ERM-INV Model Solutions
Fall 2013

1. **Learning Objectives:**
2.   The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.

4.   The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:
(2c)   Analyze and evaluate risk aggregation techniques, including use of correlation, integrated risk distributions and copulas.

(2d)   Apply and analyze scenario and stress testing in the risk measurement process.

(4f)   Develop an appropriate choice of hedging strategy for a given situation (e.g., reinsurance, derivatives, financial contracting), which balances benefits with inherent costs, including exposure to credit risk, basis risk, moral hazard and other risks.

Sources:
Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion, Chapter 14, Stress Testing

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a)   Evaluate the advantages of analyzing stress test results for the fixed and variable blocks separately versus in aggregate.

   Commentary on Question:
   Many candidates discussed one or two advantages, but focused mainly on analyzing the stress test results separately. For full credit, candidates were expected to compare advantages of separate testing versus testing in aggregate.

1. Continued

Analyzing the stress test results separately would allow Blackhawk to identify and analyze the risk drivers specific to each line of business. It could also identify the incremental impact of each line of business on the company's overall risk profile. Analyzing the stress test results in aggregate would consider any diversification benefits that exist between the two blocks. It could also identify the market movements or management actions that would have a material impact on the overall performance of the company.

(b) Recommend four key unidimensional sensitivity tests that Blackhawk should run to analyze the risks of its business. Justify your response.

Commentary on Question:
Candidates were generally successful in providing adequate tests, though sometimes the justifications didn't match the test, or were not provided at all. One common shortcoming was to provide a test that could not measure sensitivity, such as a more qualitative operational loss test.
The deferred fixed annuities in the question were intended to be accumulation-type annuities. However, some candidates assumed that they included income benefit guarantees and suggested mortality improvement as a sensitivity; candidates did receive credit for those recommendations, if justified.

1. Yield curve shift up: rates impact the discount rate for the reserves of the two blocks, as well as the assets backing the liabilities
2. Yield curve twist: this would measure the impact of key rate duration mismatches between the assets and liabilities
3. Equity market shock down: equity returns impact the VA guarantees and this test would measure the adequacy of the hedging program
4. Implied volatilities shock up: implied volatilities impact the assets backing the VA liabilities, and would also measure the adequacy of the hedging program

(c) Blackhawk is also considering performing multidimensional scenario analysis.

(i) Describe two types of multidimensional prospective scenarios.

(ii) Explain the drawbacks of using each of the two types of scenarios identified in (i).

(iii) Recommend one scenario of each type in (i) that would be meaningful to Blackhawk. Justify your response.

1. Continued

Commentary on Question:
Many candidates did not successfully identify the Factor Push Method and Conditional Scenario Method. Those who did generally performed well on the first two parts of the question. Part (iii) was challenging for all candidates, but well-formed justification of meaningful scenarios received credit.

(i)   Factor Push Method: First, push all risk factors individually up and down by a number of standard deviations and compute changes to portfolio. Second, evaluate a worst-case scenario where each variable is pushed in the direction that creates the worst loss.

Conditional Scenario Method: Group the key risk factors that are subject to extreme movements together, then group all other risk factors together. Regress the group of "other" risk factors on the group of key risk factors. This allows prediction of the "other" group of risk factors conditional on movements in key risk factors.

(ii)   Factor Push Method: This method is conservative as all risk factors are assumed to move in the direction that is most detrimental to the company. This method ignores correlation between risk factors. Looking at extreme movements may not be appropriate, as sometimes a loss may occur when an underlying risk factor doesn't move at all.

Conditional Scenario Method: This method requires a sufficient amount of data to do the regression between the risk factors, and such data may not be readily available. The underlying correlation between risk factors in the data used to run the regression may not be homogenous (e.g. normal periods vs. periods of high market volatility) and could be misestimated.

(iii)   Factor Push Method: Shock volatility and credit default rates/downgrades up; shock interest rates, swap spreads, and credit spreads down; shock policyholder behavior in adverse direction. Each risk factor shocked 2.33 times standard deviation. These variables and associated shocks would produce the greatest loss for Blackhawk; 2.33 represents the 99th percentile, which should be sufficiently conservative.

Conditional Scenario Method: Group equity, interest rates and volatility together as the key risk factors group. Group all other risk factors together as the "other" group and regress the "other" group on the key risk group. Exclude policyholder behavior. Equity, interest rates and volatility data are most readily available and in sufficient volume. Swap and credit spreads are likely not significant enough to be placed in the key group. Policyholder data may not be sufficient or credible enough to include in regression.

1. Continued

(d)   Blackhawk reviews the stress testing results for the October 1987 Market Crash scenario and determines that these are unacceptable. As a result, Blackhawk proposes the following two approaches to manage the risks associated with severe equity market declines:

(i)   De-risk the product portfolio by changing product design

(ii)   Hold sufficient capital

Describe the consequences for each of (i) and (ii).

Commentary on Question:
Candidates performed well on this section, offering substantial descriptions of the consequences of each approach.

(i)
- Could cause existing policyholders to lapse
- Likely would impact marketing of the product
- Likely would reduce competitiveness in the market
- Potential regulatory barriers/risks
- Could impact distribution channel

(ii)
- Provides greater buffer against all risks/reduces overall risk of insolvency
- Could result in holding excessive level of capital
- Adversely impacts profitability of products/shareholder returns
- Adversely impacts competitiveness of product due to capital charge passed to policyholders

2. **Learning Objectives:**

1. The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.

2. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.

Learning Outcomes:

(1a) Explain risk concepts and be able to apply risk definitions to different entities.

(2a) Demonstrate how each of the financial risks faced by an entity can be amendable to quantitative analysis including an explanation of the advantages and disadvantages of various techniques such as Value at Risk (VaR), stochastic analysis, scenario analysis.

(2c) Analyze and evaluate risk aggregation techniques, including use of correlation, integrated risk distributions and copulas.

(2f) Analyze the importance of tails of distributions, tail correlations, and low frequency/high severity events.

Sources:

Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion Ch. 12 Monte Carlo Methods

Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion Ch. 5 Computing VaR

Commentary on Question:

This question tests the impact of tail dependence on a portfolio in the context of a stock portfolio. Candidates are asked to apply tail dependency concepts in determining the portfolio's VaR and to demonstrate knowledge of variance reduction techniques.

Solution:

(a) Given the following formula:

$$\begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ \rho & \left(1-\rho^2\right)^{\frac{1}{2}} \end{bmatrix} \begin{bmatrix} n_1 \\ n_2 \end{bmatrix}$$

(i) Solve for ε_1 and ε_2.

(ii) Explain the purpose of this formula and how it works.

Commentary on Question:
Most candidates performed well on this part of the question.

2. **Continued**

$\mathcal{E}_1 = 1*n_1 + 0*n_2 = n_1$
$\mathcal{E}_2 = \rho*n_1 + (1-\rho\^2)\^(1/2)*n_2$

Cholesky decomposition transforms the $\mathcal{E}_2$ variable such that it is dependent on the value of both n_1 and n_2 (i.e., it is correlated to $\mathcal{E}_1$). This process correlates two non-correlated variables (n_1 and n_2).

(b)   Determine the one year VaR(95%) for the portfolio value. Show your work.

