

## **Syllabus: Debt Instruments and Markets**

April 30, 1998

### **Overview**

This course is concerned with fixed income securities: bonds and interest rate derivatives. The material is inherently quantitative, but we will try to balance computation with the big picture. This section will have more emphasis than usual on international aspects of fixed income: eurocurrency rates and related derivatives, emerging market debt, and so on.

### **Materials**

We will use the following, listed in declining order of priority:

- Overheads (bullet-point lectures).
- Debt Manuscript (the text for the course).
- Reading Package (articles and cases).
- Garbade, *Fixed Income Analytics*, MIT Press, 1996.
- Fabozzi, *Bond Markets, Analysis and Strategies*, Prentice-Hall, 1996.

The first two are available on my home page (see below), the last three in the book store. The overheads are required: I suggest you download the appropriate section from my home page every week before class. After the first week, they will not be distributed in class. The manuscript provides more detailed discussion of similar issues. The reading package and two books are optional. I find Garbade very helpful on basic bond analytics. Fabozzi is a standard reference; I'm not that fond of it, but students tell me they like it.

### **Home Page**

The overheads and manuscript are on my home page:

<http://www.stern.nyu.edu/~dbackus>

Most things come in two formats: postscript (which you can download to your computer and print) and pdf (which you can view and print with Adobe's Acrobat Reader, available free if you don't have it already).

## Office Hours

Tuesday and Thursday, 11:30-1:00, MEC 11-55, (212) 998-0873. Some Tuesday nights, 7:30-9:00pm, Santorini's (check to verify).

## Requirements

Grades will be based on assignments and examinations according to the formula:

Assignments	40 percent
Midterm	30 percent
Final	30 percent

Assignments can be done in groups of not more than four; due dates are noted below.

## Operating Procedures

- We will start and end class on time.
- The first row is safe, but everyone else can and will be asked questions in class.
- I'm readily available by email (dbackus@stern.nyu.edu). You'll generally get a reply within an hour or two, and almost always within a business day.
- If I can't answer a question in class, I'll try to figure it out by the next class.
- Late assignments will not be accepted without prior arrangement. If necessary, you can fax them to me at (212) 995-4212.
- Material handed out in class will not be available in the next class. You can get copies of old handouts from classmates or the home page.
- Excuses: Ask yourself, would I try this on my boss? If not, please don't try it on me.

## Important Dates

Assignments are due on the following days: February 3, February 17, March 3, April 7, April 21, and April 28. The midterm examination will be on Thursday, March 5, in class. The final examination will be scheduled by the MBA office.

### **Suggested Grade Distribution**

Although sections may vary somewhat, the Finance Department suggests a grade distribution of:

A/A-	20-25%
B's	55-70%
C & below	10-20%

This distribution is a guideline, not a requirement.

## Outline and Reading List

### 1. Fixed Income Securities

### 2. Bond Arithmetic

Fabozzi, *Bond Markets, Analysis and Strategies (Third Edition)*, chs 2-3.

Garbade, *Fixed Income Analytics*, ch 1.

### 3. Macfoundations of Interest Rates

### 4. Quantifying Interest Rate Risk

Fabozzi, *Bond Markets, Analysis and Strategies (Third Edition)*, ch 4.

Garbade, *Fixed Income Analytics*, chs 3, 4, 11.

### 5. Floating Rate Notes and Interest Rate Swaps

Fabozzi, *Bond Markets, Analysis and Strategies (Third Edition)*, ch 23.

### 6. Risk Management, Accounting, and Control

Backus, Klapper, and Telmer, "Derivatives at Banc One," NYU Salomon Center Case C55, 1995.

Figlewski, "How to lose money in derivatives," *Journal of Derivatives*, Winter 1994, 75-82.

Kuprianov, "Derivatives debacles," Federal Reserve Bank of Richmond *Quarterly Review*, Fall 1995, 1-39.

### 7. State-Contingent Claims

Black, Derman, and Toy, "A one-factor model of interest rates and its application to treasury bond options," *Financial Analysts Journal*, January-February 1990, 33-39.

