

MIT SLOAN SCHOOL OF MANAGEMENT

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Finance Theory 15.415
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Assignment 2: Valuation of Fixed-Income Securities

Due: February 25 (Thursday), 1999

1. Bond underwriting

Bond underwriters agree to purchase a corporate client's new bonds at a specific price, usually near 100% of face value, and then attempt to resell the bonds to the public. The act of reselling takes some time. Underwriting fees increase with the maturity of the bonds. Provide an explanation for this pattern of fees.

2. Mortgage payments

Consider a mortgage with initial principal of \$500,000 for 10 years and annual interest. The real interest rate is 3.85%, constant over time. The nominal rate is computed from expected inflation.

- (a) Determine the annual payments for a fixed-rate mortgage with the first payment starting in one year's time, assuming that expected inflation today is 2.5% and that the fixed mortgage rate is the nominal interest rate today plus 0.10%.
- (b) Determine the payments for a variable-rate mortgage (with the rate reset annually at the nominal interest rate based on expected inflation), assuming that expected inflation today is 2.5%, and it increases each year by 0.05%.

3. Interest-only and Principal-only (IOPO) securities

Read the enclosed article, "Merrill Lynch Posts \$250 Million of Mortgage-Issue Trading Losses."

- (a) Why would one want to create a security that pays only coupons and another that pays only the principal?
- (b) Consider the fixed-rate mortgage described in question 2a. Strip the payments to this mortgage (towards interest and towards the principal) to design an interest-only security and a principal-only security. Find the duration of the IO and the PO security. Is it the interest-only or the principal-only security that is more sensitive to changes in interest rates?

4. Inflation-indexed bonds

Let the date today be January 24, 1997. Based on the enclosed article, "How to Decide What To Do Next Week When 'Inflation-Indexed Bonds' Debut," answer the following.

- (a) Compare the cashflows of a standard 10-year treasury note (with semi-annual coupons) to the inflation indexed bond (the table below is provided as a guide). Let the principal of both bonds be \$1000, and assume that the interest rate on the standard bond (in nominal terms) is 6% per year while the interest rate on the index-bond, in real terms, is 3%. Assume that annual inflation over the next 10 years will be 3% per year. (This should allow you to come close to the calculations done by the Treasury.)

| | Standard Bond | | Indexed Bond | |
|------|---------------|----------|--------------|----------|
| Year | Principal | Interest | Principal | Interest |
| 0.5 | | | | |
| 1.0 | | | | |
| 1.5 | | | | |
| ⋮ | | | | |
| 10.0 | | | | |

- (b) How much would you be willing to pay for the indexed-bond today. How much would you pay for the standard bond. In your valuation, assume that you are tax-exempt. Your careful reading of *The Wall Street Journal* reveals the following information about the Treasury yield curve.

| | | | | | | | |
|-----------------|------|------|------|------|------|------|------|
| Maturity (year) | 1/2 | 1 | 2 | 3 | 5 | 10 | 30 |
| Yield (%) | 5.63 | 5.91 | 5.99 | 6.16 | 6.39 | 6.63 | 6.91 |

Unfortunately, the above information, as you well know, is for coupon bonds. Based on this information, your able research assistant infers the following prices for zero-coupon bonds of different maturities:

| | | | | | | | | | | |
|----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Maturity (yr.) | 0.5 | 1.0 | 1.5 | 2.0 | 2.5 | 3.0 | 3.5 | 4.0 | 4.5 | 5.0 |
| Price | 97.26 | 94.34 | 91.60 | 88.87 | 86.09 | 83.32 | 80.71 | 78.10 | 75.49 | 72.88 |

| | | | | | | | | | | |
|----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Maturity (yr.) | 5.5 | 6.0 | 6.5 | 7.0 | 7.5 | 8.0 | 8.5 | 9.0 | 9.5 | 10.0 |
| Price | 70.54 | 68.19 | 65.85 | 63.50 | 61.54 | 59.58 | 57.62 | 55.66 | 53.70 | 51.74 |

- (c) Under what economic conditions would it be attractive to hold the index bond. What are the disadvantages of holding the bond. Re-compute the values of the standard and inflation-indexed bond under the assumption that future inflation is 3.5% instead of 3% but the yield-curve is unchanged.