Commentary on Question:
Many candidates did not calculate the VaR based on the simulated data that was provided. Instead, they used the 95% percentile z-value from the standard normal distribution. Such candidates did poorly on this part as the intent was for candidates to use the values provided in the question.

Various sources gave different definitions of the VaR calculation, so credit was awarded to candidates who selected the 19th or 20th ordered values (or interpolated between the two). Similarly, some candidates answered VaR as the difference between the expected portfolio value and that of the 19th simulation. Candidates were not penalized for this alternative definition.

*A few candidates noted that the simulated variables were not sorted appropriately in descending order in the table provided. It should be noted that it was the resulting **portfolio value** that was ordered and not the random variables.*

Find the ordered simulation that you need to evaluate to get VaR(95%). VaR is the highest loss such that there is at least a (1 - 95%) chance that the loss exceeds this amount. This is 21 * .95, rounded down to the nearest integer, which equals 19.

For the 19th simulation: $\mathcal{E}_1 = n_1 = -1.12$

Determine if the variables are correlated for simulation 19: $n_1 > -1.96$, so $\rho = 0$

For the 19th simulation: $\mathcal{E}_2 = \rho* n_1 + (1-\rho\^2)\^(1/2)*n_2 = 0 *(-1.12) + (1-0\^2)\^(1/2) * (-1.05) = -1.05$

Holding XYZ value: $XYZ = 100 * e\^((0.05 - 0.15\^2/2) + 0.15 * -1.12) = 87.88$

Holding ABC value $= 150 * e\^((0.1 - 0.2\^2/2) + 0.2 * -1.05) = 131.71$

Portfolio Value $= XYZ + ABC = 219.59$

2. **Continued**

    (c)   Evaluate in qualitative terms (without performing additional calculations) the effect that each of the following changes would have on the VaR(95%) of the portfolio.

        (i)   The correlation coefficient increases from 0.8 to 0.9 when $n_1 \leq -1.96$

        (ii)   Tail dependency is reflected when $n_1 \leq -2.65$ rather than when $n_1 \leq -1.96$

        Commentary on Question:
        The weakest candidates answered this question in general terms, without regard for the specific information provided for this portfolio. Stronger candidates answered this question by speaking directly to the impact these changes would have on the portfolio. The strongest candidates provided both portfolio specific responses as well as more general responses.

        (i)   In general, an increase in the correlation triggers an even more adverse decrease in the value of the portfolio at the VaR (95%) level; however, because the correlation is zero when $n_1 > -1.96$, increasing the correlation does not impact the VaR(95%) in this sample.

        (iii)   Similarly to subpart (i), the 19th ordered statistic does not trigger the correlation at the lower threshold, so extending the condition further out to occur when $n_1 \leq -2.65$ has no impact on the VaR in this example.
             In general, however, this makes the correlation occur less often and therefore will make the VaR more favorable.

    (d)   Explain the steps required to determine VaR(95%) for the portfolio value using the antithetic variable reduction technique.

        Commentary on Question:
        On this part, we were expecting candidates to delineate the process one would take to apply the antithetic variable reduction technique. Few candidates performed well on this section. Almost everyone identified the first step (i.e. multiply the original random variables by -1), but most skipped the majority of the steps and simply stated, "Calculate the VaR". Many candidates were able to identify that re-ordering was a step, but omitted the prior step of determining the portfolio value, making it difficult to determine whether they understood what exactly was supposed to have been ordered.

        Step 1: Multiply each n_1 and n_2 by -1. This effectively doubles the sample size of the simulations.

        Step 2: Calculate the resulting ε_1 and ε_2 for each ordered statistic.

2. **Continued**

Step 3: Calculate the resulting value of each holding, add these together to get the total value of the portfolio.

Step 4: Re-Order the portfolio values. The order may have changed because of the asymmetric correlation (i.e., it is only correlated for adverse scenarios).

Step 5: Calculate the ordered statistic(s) you need to find the VaR(95%). This is 42*.95, rounded down, which = 39

Step 6: Identify the portfolio value of the 39th ordered statistic

(e) Describe two additional variance reduction techniques and evaluate whether each is appropriate to use when modeling correlated equities.

Commentary on Question:
Most candidates performed well on this part. Almost all were able to identify and describe two techniques, but fewer justified whether or not each was appropriate.

Quasi-random sampling-
Stratify the distribution into equal probabilistic ranges. Then determine the value at the average point within each of the ranges.
With correlation, we could stratify the first holding (since $\varepsilon_1 = n_1$); however, the correlation makes it difficult to stratify the second holding and it is not recommended.

Importance Sampling-
Test only the portion of the distribution in which you are interested. For this example, we would test the tail at and around the 95th percentile.
This approach is tricky when considering multiple holdings (particularly when there is correlation) because a bad scenario could come from one performing poorly while the other performs well or from both performing poorly; therefore it is not recommended.

3. **Learning Objectives:**
1.   The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.

3.   The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.

Learning Outcomes:
(1b)   Explain risk taxonomy and its application to different frameworks.

(3b)   Analyze and evaluate the properties of risk measures (e.g. Delta, volatility, duration, VaR, TVaR, etc.) and their limitations.

Sources:
ERM-105-12: Coherent Measures of Risk

Value-at- Risk, Third Edition, The New Benchmark for Managing Financial Risk, Jorion Ch. 5 Computing VaR

Commentary on Question:
Overall, the candidates did relatively well on this question. The question was testing the student's knowledge of a coherent risk measure and their understanding of the importance of using such a measure in economic capital calculations   While candidates could easily identify the coherent risk measures, they had some difficulty tying the given risk measures to the various properties of a coherent risk measure.

Solution:
(a)   Explain the benefits of satisfying each of the following properties when selecting a risk measure in the context of setting economic capital:

      (i)   Positive Homogeneity

      (ii)   Monotonicity

      (iii)   Translation Invariance

      (iv)   Subadditivity

      Commentary on Question:
      The candidates were able to define the properties of a coherent risk measure in part (a). Weaker candidates focused on a "mathematical explanation" and did not answer the question asked, which was to explain benefits of each of the properties in the context of setting economic capital.

3. **Continued**

There are two sources that could have been used for this question, as noted above. The explanations in the two sources differed in some respects; candidates could receive credit based on either of the sources.

(i)   Positive Homogeneity is a limiting case of subadditivity, representing what happens when there is precisely no diversification effect. Increasing the size of a portfolio by b should simply scale its required economic capital by the same factor. The units used (e.g., thousands or millions, US dollars or Euros) does not affect the economic capital measure.

Formula: For all b≥0 and random losses X, $\rho(bX) = b\rho(X)$.

(ii)   Monotonicity: If losses associated with one portfolio are always greater than losses associated with another portfolio, then the required economic capital associated with these portfolios should reflect this ordering.

Formula: If $X \leq Y$ for each scenario, then $\rho(X) \leq \rho(Y)$, where X, Y represent losses.

Alternatively, Monotonicity can also be stated as: when one portfolio has systematically lower returns than another portfolio for all states of the world, then its required economic capital should be greater.

Formula: If $X \leq Y$, then $\rho(X) \geq \rho(Y)$, where X, Y represent returns.

(iii)   Translation Invariance: Adding a known certain amount of loss to a random variable X increases the required economic capital by exactly that amount. This can simplify economic capital calculations when some losses are known or may be assumed to be constant.

