QFI ADV Model Solutions
Spring 2017

1.   **Learning Objectives:**
3.   Candidate will understand the nature, measurement and management of liquidity risk in financial institutions.

Learning Outcomes:
(3c)   Understand the levels of liquidity available with various asset types, and the impact on a company's overall liquidity risk.

(3d)   Understand liability termination provisions such as book-value surrender and the impact on a company's overall liquidity risk.

(3e)   Apply liquidity risk models, including modeling cashflow of various types of assets (e.g. indeterminate maturity assets) and liabilities.

(3f)   Apply liquidity scenario analysis with various time horizons.

(3g)   Understand and apply techniques to manage street liquidity risk.

Sources:
Matz and Neu, Liquidity Risk Measurement and Management: A Practitioner's Guide to Global Best Practices. Chapter 3

Commentary on Question:
This question tests an understanding of the nature, measurement and management of liquidity risk in a sample financial institution. Overall, the candidates performed as expected on this question.

Solution:
(a)   Explain omissions or concerns with the framework section provided.

   Commentary on Question:
   The candidates performed as expected on this section.

   Most candidates did not write down answers about "seasonal fluctuations in the company's liquidity" and/or "the capital market's flight to quality". Hence they missed the first and/or last items below.

1. **Continued**

- The ordinary course of business scenario should include any seasonal fluctuations in the company's liquidity.
- The scenario and its constituent elements absolutely must be relevant to the block. The liabilities of QRS have no exposure to the S&P500 index, so changes in the index are irrelevant to QRS. The exposure that QRS has is to the Canadian and US bond markets so we should model a bond market meltdown in those 2 countries.
- There is a need to evaluate very short term, as in shorter than 30 days. Historically, liquidity events have led to bank failures in as little as a few days.
- Although a funding problem can build up over months, the capital market flight to quality can become severe in just one or two days.

(b) Critique each of the following comments from the liquidity manager.

(i) "A financial crisis in Asia would be far away and very different from our company's liquidity risks"

(ii) "We should include future cash flows from management actions"

(iii) "We can use changes in the insurance company's rating to define stress level".

Commentary on Question:
The candidates performed as expected on this section. Most candidates did not explain the precise reasons (last 2 bullets below) of why it is not a good idea to use changes in company's rating.

Part (i):
- Liquidity events are often global and have inter-related elements.
- Sometimes the impact of events spreads because banks and other market participant stub their toes in one place, but feel the pain in another. Sometimes changes in confidence are the transmission belt.

Part (ii):
- It is a serious problem if we include cash flows from management actions:
- Liquidity risk is obscured when stress scenario forecast include assumptions for future cash flows from management actions such as sales of investment securities and loans.
- At best, the full extent of the liquidity risk cannot be seen unless the analysts drill down to see the "before management actions" and "after" forecast level of risk. At worst, it is hidden. "If you are covering today's risk with tomorrow's promises, you are masking the risk".

1. **Continued**

- The solution is to carefully separate the customer-driven cash flows and management-driven cash flows.

Part (iii):

- It is not a good idea to use changes in the company's rating to define stress levels.
- Rating changes are lagging indicators of trouble and almost always follow the market.
- Identify and use procurers for rating downgrades instead.

(c) Outline a framework that could be used to forecast the quantity of stand-by liquidity available.

Commentary on Question:
The candidates performed below average on this section. Most candidates did not mention the order to access the liquidity source, as well as the time to convert the asset sources into cash.

- Determine what sources are available in each scenario at each stress level
- Determine in what order we plan to access each source. This can be described as a cash flow waterfall.
- Forecast how long it will take to convert each source to cash.
- Determine how much cash we can obtain. Haircuts for "marketable securities" can vary significantly with changes in prevailing interest rates and changes in credit spreads.

(d) You are asked to review the cashable term deposit block and develop two stress scenarios to assess any liquidity risks. The QRS chief risk officer requires all tested scenarios to be supported by detailed reasoning and justification. He has asked for a brief memo from you on these two scenarios.

Outline your response.

Commentary on Question:
The candidates performed below average on this section. Most candidates did not justify why their stress scenarios were chosen. Note that a mere description of the scenario is very different from the reasoning of choosing a certain scenario.

- <u>Recommend Stress Scenario #1</u>: rapid increases of interest rates (combination of both US and Canada) and projection of liquidity needs in the future dates given these changes.

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1.   Continued

Term Structure Reasoning:
- The term structure of the term deposits' assets or liabilities may be affected by changes in prevailing interest rates.
- During a period of projected quick increase in interest rate, depositors may prefer shorter term deposits. It may not affect immediate liquidity because the funds are remained with the company, but it may affect future liquidity when the funds are withdrawn.

(or) Early Withdrawal Reasoning:
- The volume of the term deposit can be directly affected by changes in interest rates. When prevailing interest rates are high, customers are more likely to "disintermediate" the company – to take their funds out of company and invest those funds directly in capital market instruments offering actual or potentially higher yields.
- The most rate-sensitive customers are often those with the highest levels of investable funds, such as commercial depositors and retail customers with large account size.

- <u>Recommend Stress Scenario #2</u>: Recession scenario with reduced deposits from commercial customers, or "company's downgrade from rating agency", or "credit crisis", or "flight to quality"

Changes in Business Condition Reasoning:
- The volume of the term deposits' assets or liabilities may be indirectly affected as changes in prevailing interest rates track (or cause) changes in business conditions (or early withdrawal)
- During recessions, employers tend to lay off workers, reduce hiring, or in a few cases go out of business. The associated contraction in business activities creates both direct and indirect incentives for commercial customers to reduce deposits, especially term deposits.

2. **Learning Objectives:**
5. The candidate will understand the behavior characteristics of individuals and firms and be able to identify and apply concepts of behavioral finance.

Learning Outcomes:
(5b) Describe how behavioral finance explains the existence of some market anomalies.

(5c) Identify and apply the concepts of behavioral finance with respect to individual investors, institutional investors, portfolio managers, fiduciaries and corporate managers.

Sources:
A Survey of Behavioral Finance, by Barberis & Thaler

Commentary on Question:
There was a typographical error in the given Utility function in this question, which affected the calculation in part (e). Some candidates recognized the error and corrected for it, while others attempted to use the formula as given. We did not penalize candidates who used the formula as given, and candidates who made a correction also received full credit.

This question tests the understanding of behavioral finance concepts, specifically the three equity market puzzles and utility functions.

Solution:
(a) Identify and describe the "puzzle" or "puzzles" Joe could be facing.

Commentary on Question:
The candidates performed poorly on this section. Many candidates were able to identify the equity premium puzzle, but most were not able to identify the other two puzzles.

Joe is facing the equity premium, volatility, and predictability puzzles
- Equity premium puzzle – Even though stocks appear to be an attractive asset, they have higher average returns and a low covariance with consumption growth, but investors appear very unwilling to hold them. In particular they appear to demand a substantial risk premium in order to hold market supply.
- Volatility puzzle – Difficult to explain historical volatility of stock returns using any model in which investors are rational and discount rates are constant.
- Predictability puzzle – Stock returns are forecastable. Dividend-price explains a portion of the variation of cumulative stock returns over the four subsequent years.

2. Continued

(b) Describe a belief or preference from the field of behavioral finance that could impact their actions in day trading for each of the four details above.

Commentary on Question:
The candidates performed above average on this section. Many candidates were able to correctly identify at least two of the preferences.

Private information – Overconfidence – Bob may exhibit overconfidence in his private information. In this event he will take more risk that he necessarily should. Reviewing losses hourly – Mental Accounting / Narrow Framing – Narrow framing is to consider each trade separately rather than merging it with pre-existing trades. In each of Bob's bets, even though aggregated hourly, he will recognize it only as part of a narrow, hourly process
Comfortable with stocks – Ambiguity Aversion – Because he is more comfortable with airline stocks, it is most likely that Joe will avoid the more ambiguous situations and stick with the airline stocks
All are making profits – Law of Small Numbers/Representativeness – Joe may suffer from the effect of the law of small numbers, which is to believe that small samples will reflect the properties of the parent population

(c) Describe how each of $U(x,z), K_i, x$ and z helps to explain the "puzzles".

Commentary on Question:
The candidates performed poorly on this section. Many candidates were able to correctly comment that the utility function reflected prospect theory and that K_i represented loss aversion. Most candidates did not provide any comments as to how each of the components explains the puzzles.

U(x,z) = (x+z) or x:
- Prospect theory –
- Utility consists of more than straight consumption, hence multiple components.
- Helps describe the equity premium puzzle.

K_ix or K_i:
- Represents loss aversion.
- Helps to describe equity premium puzzle.
- People are loss averse, require higher risk premium

x: "House money effect"
- Willingness to gamble when ahead.
- Bob's utility will be lower because he lost $500 in the hour prior and/or Joe's utility is higher for opposite reason.

2. **Continued**

- This helps to explain the volatility puzzle. When things are looking good, people require less of a return.

z:
- Representativeness / Small numbers
- Using the prior hour's earnings to impact their utility in the next hour.
- This helps to explain volatility puzzle.

(d) Explain which value of K_i more likely belongs to Bob and which more likely belongs to Joe.

Commentary on Question:
The candidates performed below average on this section. Candidates received full credit for correctly identifying which value belonged to whom and providing an appropriate explanation. Many candidates erroneously commented that the higher K value represented lower risk aversion.

Joe's K = 2.75. Joe likes airline stocks but is otherwise uncomfortable. We would expect Joe's loss aversion to be higher than Bob's, all else equal, because of ambiguity aversion.
Bob's K = 1.75. Bob has been researching private information on computer stocks. All else equal, we would expect Bob to exhibit overconfidence and have a lower loss aversion.

Can also discuss from the perspective that Bob has lost money already and is more willing to gamble to get it back (same K answers)

(e) Calculate the expected utility for each of Bob and Joe for the current trade opportunity.

Commentary on Question:
The candidates performed below average on this section. Candidates received full credit for correctly identifying which part of the utility function applied to Joe and Bob given the prior hour's trading. Candidates that misidentified the K attributable to Bob in (d), but otherwise correctly applied the formula in (e) received full credit for that portion. Many candidates erroneously tried to use both parts of the utility function for each of Bob and Joe.

