisions they will take in their issuance.

MCS can be applied to this system if the system under investigation contains elements that show future possibilities, MCS is a probability calculation method used to predict future events by making use of past and current data (Williams et al., 2008: 401), and it is studied with random numbers (Şener and Şener 2019: 296). It is a suitable method for situations with uncertainty, situations with one or more variables (Roques et al., 2006: 5). MCS calculates the probability of occurrence of possible future situations in a system. The data to be used in the simulation is the result of analyzing the data obtained from the past, current, or recent past. This simulation focuses on the analysis of the situation, not the solution to a problem. When applying to a problem, the first random numbers are assigned to the variable at certain intervals. Due to the random distribution of input variables, predictive variables are formed with different combinations (Ross et al., 2010: 210). Therefore, the method is useful in analyzing situations involving combinations.

MCS has three main objectives (Burley & Sullivan, 1986: 122):

- Describe the actual system
- Identifying imaginary systems
- To design an advanced system

The process steps followed while applying MCS are as follows (Fabozzo & et al 2007: 210).

- Determining input variables
- Entering interest rates using historical and current data
- Estimating the rate of early repayment probability

Estimating asset pool interest yield

Estimating the amount of interest to be paid (distributed) on the security to be issued

- Estimating the cash flow of the asset pool
- Estimating asset pool return

In securitization transactions, whichever type of asset subject to securitization used is essentially the same process. The first thing to do is to create the asset pool.

In this study, financial models have been created in line with different scenarios to estimate how the total interest amount to be paid (interest to be distributed) will be affected by various future situations based on the return of the asset pool, total interest income and asset pool. Because the most comprehensive and powerful parameter of asset pools, these are the risks arising from changes in interest rates.

16.4.2 Research Input Parameters and Assumptions

Mortgage-backed asset pool to be used in calculating the value of the input parameters, has been created taking into account the calculations to be performed in Turkey. Loans in the asset pool are assumed to be 5 and 10 years. The assumptions about the pool are grouped under three headings. These are the variables of income distribution (income), interest distribution and total interest distribution. The variables used in our study are given in Table 16.1. and all variables are defined as normal distribution.

Table 16.1 Variables Used in MCS

Input Variables	Lower Limit	Upper Limit	Units	Distribution Type
Scheduled Principal	140.000	2.770.000	TL	Normal Distribution
Total Number of Periods	60	120	Month	Normal Distribution
Mortgage Payment	2.370	51.572	TL	Normal Distribution
Early Payment Period	3	30	Month	Normal Distribution
Early Repayment Rate	3	4	%	Normal Distribution
Mortgage Loan Interest Rate	11,88	14,25	%	Normal Distribution
Mortgage Loans Remaining Maturity	0	120	Month	Normal Distribution
The number of repetitions	100	5.000.000	Input Variables	Normal Distribution
Outputs				Normal Distribution
Scheduled Principal	663	22.114	TL	Normal Distribution
Interest Monthly Payment	1.707	29.458	TL	Normal Distribution
Interest to be Distributed Monthly Payment	1.253	21.078	TL	Normal Distribution
Monthly Early Repayment Rate	0.00008	0,01775	%	Normal Distribution

End of Period Mortgage Balance	5.268	2.690.867	TL	Normal Distribution
Mortgage Payment	2.370	51.572	TL	Normal Distribution
Total interest	1.348.900	1.547.900	TL	Normal Distribution
Interest Distribution	995.070	1.116.500	TL	Normal Distribution
Total Profit (Gainings)	180.970	431.400	TL	Normal Distribution

Source: Calculation data prepared by researchers.

Matlab © package program was the applications used to run the simulation codes we prepared.. There is no ready-made interface and an m-file that has been created. In Figure 16.1, the codes in this m-file and a figure obtained as a result of running the code are given as an example. As can be seen, the results obtained are also of normal distribution type.