Formula: For all random losses X and constants α,
$$\rho(X + \alpha) = \rho(X) + \alpha.$$

Alternatively, Translation Invariance can also be stated as: Adding cash in the amount k to a portfolio should reduce the required economic capital by k.

Formula: $p(X + k) = p(X) - k$.

(iv)   Subadditivity reflects the benefit of diversification when combining portfolios. Combining portfolios could possibly decrease (but could not increase) the combined required economic capital.

3. **Continued**

> Formula: For all random losses X and Y,
> $$\rho(X + Y) \le \rho(X) + \rho(Y).$$

(b) Demonstrate whether the following properties are satisfied by the associated risk measures:

    (i) Positive Homogeneity - $\rho_1(X)$

    (ii) Monotonicity - $\rho_1(X)$

    (iii) Translation Invariance - $\rho_2(X)$

Commentary on Question:
Overall, the candidates had some difficulty with part (b). Many candidates were able to identify the risk measures and answered the question based on their knowledge of the risk measures' properties, rather than demonstrating the satisfaction of the particular properties for each specified risk measure. Some candidates demonstrated by providing examples of the various properties, which received either full or partial credit, depending on how complete the demonstration was. Other candidates demonstrated, by proof, how the risk measure was satisfied by the specified property, which received full credit.

    (i) Positive Homogeneity – $\rho_1(X)$: $\rho_1(X)$ is the VaR measure, which satisfies the property of positive homogeneity.
        Definition: Probability $(X > \rho_1(X)) \le 1 - .05$
        If the entire random variable is scaled by b, then we have
        Probability $(bX > \rho_1(bX)) =$ Probability $(X > \rho_1(X)) \le 1 - .05$.

    (ii) Monotonicity – $\rho_1(X)$: $\rho_1(X)$ is the VaR measure, which satisfies the property of monotonicity. $\rho_1(X)$ is the smallest loss X such that the probability of a larger loss is no more than 5%. If $X \le Y$, then $\rho_1(Y)$, the smallest loss Y such that the probability of a larger loss is no more than 5%, must be at least as large as $\rho_1(X)$; and since $\rho_1(X)$ and $\rho_1(Y)$ are monotonically increasing functions, then, $\rho_1(X) \le \rho_1(Y)$.

    (iii) Translation Invariance – $\rho_2(X)$: $\rho_2(X)$ is the CTE measure, which satisfies the property of translation invariance.

3. **Continued**

$$\rho_2(X + c) = E(X + c \mid X + c > \rho_1(X + c))$$
$$= E(X + c \mid X + c > \rho_1(X) + c)$$
$$= E(X + c \mid X > \rho_1(X))$$
$$= E(X \mid X > \rho_1(X)) + E(c \mid X > \rho_1(X))$$
$$= E(X \mid X > \rho_1(X)) + c$$
$$= \rho_2(X) + c$$

(c)   Determine which of the criteria in (a) are satisfied by $\rho_3(X)$. Show your work.

Commentary on Question:
The candidates also had difficulty with this part of the question. $\rho_3(X)$ is a hypothetical risk measure, not something candidates would have previously seen. Thus, the question was testing whether candidates understood the properties sufficiently to apply them in a new situation.

Positive Homogeneity
$\rho_3(X)$ does not satisfy the Positive Homogeneity criteria.
For example, assume $X \sim N(\mu, \sigma^2)$.
   Then $\rho_3(X) = (1/\alpha) \log(E[e^{(\alpha X)}]) = (1/\alpha) \log(e^{(\alpha\mu + (\alpha^2)(\sigma^2)/2)}) = \mu + \alpha(\sigma^2)/2$.
   And $\rho_3(aX) = (1/\alpha) \log(E[e^{(a\alpha X)}]) = (1/\alpha) \log(e^{(a\alpha\mu + (a^2)(\alpha^2)(\sigma^2)/2)}) = a\mu + (a^2)\alpha(\sigma^2)/2$
   Since $\rho_3(aX)$ does not equal $a\rho_3(X)$, this criteria does not hold.

Monotonicity
$\rho_3(X)$ satisfies the Monotonicity criteria.
Assume $Y \geq X$. Then $e^{(\alpha Y)} \geq e^{(\alpha X)}$ and then $E[e^{(\alpha Y)}] \geq E[e^{(\alpha X)}]$
   Then $\log(E[e^{(\alpha Y)}]) \geq \log(E[e^{(\alpha X)}])$ and $(1/\alpha)\log(E[e^{(\alpha Y)}]) \geq (1/\alpha)\log(E[e^{(\alpha X)}])$
   Therefore $\rho_3(Y) \geq \rho_3(X)$

Translation Invariance
$\rho_3(X)$ satisfies the Translation Invariance criteria.
$\rho_3(X + a) = (1/\alpha) \log(E[e^{(\alpha X + \alpha a)}]) = (1/\alpha) \log(E[e^{(\alpha X)} * e^{(\alpha a)}])$
   $= (1/\alpha) \log(e^{(\alpha a)} * E[e^{(\alpha X)}]) = (1/\alpha) (\log(e^{(\alpha a)}) + \log(E[e^{(\alpha X)}]))$
   $= (1/\alpha) (\alpha a + \log(E[e^{(\alpha X)}])) = (1/\alpha)(\alpha a) + (1/\alpha)\log(E[e^{(\alpha X)}]))$
   $= a + \rho_3(X)$

Subadditivity
$\rho_3(X)$ does not satisfy the Subadditivity criteria.
$\rho_3(X + Y) = (1/\alpha) \log(E[e^{(\alpha(X+Y))}])$
   And $\rho_3(X) + \rho_3(Y) = (1/\alpha) (\log(E[e^{(\alpha X)}]) + \log(E[e^{(\alpha Y)}]))$
   $= (1/\alpha) \log(E[e^{(\alpha X)}] * E[e^{(\alpha Y)}])$

3. **Continued**

> To satisfy subadditivity, $E[e^{\wedge}(\alpha(X+Y))] \leq E[e^{\wedge}(\alpha X)])*(E[e^{\wedge}(\alpha Y)]$, but this is not true in general.
> For example, if X=Y, define Z=$e^{\wedge}(\alpha X)$, then the above becomes $E[Z^{\wedge}2] \leq E[Z]^{\wedge}2$,
> but $E[Z^{\wedge}2] > E[Z]^{\wedge}2$ for any non-degenerate Z.

(d)   Recommend a risk measure for Wrigley to use in its economic capital calculations, from the three proposed. Justify your answer.

Commentary on Question:
The candidates did very well on this part of the question. They generally knew which risk measure was a coherent risk measure and why. And quite a number of candidates knew why the other two risk measures were not coherent risk measures.

Recommend Wrigley uses $\rho_2(X)$.
$\rho_2(X)$, as the conditional tail expectation or the tail VAR, is a coherent measure of risk. It satisfies all four of the criteria given in part (a), which are properties we want our risk measure to have.
Both $\rho_1(X)$ and $\rho_3(X)$ were shown above to not satisfy some of the above criteria, so they are not coherent risk measures.

4.   **Learning Objectives:**
   4.   The candidate will understand the approaches for managing risks and how an
           entity makes decisions about appropriate techniques.

   Learning Outcomes:
   (4c)   Demonstrate means for transferring risk to a third party, and estimate the costs
           and benefits of doing so.

