Offshore Financial Markets
The Eurobond Market

BONDS

MS&E 247S International Investments
Yee-Tien Fu
The Eurobond market is the market for long-term debt instruments issued and traded in the offshore market. Like the Eurocurrency market, the necessary condition for the development of a Eurobond market is differences in national regulations. Increasing capital mobility and greater ease in telecommunications have provided the sufficient conditions, allowing the Eurobond market to flourish.

From a base of zero in the late 1950s, the Eurobond market has grown to an annual volume of new issues that often nears or surpasses the annual volume of new US corporate bond issues. Through regulatory differences as well as innovations in market processes and product offerings, the Eurobond market has carved out an important niche in the international capital market providing benefits to investors and borrowers – and on occasion profits to the parties who intermediate the transactions.

Similar to the Eurocurrency market, the Eurobond market is in effect a parallel market, but one that has not put its chief rivals – the onshore markets for domestic and foreign bonds – out of business. A Eurobond was once defined as a debt instrument (1) underwritten by an international syndicate, and (2) offered for sale immediately in a number of countries.

A Eurobond is usually denominated in a currency (or unit of account) that is foreign to a large number of buyers. A domestic bond is an obligation of a domestic issuer that is underwritten by a syndicate of domestic investment banks, denominated in domestic currency, and offered for sale in the domestic market. A foreign bond is similar to a domestic bond except that the issuer of the foreign bond is a foreign entity, which may be beyond the legal reach of investors in the event of default.

The definition of a “domestic” or “foreign” bond that we adopt comes from the nationality of the issuer in relation to the marketplace. The term foreign may lead to some confusion in this context. A US$ bond issued in the United States by General Motors and a ¥ bond issued in Japan by Toyota are both domestic bonds from the standpoint of the regulations that govern their initial offering and secondary market trading.

From the investor perspective, Americans (Japanese) would view the Toyota (General Motors) bond as “foreign” in the sense that investment is denominated in a foreign currency and traded in a foreign marketplace. Foreign currency denominated bonds play an important role in international portfolio diversification. Particular segments of the foreign bond market (as defined from the issuer perspective) sometimes take on colorful names.
**Introduction**

For example, US$ obligations of non-US firms that are underwritten and issued in the US market are called Yankee bonds. Japanese yen obligations of non-Japanese firms that are underwritten and issued in the Japanese market are called Samurai bonds. And British pound sterling obligations of non-UK firms that are underwritten and issued in the UK market are called Bulldog bonds.

These names and others have proliferated along with the development of international financial markets.

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**Comparative Characteristics of Bond Issues in the International Bond Market**

<table>
<thead>
<tr>
<th></th>
<th>U.S. Market</th>
<th>Non-U.S. Market</th>
<th>Eurobond Market</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulatory Bodies</td>
<td>Securities and Exchange Commission</td>
<td>Official agency approval</td>
<td>Minimum regulatory control</td>
</tr>
<tr>
<td>Disclosure requirements</td>
<td>More detailed</td>
<td>Variable</td>
<td>Determined by market practices</td>
</tr>
<tr>
<td>Issuing costs</td>
<td>0.75-1.00%</td>
<td>Variable to 4.0%</td>
<td>2.0-2.5%</td>
</tr>
<tr>
<td>Rating requirements</td>
<td>Yes</td>
<td>Usually not</td>
<td>No, but commonly done</td>
</tr>
</tbody>
</table>

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**Eurobond Underwriting**

A Eurobond offering brings together the bond issuer and the bond investor.

The supply side (the issuer) and the demand side (the investor) are brought together by intermediaries that fulfill some or all of the following services: lead management, underwriting, and bond sales.
Underwriting risk reflects the possibility that the sales price of the bonds may not match the price promised to the issuer.

In other words, if the manager commits to raise $100 million in a seven-year bond issue with 8 percent annual coupons, she must provide this amount even if investors are willing to pay only $98 million for the bonds.

A sudden rise in interest rates, a decline in the issuer’s credit quality, or a shift away from US$-denominated investments are but three examples of underwriting risks.

Eurobond Underwriting

Four Types of Market

direct search, brokered, dealer, auction markets

A direct search market is the least organized market -- buyers and sellers must seek each other out directly (e.g., the sale of a used refrigerator).

In markets where trading in a good is sufficiently active, brokers can find it profitable to offer search services to buyers and sellers (e.g., real estate market).

An important brokered investment market is the so-called primary market, where new issues of securities are offered to the public. In the primary market investment bankers act as brokers.

Four Types of Market

direct search, brokered, dealer, auction markets

When trading activity in a particular type of asset increases, dealer markets (e.g., over-the-counter securities market) arise.

Dealers specialize in various assets, purchasing them for their own inventory and selling them for a profit from their inventory.

Dealers, unlike brokers, trade assets for their own accounts. The dealer’s profit margin is the “bid-asked” spread.

Four Types of Market

direct search, brokered, dealer, auction markets

The most integrated market is an auction market, in which all transactors in a good converge at one place to bid on or offer a good.

The New York Stock Exchange (NYSE) is an example of an auction market.

An advantage of auction markets over dealer markets is that one need not search to find the best price of a good.

Many assets trade in more than one type of market.

Eurobond Underwriting

A diagram of a typical Eurobond offering is shown in Figure 10.4.

The “management group” organizes most of the activities related to the initial bond offering. The group meets with the issuer to design the bond issue – issue size, currency, maturity, coupon, and so forth – and assembles other firms (labeled “underwriters”) to share in the underwriting risks of the issue. Finally, the management group organizes a “selling group” of firms that place the bonds with the ultimate investors in the issue.
Structure of a Eurobond Syndication

A Eurobond offering brings together the bond issuer and investor. The process is facilitated by intermediaries. The lead management group meets with the issuer to design the issue size, currency, maturity, coupon, etc...

Finally, the management group organizes a group of firms to place the bonds with the ultimate investors.

Eurobond Underwriting

In practice, a single firm may play more than one role.

For example, the lead management firm typically bears some of the underwriting risk and often participates in the selling group.

The Gray Market

Excess competition => bonds decline in value in the aftermarket

In the 1970s, firms started to sell their allotment of bonds forward for delivery on a when-issued basis.

Once a bond issue was announced, a selling firm might decide to sell the bond immediately (for forward delivery) at 98 or 99% of par.

The practice of trading in Eurobonds on a when-issued basis, called the gray market or premarket, began with prices circulated over telephone lines. Then prices were published in newsletters and circulated across market participants.

This strategy would hedge the selling firm against further price declines but still allow the firm to participate in the syndicate, to appear in the tombstone announcing the deal, and to stay in good standing with the lead manager for the next deal.

Weyerhauser Capital Corp. NV (1983)

<table>
<thead>
<tr>
<th>Amount</th>
<th>US$60 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maturity</td>
<td>7 years (due Nov. 15, 1990)</td>
</tr>
<tr>
<td>Coupon</td>
<td>11.5%</td>
</tr>
<tr>
<td>Issue price</td>
<td>100</td>
</tr>
<tr>
<td>Fixed reoffer price</td>
<td>N.A.</td>
</tr>
<tr>
<td>Listing</td>
<td>Luxembourg Stock Exchange</td>
</tr>
<tr>
<td>Total commission</td>
<td>1.875%</td>
</tr>
<tr>
<td>Management &amp; underwriting fees</td>
<td>0.625%</td>
</tr>
<tr>
<td>Selling concession</td>
<td>1.25%</td>
</tr>
<tr>
<td>Lead manager</td>
<td>Morgan Stanley International</td>
</tr>
<tr>
<td>Gray market price</td>
<td>Minus 1.5 to 1.25</td>
</tr>
<tr>
<td>Market commentary</td>
<td>“A fairly priced deal, say traders…”</td>
</tr>
</tbody>
</table>
Weyerhauser Capital Corp, NV (1983)
The bond was issued at par (100), but it traded in the gray market at a discount of 1.25 - 1.50 percent below par.
In the row marked “total commission,” we see that the selling concession (the amount of fees allocated to a member of the selling group) was 1.25 percent.
Thus, a European trader was willing to give up his or her entire selling concession, or a bit more, to make a sale in the gray market. This bond was apparently overpriced at par, but “fairly priced” at its gray market discount.

Osaka Gas (1993)
Amount US$250 million
Maturity 5 years (due May 26, 1998)
Coupon 5.75%
Issue price 101.489
Fixed reoffer price 99.889
Listing London Stock Exchange
Total commission 1.875%
Management & underwriting fees 0.275%
Selling concession 1.6%
Lead manager Goldman Sachs International
Gray market price 100.25
Market commentary “The issue blew out in 15 minutes, say traders …”

Osaka Gas (1993)
Although the issue price of the bond was 101.489 (percent per par), it was slated for sale initially at 99.889 (percent of par) on a fixed reoffer price basis.
Note that this 1.6 percent difference happened to be the selling concession, so again it appears that the selling group would not profit from a sale at this price.
However, the gray market price (called the premarket price in 1993) was 100.25. Thus, these bonds were apparently in heavy demand, selling for 0.361 more in the gray market than the posted initial offering price.

Another Innovation: Global Bonds
Similar to a Eurobond, a global bond issue is offered for sale in many countries simultaneously. Unlike a Eurobond however, a global bond is a registered security, usually in the US.
Global bonds are held in common depositories (such as Cedel, Euroclear, or Depository Trust Company in the US) that enhance secondary market trading in local markets and between investors in different regions.

Another Innovation: Global Bonds
The global bond strategy is designed for issuers with substantial funding needs who can benefit by reaching the widest possible investor audience.
The size of issue, combined with widespread distribution, and secondary market trading opportunities offers a liquid investment that investors find attractive.

Another Innovation: Global Bonds
The World Bank undertook the first global bond in 1989 with a $1.5 billion issue.
Since then, the global bond structure has been used by other international organizations, public enterprises, and government (sovereign) borrowers.
Global bond offerings totaled $15.4 billion in 1991 (5.0 percent of all international bonds) rising to $49.0 billion in 1994 (11.4 percent of all international bonds).
As a parallel or offshore market, the Eurobond market must offer prices and terms that are advantageous to both issuers and investors to attract them from the traditional onshore markets.

In the Eurocurrency market, we saw that the wide spread between deposit and lending rates gave Eurobanks an opening to compete - offering higher rates to depositors and lower rates to borrowers, and still earning a spread for their intermediation.

The same principle could apply in the Eurobond market.

**Pricing Eurobonds**

Suppose underwriting fees in the US domestic corporate bond market were 2% and our firm issues an 8% coupon bond with a seven-year maturity. After issuing the bond at par ($1,000), our firm receives only $980 after underwriting fees. The cost of funds to the firm on a current-yield basis is 8.16% (= 80/980). The cost over the seven-year period is 8.39%, acknowledging that the firm must repay $1,000 per bond at the end of year 7. The investor earns a current yield and yield-to-maturity of 8%. The effective lending and borrowing spread (for this coupon and maturity bond) is thus 8.00% – 8.39%.

**Pricing Eurobonds**

Suppose now that underwriting fees were only 1% in an offshore market and our firm issues a seven-year bond with a higher 8.05% coupon bond in order to attract an onshore investor. If this bond is issued at par ($1,000), the firm receives $990 after underwriting fees. This makes the cost of funds to the firm on a current basis 8.13% (= 80.5/990). The all-in-cost over the seven-year period is 8.24%. Thus, the effective lending and borrowing spread is 8.05% – 8.24%, more narrow than when underwriting fee were 2%.