5. Hedging Interest Rate Risk

Many institutions have fixed future liabilities (such as pension payments) to meet and they fund these future liabilities using default-free fixed income securities. When discount bonds of all maturities are available, these institutions can simply buy discount

bonds to fund their liabilities. For example, if there is a fixed liability equal to 1 million dollars five years from now, an institution can buy a discount bond maturing in five years with a face value of 1 million dollars. Unfortunately, there may not be the “right” discount bonds for a fixed future liability and coupon bonds must be used. Then an institution faces reinvestment risk of the coupons.

For example, suppose that the yield curve is flat at 10% and we have the following coupon bonds (with annual coupons):

| Bond | Prices | Principal | Coupon | Years to Maturity |
|------|--------|-----------|--------|-------------------|
| A | 118.95 | 100 | 15 | 5 |
| B | 130.72 | 100 | 15 | 10 |

and we have a 1 million liability five years from now.

- (a) Suppose that the yield curve will remain unchanged for the following five years and you have decided to use bond A to fund the liability. That is, you want to invest in bond A and invest the coupons at the prevailing interest rates to produce a future value at the end of year five of 1 million. How much do you need to invest in bond A? How much do you need to invest if you choose bond B instead?
- (b) Now suppose that right after you invested in bond A, the yield curve makes a parallel move down by 1% to 9%. What is the future value five years from now of your investment? What is the future value if the yield curve moves up by 1% to 11%? Can you explain why the future value changes differently depending on the direction of the change in the yield curve?
- (c) Part (b) shows that the future value of your investment is sensitive to interest rate fluctuations and you face the risk that your future liabilities may not be met. You should try to “immunize” this interest rate risk. But how? Do the following:
 - i. Construct a portfolio of the two coupon bonds so that the future value of the portfolio is 1 million and the duration of this portfolio is equal to five years, assuming that the yield curve will remain flat at 10%.
 - ii. Show that if immediately after you purchased this portfolio the yield curve makes a permanent parallel downward or upward move of 1%, the future value of this portfolio at the end of year 5 will still be approximately 1 million. You have immunized the portfolio of the risk associated with parallel movements of the yield curve by buying a portfolio of coupon bonds so that the duration of the portfolio matches the number of years to the payment of the fixed liability.
 - iii. Suppose now that you have held your portfolio for one year after a 1% decrease in the yield curve to 9% which occurred immediately after you constructed

your initial portfolio with a duration of five. There are now four years to the payment of the fixed liability.

Use the money at your disposal (the market value of your investment at the end of year one) to construct a portfolio of coupon bonds with, duration equal to four years and a future value four years hence equal to approximately 1 million, given the new flat yield curve at 9%.

Show that if the yield curve then makes a parallel upward or downward move of 1%, the future value of your portfolio four years from now will be unchanged. You have approximately funded your liability of 1 million at the end of the fifth year. (Compare the difference between the future value of your portfolio and your fixed liability here and in part (b).)

This technique is called “duration matching”: if you adjust your portfolio over time so that its duration always matches the years to the payment date of your fixed liabilities, you will approximately immunize the risk of parallel shifts in the yield curve.

Merrill Lynch Posts \$250 Million Of Mortgage-Issue Trading Losses

Steve Swartz

The Wall Street Journal, April 30, 1985

(This article has been edited for class use.)

NEW YORK—Merrill Lynch & Co. said it sustained an estimated \$250 million pretax loss, largely because of unauthorized mortgage-securities dealing by a senior trader. The rest of the loss came from “subsequent market volatility” in the securities, the company added.

