INV 101 Model Solutions
March 2026

1. Learning Objectives:

1. The candidate will understand the nature and the variety of asset classes that can be used in constructing a portfolio.

Learning Outcomes:

(1a) Demonstrate an understanding of cash flow characteristics, underlying risks and roles in investment portfolios of various fixed income investments, including:
- Government and corporate bonds
- Leveraged loans
- Commercial and residential mortgages
- Mortgage-backed securities
- Structured credit products
- Private debt

Sources:

Handbook of Fixed Income Securities, Fabozzi, F.J., 9th Edition, 2021 Ch. 21-22

Commentary on Question:

This question tests the candidates' understanding of key ratios used in mortgage underwriting as well as their understanding of the prepayment risk of associated with mortgage-backed securities (MBS).

Solution:

(a) Calculate the following:

- Loan-to-Value Ratio of this mortgage.
- Front-end Debt-to-Income Ratio of this mortgage
- Back-end Debt-to-Income Ratio of this mortgage.

Commentary on Question:

Candidates performed above average on this section. Many candidates correctly calculated all three ratios. Nearly all candidates correctly calculated the loan-to-value ratio. Candidates were less successful in calculating the front-end and back-end debt to income ratios. A common mistake made when calculating these ratios was the exclusion of the Private Mortgage Insurance (PMI), property taxes, and Homeowners Association (HOA) dues from the calculations.

See Excel file.

1. Continued

Fill in your final answers here:		
Loan-to-Value Ratio	83.14%	<-- Loan Amount / Value of Property
Front-end Debt-to-Income Ratio	30.65%	<-- (Mortgage + PMI + Property Tax + HOA) / Pre-Tax Income
Back-end Debt-to-Income Ratio	37.79%	<-- (Mortgage + PMI + Property Tax + HOA + Other Debt) / Pre-Tax Income

(b)

(i) Calculate the Prepaid Principal in each period in the cashflow projection using a 0 PSA model and a 150 PSA model.

(ii) Calculate the Weighted Average Life under each PSA model.

Commentary on Question:
Candidates performed above average on this section. Candidates that knew all of the applicable formulas generally received full credit for both (i) and (ii). While many candidates did not receive full credit on (i), most received partial credit for demonstrating knowledge of how to perform some of the intermediate steps necessary to calculate the prepaid principal schedule. Many candidates received full credit for (ii). Note: candidates were not penalized in (ii) for an incorrect answer in (i) that caused their weighted average life calculations to be incorrect. Therefore, candidates who applied the correct formulas in (ii) to their answer in (i) earned full credit for (ii).

See Excel file.

(c) The intern stated, "Since the annualized yield is the same in the two PSA models, the different PSA model assumptions don't actually have much of an impact on the potential returns of the Agency RMBS."

Critique the intern's statement.

Commentary on Question:
Candidates performed above average on this section. Nearly all candidates correctly stated that the intern's statement is false. Many candidates identified the variance in cashflow patterns under different PSAs or cited the prepayment risk associated with mortgage-backed securities. Both responses earned full credit if sufficiently explained.

The statement is false. While the annualized yield may be the same between the PSA models, the cashflow patterns are vastly different. The Weighted Average Life (WAL) should also be considered. For example, as seen in part (b), the WAL decreases from 17.97 years in the 0 PSA model to 6.51 years in the 150 PSA model. Therefore, the number of years that the annualized yield is earned will vary considerably under different PSA models. Given this, the annualized yield should not be considered in isolation.

1. Continued

In addition, there is a considerable amount of reinvestment risk associated with MBSs. If rates decline, we would expect the prepayment speed to increase, which would lead to reinvestment of the paid off principal occurring at lower yields. Conversely, if rates were to rise, we would expect prepayment speeds to slow, meaning it would take longer to receive repayment of the principal, and we would not be able to reinvest as much at higher yields.

2. Learning Objectives:

1. The candidate will understand the nature and the variety of asset classes that can be used in constructing a portfolio.

Learning Outcomes:

(1a) Demonstrate an understanding of cash flow characteristics, underlying risks and roles in investment portfolios of various fixed income investments, including:
- Government and corporate bonds
- Leveraged loans
- Commercial and residential mortgages
- Mortgage-backed securities
- Structured credit products
- Private debt

(1b) Demonstrate an understanding of the distinguishing investment characteristics and potential contributions to investment portfolios of various types of equity and alternative investments, including:
- Public Equity
- Private Equity
- Real Estate
- Hedge Funds

Sources:

Handbook of Fixed Income Securities, Fabozzi, F.J., 9th Edition, Chs. 10, 21,23, 60

Portfolio Management in Practice Vol 1, CFA Ch. 11

High Yield Bond Primer

Overview of Investing in Private Corporate Debt

Commentary on Question:

This question tests candidates' understanding of basic characteristics (such as cash flows and underlying risks) of investment portfolios.