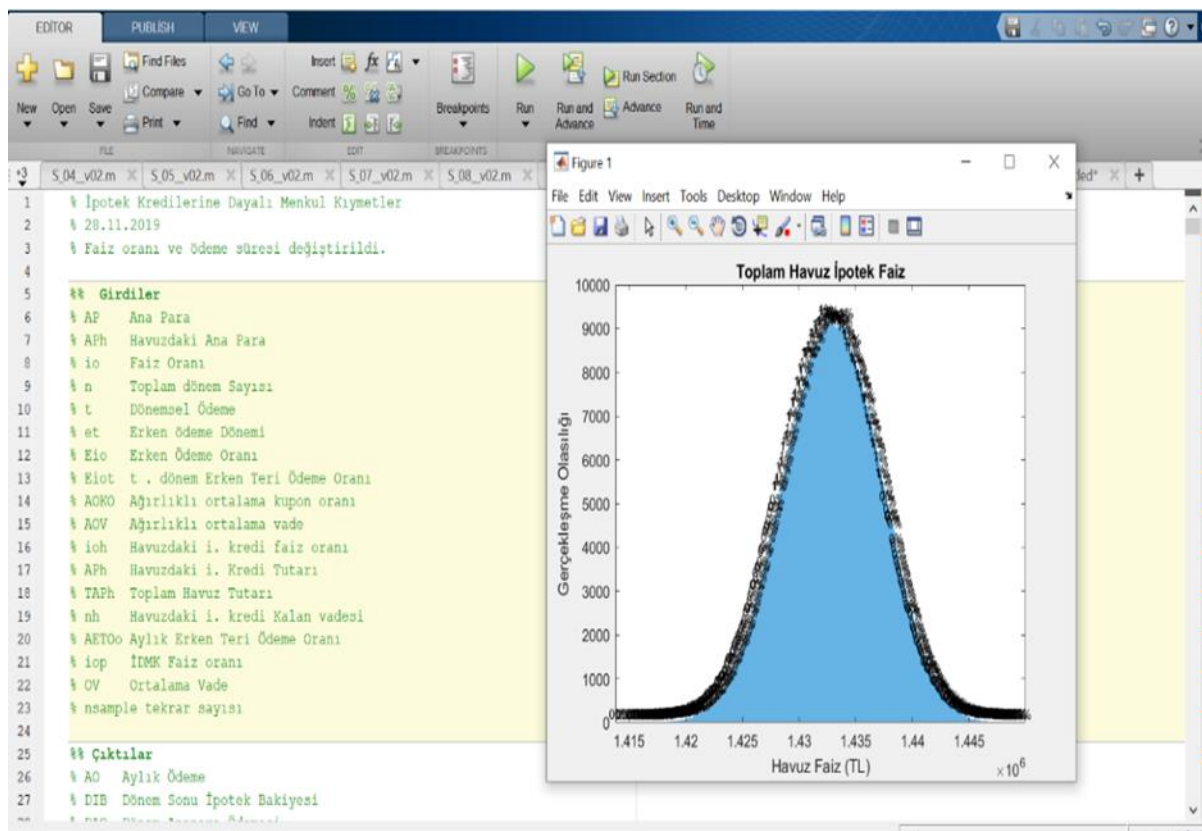


Figure16.1 Code with Monte Carlo Simulations and a Working Example

Source: Calculation data prepared by researchers.

In the simulations, securitization parameters based on mortgaged housing loans are evaluated to determine cash flows. For this purpose, 6 scenarios were created. These are;

- Asset pool based on the fixed rate assumption
- Asset pool based on fixed rate early repayment assumption
- Asset pool based on the fixed rate structured assumption
- Asset pool built on the assumption of non-repayment of fixed rate loan debt
- Asset pool based on the six-month floating rate assumption
- Hydride asset pool based on the assumption that all scenarios are realized

The data to be used in the scenarios consist of mortgaged housing loans with a 5 and 10-year term of ten customers used in different months of 2020. Interest rates applied to loans vary according to scenarios. Table 16.2 contains customer data to be used in asset pool calculations.

Table 16.2 Data of Asset Pool Customers

Customer	Year	Amount of Loan	Month	Loan Interest Rate (Year)	Interest of Securities to be Issued
A1	2020 / 2	160.000	120	%12,80	%9,40
A2	2020 / 3	140.000	60	%13,86	
A3	2020 / 4	150.000	120	%12,55	
A4	2020 / 5	240.000	60	%11,88	
A5	2020 / 6	400.000	120	%12,15	
A6	2020 / 7	280.000	60	%13,45	
A7	2020 / 8	320.000	120	%12,45	
A8	2020 / 9	250.000	60	%13,55	
A9	2020 / 10	450.000	120	%13,85	
A10	2020 / 11	380.000	60	%14,25	
	TOPLAM	2.770.000			

Source: Calculation data prepared by researchers.

