CFA Level III, Study Session 6: Asset Valuation - Debt Investments

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General Comments on Level III Fixed Income:

- This year fixed-income has been increased from one session to two sessions.
- Fixed-income readings for Level I through III are revamped entirely and put in two books specifically designed for CFA:
  - Very comprehensive and detailed list of Learning Outcome Statements (LOS)
  - Readings are very focused and relevant to AIMR's intended learning outcomes
  - Concise key points
  - Clear end of chapter problems and solutions
- I highly recommend that candidates read the original material and workout the end of chapter questions.
- Given the comprehensiveness of the fixed-income LOS list, students are advised to focus on them even more than usual.
- AIMR states that Level III students are also responsible for understanding of Level I and II material. While the substance of Level I & II materials has not changed, LOS list have been expanded significantly.

Level III Recent Fixe-Income Exam Focus:
2000: 52 points (14.4%) – International and indexing
1999: 26 points (7.2%) – International
1998: 21 points (5.8%) – International and general strategy

6. Asset Valuation - Debt Investments

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1. Fixed Income Readings for the Chartered Financial Analyst Program: Level III Readings, Frank J. Fabozzi, ed. (Frank J. Fabozzi Associates, 2000)

   A. "Introduction to Bond Portfolio Management," Frank J. Fabozzi, Ch. 1

   B. "Alternative Measures of Portfolio Risk," Frank J. Fabozzi, Ch. 2

   C. "Managing Funds Against Liabilities," Frank J. Fabozzi, Ch. 3

Note: Make sure to workout the questions at the end of each chapter and check your answers with solutions given. This may be the best way to know whether you are well prepared for the exam.

6.1.A. "Introduction to Bond Portfolio Management"

Key Points

- Investment process involves: 1) setting investment objectives, 2) developing and implementing portfolio strategy, 3) monitoring portfolio performance, 4) readjusting portfolio.
- Bond indexes can be classified as broad-based or specialized market (sector) indexes.
- Investment objectives (risk/return requirements) and constraints govern benchmark selection.
- Liabilities can be classified in four types according to the uncertainty of amount and timing.
- In addition to the risk of under performance to a market benchmark, liability-oriented investors run the risk of the benchmark not tracking their liability
- Active and passive bond strategies are differentiated by the size of allowed tracking risk with respect to the benchmark
- Call, cap, and interest rate risks of the liabilities are measured the same way as other fixed income securities.
- Mismatch between the dollar duration and dollar convexity of liability result in the risk changes in status of economic surplus (deficiency).
- In active portfolio strategies key inputs affecting performance need to be forecast: interest rates, curve, volatility, credit spreads. Additionally for international bond portfolios exchange rates and local interest rates need to be forecast.
- Monitoring portfolio should be a continuous process involving two key tasks: 1) Monitoring key inputs, and 2) Performance Monitoring. Performance monitoring entails two phases: 1) Performance measurement, and 2) Performance Evaluation (nature of added value, and attribution of added value)
- Adjusting portfolio relies on monitoring activity which indicates the need for the adjustment. The magnitude of changes in expectation, markets, cost of trading, tax laws, and time horizon determine nature and frequency of portfolio repositioning.

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a) **Discuss** the activities in the investment process (setting the investment objective, developing and implementing the portfolio strategy, monitoring the portfolio, and adjusting the portfolio) as those activities apply to fixed-income investors;

- *Investment Objectives:* Are based on characteristics of the investor and are expressed based on risk and return requirements. Client needs in terms of return, risk, and sometimes cash flows govern selection of an appropriate benchmark.

- *Developing and Implementing Portfolio Strategy:* Passive (indexing or minimizing tracking error vs. the benchmark) vs. Active (opportunistically differentiating from the index). Bond indexing is a relatively new concept. Structured portfolio strategies involves designing a portfolio as to achieve performance of some designated benchmark (typically a set of cash flow liabilities).

