Interest Rate Risk

• FIs (financial institutions or intermediaries) face two core risks
  – financial
  – strategic
• Interest rate risk: changes in the term structure of interest rates (graph of time value of money)
  – Federal Reserve monetary policy
  – repricing model
  – criticisms and alternatives
Future and Present Value

Today's Value of a Lump Sum or Stream of Cash Payments Received at a Future Point in Time

\[ FV_T = PV \times (1 + r)^T \]

\[ PV = \frac{FV_T}{(1 + r)^T} \]

Time Value of Money

- Present value \( PV = CF_t/(1+r)^t \)
- Future value \( FV = CF_t(1+r)^t \)
- Net present value \( NPV = \text{sum of all PV} \)

\[
PV = \sum_{t=1}^{4} \frac{5}{(1+r)^t} + \frac{105}{(1+r)^5}
\]
Bond/Loan Pricing

Level-coupon (fixed-rate) bond \[ PV = \sum_{t=1}^{T} \frac{C_t}{(1 + r)^t} \]

Zero coupon bond \[ \text{Price}_0 = \frac{1000}{(1 + r)^T} \]

Term structure of interest rates \[ PV = \sum_{t=1}^{T} \frac{C_t}{(1 + r_t)^t} \]

With accrued interest: \[ P_r = \sum_{t=1}^{n} \frac{C_t}{(1 + r)^v (1 + r_t)^{v-1}} \]
\[ v = \frac{\text{days between settlement and next coupon}}{\text{days in six months period}} \]

Price-Yield Relationship

- Price and yield (of a straight bond) move in opposite directions.
Interest Rates and Net Worth

• FIs exposed to risk due to maturity mismatches between assets and liabilities
  – banks are either lenders or borrowers
  – interest-rate exposure on both sides of B/S
  – consequence:

• Interest-rate changes can have severe adverse impact on net worth: mismatches
  – thrifts, during 1980s
Level & Movement of Interest Rates

• Federal Reserve Bank: U.S. central bank
  – FRB sets monetary policy
  – controls which rate?
  – conducts monetary policy how?
• Open market operations influence money supply, inflation, and interest rates
• Actions of Fed (December, 2008) in response to economic crisis
  – Target rate between 0.0 and ¼ percent
Central Bank and Interest Rates

- Target is primarily short term rates
  - Focus on Fed Funds Rate in particular
- Interest rate changes and volatility increasingly transmitted from country to country
  - Witness EU and Eurozone
  - Fed actions can have dramatic effects on world interest rates

Repricing Model

- Rate sensitivity means time to repricing
  - Net interest income
- Repricing gap is the difference between the
  - Accounting rate sensitivity of each asset and the rate sensitivity of each liability: RSA - RSL
- Refinancing risk
  - But does it really measure refinancing risk?
Maturity Buckets

- Commercial banks must report repricing gaps for assets and liabilities with maturities of:
  - One day
  - More than one day to three months
  - More than three months to six months
  - More than six months to twelve months
  - More than one year to five years
  - Over five years

- Discretizing much more exact approaches

### Repricing Gap Example

<table>
<thead>
<tr>
<th></th>
<th>Assets</th>
<th>Liabilities</th>
<th>Gap</th>
<th>Cum. Gap</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-day</td>
<td>$20</td>
<td>$30</td>
<td>-10</td>
<td>-10</td>
</tr>
<tr>
<td>&gt;1day-3mos.</td>
<td>30</td>
<td>40</td>
<td>-10</td>
<td>-20</td>
</tr>
<tr>
<td>&gt;3mos.-6mos.</td>
<td>70</td>
<td>85</td>
<td>-15</td>
<td>-35</td>
</tr>
<tr>
<td>&gt;6mos.-12mos.</td>
<td>90</td>
<td>70</td>
<td>+20</td>
<td>-15</td>
</tr>
<tr>
<td>&gt;1yr.-5yrs.</td>
<td>40</td>
<td>30</td>
<td>+10</td>
<td>-5</td>
</tr>
<tr>
<td>&gt;5 years</td>
<td>10</td>
<td>5</td>
<td>+5</td>
<td>0</td>
</tr>
</tbody>
</table>
Repricing Model: Example 1

\[ \Delta NII_i = (GAP_i) \Delta R_i = (RSA_i - RSL_i) \Delta R_i \]