**Pricing Eurobonds**

How can both issuers and investors benefit from an offshore market that typically charges higher underwriting fees than in the onshore market? From the issuer’s side, the answer is that underwriting fees are a one-time cost and only part of the total cost. There may be certain cost savings as the Eurobond market often allows firms to issue bonds more quickly and with lower disclosure cost.

**Market Segmentation and the Pricing of Eurobonds**

More important is the ongoing savings that comes from a lower annual interest cost in the Eurobond market than in the onshore market. The Eurobond market has appeared to function as a segmented capital market, where bond prices are determined primarily by Eurobond market participants who give less than full regard to how these bonds would be priced in the onshore market.

**Disclosure**

The submission of facts and details concerning a situation or business operation.

In general, security exchanges and the SEC require firms to disclose to the investment community the facts concerning issues that will affect the firms’ stock prices. Disclosure is also required when firms file for public offerings.
Market Segmentation and the Pricing of Eurobonds

By comparison, in an integrated capital market, a bond with specific terms and conditions would be priced identically by investors in the onshore market and in the Eurobond market. Arbitrage between the onshore and offshore bond markets leads the markets toward integration.

In the case of Eurobond market, it is often suggested that the early years of the market were dominated by smaller, retail investors who evaluated bond prices on different terms than the institutional investors who traded in the onshore markets.

The argument is that these retail investors were less concerned about cryptic issuer ratings and more swayed by “name recognition.” To the extent that these investors willingly paid higher prices for debt securities in the Eurobond market, issuers were offered a price incentive to issue Eurobonds instead of onshore bonds.

Eurobonds and Secrecy

Why would investors sacrifice yield by buying Eurobonds when instead they could purchase essentially identical bonds onshore? The answer relies on the secrecy of the Eurobond market and its implication for taxes.

While essentially all securities in the US are registered securities (with the name of the owner registered on the books of the issuing company), Eurobonds are bearer securities. Possession of a bearer bond is evidence of ownership because the issuer does not maintain a list. A significant fraction of Eurobonds are held in physical form.

A. If you actually get your bid executed, how much will you pay for the bond?

Price is 102% of par or 1,020 per bond; 102%x10%x100 million = $10.20 million for your share of the issue.

Suppose IBM is issuing $100 million in seven-year Eurobonds priced at U.S. Treasury minus 25 basis points. There is great demand for the issue and you are willing to bid 102 for 10 percent of the issue.

A. If you actually get your bid executed, how much will you pay for the bond?
B. A year later, the IBM Eurobonds are traded on the Luxembourg Stock Exchange at 105. What is the value of your investment? What is your capital gains (loss)?
C. You decide to sell the bond at the above price to pursue other opportunities. What amount of withholding taxes are you required to pay?

Suppose two similar seven-year maturity bonds are issued at par, one in the U.S. domestic market and the second in the Eurodollar bond market. Underwriting fees are 2.5 percent in the U.S. market and 1 percent in the Eurobond market.

A. If the U.S. domestic bond has an initial yield of 10%, what is the effective spread between lending and borrowing rates in this market?
B. If the Eurodollar bond has an initial yield of 10.5%, what is the effective spread between lending and borrowing rates in this market?
C. Suppose that the U.S. bond is subject to a withholding tax of 20% on the interest paid. What yield would an investor accept on the Eurobond issue to make him or her indifferent between the two issues?
A. If the U.S. domestic bond has an initial yield of 10%, what is the effective spread between lending and borrowing rates in this market?

In the US bond market, after underwriting fees, the firm raises $975 for a $1,000 US domestic bond issued at par. The firm repays $10 per year for six years and $1,010 in year seven for a yield-to-maturity of 10.52%. The investor earns 10.0% yield-to-maturity for a 7-year bond. The spread is 0.52%.

B. If the Eurodollar bond has an initial yield of 10.5%, what is the effective spread between lending and borrowing rates in this market?

In the Eurodollar bond market, after underwriting fees, the firm gets $990 for a $1,000 US domestic bond issued at par. The firm repays $10.50 per year for six years and $1,050 in year seven for a yield-to-maturity of 10.71%. The investor earns 10.50% yield-to-maturity for a 7-year bond. The spread is 0.21%.

C. Suppose that the U.S. bond is subject to a withholding tax of 20% on the interest paid. What yield would an investor accept on the Eurobond issue to make him or her indifferent between the two issues?

An investor will accept a lower yield in the Eurobond market if he/she does not pay the withholding tax. An 8% yield in the Eurobond market (taken as an after-tax rate) is equivalent to a 10% yield in the US bond market, on a before tax basis and subject to 20% withholding.

Yield to Maturity

• Interest rate that makes the present value of the bond’s payments equal to its price

Solve the bond formula for $r$

\[
P_B = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} + \frac{ParValue}{(1+r)^T}
\]

$P_B$ is the fair price (present value price) of the coupon-bearing bond.

Bond Pricing Theorems

• The following statements about bond pricing are always true.

1. Bond prices and market interest rates move in opposite directions.

2. When a bond’s coupon rate is (greater than / equal to / less than) the market’s required return, the bond’s market value will be (greater than / equal to / less than) its par value.
Bond Pricing Theorems

- The following statements about bond pricing are always true.

3 Given two bonds identical but for maturity, the price of the longer-term bond will change more than that of the shorter-term bond, for a given change in market interest rates.

4 Given two bonds identical but for coupon, the price of the lower-coupon bond will change more than that of the higher-coupon bond, for a given change in market interest rates.

If the U.S. 3-month bank deposit rate is 7%, the reserve requirement is 2.5% and FDIC fees are 0.20%.

(a) what would you expect the Eurodollar rate to be?
(b) What will happen if the reserve requirement increases by 0.2 percentage point?

(a) The effective cost of a domestic deposit is

\[
\left( \frac{\text{I}_{\text{US}} + \text{FDIC fees}}{1 - \text{reserve requirements}} \right) = \left( \frac{7\% + 0.20\%}{1 - 2.5\%} \right) = 7.3846\%
\]

Thus the additional cost of the reserve requirements and FDIC fees is 38 basis points and this is the extra amount the bank can afford to pay on Eurodollar deposits to achieve the same cost of funds. Competition will generally drive the Eurodollar rate to the level that equates the cost of funds to banks in the two markets, that is, to 7.38%.

(b) If the reserve requirement increases to 2.7%, the Eurodollar rate will be:

\[
\left( \frac{\text{I}_{\text{US}} + \text{FDIC fees}}{1 - \text{reserve requirements}} \right) = \left( \frac{7\% + 0.20\%}{1 - 2.7\%} \right) = 7.3998\%
\]

The U.S. bank deposit rate is now 5.15%, and the Eurodollar deposit rate 5.45%. Assuming that the entire differential is attributable to the Fed’s reserve requirement on bank deposits, what is likely to happen to the Eurodollar rate if the U.S. rate rises by one percentage point?

IE$ = 5.45\% \quad \text{I}_{\text{US}} = 5.15\%

Banks arbitrage their funding costs between the domestic and the Eurodollar market, so that in equilibrium:

Cost of Eurodollar deposit = Cost of domestic deposit

IE$ = \left( \frac{\text{I}_{\text{US}} + \text{FDIC fees}}{1 - \text{reserve requirement}} \right) = \left( \frac{\text{I}_{\text{US}} + 0}{1 - \text{reserve requirement}} \right)

Assuming the differential is entirely attributable to reserve requirements, we can set FDIC fees=0 and then

IE$ = \left( \frac{\text{I}_{\text{US}}}{1 - \text{reserve requirement}} \right) = \left( \frac{\text{I}_{\text{US}}}{1 - \text{reserve requirement}} \right) = \frac{1.5\%}{5.45\%} = 5.50\%.

Innovation in the Bond Market

- Issuers constantly develop innovative bonds with unusual features - bond design can be extremely flexible.
  - Issuers of pay in kind bonds may choose to pay interest either in cash or in additional bonds with the same face value.
  - Reverse floaters are floating rate bonds whereby the coupon rate on the bonds falls when the general level of interest rates rises.
  - Walt Disney has issued bonds with coupon rates tied to the financial performance of several of its films.

- More on indexed bonds:
  - Bonds tied to the general price level have been common in countries experiencing high inflation.
Innovation in the Bond Market

- Although Great Britain is not a country experiencing extreme inflation, about 20% of its government bonds issued in the last decade have been inflation-indexed.
- The United States Treasury started issuing such inflation-indexed bonds in January 1997. They are called Treasury Inflation Protected Securities (TIPS). By tying the par value of the bond to the general level of prices, the coupon payments, as well as the final repayment of par value, will increase in direct proportion to the consumer price index. Thus, the interest rate on these bonds is a risk-free real rate.

To illustrate how TIPS work, consider one that is maturing in one year. Assume that it offers a risk-free real coupon rate of 3% per year. The nominal rate of return is not known with certainty in advance because it depends on the rate of inflation.

If the inflation rate turns out to be only 2%, then the realized dollar rate of return will be approximately 5%.

If the rate of inflation turns out to be 10%, then the realized dollar rate of return will be approximately 13%, consisting of the 3% coupon plus a 10% increase in the dollar value of the bond, from $1,000 to $1,100.

In early 1997, TIPS bonds were trading at a real yield to maturity a shade below 3.5%.

Source: Fabozzi Bond Markets Analysis and Strategies, Seventh Ed.

The adjustment for inflation is as follows. The principal that the Treasury Department will base the dollar amount of the coupon payment and the maturity value on is adjusted semiannually. This is called the inflation-adjusted principal. For example, suppose that the coupon rate for a TIPS is 3.5% and the annual inflation rate is 3%. Suppose further that an investor purchases on January 1, $100,000 par value (principal) of this issue. The semiannual inflation rate is 1.5% (3% divided by 2). The inflation-adjusted principal at the end of the first six-month period is found by multiplying the original principal by one plus the semiannual inflation rate. In our example, the inflation-adjusted principal at the end of the first six-month period is $101,500. It is this inflation-adjusted principal that is the basis for computing the coupon interest for the first six-month period. The coupon payment is then 1.75% (one-half of the real rate of 3.5%) multiplied by the inflation-adjusted principal at the coupon payment date ($101,500). The coupon payment is therefore $1,776.25.

The principal is constantly adjusted by updated inflation figure before the coupon is calculated and paid.

Source: Fabozzi Bond Markets Analysis and Strategies, Seventh Ed.

Bond Case–Swedish Lottery Bonds.

Profiling nonsystematic risk for a bond investor, the case describes lottery bond issues by the Swedish National Debt Office (SNDO). Swedish lottery bonds are a specific type of financial fixed income instrument for Swedish retail investors. The distinctive feature of lottery bonds is that, unlike traditional institutional bonds, the normally guaranteed interest—the coupon—here only is paid as “wins” to bondholders selected in drawings. The case takes place in March 2003, when Anders Holmlund, head of analysis, is reviewing the proposal for the next lottery bond issue. While reviewing the features of the bond issue, he also considers the larger picture: What are the benefits to the Debt Office of issuing lottery bonds, especially in view of a recently launched Internet-based sales system that allows retail investors to take part in government bond auctions?
Bond Case—Bank Leu’s Prima Cat Bond Fund.
In 2001, Bank Leu, a Swiss private bank, is considering creating the world’s first public fund for catastrophe bonds. Cat bonds are securities whose payments depend on the probability of a catastrophe occurring, such as an earthquake or hurricane. Cat bonds are traditionally issued by large insurance or reinsurance companies. This case outlines the traditional reinsurance market and securitization efforts that have taken place in the past and focuses on Bank Leu’s decision as a buy-side participant in the cat bond market.