- *Monitoring Portfolio:* It should be a continuous process and involves: 1) Monitoring key inputs, and 2) Performance Monitoring. Performance monitoring has two phases: 1) Performance measurement, and 2) Performance Evaluation (nature of added value, and attribution of added value)

- *Adjusting Portfolio:* Monitoring will indicate need for adjustment to portfolio. The magnitude of changes in expectation, markets, and cost of trading determines nature and frequency of portfolio repositioning.

b) **Discuss** the relationship between an investor's investment objectives and the benchmark chosen for performance evaluation;

- Investment objectives are often first specified in terms of return, risk, and constraints. The objectives and requirements are then expressed quantitatively in terms of some benchmark for performance evaluation over time.
- There are two categories of objectives based on characteristics of the benchmark: 1) liability structure, 2) bond index.
- Benchmark selection plays a critical role in conveying the investment objectives to investment managers (internal or external)
- Liability-based clients often opt for a bond index objective, expecting that index performance will satisfy the liability requirements over the long haul.
- A misspecified benchmark could lead to insufficient cash flows to meet liabilities even if the manager has outperformed.

c) **Contrast** the four classes of liabilities;

Liabilities can be classified according to degree of certainty of their amount and timing.

	Amount of Outlay	**Timing of Outlay**	**Example**
Type I	known	known	CD or GIC
Type II	known	Uncertain	Life Insurance Policy
Type III	uncertain	known	Floating rate note
Type IV	uncertain	uncertain	Pension plans, P&C Insurance Policy

d) **Compare** and **contrast**, with respect to investment objectives, using liabilities as a benchmark versus using a bond index as a benchmark;

- Two types of investors:
  - Funded Investors: Borrow funds to invest and earn a higher return than cost of borrowing (spread). Examples are depository institutions, insurance companies, and hedge funds.
  - Real-Money (non-borrowed) Investors: Investors have a natural stream of liabilities (e.g. defined or medical benefits, lottery winnings) that are not created by borrowed money.
- Focus is on how liability structure (magnitude, timing, and uncertainty) affects selection of portfolio strategy.

	Bond Index	**Liabilities**
Benchmark	• Broad-based or specialized market indexes • **Broad-based:** Lehman Aggregate, Salomon Broad Investment Grade (BIG), Merrill Domestic Market. All three exclude below investment grade, maturities below one year, CMOs, and nonagency passthroughs • All three publish specialized indexes consisting of subsectors of their broad-based indexes. • Several firms have created specialized benchmarks for high yield (non-investment grade) corporate market.	• Nature, amount, timing, and their certainty • Funding status (sufficiency) is assessed based on the forecast liability stream discounted at some spread over treasury curve
Performance	• Often measure relative performance to the index • Performance to actual liabilities are reviewed less frequently in the context of overall plan structure.	• Measure short term relative risk as well as long term risk of not meeting liabilities
Risks	• Tracking error risk is produced by positioning portfolios differently than the benchmark (e.g. curve, sector, or issue selection bets • Negative relative return to the benchmark results from risks that go against the portfolio • Beating or meeting a market benchmark may not satisfy ultimate liabilities of an investor	• There are risks associated to liabilities as well as assets: call, cap, interest and curve risks.

e) **Explain** tracking error risk and discuss the implications of tracking error risk for active versus passive strategies**;**

- Understanding the risk characteristics/drivers of the benchmark is key to differentiating passive and active strategies.
- *Tracking Error:* Deviation of portfolio return from the benchmark, measured by the standard deviation of relative return. Mathematically tracking error is a positive number. Tracking error is considered *positive(negative)* when cumulative relative return vs. benchmark is positive (negative).
- *Bond Indexing Strategy:* Portfolio is constructed in such a way to have identical risk characteristics as the benchmark. Since it is difficult to replicate precisely broad-based market benchmarks at minimal costs, there is always some tracking error risk. Existence of a large tracking error, even when portfolio has outperformed, is an indication of a flawed investment process – i.e. either the manager does not have ability to implement the strategy well, or is taking relative risks and deviating from its mandate.
- *Active Strategy:* Portfolio manager opportunistically positions the portfolio to differ from the benchmark in certain characteristics, such as interest, curve, sector, and quality exposure. Degree of departure influences the expected tracking error over time. Active management can vary from enhanced indexing (small tracking error and expected alpha) to fully active (large tracking error and expected alpha)

f) **Discuss** the risks associated with managing a portfolio against a liability structure (cap risk, call risk, interest rate risk);