The trader, Merrill executives said, had far exceeded his limits in acquiring mortgages that were packaged into a particularly risky form of securities. The value of some of those securities plunged recently when interest rates went up.

Market experts said the trading setback was by far the biggest in recent memory, and was likely the largest in securities industry history. “This is a new world record,” said the head of mortgage trading at a rival firm.

In the largest previous loss traders could recall, Marsh & McLennan Cos., the insurance brokers, had a loss of \$155 million before taxes in 1984 in government bond trading.

Merrill Lynch said it still expects to avoid reporting a net loss for the second quarter “due to earnings in other operating areas and to other business activities.” It said that any charge resulting from the trading loss would be reduced after taxes. However, the announcement sent Merrill Lynch stock down \$2.875 to close at \$35.125 on heavy volume of 1.3 million shares in composite trading yesterday on the New York Stock Exchange.

First-Quarter Results

Merrill Lynch said the senior trader, whom it didn’t identify, had been fired. However, executives at Merrill Lynch privately identified the trader as Howard A. Rubin, 36 years old, who had been the firm’s head mortgage-securities trader. The securities said to have caused the problems are created by splitting off the interest payments on the mortgages from the principal and selling each separately. They are known as “interest-only/principal-only” securities, or IOPOs.

Mr. Rubin, a graduate of Harvard Business School, wasn’t at his Manhattan apartment yesterday. His wife said he hadn’t been to work at Merrill Lynch the past couple of days, but that the couple only learned of Mr. Rubin’s firing yesterday morning, when someone from Merrill Lynch read them a wire-service story over the phone. Mr. Rubin joined Merrill Lynch in 1985 from Salomon Brothers Inc.

People at Merrill Lynch said Mr. Rubin had accumulated for the firm’s account an unusually large portion of the principal-only securities without notifying his superiors. When interest rates went up earlier this month, principal-only securities lost as much as 15% of their value over two weeks, traders said.

“He just put them in his drawer,” said one senior Merrill Lynch executive. “We didn’t know we owned them.” Mr. Rubin eventually told his superiors about the unauthorized trades, accord-

ing to people at Merrill Lynch. Securities firms and banks usually allocate a specific amount of capital that can be risked in each area of trading.

Questions About Controls

Merrill Lynch’s announcement also raised questions about the firm’s controls.

“This would suggest to me that Merrill’s international controls are far less than they should be,” said Perrin Long, an analyst at Lipper Analytical Securities Corp. and a frequent critic of Merrill Lynch management.

Although Merrill Lynch said that the greater part of the loss stemmed from unauthorized trading, it declined to say how much.

However, rival mortgage traders said that Merrill Lynch came to market early this month with more than \$900 million in IOPOs at a time when the market was becoming unreceptive to IOPOs. The competitors say Merrill Lynch was largely stuck with the principal portion of the securities in its inventory when the price plummeted.

Merrill Lynch officials say they sold most of the \$900 million to customers, except for a portion that was kept in the belief that the price would go up. Merrill Lynch officials concede that this didn’t happen, and that a portion of the \$250 million in losses isn’t attributable to Mr. Rubin’s unauthorized trades.

But Merrill Lynch officials contend that aside from the principal-only securities they

knew they had, Mr. Rubin acquired a great deal more of them on his own. These officials asserted that Mr. Rubin paid a lot more for these securities than he should have, furthering Merrill Lynch's potential for losses.

Principal-only mortgage securities are attractive in a market where interest rates are low and mortgage holders have an incentive to pay off early. That produces a quick profit for the security holder, who buys at a discount to principal. When interest rates rise, however, early payments on fixed-rate mortgages become less attractive and the profitability schedule of these mortgage securities is stretched out.

Merrill Lynch officials said Mr. Rubin was suspended a couple of days ago after disclosing his unauthorized trading to his superiors. The officials said Mr. Rubin kept the trades secret for 10 days. They said they were unable to independently monitor Mr. Rubin's trades because he never wrote out tickets for them, a violation of standard procedure.