2.   **Continued**

The question as presented on the exam contained a typographical error. The second part of the utility function should have read $-K_i*[-(x + z)]^\alpha$ for x < -z. The parentheses were missing from the exam book. Candidates that correctly used the appropriate utility function for Bob and used the formula as shown arrived at an answer involving the square root of a negative number. Those candidates received full credit for that portion of the question. Other candidates appear to have mentally inserted the parentheses and solved the question as was expected and also received full credit for that portion of the question.

The solution presented below uses the corrected utility function.

Bob:
Both 100 and -100 are $> -z = 500$ - hence both profits use the K side of the utility function
E(U) = 0.75*-1.75*sqrt[-(100+-500)] + 0.25*-1.75*sqrt[-(-100+-500)]
       = -26.25 + -10.72 = -36.97

Joe:
Both 100 and -100 $< -z = 1000$ - hence both profits use the other side of the utility function
E(U) = 0.75*sqrt[100+1000] + 0.25*[-100+1000] = 24.87 + 7.5 = 32.37

3. **Learning Objectives:**
   4.   The candidate will understand important quantitative techniques relating to financial time series, performance measurement, performance attribution and stochastic modeling.

Learning Outcomes:
(4f)   Calculate and interpret performance attribution metrics for a given asset, portfolio.

Sources:
Fabozzi 8th, Chapter 69, p.1636

Fabozzi 8th, Chapter 69, p.1638

Fabozzi 8th, Chapter 69, p.1648-1649

Commentary on Question:
Overall, the candidate performed below average on this question. This question is focused on testing the concepts of performance attribution and its application. It first tests to see if the candidate can list and explain the three requirements of the performance attribution. Then it tests the calculations and estimations of the performance attributions. Finally it challenges the candidates to provide appropriate assessments to the portfolio.

Solution:
(a)   List and explain the three requirements of a successful performance attribution algorithm.

   Commentary on Question:
   The candidates performed brilliantly on this section. Most were able to list and explain all the three requirements.

   Additivity: The contribution of two or more agents combined is equal to the sum of the contributions from those agents.
   Completeness: The sum of all outperformance contributions is equal to the total portfolio performance.
   Fairness: The allocation of outperformance to different interacting agents is performed in a way that is perceived to be fair by all agents.

(b)   Calculate each of the following for the portfolio:

   (i)   the one-year money-weighted rate of return, and

   (ii)   the one-year time-weighted rate of return

3. **Continued**

Commentary on Question:
The candidates performed as expected on this section. Candidates in general were able to calculate the money-weighted rate of return and time-weighted rate of return.

Portfolio value at the end of the year = (100*(1+20%)+100)*(1-5%)=209 million.
Money weighted return: $100*(1+r)+100*(1+r)^{0.5}=209$ to come out with r = 6%.
Time weighted return: r=(1+20%)*(1-5%)-1=14%

(c)   Estimate each of the following:

   (i)   the outperformance contribution of GBP

   (ii)   the outperformance contribution of JPY

   (iii)   the total FX outperformance contribution

Commentary on Question:
The candidates performed below average on this section. Few candidates were able to identify the estimation needed for GBP, JPY or in particular the total FX outperformance contribution.

USD and GBP have no outperformance or 0 outperformance contribution.
EUR outperformance contribution is -5%*(-244.1)=12.2bps.
JPY outperformance contribution is 5%*319.4=16bps.
Total portfolio performance is 12.2+16=28.2bps.

(d)   Assess whether your FX views reflected in portfolio weights were correct.

Commentary on Question:
The candidates performed below average on this section. Few candidates were able to provide correct assessment on the views in regard to the portfolio weights.

The manager is correct based on the FX outperformance of 28.2bps. The Yen rallied and the Euro fell against the US dollars.

4. **Learning Objectives:**
2. The candidate will understand and be able to apply a variety of credit risk theories and models.

Learning Outcomes:
(2a) Demonstrate an understanding of events and causes of the recent global credit crisis.

(2b) Demonstrate an understanding of the basic concepts of credit risk modeling such as probability of default, loss given default, exposure at default, and expected loss.

Sources:
Sec.2 - Bluhm An Introduction To Credit Risk Modeling 2nd Ed, Chapter 1

Commentary on Question:
This question tests candidates' understanding of basic concepts in credit risk modeling as well as their applications to a real world scenario.

Solution:
(a) Calculate the present value of expected loss at time 0.

Commentary on Question:
The candidates performed as expected on this question. This question is a straight forward calculation of expected loss. Candidates that arrived at the correct final answer received full marks. Partial marks are given for interim work steps if the final answer is incorrect.

Solution 1

		Time		
	Loan to Bob	0	1	2
	Cashflow	(200,000)	-	220,500
	EAD		(210,000)	(220,500)
	LGD		100%	100%
Total	PD		3.00%	2.91%
($11,990.15)	Expected Loss		(6,300)	(6,417)

Payout at T=2 = 200,000 * (1+.05)^2=225,000
EAD$_1$= 225,000 / (1 + .05) = 210,000
Expected Loss$_1$ = EAD$_1$ x LGD$_1$ x PD$_1$ = 210,000 x 100% x 3% = 6,300
EAD$_2$= 225,000 = 220,500
PD$_2$=0.97 x 0.03 = 0.0291
Expected Loss$_2$ = EAD$_2$ x LGD$_2$ x PD$_2$ = 220,500 x 100% x 2.91% = 6,417
6300/(1+.05) = 6000; 6417/(1 + .05)^2 =5820
Total expected loss = Expected Loss$_1$ / (1 + .05) + Expected Loss$_2$ / (1 + .05)^2 = 11,820

4. **Continued**

Solution 2

State	Probability	PV of Loss	E[PV of Loss]
Default at time 1	3.00%	200,000	6,000
Default at time 2	2.91%	200,000	5,820
Does not default	94.09%	0	-
			11,820

PV of Loss (Default at time 1) = 210,000/(1 + 5%) = 200,000
PV of Loss (Default at time 2) = 220,500/(1 + 5%)^2 = 200,000

(b)   Calculate the present value of unexpected loss at time 0.

Commentary on Question:
Candidates performed as expected on this question. This question is a straight forward calculation of unexpected loss. Some candidates attempted the question using shortcuts involving Bernoulli trials. When the said shortcut was used correctly, it resulted in an elegant solution.

	Event	P	PV of Loss = L	L x P	L^2 x P	Var[L]	Unexpected Loss
A	Defaults at time 1	3.00%	200,000	6,000	1,200,000,000		
B	Defaults at time 2	2.91%	200,000	5,820	1,164,000,000		
C	Does not default	94.09%	0	-	-		
				11,820	2,364,000,000	2,224,287,600	47,162

E[L] = P(A) x L(A) + P(A) x L(A) + P(A) x L(A)   **= 11,820**
E[L^2] = P(A) x L(A)^2 + P(A) x L(A)^2 + P(A) x L(A)^2   **= 2,364,000,000**
Var[L] = E[L^2] - E[L]^2   **= 2,224,287,600**
Unexpected Loss = Var[L]$^{1/2}$ **= 47,162**

(c)   Discuss the relationship between probably of default (PD) and loss given default (LGD) with respect to a residential mortgage loan.

Commentary on Question:
Candidates performed above average on this question. Candidates need to explain why PD and LGD are not independent. Partial marks were awarded for any reasonable justification.

4. **Continued**

The solution may include the following points:
- Higher probability of default (PD) leads to a larger number of defaults.
- When a borrower defaults, the lender will seize the house which is a collateral under the terms of the loan.
- When a large number of foreclosed houses are for sale, it will depress the housing pricing.
- A low housing price means higher loss given default (LGD).
- P(D) and LGD are correlated.

5. **Learning Objectives:**
1. The candidate will understand the standard yield curve models, including:
   - One and two-factor short rate models
   - LIBOR market models

   The candidate will understand approaches to volatility modeling.

Learning Outcomes:
(1e) Understand and explain the relationship between market-quoted caplet volatilities and model volatilities.

(1h) Understand and explain the features of the G2++ model, including: The motivation for more than one factor, calibration approaches, the pricing of bonds and options, and the model's relationship to the two-factor Hull-White model.

Sources:
Brigo, D and Mercurio F, Interest Rate Models – Theory and Practice, 2nd Edition, Section 4.2.3

Brigo, D and Mercurio F, Interest Rate Models – Theory and Practice, 2nd Edition, Section 4.1

Commentary on Question:
This question tests the understanding of volatility structures based on the two-factor G2++ model. Overall, the candidates performed as expected on this question.

Solution:
(a) Describe the advantages of G2++ over the one-factor Hull-White model.

   Commentary on Question:
   The candidates performed brilliantly on this section.
   Most candidates were able to describe two or more advantages. Points were not given for an answer that was merely a rewording of another answer.

   - 2 or more factors are needed to realistically model the dynamics of the interest rate term structure
   - Decorrelation of short-term and long-term rates
   - More precise calibration to correlation-based products like caps and European swaptions
   - Useful when pricing out-of-the money exotic instruments
   - Humped volatility shape possible

(b) Write down the formula for the instantaneous forward rate at time t for maturity time T in terms of A and B.

5. **Continued**

Commentary on Question:
The candidates performed brilliantly on this section.
Most candidates were able to state the relationship between $f(t, T)$ *and* $P(t, T)$
correctly. However, some candidates took the derivative with respect to the wrong
variable (t rather than T).

$$f(t, T) = -\frac{\partial}{\partial T} \ln P(t, T)$$

$$\Rightarrow f(t, T) = -\frac{\partial}{\partial T} \ln A(t, T) + \frac{\partial}{\partial T} B(a, t, T)x(t) + \frac{\partial}{\partial T} B(b, t, T)y(t)$$

(c)   Derive the absolute volatility of the instantaneous forward rate.

Commentary on Question:
The candidates performed as expected on this section.