In all scenarios, the results will be presented comparatively by calculating the interest amount to be distributed, interest income and the amount of return and by performing MCS. In order to determine the effect of the number of cycles on the results, a convergence analysis has been made as seen in Table 16.3, Table 16.4 and Table 16.5. During the analysis, starting from 100, up to 5,000,000 cycles were examined. Although it was observed that the change in values after 100,000 cycles was very small, simulations were carried out with one million cycles so that the normal distribution can be seen clearly on the simulation graph. In this way, it has been ensured that more of the different situations in the distribution are visible on the graph.

Table 16.3 Change Graph of Simulation Result (Total Return Achieved) Based on Number of Cycles

The Number of Cycle	100	1000	10.000	100.000	1.000.000	5.000.000
Upper Limit	4.14	4.13	4.13	4.13	4.13	4.13
Lower Limit	4.20	4.20	4.20	4.20	4.20	4.20

Source: Calculation data prepared by researchers.

Table 16.4 Change Graph of the Simulation Result (Total Interest to be Distributed) Based on the Number of Cycles

The Number of Cycle	100	1.000	10.000	100.000	1.000.000	5.000.000
Upper Limit	1.070	1.069	1.069	1.069	1.069	1.069
Lower Limit	1.086	1.087	1.086	1.086	1.086	1.086

Source: Calculation data prepared by researchers.

Table 16.5 Change Graph of Simulation Result (Total Interest Income) Based on Number of Cycles

The Number of Cycle	100	1000	10.000	100.000	1.000.000	5.000.000
Upper Limit	1.484	1.483	1.483	1.483	1.483	1.483
Lower Limit	1.507	1.507	1.507	1.507	1.507	1.507

Source: Calculation data prepared by researchers.

16.5 Findings

Different results were obtained from different scenarios involving cash flows of the asset pool, changes in interest rates, non-repayment of the loan, structuring or early repayment of customers. This suggests that loan structuring, early repayment, and credit default affect asset pool revenues. The minimum and maximum values of the income, interest amount and interest amounts to be distributed are calculated with MCS.

Fixed rate mortgage backed asset pool, loan balance of 10 customers is 2.770.000 TL in total. The mortgage pool consists of 60 and 120-month term loans. The formulas used in asset pool calculations were used from the literature (Fabozzi, 2010: 200-217). The first column of Table 16.6 is the loan balance of the asset pool. It decreases due to the principal repayments paid each month. As it is assumed that there are loan entries up to 10 months into the asset pool, the pool balance increases up to the 10th month. After the 11th month, the pool balance decreases. While the pool balance was 2.690.867 TL in the 10 months, it decreased to 2.667.732 TL in the 11th month.

The early repayment rate in the second column of the asset pool in Table 16.6 is the rate determined by the lender against the possibility of the customer using the loan to close the loan debt early in the future. Early repayment calculation Central Bank of the Republic of Turkey (CBRT) market interest rates and interest rate statistics are calculated based on the data. It has been determined that the average difference between the housing interests and market rates within the period is around 3%. The prepayment rate starts at 0.1% in the first month and increases to 3% by increasing it by 0.1% per month for 30 months and continues to be constant until the end of the period.

$$\text{Early Repayment Rate} = \%3 \times \frac{1}{30} = \%1 = 0,001$$

$$\text{Early Repayment Rate} = 1 - (1 - 0,01)^{1/12} = 1 - (0,99)^{0,08333} = 0,00008$$

The third column of Table 16.6 contains the periodic payment amount, which is the sum of interest and principal of the loans collected in the pool. The periodic payment in the third column of the asset pool is calculated as follows.

$$\text{Monthly Payment}_1 = 160.000 \left[\frac{\left(\frac{0,1280}{12}\right) \left(1 + \left(\frac{0,1280}{12}\right)\right)^{120-1+1}}{\left[\left(1 + \left(\frac{0,1280}{12}\right)\right)^{120-1+1} - 1\right]} \right] = 2.370 \text{ TL}$$

In the fourth column of Table 16.6, monthly interest is calculated for mortgage housing loans in the loan pool.

$$\text{Monthly Interest Payment}_1 = \frac{0,1280}{12} \times 160.000 = 1.707 \text{ TL}$$