   (4f)   Develop an appropriate choice of hedging strategy for a given situation (e.g.,
           reinsurance, derivatives, financial contracting), which balances benefits with
           inherent costs, including exposure to credit risk, basis risk, moral hazard and
           other risks.

   Sources:
   ERM-108-12: Tiller, Chapter 5, Advanced Methods of Reinsurance

   ERM-114-13: Introduction to Reinsurance

   Commentary on Question:
   *This question tested the application of financial reinsurance concepts to a realistic
   scenario. This was a very high cognitive level question that involved comprehension and
   application rather than memorization and regurgitation. Overall candidates did poorly
   on this question. Many candidates could recall lists or information from the Tiller
   reading, but were unable to apply this information in the context of the question. In
   particular, candidates did very poorly on parts (f) and (g), with very few points being
   awarded for those sections.*

   *In general, this question is a good example of what the ERM exam is attempting to
   assess. Candidates are equipped with a variety of concepts / tools presented in the
   syllabus. The most capable candidates are able to apply these tools to specific situations
   and recognize the effectiveness (or ineffectiveness) of these tools in the particular context
   of the question. Less capable candidates have difficulty applying the tools in contexts
   which are dissimilar to those presented in the syllabus.*

   Solution:
   (a)   Provide arguments supporting the contention that the proposed agreement
           qualifies as a financial reinsurance transaction.

           Commentary on Question:
           *Many candidates confused traditional reinsurance with financial reinsurance.
           They argued that there was significant risk transfer, which is necessary for a
           transaction to qualify as reinsurance for statutory and GAAP reporting purposes.
           With financial reinsurance, on the other hand, the main purpose is to attain a
           goal other than risk transfer, such as reserve relief. Most candidates missed this
           distinction.*

4. **Continued**

Many candidates answered this subpart by describing features of the transaction that are sometimes related to financial reinsurance treaties (such as the recapture provision or risk charge) but failed to identify that there was limited risk being transferred (a required condition for financial reinsurance transactions). Partial credit was given for these feature-related types of responses. More credit was given to candidates who demonstrated an understanding that the primary purpose of financial reinsurance is typically not risk transfer and who were able to relate this to the specific transaction in the question.

The risk profile of the block of business suggests that risk transfer is not the primary objective of the transaction:
- The treaty is anticipated to be temporary in nature – E&J expected to recapture after 5 years if experience is as expected
- Low risk transferred to Hamsik – YRT reinsurance already in place covers mortality risk; reserves fully fund cash value benefits, therefore there is limited lapse risk; long duration asset portfolio appears to insulate the block from declining interest rates (as evidenced by the projected investment income)

In addition, the transaction contains several features common to financial reinsurance treaties:
- Experience refund
- E&J retains assets
- Recapture provision
- Risk charge provision
- Minimal cash flow expected to be exchanged between contracting parties

(b) Identify the characteristics of the whole life block that make it a good candidate for a financial reinsurance transaction.

Commentary on Question:
Many candidates were able to recognize that the stable or sizable nature of the block made it a good candidate for financial reinsurance. Fewer candidates recognized that the limited risk of the block made it a good candidate for financial reinsurance.

Risk is minimal and projected cash flows are stable/sizeable:
- Inforce block – well defined liabilities in terms of scope and size
- Long history – experience studies can be performed, assumptions underlying block are credible
- Sizeable block – presumably stable experience
- High level of excess cash flows

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4. **Continued**

- Already highly reinsured by YRT, which limits the mortality risk assumed by Hamsik

(c) Identify and explain two benefits, one statutory and one economic, to E&J of entering into this transaction.

Commentary on Question:
Some candidates listed benefits without labeling them as statutory or economic. Depending on the strength of the response, partial or full credit was still given to these candidates. Other candidates mislabeled statutory benefits as economic benefits or vice versa. Some candidate confused responses to this question with responses to part (d).

Statutory Benefit:
RBC relief – the transfer of business to Hamsik means that Hamsik will hold the RBC for these liabilities. This improves the RBC ratio for E&J.

Economic Benefit:
Economic capital relief - In catastrophic scenarios, the business will not perform well and Hamsik will incur permanent losses under the terms of this agreement. This dynamic should result in lower economic capital requirements as E&J will be projected to suffer less severe losses under such catastrophic scenarios and it is precisely these types of scenarios which generate economic capital, i.e. tail scenarios.

(d) Explain the benefits to both E&J and Hamsik of having this transaction be on a funds withheld basis as opposed to a coinsurance basis.

Commentary on Question:
Candidates did very well on this section. Some candidates did not distinguish between benefits to E&J and benefits to Hamsik, but credit was still given to these candidates since the wording of the question was somewhat ambiguous.

E&J:
- Do not need to sell assets and incur capital gains/losses
- E&J is exposed to less counterparty risk in relation to Hamsik
- Can maintain unified investment and dividend strategies
- Minimizes cash flows to be exchanged between contracting parties

4. **Continued**

Hamsik:
- Doesn't need to acquire large volumes of assets at current yields to back liabilities
- Doesn't need to manage assets or coordinate a dividend strategy with E&J
- Minimizes cash flows to be exchanged between contracting parties

(e)   Explain the importance of the following treaty provisions to E&J, and propose a formula to determine each for this proposed treaty.

    (i)   Outstanding Surplus Account (OSA)

    (ii)   Experience Refund (ER)

Commentary on Question:
Most candidates were able to obtain at least partial credit on this section. Many candidates were able to correctly describe both the OSA and the experience refund. Some candidates confused the OSA with the funds withheld account.

Many candidates were able to recall the OSA formula from the Tiller reading. Candidates who demonstrated understanding of the formula, but missed a sign or a component of the formula were awarded partial credit. There were two formulas given for the OSA calculation in the Tiller reading and full credit was given to candidates who listed either of these. The OSA formula given in the solution below was not explicitly given in the Tiller reading, but rather demonstrates understanding of the concept behind the OSA and would receive full credit.

Very few candidates earned any points for the experience refund formula.

Candidates who failed to provide an explicit formula but provided a conceptual explanation of the OSA and ER provisions (i.e., what these are intended to achieve) were awarded credit.

Importance of Outstanding Surplus Account:
The OSA would track any losses incurred by Hamsik as well as any uncollected risk charges (RC). It would be used to determine the amount of experience refund to be paid to E&J, i.e., no ER's paid while Hamsik is in a cumulative loss position. E&J could only recapture upon repayment or elimination of the OSA balance.

OSA formula:
$OSA (0) = 0$
$OSA (t) = OSA (t-1) [1+r] + Loss (t) - Paydown (t)$

4. **Continued**

Where
> r is some interest rate negotiated between the parties as to what interest should accrue to losses funded by Hamsik

> Loss(t) = is the loss incurred by Hamsik (including forgone risk charges) which will grow the OSA (note, the positive loss amount grows the OSA)
> = if [Pre Tax Income(t) – RC(t)] < 0 then   -(Pre Tax Income(t) – RC(t))
> Otherwise   0

> Gain(t) = is the gain on the reinsured block (net of the RC) which will go first to pay down any OSA balance and then to fund an ER
> = if [Pre Tax Income(t) – RC(t)] > 0 then   Pre Tax Income(t) – RC(t)
> Otherwise   0

> Paydown(t) = is the portion of the gain which is applied to reduce any OSA balance
> = min[OSA(t-1) (1+r) , Gain(t)]

Alternative OSA formulas from the Tiller text:
OSA Ending Balance = OSA Beginning Balance + Statutory Gain – Investment Income on Surplus – Risk Charge

OSA Ending Balance = OSA Beginning Balance + Reinsurer Premium – Benefits – Reserve Increase – Experience Refund – Risk Charge

Importance of Experience Refund:
The ER would return all profits on the reinsured block to E&J in excess of the risk charge. It would be reduced by amounts needed to eliminate the OSA (if any). It gives E&J an incentive to practice prudent underwriting.