Candidates need to recognize df is driven by dW₁ and dW₂. Some candidates were
able to state the final expression of the absolute volatility shown in the model
solution below. However, no points were given to candidates who stated the final
expression without showing any steps.

Also, there was a minor typo in the question. The correct expression was
$B(z, t, T) = \frac{1 - e^{-z(T-t)}}{z}$, *not* $B(a, t, T) = \frac{1 - e^{-z(T-t)}}{z}$. *Most candidates recognized the*
typo and corrected for it. Candidates who followed the incorrect expression
given in the question were still awarded full credit as appropriate.

Differential form of the instantaneous forward rate:

$$df(t, T) = \cdots dt + \frac{\partial}{\partial T} B(a, t, T)\sigma dW_1(t) + \frac{\partial}{\partial T} B(b, t, T)\eta dW_2(t)$$

Variance of the differential:

$$\text{Var}(df(t, T))$$
$$= \left(\frac{\partial}{\partial T} B(a, t, T)\sigma\right)^2 dt + \left(\frac{\partial}{\partial T} B(b, t, T)\eta\right)^2 dt + 2\rho\sigma\eta \frac{\partial}{\partial T} B(a, t, T) \frac{\partial}{\partial T} B(b, t, T) dt$$
$$= \sigma^2 e^{-2a(T-t)} dt + \eta^2 e^{-2b(T-t)} dt + 2\rho\sigma\eta e^{-(a+b)(T-t)} dt$$

5. **Continued**

Divide by dt:

$$\frac{\text{Var}\big(df(t, T)\big)}{dt} = \sigma^2 e^{-2a(T-t)} + \eta^2 e^{-2b(T-t)} + 2\rho\sigma\eta e^{-(a+b)(T-t)}$$

The desired volatility is:

$$\sigma_f(t, T) = \sqrt{\sigma^2 e^{-2a(T-t)} + \eta^2 e^{-2b(T-t)} + 2\rho\sigma\eta e^{-(a+b)(T-t)}}$$

(d) Explain the relationship between the correlation ρ and the possibility of achieving a humped shape of the volatility structure derived in (c).

Commentary on Question:
The candidates performed below average on this section.
Only a few candidates were able to explain the relationship between the correction and humped volatility structure correctly. Some candidates identified the relationship but did not explain it well. To receive full credit, candidates need to identify the relationship and provide an explanation.

$\rho < 0$: humped volatility structure possible
$\rho > 0$: humped volatility structure is not possible since all terms are decreasing functions of $(T - t)$

6. **Learning Objectives:**
2. The candidate will understand and be able to apply a variety of credit risk theories and models.

Learning Outcomes:
(2h) Demonstrate an understanding of credit default swaps (CDS) and the bond-CDS basis, including the use of CDS in portfolio and trading contexts.

(2i) Demonstrate an understanding an understanding of CDS valuations

(2k) Demonstrate an understanding of measuring and marking-to-market counterparty credit risk in credit derivatives.

Sources:
QFIA-104-13: Asset/Liability Management of Financial Institutions, Tilman, Leo M., 2003, Ch.9

Handbook of Fixed Income Securities, Fabozzi, F.J., 8th Edition, 2012 Ch67

Commentary on Question:
Candidates performed well on the retrieval parts of the question, but sections requiring more analysis and utilization of knowledge proved more difficult.

This question tested candidates knowledge of CDS, uses, advantages and disadvantages and basic concept of valuation.

Solution:
(a) Identify and describe three counterparty credit risk mitigants.

Commentary on Question:
Candidates performed above average on this section. Full credits were given for the three correct credit risk mitigants with a correct and complete description.

Netting agreements/netting rights – allow trades to be offset when determining the net payable amount upon the default of the counterparty

Collateral agreements – require counterparties to periodically mark to market their positions and to provide collateral to each other as exposures exceed pre-established thresholds.

Early settlement options – these are provisions that allow the party to settle and terminate the trade early; Examples include liquidity puts and credit triggers

(b) Calculate the total counterparty exposure to the above portfolio of derivatives.

6. Continued

Commentary on Question:
Candidates performed below average on this part of the question. They mostly failed to deal correctly with the collaterals and with the company C exposure where no netting agreement were involved. In the solution below, we will show you 2 ways to get the correct answer.

1-
  a. Sum the exposure of A and B as they are given that netting agreement exist: 10 000 + 150 000 + -75 000 + 400 000 + - 125 000 = 360 000
  b. Sum the exposure for C without netting agreement:
     MAX(0: 75 000) + MAX(0: -50 000) = 75 000
  c. Sum the gross exposure for A, B & C: 360 000 + 75 000 = 435 000
  d. Calculate net collateral as collateral posted minus collateral received:
     (5 000 + 125 000 + 70 000) – (70 000 + 35 000) = 95 000
  e. Net exposure = gross exposure minus net collateral
     = 435 000 – 95 000 = 340 000

2-
  a. Net exposure for A & B considering netting agreement :
       i. Gross exposure = 10 000 + 150 000 + -75 000 + 400 000 + - 125 000 = 360 000
      ii. Net collateral = (5 000 + 125 000) – (70 000) = 60 000
     iii. Net exposure for A & B = 360 000 – 60 000 = 300 000
  b. Net exposure for C, no netting agreement:
       i. Gross exposure
          = MAX(0: 75 000) + MAX(0: -50 000) = 75 000
      ii. Net collateral = 70 000 – 35 000 = 35 000
     iii. Net exposure for C = 75 000 – 35 000 = 40 000
  c. Net exposure for A, B & C = 300 000 + 40 000 = 340 000

(c) Outline the advantages and disadvantages of using a CDS to hedge counterparty risk of a derivative portfolio.

Commentary on Question:
Candidates performed as expected on this part of the question. Four items were required for full credits, with at least one advantage and one disadvantage.

6. Continued

Advantage:
-Reduces credit risk
-Predictable future costs, the premium is known in advance.

Disadvantage:
-Adds a layer of counterparty risk from the CDS itself.
-An up-front payment may be require in addition to ongoing premium
-basis risk:
-the hedge may not be perfect
-the term of the CDS may be different than the term of the derivatives.
-the CDS and the derivatives may not be perfectly correlated.

(d)   Evaluate the sensitivity of the premium leg of the CDS to the value of X.

Commentary on Question:
Candidates performed as expected on this section. This question did not require any calculation however candidates that performed calculations to arrive at the solution were also given full credit. Candidates simply had to recognize that the premium was not sensitive to X and explain why.

There is no possibility of a default payment in year 2 because the net exposure is negative.
Thus X could be anything.

(e)   Determine Y by taking into consideration the relationship between the two legs of the CDS.

Commentary on Question:
Candidates performed as expected on this part of the question. Different interpretations for the default rates were accepted in grading this question. Just as in part d) before, the loss given default (X) in the second year was not a factor, which many candidates failed to recognize. Failure to use the correct discount factor and/or correct survival rate was also a common error.

1- Present value of expected default payment at time 0:
$= \Sigma$ net exposure$_i$ x default$_i$ x loss$_i$ x discount$_i$
$= $ MAX(0 : 400 000) x 3% x 20% x 95%
$+ $ MAX(0 : -150 000) x 5% x X x 91%
$+$MAX(0 : 225 000) x 10% x Y x 87%
$= $ 2280
$+ 0$
$+ 19\ 575\ Y$

6. Continued

2- Present value pf premiums at time 0 :
Note: for CDS, the premium is paid at the end of the period, there is an upfront cost at time 0, which is stated to be 0 in this question.

$$= \Sigma \text{ premium}_i \text{ x P(survive to T = i) x discount}_i$$

= 3554 x (1 – 3%)	x 95%
+ 3554 x (1 – 3% - 5%)	x 91%
+ 3554 x (1 – 3% - 5% - 10%)	x 87%

= 3554 x 2.4721 = 8785.84

3- Present value of premiums = present value of expected default payments

   a. => 8785.84 = 2280 + 19575 Y

   b. => Y = (8785.84 – 2280) / 19575

   c. => Y = 33.24%

7. **Learning Objectives:**
2.   The candidate will understand and be able to apply a variety of credit risk theories and models.

6.   The candidate will understand and be able to describe the variety and assess the role of alternative assets in investment portfolios. The candidate will demonstrate an understanding of the distinguishing investment characteristics and potential contributions to investment portfolios of the following major alternative asset groups:
- Real Estate
- Private Equity
- Commodities
- Hedge Funds
- Managed Futures
- Distressed Securities
- Farmland and Timber

Learning Outcomes:
(2j)   Demonstrate an understanding of mortgage default models in the valuation of MBS.

(6e)   Demonstrate an understanding of infrastructure investments.

Sources:
QFIA-100-13: Modeling of Mortgage Defaults, Jan 22, 2008, pp. 5- 38

QFIA-126-16 Infrastructure as an Asset Class

Commentary on Question:
This question tests the concept of mortgage default risk and infrastructure investing. Overall, the candidates performed as expected.

Solution:
(a)   Identify and describe (where applicable) stylized economic characteristics that would make the infrastructure project attractive to your company.

Commentary on Question:
The candidates performed above average in this section. Most candidates identified financial characteristics of infrastructure. Common characteristics there were left out included low sensitivity to swings in economy and operating cost and margins.

7. **Continued**

Economic characteristics that would make infrastructure project attractive to the insurance company are: (at least 4 items on the list below)

> The inelastic demand for services;
> Low operating costs and high operating margins;
> Low sensitivity to swings in the economy and markets;
> Capture financial characteristics appropriated for an insurance company as:
>> Long-term investment with stable and predictable cash flows;
>> Attractive return;
>> Long duration;
>> Low correlation of returns with other assets;
>> Low default rates.

(b) Recommend and justify the suitability of investing in the infrastructure project or a mortgage fund from your company's perspective.

Commentary on Question:
The candidates performed as expected in this section. Many candidates provided a recommendation of mortgage funds but with limited justification.

For our small company with limited funds we need to protect liquidity and have an asset without high fixed costs as infrastructure. Also, infrastructure is more adapted to long duration liabilities with inflation protection as pension plans instead to match term life insurance. For our product we recommend mortgage funds as more liquid and good diversified assets.

