The Handbook of Fixed Income Securities

Author: Frank J. Fabozzi
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1 - Overview of the Types and Features of Fixed Income Securities

- A **bond** is an instrument of debt; bond issuers borrow money from bond investors
  - The **indenture** is a legal document describing agreement between investors and issuer
- Largest bond issuers: domestic corporations, municipal govts, and federal govts/agencies
- Maturity of a bond
  - **Term-to-maturity** or **term** is number of years until borrower redeems issue and pays face value to investor
  - **Maturity** is the date when a borrower can redeem an issue and
  - Shape of yield curve determines how maturity will affect yield
- Certain provisions of a bond may modify maturity (e.g. **call privilege**, **sinking fund provisions**, **serial bonds**)
- **Short-term** bonds usually have maturity from 1-5 yrs, **intermediate term** / **notes** have maturity from 5-12 yrs, **long-term** bonds have maturity greater than 12 years
- **Coupon rate** is the interest rate paid by issuers to bond investors
  - Paid semiannually (US) or annually (European) (note MBS/ABS have monthly payments)
  - Coupon structures
    - **Zero-coupon bonds** are usually bought below par and held until maturity
    - **Inflation-linked bonds** have principal tied to the rate of inflation
      - **Treasury-Inflation Protected Securities** (TIPS) are inflation-linked bonds issued by the US Treasury
      - Reference rates used include CPI (US), RPI (UK), etc.
    - **Step-up notes** have a coupon that increases incrementally over time (e.g. **stairway notes** increase until they reach LIBOR/SOFR)
    - **Floating-rate securities** ("floaters") are securities with variable interest rates, which depend on a variable rate + a spread (max/min rates are called **caps/floors**)
      - Reference rate not restricted an interest rate index; can be commodity prices, equity indices, bond indices, etc.
      - **Inverse/reverse floaters** are floaters whose coupon rate moves in opposite dir from ref rate
  - Secured Overnight Financing Rate (SOFR)
    - Volume-weighted median rate based on tri-party repo rates (banks/dealers required to submit repo trade to Fed via DTCC)
- **Par value** is the basis on coupon rate/periodic interest payments
  - Repaid at maturity or when bond is retired
- **Bearer bonds** require investors to clip coupons and send to obligors for payments; **registered bonds** automatically send payment to investors (new bond issues are required to be registered)
- Quoting conventions: bond prices are quoted as percentages of the par/face value
- **Embedded options** allow issuers and bondholders to alter maturity of a bond
  - **Call features** give issuers the right to retire debt before maturity
    - **Callable bonds** therefore have higher yields and have a **call premium**
    - **Noncallable bonds** (bonds noncallable for life) are referred to as bullet bonds

    - A **make-whole call provision** allows an issuer to completely pay off debt before maturity
    - Municipal bonds can be **prerefunded** before maturity (debt is funded via risk-free securities such as USTs)
    - A **put provision** allows investors to sell bond back to issuer at par on a certain date
        - **Hard puts** require the bond to be sold for cash, whereas **soft puts** can allow the bond to be redeemed for cash, another stock, or another debt instrument (or a combo)
    - **Convertible bonds** are bonds able to be converted into common stock
        - The **conversion ratio** specifies how many shares can be converted and the **conversion price** is the price at which the common stock are issued
    - **Exchangeable bonds** can be exchanged for common stock of a corporation other than the bond issuer
    - **Warrants** are options that allow holder to buy certain amt of common stock at an **exercise price**
- Bond yields
    - A **yield to worst** is quoted as min(yield-to-maturity, yields to all possible call dates, yields to all possible put dates)
    - Negative yields do not mean negative return, as the bond can be sold before maturity at a higher price if its yield decreases
- **Medium-term notes** are debt instruments with maturity 9-30 yrs (usually noncallable, unsecured)
    - Structured (medium-term) notes are debt instruments linked to a derivative position
- **Preferred stock** is not a debt instrument but has similarities between commons stock and debt
    - Pays dividend at the **dividend rate**
- Mortgage-backed securities
    - **Residential mortgage-backed securities** (RMBS) are MBS whose cash flow depends on cash flow of underlying mortgage pool
        - Agency vs. non-agency (private-label) MBS
            - Non-agency RMBS divided into **prime** vs. **subprime** RMBS
    - Forms: mortgage pass-through securities, collateralized mortgage obligations (CMOs), stripped MBS
    - **Commercial mortgage-backed securities** are MBS backed by commercial mortgage loans on income-producing property
- **Asset-backed securities** are backed by non-mortgage loans (structuring is similar to MBS)
- **Covered bonds** are debt instruments secured by a specific pool of assets