Applying the interest rates applied to the security to be issued based on the asset pool in accordance with the market conditions is of great importance for both the issuer and the investor. In this respect, the asset pool return, the total interest amount and the interest amounts to be distributed, the predictions made for the future will be useful in determining the interest rates to be applied to the securities to be issued. The interest amount to be paid for the security issued in the fifth column of Table 16.6 is calculated below.

$$\text{Monthly Interest Payment to be Distributed} = \frac{0,940}{12} \times 160.000 = 1.253 \text{ TL}$$

The monthly principal amount for each month is calculated by subtracting the interest calculated from the periodic payment amount. In the sixth column of Table 16.6, the first month principal payment of the asset pool is calculated as 663 TL.

$$\begin{aligned} \text{Monthly Principal Payment} &= \text{Monthly Total Payment} - \text{Monthly Interest Payment} \\ \text{Monthly Principal Payment} &= 2.370 - 1.707 = 663 \text{ TL} \end{aligned}$$

It is unfavorable for the creditors if customers repay the loans they have used earlier than planned. The early repayment situation causes a decrease in the interest income of the lender. In the seventh column of Table 16.6, the asset pool is the early repayment in the first month and is calculated below.

$$\begin{aligned} \text{Monthly Early Repayment} &= \text{Early Repayment Rate} \times (\text{Previous Month's Closing Balance} - \\ &\quad \text{Related Month's Principal Payment}) \\ \text{Monthly Early Repayment} &= 0.00008 (160.000 - 663) = 13 \text{ TL} \end{aligned}$$

Calculation of the total principal amount of the asset pool of Table 16.6 is calculated as follows.

$$\begin{aligned} \text{Total Principal Payment} &= \text{Principal Amount} + \text{Early Repayment Amount} \\ \text{Total Principal Payment} &= 663 + 13 = 676 \text{ TL} \end{aligned}$$

Payments for securities issued are made with the cash flows obtained from the asset pool. Monthly (periodic) payment amounts are collected and transferred to investors who purchase securities after the expenses are deducted. The asset pool cash flow is 2,383 TL. The securities holders will be paid after deducting expenses from this amount.

Table 16.6 Mortgage Backed Asset Pool

Month	(1) Starting Balance	(2) Early Repayment Rate	(3) Mortgage Payment	(4) Interest Monthly Payment	(5) Interest Distribution	(6) Scheduled Principal	(7) Prepay- ment	(8) Total Principal	(9) Cash Flow
1	160.000	0,00008	2.370	1.707	1.253	663	13	676	2.383
2	299.323	0,00025	5.617	3.316	2.345	2.301	38	2.339	5.655
3	446.984	0,0005	7.817	4.859	3.501	2.958	75	3.033	7.891
4	683.952	0,00083	13.140	7.201	5.358	5.938	131	6.069	13.270
5	1.077.882	0,00125	18.911	11.187	8.443	7.723	219	7.943	19.130
6	1.349.940	0,00175	25.342	14.243	10.575	11.099	329	11.429	25.671
7	1.658.511	0,00234	30.011	17.441	12.992	12.570	464	13.034	30.475
8	1.895.477	0,00301	35.761	20.125	14.848	15.636	617	16.253	36.378
9	2.329.224	0,00376	42.696	25.144	18.246	17.551	805	18.357	43.501
10	2.690.867	0,00460	51.572	29.458	21.078	22.114	1.022	23.135	52.594
11	2.667.732	0,00544	51.553	29.203	20.897	22.349	1.234	23.583	52.787
66	904.202	0,01775	32.738	9.737	7.083	23.001	2.234	25.235	34.972
67	878.967	0,01775	32.655	9.455	6.885	23.200	2.169	25.370	34.824
68	853.597	0,01521	27.440	9.171	6.687	18.269	2.118	20.387	29.558
69	833.210	0,01521	27.371	8.944	6.527	18.427	2.066	20.492	29.436
70	812.718	0,01268	19.379	8.716	6.366	10.663	2.033	12.696	21.412
71	800.022	0,01268	19.329	8.580	6.267	10.750	2.001	12.750	21.330
72	787.272	0,01268	19.280	8.443	6.167	10.837	1.968	12.805	21.249
73	774.466	0,01268	19.232	8.307	6.067	10.925	1.936	12.861	21.167
74	761.606	0,01268	19.183	8.169	5.966	11.014	1.903	12.917	21.086
99	420.309	0,01268	18.003	4.517	3.292	13.487	1.031	14.518	19.035
100	405.791	0,01268	17.958	4.361	3.179	13.596	994	14.591	18.952
101	391.201	0,01268	17.912	4.205	3.064	13.707	957	14.664	18.869
102	376.537	0,01268	17.867	4.048	2.950	13.818	920	14.738	18.786
103	361.799	0,01268	17.821	3.890	2.834	13.931	882	14.813	18.703
104	346.986	0,01268	17.776	3.732	2.718	14.044	844	14.888	18.620
124	40.988	0,00761	13.417	454	321	12.963	71	13.034	13.488
125	27.954	0,00507	8.965	314	219	8.651	49	8.700	9.014
126	19.254	0,00507	8.942	218	151	8.724	27	8.751	8.969
127	10.503	0,00254	5.343	121	82	5.221	13	5.235	5.356
128	5.268	0,00254	5.329	61	41	5.268	0	5.268	5.329
129	-	-	-	-	-	-	-	-	-