Derman, "Valuing models and modeling value," *Journal of Portfolio Management* (Spring 1996), 106-114.

### 8. Forwards and Futures

Fabozzi, *Bond Markets, Analysis and Strategies (Third Edition)*, ch 21.

## **9. Options**

Fabozzi, *Bond Markets, Analysis and Strategies (Third Edition)*, chs 14, 22, parts of 23.

## **10. Credit Risk on Corporate Bonds**

Fabozzi, *Bond Markets, Analysis and Strategies (Third Edition)*, ch 7.

Litterman and Iben, "Corporate bond valuation and the term structure of credit spreads," Goldman Sachs, November 1988; reprinted in *Journal of Portfolio Management*, Spring 1991.

## **11. Emerging Market Debt**

Smith and Walter, "Goldman Sachs and the Republic of the Philippines," NYU Salomon Center Case C39, 1993.

Smith and Walter, "ICICI," NYU Salomon Center Case C60, 1996.

## **12. Mortgages and Mortgage Derivatives**

## Assignment 1

*Due February 3 at the start of class. Assignments will not be accepted late without prior arrangement. Like all assignments in this course, it should be done and submitted as a group. One copy is sufficient, with all names listed on the first page or cover sheet.*

1. You are given prices for US treasury STRIPS:

Bond	Maturity (Yrs)	Price
A	0.5	97.087
B	1.0	94.719
C	1.5	92.409

- (a) Use these prices to compute spot and forward rates. What do they suggest about interest rates six months down the road?
- (b) Use the STRIPS to replicate and price a treasury with a coupon rate of 8% and one year remaining to maturity.
- (c) Your research department has come up with three scenarios for spot rates in six months:

Spot Rates (%)	Scenario 1	Scenario 2	Scenario 3
$y_1$	4.00	5.00	7.00
$y_2$	4.00	5.00	7.00
$y_3$	4.00	5.00	7.00
	“down”	“flatten”	“up”

For each of these scenarios, compute the returns on bonds A and B. Comment on their differences.

2. Banc One Corp issued a corporate bond maturing March 25, 2002, with semi-annual coupon payments and an annual coupon rate of 7 percent. Bloomberg quoted a price of 104.0257 for settlement January 13, 1998. Compute, using the appropriate convention, (a) the number of days since the previous coupon, (b) accrued interest, (c) the invoice price, and (d) the yield.
3. Citicorp’s 7’s of January 2, 2004, a dollar-denominated eurobond issue, was quoted by Bloomberg at 104.6100 for settlement on January 13, 1998. Compute, using the appropriate convention, (a) the number of days since the previous coupon, (b) accrued interest, (c) the invoice price, and (d) the yield.

## Assignment 2

*Due February 17 at the start of class. Assignments will not be accepted late without prior arrangement. Like all assignments in this course, it should be done and submitted as a group.*

1. Write a one-page overview of a firm's approach to interest-rate risk management. Your report should be in bullet-point form and include:

- A one-line summary of the firm's business
- A description of the firm's fixed income assets and liabilities
- A review of the firm's stated approach to interest-rate risk management
- A summary of the firm's use (or not) of interest rate swaps and other derivative products to manage interest rate risk.

You may choose any firm you like (some are more interesting than others), but links are provided on my home page to Banc One, Bell Atlantic, Coca-Cola, Disney, Citicorp, Intel, and Pfizer.

2. Your research department reports spot rates as

Maturity (Years)	Spot Rate (%)
0.5	9.000
1.0	8.000
1.5	7.000
2.0	6.000

- (a) Use these spot rates to compute the price and yield of a two-year 10% bond.
  - (b) What is the duration of this bond?
  - (c) Construct a portfolio of zeros that replicates the two-year bond. Use the durations of the zeros and the formula for the duration of a portfolio to compute the duration of the two-year bond.
  - (d) Explain the difference between your two duration calculations.
3. For the bonds in Problems 2 and 3 of Assignment 1:
  - (a) Compute the PVBP and duration.
  - (b) If yields of all maturities were to rise 100 basis points, by what percent would the price of each bond fall?
  - (c) Explain briefly the difference in price sensitivity of the two bonds.