2 - Risks Associated with Investing in Fixed Income Securities

- **Interest rate risk** is risk associated with changes in interest rates; it is split into **level risk** and **yield-curve risk**
    - Level risk
        - Bond market is often represented by yields on Treasury securities
        - Measures duration (approximate change in bond price due to 100bp change in yields)
    - Yield-curve risk
        - Exposure of a portfolio to change in shape of yield curve
        - Often measured by key rate duration
- **Reinvestment risk** is risk associated with variance in returns of reinvesting returns
    - Greater for longer holding periods
    - "Opposite" of yield-curve risk, as it is the risk of interest rates falling
- **Call/prepayment risk** is risk associated with a call provision on a callable bond
    - Investor becomes exposed to reinvestment rate as well, since call provisions are exercised when interest rates are lower
    - Leads to reduced capital appreciation potential
    - Called prepayment risk for MBS (such investors also exposed to contraction/extension risk)

- **Corporate credit risk**
  - The credit risk of a bond includes:
    1. Risk of a borrower defaulting on their obligation (**default risk**)
    2. Declining bond value due to increased **credit spreads** or decreased credit ratings (**downgrade risk**
  - Credit risk models: used to compute VaR, conditional VaR
    - Divided into structural, reduced-form, and incomplete-information models
- **Sovereign credit risk**
  - While governments are sometimes thought of as being risk-free, since Global Financial Crisis/COVID, they have intervened via QE, etc. by buying debt
  - Further, while there are limited legal means to ensure contract between govt borrower and investor, defaults have negative implications
- **Inflation/purchasing-power risk**
  - Ex: Coupon rate of 7% but rate of inflation is 8%
  - Most bonds have inflation risk (exception is inflation-linked ("linkers"))
- **Liquidity risk**
  - Measured by small bid/ask spreads given by dealers
  - Overall market computes bid/ask spread by taking highest bid between dealers and lowest offer at which dealers are willing to sell
  - Bond market has become less liquid post-GFC due to shrinking dealer inventories
  - Fixed income ETFs can be traded in conditions with poor liquidity, but ETF prices and NAVs could be significantly different
- **Exchange-rate/currency risk**
  - A non-dollar denominated currency is exposed to risks in changing currencies, as well as foreign interest rate risks
- **Volatility risk**
  - Bonds with embedded options, as well as callable bonds and MBS, are exposed to volatility (**vega**) risk
- **Political/legal risk**
  - Government bonds may be exposed to risk incurred by new legal structures/regulations
  - **Tax risk** is another risk incurred by changing tax rates (e.g. for tax-exempt municipal bonds, increasing tax rates will cause increasing prices and vice versa)
- **Event risk** is risk incurred by natural disasters/industrial takeovers or takeover/corporate restructuring
- **Sector risk** is risk incurred based on the specific sector of the bond market a security is in (e.g. corporate vs. mortgage-backed bonds, discount vs. premium bonds, etc.)
- **Basis risk** consists of all risk other than market risk (term used in marketplace)
- Statistical measures of risk: stdev of returns, VaR, DaR (drawdown at risk), symmetry of a return distribution (skewness), kurtosis
  - Mean/stdev of returns, portfolio return - benchmark return,
  - **Tracking error risk** is the stdev of active return (portfolio return - benchmark return)
    - Backwards vs. forward-looking/ex-ante tracking error

3 - The Structure of Interest Rates

- The **base interest rate** or **benchmark interest rate** is the minimum interest rate that investors ask when investing in a non-Treasury security and is usually set to a comparable maturity for an on-the-run Treasury
- A **risk premium** is the spread between a non-UST and on-the-run UST at a comparable maturity
  - Interest rate on a non-UST = Base interest rate + spread (or Base interest rate + risk premium)
- Factors affecting spread: issuer, issuer creditworthiness, taxability, embedded options, expected liquidity, maturity