Solution:

(a) Explain the key feature (or features) that leads to the price behavior of each of the five bonds.

Commentary on Question:

Candidates performed as expected on this section. Some candidates were able to correctly make the connection between the risk profile (as shown in each graph) and the bond type. Credit was given for each correct connection.

Note 1: Those that merely stated the facts (such as "bond 2 exhibits higher convexity than bond 1" earned no credit.

2. Continued

Note 2: The question clearly stated that the five bonds are coupon-bearing bonds with 10 years to maturity. Some candidates tried to link the graph to zero-coupon bonds or bonds with very short maturity – neither of them is consistent with the given question.

Bond 1: The red curve is consistent with an option-free bond

Bond 2: The black curve shows negative convexity and is consistent with MBS security due to prepayment risk "contraction" and "extension"

Bond 3: The green curve shows (1) similar price behavior as red curve when yield increases; (2) similar behavior as red curve when yield decreases up to 40bp; (3) constant price when the yield dropped more than 40bp. This behavior is consistent with a callable bond that will be called when the yield decreases 40bp from the current level.

Bond 4: The purple line's left side resembles Bond 2, while the right side resembles Bond 3. This indicates that Bond 4 may be a Tranche (a sequential or a PAC without enough prepayment protection) from CMO. In rising rate environment, pre-payment slows, the bond behaves like a long-duration bond. In falling rate environment, pre-payment rises and other Tranches are paid off, the bond is exposed to pre-payment and behaves like a short bond.

Bond 5: The blue curve shows very low sensitivity to yield change. Because bond's maturity of 10 years, this behavior indicates that the bond may have a floating coupon rate that rises/falls with the yield level such as an ARM mortgage, or floating rate private debt.

(b) Calculate the number of ABC bonds your firm purchased and the coupon rate of the ABC bond.

Commentary on Question:
Candidates performed as expected on this section. In calculating the number of ABC bonds that were purchased, some candidates forgot to reflect the accrued interest. In calculating ABC bond's coupon rate, some incorrectly applied the 30/360 rule. Partial credit was given for each correct step that led to the final solution.

$$\#\text{of ABC bond} = \frac{Total\ cash\ received\ from\ \text{sec}\ lending - ABC\ bond\ accrued\ intest}{ABC\ bond\ price}$$

$$\#\text{of ABC bond} = \frac{1024.06 * 700 - 3{,}034}{995} = 717.39$$

2. Continued

$$\text{ABC bond coupon rate} = \frac{ABC\ bond\ accrued\ intest}{(\frac{1}{2} ABC\ bond\ par\ value * \#of\ ABC\ bonds) * \frac{Accrued\ Days}{360})}$$

Under 30/360 rule, the accrued days from the last coupon date of September 15 to the settlement date of Nov 14 is 16(Sep) + 30(Oct) + 13(Nov) = 59

$$\text{ABC bond coupon rate} = \frac{3{,}034}{(\frac{1}{2} 1000 * 717.39) * \frac{59}{360})} = 5.16\%$$

Note: though the correct coupon rate is 5.16%, full credit is also given if candidates arrived at 2.58% (=5.16% / 2) by not applying ½ factor in the above formula. *This is due to an error in the study material (Higher Yield Bond Primer, p11), in which the coupons were illustrated as being paid annually despite the notion of two coupon payment dates per year in the same illustration.*

(c) Describe the types of assets that you would propose.

Commentary on Question:
Candidates performed as expected on this section. Many candidates were able to identify TIPS or floating rate bonds, as well as equities to help hedge the inflation risk.

Assets that can help hedge the inflation risk include

- Many private corporate debts offer floating-rate coupons that can either partially or fully offset increases in inflation via an increase in the reference rate as market interest rate rises due to inflation expectations. (Investing in Private Corp Debt p.221)

- Some individual equities or sectors can provide some protection against inflation (CFA Vol 1 PM-Inv Mgmt.-Ch 11, page 577).
    - Companies that are capable of passing along higher input cost to customers
    - Companies within sectors that produce broad-based commodities can directly benefit from increases in commodity prices.

