Mortgage-Backed Securities

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Mortgages and MBS

- Mortgage Loans
- Pass-throughs and Prepayments
- CMOs
- Analysis of MBS Pricing and Convexity
Structure of the US MBS Market

Mortgage Loan
Bank (mortgage originator) makes a whole loan
Ancillary: brokers, servicers, insurers

Mortgage Pass-Through
FNMA or GMAC (conduit) pools mortgage loans with similar characteristics

CMO or REMIC
Takes a mortgage pool and makes the cash flows more predictable by assigning priority of claims to the cash flows

MBS Portfolio
Institutional investor evaluates risk/return behavior of mortgage-backed securities through option-adjusted price and spread analysis

Mortgage Strips
Interest-Only and Principal-Only

US Mortgage-Backed Securities

AGENCY PASS-THROUGHS
INTEREST
PRINCIPAL
PREPAYMENT
GRANTOR TRUST STRUCTURE

PRIVATE-LABEL PASS-THROUGHS
INTEREST
PRINCIPAL
PREPAYMENT
GRANTOR TRUST STRUCTURE

Credit enhancement:
- Corp g’tee
- L/C
- Insurance (FSA)
- Senior/sub debt
Mortgage-Backed Securities

Mortgage-backed securities are prepayable, so one cannot measure returns or values easily.

They tend to pay down early when rates fall, and later when rates rise.
**Mortgage Prepayments**

Complexity of the option -

- **Systematic risk:** exercise of the interest rate option
- **Unsystematic risk:** reasons unrelated to mortgage interest rates (e.g., demographic)

**Mortgage Pool Prepayment Conventions**

Traditional method is to forecast prepayments by adjusting the PSA (Public Securities Association) benchmark of a prepayment rate that reaches 6% a year for 30 year mortgages.

**Annual prepayment rate (CPR):**

100% PSA:
- If $t \leq 30$, $CPR = 6% \times t / 30$
- If $t > 30$, $CPR = 6$

170% PSA:
- If $t \leq 30$, $CPR = 170% \times [6% \times t / 30]$
- If $t > 30$, $CPR = 170% \times [6%]$

**Monthly prepayment rate (SMM):**

SMM = $[1 - (1 - CPR)] / 12$

**Prepayment amount in dollars:**

$= (\text{Beginning Principal Balance} - \text{Scheduled Principal Repayment}) \times \text{SMM}$
Prepayment Assignment

- Consider a $100,000 10-year, 9% mortgage loan, with monthly equal payments.
- Make the following calculations, using a computer spreadsheet or financial calculator:
  1. What are the scheduled monthly payments?
  2. After 1 month and 3 months,
     - What is the CPR and SMM, assuming 200% PSA?
     - What is scheduled principal payment?
     - If it pays down at 200% PSA, what is the prepayment amount?
     - What is the remaining principal balance?

CMOs and Strips

The technique:
- Allocate cash flows (interest & principal) of MBS to mitigate prepayment risk
- Pay different returns based on risk
- The sum of the part should be worth more than the whole alone.

Example: MDC Series J CMO with underlying pool WAC 9.5%, 297 months final maturity
CMOs and Strips

- First.priority classes
- Z-class: last to be paid off
- Floating/inverse floating CMOs
- Planned Amortization Class bonds (PACs) and TACs
- Companions with priority schedules (PAC IIs)
- VADM bonds (use early principal and interest to pay priority bondholders)
- CMO residuals (collateral interest - CMO interest)
- IOs and POs

The Negative Convexity of MBS

Securities backed by fixed-rate mortgages have "negative convexity." This refers to the fact that when interest rates rise, the MBS behave like long-term bonds (their prices fall steeply); but when rates fall, their prices rise slowly or not at all.

Price-yield curve of 20 year bond callable in 3 years
**Convexity of Callables**

Mortgage-backed securities and other callable bonds may have negative convexity which cushions a bond’s price rise and accelerates its fall!

<table>
<thead>
<tr>
<th>PRICE</th>
<th>YIELD</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td></td>
</tr>
<tr>
<td>102</td>
<td></td>
</tr>
</tbody>
</table>

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**MBS:**

*Fannie Mae REMIC Pass-Throughs*

- What are the underlying mortgage pools?
- Look at different asset groups:
- Yields on different classes
- Price risks on each class
- What do the seller & servicer gain?