Source: Calculation data prepared by researchers.

The asset pool return (income obtained) in Table 16.6 was calculated as 431.300 TL, the total interest amount as 1.547.900 TL, and the interest amount to be distributed as 1.116.500 TL. Under the assumption that interest rates change every six months, the asset pool return is 391.900 TL, the total interest amount is 1.442.800 TL, and the total interest to be distributed is 1.050.900 TL. Under the assumption that loans in the asset pool have floating rates, fluctuations in interest rates caused a decrease in asset pool revenues. Fixed and floating rate asset pool total interest income graphs are shown in Figure 16.2-16.3 below.

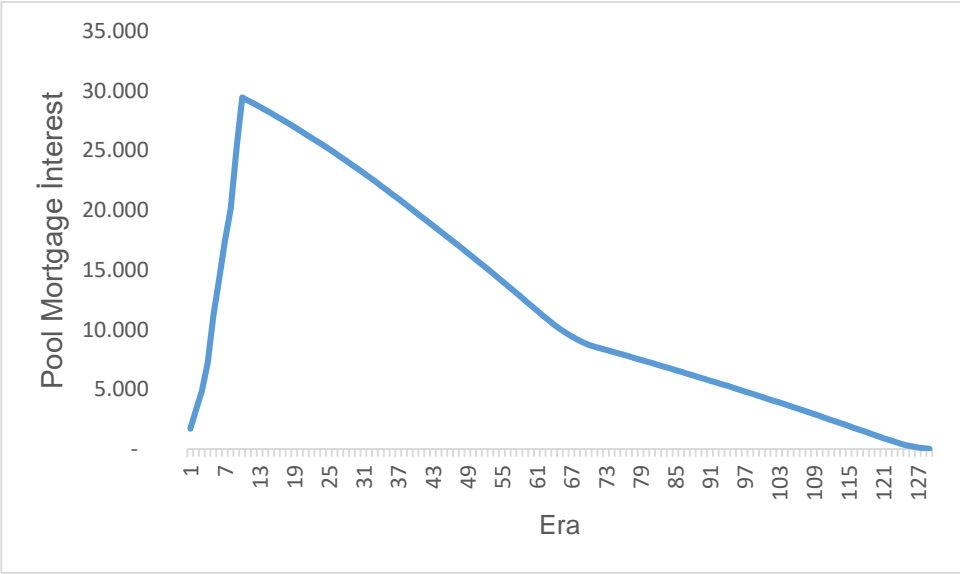


Figure 16.2 Fixed Rate Asset Pool Interest Distribution
Source: Calculation data by researchers.