- TIPS, issued by the U.S government, is also a feasible asset choice to hedge the inflation (Fabozzi Ch. 20).

3. Learning Objectives:

2. The candidate will understand portfolio construction, management, and assessment.

Learning Outcomes:

(2a) Describe the portfolio management process and recommend investment governance structure.

(2c) Demonstrate an understanding of portfolio construction approaches and techniques for asset allocation, passive/active management and rebalancing.

(2d) Recommend and justify an optimal portfolio allocation in a risk-return framework.

Sources:

Portfolio Management in Practice Vol 1, CFA, ch 5 & ch 6

Commentary on Question:

This question requires candidates to demonstrate understanding of various asset allocation approaches and to evaluate different asset allocations based on investor objectives, constraints and preferences.

Solution:

(c) Describe the three broad approaches to asset allocation.

Commentary on Question:

Candidates performed about average on this section. Most candidates focused on describing asset-only approaches and did not provide enough description for liability-driven or goals-based approaches and hence did not receive full credit.

The three broad approaches to asset allocation are:

- Asset-only: Focused solely on the asset side of the investor's balance sheet. Liabilities are not explicitly modeled.
- Liability-driven investing: Focused on investing to funding the liabilities on the balance sheet.
- Goals-based: Used primarily by individuals and families and involves specifying asset allocations for sub-portfolios that are aligned to specific goals

(d) Evaluate your colleague's recommendation.

Commentary on Question:

Candidates performed just slightly above average on this section. In addition to the model answer points below, credit was also given where candidates described the need for asset diversification or to elevate the funded ratio to a surplus level.

3. Continued

Colleague's recommendation is not correct as there should be some exposure to equities, given the current funded ratio. Key points to consider:

- If the plan's funded ratio is exactly 100%, there is no buffer/safety net.
- Fixed income is generally less risky than equities but has a lower expected return.
- If there is no allocation to equities, the chance to increase the funded ratio above 100% to create a buffer is reduced.
- The plan and its pensioners would likely benefit from some increase in the funded ratio to allow for a buffer to ensure that all obligations can be met.
- Additionally, equities can be a hedge against inflation.
- And since the plan benefits increase with inflation, it would be appropriate to have some allocation to equities. It would be appropriate to have the funded predominantly invested in fixed income

(c) Recommend the best asset allocation option for the fund.

Commentary on Question:
Candidates performed below average on this section. Some candidates made rudimentary errors in calculating the Utility for each asset allocation because they applied the formula Um = E(Rm) - .005λσ^2 to the decimal percentage expression of E(R_m)and σ_m (e,g, 0.12 or 0.2). A good number of candidates did not calculate the probability of exceeding the minimum return threshold (assuming normal distribution) and thus did not differentiate correctly between asset allocation approaches A & B.

First, determine the threshold level of return: 20*(1+RL) – 1 = 20*1.02. RL = 7%.
Left side of the equation represents the fund balance grown at the required return for one-year less the contribution, and the right side of the equation represents the current fund balance grown at the inflation rate.

Next, calculate the utility for each asset allocation: Um = E(Rm) - .005λσ^2
Ua = 12 - 0.005*2*(20)^2 = 8.0 or 8%
Similarly:
Ub = 8.0 or 8%
Uc = 7.0 or 7%

· The fund would be indifferent between A and B, based solely on their utilities of 8%.
· To decide which allocation is best calculate the [E(Rp)-RL]/σ ratio, which represents the probability of exceeding the minimum return threshold given a normal return distribution.

3. **Continued**

For A, this is: 0.25
For B, this is: 0.20
For B, this is: 0.05

· Given that A and B have the same utility, but A has a higher probability of exceeding the 7% return threshold, we recommend option A.

4. Learning Objectives:

2. The candidate will understand portfolio construction, management, and assessment.

Learning Outcomes:

(2g) Construct and manage portfolios of equity under various passive strategies

Sources:

Portfolio Management in Practice Vol 1, CFA, ch 12, INV101-104-25: The Hidden Dangers of Passive Investing

Commentary on Question:

This question tests the concept of passive equity portfolio construction.

Solution:

(a) Describe three potential causes of tracking errors for a passive strategy.

Commentary on Question:

Most candidates did well on this part. Some candidates mentioned simultaneously transaction costs of rebalancing and management fees or broker commissions. All of these are trading costs and count for credit for one cause. A few candidates mentioned tax from trading. This is not the main constituent of trading cost so no credit was given.