The disclosure of Mr. Rubin's firing surprised other Wall Street traders and his colleagues at Merrill Lynch. They say Mr. Ru-

bin was highly regarded and well known in mortgage-trading circles.

Yesterday's announcement comes at a time when Merrill Lynch is pushing to become a major player in the mortgage-securities market. In recent quarters, the volume of mortgages handled by Merrill Lynch has increased substantially. In the past quarter, it offered more collateralized mortgage obligations—a popular mortgage product—than anyone on Wall Street.

Merrill Lynch sources also contend that the mortgage unit's profitability had also jumped substantially in recent quarters.

The risk of stripped mortgage-backed securities has been a hotly debated topic on Wall Street since the technique was developed last summer. Many investment bankers believed the extraordinary volatility of the security wasn't well understood, and have been predicting that holders could get badly hurt if interest rates moved sharply.

However, nobody was expecting a hit as large as the one Merrill took. Although the price of the securities the firm held has dropped dramatically in the last couple of weeks, it didn't fall more

than about three points in any one day.

Even if Merrill had known it had all the securities, however, selling them when the market began to drop might not have been as easy as it looked. An official at one major firm called the market for stripped securities, of which IOPOs are by far the most popular form, "the most illiquid \$11 billion market in the financial world."

Merrill Lynch has been selling its position gradually over the last 48 hours, and made its announcement after most of it was sold, market sources said. The firm was extraordinarily active in the Treasury market Tuesday, they added, leading to speculation it was trying to hedge what it hadn't yet sold.

Merrill Lynch officials won't say where they sold the securities, but the firm is rumored to have disposed of at least part through its retail system. Merrill Lynch has sold portions of other stripped offerings retail, but the question of whether retail investors understand a product that complex is a much-debated one.

(Ann Monroe contributed to this article)

How to Decide What To Do Next Week When ‘Inflation-Indexed Bonds’ Debut

Tom Herman

The Wall Street Journal, Friday, Jan 24, 1997, Section C, page 1

This article has been edited for class use

Next week, investors will have an opportunity for the first time to buy a U.S. government-guaranteed security designed to protect them from one of the biggest risks of investing – the scourge of inflation.

For generations of investors worried about the savage impact of rising prices, the new ‘inflation-indexed’ Treasury notes could look like a godsend.

But although the much-anticipated new securities could be an attractive addition to many people’s portfolios, they aren’t without drawbacks. Some smart investors may well decide to pass up this initial offering of about \$7 billion in notes to gain a better understanding of pluses and minuses before committing their own money.

The securities, which are being sold Wednesday with a 10-year maturity in minimum denominations of \$1,000, are being brought to market with all the fanfare befitting a new offering from the bond market’s premier issuer. ‘We rarely introduce new products,’ Treasury Secretary Robert Rubin told reporters this week. ‘This is a big idea, and now it is a reality.’

Mr. Rubin says the notes not only will offer investors important advantages but also will save the Treasury money.

Investment advisers say the notes could be a good idea for many investors looking for a way to diversify their holdings while gaining a valuable form of insurance against an unexpected surge of inflation.

Think of the new notes as ‘buying flood insurance during a drought,’ says Barbara J. Moore, a managing director at SEI Investments in New York. ‘Just because it may look like you don’t need this kind of insurance right now doesn’t mean you shouldn’t have it.’

Still, even the most enthusiastic advocates caution that the new notes certainly aren’t ideal or even advisable for everyone. For instance, there is a potential tax trap. Some people also are leery of notes tied to an inflation index that may be tinkered with by the government. Others are unsure how the resale markets will work.

Here is a primer on how the notes work, how to buy them and what financial advisers see as their major pros and cons.