(c) Describe two types of models that you can combine to value mortgages credit risk.

Commentary on Question:
The candidates performed as expected in this section with many identifying both the prepayment model and the loss severity model.

1- The prepayment model projects the overall level of payoff which includes defaults. With more prepayment, this reduces the number of borrowers and this affects the risk of default.
2- The loss severity model predicts the loss when a mortgage defaults.

7. Continued

(d) Identify and describe the mortgage fund characteristics that can be used as variables in your credit risk model.

Commentary on Question:
The candidates performed below average in this section. Only a small number of candidates were able to identify all 4 components.

In our credit risk model we need to consider those 4 characteristics of a Mortgate fund :

- Loan-to-Value Ratio (LTV) which measures the amount of equity in a home and is estimated using the home price appreciation.
- Debt-to-Income Ratio (DTI) as the ratio of monthly payments and other debts to monthly income of borrowers.
- Adjustable rate which represents mortgages with a coupon rate that is fixed for a period of time and resets periodically at a specified spread over a reference index. Usually the initial coupon is set below the fully indexed rate (index + margin) then increases by substantial amount at reset.
- The Spread at Origination (SATO) is the difference between the coupon rate on a mortgage loan and some measure of the average prevailing mortgage rates.

(e) Explain why the characteristics identified in (d) are key factors in projecting mortgage defaults.

Commentary on Question:
The candidates performed as expected in this section. A larger percentage of candidates adequately explained DTI and LTD but far fewer were able to explain SATO and Adjustable Rate.

- LTV Ratio determines how feasible it will be for the borrower to refinance or sell the house if they can no longer make payments.
- DTI Ratio represents the strain on the borrower's ability to continue payments. The higher the ratio the greater the pressure.
- Adjustable rate resets trigger a default event where the borrower may not be able to make the higher reset payments, which results in spike in defaults. The default events are accentuated if at the time of the reset interest only period ends and amortization of principle begins.
- SATO mortgage loans that originated well above prevailing rates indicate the lender perceived above-average risk of the borrower. Due to the uncertainty surrounding variables like DTI ratio and LTV ratio, SATO provides more info.

7. Continued

(f)   Recommend and justify a mortgage fund to the CIO that has the lowest default risk, including commentary on the mortgage fund characteristics to support your decision.

Commentary on Question:
The candidates performed below average in this section. While many candidates recommended the appropriate fund (Gamma) in general the supporting justification was lacking.

I recommend the Fund Gamma because:

(i)   The lowest proportion of adjustable rate mortgages of all funds and the average fund in the market. Since Adjustable rate mortgages have higher rates of default due to mortgage payments increasing at reset points, so fewer adjustable rate mortgages would indicate lower default risk in the fund Gamma.

(ii)   The lowest percentage of spread at origination (SATO) among all funds and the average fund in the market. Low SATO indicates the lenders of the mortgages perceive the borrowers to have lower than average risk in their ability to make payments, so lower default risk is expected in the Fund Gamma.

(iii)   With the other characteristics, LTV and DTI for Gamma is not the lowest but close to the average ratios of the market. Those variables are not the most important.

8.   **Learning Objectives:**
1.   The candidate will understand the standard yield curve models, including:
- One and two-factor short rate models
- LIBOR market models

The candidate will understand approaches to volatility modeling.

Learning Outcomes:
(1a)   Identify and differentiate the features of the classic short rate models including the Vasicek and the Cox-Ingersoll-Ross (CIR) models.

(1b)   Understand and explain the terms Time Homogeneous Models, Affine Term Structure Models and Affine Coefficient models and explain their significance in the context of short rate interest models.

Sources:
Brigo and Mercurio, Interest Rate Models – Theory and Practice, 2nd Edition, Chapter 3

Commentary on Question:
This question tests the concept of affine term structure models and their significance in bond pricing.

While there was a minor typographical error in the Model 2 equation (radical sign extended over the dW_t term), most candidates noted this error at the start of their responses and answered the intended question.

Solution:
(a)   Explain the advantages of working with an affine term structure model.

        Commentary on Question:
        The candidates performed as expected on this section. Most candidates explained at least one advantage. Candidates who received full marks described multiple advantages in some detail.

        Working with affine term structure (ATS) interest rate models provides several benefits.
- Under an ATS interest rate framework, bond and bond option prices can be easily derived.
- Because ATS models have analytical solutions, model implementation is both computationally and analytically tractable.
- The compound spot rate R(t, T) is a linear function of the instantaneous short rate r(t): $R(t,T) = \alpha(t,T) + \beta(t,T)\, r(t)$

8. Continued

(b) Identify which of Model 1 and 2 is an affine term structure model.

Commentary on Question:
Candidates performed above average on this section, in spite of the Model 2 typo. Many candidates recognized that Model 2 was supposed to be a well-known example of an affine term structure model. In order to receive full marks, candidates had to identify that Model 2 was an affine term structure model and that Model 1 was not. Many candidates received partial credit for only discussing one of the 2 models.

For a short rate model to be an affine term structure (ATS) model, both the drift term's (dt) coefficient and the square of the diffusion term's (dW_t) coefficient should be linear (affine) functions of the short rate process $\{r_t\}$.
- Model 1 is a Dothan model (geometric Brownian motion), where the drift term is linear in r_t. But the square of Model 1's diffusion term is quadratic in r_t. Therefore, Model 1 is **not** ATS.
- Model 2 is a Cox-Ingersoll-Ross (CIR) process, also known as a square-root diffusion. Both its drift term coefficient and the square of its diffusion term coefficient are linear in r_t. Therefore, Model 2 is ATS.

Alternative solution:
It is a well-known fact that CIR processes belong to the class of ATS interest rate models, so Model 2 is ATS by virtue of being CIR. It is also known that Dothan models (geometric Brownian motions) do not belong to the class of ATS models. So Model 1 is not ATS by virtue of being a Dothan/geometric Brownian motion.

(c) Determine the expected short rate at time *t* for Model 1.

Commentary on Question:
Candidates performed above average on this section. Many candidates recognized that Model 1 was the Dothan model and referenced the appropriate formula from the formula sheet. Other successful candidates derived the result from first principles. Some candidates had difficulty applying Itô's Lemma to the Model 1 stochastic differential equation and were unable to obtain the desired result.

8.   Continued

Formula 3.19 tells us that, for the Dothan model, $\mathbb{E}[r(t)|\, \mathcal{F}_s] = r(s)\, e^{a(t-s)}$. We are told the initial short rate r_0. So we have $\mathbb{E}[r(t)] = \mathbb{E}[r(t)|\, \mathcal{F}_0] = r_0\, e^{at}$.

Alternative solution:

$$\frac{dr_t}{r_t} = adt + \sigma dW_t \quad \Rightarrow \quad d[\ln(r_t)] = adt + \sigma dW_t$$

$$\Rightarrow \quad \ln(r_t) - \ln(r_0) = \left(a - \frac{1}{2}\sigma^2\right)t + \sigma W_t$$

$$\Rightarrow \quad r_t = r_0 \exp\left[\left(a - \frac{1}{2}\sigma^2\right)t + \sigma W_t\right]$$

When you take the expectation of both sides of the last equation, you obtain:

$$\mathbb{E}[r(t)] = \mathbb{E}\left[r_0 \exp\left\{\left(a - \frac{1}{2}\sigma^2\right)t + \sigma W_t\right\}\right] = r_0 \exp\left[\left(a - \frac{1}{2}\sigma^2\right)t\right]\mathbb{E}[e^{\sigma dW_t}]$$

Since $\mathbb{E}[e^{\sigma dW_t}] = \exp\left[\frac{1}{2}\sigma^2\, t\right]$, we are left with $\mathbb{E}[r(t)] = r_0\, e^{at}$.

(d)   Show that $m(t) = r_0 + \int_0^t k\big(\theta - m(s)\big)ds$

Commentary on Question:
Candidates performed as expected on this section, ignoring the Model 2 typo. Most successful candidates proceeded with a direct approach by integrating the Model 2 stochastic differential equation. Other successful candidates demonstrated the relationship by starting with the right-hand side of the equation and worked through the algebraic relationships to show its equivalence to the left-hand side.

Integrating the Model 2 stochastic differential equation yields:

$$r_t - r_0 = \int_0^t k(\theta - r_s)ds + \int_0^t \sigma\sqrt{r_s}dW_s$$

$$\Rightarrow \quad m(t) = \mathbb{E}[r_t] = \mathbb{E}[r_0] + \mathbb{E}\left[\int_0^t k(\theta - r_s)ds\right] + \mathbb{E}\left[\int_0^t \sigma\sqrt{r_s}dW_s\right]$$

$$\Rightarrow \quad m(t) = r_0 + \mathbb{E}\left[\int_0^t k(\theta - r_s)ds\right]$$

We can remove the expectation operator from $r0$, because it is a known constant, and the final expectation term equals 0, because it is an Itô integral.

8. Continued

For the last step, we pass the expectation operator through the integral sign (via Fubini's Theorem) to demonstrate the relationship:

$$\Rightarrow m(t) = r_0 + \int_0^t \mathbb{E}[k(\theta - r_s)]ds = r_0 + \int_0^t k(\theta - \mathbb{E}[r_s])ds$$

$$= r_0 + \int_0^t k(\theta - m(s))ds$$

(e) Determine an explicit expression for $m(t)$ in terms of θ, t, k, and r_0. (Hint: Find and solve a differential equation for $m(t)$.)

Commentary on Question:
Candidates performed below average on this section. Many candidates successfully followed the hint to differentiate the expression established in part (d) but then had trouble proceeding from there to the final solution. Some candidates received partial credit for not expressing the final answer with the requested parameters.