Causes of tracking error for a passive strategy are:

- Trading costs – an index incurs no trading costs when rebalancing, but a fund does, which drives down the fund's returns.
- Mismatch between the fund and the index – most funds wouldn't attempt to fully replicate the index, which would introduce tracking error from mismatches between fund allocations and index allocations.
- Cash drag – indices don't have a cash allocation, but a portfolio can accumulate cash that cannot be invested immediately, which would drag down the fund's performance.

(b) Explain three reasons why it is not appropriate for the pension plan to change its equity strategy from an active strategy to a passive strategy based on their above rationale.

Commentary on Question:

Candidates did extremely poorly on this part. Partial credit was given for providing reasons for the board's rationale being too narrow. A few candidates realized the key point was explaining hidden dangers of passive investing. Partial credit was given for only mentioning overcrowding or due diligence without tying those reasons back to the data provided in the question. Some candidates reiterated tracking errors from part a, which did not earn credit.

4. Continued

It is not appropriate for the pension fund to switch the equity portfolio's management strategy from active to passive based purely on their rationale because their rationale is too narrow in scope for a major pension plan, and it ignores some notable issues associated with a major pension plan utilizing a passive strategy.

It is true that active management has higher investment management costs compared to passive management and as a result, it's harder for the pension plan to earn enough returns (net of expenses) to support its future liabilities. However, changing the portfolio's entire investment strategy just because of higher expenses is too extreme of a rationale to be appropriate and it ignores some fundamental issues of a major pension plan using a passive strategy.

Namely, the nature of the pension plan and the sheer size of its equity portfolio can exacerbate some key issues associated with a passive strategy:

- The passive strategy is a very crowded strategy and this has led to lower diversification benefits from holding a portfolio of assets because returns are highly correlated amongst the index constituents. This is a major issue for pension plans because this increases the volatility of the portfolio returns, which increases the risk of the plan becoming underfunded.
- By design, the strategy would compound the overcrowding because most passive indices are constructed based on market capitalization and as more money pours into the strategy, it raises the market capitalization of the underlying stocks. In this instance, switching to a passive strategy would significantly crowd the trade because $120B is being poured into the strategy.
- The switch may introduce enormous legal risk to the pension plan because the plan has a fiduciary duty to its plan members to manage the plan assets well. However, by design, a passive strategy is blind to relative value, which means that the plan would need to allocate capital to a company even if it doesn't deserve the allocation. As a result, there's an inherent conflict between the nature of a passive strategy and the plan's need for due diligence.

(c) Describe how you can use equity futures to address the above operational issues.

Commentary on Question:
Candidates did not perform as expected on this part. Many candidates simply repeated part of the questions, without providing further analysis and were given no credit. Some candidates confused equity futures with forwards or equities and were given no credit. Mentioning leverage, TAA and ETF was given partial credit.

4. Continued

Equity futures and equity ETFs can be used to improve the efficiency of the active strategy in the following manner:

- Rather than waiting for the perfect opportunity for investment, PMs would invest the plan member deposits in equity futures/ETFs to minimize the return difference between the portfolio and its benchmark (i.e., minimizes the portfolio cash drag).
- Because the instruments are highly liquid, PMs can use them to quickly capitalize on short-term opportunities in the market. This is especially relevant for equity futures because PMs don't need to liquidate any of their positions to capitalize on these potential opportunities.

5. Learning Objectives:

2. The candidate will understand portfolio construction, management, and assessment.

Learning Outcomes:

(2e) Demonstrate an understanding of common techniques to enhance yield and manage liquidity in fixed income portfolios.

(2f) Construct and manage portfolios of fixed income investments under various strategies, including indexing and target return.

Sources:

Portfolio Management in Practice Vol 1: Investment Management, CFA Institute, 2003. Chs. 9 and 10.

Commentary on Question:

This question tests candidates' understanding of managing fixed-income portfolios to satisfy clients' needs, in terms of liquidity and yield enhancement strategies.

Solution:

(a) Describe the type of fixed-income mandate that XYZ's pension plan is most likely to adopt.

Commentary on Question:

Candidates performed fairly on this question, often recognizing that the plan should adopt a liability-driven mandate linked to the associated liabilities of the new retirees.

The plan should adopt a liability-driven mandate to meet the immediate needs of the expected liabilities due to the new retirees and minimize the risk of plan shortfalls.

(b) Recommend which bond to invest for XYZ's DB pension plan.

