FRM Part 1

Book 3 - Financial Markets and Products

MORTGAGES AND MORTGAGE-BACKED SECURITIES

Learning Objectives

After completing this reading you should be able to:

- ✓ Describe the various types of **residential mortgage products**.
- ✓ Calculate a **fixed rate mortgage payment**, and its principal and interest components.
- ✓ Describe the **mortgage prepayment option** and the factors that influence prepayments.
- ✓ Summarize the **securitization process** of mortgage-backed securities (MBS), particularly the formation of mortgage pools including specific pools and TBAs.
- ✓ Calculate **weighted average coupon**, **weighted average maturity**, and conditional prepayment rate (CPR) for a mortgage pool.
- ✓ Describe a **dollar roll transaction** and how to value a dollar roll. Explain prepayment modeling and its four components: refinancing, turnover, defaults, and curtailments.
- ✓ Describe the steps in valuing an MBS using **Monte Carlo simulation**.
- ✓ Define **Option-Adjusted Spread** (OAS), and explain its challenges and its uses.

Types of Residential Mortgage Products

- A mortgage is a loan that has a **specific piece of property as collateral**.

- We shall dwell on **residential mortgages** - loans that one or more persons receive in order to buy a house or other **residential** property.
  - In the **primary mortgage market**, banks issue mortgage products to customers who in turn repay the principal plus interest
  - In the **secondary market**, mortgages are pooled together and repackaged to form **mortgage-backed securities**

Types of Residential Mortgage Products

Prime (A-grade) loans

- **Low rates of delinquency and default** thanks to low loan-to-value ratios, typically far less than 95%.
- Borrowers are individuals with **stable and sufficient income**.

Alternative A-loans

- Lie in **between prime** and **subprime loans**
- Are essentially prime loans with characteristics that make them riskier than pure A-grade loans, e.g., **less documentation to support income levels**.

Sub-prime (B-grade) loans

- **Higher rates of default and delinquency** compared to prime loans.
- Associated with loan-to-value ratios of 95% or more.
- Borrowers may be individuals with **lower income levels** and **marginal/poor credit histories**.

Types of Residential Mortgage Products

Other notable differences (1/2)

Lien Status:

- A **first-lien mortgage** is more desirable than a second-lien mortgage from the perspective of the lender.
  - In the event of liquidation, a first-lien status would give the lender the right to submit the **first claim on the proceeds of the liquidation process**.

Original Loan Term:

- **Long-term** mortgages have a **maturity period of 30 years**, with **medium-term** ones ranging between **10-20 years**.
  - In recent years, however, borrowers increasingly **prefer medium-term** loans to long-term ones

Types of Residential Mortgage Products

Other notable differences (2/2)

- Fixed-rate mortgages are associated with a **fixed rate of interest** up to maturity.

- Adjustable-rate mortgages are associated with a **floating rate of interest**.
  - For example, the rate could be LIBOR + 100 bps. In such an arrangement, the rate would change every six months.

Fixed Rate Mortgage Products (1/4)

Notable characteristics include:

- **Equal payments** are made at fixed intervals over the life of the mortgage
- Loan is **amortize**d over its term such that each scheduled payment goes toward settlement of both principal and interest
- As the loan matures, the amortization schedule works in such a way that the **borrower pays more principal and less interest** with each payment.
- Level of interest depends in part on the **creditworthiness** of the borrower whereby the riskier the borrower, the higher the interest rate.
- The most common fixed rate mortgages are **15 and 30 years** in duration.