ER formula:
ER(t) = max [Pre Tax Income(t) – RC(t) – Paydown(t), 0]

(f) E&J has indicated that it is interested in obtaining some amount of statutory reserve relief.

Provide an estimated range for the amount of statutory reserve relief Hamsik would be willing to provide under the terms of this agreement. Justify your estimate and explain the process that Hamsik might follow in order to determine how much relief it is comfortable providing under the terms of this agreement.

4. Continued

Commentary on Question:
Candidates did very poorly on this section demonstrating a lack of familiarity with surplus relief transactions. In such transactions, Hamsik is essentially providing a loan to E&J which is secured by the future profits on the reinsured block of business. Only a handful of candidates understood this. If a candidate demonstrated understanding of this concept, but did not arrive at the estimated amount shown below, then partial credit was given. Many candidates responded that Hamsik would provide reserve relief on the entire reserve amount of $512 million, a response that received no credit.

A few candidates were not able to arrive at a reasonable estimate of the reserve relief, but suggested that Hamsik consider the risks associated with the transaction/run stress tests/consider VaR. Some partial credit was awarded for these answers as well.

Estimated Range of Relief:
Hamsik will want to consider how much pre-tax profits are projected over the next 5 year period under best estimate and stress scenarios. This indicates the level of adversity that the block can sustain before Hamsik is exposed to the risk of not recouping the initial allowance extended to E&J.

To the extent that dividends will be reduced to absorb any adverse scenario experience, this should be considered as well (i.e., this should increase the amount Hamsik is willing to front). Assuming dividends absorb adverse experience impact then the maximum profit is approximately $155M as this is the sum of profits – RC over the 5 year period.

Estimated Reserve Relief
= Sum (Pre-tax Income 2014-2018) – 1%*Sum (End of Year Statutory Reserve 2014-2018)
= (39+37+36+35+34) – .01*(511+509+507+505+502)
= $155M

Process to Determine Relief Amount:
- Hamsik should consider providing relief based on the amount which could be paid back over a 5 year period with some high level of assurance (i.e. high VaR)
- Hamsik would project treaty profits under stressed scenarios, determine how effective dividends are in mitigating the impact of adverse scenarios, and then determine how much they are comfortable extending to E&J.
- Hamsik will want to run adverse stresses and determine that under such stresses they are assured payback of any initial allowance they extend to E&J.

4. Continued

(g) The pricing manager at Hamsik proposes increasing the risk charge to 1,000 basis points (instead of 500 basis points) at the end of five years to afford Hamsik increased protection against extremely adverse experience. Propose a response to the pricing manager

Commentary on Question:
Candidates did very poorly on this section as well.

Many candidates suggested that raising the risk charge to this amount may damage the relationship between E&J and Hamsik or that E&J may be more likely to either recapture the business or not enter into the agreement at all with a risk charge of this magnitude. These candidates missed that E&J planned to recapture the business at the end of 5 years in the first place and would not expect to pay this increased fee.

*From Hamsik's perspective, some candidates argued that the increased fee was not needed because the deal was **expected** to be recaptured. These candidates missed the point that Hamsik is attempting to structure a transaction which provides sufficient protection in adverse scenarios, i.e., risk management is focused on managing outcomes under adverse scenarios and not expected scenarios.*

Increasing the risk charge to 500 bps, as in the original proposal, already provides incentive to E&J to recapture the business. Having the increased charge instead be 1000 bps does not provide additional incentive (i.e., if the block is performing, E&J will want to recapture at 1000, 500 and probably even 150 bps depending on market pricing for reserve relief.) In extremely adverse scenarios, there will be experience losses at which point it does not matter what the risk charge is (i.e. Hamsik will not collect the risk charge no matter the level and E&J does not mind a large risk charge because it will never be paid since there are insufficient profits from which to pay it).

5.   **Learning Objectives:**
   2.   The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.

   4.   The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

   5.   The candidate will understand the concept of economic capital, risk measures in economic capital assessment and techniques to allocate the cost of risks within business units.

Learning Outcomes:
(2h)   Construct approaches to managing various risks and evaluate how an entity makes decisions about techniques to model, measure and aggregate risks including but not limited to stochastic processes.

(4a)   Evaluate the rationale for managing risk and demonstrate the selection of the appropriate risk retention level and hedging of risk.

(4b)   Demonstrate and analyze applicability of risk optimization techniques and the impact on an organization's value of an ERM strategy.

(4d)   Demonstrate means for reducing risk without transferring it.

(4i)   Analyze funding and portfolio management strategies to control equity and interest rate risk, including key rate risks. Explain the concepts of immunization including modern refinements and practical limitations. Contrast the various risk measures and be able to apply these risk measures to various entities.

(5a)   Describe the concept of economic measures of value and demonstrate their uses in the risk management and corporate decision-making processes.

(5b)   Define the basic elements and explain the uses of economic capital.

Sources:
Risk Appetite: Linkage with Strategic Planning Report

ERM-112-12: Revisiting the Role of Insurance Company ALM within a Risk Management Framework

Commentary on Question:
Candidates are expected to demonstrate an understanding of Risk Appetite Statements and their role in the ERM process. The concepts are examined at a general level and through analysis of a sample statement provided to the candidates. Most of the candidates did well in part (a).

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5. **Continued**

Many candidates didn't do well in part (b) because, instead of explaining the rationale for the use of the metrics and their effect in business decisions, the candidates merely stated what the metrics are. Candidates are encouraged to read the questions carefully and understand the key words that tell them the expectations for the questions.

Solution:
(a)   Define Risk Appetite.

Commentary on Question:
Answers that convey the same message as any of the definitions listed below are acceptable. Candidates should understand and express in writing that a company sets risk preference in pursuit of its objectives, not just for the sake of risk taking.

- The total risk exposure an organization is willing to undertake in order to achieve its objectives.
- The amount of risk that an organization is willing to take on in pursuit of value.
- The maximum amount of risk a company is willing to accept in pursuit of its mission/objectives/plans.

(b)   Explain the rationale for including each of the metrics in Millenium's RAS and how they individually and collectively affect business decisions.

Commentary on Question:
Most of the candidates provided answers for individual metrics. Some, but not all, discussed their collective interaction, which is part of what the question required.

Some candidates showed confusion between Statutory Capital and Economic Capital. And many had difficulty explaining how the metrics would affect business decisions.

Excess Capital statement (item I) limits riskiness of liabilities and/or investments. Statutory accounting is not an accurate measure of economic return – so this metric may lead to business decisions focused more on statutory results rather than economic results
RoC statement (item II) limits excessive safe investments or business lines with inadequate returns. The shareholders require a minimum return for their risk of making an equity investment in the company, and this goal helps set the expectations for target returns. RoC minimum level requirement is fairly high in this economic environment, so this may encourage riskier investments / LOB's.