Following the hint, one can differentiate the relationship established in part d) and obtain an ordinary linear differential equation, which can be solved with basic techniques:

$$m(t) = r_0 + \int_0^t k(\theta - m(s))ds \Rightarrow m'(t) = k(\theta - m(t))$$

$$\Rightarrow m'(t) + km(t) = k\theta \Rightarrow e^{kt} m'(t) + ke^{kt}m(t) = k\theta e^{kt}$$

$$\Rightarrow d[e^{kt} m(t)] = d[\theta e^{kt}] \Rightarrow e^{kt}m(t) - m(0) = \theta(e^{kt} - 1)$$

$$\Rightarrow e^{kt}m(t) = r_0 + \theta(e^{kt} - 1) \Rightarrow m(t) = (r_0 - \theta)e^{-kt} + \theta$$

An equivalent formulation is $m(t) = r_0 e^{-kt} + \theta(1 - e^{-kt})$.

Alternative solution:
Recognizing that Model 2 is a Cox-Ingersoll-Ross short rate model, one could appeal directly to Formula 3.23:

$$\mathbb{E}[r(t) \mid \mathcal{F}_s] = r(s)e^{-k(t-s)} + \theta(1 - e^{-k(t-s)})$$

8. Continued

As the question directs, the final answer should be given in terms of the specified parameters. So we would apply 3.23 using $s = 0$ to obtain the final expression:

$$m(t) = \mathbb{E}[r(t) \,|\, \mathcal{F}_0] = r_0 e^{-kt} + \theta(1 - e^{-kt})$$

9. **Learning Objectives:**
1.   The candidate will understand the standard yield curve models, including:
   - One and two-factor short rate models
   - LIBOR market models

   The candidate will understand approaches to volatility modeling.

4.   The candidate will understand important quantitative techniques relating to financial time series, performance measurement, performance attribution and stochastic modeling.

Learning Outcomes:
(1a)   Identify and differentiate the features of the classic short rate models including the Vasicek and the Cox-Ingersoll-Ross (CIR) models.

(1q)   Describe and contrast several approaches for modeling smiles, including: Stochastic Volatility, local-volatility, jump-diffusions, variance-gamma and mixture models.

(4b)   Apply various techniques for analyzing factor models including Principal Component Analysis (PCA) and Statistical Factor Analysis.

Sources:
Market Models: *A Guide for Financial Data Analysis, Alexander, Carol*, Ch 6, p.145-146

Volatility Correlation – *The Perfect Hedger and the Fox, Rebonato, R., 2nd Edition,* Section 8.5, p. 244.

Commentary on Question:
This question tested the candidate's understanding of PCA, including interpreting its results. It focuses on the candidate's ability to determine the relative importance of each principal component.

Solution:
(a)   Explain why data may need to be transformed and normalized before the PCA analysis.

Commentary on Question:
The candidates performed as expected on this section. While many candidates were able to cite a reason for data transformation, fewer candidates earned full credit by also noting a reason for normalization of the data.

Transformation – addresses non-stationarity of data
Normalization – reduces volatility, especially for first PCA component

9. Continued

(a) Express the eigenvalues of V in terms of L for Model 1.
(Hint: The determinant $|V-(I)\lambda| = 0$ where (I) is identity matrix.)

Commentary on Question:
The candidates performed as expected on this section. Most candidates were able to earn credit for solving for λ; however, only a small portion of candidates were able to conclude there were multiple possible solutions.

$$VW = W\Lambda$$

$$V-(I)\lambda = \begin{bmatrix} 1-\lambda & L \\ L & 1-\lambda \end{bmatrix} \qquad |V-(I)\lambda| = (1-\lambda)(1-\lambda)-L^2 = 0$$

λ= 1-L or 1+L

(c) Calculate λ_1, λ_2 and λ_3 for the m<-1 bucket for Model 2.

Commentary on Question:
Candidates performed below average for this section. The candidates who correctly interpreted the relationship between each PC component and each λ were able to earn full credit; however, the majority of candidates applied an incorrect formula to solve for the eigenvalues, or loss credit due to computational errors.

$\lambda_{1} + \lambda_{2} + \lambda_{3} = 3$
$\lambda_{1}/(\lambda_{1} + \lambda_{2} + \lambda_{3}) = 0.5, \lambda_{1=} = 1.5$
$\lambda_{2}/(\lambda_{1} + \lambda_{2} + \lambda_{3}) = 0.4, \lambda_{3=} = 1.2$
$\lambda_{3}/(\lambda_{1} + \lambda_{2} + \lambda_{3}) = 0.1, \lambda_{3=} = 0.3$

(d) Discuss the ability of your PCA results for Model 2 to explain the total variation in implied volatility for the various moneyness buckets.

Commentary on Question:
Candidates performed as expected for this section. While many candidates were able to note that the explanatory value of the first three PC components initially decreased with moneyness, many did not continue to note that it then increased when deep-in-the-money.

The implied volatility explained by the first three components first decreases when moving from out-of-the-money to at-the-money, then increases when moving from at-the-money to in-the-money.

9. Continued

(e)   Discuss the relative ability of each of PC1, PC2, and PC3 to explain variation in implied volatility for the various moneyness buckets.

Commentary on Question:
Candidates performed as expected for this section. The majority of candidates were able to interpret the contribution to total variance for the first two PCs. Candidates lost credit when interpreting the third PC and for failing to mention the relationship between moneyness and each PC.

In terms of contribution to total variance:
1st PC decreases until approximately ATM, then increases sharply.
2nd PC expected to flatten at ATM to ITM.
3rd PC peaks near ATM regime ($0.5 =< m < 1$).

(f)   Discuss the relative ability of each of PC1, PC2, and PC3 to explain variation in implied volatility for the various moneyness buckets, under the shorter and longer maturity buckets.

Commentary on Question:
Candidates performed as expected for this section. The majority of candidates who attempted this section were able to earn full credit. A large proportion of candidates did not attempt this section and thus, earned no credit.

The first PC is dominant in the long term and when OTM.
The second and third PC are more important in the short term, and when the options are ATM or ITM.

(g)   Recommend the model that best reproduces the observed shape of the implied volatility surface across various maturities. Justify your answer.

Commentary on Question:
Candidates performed as expected for this section. Most candidates were able to earn credit for justifying the use of the Jump CIR++ model. Candidates lost credit in failing to discuss each model in terms of the observed volatility curve provided.

CIR model - produces appreciable smiles for intermediate maturities, but has difficulty producing the sharp smiles for short maturities often observed in the market.

Jump CIR++ model - a stochastic diffusive component with jumps can produce appreciable smile for both short and intermediate maturities.

9. **Continued**

Recommend Jump CIR++ model as it is able to produce appreciable smile for both short and intermediate maturities similarly to PCA model

10. **Learning Objectives:**
7. The candidate will understand various investment related considerations with regard to liability manufacturing and management.

Learning Outcomes:
(7a) Identify and evaluate the impact of embedded options in liabilities, specifically variable annuities guaranteed riders (GMAB, GMDB, GMWB and GMIB).

(7b) Demonstrate understanding of risks associated with guarantee riders including: market, insurance, policyholder behavior, basis, credit, regulatory and accounting.

(7c) Demonstrate understanding risk management and dynamic hedging for existing GMXB and it embedded options – including:
   (i) Hedgeable components including equity, interest rate, volatility and cross Greeks
   (ii) Partially Hedgeable or Unhedgeable components include policyholder behavior, mortality and lapse, basis risk, counterparty exposure, foreign bonds and equities, correlation and operation failures
   (iii) Static vs. dynamic hedging

Sources:
QFIA-116-13: Alexander Kling, Frederik Ruez and Jochen Rub
The Impact of Stochastic Volatility on Pricing, Hedging and Hedge Efficiency of Withdrawal Benefit Guarantees in Variable Annuities, Astin Bulletin, Volume 41, Number 2, 2011

QFIA-115-13: IAA, Stochastic Modeling, Theory and Reality from and Actuarial Perspective IV.A.1-8.

Commentary on Question:
Question tested the ability to identify the risks associated with contract riders, evaluate their impact on a qualitative level and differences between interest rate models. The candidates received maximum points for associating contract differences to risk severity and for fully listing reasons why the two models presented achieve different results.

Solution:
(a) Explain the rationale of using dynamic lapse assumptions in GLWB product pricing.

   Commentary on Question:
   Candidates performed as expected on this section, typically identifying the need for a dynamic lapse assumption.

   Lapse rates will dynamically decrease as GLWB becomes increasingly in the money, therefore the cost of the contract will be underestimated using a static lapse assumption.

10. Continued

(b) Outline challenges in managing policyholder behavior risk that may make it difficult to hedge against.

Commentary on Question:
Candidates performed below average on this question and identified that policyholders may behave irrationally.

Policyholders do not act as rationally as a model assumes but will often maintain coverage as the guarantee becomes more valuable.

(c) Determine a ranking of z_{WL} from these three simulations in order of lowest to highest. Justify you answer.

Commentary on Question:
Candidates performed above average, typically ranking the risk properly and adding appropriate rationale and related B and C to a put option, a small portion of candidates analyzed the rider risk rather than cost.

A > B because ratchet on B is more valuable hence a lower guarantee benefit percentage must be charged. Likewise, B > C since C's higher volatility leads to a lower benefit percentage at the same fee level and ratchet type because greater gains are locked in with C's ratchet.

(d) Justify the GLWB type (type I or II from above) that corresponds to each line on the graph.

Commentary on Question:
Candidates performed above average, typically identifying the type of ratchet associated with each line on the graph and supporting their observation.

Dotted line is Type I, solid is Type II. The non-ratcheted product has higher delta at the offset but the ratcheted product can never be far out of the money even if the fund value decreases.

(e) Critique each of the claims made by your colleague.

Commentary on Question:
Candidates performed as expected and were able to provide answers with supporting reasoning, frequently candidates provided answers without a specific evaluation.

10. Continued

It is correct to say that Heston assumes stochastic volatility and the P to Q transformation does not have typically have a unique solution. However, it is actually driven by two stochastic processes and S(t) does not have a solution.

11. **Learning Objectives:**
   2.   The candidate will understand and be able to apply a variety of credit risk theories and models.

Learning Outcomes:
(2e)   Demonstrate an understanding of the term structure of default probability.

Sources:
Introduction to Credit Risk Modeling, Bluhm, Christian, 2nd Edition Chapter 6   p. 229.