Risk	Description
Call Risk	• Note Fabozzi uses the term "call" option in the context of liability, as the term "put" is used in a context of a bond – i.e. his callable liability is the same as a putable bond from a price/yield characteristic standpoint. • Callability of a liability leads to timing uncertainty and mirrors a call (put) risk in a bond – early termination in rising rate, and extension in falling rate environments. • When holder of liability can terminate at will, e.g. depositors of CDs • Institution has to fund itself at higher cost, if rates have risen since the initial CD • If the assets are invested in fixed-rate bonds, this could create a mismatch risk
Cap Risk	• Created when the floating borrowing costs are not capped but floating assets held are capped. Depending on prevailing interest rates and portfolio caps, this may generate a negative spread.
Interest Rate Risk	• Liabilities can be viewed as a portfolio of bonds that are issued rather than invested in. • Interest and curve sensitivity (duration) of market value of liabilities can be measured the same way as bonds. • *Economic Surplus (Deficit)* = Market Value of Assets – Market Value of Liabilities • Market Value = Present value of future cash flows

g) **Explain** the importance of duration and convexity in surplus management (i.e., for both the assets and the liabilities) and compute the change in the surplus of an institution given a change in interest rates;

Neglecting convexity of assets and liabilities and using a linear approximation of PV change:

- Change in Economic Surplus ≈ - [(Asset Dur * PV Assets) – (Liability Dur * PV Liability)] * Change in Yield
- Note that to keep the surplus immunized to interest rates, it's the dollar duration (PV * Duration) that has to be matched, not the duration.

Convexity effect in surplus management

- If the assets or liabilities are negatively convex (callable), even when matched dollar duration, the surplus can be eroded when interest rates move.
- To hedge against assets that are callable, one would need liabilities that are
- To hedge risk of liabilities callable by holders, institution would need to hold putable assets.

h) **Discuss** the issues relating to the imposition of client constraints;

- Constraints imposed by the client should be realistic and consistent with the investment objectives.
- Typical client imposed constraints:
  - Maximum duration deviation (relative duration)
  - Minimum acceptable credit rating for an issuer
  - Maximum allocation to an issuer or industry
  - Limits on security types such as 144a, yankees, structured notes, CMOs
  - Whether derivatives are allowed, if so maximum limits and proper use
  - Whether leverage is permitted
  - Shorting policy
- Regulatory imposed constraints (state and Federal)
  - Department of Labor (ERISA) (Pension Funds)
  - National Association of Insurance Commissioners (NAIC)
  - National Credit Union Administration (NCUA)

- Tax regulations should be considered.

i) **Contrast** active and passive strategies with respect to expectational input and tracking error risk;

Active Strategies

- First step requires forecasting inputs that are expected to impact performance:
  - Interest rates
  - Volatility
  - Credit spreads
  - Credit view changes of specific issuers
  - Exchange rates and local interest rates (international bond portfolios)

- Second step requires assessing 'market expectation" and what is already priced in – e.g. 2 year rate six months from now.
- Depending of the difference between market expectation and manager view, portfolios exposures to various risk factors can be adjusted.
- Magnitude of deviations from the benchmark governs the size of tracking error.

Passive Management:

- Minimal deviation from benchmark is allowed
- Low tolerance for tracking error
- No need for expectational inputs

j) **Discuss** the relationship between monitoring and adjusting the portfolio.

- Monitoring portfolio and market key factors should be a continuous process.
- Monitoring involves two activities: 1) monitoring key inputs/forecasts in constructing the portfolio, 2) Monitoring performance.
- Monitoring performance includes two steps: 1) Performance measurement, 2) Performance Evaluation (nature of added value, and attribution of added value)
- Monitoring will indicate need for adjustment to portfolio. The magnitude of changes in expectation, markets, and cost of trading, tax laws, and time horizon determine nature and frequency of portfolio repositioning.