To explore how insurance risks can be transferred to the capital markets and how risks in general can be brokered, securitized, and traded.


Zurich; Switzerland; Banking industry; 116 million CHF revenues; 600 employees; 2001 10-67

Bond Case—Mortgage Backs at Ticonderoga.
Ticonderoga is a small hedge fund that trades in mortgage-backed securities—securities created from pooled mortgage loans. They often appear as straightforward so-called “pass-throughs,” but can also be pooled again to create collateral for a mortgage security known as a collateralized mortgage obligation (CMO). CMOs allow cash flows from the underlying pass-throughs to be directed, allowing the creation of different classes of securities—tranches—with different maturities, coupons, and risk profiles. In April 2005, the general managers of Ticonderoga are looking at the market data, trying to construct a trade given their view on the prepayment speed of mortgages vs. the implied prepayment speed they derive from CMOs in the market.

To learn about the institutional details behind the mortgage-backed securities (MBS) market, covering both the actors as well as the mechanics (with special emphasis on the important prepayment feature). Also, to go through the mathematics and calculations behind MBSs—in essence, students are asked to behave as if they worked at a mortgage-back trading desk.

Derivatives, Finance, Hedging, Over the counter trading, Securities, Trade. London; Financial industry; 10 employees; 2005 10-69

KAMCO and the Cross-Border Securitization of Korean Non-Performing Loans.
Covers the first international nonperforming loan securitization done in Korea. The CEO of KAMCO is trying to dispose of a portfolio of nonperforming commercial loans that the organization acquired from a number of banks. A group of investment bankers have proposed securitizing the loans and selling them to institutional investors. Securitization of loans (or any other type of assets) is not common in Korea, so the CEO must think through several factors as he decides whether to accept this proposal, the most important of which is the recovery price.

To understand financial securitization—both structuring and valuation principles.

Capital markets, Debt management, Financial instruments, Financing.
Korea; South Korea; $160 million; 1,500 employees; 2000 10-70

Nexgen: Structuring Collateralized Debt Obligations (CDOs).
A client asks Luc Giraud, CEO of the structured finance solutions provider Nexgen Financial Solutions, to put together a solution that allows the client to add AAA-rated bonds to its portfolio. The client cannot find suitably priced top-rated bonds in the market and wonders whether Nexgen can use lower grade bonds to create AAA-equivalent instruments. The process of securitization packages together securities to create new securities with different risk and return profiles.

To examine the process of securitization—in this case, a financial intermediary creates value by putting together a package of securities and offering the client a risk tranche that the client could not otherwise obtain. In terms of credit risk, to look at the impact of correlation in credit risk in portfolios of collateralized debt securities.

Bonds, Capital markets, Credit risk, Debt management, Derivatives, Finance, Securities, Securitization.
France; Financial industry; 20 employees; 2004 10-71

Chapter 10 (C&J)
Bond Prices and Yields
• Bond Basics
• Straight Bond Prices & Yield to Maturity
• More on Yields
• Interest Rate Risk & Malkiel’s Theorems
• Duration
• Dedicated Portfolios and Reinvestment Risk
• Immunization
• Summary & Conclusions

Source: Fundamentals of Investments: Valuation and Management By Corrado, Charles J., and Bradford D. Jordan 10-72
Bond Basics

Straight bonds and their yields
- Straight bonds
- Notes, bonds, debentures
- Other features: convertible, putable
- Yields
  - Coupon rate or coupon yield
  - Current yield
  - Yield to maturity

Bond Calculations

Bond's coupon rate:
\[ \text{Coupon rate} = \frac{\text{Annual coupon}}{\text{Par value}} \]

Bond's current yield:
\[ \text{Current yield} = \frac{\text{Annual coupon}}{\text{Bond price}} \]

Straight bond prices:
\[ \text{Price} = \frac{C}{YTM} \left( 1 - \frac{1}{(1 + \frac{YTM}{2})^M} \right) + \frac{FV}{(1 + \frac{YTM}{2})^M} \]

Now assume a bond has 25 years to maturity, a 9% coupon, and the YTM is 8%. What is the price?
\[ \text{Price} = \frac{90}{.08} \left( 1 - \frac{1}{(1 + .08/2)^{25}} \right) + \frac{1000}{(1 + .08/2)^{25}} = \$1,107.41 \]

Now assume the same bond has a YTM of 10%. (9% coupon & 25 years to maturity) What is the price? Is the bond selling at premium or discount?
\[ \text{Price} = \frac{90}{.1} \left( 1 - \frac{1}{(1 + .1/2)^{25}} \right) + \frac{1000}{(1 + .1/2)^{25}} = \$908.72 \]

Now assume the same bond has 5 years to maturity (9% coupon & YTM of 8%) What is the price? Is the bond selling at premium or discount?
\[ \text{Price} = \frac{90}{.08} \left( 1 - \frac{1}{(1 + .08/2)^{5}} \right) + \frac{1000}{(1 + .08/2)^{5}} = \$1,040.55 \]

Now assume the same bond has a YTM of 10%. (9% coupon & 5 years to maturity) What is the price? Is the bond selling at premium or discount?
\[ \text{Price} = \frac{90}{.1} \left( 1 - \frac{1}{(1 + .1/2)^{5}} \right) + \frac{1000}{(1 + .1/2)^{5}} = \$961.39 \]

More on Bond Prices (cont'd)

Where does this leave us? We found:

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<thead>
<tr>
<th>Coupon</th>
<th>Years</th>
<th>YTM</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>9%</td>
<td>25</td>
<td>8%</td>
<td>$1,107</td>
</tr>
<tr>
<td>9%</td>
<td>25</td>
<td>10%</td>
<td>$908</td>
</tr>
<tr>
<td>9%</td>
<td>5</td>
<td>8%</td>
<td>$1,040</td>
</tr>
<tr>
<td>9%</td>
<td>5</td>
<td>10%</td>
<td>$961</td>
</tr>
</tbody>
</table>

Now assume the same bond has a YTM of 10%. (9% coupon & 5 years to maturity) What is the price? Is the bond selling at premium or discount?
\[ \text{Price} = \frac{90}{.1} \left( 1 - \frac{1}{(1 + .1/2)^{5}} \right) + \frac{1000}{(1 + .1/2)^{5}} = \$961.39 \]
More on Prices

Prices and Par values
- Premium bonds
- Discount bonds
- Par bonds
- Relations among yields
- YTM > current > coupon
- YTM < current < coupon
- YTM = current = coupon

Calculating Yields

The formula:
\[ \text{Bond price} = \frac{C}{YTM} \left( \frac{1 - \frac{1}{(1 + YTM)^T}}{YTM} \right) + \frac{FV}{(1 + YTM)^T} \]

- Use the same formula, but solve for YTM
- How?
  - Trial and error . . .
  - Financial calculator
- Prices versus yields

Bond YTM

Assume a bond has 15 years to maturity, a 9% coupon, and the bond is selling for $1,080. What is the YTM?

\[ \frac{1}{YTM} \left( \frac{1 - \frac{1}{(1 + YTM)^{15}}}{YTM} \right) + \frac{1000}{(1 + YTM)^{15}} = \frac{90}{YTM} \]

\[ \text{YTM} = 4.0354\% \times 2 = 8.07\% \]

Bond Yield to Call

Callable bond price:
\[ \frac{C}{YTC} \left( \frac{1 - \frac{1}{(1 + YTC)^T}}{YTC} \right) + \frac{CP}{(1 + YTC)^T} \]

Assume the previous bond has 5 years until it can be called with a $90 call premium. (9% coupon & selling for $1,080.) What is the YTC?

\[ \frac{1}{YTC} \left( \frac{1 - \frac{1}{(1 + YTC)^{10}}}{YTC} \right) + \frac{1090}{(1 + YTC)^{10}} = \frac{90}{YTC} \]

\[ \text{YTC} = 4.243\% \times 2 = 8.49\% \]
Malkiel's Theorems

Summarizes the relationship between bond prices, yields, coupons, and maturity:

Malkiel's Theorems paraphrased (see text for exact wording); all theorems are ceteris paribus:

1) Bond prices move inversely with interest rates.
2) The longer the maturity of a bond, the more sensitive is its price to a change in interest rates.
3) The price sensitivity of any bond increases with its maturity, but the increase occurs at a decreasing rate.
4) The lower the coupon rate on a bond, the more sensitive is its price to a change in interest rates.
5) For a given bond, the volatility of a bond is not symmetrical, i.e. a decrease in interest rates raises bond prices more than a corresponding increase in interest rates lowers prices.

Malkiel's Theorems (cont'd)

Bond Prices and Yields (8% bond)

<table>
<thead>
<tr>
<th>Time to Maturity</th>
<th>Yields</th>
<th>5 years</th>
<th>10 years</th>
<th>20 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 percent</td>
<td></td>
<td>$1,041.58</td>
<td>$1,071.06</td>
<td>$1,106.78</td>
</tr>
<tr>
<td>9 percent</td>
<td></td>
<td>969.44</td>
<td>934.96</td>
<td>907.99</td>
</tr>
<tr>
<td>Price Difference</td>
<td></td>
<td>$81.14</td>
<td>$136.10</td>
<td>$198.79</td>
</tr>
</tbody>
</table>
Macaulay Duration
alternative formula

Macaulay Duration = \sum_{t=1}^{n} \frac{PV(CF_t)}{Bond\ Price} \times t

Figure 10.3: Calculating bond duration

<table>
<thead>
<tr>
<th>Years</th>
<th>Cash flow factor</th>
<th>Present value</th>
<th>Years x Present value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>0.96154</td>
<td>38.4615</td>
<td>0.0192</td>
</tr>
<tr>
<td>1</td>
<td>0.92456</td>
<td>36.9822</td>
<td>0.0370</td>
</tr>
<tr>
<td>1.5</td>
<td>0.88900</td>
<td>35.5999</td>
<td>0.0553</td>
</tr>
<tr>
<td>2</td>
<td>0.85480</td>
<td>34.1922</td>
<td>0.0684</td>
</tr>
<tr>
<td>2.5</td>
<td>0.82193</td>
<td>32.8771</td>
<td>0.0822</td>
</tr>
<tr>
<td>3</td>
<td>0.79031</td>
<td>821.9271</td>
<td>2.4658</td>
</tr>
</tbody>
</table>

Bond price Bond duration

Assume you have a par value bond with 9% coupon, 9% YTM, and 15 years to maturity. Calculate Macaulay’s Duration.

Mac. duration \[= \left( \frac{1 + 0.09/2}{0.09} \right) \left( \frac{1}{1 + 0.09/2} \right) = 8.51 \text{ years} \]

Assume you have a bond with 9% coupon, 8% YTM, and 15 years to maturity. Calculate Macaulay’s Duration.