*Group work*
Bond Valuation
Duration and Convexity

Bond Valuation

The formula for a bond's price is

\[ B_0 = Ix(PVIFA_{k,n}) + Mx(PVIF_{n}) \]

\[ B_0 = \sum_{t=1}^{n} \frac{I}{(1+k)^t} + \frac{M}{(1+k)^n} \]
Treasury Notes and Bonds as quoted in the Wall Street Journal

<table>
<thead>
<tr>
<th>Rate</th>
<th>Maturity, Mo/Yr</th>
<th>Bid Asked</th>
<th>Ask Yld.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Dec 97</td>
<td>99:29 99:31</td>
<td>6.01</td>
</tr>
</tbody>
</table>

- When US Government bonds are stripped, the coupons and principal are separated out and sold as individual zero-coupon instruments.
- Investment banks create Strips when the total can be sold for more than the cost of the bond.

Price Risk of Treasuries

Treasuries differ:
- Liquidity - traders quote wider bid-ask spreads for illiquid bonds
- Duration - sensitivity of price to a change in interest rates - is based on the bond’s coupon levels and maturity date (low duration means less risky)
- Convexity - measures how duration changes with a change in rates (high convexity is desirable)
The Price-Yield Relationship

Bond prices and interest rates have an inverse relationship:

- Selling at a discount is when a bond sells for less than its par value (i.e., the quote is <100)
- Selling at premium is when a bond sells for more than its par value (i.e., the quote is >100)
**Maturity**

In general, the longer the maturity, the more sensitive is a bond's price to interest-rate changes, other things being equal:

<table>
<thead>
<tr>
<th>Price</th>
<th>Required yield</th>
<th>9%, 5 year</th>
<th>9%, 25 year</th>
<th>8%</th>
<th>104.0554</th>
<th>110.7510</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>9%, 5 year</td>
<td>9%, 25 year</td>
<td>9%</td>
<td>100.0000</td>
<td>100.0000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9%</td>
<td>9%</td>
<td>10%</td>
<td>96.1391</td>
<td>90.8720</td>
</tr>
</tbody>
</table>

**The Coupon Effect...**

But three bonds with the same maturity can have very different sensitivities, depending on their coupon levels:

<table>
<thead>
<tr>
<th>Price</th>
<th>Required yield</th>
<th>9%, 5 year</th>
<th>6%, 5 year</th>
<th>0%, 5 year</th>
<th>8%</th>
<th>104.05</th>
<th>91.88</th>
<th>67.56</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>9%, 5 year</td>
<td>6%, 5 year</td>
<td>0%, 5 year</td>
<td>9%</td>
<td>100.00</td>
<td>88.13</td>
<td>64.39</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9%</td>
<td>6%</td>
<td>0%</td>
<td>10%</td>
<td>96.13</td>
<td>84.56</td>
<td>61.39</td>
</tr>
</tbody>
</table>
**Duration**

Duration measures the % price change for a given change in yield:

![Graph showing the relationship between price and yield with a downward sloping line indicating the price change for a given rise in yield.]

The steeper the line, the more the price falls for a given rise in yield.

**Greater Duration, Greater Risk**

Duration is measured as the PV-weighted average life, so low-coupon bonds have greater duration.

![Graph showing three lines representing different bonds (9% bond, 6% bond, 0% bond) and their respective price changes at different yields.]

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Mortgage-Backed Securities
Calculating Duration:
MacCauley and Modified

\[ D_{MAC} = \sum_{t=1}^{n} \frac{tCF_t}{(1 + r)^t} \]

\[ D_{MOD} = \% \Delta P = \frac{dP}{P} = -\frac{D}{(1 + r)} \]

Assignment

For a 2-year, semiannual bond with a coupon rate of 10% and a yield of 8%:

- Find the price sensitivity for a 10bp rise and fall of the yield
- Find the price sensitivity for a 100bp rise and fall of the yield
- Find the duration.
### Duration: An Excel Spreadsheet

<table>
<thead>
<tr>
<th>Yield</th>
<th>8.0%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bond A</strong></td>
<td></td>
</tr>
<tr>
<td>Time (year)</td>
<td>0.5</td>
</tr>
<tr>
<td>Cash-Flows</td>
<td>5</td>
</tr>
<tr>
<td>PV of CFs</td>
<td>4.80769</td>
</tr>
<tr>
<td>Price</td>
<td>103.63</td>
</tr>
<tr>
<td>Weighted CFs</td>
<td>5</td>
</tr>
<tr>
<td>PV of weighted CFs</td>
<td>4.80769</td>
</tr>
<tr>
<td>Sum of weight. CFs</td>
<td>386.406</td>
</tr>
<tr>
<td>Semiannual duration</td>
<td>3.72871</td>
</tr>
<tr>
<td><strong>Macaulay duration</strong></td>
<td>1.86436</td>
</tr>
<tr>
<td>Modified</td>
<td>1.72626</td>
</tr>
</tbody>
</table>

### Bond Price Changes: Actual vs. Duration-Based

There's an error in duration-based estimation, because duration is linear.
**Bond Price Changes: Actual vs. Duration-Based**

There’s an error in duration-based estimation, because duration is linear.