6.1.B. "Alternative Measures of Portfolio Risk"

Key Points

- Review: 1) various summary measures for probability distributions (mean, variance, and standard deviation), 2) properties of standard normal distribution, 3) positive and negative skewness, 4) fat tail, and 5) serial or positive autocorrelation. (Section II of reading)
- *Target Return:* For defining downside risk measure, returns below target return represent adverse consequences. For managing against the index, the target return is set as a relative return target.
- *Target Semivariance:* Measure of dispersion of the outcomes below a target return. When expected return is used as the target, the resulting value is called *semivariance*. Semivariance gives the same ranking as variance when distribution is symmetric about the mean. Problems: 1) lack of familiarity by all parties involved, 2) lack of well known statistical properties, 3) computationally challenging to extend to large portfolios, 4) relative return of most managers tend to be symmetric.
- *Short Fall Risk:* Probability of return falling below a target return. It suffers from same problems as target semivariance.
- *Value-at-Risk:* Given a prespecified target probability (confidence level), VaR risk measure is the value by which the returns will not fall below over a given horizon time. VaR is typically expressed in dollar amount rather than percent. Limitations/Criticisms: 1) VaR depends on good estimates of sensitivities of positions to rate changes, volatility of yield changes and their correlations, 2)This reading assumes (not true in general) that yield changes have to be normally distributed, 3) Multiplying daily VaR by square of number of days to horizon neglects a possibility of serial correlation and nonstationary behavior.
- Understand concepts such as duration contribution, dollar duration contribution, and spread duration.
- Sector spread duration contribution can be used to compare portfolio vs benchmark risk to various sectors
- Foreign interest rates are not perfectly correlated with the U.S. Therefore, U.S. equivalent duration should be used to measure portfolio total interest rate risk.

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a) **Compare**, contrast, and critique measures of downside risk (target semivariance, shortfall risk, and value at risk);

Target Return:

- For defining downside risk measure, returns below target return represent adverse consequences.
- For managing against the index, the target return is set as a relative return target.

Target Semivariance:

- Measure of dispersion of the outcomes below a target return. When expected return is used as the target, the resulting value is called *semivariance*.

$$\sum_{\text{For } r_t < r_{\text{target}}}^{T_{< \text{target}}} (r_t - r_{\text{target}})^2 / (T_{< \text{target}} - 1)$$

- Semivariance gives the same ranking as variance when distribution is symmetric about the mean.
- Limitations: 1) lack of familiarity by all parties involved, 2) lack of well known statistical properties, 3) computationally challenging to extend to large portfolios, 4) relative return of most managers tend to be symmetric.

Short Fall Risk:

- Probability of return falling below a target return. Given a target return, short fall risk is the ratio of observations below the target return over the total number of observations.
- Limitations: It suffers from same problems as target semivariance.

Value-at-Risk:

- Given a prespecified target probability (confidence level), VaR risk measure is the value by which the returns will not fall below over a given horizon time.
- VaR Interpretations: 1) At some confidence level Y% return will exceed a given floor (VaR) over a given time horizon T. 2) Returns will fall below VaR with a probability of 1-Y% over a given time horizon.
- VaR is typically expressed in dollar amount rather than percent.
- For normal distribution:
  VaR = Expected Value – Standardized Value for a Given Confidence Level * Standard Deviation

  Standardized Value = Number of standard deviation below mean corresponding to a given confidence level
  Note: VaR uses one-tail confidence levels.

- **Example:** For next four days
  4-Day Expected Value = $3,000
  4-Day Standard Deviation = $20,000
  Y% = One Tail Confidence Level or Target Probability = 95%.
  For 95%, the standard value is 1.65.
  VaR for 4 Day at C.L. 95%=$3,000 – $20,000 * 1.65 = $30,000

- Limitations/Criticisms: 1) VaR depends on good estimates of sensitivities of positions to rate changes, volatility of yield changes and their correlations, 2)This reading assumes (not true in general) that yield changes have to be normally distributed, 3) Multiplying daily VaR by square of number of days to horizon neglects a possibility of serial correlation and nonstationary behavior.

b) **Compute** and interpret value at risk for a bond;

- For normal distribution:
  VaR = Expected Value – Standardized Value for a Given Confidence Level * Standard Deviation
- See example above.
- For bonds, instead of standard deviation of return it would be better to use duration * standard deviation of yield changes

c) **Construct** and interpret a confidence interval for the expected return of a bond;

- *Confidence Interval*: is a range, within which a value (or return) falls assuming a normal probability distribution. For example: Within a 95% confidence interval the price of a bond or portfolio will change by no more than150 basis points during the next week.