Introduction to Credit Risk Modeling, Bluhm, Christian, 2nd Edition Chapter 6   p. 237-238.

Introduction to Credit Risk Modeling, Bluhm, Christian, 2nd Edition Chapter 6   p. 241-243.

Commentary on Question:
This question tests an understanding of the term default structure through an understanding of the risk premium concept, migration matrices and default generators.

Solution:
(a)   Calculate the risk premium, defined as the difference between the risk neutral and actual default probabilities, implied by the one-year par bond.

   Commentary on Question:
   The candidates performed as expected on this section. Many candidate responses were incomplete because they did not recognize the need to calculate the recovery rate as an intermediate step.

   First solve for the recovery rate (RR).
   [(Par + Coupon) * Actual Survival probability + RR * Par *(1- Actual Survival probability)] / (1 + 1yr risk free rate)   = Expected value with actual default probability
   [(100 + 5.47) * .985 + recovery rate * 100 *(1- .985)] / (1 + .0375)   = 101
   RR = (101 * 1.0375 - (100 + 5.47) * .985)/ [100 *(1- .985)] = .60

   Then solve for the risk-neutral default probability (PD).
   [(Par + Coupon) * (1 – PD + RR) * Par * PD] / (1 + 1yr risk free rate)   = Par
   [(100 + 5.47) * (1-PD) + 0.6 * 100 *(PD)] / (1 + .0375)   = 100
   PD = [100 * 1.0375 - (100 + 5.47)]/ (0.6 * 100 - (100 + 5.47)) = .037827

   Risk premium = PD - (1- Actual Survival Probability) = .0378 - .015 = .0228

11. Continued

(b) Identify in M_{data} all areas which do not pass plausibility constraints.

Commentary on Question:
The candidates performed as expected on this section. Very few candidates identified all 4 areas that did not pass plausibility constraints and received full grading points. Most candidates identified several areas and partial credit. Some candidates did not complete the question and received 0 grading points.

4 plausibility constraints all of which are violated.
1) Low risk states should not show a higher default probability than high risk states, i.e. $M_{i5} <= M_{i+15}$ for all i
   Violated at $M_{25} = 0.07$ and $M_{35} = 0.05$

2) It should be more likely to migrate to closer states than to more distant states (row monotony towards the diagonal), i.e. $M_{ii+1} >= M_{ii+2} >= M_{ii+3} \ldots$ and $M_{ii-1} <= M_{ii-2} <= M_{ii-3} \ldots$
   Violated at $M_{23} = 0.06$ and $M_{24} = 0.10$

3) The chance of migration into a certain rating class should be greater for more closely adjacent rating categories (column monotony towards the diagonal), i.e. $M_{i+1i} >= M_{i+2i} >= M_{i+3i} \ldots$ and $M_{i-1i} <= M_{i-2i} <= M_{i-3i} \ldots$
   Violated at $M_{21} = 0.08$ and $M_{31} = 0.09$

4) The underlying Markov chain should be stochastically monotonic.
   $\sum_{j>=k} m_{ij}$ is a nondecreasing function of *i* for every fixed *k*
   Start with *k*=2
   $\sum_{j>=k} m_{ij}$ for *i*=1, $M_{12}+M_{13}+M_{14}+M_{15} = 0.20+0.05+0+0 = 0.25$
   $\sum_{j>=k} m_{ij}$ for *i*=2, $M_{22}+M_{23}+M_{24}+M_{25} = 0.69+0.06+0.10+0.07 = 0.92$
   $\sum_{j>=k} m_{ij}$ for *i*=3, $M_{32}+M_{33}+M_{34}+M_{35} = 0.11+0.65+0.10+0.05 = 0.91$
   $\sum_{j>=k} m_{ij}$ for *i*=4, $M_{42}+M_{43}+M_{44}+M_{45} = 0+0.04+0.60+0.36 = 1.00$
   Since i=3 is less than i=2 the sum is decreasing.
   Alternatively and more simply for *k*=5
   $\sum_{j>=k} m_{ij}$ for *i*=1, $M_{15} = 0$
   $\sum_{j>=k} m_{ij}$ for *i*=2, $M_{25} = 0.07$
   $\sum_{j>=k} m_{ij}$ for *i*=3, $M_{35} = 0.05$
   $\sum_{j>=k} m_{ij}$ for *i*=4, $M_{45} = 0.36$ which also is decreasing.
   Lastly for *k*=4
   $\sum_{j>=k} m_{ij}$ for *i*=1, $M_{14}+M_{15} = 0+0 = 0$
   $\sum_{j>=k} m_{ij}$ for *i*=2, $M_{24}+M_{25} = 0.10+0.07 = 0.17$
   $\sum_{j>=k} m_{ij}$ for *i*=3, $M_{34}+M_{35} = 0.10+0.05 = 0.15$
   $\sum_{j>=k} m_{ij}$ for *i*=4, $M_{44}+M_{45} = 0.60+0.36 = 0.96$ which is decreasing

11. Continued

(c) Determine which Q matrix generated would be the best approximation, using an L^1 Norm computation.

Commentary on Question:
The candidates performed as expected on this section. The candidate responses were very binary – either they understood how to calculate an L^1 norm and received full credit, or they did not complete the question and received 0 grading points. A relatively small number of candidates received partial credit by stating the L^1 norm formula but not calculating it correctly.

L^1 Norm of a matrix M is defined as $\|M\|_1 = \sum_{i,j} |m_{ij}|$
L^1 Norm^2 $_A = \sum_{i,j} |M_{data} - \exp(Q_{data})_A|$ or the absolute value of the differences of the two matrices. Best fit is lowest L^1 Norm^2

L^1 Norm^2 $_A = |0.76\text{-}0.75| + |0.04\text{-}0.05| + |0.10\text{-}0.08| + |0.70\text{-}0.69| + |0.10\text{-}0.06| + |0.06\text{-}0.10| + |0.04\text{-}0.07| + |0.62\text{-}0.60| + |0.34\text{-}0.36| = 0.20$
L^1 Norm^2 $_B = |0.15\text{-}0.20| + |0.08\text{-}0.05| + |0.02\text{-}0.00| + |0.10\text{-}0.08| + |0.14\text{-}0.06| + |0.07\text{-}0.10| + |0.00\text{-}0.07| = 0.30$
L^1 Norm^2 $_C = |0.16\text{-}0.04| + |0.24\text{-}0.36| = 0.24$

$(Q_{data})_A$ is the lower value and hence the best fit.

12.   **Learning Objectives:**
4.   The candidate will understand important quantitative techniques relating to
financial time series, performance measurement, performance attribution and
stochastic modeling.

Learning Outcomes:
(4a)   Understand the concept of a factor model in the context of financial time series.

(4b)   Apply various techniques for analyzing factor models including Principal
Component Analysis (PCA) and Statistical Factor Analysis.

(4h)   Understand and apply various techniques of adjusting auto correlated returns for
certain asset classes.

Sources:
QFIA-119-14: Analysis of Financial Time Series, Tsay, 3rd edition, Ch. 9

QFIA-110-13: CAIA Level II, Advanced Core Topics in Alternative Investment, 2nd
Edition, 2012, Ch. 16

Commentary on Question:
*This question is testing the candidate's ability to apply the mathematical methods used to
deal with autocorrelation. The problem also tests the candidate's ability to recognize
when and how to use techniques to adjust autocorrelated returns among certain asset
classes.*

Solution:
(a)   Recommend one of the three investments and justify your recommendation.

Commentary on Question:
*Overall, candidates performed below average on this part of the question. Many
candidates recognized that autocorrelation was an issue that needed to be
addressed. However, many candidates missed that or failed to realize that the
company was making the decision based on the ex-post Sharpe ratio alone.*

*Many candidates recommended S&P 500 and gave reasonable arguments for
their choice. However, many candidates did not perform a calculation to
determine the impact autocorrelation was having on the NCIREIF Sharpe ratio.
Such a calculation (or a reasonable approximation) was the only way to
completely justify the choice of the S&P 500.*

*Candidates who chose S&P 500 and gave a reasonable explanation but no
mathematical justification received a substantial amount of credit. Candidates
that gave a mathematical justification that was correct received full marks.*

12. Continued

XYZ insurance is relying on the ex-post Sharpe ratio to make the investment decision. No other criteria is mentioned.

The NCIREIF NPI needs to be unsmoothed since the index is based on stale prices.
S&P 500 and NAREIT do not need to be unsmoothed since prices are not stale.
Unsmoothing of NCREIF NPI is performed using the following formula:

$R_{T,True} = (R_{T,Reported} - \rho R_{T-1,Reported})/(1-\rho)$
$R_{T1} = (3\% - (0.5)*(3\%))/(1-.5) = 3.00\%$
$R_{T2} = (6\% - (0.5)*(3\%))/(1-0.5) = 9.00\%$
$R_{T3} = (6\% - (0.5)*(6\%))/(1-0.5) = 6.00\%$

Next estimate the excess return and find the mean of the excess return:
Excess return T1: 3.00% - 2.00% = 1.00%
Excess return T2: 9.00% - 2.00% = 7.00%
Excess return T3: 6.00% - 2.00% = 4.00%
Mean of excess return = (1%+7%+4%)/3 = 4%

Next calculate the standard deviation of the excess return relative to the risk free rate of the true return series for NCIREIF:
$= (((1\%-4\%)^2 + (7\%-4\%)^2 + (4\%-4\%)^2)/(3-1))^{(1/2)} = 3.00\%$

Calculate the Sharpe Ratio of the NCIREIF NPI:
= 4%/3% = 133.33%

S&P 500 and NAREIT Sharpe ratios are the same since each of those series do not need to be unsmoothed.

Based on the unsmoothed Sharpe ratio for NCIREIF NPI and the investment selection criteria, I recommend S&P 500 since it has the highest ex-post sharpe ratio.

(b) Explain why price smoothing can be a problem for risk and portfolio management.

Commentary on Question:
Candidates performed above averagel on this section.