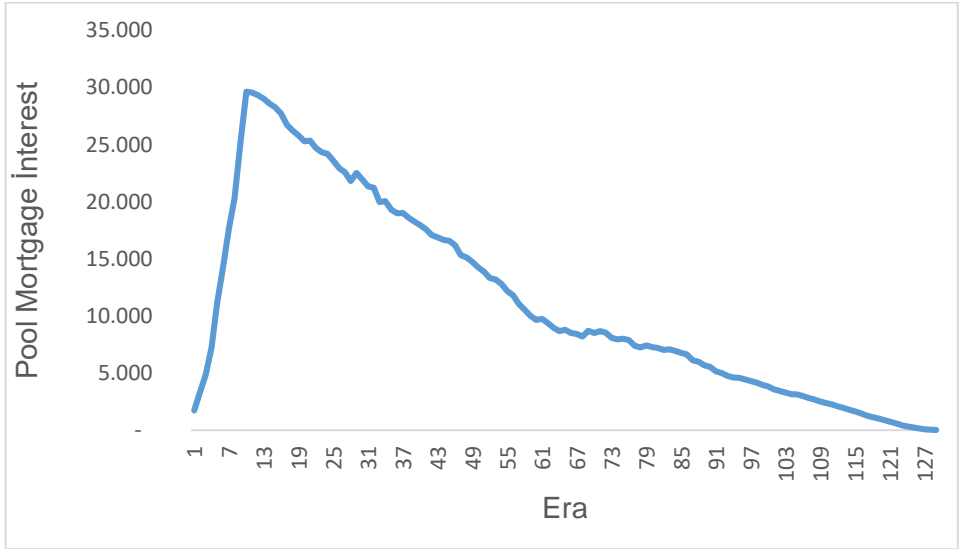


Figure 16.3 Six-Month Variable Interest Rate Asset Pool Interest Distribution
Source: Calculation data by researchers.

The results and figures for the mortgage-backed six-month floating-rate asset pool MCS are presented below.

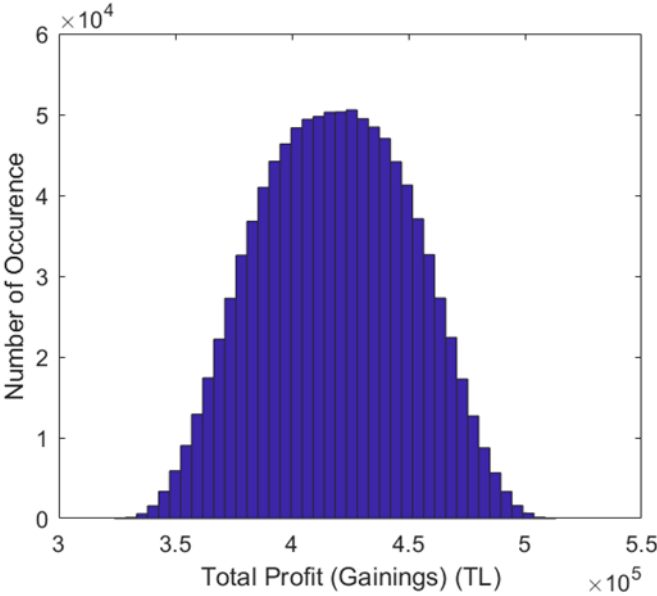


Figure 16.4 Total Profit (Gainings)
Source: Calculation data by researchers.

In Figure 16.4, the six-month variable-rate asset pool total obtained income (return) distribution is with a probability of 0.1%, with a minimum return of 325,750 TL. The maximum total return of the pool is estimated to be 513,320 TL with a probability of 2%. As a result of the simulation, the total return of the asset pool is expected to be in the range of 3.86 - 3.88 TL with a probability of 51%. MCS calculations are in the table below.

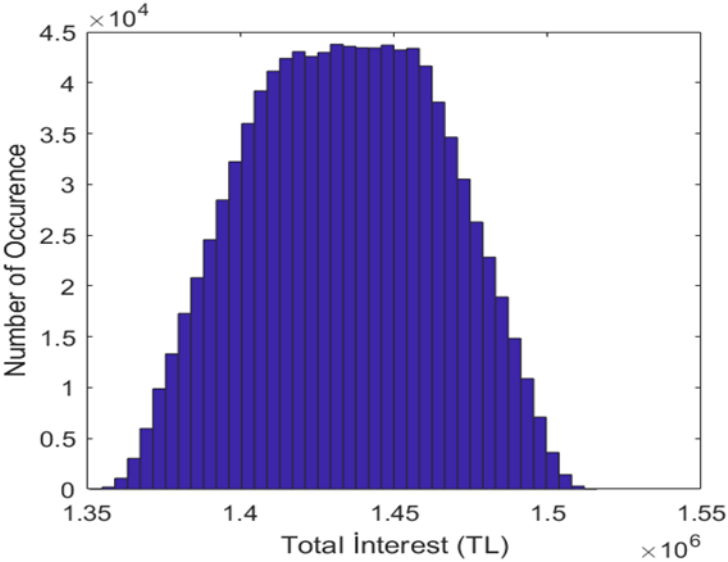


Figure 16.5 Distribution of Total Pool Mortgage Interest
Source: Calculation data by researchers.