Mac. Dur. \[= \frac{1 + 0.08/2}{0.08} \left( \frac{1 + 0.08/2}{0.08 + 0.09} \right) \left( \frac{0.08 - 0.08}{1 + 0.09/2} \right) = 8.78 \text{ years} \]

Price Change & Duration

To compute the percentage change in a bond’s price using Macaulay Duration:

% \Delta \text{ in bond price} \approx MD \times \frac{\text{Change in YTM}}{\left( 1 + \frac{\text{YTM}}{2} \right)}

To compute the Modified Duration:

Modified duration = \frac{\text{Macaulay duration}}{\left( 1 + \frac{\text{YTM}}{2} \right)}

To compute the percentage change in a bond’s price using Modified Duration:

% \Delta \text{ in bond price} \approx \text{Modified Duration} \times \text{Change in YTM}

Calculating Price Change

Assume a bond with Macaulay’s duration of 8.5 years, with the YTM at 9%, but estimated the YTM will go to 11%, calculate the percentage change in bond price and the new bond price.

% \Delta \text{ in bond price} \approx 8.5 \times \left( \frac{0.09 - 0.11}{1 + 0.09/2} \right) = -16.27\% \]

Change in bond price, assuming bond was originally at par:

Approx. new price = $1,000 \times (-16.27\% \times $1,000) = $837.30

Price Change & Duration

Assume you have a bond with Macaulay’s duration of 8.5 years and YTM of 9%, calculate the modified duration.

Modified duration = \frac{8.5}{1 + 0.09/2} = 8.134 \text{ years}

Using the bond above with modified duration of 8.134 years and a change in yields from 9% to 11%, calculate the percentage change in bond price.

% \Delta \text{ in bond price} \approx 8.134 \times (0.09 - 0.11) = -16.27\% \]

Note this is the same percentage change as computed previously.
Duration

The key to bond portfolio management
• Properties:
  ¤ Longer maturity, longer duration
  ¤ Duration increases at a decreasing rate
  ¤ Higher coupon, shorter duration
  ¤ Higher yield, shorter duration
• Zero coupon bond: duration = maturity

Immunization

Target date hedging:
• Dedicated portfolios
• Reinvestment rate risk vs price risk
• Duration matching
• Rebalancing
• Dynamic immunization

Example of Target Date Hedging

Assume you are setting up a target portfolio. You need $1,470 in five years. You can choose a 7.9% coupon bond with 5 years to maturity or a 7.9% coupon bond with 6 years to maturity and a 5-year duration. The YTM is now 7.9%. Which do you choose?

Solution:
To compare, calculate the total wealth in five years:
If interest rates do not change the total wealth of the 5-year bond in 5 years is $1,473.14 (in five years you receive $1,000 plus 5 coupon payments of $79 each, which earn interest at 7.9%)
If interest rates change to 6%:
The 5-year bond will earn total wealth of $1,452.82 ($1,000 plus 5 coupon payments of $79, which earn interest at 6%)
The 6-year bond (MD = 5 years) will earn total wealth of $1,471.00 (5 coupon payments of $79 compounded at 6%, plus a bond with 1-year to maturity worth $1,018.18)
The duration matched bond protected your portfolio.

Problem 10-9

CIR Inc. has 7% coupon bonds on the market that have 11 years left to maturity. If the YTM on these bonds is 8.5%, what is the current bond price?

Solution:

\[
\text{Bond price} = \frac{70}{.085} \left[1 - \frac{1}{1 + .085^{11}}\right] + \frac{1000}{(1 + .085)^{11}} = 894.16
\]
Problem 10-10

Trincor Company bonds have coupon rate of 10.25%, 14 years to maturity, and a current price of $1,225. What is the YTM? The current yield?

Solution:

\[
\frac{1225}{1000} = \frac{102.50}{YTM}\left[1 - \frac{1}{(1 + YTM)^{14}}\right] + \frac{1000}{(1 + YTM)^{14}}
\]

\[
YTM = 3.805\% \times 2 = 7.61\%
\]

Current yield = $102.50 / $1,225 = 8.37%

Problem 10-22

XYZ Company has a 9% callable bond outstanding on the market with 12 years to maturity, call protection for the next 5 years, and a call premium of $100. What is the YTC for this bond if the current price is 120% of par value?

Solution:

\[
\frac{1200}{100} = \frac{90}{YTC}\left[1 - \frac{1}{(1 + YTC)^{10}}\right] + \frac{1100}{(1 + YTC)^{10}}
\]

\[
YTC = 3.024\% \times 2 = 6.05\%
\]

[see next slide for additional information]

Problem 10-22 (cont'd)

Since the bond sells at a premium to par, you know the coupon is greater than the yield. If interest rates stay at current levels, the bond issuer will likely call the bonds to refinance at the earliest possible time.

What is the YTM, with zero call premium?

Solution:

\[
\frac{1200}{100} = \frac{90}{YTM}\left[1 - \frac{1}{(1 + YTM)^{10}}\right] + \frac{1100}{(1 + YTM)^{10}}
\]

\[
YTM = 3.283\% \times 2 = 6.57\%
\]

[see next slide for additional information]

Problem 10-22 (cont'd)

What would be the break-even call premium? (If interest rates don't change, at what level would the call premium have to be to not call the bonds?)

Solution:

\[
\frac{1200}{100} = \frac{90}{0.03283}\left[1 - \frac{1}{(1 + 0.03283)^{10}}\right] + \frac{1000 + X}{(1 + 0.03283)^{10}}
\]

\[
X = 134.91
\]

The bond will not be called if the call premium is greater than $134.91.

Problem 10-23

What is the Macaulay duration of an 8% coupon bond with 3 years to maturity and a current price of $937.10? What is the modified duration?

Solution:

First calculate the yield:

\[
\frac{937}{YTM}\left[1 - \frac{1}{(1 + YTM)^{3}}\right] + \frac{1000}{(1 + YTM)^{3}}
\]

\[
YTM = 5.249 \times 2 = 10.498\%
\]

Now calculate the Macaulay's duration.

Solution:

\[
\text{Mac. Dur.} = \frac{1 + 0.10498}{2} + 3(0.08 - 0.10498) + \frac{0.10498}{0.10498 + 0.08}\left[1 + \frac{0.10498}{2}\right] - 1
\]

Mac. Duration = 2.715 years

Modified duration

\[
= 2.715 \times \frac{1 + 0.10498/2}{2} = 2.58 \text{ years}
\]
Chapter 4 (Fabozzi) Bond Volatilities

Source: Bond Markets Analysis and Strategies, Seventh Edition
By Frank Fabozzi

Review of the Price-Yield Relationship for Option-Free Bonds

- As illustrated in Exhibit 4-1 (See Overhead 4-5):
  - An increase in the required yield decreases the present value of its expected cash flows and therefore decreases the bond's price.
  - An decrease in the required yield increases the present value of its expected cash flows and therefore increases the bond's price.

- As shown in Exhibit 4-2 (See Overhead 4-6):
  - The price-yield relation is not linear.
  - The shape of the price-yield relationship for any option-free bond is referred to as a convex relationship.

### Exhibit 4-1

<table>
<thead>
<tr>
<th>Required Yield (%)</th>
<th>Price at Required Yield (coupon/maturity in years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6%</td>
<td>103.7053 9% / 5</td>
</tr>
<tr>
<td>6%</td>
<td>103.9464 9% / 25</td>
</tr>
<tr>
<td>6%</td>
<td>100.0000 6% / 5</td>
</tr>
<tr>
<td>6%</td>
<td>100.0080 6% / 25</td>
</tr>
<tr>
<td>7%</td>
<td>99.4896 7% / 5</td>
</tr>
<tr>
<td>7%</td>
<td>99.4966 7% / 25</td>
</tr>
<tr>
<td>7%</td>
<td>98.2722 7% / 5</td>
</tr>
<tr>
<td>7%</td>
<td>98.1221 7% / 25</td>
</tr>
<tr>
<td>8%</td>
<td>97.5178 8% / 5</td>
</tr>
<tr>
<td>8%</td>
<td>97.5178 8% / 25</td>
</tr>
<tr>
<td>8%</td>
<td>96.8015 8% / 5</td>
</tr>
<tr>
<td>8%</td>
<td>96.8015 8% / 25</td>
</tr>
<tr>
<td>9%</td>
<td>96.0000 9% / 5</td>
</tr>
<tr>
<td>9%</td>
<td>96.0000 9% / 25</td>
</tr>
<tr>
<td>9%</td>
<td>95.2804 9% / 5</td>
</tr>
<tr>
<td>9%</td>
<td>95.2804 9% / 25</td>
</tr>
<tr>
<td>10%</td>
<td>94.5663 10% / 5</td>
</tr>
<tr>
<td>10%</td>
<td>94.5663 10% / 25</td>
</tr>
<tr>
<td>10%</td>
<td>93.8723 10% / 5</td>
</tr>
<tr>
<td>10%</td>
<td>93.8723 10% / 25</td>
</tr>
</tbody>
</table>

### Exhibit 4-2

Shape of Price-Yield Relationship for an Option-Free Bond

- Price Volatility Characteristics of Option-Free Bonds

  - There are four properties concerning the price volatility of an option-free bond:
    1. Although the prices of all option-free bonds move in the opposite direction from the change in yield required, the percentage price change is not the same for all bonds.
    2. For very small changes in the yield required, the percentage price change for a given bond is roughly the same, whether the yield required increases or decreases.
    3. For large changes in the required yield, the percentage price change is not the same for an increase in the required yield as it is for a decrease in the required yield.
    4. For a given large change in basis points, the percentage price increase is greater than the percentage price decrease.

  - An explanation for these four properties of bond price volatility lies in the convex shape of the price-yield relationship.

### Price Volatility Characteristics of Option-Free Bonds (continued)

- Characteristics of a Bond that Affect its Price Volatility

  - There are two characteristics of an option-free bond that determine its price volatility: coupon and term to maturity.
    1. First, for a given term to maturity and initial yield, the price volatility of a bond is greater, the lower the coupon rate.
    2. This characteristic can be seen by comparing the 9%, 6%, and zero-coupon bonds with the same maturity.

  - Second, for a given coupon rate and initial yield, the longer the term to maturity, the greater the price volatility.
    - This can be seen in Exhibit 4-3 (See Overhead 4-9) by comparing the five-year bonds with the 25-year bonds with the same coupon.
### EXHIBIT 4-3  
Instantaneous Percentage Price Change for Six Hypothetical Bonds

<table>
<thead>
<tr>
<th>Yield (%)</th>
<th>Change in Basis Points</th>
<th>Percentage Price Change (coupon/maturity in years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>-100</td>
<td>30.59</td>
</tr>
<tr>
<td>0.50</td>
<td>-10</td>
<td>0.01</td>
</tr>
<tr>
<td>0.99</td>
<td>-1</td>
<td>0.01</td>
</tr>
<tr>
<td>9.01</td>
<td>1</td>
<td>0.01</td>
</tr>
<tr>
<td>9.10</td>
<td>10</td>
<td>-0.99</td>
</tr>
<tr>
<td>9.50</td>
<td>50</td>
<td>-1.95</td>
</tr>
<tr>
<td>10.00</td>
<td>100</td>
<td>-5.72</td>
</tr>
<tr>
<td>11.00</td>
<td>200</td>
<td>-11.64</td>
</tr>
<tr>
<td>15.00</td>
<td>300</td>
<td>-21.54</td>
</tr>
</tbody>
</table>

As a result of a 100-basis-point increase in yield.