Commentary on Question:

Candidates performed well on this question, often identifying that bond D is appropriate due to the liquidity needs of the plan and the benefit from the inflation-linked property of the asset.

Bond D is the most appropriate choice because it addresses the upcoming liquidity needs of the plan due to the surge of retirees and its inflation linked property will benefit the CPI linked portion of the benefits.

5. Continued

(c) Describe stratified sampling and its steps.

Commentary on Question:
Candidates performed well on this question, with most candidates identifying the intuition behind stratified sampling and identifying two out of three implementation steps but losing points for not identifying the rebalancing step.

The stratified sampling approach mimics and index's return with fewer securities, saving transaction and management costs. This is carried out by mapping significant characteristics between the portfolio and index, select a subset of bonds from that index for the portfolio. The portfolio must be rebalanced at regular intervals to continue to match it's index.

(d) Assess whether the return objective is satisfied.

Commentary on Question:
Candidates performed above average on this part of this question, almost always calculating and identifying a return that is less than the 3% target. Common calculation errors include missing the 0.5 factor on the convexity term in the expected price change and using modified duration and convexity instead of the effective version.

The return of 2.79% does not satisfy the 3.0% limit. The return is the sum of 3.57 Euro / 99.27 price, 98.43/99.27-1 for the rolldown return, -4.12 x 0.0018 + 0.5 x 0.9 x 0.0018^2 for price expectation, 0.13% for credit losses and 0.65% for currency risk.

(e) Describe three methods of leveraging fixed-income portfolios.

Commentary on Question:
Candidates performed well on this question, usually identifying two to four of the available answers. Candidates occasionally lost points for not providing sufficient reasoning for every response.

The return can be enhanced by borrowing funds, engaging in futures contracts or swaps, security's lending, inverse floaters, or repurchase agreements.

6. Learning Objectives:

2. The candidate will understand portfolio construction, management, and assessment.

Learning Outcomes:

(2h) Apply performance measurement methodologies to various asset portfolios.

(2j) Assess and interpret performance attribution metrics for a given asset or portfolio.

Sources:

Portfolio Management in Practice Vol 1, CFA, ch 19, p. 11258

Portfolio Management in Practice Vol 1, CFA, ch 19, pp. 1127-1135

Portfolio Management in Practice Vol 1, CFA, ch 19, pp. 1138-1143

Commentary on Question:

This question tests the candidates' understanding of performance attribution.

Solution:

(a) Describe the three approaches to performance attribution.

Commentary on Question:

The candidates performed poorly on this question. Many candidates misinterpreted the scope the question. A large number of candidates listed and described performance attribution models, while the question was looking for approaches to performance attribution. However, most candidates who correctly identified the three broad performance attribution approaches were able to give very solid descriptions in their answers.

The three broad approaches to performance attribution are:

- Returns-based: uses only the total portfolio returns over a period to identify the components of the investment process that have generated the returns.
- Holdings-based: References the beginning of period holdings of the portfolio and is calculated with monthly, weekly, or daily data.
- Transactions-based: uses both the holdings of the portfolio and the transactions that occurred during the period (including transaction costs).

6. Continued

You work as an investment analyst for XYZ Company and have been tasked with providing return attribution results for their equity portfolio. The table below provides the relevant information on XYZ's portfolio and the benchmark portfolio.

	XYZ Weight	Benchmark Weight	XYZ Return	Benchmark Return
Financials	40%	40%	15%	10%
Technology	20%	30%	-5%	-1%
Energy	40%	30%	3%	0%

(b) Calculate each of the following for XYZ's portfolio using the Brinson-Fachler model.

- Excess Return
- Allocation Effect
- Selection Effect
- Interaction Effect

Commentary on Question:
Candidates performed well for this question. One common mistake from candidates not receiving full marks was not deducting the benchmark return in the calculation of the allocation effect, which is required under the Brinson-Fachler model.

See Excel file.

XYZ is now reviewing its fixed income portfolio allocations. Your colleague suggests that the company should establish an overweight allocation relative to the benchmark portfolio for long-term corporate bonds given the company's expectation that the risk-free interest rate curve will shift from upward sloping to inverted.

(c) Evaluate your colleague's recommendation assuming the company's expectation for the risk-free interest rate curve will materialize as expected.

Commentary on Question:
Candidates performed below average for this question. Few candidates were able to provide a complete explanation of the impact from the risk-free curve inversion on the corporate bond prices. Many candidates were able to point out the additional risk from credit spread widening which applies to corporate bonds in the given scenario.