- Assuming normal distribution, the confidence interval is calculated by:
  Lower Limit: (expected value – standardized value x standard deviation) to
  Upper Limit: (expected value + standardized value x standard deviation)

Example:

- The client asks for a confidence interval of 95% (given) of the price change of his portfolio over the next two weeks.
  95% probability means 2.5% in each tail
  The standardized value with a 2.5% probability is 1.96
  Assume that the following values are given: expected value is 3,000 with a standard deviation of $20,000.

Confidence interval is +3,000 ± 20,000* 1.96

d) **Explain** the role of the covariance and correlation of returns in computing portfolio standard deviation;

- Correlation coefficient:
  - Has a value between –1 and 1.
  - Measures association between two variables
    - Portfolio A and Portfolio B
    - Treasuries and High Yield
    - Two corporate bonds
  - Assumes no cause and effect
  - A positive value (positively correlated) means rates of return move together.
  - A negative value (negatively correlated) means rates of return move in the opposite direction.

- Covariance:
  - Has values that reach outside of the –1 and 1 range.
  - Also measures how two random variables vary together ("co-movement").
  - Will have the same sign (positive or negative) as the correlation coefficient.
  - In essence, measures the standard deviations for each (always positive) along with the two variables' correlation coefficients.
  - $Cov(r_1, r_2) = Std(r_1)\ Std(r_2)\ Cor\ (r_1, r_2)$

- To calculate standard deviation of a bond portfolio, variance/covariance for each bond held in portfolio is required. If a factor model is not used, the number of estimated parameters increase exponentially with the number of bonds –the number of terms that must be estimated is [J*(J+1)/2] where J is the number of bonds in the portfolio (try calculating this for broad-based indexes!)

e) **Explain** why a duration approach would be used as a measure of portfolio risk instead of variance (or standard deviation) estimated from historical returns;

- Historical standard deviations of returns are not meaningful in the bond market.
  - Unless one develops constant maturity series, historical returns of bonds include change in duration over time due to aging and are not reflective of future risks of current bonds.
  - Bonds change volatility characteristics due to changes in call characteristics due to yield curve changes.

- If standard deviation is used as a measure of risk, variance/covariance for each bond in a portfolio is required. If a factor model is not used, the number of estimated parameters increase exponentially with the number of bonds – if J is the number of bonds, the number of terms that must be estimated is [J*(J+1)/2]
- Factor models focus of main drivers of returns and reduce the number of required estimated parameters.
- Drivers of fixed income returns:
  - Changes in the levels of interest rates (90%)
  - Duration best quantifies a bond or portfolio's exposure to a change in interest rates
  - Duration represent return of the portfolio to a 100 bp. shift in rates.

- Duration definitions:
  - Macaulay: Weighted average term to maturity of the cash flows, in which the time of receipt of each payment is weighted by the PV of that payment. The entire formula is divided by the bond price.
  - Modified: Macaulay duration divided by (1+ y/f)
  - Effective: takes into account optionality (MBS, ABS, callable bonds, etc.)

- Portfolio duration is equal to market weighted duration of individual securities.

$$w_1 D_1 + w_2 D_2 + w_3 D_3 + w_4 D_4 + w_5 D_5 \ldots$$

f) **Compute** the contribution of a bond or sector to the duration of a portfolio or index, on both a duration and dollar duration basis;

- Contribution of a bond or sector to the duration of a portfolio:
  = (market value of sector / market value of portfolio) x duration of the sector
- Dollar Duration (Impact) Contribution:
  = (sector duration) x (market value of sector) x (decimal change in interest rates)
- To get sector contribution in percentage, divide the dollar duration of the sector by the dollar duration of the portfolio.

g) **Compute** a portfolio's duration, incorporating leverage, and interpret how the leverage affects the overall risk of the portfolio;