5.   **Continued**

S&P goal (item III) is probably included as a requirement for at least two purposes: (i) so that the company remains attractive for new business / marketing purposes, and (ii) so the company holds adequate capital in order to maintain credit worthiness for capital-raising needs. The S&P rating reflects not only the financial metrics of the company, but a qualitative assessment of management and its ERM processes. Higher ratings secure the reputation and lower the cost of funds for a company.

Looking at the measures collectively, the RAS helps Millenium set target capital position, as well as the worst risk / return position expected on its capital.   These measures require Millenium to maintain a balanced profile of being neither too aggressive nor too conservative.

(c)   Explain how the following stakeholders may view the existing RAS:

   (i)   Millennium's Pricing Department

   (ii)   Regulators

   (iii)   Shareholders

   (iv)   Debt Holders

Commentary on Question:
Answers that convey the same message as the statements listed below or alternative ones with good reasoning were considered acceptable. However, a number of candidates provided weak statements that did not directly answer the question and, thus, received minimal points.

Depending on their background and experiences, candidates may have interpreted each individual component of the RAS as being either conservative or liberal. Either interpretation was acceptable, as long as the stakeholder views were consistent with the candidate's interpretation. The sample answer that follows assumes a "conservative" interpretation for the entire RAS.

   (i)   Pricing area may find these restrictions make it difficult to compete with firms with looser risk appetite statements. The ROC requirement is a stretch target and the capital requirement restricts the riskiness of the product and supporting investments.

   (ii)   Regulators would probably like these conservative criteria, since their primary concern is solvency.

5. Continued

        (iii)   Shareholders may feel that these restrictions hinder the potential for large returns; as a result of the RAS, riskier product offerings or investments may be avoided.

        (iv)   Debt holders would probably like these conservative restrictions, as their ability to be re-paid depends upon the company's solvency.

(d)   Explain the implications of Millennium's approach to managing to its RAS by LOB.

Commentary on Question:
Candidates needed to provide and explain at least two implications to earn full credit. A few candidates were able to do that; most candidates only provided a single statement.

- Millennium would be able to execute its RAS, monitor business practices and compare results at the LOB level.

- Millennium is probably managing to a considerably conservative level because it doesn't consider diversification across LOBs, i.e. assumes no diversification offset.

- Millennium may be missing out on business or investment opportunities because the RAS items by LOB may not comply with the risk appetite statement, even though the company in total might still be able to meet the RAS requirements.

- Holding too much capital can reduce return to shareholders.

(e)   During the 2008 financial crisis, Excess Capital dropped by 25% and ROC was -1%, but the risk limits have been consistently met since 2010.

Explain how Millennium's ERM department should have viewed this failure to satisfy the RAS and what actions, if any, should have been taken.

Commentary on Question:
None of the candidates provided a full-credit answer to this question. A candidate needed to express a view on the situation, with explanation, and indicate actions that should have been taken, if applicable, in order to receive full credit. The answers below are samples of appropriate responses; other reasonable answers could receive credit.

5.   Continued

Millenium could view the 2008 crisis as a greater than 1 in 200 event, in which case it could argue that it was still passing the RAS criteria. In other words, do nothing.

Millenium could redefine its scenario construction if it considered 2008 as less than a 1 in 200 event, i.e. revisit its modeling approach and scenario assumptions in order to capture such events in its capital requirements.

Millenium could have de-risked its business via numerous possible methods:
1. Try to shift its investment portfolio to "safer" investments, assuming it could do so and still meet the minimum investment returns.
2. Try to exit out of (or reduce exposure to) riskier LOBs that were the primary contributors to this negative result.

6. **Learning Objectives:**
1.   The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.

4.   The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:
(1c)   Identify and analyze risks faced by an entity, including but not limited to market risk, currency risk, credit risk, spread risk, liquidity risk, interest rate risk, equity risk, hazard/insurance risk, inflationary risk, environmental risk, pricing risk, product risk, operational risk.

(4b)   Demonstrate and analyze applicability of risk optimization techniques and the impact on an organization's value of an ERM strategy.

(4k)   Analyze methods of managing other risks (operational, strategic, legal and insurance) both pre-event and post-event

Sources:
Financial Enterprise Risk Management, Sweeting, Chapter 8 Risk Identification

SOA Monograph – A New Approach to Managing Operation Risk, Chapter 8

ERM-107-12: Strategic Risk Management Practice, Anderson and Schroder, 2010, Chapter 7

Commentary on Question:
In general this question was well done. Many candidates were able to obtain some points because survey questions and potential shortcomings could come from their general knowledge base. The higher scoring candidates were able to go more in depth and could tailor their responses to the specific situation presented.

Solution:
(a)   Currently Dearbourne uses the following practices to identify its top operational risks:

        I.   Survey managers

        II.   Use external data – i.e., Expert/Industry surveys

        III.   Use internal data

        Identify the potential shortcomings with each of these practices.

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6. **Continued**

> **Commentary on Question**:
> *Subpart (a) was done relatively well. Many candidates were able to identify at least two shortcomings for each risk identification process, which is what was required for full credit.*

> Survey Managers: Managers could be too close to their business and might miss risks that are not observable and have not happened yet. Also, managers may not have broad enough experience to have a sense of the likelihood and severity of the risks.

> Use of External Data: External surveys may miss operational risks that are specific to the company, and, conversely, external data may not apply to Dearbourne. Also, the cost of obtaining external data may be large.

> Use of Internal Data: May not contain enough data or data specific to the company to fit credible distributions when looking at heavy tailed events. Internal data may have biases or may not be in a useable form, for example, anecdotal or qualitative data.

(b)   Outline the objectives you intend to achieve in conducting these surveys.

> **Commentary on Question**:
> *Candidate responses on subpart b) were adequate, but not sufficient for full credit in most cases. Many candidates missed the idea that the survey objectives could be used to get a sense of the likelihood and severity of operational risks.*

> Objectives include the following:
> Risk Identification - Identify risks facing the company and the manager's particular department
> Quantify risks - Determine the likelihood of risks or frequency/severity, rank risks, and fit aggregate distributions
> Determine the best ways to manage risks

(c)   The following managers are among those selected to be surveyed.

    I.   Building Security Manager

    II.   Chief Information Officer

    III.   Chief Officer of Quality Control

    Propose key survey questions specific to each manager.

6. Continued

Commentary on Question:
This subpart was well done by many candidates. Some candidates, however, suggested questions that were too general (not related to the manager being surveyed) or that did not relate to operational risks. Candidates who provided three appropriate and distinct questions for each manager could receive full credit.

Some candidates did not understand that a Chief Information Officer is normally the manager responsible for Information Technology (IT). If candidate responses indicated a different interpretation of this position, credit was still given for questions appropriate to that position.

Building Manager:
- Determine ease of access to building - Who can access the building, could a competitor get in and steal information?
- People risk - Determine current employee access to certain places in building - What prevents employees from gathering info from other departments?
- Determine the ability of employees to leave with certain documents/ technology, etc. What procedures exist to deter employee theft of confidential data or technology?