6. Continued

Your colleague's recommendation is incomplete (i.e., partly agree).

- In this case, the flattening and inverting of the risk-free curve would cause the long-end of the curve to decrease more/increase less than on the short-end of the curve. This will contribute favorably to price return of the long-term bonds relative to the short-term bonds (supports your colleague's statement).
- However, you will also need to consider expectations for long-term corporate spreads as well. If they are expected to increase considerably, then it may not be beneficial to be overweighted towards long-term corporate bonds
- You may need to also consider whether the level of rates changes, even if the assumption of the curve inversion is correct.
    - E.g., general level of rates may increase as well, affecting duration. This would counter the impact of the recommendation

7. Learning Objectives:

3. The candidate will understand the best practices of credit risk management.

Learning Outcomes:

(3a) Demonstrate an understanding of credit risk analysis including at the portfolio level.

(3b) Demonstrate an understanding of and the ability to apply both the concepts and techniques used in the measurement of default risk of individual securities.

Sources:

The Handbook of Credit Risk Management, Bouteille & Coogan-Pushner, 2nd Edition, 2022, Chapters 4, 13

Commentary on Question:

This question tests candidates' understanding of credit risk management at both the individual exposure and portfolio levels, including Level 2 and Level 3 Credit Portfolio Management (CPM) concepts. It combines conceptual critique, numerical calculation of expected loss using net exposure, and practical considerations in collateral evaluation and portfolio risk management.

Solution:

(a) An analyst on your team, Jean, has made the following comments about the Level 2 (Intermediate) Credit Portfolio Management (CPM) as defined in The Handbook of Credit Risk Management:

I. Stress testing is done to evaluate how the portfolio will behave in circumstances reflecting historical extremes.

II. When rebalancing transactions, only transactions incurring losses will be replaced.

Critique each of Jean's comments.

Commentary on Question:

Candidates performed above average for this part. Most candidates were able to identify the key limitations. Some candidates did not provide a legitimate reason for why statement 2 is not correct.

Statement 1 is incomplete. (Tests based on historical periods of stress are used in practice.)

The stress test circumstances can also reflect scenarios that have not yet been experienced.

7. Continued

Statement 2 is not correct.

Transactions generating profits can also be replaced by more profitable transactions.

(b) Calculate the expected loss of this loan using the net exposure.

Commentary on Question:
Candidates performed brilliantly for this part. Some candidates did not correctly calculate the net exposure.

Net Exposure=Loan Amount−Collateral Value = 50M−20M=30M

EL=PD×(1-RecoveryRate)×Net Exposure

EL=0.03×0.60×30M=0.54M

(c) Describe three checklist items that should be considered when evaluating collateral value.

Commentary on Question:
Candidates performed as expected for this part. Many candidates did not describe three correct items.

Who owns the collateral in case of bankruptcy? Only collateral whose ownership is not disputed should be taken into account.

Can the collateral be valued? In case of uncertainty over the value, a discount or "haircut" to the notional amount of the collateral has to be applied.

Can the collateral be sold? Collateral should consist of liquid instruments that can be sold easily.

Is the collateral correlated with the underlying exposure? If this is the case, collateral can be worthless.

(d) Describe two Level 3 CPM techniques XYZ can use to manage its credit risk exposure.

Commentary on Question:
Candidates performed as expected for this part. Many candidates failed to identify two techniques, or failed to correctly describe what transfer pricing is.

7. Continued

Transfer Pricing: Moves management of risk from origination team to the CPM group who have the expertise to better manage the risk.

Acquisitions: Acquire exposures in other sectors to add diversification or exposures that the business is unable to generate.

Swaps of Exposures: XYZ can swap exposures with another institution with low exposure to the manufacturing sector.

8. Learning Objectives:

3. The candidate will understand the best practices of credit risk management.

Learning Outcomes:

(3c) Understand, evaluate, and apply credit risk modeling techniques.

Sources:

Credit Risk Modeling, Bolder, David (2018), Chapters 2 & 3

Commentary on Question:

This question tested candidates' understanding of default modeling and the appropriateness of various methods.

Solution:

(a) Recommend which approach would best suit each portfolio.

Commentary on Question:

Candidates performed as expected on this question. Many candidates were able to assign the correct approaches to each portfolio and state the exposure sizes as a main reason. To receive full credit, candidates also tied the number of obligors to run time or ability to produce realistic results.