12.   **Continued**

- The primary problem resulting from price smoothing is that it causes substantial understatement of volatility and correlation.
- Risk understatement may cause higher allocations to assets with smoothed prices
- Portfolio optimization will tend to overweight assets with understated risks
- Investor selecting investments with high Sharpe ratios will be attracted to asset classes with smoothed prices.
- Underestimated price correlations due to price smoothing may distort the estimation of appropriate hedge ratios and interfere with risk management.

13. Learning Objectives:
1.   The candidate will understand the standard yield curve models, including:
   - One and two-factor short rate models
   - LIBOR market models

   The candidate will understand approaches to volatility modeling.

Learning Outcomes:
(1q)   Describe and contrast several approaches for modeling smiles, including: Stochastic Volatility, local-volatility, jump-diffusions, variance-gamma and mixture models.

(1r)   Describe and explain various issues and approaches for fitting a volatility surface.

Sources:
Rebonato, R, Volatility and Correlation, 2nd Edition, Section 8.1 – 8.5.

Rebonato, R, Volatility and Correlation, 2nd Edition, Section 9.3, 9.6.

Commentary on Question:
This question tested the candidates' understanding of different ways to model and fit volatility surfaces. It required candidates to recall various volatility models and their features, give pros and cons of various fitting approaches, and apply their knowledge by giving a recommendation. Overall, candidates performed above average on the question.

Solution:
(a)   For a fully-stochastic-volatility model category:

   (i)   Describe this model category.

   (ii)   Explain why this model category gives rise to a smile.

   ### Commentary on Question:
   The candidates performed brilliantly on part (i) of this section, but below average on part (ii) of this section. Many candidates mentioned the convexity of the Black-Scholes formula, but incorrectly described it as convexity with respect to the underlying, instead of convexity with respect to the implied volatility.

   (i)   A fully-stochastic-volatility model describes the dynamics of the underlying with two stochastic processes, one given to the underlying and the other given to the volatility of the underlying.

   A general example of a fully-stochastic-volatility model is:
   $$dS = \mu_S(S,V,t)dt + \sigma_S(S,V,t)dz_t$$
   $$dV = \mu_V(S,V,t)dt + \sigma_V(S,V,t)dw_t$$
   $$V = \sigma^2$$
   $$E[dz_t \cdot dw_t] = \rho dt$$

13. Continued

(ii) In fully-stochastic-volatility models, call option prices are given by the integral over the density of the root-mean-squared volatilities of the Black-Scholes call option price as a function of the root-mean-squared volatility.

[Expressed as a formula,

$$Call_{StVol} = \int Call_{BS}(\hat{\sigma})\phi(\hat{\sigma})d\hat{\sigma}$$

where $\hat{\sigma}$ is the root-mean-squared volatility and $\phi(\hat{\sigma})$ is the probability density of the root-mean-squared volatility.]

At-the-money, the Black-Scholes formula is virtually linear with respect to the root-mean-squared volatility, so the Black-Scholes price calculated using the average volatility is equal to the average of Black-Scholes prices calculated using higher and lower than average root-mean-square volatilities.

Away from at-the-money, the Black-Scholes formula is convex with respect to the root-mean-squared volatility. Therefore, the Call option price (and implied volatility) will be higher than the Black-Scholes price calculated using the average volatility.

Thus, the volatility smile is a direct consequence of the convexity of the Black-Scholes formula with respect to implied volatility.

(b) For a local-volatility (restricted-stochastic-volatility) model category:

(i) Describe this model category.

(ii) Explain why the market is complete under this model.

Commentary on Question:
The candidates performed above average on this section.

(i) A local-volatility model describes the dynamics of the underlying with only one stochastic process. The volatility of the process is not constant, but is nonetheless a deterministic function of the underlying.

A general example of a local-volatility model is:
$$dS = \mu(S,t)dt + \sigma(S,t)dz_t$$

13. Continued

    (ii)   Since the stochastic volatility functionally depends on the underlying security, for any contingent payment, an exact replicating portfolio can always be set up with a portfolio of the underlying security and a risk-free bond. In addition, the risk-neutral valuation will always give rise to a unique option price for such portfolios. Therefore, the market is complete.

(c)   Explain two processes that are capable of producing this empirical behavior.

Commentary on Question:
The candidates performed above average on this section. Most candidates could explain at least one process that is capable of producing volatility smiles that become shallower with longer maturities.

Some stochastic processes that can produce pronounced smiles for shorter maturities and shallow smiles for more distant maturities are:
1.   Jump-diffusion models: These models add a random jump component to the Brownian diffusion model.
2.   Variance-gamma models: These pure-jump models describe movements in the underlying as a serious of jumps, with smaller jumps occurring more frequently. They do not have a diffusion component.
3.   Fully-stochastic-volatility models. With a sufficiently high mean-reversion speed and high "volatility of volatility", this model category can generate pronounced smiles for short maturities that deteriorate at longer maturities.
4.   Mixing processes that join a diffusive stochastic model with a jump model.

In general, models that have random jumps can produce the desired behavior. Since the size of the jump does not scale with the time to maturity, jump-diffusion models have a much higher probability of large moves of the underlying for shorter maturities, as compared to models without jumps. Therefore, the volatility smile is much more pronounced at short maturities than at distant maturities.

(d)   Contrast the advantages and disadvantages of calibrating to pure market prices as opposed to applying pre-processing to the inputs before calibrating the model.

Commentary on Question:
The candidates performed as expected on this section. Almost all candidates mentioned using pure market prices as the cleaner approach, and mentioned noisy prices.

13. Continued

Calibrating to pure market prices:
- Is the cleaner approach and has the least data pollution. (Advantage)
- May overweight at-the-money and in-the-money options (because they have bigger prices), and underweight out-of-the-money options (because they have smaller prices). (Disadvantage)
- Assumes that prices are known with infinite precision, and that there are no liquidity effects, bid-ask spreads, or other sources of noise in the prices. (Disadvantage)
- Is impossible for some models as the fitting methodology becomes a noise amplifier. (Disadvantage)
- A model's inability to price plain vanilla options exactly might convey important relative-value information. (Advantage)

Applying pre-processing to prices:
- Can turn a small number of input data points into a smooth differentiable surface that is easier to work with analytically. (Advantage)
- Allows for the possibility of a trade-off between the quality of the global fit and a small variation in the input prices. (Advantage)
- Can be calibrated to recovery a set of "synthetic" prices that have been adjusted for noise in the input data. (Advantage)

Whether pure market prices or pre-processed inputs should be used depends on whether the fitting procedure is stable under small perturbations of the input quantities.

(e)   Recommend whether pure market prices or pre-processed market inputs should be used for calibration.

Commentary on Question:
The candidates performed above average on this section. Many candidates were able to recognize that in this example, pure prices were prone to noise. Some candidates also recognized that the magnitudes of the input prices are very different.

Pre-processed market inputs should be used, as they help with the following problems:
- Real estate markets are prone to noise (e.g. lagged reporting, liquidity effects, and heterogeneous assets)
- Only a small set of input prices are available, whereas the model is complex and has many parameters. Therefore it is better to turn the input data into a smooth differentiable surface.
- The model is being calibrated using both asset prices and option prices. These have very different price magnitudes, and should not be weighted equally.

14.

Learning Objectives:

1. The candidate will understand the standard yield curve models, including:
   - One and two-factor short rate models
   - LIBOR market models

   The candidate will understand approaches to volatility modeling.

Learning Outcomes:

(1l) Define and explain the concept of volatility smile and some arguments for its existence.

(1m) Calculate the hedge ratio for a call option given the dependency of the Black-Scholes volatility on the underlying.

(1n) Compare and contrast "floating" and "sticky smiles.

Sources:

Volatility Correlation – The Perfect Hedger and the Fox, Rebonato, R., 2nd Edition section 6.4.2, 6.4.3, and 6.4.4

Commentary on Question:

This question tested the candidates' knowledge of the concept of volatility smiles. Overall, the candidates performed as expected on this question.

Solution:

(a) Describe the characteristics of the observed implied volatility.

   Commentary on Question:
   The candidates performed above average on this question. Most of the candidates successfully described the characteristics of the observed implied volatility.

   Implied volatility stays the same when the ratio of stock price to strike price (i.e. moneyness) does not change. This behavior is called floating smile.

(b) Calculate the value of the at-the-money option.

   Commentary on Question:
   The candidate performed as expected on this question.

14. Continued

$$C(S, T) = N(d1)S - N(d2)Ke^{-rT}$$

$$d1 = \frac{1}{\sigma\sqrt{T}}[\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)T]$$

$$d1 = \frac{1}{(20\%)\sqrt{1}}[\ln\left(\frac{100}{100}\right) + \left(3\% + \frac{(20\%)^2}{2}\right)(1)] = 0.25$$

$$d2 = d1 - \sigma\sqrt{T}$$

$$d2 = 0.25 - (20\%)\sqrt{1} = 0.05$$

$$C(100,1) = N(0.25)(100) - N(0.05)(100)e^{-(3\%)(1)}$$

$$C(100, 1) = (0.59871)(100) - (0.51994)(100)e^{-3\%} = 9.41$$

Alternatively, under floating smile, the value for at-the-money option changes by the same proportion of stock price changes

$$C(100,1) = \frac{100}{99}C(99,1)$$

$$C(100,1) = \frac{100}{99}9.32 = 9.41$$

(c)   Assess the appropriateness of this approach.

Commentary on Question:
The candidate performed as expected on this question. Many candidates were able to point out why this approach is not appropriate.

The Black formula is based on the assumption that volatility is constant. The implied volatility has no link with the volatility of the true process. Using the Black formula to calculate delta does not capture the change in implied volatility when underlying changes. Since the implied volatility changes when the moneyness changes under a floating smile, it is not appropriate to delta-hedge the at-the-money option based on the Black formula.

14. Continued

(d)   Propose an alternative delta hedging strategy.

Commentary on Question:
The candidates performed above average on this question.

Delta should be calculated by taking into account that the implied volatility changes with stock price and strike price. The delta should be calculated using the following formula:

$$\Delta = N(h1) + \frac{\partial Black(S,T,K,\sigma_{impl}(S,K))}{\partial \sigma_{impl}(S,K)} \frac{\partial \sigma_{impl}(S,K)}{\partial S}$$

(e)   Calculate the delta according to the strategy in (d).