Chief Information Officer:
- Determine quality of the security surrounding computer information. How can the system be compromised by hacking or by other methods?
- People Risk - How can employees be prevented from transmitting proprietary information?
- Technology Risk – What gaps are in the system such that data could be compromised by a technological failure?

Chief Officer of Quality Control
- Process Risk - What are the controls over the manufacturing processes?
- Process Risk – Where have controls failed in the past and how can they be improved? How do you measure process failure?
- People Risk – Are staff members aware of the controls and following them? How do you evaluate this?

6. **Continued**

(d)

       (i)   Explain how a conditional viewing on the evolution of wearable technology could help identify Dearbourne's competitive risks.

       (ii)   Provide four specific examples of information that Dearbourne might obtain by using this approach.

Commentary on Question:
This question was reasonably well done. Many candidates could provide specific examples of conditional viewing. In subpart (i) some candidates missed the idea that conditional viewing involves using pre-selected information to provide specific insights.

The definition of conditional viewing is provided in the response below for educational purposes. The question did not ask candidates for the definition so it was not required for full credit.

       (i)   Conditional viewing involves tracking pre-selected information from particular sources focused on the topic of wearable technology. This would provide Dearbourne with specific insights as to the direction of new wearable technology products that could threaten the company's existing products.

       (ii)   Could identify what wearable technology is emerging i.e., Wristwatches, Eyeglasses, gloves etc.
                  Could identify what customers would like in a wearable technology
                  Could identify extra costs of switching possible current products to wearable tech
                  Could identify new technology that is needed to produce wearable technology.

(e)   Explain how undirected viewing of the current technology environment could help identify Dearbourne's competitive risks.

Commentary on Question:
Many candidates understood that undirected viewing is a broad based view; however some candidates did not sufficiently describe how a broad based view could be advantageous to Dearbourne.

The definition of undirected viewing is provided in the response below for educational purposes. The question did not ask candidates for the definition so it was not required for full credit.

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6. Continued

An undirected view is an approach whereby the corporation follows various informational sources without any specific objectives in mind in order to find emerging trends.

This broad based view might identify new trends that competitors have not seen; it might identify potential company acquisitions; it might suggest areas for further research.

7.   **Learning Objectives:**

2.   The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.

3.   The candidate will understand how the risks faced by an entity can be quantified and the use of metrics to measure risk.

Learning Outcomes:

(2a)   Demonstrate how each of the financial risks faced by an entity can be amendable to quantitative analysis including an explanation of the advantages and disadvantages of various techniques such as Value at Risk (VaR), stochastic analysis, scenario analysis.

(2g)   Analyze and evaluate model and parameter risk.

(3a)   Apply and construct risk metrics to quantify major types of risk exposure such as market risk, credit risk, liquidity risk, regulatory risk, etc., and tolerances in the context of an integrated risk management process.

(3b)   Analyze and evaluate the properties of risk measures (e.g. Delta, volatility, duration, VaR, TVaR, etc.) and their limitations.

Sources:

Value-at- Risk: The New Benchmark for Managing Financial Risk, Jorion, 3rd Edition, Chapter 8 Multivariate Models

Commentary on Question:

The overall performance on this question was mixed. The question is focused on interpreting the results from models used to measure interest rate risk, starting with a basic duration model and following with the more advanced PCA model. While candidates showed reasonable understanding of the concepts, they struggled with applying the concepts and completing the calculations.

Solution:

(a)   Describe the simplifying assumptions inherent in SLIC's use of the one-factor duration model for measuring interest rate risk.

- The duration model assumes that the yield curve experiences parallel moves, either up or down
- This implies that the volatility of yield changes is the same across all maturities and that correlations between yield changes are all equal to 1
- However, the yield data indicates that volatility decreases with term and returns are not perfectly correlated

7. Continued

(b)   Assume a normal distribution of bond yields for your $100 million portfolio and a portfolio yield volatility of 0.28%.

Calculate the following using the one-factor duration model:

(i)   Yield VaR(95%)

(ii)   Returns VaR(95%)

Show your work.

Commentary on Question:
Overall performance on this part was about average. Some candidates used the duration instead of the modified duration in their answers; this was acceptable and candidates received credit.

(i) Yield VaR(95%) = alpha x sigma = 1.645 x $100m x .0028 = $0.461m
(ii) Returns VaR = Modified Duration x Yield VaR
Modified Duration of zero (D*) = T/(1+y), where T = maturity and y = yield
D*(1 year) = 1/(1+.008) = 0.99
D*(10 years) = 10/(1+.023) = 9.78
D*(30 years) = 30/(1+.02) = 29.41
D*(Portfolio) = .45 x .99 + .50 x 9.78 + .05 x 29.41 = 6.806
Returns VaR(95%) = 6.806 x .461 = $3.138m

(c)

(i)   Determine the percentage of variation explained by each of the two principal component factors for each of the zero coupon Treasuries.

(ii)   Determine the percentage of variation explained in total for each of the zero coupon Treasuries.

Commentary on Question:
*Most of the candidates did not do well on this part. Many candidates did not read the question carefully in subpart (i), where they needed to explain percentage of variation by **each of the two** PCA factors for **each of the three Treasuries**; several gave only partial answers. Candidates also had problems with the set-up of the solution, which resulted in overall low scores for this part.*

Values on the diagonal of the fitted correlation matrices give the percentage of variation explained by the corresponding factor. Their sum is the total variation explained.

7. Continued

| Maturity | % Variation Explained by | | Total Variance Explained |
	Factor 1	Factor2	
1	0.889	0.111	1.000
10	0.978	0.019	0.997
30	0.965	0.033	0.998

(d) Explain what aspect of interest rate risk exposure appears to be captured by each of the two principal components in your analysis.

Commentary on Question:
The majority of the candidates did well on this part. While most of the candidates struggled with the numerical values in part (c), they showed good understanding of the concepts in this part.

- The first factor averages 93.7% (on a weighted basis) and has high explanatory power, and it has similar high values across all maturities.
- Thus the first factor can be defined as a yield level factor.

- The second factor explains an additional 6.1% on average (on a weighted basis), and it has highest explanatory power for short and long maturities.
- Thus the second factor describes the slope of the term structure.

(e) Determine the portfolio's exposure to each of the two Principal Components. Show your work.

Commentary on Question:
Candidates did not do well on this part. It did not appear that the candidates knew how to apply the formula that was given.

$\beta_{1P} = X' \times \beta_1$ and $\beta_{2P} = X' \times \beta_2$
Where X' is the vector of exposures and β_1 and β_2 are the eigen vectors
β_{1P} = (0.14 x 0.56) + (1.32 x 0.59) + (0.35 x 0.58) = $1.06M
β_{2P} = (0.14 x 0.83) + (1.32 x (-.034)) + (0.35 x (-.045)) = - $0.49M

(f) Determine the portfolio Return VaR(95%) under your two-factor PCA model. Show your work.

Commentary on Question:
Candidates also did poorly on this part. Most candidates did not know how to calculate variance for a 2-factor model. Some candidates did not calculate β_{1P} and β_{1P} in part (e) but used the correct setup for this part; such candidates received partial credit.