Unlike regular Treasury issues, the new notes will guarantee a return that will beat inflation if the securities are held to maturity. That margin is expected, at least initially, to be between three and four percentage points a year. If so, that would easily surpass the meager 2% annual rate of return, after inflation, that regular long-term Treasury bonds have delivered over the past 70 years, according to Ibbotson Associates, a Chicago research and consulting firm.

The Treasury says the principal amount of the securities will be adjusted for inflation – or deflation, which means falling prices. But this inflation-adjusted amount won’t be paid until the

notes mature. For tax purposes, this inflation-adjusted amount represents interest, and thus is taxable, a Treasury spokesman says.

The securities will also offer regular interest payments twice a year, in mid-July and mid-January. The interest rate, which will be set at auction, will remain fixed throughout the life of the security.

Here is an example supplied by the Treasury: Suppose you buy a \$1,000 note at the beginning of the year. Also assume the interest rate on the notes was set at auction at 3%. Inflation that year is 3%. At the end of the first year, your \$1,000 principal turns into \$1,030 – although you won’t receive any of that increased amount. You will receive your 3% interest payment. At the end of the first year, the notes will be paying 3% interest on the new \$1,030 value. If you hold your note until it matures and inflation remains 3%, you will get back nearly \$1,344 from the Treasury. That will be in addition to the regular interest payments of nearly \$352 you will have received for a decade.

With inflation as tame as it has been, why bother with the new notes at all? After all, don’t many economists agree inflation is well under control? Yes, but as Ms. Moore of SEI Investments notes: ‘Whenever there is a strong economic consensus like this, watch out.’

For investors uncomfortable with keeping all their money in stocks, inflation-indexed securities

provide a good way to diversify, says Peter L. Bernstein, an investment consultant and best-selling author. He calls the new notes 'a good idea, maybe even an essential idea' as a way to diversify for investors for their tax-sheltered accounts, such as individual retirement accounts. The new notes won't be nearly as sensitive to interest-rate changes as regular bonds, and thus should allow investors to increase their holdings of stocks as a share of their total portfolio, he says.

'But you don't have to buy them the first day they come out,' Mr. Bernstein cautions. It might be advisable for investors to wait and see how the resale markets develop, how complex pricing issues are handled, and how the inflation-indexed notes trade compared with regular Treasuries. 'We don't really know about that yet,' Mr. Bernstein says.

Among the drawbacks, there is a tax trap that may ensnare unsuspecting investors. The law requires you to pay income tax each year not only on the inter-

est you receive but also on any increase in the value of your principal. Thus, if inflation surges, some investors, especially those in the highest tax brackets, could wind up owing more in taxes than they get in cash each year – hardly an attractive prospect.

That's why the notes may make more sense in a tax-deferred plan, such as an IRA, says a report by Vanguard Group, the big Valley Forge, Pa., mutual-fund group. 'Here, incremental increases in value would not be taxed. Instead, the overall principal adjustment would be included in the amount taxed upon withdrawal (assuming no penalty for withdrawing before age 59 1/2).'

Moreover, the new notes won't generate nearly as much current income as regular bonds, which could be a big problem for investors who need the income immediately. The new notes also clearly aren't right for investors who fear deflation more than inflation. These investors clearly would be much better off buying regular Treasury bonds. Ordinary

Treasury issues due in 10 years now yield 6.58%.

Even the most ardent enthusiasts agree that investors, especially young investors, shouldn't sink every penny into the new bonds. Over the past 70 years, stocks have easily outperformed bonds, Ibbotson's numbers show.

Finally, some investors are worried about buying notes tied to the consumer price index at a time when Washington may change important details of the CPI. Advocates of the notes reply that the changes, if they occur, aren't likely to be significant.

Even though the notes haven't actually been auctioned or issued, they already are trading on Wall Street in the 'when-issued market' at a yield of just under 3.5%. 'That return is too small in relation to all the uncertainties about liquidity and what might happen to the CPI,' says Mr. Bernstein. 'At 4% or more, I would grab them, and between 3.5% and 4%, I'd think about them.'