### EXHIBIT 4-4  
Price Change for a 100-Basis-Point Change in Yield for a 5% 25-Year Bond Trading at Different Yield Levels

<table>
<thead>
<tr>
<th>Yield Level (%)</th>
<th>Initial Price</th>
<th>New Price</th>
<th>Price Decline</th>
<th>Percent Decline</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>$123.46</td>
<td>$118.74</td>
<td>$12.72</td>
<td>10.30</td>
</tr>
<tr>
<td>8</td>
<td>100.00</td>
<td>90.87</td>
<td>9.13</td>
<td>9.13</td>
</tr>
<tr>
<td>10</td>
<td>90.87</td>
<td>83.07</td>
<td>7.80</td>
<td>8.58</td>
</tr>
<tr>
<td>11</td>
<td>83.07</td>
<td>76.36</td>
<td>6.71</td>
<td>8.08</td>
</tr>
<tr>
<td>12</td>
<td>76.36</td>
<td>70.55</td>
<td>5.81</td>
<td>7.61</td>
</tr>
<tr>
<td>13</td>
<td>70.55</td>
<td>65.50</td>
<td>5.05</td>
<td>7.16</td>
</tr>
<tr>
<td>14</td>
<td>65.50</td>
<td>61.08</td>
<td>4.42</td>
<td>6.75</td>
</tr>
<tr>
<td>8</td>
<td>100.00</td>
<td>100.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

*As a result of a 100-basis-point increase in yield.

### Measures of Bond Price Volatility (continued)

- **Price Value of a Basis Point** ([basis point $(0.01)$ of $1%$]
  - The price value of a basis point, also referred to as the dollar value of an 81, is the change in the price of the bond if the required yield changes by 1 basis point.
  - Note that this measure of price volatility indicates dollar price volatility as opposed to percentage price volatility (price change as a percent of the initial price).
  - Typically, the price value of a basis point is expressed as an absolute value of the change in price.
  - Price volatility is the same for an increase or a decrease of 1 basis point in required yield.
  - Because this measure of price volatility is in terms of dollar price change, dividing the price value of a basis point by the initial price gives the percentage price change for a 1-basis-point change in yield.

### Measures of Bond Price Volatility (continued)

- **Yield Value of a Price Change**
  - Another measure of the price volatility of a bond used by investors is the change in the yield for a specified price change.
  - This is estimated by first calculating the bond’s yield to maturity if the bond’s price is decreased by, say, X dollars.
  - Then the difference between the initial yield and the new yield is the yield value of an X dollar price change.
  - Price volatility is the same for an increase or a decrease of 1 basis point in required yield.
  - The smaller this value, the greater the dollar price volatility, because it would take a smaller change in yield to produce a price change of X dollars.
Measures of Bond Price Volatility (continued)

**Duration**

- The Macaulay duration is one measure of the approximate change in price for a small change in yield:

\[
\text{Macaulay duration} = \frac{1C + 2C(1+y)^{-1} + \cdots + nC(1+y)^{-n} + nM(1+y)^{-n}}{P}
\]

where \( P \) = price of the bond

\( C \) = semiannual coupon interest (in dollars)

\( n \) = number of semiannual periods (number of years times 2)

\( y \) = one-half the yield to maturity or required yield

\( M \) = maturity value (in dollars)

Investors refer to the ratio of Macaulay duration to \( 1 + y \) as the modified duration. The equation is:

\[
\text{modified duration} = \frac{\text{Macaulay duration}}{1 + y}
\]

where \( y \) = one-half the yield to maturity or required yield.

The modified duration is related to the approximate percentage change in price for a given change in yield as given by:

\[
\frac{dP}{P} = -\text{modified duration} \cdot dy
\]

where \( dP \) = change in price, \( dy \) = change in yield, \( P \) = price of the bond.

---

**Exhibit 4-5**

**Calculation of Macaulay Duration and Modified Duration for 5-Year Bond Selling to Yield 9%**

<table>
<thead>
<tr>
<th>Period, t</th>
<th>Initial yield: 9.00%</th>
<th>Term (years): 5</th>
<th>Initial yield: 9.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cash Flow</td>
<td>PV of $1 at 4.5%</td>
<td>PV of CF</td>
</tr>
<tr>
<td>1</td>
<td>$4.50</td>
<td>0.956337</td>
<td>4.306220</td>
</tr>
<tr>
<td>2</td>
<td>4.50</td>
<td>0.915729</td>
<td>4.120785</td>
</tr>
<tr>
<td>3</td>
<td>4.50</td>
<td>0.876296</td>
<td>3.943335</td>
</tr>
<tr>
<td>4</td>
<td>4.50</td>
<td>0.838561</td>
<td>3.773526</td>
</tr>
<tr>
<td>5</td>
<td>4.50</td>
<td>0.802451</td>
<td>3.611030</td>
</tr>
<tr>
<td>6</td>
<td>4.50</td>
<td>0.767895</td>
<td>3.455331</td>
</tr>
<tr>
<td>7</td>
<td>4.50</td>
<td>0.730185</td>
<td>3.306728</td>
</tr>
<tr>
<td>8</td>
<td>4.50</td>
<td>0.697294</td>
<td>3.164333</td>
</tr>
<tr>
<td>9</td>
<td>4.50</td>
<td>0.672904</td>
<td>3.028070</td>
</tr>
<tr>
<td>10</td>
<td>5104.50</td>
<td>0.643927</td>
<td>2.886666</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>67.290443</td>
<td>765.8799</td>
</tr>
</tbody>
</table>

**Exhibit 4-6**

**Calculation of Macaulay Duration and Modified Duration for 5-Year Bond Selling to Yield 9%**

<table>
<thead>
<tr>
<th>Period, t</th>
<th>Cash Flow</th>
<th>PV of $1 at 4.5%</th>
<th>PV of CF</th>
<th>t × PVCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$4.50</td>
<td>0.956337</td>
<td>4.306220</td>
<td>4.30622</td>
</tr>
<tr>
<td>2</td>
<td>4.50</td>
<td>0.915729</td>
<td>4.120785</td>
<td>3.611030</td>
</tr>
<tr>
<td>3</td>
<td>4.50</td>
<td>0.876296</td>
<td>3.943335</td>
<td>3.00</td>
</tr>
<tr>
<td>4</td>
<td>4.50</td>
<td>0.838561</td>
<td>3.773526</td>
<td>2.50</td>
</tr>
<tr>
<td>5</td>
<td>4.50</td>
<td>0.802451</td>
<td>3.611030</td>
<td>2.00</td>
</tr>
<tr>
<td>6</td>
<td>4.50</td>
<td>0.767895</td>
<td>3.455331</td>
<td>1.50</td>
</tr>
<tr>
<td>7</td>
<td>4.50</td>
<td>0.730185</td>
<td>3.306728</td>
<td>1.00</td>
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<tr>
<td>8</td>
<td>4.50</td>
<td>0.697294</td>
<td>3.164333</td>
<td>0.50</td>
</tr>
<tr>
<td>9</td>
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<td>0.672904</td>
<td>3.028070</td>
<td>0.00</td>
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<tr>
<td>10</td>
<td>5104.50</td>
<td>0.643927</td>
<td>2.886666</td>
<td></td>
</tr>
</tbody>
</table>

**Exhibit 4-7**

**Calculation of Macaulay Duration and Modified Duration for 5-Year Bond Selling to Yield 9%**

<table>
<thead>
<tr>
<th>Period, t</th>
<th>Cash Flow</th>
<th>PV of $1 at 4.5%</th>
<th>PV of CF</th>
<th>t × PVCF</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>4.306220</td>
<td>4.30622</td>
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<td>4.50</td>
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<td>4.120785</td>
<td>3.611030</td>
</tr>
<tr>
<td>3</td>
<td>4.50</td>
<td>0.876296</td>
<td>3.943335</td>
<td>3.00</td>
</tr>
<tr>
<td>4</td>
<td>4.50</td>
<td>0.838561</td>
<td>3.773526</td>
<td>2.50</td>
</tr>
<tr>
<td>5</td>
<td>4.50</td>
<td>0.802451</td>
<td>3.611030</td>
<td>2.00</td>
</tr>
<tr>
<td>6</td>
<td>4.50</td>
<td>0.767895</td>
<td>3.455331</td>
<td>1.50</td>
</tr>
<tr>
<td>7</td>
<td>4.50</td>
<td>0.730185</td>
<td>3.306728</td>
<td>1.00</td>
</tr>
<tr>
<td>8</td>
<td>4.50</td>
<td>0.697294</td>
<td>3.164333</td>
<td>0.50</td>
</tr>
<tr>
<td>9</td>
<td>4.50</td>
<td>0.672904</td>
<td>3.028070</td>
<td>0.00</td>
</tr>
<tr>
<td>10</td>
<td>5104.50</td>
<td>0.643927</td>
<td>2.886666</td>
<td></td>
</tr>
</tbody>
</table>

**Measure of Bond Price Volatility (continued)**

**Duration**

- Because for all option-free bonds modified duration is positive, the modified duration equation, \( dP/P = -\text{modified duration} \cdot dy \), states that there is an inverse relationship between modified duration and the approximate percentage change in price for a given yield change.

- This is to be expected from the fundamental principle that bond prices move in the opposite direction of the change in interest rates.

- Exhibit 4-5 (see Overhead 4-18) and Exhibit 4-6 (see Overhead 4-19) show the computation of the Macaulay duration and modified duration of a two-year coupon bond.

- The durations computed in these exhibits are in terms of duration per period.

---

**Measure of Bond Price Volatility (continued)**

**Duration**

- In general, if the cash flows occur \( m \) times per year, the durations are adjusted by dividing by \( m \), that is, division in years = duration in \( m \) periods per year

- We can derive an alternative formula that does not have the extensive computation of the Macaulay duration and the modified duration.

This is done by rewriting the price of a bond in terms of its present value of an annuity and the present value of the par value, taking the first derivative, and dividing by \( P \):

\[
\text{modified duration} = \frac{C}{y} \left( \frac{1}{1+y} \right) + \frac{n(100-C)/y}{(1+y)^{n+1}}
\]

where the price is expressed as a percentage of par value.
Measures of Bond Price Volatility (continued)

- **Properties of Duration**
  - The modified duration and Macaulay duration of a coupon bond are less than the maturity.
  - The Macaulay duration of a zero-coupon bond equals its maturity; but a zero-coupon bond’s modified duration is less than its maturity.
  - Lower coupon rates generally have greater Macaulay and modified bond durations.
  - There is a consistency between the properties of bond price volatility and the properties of modified duration.
    - For example, a property of modified duration is that, ceteris paribus, a bond with a longer maturity will have a greater modified duration.
    - Generally, a lower coupon rate implies a greater modified duration and a greater price volatility.

- **Approximating the Dollar Price Change**
  - Modified duration is a proxy for the percentage change in price. Investors also like to know the dollar price volatility of a bond.
  - For small changes in the required yield, the below equation does a good job in estimating the change in price yield:
    \[ \frac{\Delta P}{P} = -\text{modified duration} \cdot \Delta y \]
    - where \( \Delta P \) = change in price and \( \Delta y \) = change in yield.
  - When there are large movements in the required yield, dollar duration or modified duration is not adequate to approximate the price reaction.
  - Duration will overestimate the price change when the required yield rises, thereby underestimating the new price.
  - When the required yield falls, duration will underestimate the price change and thereby underestimate the new price.