- Borrowing (or "leveraging") adds exposure (risk) to a portfolio.
- Duration is generally used to measure risk in a bond portfolio
- One can use dollar duration to calculate the duration impact of derivatives on portfolios
- Formula:
  Dollar price change of all bonds when rates change
  - Dollar price change of the liabilities when rates change
  + Dollar price change of the derivatives when rates change
  = Total change in the portfolio value when rates change

  Solve for the duration effect on the equity base.
  = - Percent Change in Market Value / Change in Yield

h) **Explain** how a bond manager would use a controlling position to adjust the dollar duration of a portfolio to a target duration;

- "Controlling Position" is the position that is used to adjust the current portfolio to the target portfolio
  Examples: Out right sale or swap of cash market instruments, short sale or forward purchases of treasuries, and long/short positions in derivatives (futures or OTC)
- Target dollar duration =
  Current dollar duration of portfolio without the controlling position
  + Dollar duration of controlling position

i) **Explain** the importance of spread duration;

- Spread risk: bond price changes due to spread changes.
- Non-Treasury bonds are often referred to as "spread-product"
- This "spread" refers to the yield premia of a bond over a risk-free Treasury of like duration.
- Spread duration measures how much market value of each Non-Treasury sector (or individual bonds) would change due to a change in spread sought by the market changes by 100bp for that sector.
- Spread duration of the portfolio is the sum of the contribution to portfolio duration of non-Treasury issues.
  Agencies (Government sponsored)
  Corporate bonds
  Mortgage Backed Securities
  Same holds true for an index.
- Comparing a portfolio's "spread duration" to an index's allows the portfolio manager to determine how much "spread risk" a portfolio is running.

- There are three types of spread duration measures: 1) nominal spread, 2) zero-volatility spread, 3) option-adjusted spread.
  - *Nominal*: The yield of a sector minus the yield of a comparable maturity Treasury.
  - *Zero-volatility or static*: Spread that when added to the Treasury spot curve will make the present value of flows equal to the bond plus accrued interest. Adjusts for curve but not cash flow uncertainty.
  - *Option-adjusted (OAS):* adjusts for callability (MBS, ABS, etc.) and curve.

- **Caution:** There are errors in the (b) Hypothetical Portfolio exhibit on Fabozzi's p.43. See website for errata: www.frankfabozzi.com/cfa/readings The figure in the lower right, Spread Duration, should be 3.24, not 3.07. The hypothetical portfolio, light in Treasury and heavy in mortgage and corporate securities, has a higher spread duration than the index, 3.24 versus the index 2.63.

j) **Compute** and interpret the spread duration of a portfolio and its index;

- Portfolio/Index Spread Duration = Market weighted average of spread duration of each sector in portfolio/index.
- Spread duration is used in measuring how much "spread risk" (non-Treasury risk) a portfolio has versus an index.

k) **Contrast** spread duration and portfolio duration;

- Spread duration measures the non-Treasury sector exposure to a parallel change in spreads.
- Portfolio duration measures the overall portfolio exposure to a parallel change in interest rates
- Spread duration of a portfolio may be different from the duration because of 1) holding of treasuries, 2) holding of floating instruments. Note that while floating instruments have minimal interest rate risk, they have spread duration risks comparable with duration of fixed-rate instruments of comparable maturity.

l) **Discuss** the difficulties of computing the duration of a portfolio that includes foreign bonds.

- Different countries' interest rate curves are not perfectly correlated (move in tandem).
- Calculating duration in a local country (United States, France, etc.) is only useful when measuring changes in that country's interest rate curve.

Procedure to Calculate Duration of Portfolios Including Foreign Bonds

1) Calculate the duration of the foreign bonds in their local markets.
2) Estimate empirically (or be given) the relationship (or correlation) between changes in that foreign country's yields versus U.S. yields. This relationship is called a "country beta", e.g. the country beta for Spain is 0.47.
3) Multiply the country beta times the bond's duration to get the U.S. equivalent duration.
4) U.S. equivalent duration can be used in the same way as domestic durations.
5) Note that this addresses interest rate sensitivity but not the currency changes.

6.1.C. "Managing Funds Against Liabilities"
Note: Refer to Reading 6.1.A for additional discussion of classifying liabilities and liability benchmarks.