• Individual gap: particular bucket
  In the one day bucket, gap is -$10 million. If rates rise by 1%,

\[ \Delta NII_{(1)} = (-$10 \text{ million}) \times .01 = -$100,000 \]

Repricing Model: Example 2

• Cumulative gap

If we consider the cumulative 1-year gap,

\[ \Delta NII = (CGAP) \Delta R = (-$15 \text{ million})(.01) = -$150,000 \]
Rate-Sensitive Assets

- Short-term consumer loans. If repriced at year-end, would just make one-year cutoff
- Three-month T-bills repriced on maturity every 3 months
- Six-month T-notes repriced on maturity every 6 months
- 30-year floating-rate mortgages repriced (rate reset) every 9 months

Rate-Sensitive Liabilities

- RSLs bucketed in same manner as RSAs
  - same instruments
  - but: different position
- Demand deposits and passbook savings accounts warrant special mention
  - generally considered rate-\textit{insensitive} (act as core deposits), but
  - there are arguments for their inclusion as rate-sensitive liabilities
CGAP Ratio: Cumulative Gap

• May be useful to express CGAP in ratio form as CGAP/Assets
  – Provides direction of exposure and
  – Scale of the exposure
• Example:
  – CGAP/A = $15 million / $270 million = 0.56, or 5.6 percent

Equal Rate Changes on RSAs, RSLs

• Example: Suppose rates rise 2% for RSAs and RSLs. Expected annual change in NII,
  \[ \Delta \text{NII} = \text{CGAP} \times \Delta R \]
  \[ = 15 \text{ million} \times .01 \]
  \[ = 150,000 \]
• With positive CGAP, rates and NII move in the same direction
• Change proportional to CGAP
  – but how do yields typically change?
Unequal Changes in A&L Rates

• Yield curve: Term Structure of Interest Rates
  – short rates more volatile than long rates
  – rising rates: yield curve flattens
  – falling rates: yield curve steepens
• If changes in rates on RSAs and RSLs are not equal, the spread changes
  – in this case, still parallel shift but A&L rates differ
  \[ \Delta NII = (RSA \times \Delta R_{RSA}) - (RSL \times \Delta R_{RSL}) \]

Unequal Rate Change Example

• Spread effect example:
  RSA rate rises by 1.2% and RSL rate rises by 1.0%

  \[ \Delta NII = \Delta \text{ interest revenue} - \Delta \text{ interest expense} \]
  \[ = ($155 \text{ million } \times 1.2\%) - ($155 \text{ million } \times 1.0\%) \]
  \[ = $310,000 \]
Restructuring Assets & Liabilities

• FI can restructure assets and liabilities to benefit from projected interest rate changes
  – on or off the balance sheet: sell and buy, or
  – pricing and terms of products: steer customers

• What does a FI need to strive for?
  – Positive gap: increase in rates increases NII
  – Negative gap: decrease in rates increases NII

Restructuring the Gap

• Example: Harleysville Savings Financial Corporation at the end of 2008
  – One year gap ratio was 1.45 percent
  – Three year gap ratio was 3.97 percent
  – If interest rates rose in 2009, it would experience large increases in net interest income

• What were they betting on? What happened?
• Commercial banks recently reducing gaps to decrease interest rate risk
Weaknesses of Repricing Model

- Ignores market value effects of rate changes
- Overaggregative
  - Distribution of assets & liabilities within individual buckets is not considered
  - Mismatches within buckets can be substantial
- Ignores effects of runoffs: reinvestment risk
  - Bank continuously originates and retires consumer and mortgage loans
  - Runoffs may be rate-sensitive

Off-Balance Sheet Issues

- Off-balance-sheet items are not included
  - Hedging effects of off-balance-sheet items not captured
  - Example: Futures contracts
- But: a lot of smaller FIs bet on interest rates
  - off-balance sheet: regulatory avoidance
- Repricing does not capture income effects
Maturity of Portfolio

- Maturity of portfolio of assets (liabilities)
  - weighted average of maturities of individual components of the portfolio
- Maturity effects apply to portfolio as well as to individual assets or liabilities
- Typically, maturity gap, $M_A - M_L > 0$ for most banks and thrifts
  - sign of what function of FIs?