Commentary on Question:
The candidates performed poorly on this question. Most of the candidates struggled to calculate the derivative of the implied volatility with regard to the stock price.

$$\Delta = \frac{\partial Black(S,T,K,\sigma_{impl}(S,K))}{\partial S}$$

$$\Delta = N(h1) + \frac{\partial Black(S,T,K,\sigma_{impl}(S,K))}{\partial \sigma_{impl}(S,K)} \frac{\partial \sigma_{impl}(S,K)}{\partial S}$$

$$\Delta = BlackDelta(S,T,K,\sigma_{impl}(S,K))$$
$$+ BlackVega(S,T,K,\sigma_{impl}(S,K)) \frac{\partial \sigma_{impl}(S,K)}{\partial S}$$

$$\Delta = 0.5987 + 38.67 \times \frac{20.2\% - 19.8\%}{(101 - 99)} = 0.676$$

To execute the hedge, sell 0.676 shares per call option

15. **Learning Objectives:**

6.   The candidate will understand and be able to describe the variety and assess the role of alternative assets in investment portfolios. The candidate will demonstrate an understanding of the distinguishing investment characteristics and potential contributions to investment portfolios of the following major alternative asset groups:
  • Real Estate
  • Private Equity
  • Commodities
  • Hedge Funds
  • Managed Futures
  • Distressed Securities
  • Farmland and Timber

Learning Outcomes:

(6a)   Demonstrate an understanding of the types of investments available in each market, and their most important differences for an investor.

(6c)   Demonstrate an understanding of the investment strategies and portfolio roles that are characteristic of each alternative investment.

(6e)   Demonstrate an understanding of infrastructure invesetments.

Sources:
QFIA-111-13: Maginn & Tuttle, Managing Investment Portfolios, 3rd Ed. 2007, Ch. 8 Infrastructure as an Asset Class, Interest [DPD: Confirm the second item.]

Commentary on Question:
This question tested the candidate's understanding of the role of alternative assets in an investment portfolio including the appropriateness of the asset classes to different investors. Generally, candidates did well on being able to list and describe the asset classes. This question allowed for multiple answers, thus full credit required clear recommendations along with explanations of those recommendations.

Solution:
(a)   Identify four alternative assets classes (other than infrastructure) available to investors.

   Commentary on Question:
   The candidates performed brilliantly on this section. Listing 4 of the 6 categories was needed for full credit.

15. Continued

Four alternative asset classes are:
1. Real Estate
2. Private Equity / Venture Capital
3. Commodity Investments
4. Hedge Funds
5. [Managed Funds]
6. [Distressed Securities]

(b) Describe the investment role that these asset classes typically perform for an institutional investor. Note: Relevant issues may include diversification, return enhancement, and inflation.

Commentary on Question:
The candidates performed as expected on this section. No credit was given for re-writing the question as a statement with a simple added adjective. Some candidates wrote about the role of alternative assets as a whole, which was acceptable as long as specific classes were mentioned for the various uses.

Real Estate
It is a diversifier including w/ itself.
Adds values due to direct management
Opportunities for worldwide diversification.

Private Equity
Moderate Role as a risk diversifier
Many look as a vehicle for Long Term Return Enhancer

Commodities
Potent risk diversifier
Inflation Hedge

Hedge Funds
Diverse Set of Strategies
Diversification benefits can be quite distinct
Fund of Funds are popular method for entry level.
Higher Moments (need to expand what is meant by this)
Improve the risk-return trade-off

Managed Futures
Diversifying risk in portfolios of Bond, Stocks and Hedge Funds.
Depends on the investment vehicles.
Can use CTA managed index to determine optimal asset allocation.

15. Continued

Distressed Securities
5% of educational endowments
Long-only Value Investors
Distress Debt Arbitrage.
Private Equity "Active" approach – prepackaged bankruptcy.

(c) For each client, you have been asked to recommend two alternative asset classes to add to their basic stock and bond portfolios. Your recommendation must discuss appropriate investment vehicles within each asset class, approximate allocations that may be appropriate, and any advantages and disadvantages that each asset class would present.

Outline your recommendations.

Commentary on Question:
The candidates performed above average on this section. Candidates generally did well in making a clear recommendation for partial credit. This question allowed for a large range of answers and the explanation of the recommendation was necessary to get full credit. It was necessary to discuss advantages, disadvantages, and allocations for each recommended class for each investor to get full credit. Just listing the characteristics of the alternative asset classes without relating it to the actual investor was insufficient. A few candidates included additional alternative asset classes. This took away from the quality of the answer as it no longer provided a clear recommendation. Some answers for allocations were not complete as they only addressed the allocation to the alternative classes and not to how much those classes should have been in the overall portfolio. The illustrative answer below is representative of an answer which would achieve full credit.

For Investor 1, I would recommend investing in Real Estate and Hedge Funds.

Real Estate:
Direct Real Estate makes sense for client 1 especially since they are a long term investor and have a large investment staff that will be capable to perform appropriate research and due diligence.

Advantages:
Tax benefits, financial leverage (mortgages), direct ownership control, geographical diversification, real estate returns have low volatility.
Disadvantages:
Can't divide most parcels, high cost of info, large commissions to brokers, substantial operating and maintenance costs, risk of neighborhood deterioration, tax benefits subject to political risk.

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15. Continued

    Allocation: A 5-10% allocation of the total investment portfolio would be appropriate.

Hedge Funds:
The large amount of due diligence can be mitigated by the large investment staff. The total return objective with longer time-frames also fits in well with Investor 1's goals.
An Allocation of 5% would be appropriate.

There are many types available for example:
Equity Market neutral: short / long positions to exploit valuation issues.
Convertible Arbitrage: mispricings in convertible securities
Fixed Income Arbitrage: bond mispricings on expectations of interest rates.
Distressed Securities, Merger Arbitrage, Hedged Equity, Global Macro, Emerging Markets, Fund of Funds (two layers of fees, more appropriate for individual rather than our client.
Hedge funds are often promoted as Absolute Return Vehicles – not tied to any benchmark.
Indices available but performance against can be meaningfully different within a given time period. Biases in indices: value weighting, relevance of past data, survivorship bias, stale price bias, backfill (inclusion) bias
Issues:
Performance Fees and lock-up impacts (may close fund rather than not make incentive fee)
Effect of Fund Size – smaller may be more nimble. Larger can do more research.
Age Effects – when it was started may have impacts when comparing to other funds.
High due diligence needs.

For Investor 2, I would recommend investing in Real Estate and Commodities.

REITs are probably more appropriate for client 2, due to the limited resources available for due diligence. They offer an easy entry into the alternative class even though some of the inflation protection being sought for the investor may not be achieved as well as direct investment. They same advantages and disadvantages would apply and an allocation of 5-10% would also be appropriate with consideration possibly given to include personal real estate assets as part of that allocation (homes, business location if applicable)

15. Continued

Commodities:
Direct investment (purchase of physical commodities)
Indirect (more typical) – derivative markets (futures and forwards)
Evaluated using commodities indices.
Judged by Sharpe ratio, underperformed stocks and bonds.
Potential as risk diversifier.
Typically under 5% of a portfolio.
Special Risk Characteristics: Business cycle Supply & Demand, Convenience yield,
   Real options under uncertainty.
Physical commodities may serve as hedge to inflation.
Discussion above mostly on long only passive positions, can also actively manage.
   (Not likely for individual investor.)
One has to be careful on how to approach the commodities. Likely given the single
investment manager, indirect investing is the safer approach. This is a good way to
achieve the inflation protection being sought and a 5% allocation would be
appropriate for protecting the family investments.

(d) Explain emerging issues related to the risk-return profile of infrastructure
   investments.

Commentary on Question:
*The candidates performed poorly on this section. Generally candidates described
the risk-return profile of infrastructure rather than the emerging issues as asked
by the question.*

The infrastructure sector has become overcrowded, the prime mover advantage
has evaporated.
The financial environment has changed as a result of the global financial crisis.
Sectors greatly differ in their resilience to the recent ups and downs of the
economy.
Investors have come to realize the enormous heterogeneity of infrastructure
assets.

(e) Identify five risks relating to infrastructure investments, noting how applicable
   they are to each client.

Commentary on Question:
*The candidates performed as expected on this section. Partial credit was given
for simply listing risks with a short description. Full credit required that the
candidate answered the applicability portion of the question for each of the
investors. There was an extensive list of possible risks to consider and most are
listed below. Full credit was obtained by providing 5 risks, along with the
required assessment of applicability to each Client.*

15. **Continued**

Risk and Issues	Client 1	Client 2
1. Lack of experience with asset class and investment vehicles;	Not applicable (has well-staffed investment research department)	Applicable
2. Investment and re-investment program, diversification by time;	Applicable	Applicable
3. Integration in asset-liability management, strategic asset allocation;	Applicable	Not applicable (liabilities are not well defined)
4. Timing (boom and bust cycles);	Applicable	Applicable
5. Advisers and counterparties;	Applicable	Applicable
6. Legal, regulatory and fiduciary risks; and	Applicable	Applicable
7. Reputation risk	Applicable	Not applicable (individual investor has less reputation risk)
8. Construction risk	Applicable	Applicable
9. Business risk	Applicable	Applicable
10. Environmental risk	Applicable	Applicable
11. Leverage,;	Not Applicable	Not Applicable
12. interest rate risk	Not Applicable	Not Applicable
13. Legal and ownership risk	Applicable	Applicable
14. Regulatory risk (fees, concessions);	Applicable	Applicable
15. Refinancing risk;	Not Applicable	Not Applicable
16. Legal and ownership risk;	Applicable	Applicable
17. Political and taxation risks	Applicable	Applicable
18. Social risks (e.g. opposition from pressure groups, corruption).	Applicable	Applicable
19. Pricing Risk	Applicable	Applicable
20. Concentration or Cluster Risk	Applicable	Applicable
21. Illiquidity Risk	Applicable	Applicable
22. Risks related to the governance of investment vehicles	Applicable	Applicable