Key Points:

- Immunization strategy matched duration and market value of portfolio with the liabilities to balance reinvestment risk with price risk. Minimizing the dispersion of portfolio cash flows with respect to liabilities lowers immunization risk.
- Cash flow matching minimizes the difference between portfolio cash flow stream with required liability cash flows. This strategy, sometimes referred to as *dedicated strateg*y, is costly but could be extended by horizon matching.
- An immunization risk measure can be constructed for portfolios designed to immunize against multiple liabilities.
- Due to duration drift, immunized portfolios need to be rebalanced from time to time, but tradeoffs between transaction costs and mismatch need to be evaluated.
- Contingent immunization is a way to continue active management until an adverse investment experience drive down the available potential return to a *safety net level* (minimal level to meet liabilities or satisfy client). This strategy requires careful monitoring and adjusting down risk when approaching safety net level.
- The most accurate way to discount liabilities is to use spread over Treasury spot curve.

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a) **Design** a bond immunization strategy that will ensure funding of a predetermined liability;

- Objective: Lock in minimum target rate/minimum target value regardless of how interest rates move
- Immunization requires offsetting reinvestment and interest rate (price) risks:

  Loss (gain) from reinvestment income under lower (higher) rate scenario ≤ Gain (loss) in portfolio value

- Main risk is duration:
  An asset portfolio with too long a duration leads to price risk when the liability is due.
  An asset portfolio with too short a duration exposes the portfolio to reinvestment risk.

Immunization Requirements:

- The effective duration must equal to effective duration of liability
- The market value (present value) of the portfolio must match the present value of liabilities
- When bonds with embedded options are used, effective (option adjusted) durations must be used in matching liability duration.

b) **Determine** why and how an immunized portfolio should be adjusted over time, and discuss how the implementation of the immunization might affect the frequency of rebalancing;

- Portfolio and liability durations change over time: 1) yield and yield curve changes, 2) embedded options in selected securities
- Portfolio needs to be rebalanced periodically to correct duration drift (mismatch) from the liability duration.
- The tradeoffs between the transaction costs of portfolio rebalancing and risks of duration mismatch must be considered.

Additional Considerations/Limitations:

- The lower the quality of the portfolio, the higher the risks and returns
- Current immunization process assumes no default, and securities respond to only changes in interest rates (ignores spread change possibility)
- Securities with embedded options and prepayment risk can reduce accuracy of immunization
- Portfolio rebalancing relies on liquidity and reasonable transaction costs

Optimization Procedures

- Minimize initial costs subject to constraints
- Typical constraints:
  - Sufficient cash to satisfy the liability at the end
  - Average and minimum quality
  - Issuer concentrations
  - Other guideline considerations
  - Initial and rebalancing transaction costs
- Sensitive to bond prices – should verify prices with an experienced trader
- It is an iterative process to arrive at a final practical portfolio that meets all requirements and considerations.

c) **Discuss** immunization risk with respect to non-parallel yield curve changes, and explain how this risk can be addressed;

- Classical immunization theory does not address non-parallel risk.
- One approach is to use alternative duration measures (e.g. key rate durations) to minimize this risk
- Fong/Vasicek established a measure of *immunization risk* that is valid for arbitrary interest rate moves that augments duration measure
- When duration is matched, the *immunization risk* is the reinvestment risk, and barbelled portfolios are riskier than bullet portfolios.
- Portfolios with a higher dispersion of cash flows around the horizon date (barbells) expose the portfolio (under a single liability scenario) to higher reinvestment risk.
- In the extreme, a perfectly matched cash flow portfolio has the least reinvestment risk.

d) **Design** a contingent immunization strategy and evaluate the strategy under various scenarios;

- Contingent immunization is a way to continue active management until an adverse investment experience drive down the available potential return to a *safety net level* (minimal level to meet liabilities or satisfy client)
- Key Considerations:
  - Establish well defined immunized initial return and ongoing available target return
  - Identify a suitable and "immunizable" lower safety net level of return (starts out lower than achievable rates)
  - Implement an effective monitoring procedure to ensure safety net is not violated and is accurately calculated
  - Measuring dynamically how much leeway there is at any particular point
  - Risks: 1) Rapid adverse movements prevents timely shift to immunization, 2) immunization, once operational, may not achieve the required rate.