7. **Continued**

Portfolio Variance = $\sigma^2(R_p) = \beta_{1P}{}^2\sigma^2(z_1) + \beta_{2P}{}^2\sigma^2(z_2) = [(1.06)^2 \times 2.832] + [(-0.49)^2 \times 0.163] = 3.22$
where $\sigma^2(z_i)$ are the eigenvalues
Portfolio Volatility = sqrt(Portfolio Variance) = sqrt(3.22) = $1.795M
Two-factor Portfolio VaR(95%) = 1.645 x 1.795 = $2.953M

(g) Compare and explain the difference in VaR results between the one-factor
duration model and the two-factor PCA model.

Commentary on Question:
*Since many candidates were unable to complete the earlier parts of the question,
they did not have specific results in order to do the comparison.*

Duration model VaR = $3.138M, PCA model VaR = $2.953M
Duration model VaR is close to the PCA model VaR, which shows that for this
portfolio duration captures most of the interest rate risk exposure.
The duration model only captures the level of interest rate risk; it assumes that all
elements of the first eigenvector are identical and that all yield volatilities are
equal.
Using just the first PCA factor produces a VaR of 1.645 x sqrt(3.182) = $2.934
For this portfolio the one factor PCA model may suffice.

8. **Learning Objectives:**
1. The candidate will understand the types of risks faced by an entity and be able to identify and analyze these risks.

2. The candidate will understand the concepts of risk modeling and be able to evaluate and understand the importance of risk models.

4. The candidate will understand the approaches for managing risks and how an entity makes decisions about appropriate techniques.

Learning Outcomes:
(1b) Explain risk taxonomy and its application to different frameworks.

(1c) Identify and analyze risks faced by an entity, including but not limited to market risk, currency risk, credit risk, spread risk, liquidity risk, interest rate risk, equity risk, hazard/insurance risk, inflationary risk, environmental risk, pricing risk, product risk, operational risk.

(2b) Evaluate how risks are correlated, and give examples of risks that are positively correlated and risks that are negatively correlated.

(4i) Analyze funding and portfolio management strategies to control equity and interest rate risk, including key rate risks. Explain the concepts of immunization including modern refinements and practical limitations. Contrast the various risk measures and be able to apply these risk measures to various entities.

(4j) Analyze the application of Asset Liability Management and Liability Driven Investment principles to Investment Policy and Asset Allocation.

Sources:
ERM-601-12: C. Ford, Managing your Advisor

ERM-607-12: J. Gold, Creating Value in Pension Plans

ERM-603-12: The Handbook of Fixed Income Securities, Fabozzi, Ch 47 Bond Immunization

Commentary on Question:
The question tested candidates' understanding of investment strategy considerations for DB pension plans. Most candidates were able to provide responses to each part of the question, but many did not provide sufficient explanations to demonstrate their understanding of the issues.

Solution:
(a) Identify three key stakeholders with an interest in the investment management policy for SLIC's DB Plan and explain each of their perspectives.

8. Continued

Commentary on Question:
Candidates did not have trouble identifying stakeholders but sometimes did not do well at explaining their perspectives. The sample answer below gives more than three stakeholders as examples – only three well-supported answers were needed for full credit.

- Plan Trustees -- focus on plan participant benefit levels and security. Investment strategy can have a direct effect on how secure the plan is. Plan Trustees act as plan fiduciary with oversight of all aspects of the plan. ERISA's prudent man rule leads to diversification of investments.
- Management of SLIC, the Plan sponsor, is interested in reducing the pension funding contribution and the risk of increased contributions in the future; Management of SLIC may trade off higher returns/lower pension costs for higher risk/volatility; they may have a bias toward riskier assets with higher expected returns that lower pension accounting costs.
- SLIC's DB Plan members, retired and active, have a similar perspective to trustees; they want to receive their pension promise, not eroded by inflation.
- SLIC's shareholders, similar to SLIC's management, want to maximize profits by minimizing pension expense and volatility.
- The Plan's investment advisors/asset managers/accountants/actuaries, who generate fee income from the Plan's investment process – there are often higher fees for active management or certain asset classes, which may bias their view on investment policy.

(b) Explain the traditional arguments for large allocations to equities in DB plans that would support the Plan advisors' recommendation.

Commentary on Question:
Most candidates could provide a basic response, but many gave just a single argument and did not give sufficient explanation to earn full credit.

Equities have generally outperformed bonds over the long run. Pension liabilities have long durations and can usually absorb short-term volatility. The long-term nature of the liabilities justifies smoothing, deferring, and amortizing from an accounting standpoint.
Equities are better than bonds as a hedge against salary inflation and thus against increases in pension liabilities.
Using the higher expected returns from equity rather than actual returns produces a lower liability value and reduces annual Plan costs.

8. Continued

(c)   Counter the traditional arguments in support of high equity allocations in DB plans by identifying and explaining two specific aspects of SLIC's DB Plan which are not consistent with these arguments.

Commentary on Question:
Candidates generally did not do well at identifying specific aspects of SLIC's plan that would argue against a high equity allocation. Candidates could receive minimal credit for general arguments in favor of more fixed income that did not relate back to SLIC.
Two responses were needed for full credit; the example below provides a more complete response than required.

- The overall duration of SLIC's plan is only 10 years, and more than half of the liabilities are for retirees, with a duration of 7.8 years. Thus, the duration is not that long to allow for significant volatility.
- The asset duration of the SLIC plan is quite short, leaving the plan with a large exposure to interest rate risks. An increasing equity allocation would exacerbate this.
- SLIC's plan has a large funding shortfall, which also contributes to the large interest rate exposure. Increasing the equity allocation would expose the plan to further downside funding risk, increasing the potential level of pension expense and year-to-year volatility in the amount.

(d)   Demonstrate and explain the Tepper tax arbitrage if SLIC's DB Plan shifts $1 of assets from equities to bonds while SLIC's shareholders shift their own portfolios to maintain their equity exposure. Show your work.

Commentary on Question:
Many candidates did well on this part, showing an understanding of the Tepper tax arbitrage. The solution presented below shows more steps and details than required for full credit.

1. The plan gains the actual return on bonds r_b but gives up the actual return on equities r_e:
$$\$1*(r_b - r_e) = \$1*(7\% - 12\%) = -\$0.05$$
2. This amount is reduced by corporate taxes:
$$\$1*(1 - 35\%)* -0.05 = -\$0.0325$$
3. The return to shareholders is reduced by personal equity taxes:
$$\$1*(1-15\%)* -0.0325 = -\$0.027625.$$

8.   Continued

But if shareholders simultaneously shift $(1 - t_c)$ from bonds to equities in their personal portfolio:

4. Shareholders earn additional personal equity returns:

$0.65*12\% = \$0.078$

and give up personal bond returns:

$0.65*7\% = \$0.0455$

Which after personal taxes equals:

$(1-15\%)*\$0.078 - (1-40\%)*\$0.0455$

$= \$0.0663 - \$0.0273$

$= \$0.039$

5. Combined with 3, the net gain to shareholders is:

$-\$0.027625 + \$0.039 = \$0.011375$, or

$\$1*(1-t_c)*r_b*(t_{pb}-t_{ps})$

$= \$1*(1-35\%)*7\%*(40\%-15\%)$

$= \$0.011375$

This demonstrates a riskless tax arbitrage to SLIC's investors, as the personal bond income tax rate is much greater than the personal equity tax rate and the gain is actually independent of the return on equities. Generally, at any time and no matter how stocks perform relative to bonds, the tax arbitrage strategy will be value-adding.