- **Approximating the Percentage Price Change**
  - The below equation can be used to approximate the percentage price change for a given change in required yield:
    \[ \frac{\Delta P}{P} = -\text{modified duration} \cdot \Delta y \]
    - where \( \Delta P \) = change in price, \( P \) = price of the bond and \( \Delta y \) = change in yield.
  - Suppose that the yield on any bond changes by 100 basis points. Then, substituting 100 basis points (0.01) for \( \Delta y \) into the above equation, we get:
    \[ \frac{\Delta P}{P} = -\text{modified duration}(0.01) = -\text{modified duration}(1\%) \]
  - Thus, modified duration can be interpreted as the approximate percentage change in price for a 100-basis-point change in yield.

- **Spread Duration**
  - Market participants compute a measure called spread duration.
    - This measure is used in two ways: for fixed bonds and floating-rate bonds.
    - A spread duration for a fixed-rate security is interpreted as the approximate change in the price of a fixed-rate bond for a 100-basis-point change in the spread bond.

- **Portfolio Duration**
  - Thus far we have looked at the duration of an individual bond.
  - The duration of a portfolio is simply the weighted average duration of the bonds in the portfolio.
  - Portfolio managers look at their interest rate exposure to a particular issue in terms of its contribution to portfolio duration.
    - This measure is found by multiplying the weight of the issue in the portfolio by the duration of the individual issue given as:
      \[ \text{contribution to portfolio duration} = \text{weight of issue in portfolio} \times \text{duration of issue} \]

---

EXHIBIT 4-7: Calculation of Duration and Contribution to Portfolio Duration for an Asset Allocation to Sectors of the Lehman Brothers U.S. Aggregate Index: October 26, 2007

<table>
<thead>
<tr>
<th>Sector</th>
<th>Portfolio Weight</th>
<th>Sector Duration</th>
<th>Contribution to Portfolio Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treasury</td>
<td>0.000</td>
<td>4.95</td>
<td>0.00</td>
</tr>
<tr>
<td>Agency</td>
<td>0.121</td>
<td>3.44</td>
<td>0.42</td>
</tr>
<tr>
<td>Mortgages</td>
<td>0.449</td>
<td>3.58</td>
<td>1.61</td>
</tr>
<tr>
<td>Commercial Mortgage-Backed Securities</td>
<td>0.139</td>
<td>5.04</td>
<td>0.70</td>
</tr>
<tr>
<td>Asset-Backed Securities</td>
<td>0.017</td>
<td>3.16</td>
<td>0.05</td>
</tr>
<tr>
<td>Credit</td>
<td>0.274</td>
<td>6.35</td>
<td>1.74</td>
</tr>
<tr>
<td>Total</td>
<td>1.000</td>
<td>4.52</td>
<td>9.04</td>
</tr>
</tbody>
</table>

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Tuesday July 21, 2009
Measures of Bond Price Volatility (continued)

- **Portfolio Duration**
  - Exhibit 4-8 (see Overhead 4-28) shows the size of each sector in the Lehman Brothers U.S. Aggregate Index.
  - You can see the importance of each sector.
  - The duration for each sector is shown in the third column and uses the same values as in Exhibit 4-7.
  - The calculation of the spread duration for the recommended portfolio allocation and the Lehman Brothers U.S. Aggregate Index are shown in Exhibit 4-9 (see Overhead 4-29) and Exhibit 4-10 (see Overhead 4-30), respectively.
  - While the portfolio and the index have the same duration, the spread duration for the recommended portfolio is 4.60 vs. 3.49 for the index.
  - The larger spread duration for the recommended portfolio is expected given the greater allocation to non-Treasury sectors.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Weight in Index</th>
<th>Sector Duration</th>
<th>Contribution to Index Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treasury</td>
<td>0.230</td>
<td>4.95</td>
<td>1.14</td>
</tr>
<tr>
<td>Agency</td>
<td>0.105</td>
<td>3.44</td>
<td>0.56</td>
</tr>
<tr>
<td>Mortgages</td>
<td>0.381</td>
<td>3.58</td>
<td>1.36</td>
</tr>
<tr>
<td>Commercial Mortgage-Backed Securities</td>
<td>0.056</td>
<td>5.04</td>
<td>0.28</td>
</tr>
<tr>
<td>Asset-Backed Securities</td>
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<td>3.16</td>
<td>0.03</td>
</tr>
<tr>
<td>Credit</td>
<td>0.219</td>
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<td>1.39</td>
</tr>
<tr>
<td>Total</td>
<td>2.000</td>
<td>26.52</td>
<td>9.12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sector</th>
<th>Weight in Index</th>
<th>Sector Spread Duration</th>
<th>Contribution to Index Spread Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treasury</td>
<td>0.230</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Agency</td>
<td>0.105</td>
<td>3.53</td>
<td>0.37</td>
</tr>
<tr>
<td>Mortgages</td>
<td>0.381</td>
<td>3.62</td>
<td>1.38</td>
</tr>
<tr>
<td>Commercial Mortgage-Backed Securities</td>
<td>0.056</td>
<td>5.04</td>
<td>0.28</td>
</tr>
<tr>
<td>Asset-Backed Securities</td>
<td>0.010</td>
<td>3.16</td>
<td>0.03</td>
</tr>
<tr>
<td>Credit</td>
<td>0.219</td>
<td>6.35</td>
<td>1.43</td>
</tr>
<tr>
<td>Total</td>
<td>2.000</td>
<td>21.88</td>
<td>6.98</td>
</tr>
</tbody>
</table>

**Exhibit 4-11**

**Measures of Bond Price Volatility and Their Relationships to One Another**

Notation:

- \( D \) = Macaulay duration
- \( D^* \) = modified duration
- \( PVBP \) = price value of a basis point
- \( y \) = yield to maturity in decimal form
- \( Y \) = yield to maturity in percentage terms (\( Y = 100 \times y \))
- \( P \) = price of bond
- \( m \) = number of coupons per year

Relationships:

- \( D^* = \frac{D}{1 + y/m} \) \( \rightarrow \) by definition
- \( \Delta P/P = \frac{D}{\Delta y} \) \( \rightarrow \) to a close approximation for a small \( \Delta y \)
- \( \Delta P/\Delta Y = \text{slope of price-yield curve} \) \( \rightarrow \) to a close approximation for a small \( \Delta Y \)
- \( PVBP = D^* \times P = \frac{D^* \times P}{10,000} \) \( \rightarrow \) to a close approximation

For bonds at or near par:

- \( PVBP = D^*/100 \) \( \rightarrow \) to a close approximation
- \( D^* = \Delta P/\Delta Y \) \( \rightarrow \) to a close approximation for a small \( \Delta Y \)
Convexity

- Because all the duration measures are only approximations for small changes in yield, they do not capture the effect of the convexity of a bond on its price performance when yields change by more than a small amount.
- The duration measure can be supplemented with an additional measure to capture the curvature or convexity of a bond.
- In Exhibit 4-12 (see Overhead 4-34), a tangent line is drawn to the price–yield relationship at yield \( y^* \).
  - The tangent shows the rate of change of price with respect to a change in interest rates at that point (yield level).

Exhibit 4-12: Line Tangent to the Price-Yield Relationship

Convexity (continued)

- If we draw a vertical line from any yield (on the horizontal axis), as in Exhibit 4-13 (see Overhead 4-36), the distance between the horizontal axis and the tangent line represents the price approximated by using duration starting with the initial yield \( y^* \).
- The approximation will always underestimate the actual price.
- This agrees with what we demonstrated earlier about the relationship between duration (and the tangent line) and the approximate price change.
- When yields decrease, the estimated price change will be less than the actual price change, thereby underestimating the actual price.
- On the other hand, when yields increase, the estimated price change will be greater than the actual price change, resulting in an underestimate of the actual price.

Exhibit 4-13: Price Approximation Using Duration

Convexity (continued)

- Measuring Convexity
  - Duration (modified or dollar) attempts to estimate a convex relationship with a straight line (the tangent line).
    - The dollar convexity measure of the bond: 
      \[ \text{dollar convexity measure} = \frac{d^2P}{dy^2} \]
    - The approximate change in price due to convexity is: 
      \[ dP = \left( \text{dollar convexity measure} \right) dy \]
    - The percentage change in the price of the bond due to convexity or the convexity measure is: 
      \[ \text{convexity measure} = \frac{dP}{P} \cdot \frac{1}{y^2} \]
    - The percentage price change due to convexity is: 
      \[ \frac{dP}{P} = \frac{1}{2} \left( \text{convexity measure} \right) \left( \frac{dy}{y} \right)^2 \]

Convexity (continued)

- Measuring Convexity
  - Exhibit 4-14 (see Overhead 4-39) and Exhibit 4-15 (see Overhead 4-40) demonstrate how to calculate the second derivative, annualized dollar convexity measure, and annualized convexity measure for the two five-year coupon bonds.
  - The convexity measure is in terms of periods squared.
  - In general, if the cash flows occur \( m \) times per year, convexity is adjusted to an annual figure as follows:
    \[ \text{convexity measure in year} = \frac{\text{convexity measure in } m \text{ period per year}}{m^2} \]
### Exhibit 4-14
Calculation of Convexity Measure and Dollar Convexity Measure for Five-Year 9% Bond Selling to Yield 9%

<table>
<thead>
<tr>
<th>Period, t</th>
<th>Cash Flow</th>
<th>(1/(1.045)^{t+2})</th>
<th>(\Delta(t+1)\Delta CF \times \frac{1}{(1.045)^{t+2}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.50</td>
<td>0.876296</td>
<td>9.786</td>
</tr>
<tr>
<td>2</td>
<td>4.50</td>
<td>0.838561</td>
<td>27.224</td>
</tr>
<tr>
<td>3</td>
<td>4.50</td>
<td>0.804581</td>
<td>54.433</td>
</tr>
<tr>
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<td>4.50</td>
<td>0.776995</td>
<td>90.691</td>
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<tr>
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<td>4.50</td>
<td>0.754828</td>
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</tr>
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<td>4.50</td>
<td>0.699527</td>
<td>324.208</td>
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<td>0.685898</td>
<td>405.266</td>
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<td></td>
<td>12,980.778</td>
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### Exhibit 4-15
Calculation of Convexity Measure and Dollar Convexity Measure for Five-Year 6% Bond Selling to Yield 9%

<table>
<thead>
<tr>
<th>Period, t</th>
<th>Cash Flow</th>
<th>(1/(1.045)^{t+2})</th>
<th>(\Delta(t+1)\Delta CF \times \frac{1}{(1.045)^{t+2}})</th>
</tr>
</thead>
<tbody>
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<td>6.257</td>
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<td>2</td>
<td>3.00</td>
<td>0.838561</td>
<td>18.159</td>
</tr>
<tr>
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<td>3.00</td>
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<td>36.289</td>
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<td>0.776995</td>
<td>60.467</td>
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<td>12,320.749</td>
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</table>

### Convexity (continued)

- **Approximating Percentage Price Change Using Duration and Convexity Measures**
  - Using duration and convexity measures together gives a better approximation of the actual price change for a large movement in the required yield.
- **Some Notes on Convexity**
  - Three points to know for a bond’s convexity and convexity measure.
    - Convexity refers to the general shape of the price-yield relationship, while the convexity measure relates to the quantification of how the price of the bond will change when interest rates change.
    - The approximation percentage change in price due to convexity is the product of three numbers: \(\frac{1}{2}\), convexity measure, and square of the change in yield.
    - In practice different vendors compute the convexity measure differently by scaling the measure in dissimilar ways.