The minimum return of the six-month variable interest asset pool total interest income distribution in Figure 16.5 is 1.348.900 TL with a probability of 1%. The maximum interest income of the pool is estimated as 1.519.800 TL with a probability of 1%. As a result of the

simulation, the interest income of the asset pool in Figure 16.5 is expected to be between 1.4 - 1.45 TL with a probability of 45%.

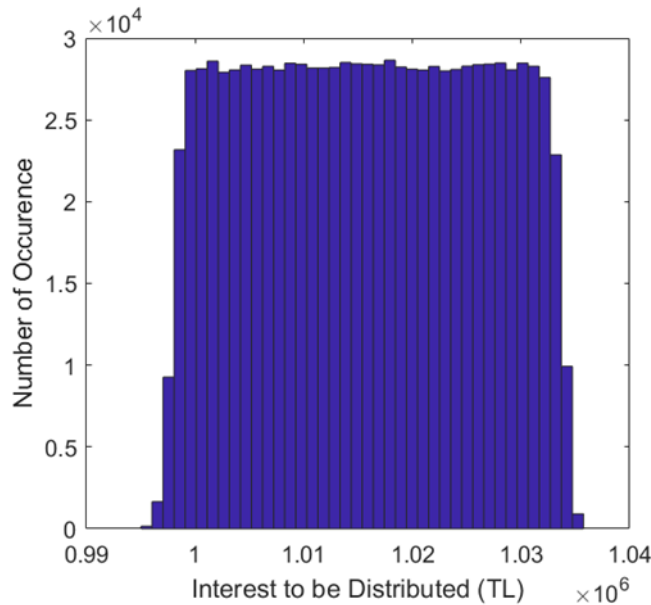


Figure 16.6. Total Interest Distribution

Source: Calculation data by researchers.

The six-month variable interest asset pool in Figure 16.6 will have a minimum return of 995.070 TL with a probability of 1% of the total interest distribution. The maximum amount of interest to be distributed for the pool was estimated as 1.036.100 TL with a probability of 2%. As a result of the simulation, the interest amount to be distributed in the asset pool in Figure 16.6 is expected to be in the range of 1 - 1.03 TL with a probability of 11.8%. The asset pool results of the six-month variable interest scenario are included in Table 16.7.

Table 16.7 Six-Month Asset Pool Results

	Profit (Gains)	Interest Distribution	Total Interest
Calculated	391.900	1.050.900	1.442.800
MCS Min	325.750	995.070	1.348.900
MCS Max	413.320	1.036.100	1.519.800

Source: Calculation data by researchers.

The better the probability of deviation when reaching a targeted result in a given time period is predicted, the more successful the action will be. As can be seen in Table 16.7, the percentage actual relative error of the calculated and estimated values is between $|(391.900-325.750)/391.900|*100=\%16.8$ and $|(391.900-513.320)/391.900|*100=\%30,9$. This is a crucial and reliable result in terms of risk management for the institution that will issue the security. The less risk it contains in the asset pool the better quality it will be. If the risks are manageable and the asset pool risk can be managed, the asset pool return will be far higher.

Various scenarios have been developed to observe how changes in interest rates, early repayment, non-repayment of the loan or restructuring affect the asset pool revenues and in which cases the asset pool will be more profitable. In order to confirm the accuracy of the

simulation results, analytical calculations of each scenario have been made and the comparison of the simulation results was made. The reliability of the simulation results has been demonstrated as a result of the comparisons made. A complete comparison of the calculations and the result of MCS obtained for the different scenarios investigated is given in Table 16.8. The table includes the estimation results of the yield, interest to be distributed and mortgage interest income.