Effects of Interest Rate Changes

- Size of the gap determines the size of interest rate change that would drive net worth to zero
- Immunization and effect of setting
  \[ M_A - M_L = 0 \]
Maturity Model

• Leverage also affects ability to eliminate interest rate risk using maturity model
  – Assets: $100 million in one-year 10-percent bonds, funded with
  – Liabilities: $90 million in one-year 10-percent deposits (and equity)
• Maturity gap is zero but exposure to interest rate risk is not zero.

Repricing Model

• Repricing or funding gap model based on book value: difference between
  – interest income and expense: measures what?
  – outdated but unfortunately widespread: small Fis
  – book- not market-value based: meaningless
• Market value-based models: Bank for International Settlements (BIS)
  – maturity and duration models
The Maturity Model

- Explicitly incorporates market value effects
  - maturity as a rough indicator of interest rate risk
- For fixed-income assets and liabilities:
  - Rise (fall) in interest rates leads to fall (rise) in market price
  - The longer the maturity, the greater the effect of interest rate changes on market price
  - Fall in value of longer-term securities increases at diminishing rate for given increase in interest rates

### 8% Coupon Bond

<table>
<thead>
<tr>
<th>Yield to Maturity</th>
<th>T=1 yr.</th>
<th>T=10 yr.</th>
<th>T=20 yr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>8%</td>
<td>1,000.00</td>
<td>1,000.00</td>
<td>1,000.00</td>
</tr>
<tr>
<td>9%</td>
<td>990.64</td>
<td>934.96</td>
<td>907.99</td>
</tr>
<tr>
<td>Price Change</td>
<td>0.94%</td>
<td>6.50%</td>
<td>9.20%</td>
</tr>
</tbody>
</table>

### Zero Coupon Bond

<table>
<thead>
<tr>
<th>Yield to Maturity</th>
<th>T=1 yr.</th>
<th>T=10 yr.</th>
<th>T=20 yr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>8%</td>
<td>924.56</td>
<td>456.39</td>
<td>208.29</td>
</tr>
<tr>
<td>9%</td>
<td>915.73</td>
<td>414.64</td>
<td>171.93</td>
</tr>
<tr>
<td>Price Change</td>
<td>0.96%</td>
<td>9.15%</td>
<td>17.46%</td>
</tr>
</tbody>
</table>
Maturities and Interest Rate Exposure

- If $M_A - M_L = 0$, is the FI immunized?
  - Liabilities: 1Y zero coupon bond with face value $100.
  - Assets: 1Y loan, which pays back $99.99 shortly after origination, and 1¢ at the end of the year.
  - Both have maturities of 1 year.
- Not immunized,
  - although maturity gap equals zero
- Reason: Differences in duration – coming soon

Duration

- The average life of an asset or liability
  - also: its interest-rate (yield) sensitivity
- Definition: the weighted-average time to maturity
  - using present value of the cash flows, relative to
  - the total present value of the asset or liability as weights
Summary

• Introduction to interest-rate risk
  – repricing model
  – maturity model
• Widespread but not very helpful:
  – duration: market based DCF approach
  – properly measures interest-rate exposure
• Why do we treat small and large FIs differently?  
  – business model
  – regulatory fragmentation, political economy

Appendix: Yield Curves

• Yield curves: graphical representations of TVM as determined in FI markets
• Typical Shapes
• Typical explanations: hypotheses
  – expectations
  – liquidity
  – segmentation
Unbiased Expectations Theory

- Yield curve reflects market’s expectations of future short-term rates
- Long-term rates are geometric average of current and expected short-term rates

\[ (1 + R_N)^N = (1 + R_1)[1 + E(r_1)] \ldots [1 + E(r_N)] \]
Liquidity Premium Theory

- Allows for future uncertainty
- Premium required to hold long-term
  - impatience
  - risk
  - inflation

Market Segmentation Theory

- Investors have specific needs in terms of maturity
  - clientele effects
- Yield curve reflects intersection of demand and supply of individual maturities
Web Resources

- For information related to central bank policy, visit:
  Bank for International Settlements
  www.bis.org
  Federal Reserve Bank
  www.federalreserve.gov