### Convexity (continued)

- **Value of Convexity**
  - Up to this point, we have focused on how taking convexity into account can improve the approximation of a bond’s price change for a given yield change.
  - The convexity of a bond, however, has another important investment implication, which is illustrated in Exhibit 4-16 (see Overhead 4-43).
  - The exhibit shows two bonds, A and B. The two bonds have the same duration and are offering the same yield; they have different convexities, however, Bond B is more convex (bowed) than bond A.

### Convexity (continued)

- **Value of Convexity**
  - The market considers a bond’s convexity when pricing it.
  - If investors expect that market yields will change by very little, investors should not be willing to pay much for convexity.
  - If the market prices convexity high, investors with expectations of low interest rate volatility will probably want to “sell convexity.”
- **Properties of Convexity**
  - All option-free bonds have the following convexity properties.
    - As portrayed in Exhibit 4-17 (see Overhead 4-45), the required yield increases (decreases), the convexity of a bond decreases (increases). This property is referred to as positive convexity.
    - For a given yield and maturity, lower coupon rates will have greater convexity.
    - For a given yield and modified duration, lower coupon rates will have smaller convexity.
Exhibit 4-17
Change in Duration as the Required Yield Changes

Price

Yield

As yield ↓
Slope (duration) ↑
As yield ↑
Slope (duration) ↓

Additional Concerns when Using Duration

- Relying on duration as the sole measure of the price volatility of a bond may mislead investors.
- There are two other concerns about using duration that we should point out.
  i. First, in the derivation of the relationship between modified duration and bond price volatility, we assume that all cash flows for the bond are discounted at the same discount rate.
  ii. Second, there is misapplication of duration to bonds with embedded options.

Measuring a Bond Portfolio’s Responsiveness to Nonparallel Changes in Interest Rates

- Yield Curve Reshaping Duration
  - The yield curve reshaping duration approach focuses on the sensitivity of a portfolio to a change in the slope of the yield curve.
- Key Rate Duration
  - The most popular measure for estimating the sensitivity of a security or a portfolio to changes in the yield curve is key rate duration.
  - The basic principle of key rate duration is to change the yield for a particular maturity of the yield curve and determine the sensitivity of a security or portfolio to that change holding all other yields constant.

Assignment from Chapter 10
Exercises 1, 2.

Chapter 10, Exercise 1

1. Suppose IBM is issuing $100 million in 7-year Eurobonds priced at U.S. Treasury minus 25 basis points. There is great demand for the issue and you are willing to bid 102 for 10% of the issue.
   a. If you actually get your bid executed, how much will you pay for the bond?
   b. A year later, the IBM Eurobonds are traded on the Luxembourg Exchange at 105. What is the value of your investment? What is your capital gain (loss)?
   c. You decide to sell the bond at the above price to pursue other opportunities. What amount of withholding taxes are you required to pay?

SOLUTIONS:

a. Price is 102% of par or 1,020 per bond; 102% * 10% * 100 million = $10.20 million for your share of the issue.
   b. Price is 105%*10%*100 = $10.50 million. Gain is $300,000.
   c. No withholding taxes apply in the Eurobond market.
Chapter 10, Exercise 2

2. Suppose Credit Suisse First Boston (CSFB) is the sole lead manager in a $100 million bought deal for the World Bank. CSFB decides to price the seven-year issue at par to yield 8%.

a. What will be CSFB’s position if the Fed decides to increase short-term interest rates by 50 basis points during the offering period?

b. Instead of the Fed move described in a, suppose that international trade talks break down leading to a depreciation of the dollar on currency markets. What will be CSFB’s position in this case?

c. Calculate the gain or loss for CSFB if the seven-year Eurobond rate rises to 8.25% on the offering day. (Note: Eurobonds pay interest only once each year.)

d. Suppose CSFB collects 2% in fees for lead managing the issue. Again, calculate the overall gain or loss for CSFB if the seven-year Eurobond rate rises to 8.25%.

e. (Optional) How could CSFB hedge the risks described in (a) and (b)?

SOLUTIONS:

a. The yield required by the market on long-term bonds may change in response to the 50 basis point increase in short-term rates. If long-term interest rates rise, then by pledging to sell the Eurobonds at par, CSFB will lose the difference between par and the new lower price of the bond. Long-term interest rates may fall, however, if the market senses that the increase in short-term rates will reduce longer-run inflationary pressures. In this case, CSFB enjoys a capital gain.

b. Same as in (a). To attract investors that shy away from dollar assets, CSFB will have to lower the Eurobond price to a level attractive to lenders.

c. The Eurobond price falls to $987.09 per $1,000.00 face value. The underwriter loses 1.291% on the $100,000,000 issue or $1,291,000.

d. If CSFB collects 2.0% in fees, it transfers only $980 per bond, or $98,000,000 on the entire issue to the World Bank. CSFB’s net profit is then $2,000,000 - $1,291,000 = $709,000.

e. CSFB can hedge the increase in interest rates by selling interest rate futures.

The Treasury Auction Process

The Public Debt Act of 1942 grants the Department of the Treasury considerable discretion in deciding on the terms for a marketable security. An issue may be sold on an interest-bearing or discount basis and may be sold on a competitive or other basis, at whatever prices the Secretary of the Treasury may establish.

Treasury securities are sold in the primary market through sealed-bid auctions. Each auction is announced several days in advance by means of a Treasury Department press release or press conference. The announcement provides details of the offering, including the offering amount and the term and type of security being offered, and describes some of the auction rules and procedures. Treasury auctions are open to all entities.

The highest yield accepted by the Treasury is referred to as the high yield (or stop-out yield). Bidders whose bid is higher than the high yield are not distributed any of the new issue (i.e., they are unsuccessful bidders). Bidders whose bid was the high yield (i.e., the highest yield accepted by the Treasury) are awarded a proportionate amount for which they bid.

Within an hour of the auction deadline, the Treasury announces the auction results including the quantity of noncompetitive tenders, the median-yield bid, and the ratio of the total amount bid for by the public to the amount awarded to the public (called the bid-to-cover ratio). For notes and bonds, the announcement includes the coupon rate of the new security.
Arbitrage in the US Treasury Market?

How?

“We firmly believe that the on-the-run issues should command a high liquidity premium in the current environment. But with very high probability, the 5 1/2s of 8/15/2028 will NOT be the current bond a month from now. The Bond/Old Bond spread is currently about 13bp. The average of this spread around auction is historically about 3bp. Hence we think that much of the premium now assigned to the current bond should be ultimately passed on to the new issue by the expected auction date. Therefore it makes sense to begin scaling into a reverse roll now, at these levels.”


GLOSSARY

On-the-run: The most recently issued Treasury bond in any given sector (e.g. 10 year sector, 30 year sector) of the yield curve.

The Current Bond: the most recently issued 30 year US Treasury bond (also shortened to just "The Bond").

The Old Bond: the second most recent 30 year US Treasury issue.

Bond/Old Bond spread: the yield difference between the most recent and the previously issued 30 year Treasuries.

Basis point (bp): 1/100 * 1%

The Yield Curve

The yield on the "on-the-run" 30yr bond is lower than similar bonds => it is worth more:

- Liquidity?
  - WHY?
  - Different Maturity? NO
  - Better Credit? NO
  - YES!

Properties of the on-the-run Bond

- Tighter bid-offer spread
- Transactions costs are lower for quick and easy buying & selling
- Worth more (=> lower yield)

This Liquidity Premium has historically been worth about 3bp...

... So why is it worth 13bp today?
Why is there an extra 10bp?
Could it be Arbitrage?
The Goldman Sachs US Treasury bond trader thinks so!

The Arbitrage Trade

TODAY

Sell the 8/28 (today's "on-the-run" bond)
Buy the 5/28 (today's "old bond")
Net Profit: 13bp (because the on-the-run is 13bp more costly than the old bond).

ONE MONTH'S TIME

Buy back the 8/28 (today's "old" bond)
Sell the 5/28 (today's "old old bond")
Net cost: zero (now the two bonds cost the same amount; liquidity premium is now on the new "on-the-run" bond)
Chapter 10 Residential Mortgage Loans

Origination of Residential Mortgage Loans (continued)

- **Payment-to-Income Ratio**
  - The payment-to-income ratio (PTI) is the ratio of monthly payments to monthly income, which measures the ability of the applicant to make monthly payments (both mortgage and real estate tax payments).
  - The lower the PTI, the greater the likelihood that the applicant will be able to meet the required monthly mortgage payments.

Origination of Residential Mortgage Loans (continued)

- **Loan-to-Value Ratio**
  - The loan-to-value ratio (LTV) is the ratio of the amount of the loan to the market (or appraised) value of the property.
  - The lower this ratio is, the greater the protection for the lender if the applicant defaults on the payments and the lender must repossess and sell the property.
  - The LTV has been found in numerous studies to be the single most important determinant of the likelihood of default.
  - The rationale is straightforward: Homeowners with large amounts of equity in their properties are unlikely to default.

Types of Residential Mortgage Loans

- There are different types of residential mortgage loans.
- They can be classified according to the following attributes:
  i. lien status
  ii. credit classification
  iii. interest rate type
  iv. amortization type
  v. credit guarantees
  vi. loan balances
  vii. prepayments and prepayment penalties

Types of Residential Mortgage Loans (continued)

- **Lien Status**
  - The lien status of a mortgage loan indicates the loan’s seniority in the event of the forced liquidation of the property due to default by the obligor.
  - For a mortgage loan that is a first lien, the lender would have first call on the proceeds of the liquidation of the property if it were to be repossessed.
  - A mortgage loan could also be a second lien or junior lien, and the claims of the lender on the proceeds in the case of liquidation come after the holders of the first lien are paid in full.

Types of Residential Mortgage Loans (continued)

- **Credit Classification**
  - A loan that is originated where the borrower is viewed to have a high credit quality is classified as a prime loan.
  - A loan that is originated where the borrower is of lower credit quality or where the loan is not a first lien on the property is classified as a subprime loan.
  - While the credit scores have different underlying methodologies, the scores generically are referred to as “FICO scores.”
  - FICO scores range from 350 to 850.
  - The higher the FICO score is, the lower the credit risk.
Types of Residential Mortgage Loans

(continued)

- **Credit Classification**
  - The LTV has proven to be a good predictor of default: a higher LTV implies a greater likelihood of default.
  - When the loan amount requested exceeds the original loan amount, the transaction is referred to as a cash-out-refinancing.
  - If instead, there is financing where the loan balance remains unchanged, the transaction is said to be a rate-and-term refinancing or no-cash refinancing.

- **Interest Rate Type**
  - The interest rate that the borrower agrees to pay, referred to as the note rate, can be fixed or change over the life of the loan.
  - For a fixed-rate mortgage (FRM), the interest rate is set at the closing of the loan and remains unchanged over the life of the loan.