Fixed Rate Mortgage Products (2/4)

Calculating the amount of each payment

- To determine the amount of each scheduled payment, PMT, we customize the formula for the present value of an annuity.

$$\mathbf{Principal} = \mathbf{PMT}\frac{(\mathbf{1}-(\mathbf{1}+\mathbf{r})^{-\mathbf{n}})}{\mathbf{r}}$$

- Where:
  - r = monthly interest rate (annual rate/12)
  - n = total number of months

- Making PMT subject of the formula,

$$\boldsymbol{PMT} = \frac{\boldsymbol{Principal}}{\frac{(\mathbf{1}-(\mathbf{1}+\boldsymbol{r})^{-\boldsymbol{n}})}{\boldsymbol{r}}}$$

Fixed Rate Mortgage Products (3/4)

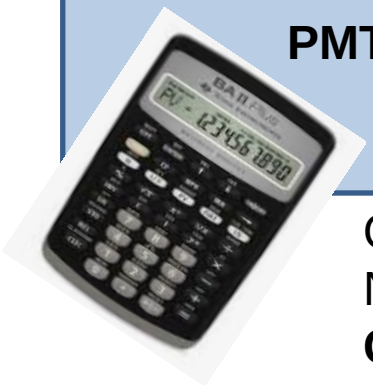
Example

- Consider the following loan:
  - Loan amount: $250,000
  - Annual rate of interest: 4.5%
  - Term: 10 years
  - Start date: 01/01/2019
- What's the periodical payment?

Solution

r = 0.045/12 = 0.00375, n = 12 * 10 = 120

$$\text{PMT} = \frac{250{,}000}{\frac{\left(1-(1+0.00375)^{-120}\right)}{0.00375}} = \$2{,}590.96$$



On a financial calculator,
N = 120; I/Y = (4.5/12) = 0.375; PV = -250,000; FV = 0;
CPT -» PMT = 2,590.96

Fixed Rate Mortgage Products (4/4)

Example: Amortization schedule

	Amortization Schedule			
Month	**Month 1**	**Month 2**	**Month 3**	
Total payment	$2,590.96	$2,590.96	$2,590.96	**<< Equal**
Principal	$1,653.46	$1,663.18	$1,672.89	**<< Increasing**
Interest	$937.50	$927.78	$918.07	**<< Decreasing**
Loan balance	$248,346.54	$246,693.08	$245,039.62	**<< Decreasing**

- Note: Interest payable is based on amount of **loan outstanding** (loan balance).

- Note 2: The **loan balance** only decreases by the **principal amount** on each payment. The **interest payable** portion of the payment is **paid to the financial institution** issuing the loan.

Prepayment Risk (1/2)

- Prepayment risk is the risk involved with the **premature return of principal** on a mortgage.
  - A prepayment effectively renders the borrower free of mortgage obligations.

- Mortgage prepayments take one of two forms:
  i. **Increasing the amount/frequency of payments**; or
  ii. **Repaying/refinancing the entire outstanding balance**.

- Prepayments are more likely to occur following a **drop in interest rates**.
  - In such circumstances, the borrower may decide to **refinance at the lower rates**.
  - **Refinancing** involves using the proceeds of a new mortgage to pay off the principal from an existing mortgage

Prepayment Risk (2/2)

- Other factors that influence prepayment include:

Seasonality	Housing turnover **increases at certain periods** during the year, e.g., over **summer** when the weather is favorable
Age of mortgage pool	Borrowers prefer to **refinance** a significant number of years into the mortgage to **minimize penalties** and administrative charges that are usually tied to principal outstanding
Housing prices	An **increase in home prices** may **spur prepayments** as borrowers scramble to take out some of the increased equity for personal use
Refinancing burnout	**Prepayment risk decreases** following a sustained **period of refinancing** activity

The Securitization Process

- **To reduce the risk from holding a potentially undiversified portfolio** of mortgage loans, a number of originators (financial institutions) work together to:
  1. Pool **residential mortgage loans** that have similar characteristics together.
  2. The pool is then **sold to a separate entity**, called a special purpose vehicle (**SPV**), in exchange for cash.
  3. An issuer will purchase those mortgage assets in the SPV and then use the SPV to **issue mortgage-backed securities to investors**.