Changes in interest rates are the determinant of asset pool revenues. When the results of sample application are examined, the highest return is obtained from scenarios 1 and 5, and the lowest from scenarios 3 and 4, which is seen in Table 16.8. Whereas the upward movements in the interest rates are seen positive in terms of the asset pool, the downward movements present negativity

Table 16.8 Simulation Results for Scenarios

Scenario	Profit (Gains)	Percentage of Actual Relative Error	Interest Distribution	Percentage of Actual Relative Error	Total interest	Percentage of Actual Relative Error
1_ Calculated	431.300		1.116.500		1.547.900	
2_ Calculated	404.480		1.078.000		1.482.500	
2_ MCS Min	413.850	2.3	1.069.900	0.7	1.483.800	0.1
2_ MCS Max	420.490	3.9	1.086.700	0.8	1.507.200	1.6
3_ Calculated	303.400		1.107.500		1.410.500	
3 MCS Min	293.540	3.2	1.082.300	2.2	1.375.900	2.4
3 MCS Max	318.430	4.9	1.109.400	1.7	1.413.800	2.3
4_ Calculated	197.350		1.071.900		1.486.700	
4_ MCS Min	180.970	0,8	1.062.700	0.8	1.473.900	0.8
4_ MCS Max	209.000	0.5	1.079.900	0.7	1.497.900	0,7
5_ Calculated	391.900		1.050.900		1.442.800	
5_ MCS Min	375.750	4.1	995.070	5.3	1.348.900	6.5
5_ MCS Max	413.320	5.4	1.036.100	1.4	1.519.800	5.3
6_ Calculated	323.200		1.089.600		1.412.600	
6_ MCS Min	307.580	4.3	1.077.900	1.07	1.365.800	3.3
6_ MCS Max	340.750	5.4	1.096.800	0.66	1.491.400	5.5

Source: Table data calculated by authors

There have been changes in the asset pool data because of reasons such as changes in interest rates used in the scenarios, restructuring early repayment and non-repayment of the loan. As can be seen from the table, the biggest deviation has been observed in the 4th scenario. This is because some customers in the asset pool have not repaid their overdue loan debts. Such a situation has caused a decrease in asset pool revenues.

Percentage real relative error analysis is considered significant for comparison in numerical solutions. The values obtained from the asset pool calculation, namely the measurement values, have attempted to determine how close they are to the real value as a result of the real relative calculations.

In this study, the results found in the scenario calculations have been obtained by numerical methods and the results are not absolute values but approximate. The 5th scenario shows that the largest deviation in the interest estimates to be distributed is 5,3%. There is a 6,5% deviation in interest estimates in the 4th scenario (Huanga, Liu & Yang, 2019:9-11). It has been observed

that the calculated deviation values are within acceptable limits in the organization's future decision-making processes and risk analysis. Because the MCS method involves repetitive operations by nature, it has been considered that in case the number of transactions increases, the calculation time will increase and analysis, it has been determined that by conducting a convergence, the most appropriate number of repetitions required for the practical application of the method should not be less than 1.00.000, but to obtain a result suitable for normal distribution, at least 1.000.000 cycles should be used.

16.6 Conclusion

Certain fluctuations in the financial markets create risky effects for both securities issuers and investors. Making the right decision is difficult in an environment of uncertainties, especially in the correct planning for the future, some methods can be used to minimize these risks. Although mortgage-backed securities are low-risk investment tools compared to other investment instruments, the asset pool of mortgage-backed securities is affected by interest rate changes. Besides, the decrease in cash flows of the customers in the asset pool due to reasons such as non-payment, early repayment or restructuring is a risk for the mortgage-backed securities issuer. Because there are future uncertainties, it is difficult to calculate the risks. However, some methods are used to make accurate prediction. One of these methods is Monte Carlo Simulation, which analyzes how the mortgage-backed security asset pool return, total interest income and the total interest amount to be distributed on the securities to be issued. Future interest fluctuations, early repayment, loan structuring and non-payment affect these. Asset pool calculations provide the issuer with information about the interest rate to be applied to the security to be issued and the income to be obtained as a result of this issue. In this study, we investigated the asset pool in six different scenarios since it is insufficient to evaluate the asset pool calculations in a single case. According to the simulation results, the first scenario suggests that fixed rate securities and regular payments give the highest return in the asset pool. In the future, it is possible to encounter all of the asset pool early repayment, restructuring, non-payment of the loan. Therefore, it would be more appropriate to use the asset pool estimates of the sixth scenario, which includes all probabilities in the future return estimates in the created asset pool scenarios.

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