    - An **intermarket spread** is a spread between comparable bonds in different sectors; an **intramarket spread** is a spread between comparable bonds in the same sector
    - A **credit spread** or **quality spread** is the spread between USTs and comparable bonds with everything alike except for their "quality" (rating by commercial rating companies)
    - Bonds with taxable yields vs. tax-exempt yields trade at a spread (we can calculate the **after-tax yield** vs **equivalent yield** based on the marginal tax rates)
- Term structure of interest rates
    - Graph of yield on USTs at different maturities is called the **yield curve**; this curve functions as a benchmark to price bonds and set yields in other parts of the debt market
        - Shapes: normal, inverted, flat
    - Bonds can be viewed as a series of zero-coupon payments; this view can be used to price bonds by using the yield on a zero-coupon UST with the same maturity as each payment (called the **spot-rate**)
        - A **spot-rate curve** depicts the yield on zero-coupon UST and its maturities
        - However, because Treasury only issues zero-coupon UST with maturity date ≤ 1 year, we need to derive a **theoretical spot-rate curve**
    - Constructing theoretical spot rate curve
        - **Bootstrapping** is using observed T-bill yields and Treasury coupon securities to create the theoretical spot-rate curve, but this does not work because the zero-coupon securities with maturity > 1yr in the market do not accurately represent spot rates
        - The **yield-to-maturity** of a T-bill is the annualized yield
    - Why USTs are priced using spot rates
        - Motivation: What economic force ensures UST price does not change from theoretical price?
            - Process of coupon stripping and reconstituting
    - Forward rates
        - Ex: The yield on a six-month T-bill six months from now is called a **forward rate**
        - Using theoretical spot rates to compute the forward rate yields an **implied forward rate**
        - The relationship between a t-period spot rate and the current six-month spot rate is

          $$z_t = [(1 + z_1)(1 + f_1)(1 + f_2) \cdots (1 + f_{t-1})]^{1/t} - 1$$

          where z_t is the t-period spot rate and f_i is the implied forward rate i six-month periods from the present
- Shape of the term structure: two major theories attempt to explain yield curve shape
    - The **expectations theory** hypothesizes about the future of short-term forward rates and is split into three subtheories
        - The **pure expectations theory** states that forward rates exclusive represent market's expectations of future rates
            - Curve will steepen when future interest rates are projected higher, flatten when future interest rates are projected lower based on demand for short-term bonds
            - Shortcoming: theory does not take into account risks of investing in bonds
                - **Price risk** is the risk of a bond price being lower than expected over an investment horizon
            - Interpretations: broad, **local-expectations**, **return-to-maturity**
        - The **liquidity theory** states that investors will hold bonds with longer maturities if they are offered a long-term rate higher than average expected future rates (this difference is called a **liquidity premium**)
        - The **preferred-habitat theory** implies that the shape of the yield curve is determined by expectations of future interest rates and a positive (or negative) risk premium to induce market participants to get out of their preferred habitat
        - The **market segmentation theory** asserts that the shape of the yield curve is determined by supply/demand of securities in each maturity sector and implies that neither investors nor borrowers are willing to switch maturity sectors to take advantage of better forward rates/expectations

4 - Bond Pricing, Yield Measures, and Total Return

Bond Pricing

- Price of any financial instrument is equal to present value of expected cash flow
  - Interest rate used to compute this present value is yield offered on comparable securities
- Determining cash flow for option-free bonds
  - Cash flow of a bond consists of periodic coupon interest payments + par value payment
    - Most bonds in US pay coupons semiannually; we also assume this
    - Price is therefore sum of discounted cash flows of periodic coupon interest payments (annuity) + par value payment
  - Required yield is determined by yield offered on comparable (option-free, same credit quality/maturity) bonds in market
- Determining price
  - Formula to price a bond with n periods, semiannual coupon payment of c, i as the periodic interest rate, and M paid at maturity is

$$c\left[\frac{1-\frac{1}{(1+i)^n}}{i}\right]+\frac{M}{(1+i)^n}$$

- Relationship between required yield and price
  - Price and yield are inversely correlated; shape of price vs. yield curve is **convex** (this is explored in Ch. 5)
  - Properties
    - Coupon rate = required yield implies bond price is equal to par
    - Price = par value implies coupon rate is equal to yield
    - Coupon rate < required yield implies price is is less than par value (and vice versa)
    - Coupon rate > required yield implies price is greater than par value (and vice versa)
- Time path of a bond
  - If required yield is unchanged, price of bond is only unchanged if coupon rate is equal to required yield
    - If coupon rate > required yield (premium bond), bond price will decrease
    - If coupon rate < required yield (discount bond), bond price will increase
- Why bond prices change
  - Interest rate level shifts in economy (i.e. because of Fed policy)
  - Changes in the bond price as bond moves towards maturity (described above)
  - Perceived credit quality of issuer
  - Factors affecting embedded options (if bonds have embedded options)
- Pricing a zero-coupon bond: same as coupon bond (except without annuity/coupon payments, as only cash flow is maturity value)
  - Number of periods used is twice num. of years to maturity
- Determining price when settlement date is between coupon payments
  - Day count convention: actual/actual (num days in month/year) for UST, 30/360 for credit/municipal bonds/agency securities
  - Ratio $w=\frac{\text{num of days between settlement and next coupon period}}{\text{num of days in coupon period}}$
  - Updated present value calculations: for a bond with n remaining coupon payments, ratio w, semiannual coupon payment m, the price of a bond is