Example:

- Initial portfolio of $100 million to be invested for 5 years in contingent immunization strategy.
- The immunizable return: 7.50%
- Safety net level: 6.00%
- The cushion: 1.50% (150 basis points)

Steps

a) Calculate the "required terminal value" (RTV):

$$RTV = PV\ (1+ s/2)^{2H}$$

Where s = safety net rate

$$RTV = \$100 \text{ million } (1.03)^{10} = \$134.39 \text{ million}$$

b) Determine the safety margin/cushion

Required assets at time t = $RTV / (1+i_t)^{2(H-t)}$

Where i_t is the immunizable semi-annualize yield at time t.

Initially: \$134.39 million/ $(1.0375)^{10}$ = \$93 million
150 basis points of a cushion or a safety margin of \$7 million.

c) Step (b) is frequently re-run to determine how much safety margin is available.
d) The "trigger point" is the yield level at which the active strategy must be abandoned and immunization becomes mandatory.

e) Monitoring can be summarized by:
Simulating interest rate changes with existing portfolio to set the current trigger point
Interest rates level causing the trigger point?
Calculating difference between existing value and trigger point.

e) **Explain** cash flow matching and its extensions for multiple liabilities;

- Cash flow matching minimizes the difference between portfolio cash flow stream with required liability cash flows. This strategy is sometimes referred to as *dedicated strateg*y.

Simple Procedure:

- Starts with last required liability cash flow and match with the last cash flow of a bond (principal + coupon).
- Remaining liabilities are adjusted down by the cash flows of the selected bond. Another bond is used to offset the next to last liabilities.
- Going backward in time, this procedure is repeated liability cash flows are all matched by selected securities cash flow.
- Linear programming can be used to find the least cost portfolio to match all cash flows.
- Because perfect matching of cash flows is often very difficult, there is always excess cash in portfolio that needs to be reinvested. A relatively conservative short-term rate must be used in constructing the portfolio. This in general lead to a higher cost of immunization.
- Cash flow matching is generally less flexible than minimum risk immunization strategy, but requires minimal rebalancing. It can be an expensive strategy, like buying Treasury zeroes.

Extensions of Cash Flow Matching

- In its most restrictive application, *only* cash flows occurring from assets before a liability can be used. This assumption can be relaxed to include cash flows from before and after within a range. This would require some rebalancing.
- Combination matching or horizon matching: Overall portfolio is duration matched with added constraint that it is cash matched for the first few (usually 5) years.

f) **Discuss** immunization strategies for multiple liabilities (multiperiod immunization and cash flow matching);

- There are 2 strategies that can be used to hedge or meet liabilities:
  - Immunization
  - Cash flow matching (identical procedure as single period)
- Three Immunization Criteria

1) PV of assets must be greater than or equal to the PV of the liabilities
2) Effective duration of portfolio must equal the duration of the liabilities
3) The distribution of the individual assets in the portfolio must have a wider range than the distribution of the liabilities. Bracketing of liability with a pair of shorter and longer cash flows to address re-investment risk.

- To address non-parallel risk an *immunization risk* measure minimized. Portfolio with the least amount of dispersion with respect to liability cash flow stream has the lowest *immunization risk*.
- Constructing minimum risk immunized portfolios can be achieved using linear programming.

g) **Explain** how an appropriate discount rate is selected for determining the present value of liabilities and discuss the importance of that discount rate.

- Selection of a discount rate will have a significant impact on:
  - PV assumptions and hence surplus and sufficiency
  - Construction of portfolio of supporting assets (including duration)

Three Discounting Choices:

- *Treasury yield curve with spread:* Has no theoretical bases because duration, convexity, and coupon flows make the rate not applicable to single cash flow.
- *Yield curve derived from a portfolio of assets:* This approach also has problems because some corporate bonds may suffer downgrades (or defaults) and skew the price/yield valuation.
- *Treasury spot curve plus spread:* Best choice, because the duration levels are cleanest and will lead the manager and plan sponsor to the most accurate valuation for the assets, liabilities and hence surplus.

- The crucial discussion of how the spread is set/calculated and how often is updated has not been addressed by the reading.