- MBSs are backed by the mortgage loans **as collateral**.
- The simplest MBS structure, a **mortgage pass-through**, involves cash (interest, principal, and prepayments) flowing from borrowers to investors with some short processing delay

Factors that Determine the Value of a MBS (1/3)

Weighted Average Maturity (WAM)

- Weighted average maturity (WAM) is the weighted average amount of time **until the maturities on mortgages** in a MBS.
- To compute WAM,
  1. Compute the percentage value of each mortgage or debt instrument in the portfolio.
     - This is achieved by adding the current principal value of all the mortgages together and then calculating the percentage of each mortgage in comparison to the total value.
  2. Multiply each percentage by the number of years to maturity
  3. Add together the subtotals

Example >>

Factors that Determine the Value of a MBS (1/3)

Weighted Average Maturity (WAM)

Example

- A mortgage-backed portfolio includes four mortgage investments as follows:
  - Mortgage 1: $100,000 in current value, maturity in 5 years
  - Mortgage 2: $10,000 in current value, maturity in 2 years
  - Mortgage 3: $50,000 in current value, maturity in 6 years
  - Mortgage 4: $40,000 in current value, maturity in 3 years

Determine the WAM of the portfolio.

Factors that Determine the Value of a MBS (1/3)

Weighted Average Maturity (WAM)

Solution

Mortgage	Current Value	% value of mortage in portfolio	% value × Remaining duration
Mortgage 1	$100,000	$100,000/$200,000 = 50%	50% * 5 years = **2.5 years**
Mortgage 2	$10,000	$10,000/$200,000 = 5%	5% * 2 years = **0.1 years**
Mortgage 3	$50,000	$50,000/$200,000 = 25%	25% * 6 years = **1.5 years**
Mortgage 4	$40,000	$40,000/$200,000 = 20%	20% * 3 years = **0.6 years**
Total	**$200,000**		**WAM = 2.5 + 0.1 + 1.5 + 0.6 = 4.7 years**

How is WAM useful? It helps to determine the **interest rate sensitivity** of mortgage backed portfolios. The **larger the WAM**, the longer the **period of exposure** to interest rate movements, and the greater the chances of a material effect on portfolio value relative to other investment alternatives.

Factors that Determine the Value of a MBS (2/3)

Weighted Average Coupon (WAC)

- WAC is the weighted-average interest rate of mortgages that underlie a mortgage-backed security (MBS) at the time the securities were issued.
- It represents the **average interest rate** of a pool of mortgages with varying interest rates.
- It helps assess the **pre-pay characteristics of a MBS** – the higher he average coupon rate, the higher the probability of default

To compute WAC,

1. Compute the percentage value of each mortgage or debt instrument in the portfolio
   - **Just like under WAM**, this is done by adding together the current principal values of all the mortgages and then calculating the percentage of each mortgage in comparison to the total value.
2. Multiply each percentage by the gross interest rate of the mortgage
3. Add together the subtotals

Factors that Determine the Value of a MBS (3/3)

Prepayment Rate

- **Prepayments speed up principal repayments** and also **reduce the amount of interest paid** over the life of the mortgage. Thus, they can adversely affect the amount and timing of cash flows to MBS investors.
- Markets have adopted two main benchmarks that are used to track prepayment risk - the **conditional prepayment rate** (CPR) and the **Public Securities Association** (PSA) prepayment benchmark

CPR

PSA

Factors that Determine the Value of a MBS (3/3)

Prepayment Rate

Conditional Prepayment Rate

- The CPR is a proportion of a loan pool's principal that is **assumed to be paid off ahead of time in each period**.
- It is always **expressed as a percentage, compounded annually**.
  - For example, a 5% CPR means that **5%** of the pool's outstanding loan balance pool is likely to **prepay over the next year**.
- It is estimated based on **historical prepayment rates for past loans** with similar characteristics as well as future economic prospects.
- The CPR can be converted to a **single monthly mortality rate** (SMM) as follows:

$$\mathbf{SMM = 1 - (1 - CPR)^{\frac{1}{12}}}$$

Factors that Determine the Value of a MBS (3/3)

Prepayment Rate

Public Securities Association (PSA) Prepayment Benchmark

- The PSA is based on the assumption that rather than remaining constant, the **monthly repayment rate gradually increases as a mortgage pool ages**.
  - The PSA is expressed as a **monthly series** of CPRs.

- The model assumes that:
  i. **CPR = 0.2%** for the first month after origination, increasing by 0.2% every month up to 30 months; and
  ii. **CPR = 6%** for months 30 to 360.