$$p=\frac{c}{(1+i)^w}+\frac{c}{(1+i)^{1+w}}+\frac{c}{(1+i)^{2+w}}+\cdots+\frac{c}{(1+i)^{n-1+w}}+\frac{M}{(1+i)^{n-1+w}}$$

- This price is called **full price** or **dirty price**
- Accrued interest (AI) if coupon payment is c:

$$\text{AI} = c\left(\frac{\text{num of days from last coupon payment to settlement date}}{\text{num of days in coupon period}}\right)$$

  - Full/dirty price does not include accrued interest seller is entitled tor receive, whereas clean/flat price is full price minus AI
  - Accrued interest is an undiscounted value, so yield is slightly lower if settlement date is not a coupon date
  - U.S. bond market convention: clean/flat price is quoted, but buyer pays full price

Conventional Yield Measures

- A bond can expect to receive a dollar return from following sources:
  - Coupon interest payments
  - Capital gain when bond is sold
  - Reinvestment income from coupon payments
- Yield measures: currently yield, yield-to-maturity, yield-to-call (expressed as a percent return as opposed to dollar return)
  - **Current yield** relates annual coupon interest to market price
    - Annual dollar coupon interest/price
    - Does not consider reinvestment income or and other realized capital gain/loss
  - **Yield-to-maturity** considers coupon income and any gain/loss investor realizes by holding bond to maturity; it also considers reinvestment income but assumes the interest rate for reinvestment is equal to yield-to-maturity
    - Reinvestment risk is determined by maturity length and coupon rate
      - A zero-coupon bond has no reinvestment risk
    - Interest-rate risk is determined by current interest rates if an investor has to sell the bond before maturity
    - Yield-to-maturity for a zero-coupon bond
      - If n is double the number of years, $y = (\text{future value per dollar invested})^{1/n} - 1$ where y is one-half the YTM and the future value per dollar invested is $\frac{\text{maturity value}}{\text{price}}$
    - Doubling semiannual yield is the convention in the bond market and called **bond-equivalent yield**, even though this is technically underestimates the effective annual yield of the bond
  - **Yield-to-call** is the interest rate that makes present value of cash flows if a bond is held to assumed call date equal to the price of the bond
    - Conservative investors make compute YTC and YTM and select lower of two as a measure of potential return (some investors calculate all possible call dates)
    - Assumes investor will hold bond until call date and that issuer will call bond on a specific date
- Yield/internal rate of return for a portfolio
  - Computed via determining cash flows for portfolio and finding interest rate that will make PV of cash flows equal to portfolio's market value
- Yield for floating-rate securities
  - As reference rate in future is unknown, it is not possible to determine future cash flows (so YTM cannot be computed)
  - A security's **discount margin** estimates average spread/margin over ref rate investor can expect to earn over life of security
    - For a security selling at par, discount margin is spread over ref rate
    - Drawbacks of discount margin: does not take into account cap or floor and does not account for ref rate changing
- Total return analysis

    - The **total/horizon return** considers all three sources of potential dollar return
        - Steps to compute:
            1. Compute total coupon payments + interest-on-interest based on assumed reinvestment rate
            2. Determine projected sale price at end of investment horizon
            3. Add values obtained in steps 1-2 (this is **total future dollars**) received from investment given assumed reinvestment rate
            4. Use $\left(\frac{\text{total future dollars}}{\text{bond purchase price}}\right)^{1/h} - 1$ to obtain semiannual return
            5. Double semiannual return or find effective annual interest rate using $(1 - \text{semiannual total return})^2 - 1$
- Types of bond swaps
    - A **pure yield pickup swap** is switching from a bond to another with higher yield (higher coupon income or YTM)
    - A **rate-anticipation swap** is switching to a bond based on expectations of future direction of interest rates
        - Ex: In anticipation of falling rates, bonds with greater price vol switched to bonds with lower price vol to take advantage of larger change in price if rates do decline
    - An **intermarket-spread swap** is taken based on current yield spread between two bonds in a market that that should realign at end of investment horizon
    - A **substitution swap** occurs when two identical bonds (except one has a higher YTM) are swapped