### Assignment 3

*Due March 3 at the start of class. Assignments will not be accepted late without prior arrangement. Like all assignments in this course, it should be done and submitted as a group.*

- You are transferred to Salomon Smith Barney's London swap desk and asked to compute rates for a variety of Deutschemark swaps. Current DM spot rates (inferred from euro-dm futures contracts on the LIFFE) are:

Maturity (Years)	Spot Rate
0.5	3.92
1.0	4.08
1.5	4.38
2.0	4.64
2.5	4.85
3.0	5.04

- Compute swap rates for semiannual DM interest rate swaps with maturities of 2 and 3 years.
  - Consider a 3-year swap with a fixed rate of 2% the first year. What is a fair rate for the following two years?
- Using the same spot rates as the previous problem, you are asked to price a 3-year inverse floater with semiannual payments at a floating (annualized) coupon rate of

$$\text{Rate} = C - \text{6-month DM LIBOR.}$$

- If  $C = 15\%$ , what is the value of the inverse floater?
  - What value of  $C$  produces a price of 100?
- The "belly of the yield curve" is much flatter than usual, and you are convinced that the current miniscule spread between 5- and 10-year treasury notes will widen in the next six months. Among other things, you believe the continuing Asian crisis will lead the Fed to put downward pressure on short rates. You are particularly interested in these issues:

Issue	Maturity (Yrs)	Yield (%)
11 1/8's of 03	5.0	5.50
8 3/8's of 08	10.0	5.54

- (a) Compute the price and PVBP of these two bonds.
- (b) Despite your strong view on the slope of the yield curve, you have no view on the level of interest rates over the next six months, and worry that both sharp rises (inflation panic) and falls (Asian crisis) are possible. You decide to construct a combination of the two bonds that has exposure to general interest rate movements, but benefits from an increase in 10-year yields relative to 5-years. What does this combination look like?
- (c) (optional) In practice it's not that easy to short a bond. How might you accomplish the same thing in other markets?

## Assignment 4

*Due March 26 at the start of class. Assignments will not be accepted late without prior arrangement. Like all assignments in this course, it should be done and submitted as a group.*

1. Your mission is to use the Ho and Lee model to compute state prices and discount factors.
  - (a) If the current short rate is 5%, “volatility” is  $\sigma = 2\%$ , and “drift parameters” are  $\mu_t = 0$ , what is the short rate tree over two periods (ie, for  $n = 0, 1, 2$ )?
  - (b) Consider a claim to one dollar in state  $(i, n) = (1, 2)$ . Use the pricing relation and fifty-fifty rule to compute the value of this claim in all states.
  - (c) Use Duffie’s formula to compute state prices for the entire tree. Verify that the current price for state  $(1, 2)$  is the same one you computed above.
  - (d) Use the state prices to find, for  $n = 0, 1, 2$ , the current discount factors  $d_n$  and spot rates  $y_n$ .
  
2. Interest-rate models contain scenarios for long rates as well as short rates. Consider a version of the Ho and Lee model with volatility  $\sigma = 0.02$  and drift parameters  $\mu_t$  chosen to match the current eurodollar spot rate curve:  $y_1 = 0.06000$ ,  $y_2 = 0.05500$ ,  $y_3 = 0.05333$ .
  - (a) Compute the drift parameters that reproduce this spot rate curve. What is the implied short rate tree?
  - (b) Compute the price path for a 3-period zero. Note the prices of two-period zeros for the two second-period nodes — in more technical language, states  $(0, 1)$  and  $(1, 1)$ .
  - (c) Graph the current spot rate curve for maturities  $n = 1, 2$  along with its two possible configurations one period in the future. Explain briefly what you find.
  