- **Amortization Type**
  - The amount of the monthly loan payment that represents the repayment of the principal borrowed is called the amortization.
  - Traditionally, both FRMs and ARMs are fully amortizing loans.
  - What this means is that the monthly mortgage payments made by the borrower are such that they not only provide the lender with the contractual interest but also are sufficient to completely repay the amount borrowed when the last monthly mortgage payment is made.
Types of Residential Mortgage Loans (continued)

- Amortization Type
  - Fully amortizing fixed-rate loans have a payment that is constant over the life of the loan.
  - For example, suppose a loan has an original balance of $200,000, a note rate of 7.5%, and a term of 30 years.
  - Then the monthly mortgage payment would be $1,398.43.
  - The formula for calculating the monthly mortgage payment is:

\[
MP = MB_0 \left( \frac{i(1+i)^n}{(1+i)^n-1} \right)
\]

where
\[
MP = \text{monthly mortgage payment (S)},
\]
\[
MB_0 = \text{original mortgage balance (S)},
\]
\[
i = \text{note rate divided by 12 (in decimal)},
\]
\[
n = \text{number of months of the mortgage loan}.
\]

Types of Residential Mortgage Loans (continued)

- Amortization Type
  - To calculate the remaining mortgage balance at the end of any month, the following formula is used:

\[
MB_t = MB_0 \left( \frac{(1+i)^n - (1+i)^t}{(1+i)^n-1} \right)
\]

where
\[
MB_t = \text{mortgage (principal) balance after } t \text{ months},
\]
\[
MB_0 = \text{original mortgage balance (S)},
\]
\[
i = \text{note rate divided by 12 (in decimal)},
\]
\[
n = \text{number of months of the mortgage loan}.
\]

Types of Residential Mortgage Loans (continued)

- Amortization Type
  - EXAMPLE: Suppose that for month 12 (\(t = 12\)), we have \(MB_0 = \$200,000\), \(i = 0.00625\), \(n = 360\), then the scheduled principal repayment for month 12 is:

\[
SP_t = MB_0 \left( \frac{(1+i)^{t-1}}{(1+i)^n-1} \right)
\]

\[
= \frac{0.00625(1.00625)^{12-1}}{(1.00625)^{12}-1} \approx \$158.95
\]
Types of Residential Mortgage Loans (continued)

- Credit Guarantees
  - Mortgage loans can be classified based on whether a credit guarantee associated with the loan is provided by the federal government, a government-sponsored enterprise, or a private entity.
  - Loans that are backed by agencies of the federal government are referred to under the generic term of government loans and are guaranteed by the full faith and credit of the U.S. government.
  - The Department of Housing and Urban Development (HUD) oversees two agencies that guarantee government loans.
    - The first is the Federal Housing Administration (FHA).
    - The second is the Veterans Administration (VA).

- In contrast to government loans, there are loans that have no explicit guarantee from the federal government.
  - Such loans are said to be obtained from “conventional financing” and therefore are referred to in the market as conventional loans.
  - A conventional loan can be insured by a private mortgage insurer.

Types of Residential Mortgage Loans (continued)

- Loan Balances
  - For government loans and the loans guaranteed by Freddie Mac and Fannie Mae, there are limits on the loan balance.
  - The loan limits, referred to as conforming limits, for Freddie Mac and Fannie Mae are identical because they are specified by the same statute.
  - Loans larger than the conforming limit for a given property type are referred to as jumbo loans.

- Prepayments and Prepayment Penalties
  - Homeowners often repay all or part of their mortgage balance prior to the scheduled maturity date.
  - The amount of the payment made in excess of the monthly mortgage payment is called a prepayment.
  - This type of prepayment in which the entire mortgage balance is not paid off is called a partial payment or curtailment.
  - When a curtailment is made, the loan is not recast.
  - Instead, the borrower continues to make the same monthly mortgage payment.

Conforming Loans

- Freddie Mac and Fannie Mae are government-sponsored enterprises (GSEs) whose mission is to provide liquidity and support to the mortgage market.
- While Fannie Mae and Freddie Mac can buy or sell any type of residential mortgage, the mortgages that are packaged into securities are restricted to government loans and those that satisfy their underwriting guidelines.
- The conventional loans that qualify are referred to as conforming loans.
- A conforming loan is simply a conventional loan that meets the underwriting standard of Fannie Mae and Freddie Mac.
- Thus, conventional loans in the market are referred to as conforming conventional loans and nonconforming conventional loans.
Conforming Loans (continued)

- Qualifying for a conforming loan is important for both the borrower and the mortgage originator.
- This is because the two GSEs are the largest buyers of mortgages in the United States.
- Hence, loans that qualify as conforming loans have a greater probability of being purchased by Fannie Mae and Freddie Mac to be packaged into an MBS.
- As a result, they have lower interest rates than nonconforming conventional loans.

Risks Associated with Investing in Mortgage Loans

- The principal investors in mortgage loans include thrifts and commercial banks.
- Pension funds and life insurance companies also invest in these loans, but their ownership is small compared to that of the banks and thrifts.
- Investors face four main risks by investing in residential mortgage loans:
  i. credit risk
  ii. liquidity risk
  iii. price risk
  iv. prepayment risk

Credit Risk

- Credit risk is the risk that the homeowner/borrower will default.
- For FHA- and VA-insured mortgages, this risk is minimal.
- The LTV ratio provides a useful measure of the risk of loss of principal in case of default.
- At one time, investors considered the LTV only at the time of origination (called the original LTV) in their analysis of credit risk.
- For periods in which there is a decline in housing prices, the current LTV becomes the focus of attention.

Liquidity Risk

- Although there is a secondary market for mortgage loans, the fact is that bid-ask spreads are large compared to other debt instruments.
- That is, mortgage loans tend to be rather illiquid because they are large and indivisible.
- The degree of liquidity determines the liquidity risk.

Price Risk

- The price of a fixed-income instrument will move in an opposite direction from market interest rates.
- Thus, a rise in interest rates will decrease the price of a mortgage loan.

Prepayments and Cash Flow Uncertainty

- The three components of the cash flow are:
  i. interest
  ii. principal repayment (scheduled principal repayment or amortization)
  iii. prepayment.
- Prepayment risk is the risk associated with a mortgage's cash flow due to prepayments.
- More specifically, investors are concerned that borrowers will pay off a mortgage when prevailing mortgage rates fall below the loan's note rate.

Topics in Bond-related Innovation and Challenges

The innovation of credit derivative instruments does not stop at single name credit default swaps, which shift credit exposure to a credit protection seller, and operate like standby letters of credit or insurance. Collateralized Debt Obligations (CDOs) alone, where a pool of credits such as bonds or loans are created and pieces of the pool are sold to different investors based on their risk/return appetite, is another trillion-dollar market.
**Topics in Financial Innovation and Challenges**

“Credit Default Swap”: Banks may sell credit default swap and pay premium in exchange for face amount of lending/loans in case of default. Investors who invest in “credit default swap” receive premium (just like selling insurance) but lose their investment when there are defaults. Therefore, “credit default swap” sells for excellent price when economy is good; and “credit default swap” loses most of its value (not attractive to investors) when economy turns sour.

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**Topics in Financial Innovation and Challenges**

Banks and investors sell credit-default swaps to protect against losses on bonds or loans they hold; many traders and hedge funds also use the swaps to bet on the fortunes of companies or sectors. The swaps moves don't always correlate to the actual securities.

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**Topics in Financial Innovation and Challenges**

In the past week of June 28, 2008, the ABX index of swaps, which tracks the performance of subprime-mortgage bonds, dropped to new lows as the cost of default insurance on these assets soared. The index that tracks triple-A subprime-mortgage-backed securities fell to 45.9 cents on the dollar, down 17% from a month ago and 38% in the year to date, according to data from Markit.

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**Topics in Financial Innovation and Challenges**

The ABX has been criticized as an inaccurate indicator of subprime mortgage losses -- even the Bank for International Settlements said in a recent report that loss estimates implied by the triple-A slice of the index may be overstated. Financial institutions continue to use the index to hedge their holdings of mortgage assets, and their buying of protection has the effect of pushing the index lower still. Credit-default swaps tied to GM imply it has a 31% chance of defaulting in the next year, even though GM has billions in cash to tide it over the near term.

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**Topics in Financial Innovation and Challenges**

The CDO market started with cash CDOs where the underlying pool contains actual bonds or loans. The life insurer is the largest investor's group of the cash CDO securities. CDO's future cash flow comprises interests receivable and principal receivable.

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**Topics in Financial Innovation and Challenges**

Then synthetic CDOs, which have a collateral pool consisting of a portfolio of single name default swaps, quickly followed suit. This innovation overcame the constraint that only limited actual assets could be taken as collateral in the cash CDO markets. Be alert!!!
Topics in Financial Innovation and Challenges

Credit Default Swap: An Innovation

The investor owns the reference asset [mortgage-backed security], which was issued by XYZ. The investor buys a credit default swap and pays 40 basis points per year in exchange for the swap writer's payment in the event of a default by XYZ. [i.e., investors bet on the potential failure of XYZ for claims, if insurer survives to pay.] In theory, no limit on the amount of default swaps that can be created.

How Does a Synthetic CDO Work?

Managers created so-called "synthetic" CDOs, in which the portfolios consisted of credit-default swaps (CDS). Shorten Recovery Time With Liquidity

Now International coordination and orchestrating, known as mushrooming or bambooing, are observed for the first time in the global bailout effort. Get Money's Worth from Distressed Assets.

Only to See their Own "Tickers"

The time when investment firms selling CDS of other companies see their own CDS market value (insurance premiums) surge, i.e., approach default or bankruptcy. Of course, if the insurer bankrupts, all the CDS issued by them loses all the value.

In 2008, the CDS market ballooned to 54.6 trillions, when world GDP was at 54.3 trillions.

The modelling of default events using survival time distribution is very similar to the modelling of the death of a human life. A credit curve, which describes the term structures of default probabilities for an obligor, is very much like a mortality table. Pricing a default swap is not much different from pricing a life insurance contract. David Li on Synthetic CDO

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Fixed Income Securities: Analytics and Derivatives
Fabozzi: Bond Markets, Analysis, and Strategies

Individual Bond Strategies:
Barbells Strategy
Ladders Strategy
Bullets Strategy

Example: Ladder strategy
You buy three bonds with different maturity dates: two years, four years, and six years. As each bond matures, you have the option of buying another bond to keep the ladder going. In this example, you buy 10-year bonds. Longer-term bonds typically offer higher interest rates.

Ladders are popular among investors who want bonds as part of a long-term investment objective, such as saving for college tuition, or seeking additional predictable income for retirement planning.

Ladders have several potential advantages:
1. The periodic return of principal provides the investor with additional income beyond the set interest payments.
2. The income derived from principal and interest payments can either be directed back into the ladder if interest rates are relatively high or invested elsewhere if they are relatively low.
3. Interest rate volatility is reduced because the investor now determines the best investment option every few years, as each bond matures.
4. Investors should be aware that laddering can require commitment of assets over time, and return of principal at time of redemption is not guaranteed.

Example: Barbell strategy
You see appealing long-term interest rates, so you buy two long-term bonds. You also buy two short-term bonds. When the short-term bonds mature, you receive the principal and have the opportunity to reinvest it.

Barbells are a strategy for buying short-term and long-term bonds, but not intermediate-term bonds. The long-term end of the barbell allows you to lock into attractive long-term interest rates, while the short-term end insures that you will have the opportunity to invest elsewhere if the bond market takes a downturn.

Example: Bullet strategy
You want all bonds to mature in 10 years, but want to stagger the investment to reduce the interest rate risk. You buy the bonds over four years.

Bullets are a strategy for having several bonds mature at the same time and minimizing the interest rate risk by staggering when you buy the bonds. This is useful when you know that you will need the proceeds from the bonds at a specific time, such as when a child begins college.