7 - U.S. Treasury Securities

- U.S. Treasury securities are bonds issued by U.S. Department of the Treasury (backed by full faith/credit of U.S. govt, so considered free of credit risk)
    - Highly liquid, narrow bid/ask spreads
    - **Marketable** securities are traded on a secondary market, whereas **nonmarketable** securities are not
- Types of securities
    - **Discount** securities are issued at a price below face value and pay face value at maturity
    - **Coupon** securities are issued at a price close to par, pay interest every six months, and
    - **Bills** are Treasury coupon securities with maturities 1yr or less
    - **Notes** are Treasury coupon securities with maturities greater 1yr but less than 10yr
    - **Bonds** are Treasury coupon securities with maturities of more than 10yr (20/30 yr)
    - **Treasury Inflation-Protected Securities** (TIPS) are Treasury coupon securities whose principal (and therefore coupon payments) is inflation-adjusted
    - **Floating-rate notes** are fixed-principal securities paying interest dependent on short-term rates
- Primary Treasury market
    - Marketable Treasury securities are sold in primary market through sealed-bid, **single-price** (**uniform-price**) **auctions**
    - Competitive vs. noncompetitive bids
    - Highest yield accepted is **stop-out** yield
    - Historically, the Treasury auctioned securities through **multiple-price** (or **discriminatory**) auctions
- Primary dealers
    - **Primary government dealers** are counterparties of NY Fed and have the following mandates:
        - Participating in open market operations conducted by NY Fed trading desk
        - Provide NY Fed with market developments
        - Participate competitively in all Treasury auctions
        - Make markets for NY Fed on behalf of its foreign account holders
        - As of 12/31/2019, there are 24 primary dealers

- Auction schedule
  - Bills are auctioned weekly
  - Notes (except 10yr) are auctioned monthly
  - 10yr notes and 30yr bonds are auctioned at Treasury **quarterly refunding**
  - Treasury tries to maintain a regular issuance cycle and stable size for issues of a given maturity
- **Reopenings** are when the Treasury offers additional amounts of outstanding securities
- The Treasury uses **buybacks** to redeem outstanding unmatured Treasury securities by purchasing them in secondary market via reverse auctions
  - No meaningful buyback operation since 2002 (though 1-2 every year)
- Secondary market
  - Main trading hubs: Tokyo, London, New York
  - Primary dealers are principal market makers
- **Interdealer brokers** facilitate trades via dealers via trading platforms that post best bid/offers (charging a small fee)
  - **BrokerTec** now facilitates most of electronic Treasury securities trading
    - In addition to government dealers, hedge funds and HFT firms also trade on electronic platforms
- Federal Reserve
  - NY Fed buys/sells Treasury securities to implement FOMC monetary policy
- Trading activity
  - Most recently issued Treasury securities are **on-the-run** (the rest are **off-the-run**)
  - **When-issued** securities have been announced for auction but not yet issued
    - Facilitates price discovery for new issues, can reduce uncertainty about bidding levels near auctions, allows dealers to bid competitively with little risk
- Quoting conventions for Treasuries
  - Bills
    - Rate on a discount basis is computed as $Y_d = \frac{F-P}{F} \times \frac{360}{t}$ where Y_d is rate on a discount basis, F is face value, P is price, t is number of days until maturity
  - Treasury coupon securities
    - Quoted in secondary market on a price basis (1 point = 1 percent of par)
      - Split into units of 32nds (e.g. 97-14 = 97 14/32 = 97.4375)
      - +/- implies addition/subtraction of 1/64
      - A third number (e.g. in 97-142) indicates how many 1/256 are added to price
- Zero-coupon Treasury securities
  - Created from existing Treasury notes/bonds via **coupon stripping**
  - Sell at deep discounts to face value
  - STRIPS (Separate Trading of Registered Interest and Principal Securities) program allows individual components of Treasury securities to be held separately in Fed book-entry system
  - Coupon strips can also be reassembled into fully constituted form

15 - Inflation-Linked Bonds

- Treasury Inflation-Protected Securities (TIPS) are bonds with principal and coupon payments adjusted based on changes in CPI
-