3. Given an interest-rate tree, we can value interest-rate dependent assets with relatively complex cash flows. By way of example, consider a structured note with semiannual interest payments over three six-month periods based on

$$\text{Rate} = \begin{cases} \text{LIBOR} & \text{if LIBOR} < 5.00 \\ 5 + 3 \times (\text{LIBOR} - 5) & \text{if LIBOR} \geq 5.00 \end{cases}$$

As usual, semiannual payments are half the rate. After three periods, the note returns its principal of 100 as well as its final interest payment.

- (a) Graph the note's rate versus LIBOR for LIBOR between 0 and 10.
- (b) Using the rate tree from the first problem, compute the cash flows generated by this instrument for each state and report them in a tree. Note that you will have to "move them back one period."
- (c) Use the cash flows to compute the price path for this asset, indicating its value at each node in the tree.
- (d) Describe qualitatively the interest-sensitivity of this asset for changes in LIBOR in both directions.

## Assignment 5

*Due April 7 at the start of class. Assignments will not be accepted late without prior arrangement. Like all assignments in this course, it should be done and submitted as a group.*

1. Eurodollar spot rates (inferred from euro-dollar futures contracts on the CME) are:

Maturity (Years)	Spot Rate
0.5	5.61
1.0	5.63
1.5	5.78
2.0	5.89
2.5	5.96
3.0	5.98

- (a) Calibrate a multiplicative interest rate model to these spot rates. (The reason for using this model is that the Ho and Lee model tends to produce negative interest rates in some states.) A reasonable value for  $\sigma$  in this case is 0.15.
- (b) For the same tree, compute the price path of a 3-year semiannual interest rate cap with a cap rate of 7%.
- (c) Describe qualitatively the interest-sensitivity of the cap in different parts of the tree.
2. Investors often find “puttable bonds” attractive, since the put option generates positive convexity and protects them against rising yields. Issuers find them attractive, too, in flat yield curve environments like the present, since the perceived risk of yield increases is lower. We consider the behavior of a prototypical puttable bond, giving its owner the right to sell the bond back to the issuer at par at any time.
- (a) Compute the price path of a 3-year 6% corporate bond with comparable credit risk to LIBOR.
- (b) Use the model to compute the theoretical price of the bond. Describe, in particular, the optimal exercise strategy.

- (c) Given the tree, we can — in principle — replicate the puttable bond with a combination of a one-period bond (a claim to 100 in six months) and the underlying nonputtable bond. For the first six nodes of the tree ( $n = 0, 1, 2$ ), compute the quantities in the replicating portfolio. What do they tell you about the interest-sensitivity of the puttable bond?

## Assignment 6

*Due April 28 at the start of class. Assignments will not be accepted late without prior arrangement. Like all assignments in this course, it should be done and submitted as a group.*

### ANSWER ANY TWO OF THESE QUESTIONS

1. Suppose semiannual spot rates for treasuries and Baa corporates are

Maturity (Yrs)	Treasury	Baa Corporates
0.5	5.00	5.25
1.0	6.00	6.50
1.5	6.50	7.25

- (a) Consider a treasury with three periods to maturity and an annual coupon rate of 8%. What is its market value? Its yield?
- (b) Compute the price and yield of a comparable Baa corporate. What is the yield spread?
- (c) Use the spot rates to infer the probabilities of default of Baa corporates in each period.
2. *(This problem is from Bloomberg's Brady Bond Tutorial (no answer is given).)* A Brady Bond has the following features: (i) current price is 60, (ii) coupon is 6% (quoted and paid annually), (iii) maturity is 25 years, (iv) principal is 100% collateralized with US treasuries. US treasury spot rates are 7% for all maturities. Compute (a) blended yield, (b) present value of principal (guaranteed), (c) stripped yield, and (d) sovereign spread.
3. Use Bloomberg to find an emerging market bond. Describe and assess its essential features (one page). Examples include:
- Argentina FRB 8's of 3/05 (type ARGENT CORP GO)
  - Mexico Global 11.5's of 2026 (type MEX CORP GO)
  - ICICI 8's of 01 (type ICICI CORP GO)