Portfolio 1 is suited for Analytical Approach. Identical exposures is one of the simplifying assumptions needed for this approach, along with independence, which is also assumed. Furthermore, it has a large number of obligors so defaults will converge.

Portfolio 2 would use the Numerical Approach because it has varying exposures. It also has relatively few obligors, so runtime shouldn't be an issue.

(b) Describe the expected impact to the default loss distribution assuming correlation of defaults.

Commentary on Question:

Candidates performed above average on this question. Most candidates were able to correctly identify that fatter tails would be produced under the beta-binomial mixture model with correlation. Some candidates correctly added additional information, such as increased variance or unchanged expected loss, to receive full credit.

Assuming a correlation of defaults will result in fatter tails of the distribution. The resulting distribution will have the same expected loss but risk metrics (such as Value-at-Risk and Expected Shortfall) will be more severe.

8. Continued

(c) Describe the problem you will encounter in calibrating the model assuming a portfolio wide unconditional default probability of 0.01 and an average default correlation of 0.05. (Note: no formulas are required to answer this question)

Commentary on Question:
Candidates performed poorly on this question. Some candidates were able to correctly identify the w1 & alpha parameters as the issue and that there is no unique way to solve them, which was needed to earn full credit.

You cannot determine the value of w_1 and the parameter of Gamma distribution a. Using the unconditional default probability and average default correlation, one can get the value of w_1^2/a, but not individual values. Therefore, to get the individual values of w_1 and a, we need to estimate one of the values.

(d) Describe the additional assumptions that will be required to calibrate the model assuming a portfolio wide unconditional default probability of 0.01 and an average default correlation of 0.05. (Note: no formulas are required to answer this question)

Commentary on Question:
Candidates performed below average on this question. Many candidates were able to earn credit for understanding that each additional systematic factor would require a factor loading. Full credit was awarded to those who provided additional insight, such as each systematic factor being independent of one another. Some candidates were given partial credit for only mentioning the independence of the systematic factors.

We must assume that:
1. The sum of all factor loadings, w0 to wk, must equal to 1.
2. Each systematic factor Sk is gamma distributed with its own parameter ak.
3. All systematic factors are independent with each other.

9. **Learning Objectives:**

1. The candidate will understand the nature and the variety of asset classes that can be used in constructing a portfolio.

3. The candidate will understand the best practices of credit risk management.

Learning Outcomes:

(1a) Demonstrate an understanding of cash flow characteristics, underlying risks and roles in investment portfolios of various fixed income investments, including:
- Government and corporate bonds
- Leveraged loans
- Commercial and residential mortgages
- Mortgage-backed securities
- Structured credit products
- Private debt

(3c) Understand, evaluate, and apply credit risk modeling techniques.

Sources:

Fabozzi Ch. 22: Agency Mortgage Passthrough ((up to page 491)

Fabozzi Ch. 23: Agency Collateralized Mortgage Obligations (up to page 520 before Exotics)

Bolder, Ch 3: Mixture or Actuarial Models

Bolder, Ch 4: Threshold Models (sections 4.1-4.4 only)

Commentary on Question:

Commentary listed underneath question component.

Solution:

(a)

(i) Calculate the duration of the MBS security.

Commentary on Question:

Overall candidates did well on this question. Common weakness was incomplete or incorrect duration formula.

$$\text{Duration} = \frac{V_- - V_+}{2V_0 * (\Delta y)}$$

$$= \frac{490000 - 455000}{2 * 480000 * (0.5\%)}$$

$$= 7.29$$

9. Continued

(ii) Explain why the magnitude of the change in market value when interest rates increase is higher than when interest rates decrease.

Commentary on Question:
Overall candidates did well on this question. The most common weakness was an incomplete explanation. While many candidates correctly mentioned prepayment behavior, they did not fully articulate how this leads to reduced price gains compared to traditional bonds. The key gap across these responses was the failure to link prepayment behavior to negative convexity and its impact on valuation.

Mortgage-backed securities exhibit negative convexity due to borrower prepayment behavior. When interest rates fall, borrowers are more likely to prepay or refinance their mortgages, resulting in earlier return of principal to investors.

This shortens the expected cash flow profile (thus shorter duration) and reduces future interest payments. As a result, the price of the MBS increases less than that of a traditional bond when interest rates decline. Therefore, prepayment behavior limits the upside price movement of MBS in a falling interest rate environment.

(b)

(i) Explain how the market value of MBS IO and MBS PO securities would change when interest rates go up.