![Graph showing actual price vs. duration-based price with an error indicator.]

**Convexity**

Convexity, or curvature, helps correct duration’s mispricing. Because duration itself changes, we need a measure of the price change due to a change in duration. This is the second derivative of the price change, annualized and divided by the price:

\[
CONV = \left[ \frac{mC}{y} \left(1 - \frac{1}{1+y} \right) - \frac{mCn}{y} \frac{n(n+1)(100 - C/y)}{n+2} \right]^{1/2} \frac{1}{P}
\]

where \(C\) is the coupon, \(m\) the frequency, \(n\) the maturity and \(n\) the yield.
**Convexity**

<table>
<thead>
<tr>
<th>Yield</th>
<th>0.08</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bond A</strong></td>
<td></td>
</tr>
<tr>
<td>Time (year)</td>
<td>0.5</td>
</tr>
<tr>
<td>Cash-Flows</td>
<td>4</td>
</tr>
<tr>
<td>PV of CFs</td>
<td>3.84615</td>
</tr>
<tr>
<td>Price</td>
<td>100</td>
</tr>
<tr>
<td>CFs.t.(t+1)</td>
<td>8</td>
</tr>
<tr>
<td>Above/(1+y)^(t+2)</td>
<td>7.11197</td>
</tr>
<tr>
<td>Second Derivative</td>
<td>1710.93</td>
</tr>
<tr>
<td>Semiannual Convexity</td>
<td>17.1093</td>
</tr>
<tr>
<td>convexity (years)</td>
<td>4.27733</td>
</tr>
</tbody>
</table>

**Convexity: The Change in Duration**

The percentage price change in a bond can be approximated using both duration and convexity.

![Diagram showing the relationship between price, yield, and convexity](image)
An Example

<table>
<thead>
<tr>
<th>BOND A</th>
<th>BOND B</th>
<th>APPROXIMATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coupon</strong></td>
<td>10.00%</td>
<td><strong>Coupon</strong></td>
</tr>
<tr>
<td><strong>Face value</strong></td>
<td>100</td>
<td><strong>Face value</strong></td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>2</td>
<td><strong>Frequency</strong></td>
</tr>
<tr>
<td><strong>Maturity</strong></td>
<td>2</td>
<td><strong>Maturity</strong></td>
</tr>
<tr>
<td><strong>Yield</strong></td>
<td>7.90%</td>
<td><strong>Yield</strong></td>
</tr>
<tr>
<td><strong>Price</strong></td>
<td>103.816</td>
<td><strong>Price</strong></td>
</tr>
<tr>
<td>Macaulay Dur</td>
<td>1.864</td>
<td>Macaulay Dur</td>
</tr>
<tr>
<td>Modified Dur</td>
<td>1.794</td>
<td>Modified Dur</td>
</tr>
<tr>
<td>Dollar Dur</td>
<td>186.209</td>
<td>Dollar Dur</td>
</tr>
<tr>
<td>Convexity</td>
<td>437.122</td>
<td>Convexity</td>
</tr>
<tr>
<td>Dollar Conv</td>
<td>4.211</td>
<td>Dollar Conv</td>
</tr>
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Positive convexity is desirable, because it cushions a bond's price fall and accelerates its rise.
**Convexity of Callables**

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**MBS: Fannie Mae**

- What is the underlying mortgage pool?
- Look at different classes:
- Who is repaid when
- Yields on different classes
- Price risks on each class

**Group work**
Case Study: Dah Sing

- What is the underlying mortgage pool?
- Who plays what role in the deal?
- Sketch the relationships and flows between the parties
- Why did it make sense for Dah Sing Bank?

Group work

Case Study: Harbour City

- What is the underlying mortgage pool?
- Who plays what role in the deal?
- Sketch the relationships and flows between the parties
- Why did it make sense for the bank?

Group work