Factors that Determine the Value of a MBS (3/3)

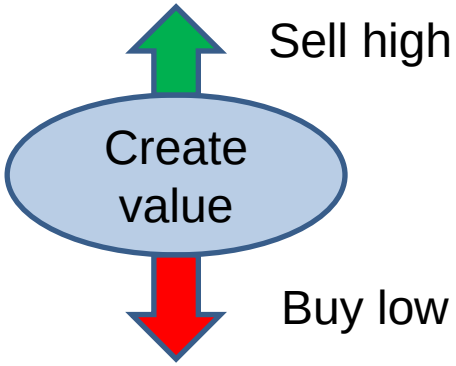
Prepayment Rate

Public Securities Association (PSA) Prepayment Benchmark

- A mortgage pool whose prepayment speed (experience) is in line with the assumptions of the PSA model is said to be **100% PSA**.
- Similarly, a pool whose prepayment experience **is 1.5 times the CPR** under the PSA model is said to be **150% PSA** (or 150 PSA).

Dollar Roll (1/2)

- A dollar roll transaction is a form of repurchase agreement in which an investor sells a mortgage-backed security during one period, called the "**front month**," and repurchases it in a subsequent period, called the later or "**back month**."
- In so doing, the investor relinquishes their access to the principal and interest on the loan that is sold. However, the investor **receives cash from the sale** which could be reinvested and used to purchase the security later.
- The aim of the investor is to **capitalize on a drop in price of the MBS** by "selling high and buying low."



Dollar Roll (2/2)

- The trade counterparty benefits in that they **do not have to deliver the MBS in the current month** and thus get to **keep the principal and interest payments** that would otherwise be passed through to the holder of those securities.
  - A dollar roll works much like **selling stocks short**.
- The price difference between the front month and the back month is known as the **drop**. When the drop is significant, the dollar roll is said to be "**on special**."
- The size of the drop is influenced by:
  i. Demand for mortgage pass-through securities
  ii. Holding period (period between the two settlement dates)
  iii. Funding cost in the repo market
  iv. The volume of mortgage closings in a mortgage originator's pipeline.

Monte Carlo Simulation

- A popular method for valuing MBSs is called the Monte Carlo Methodology.
- A simulation creates **thousands of interest paths** that the MBS could follow over its life. The process recognizes the fact that there is a probability distribution of the possible outcomes of a MBS.
  - Interest rates **impact repayments** and will therefore i**mpact the amount and timing of cash flows** to the investor.
- The steps involved:
  1. Simulate short-term interest rate and refinancing rate paths;
  2. Project the cash flow on each interest rate path;
  3. Determine the present value of the cash flows on each interest rate path;
  4. Compute the theoretical value of the mortgage security.

Option Adjusted Spread (1/2)

- When modeling the value of a mortgage backed security, the option-adjusted spread (OAS) is the **spread that, when added to all the spot rates** of all the interest rate paths will **make the average present value of the paths equal to the actual observed market price plus accrued interest.**
  - In other words, we purpose to find a **single spread** such that shifting the paths of short term rates by that spread results in a **model value equal to the market price**.
- Mathematically, OLS is determined by the following relationship:

$$\boldsymbol{Market\ price} = \frac{\mathbf{PV[path(1)]} + \mathbf{PV[path(2)]} + \cdots + \mathbf{PV[path}(\boldsymbol{n})\mathbf{]}}{\boldsymbol{n}}$$

- The OAS is determined **iteratively** (repeated cycle of operations)**.**

Option Adjusted Spread (2/2)

- OAS is a **byproduct of Monte Carlo simulation**, not the traditional value approaches used to value options. This makes it have several limitations:

It is **dependent on some type of a prepayment model**, e.g., the PSA model. As established earlier, most of these models are based on **historical data** which may not always reconcile with actual future results

It is subject to all **modeling risks** associated with simulation.

The process of adjusting interest rate paths is subject to **modeling error**.

OAS **assumes** that the **investor holds the securities to maturity** while in reality, most investors hold securities for a finite period

MORTGAGES AND MORTGAGE-BACKED SECURITIES

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