Commentary on Question:
Overall performance was moderate. The most common weakness was incomplete reasoning—while candidates often mentioned slower prepayments, they did not fully explain how this affects the timing of cash flows and ultimately the value of IOs and POs. The key gap was the inability to clearly connect interest rate changes to prepayment behavior, and the subsequent impact to the cash flow timing and resulting valuation impact for both securities.

When interest rates rise, mortgage prepayments slow down because fewer borrowers refinance. For interest-only (IO) securities, slower prepayments mean that interest payments are received over a longer period. Since IO values depend on the stream of interest payments, this increases their value. As a result, IOs exhibit negative duration, with prices tending to rise when interest rates increase.

For principal-only (PO) securities, slower prepayments delay the return of principal. This extends the timing of cash flows, and due to the time value of money, the present value of these later payments decreases. Therefore, PO prices decline when interest rates rise.

(ii) Explain why Treasury STRIPS are preferred over MBS IO/PO securities in a fixed-income portfolio that supports pension-type liabilities that are entirely made up of retirees.

9. Continued

Commentary on Question:
Overall performance was moderate. The most common issue was incomplete comparisons. Many candidates identified the absence of prepayment risk in Treasury STRIPS, but did not provide a sufficiently comprehensive answer covering other key aspects. Another frequent gap was failing to explicitly link these differences to the pension portfolio objective, particularly the importance of stable and predictable cash flows for liability matching.

Treasury STRIPS can be structured as either interest-only (coupon strips) or principal-only securities, similar in form to MBS IO/POs. However, unlike MBS IO/POs, Treasury STRIPS are not subject to prepayment risk, as their cash flows are fixed and determined at issuance. In addition, Treasury STRIPS are considered to have negligible credit-risk, whereas MBS IO/POs are exposed to credit risk. This makes STRIPS more suitable for pension portfolios that prioritize having low credit risk. Furthermore, Treasury STRIPS provide fixed and predictable cash flows, which align well with the liability-driven needs of pension funds.

(c)

(i) Calculate the alpha and beta parameters of the Poisson-Gamma model.

Commentary on Question:
Overall results were polarized, with many candidates scoring either very high or very low.
The most common issue among lower-scoring responses was the failure to recognize and leverage the closed-form formulas for the Poisson-Gamma model.

For Poisson-Gamma model:

$$E(\lambda) = \frac{a}{b} = \underline{p}$$

$$Var(\lambda) = \frac{a}{b^2} = \text{Var}(\underline{p})$$

Solve for a and b:

a = 0.0251
b = 5.0251

(ii) Explain why calibrating a Poisson-Gamma Mixture model requires less runtime than calibrating a Probit- and Logit Normal Mixture model.

Commentary on Question:
Overall performance on this part was weak, with fewer candidates achieving full marks. While some candidates demonstrated familiarity with the different mixture models, many struggled to clearly articulate the computational implications highlighted in the question.

9. Continued

Lower-scoring responses were often descriptive but unfocused, listing model names without explaining their computational properties, or demonstrating confusion about which models require numerical integration.

The Poisson-Gamma mixture model has closed-form expressions for the first and second moments of default probabilities. As a result, there is no need to perform numerical integration when calculating these moments, making these models computationally efficient. In contrast, the Probit-Normal and Logit-Normal mixture models do not have closed-form solutions for moments. This requires the use of numerical integration, which increases computational complexity and leads to longer calibration runtimes.

(d) Explain the limitation of the Gaussian model for credit risk in modeling this portfolio.

Commentary on Question:
Overall performance on this part was relatively weak. The most common issue was incomplete explanation. Many candidates mentioned correlation increasing in stress scenarios but did not explicitly reference tail dependence. Lower-scoring responses were often vague or focused only on general correlation without addressing behavior in extreme scenarios.

In distressed scenarios, defaults tend to cluster, as obligors that appear uncorrelated in normal conditions can become highly correlated during periods of economic stress. For example, even unrelated sectors may experience increased default correlation due to shared exposure to macroeconomic, geographic, or supply chain factors. This behavior is captured by tail dependence, which measures the likelihood that extreme default events occur together. Tail dependence is a desirable property in credit risk modeling because loss distributions are often driven by outcomes in the extreme tail.

A key limitation of the Gaussian (threshold) credit risk model is that it assumes zero tail dependence. As a result, Gaussian models tend to underestimate tail risk. This makes them unsuitable for stress testing and financial crisis modeling, where capturing extreme co-movements in defaults is critical.