Study Guide on Risk Margins for Unpaid Claims for the Society of Actuaries (SOA) Exam GIADV: Advanced Topics in General Insurance

(Based on the Paper "A Framework for Assessing Risk Margins" by Karl Marshall, Scott Collings, Matt Hodson, and Conor O'Dowd)

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Problem RM-1. According to Marshall et al. (p. 4), what are the four general steps in the generally adopted risk-margin calculation methodology in use by Australian actuaries?

Solution RM-1.
Step 1. Determine coefficients of variation (CoVs) for individual valuation portfolios or groupings of portfolios with relatively homogeneous risks.
Step 2. Populate a correlation matrix with assumed correlation coefficients between valuation portfolios/portfolio groupings.
Step 3. Determine CoVs and correlation matrices separately for outstanding claim and premium liabilities and make assumptions about the correlation between these two components of liabilities.
Step 4. Select a statistical distribution and combine it with the adopted CoVs and correlation coefficients to determine the aggregate risk margin at a particular probability of adequacy. (Marshall et al., p. 4)

Problem RM-2. What is a major shortcoming of deriving coefficients of variation (CoVs) using benchmark data/coefficients from a paper written on risk-margin analysis in the past? (Marshall et al., p. 5)

Solution RM-2. Deriving CoVs from a paper written in the past ignores the individual characteristics of the valuation portfolio for which risk margins are being assessed, and instead defers to the characteristics of the portfolios analyzed by the paper's authors. (Marshall et al., p. 5)

Problem RM-3. Answer the following questions based on the discussion by Marshall et al., p. 5.
(a) What is the most common approach to populating the correlation matrix with correlation coefficients?
(b) Why is it "more the exception than the norm" for a quantitative analysis of past experience to be included in the assessment of correlation effects?
(c) Under what circumstances is it more common to see quantitative techniques deployed?

Solution RM-3.
(a) The most common approach is to use **actuarial judgment**. Key risks that cause valuation portfolios to be correlated are considered, and the correlation between classes is categorized as high, medium, or low, with each category having associated correlation-coefficient values.
(b) Most quantitative techniques require significant data, time, and cost to produce credible, intuitive results.
(c) Quantitative techniques are more commonly deployed when assessing more extreme probabilities of adequacy (i.e., significantly greater than 90%). (Marshall et al., p. 5)

Problem RM-4. ***Fill in the blanks*** (Marshall et al., p. 5): The most common distribution adopted to determine the aggregate risk margin at a particular probability of adequacy is the ________ distribution. The __________ distribution is also sometimes used, particularly at __________ [higher or lower?] probabilities of adequacy, where it can generate a risk margin that is ________ [higher or lower?] than a heavier-tailed distribution, such as the ___________ distribution.

Solution RM-4. The most common distribution adopted to determine the aggregate risk margin at a particular probability of adequacy is the **lognormal** distribution. The **Normal** distribution is also sometimes used, particularly at **lower** probabilities of adequacy, where it can generate a risk margin that is **higher** than a heavier-tailed distribution, such as the **lognormal** distribution. (Marshall et al., p. 5)

Problem RM-5.
(a) What is the name often used to refer to the general risk-margins approach adopted by most actuaries and why?
(b) To what other approaches can this name also refer? (Marshall et al., pp. 5-6)

Solution RM-5.
(a) This general approach is called the **bolt-on approach**, because separate analyses are conducted to estimate the central estimate of insurance liabilities and the risk margins.
(b) A "bolt-on" approach can also be any approach that does not involve the development of single unified distribution of possible future claim-cost outcomes. (Marshall et al., pp. 5-6)

Problem RM-6. Identify the nine general steps outlined in the risk-margin analysis framework described by Marshall et al. (p. 8)

Solution RM-6.
Step 1. Portfolio preparation
Step 2. Independent-risk analysis
Step 3. Internal-systemic-risk analysis
Step 4. External-systemic-risk analysis
Step 5. Analysis of correlation effects
Step 6. Consolidation of analysis
Step 7. Additional analysis
Step 8. Documentation
Step 9. Review

Problem RM-7. ***Fill in the blanks*** (Marshall et al., p. 11): At the highest level, the sources of uncertainty can be categorized as belonging to either the __________ risk source or the _________ risk source.

Solution RM-7. At the highest level, the sources of uncertainty can be categorized as belonging to either the **systemic** risk source or the **independent** risk source. (Marshall et al., p. 11)

Problem RM-8.
(a) Define **systemic risk**.
(b) Identify and briefly describe the two sources of systemic risk.
(Marshall et al., p. 11)

Solution RM-8.
(a) Systemic risk represents those risks that are potentially common across valuation classes or claim groups.
(b) 1. Internal systemic risk: Risks internal to the insurance liability valuation process, encapsulating the extent to which the adopted actuarial valuation approach is an imperfect representation of a complex reality.
2. External systemic risk: Risks external to the actuarial modeling process that result in actual experience differing from the expected experience (which is based on the current environment and trends). (Marshall et al., p. 11)

Problem RM-9.
(a) Define **independent risk**.
(b) Identify and briefly describe the two sources of independent risk.
(Marshall et al., p. 11)

Solution RM-9.
(a) Independent risk represents those risks arising due to randomness inherent in the insurance process.
(b) 1. Random component of parameter risk: Extent to which the randomness associated with the insurance process compromises the ability to select appropriate parameters in the valuation models.
2. Random component of process risk: Pure effect of the randomness and volatility associated with the insurance process (which would exist even in a model perfectly calibrated to reflect expected future outcomes). (Marshall et al., p. 11)

Problem RM-10.
(a) According to Marshall et al. (p. 11), traditional quantitative modeling techniques such as bootstrapping and stochastic chain-ladder techniques are best suited for analyzing what two sources of risks?
(b) For reflecting what two other sources of risk would traditional quantitative modeling techniques not be sufficient?

Solution RM-10.
(a) Traditional quantitative modeling techniques such as bootstrapping and stochastic chain-ladder techniques are best suited for analyzing (i) **independent risk** and (ii) **past episodes of external systemic risk**.
(b) Traditional quantitative modeling techniques would not be sufficient for reflecting (i) **internal systemic risk** and (ii) **external systemic risk that differs from the past**.
(Marshall et al., p. 11)

Problem RM-11. ***Fill in the blanks*** (Marshall et al., p. 12): The first step in a risk-margin analysis is to prepare the ___________, which represents the aggregate insurance entity/entities for which the analysis is being conducted. This ____________ should be split into appropriate ____________.

Solution RM-11. The first step in a risk-margin analysis is to prepare the **claims portfolio**, which represents the aggregate insurance entity/entities for which the analysis is being conducted. This **claims portfolio** should be split into appropriate **valuation classes**. (Marshall et al., p. 12)

Problem RM-12. ***Fill in the blanks*** (Marshall et al., p. 12): In splitting the claims portfolio into valuation classes, an important consideration is whether the split adopted to determine _________ of insurance liabilities, or outstanding ______ liabilities and _________ liabilities where the split is different, should be adopted for risk-margin analysis purposes.

Solution RM-12. In splitting the claims portfolio into valuation classes, an important consideration is whether the split adopted to determine **central estimates** of insurance liabilities, or outstanding **claim** liabilities and **premium** liabilities where the split is different, should be adopted for risk-margin analysis purposes. (Marshall et al., p. 12)

Problem RM-13. What are two possible reasons why, according to Marshall et al. (p. 12), it might not be possible or particularly insightful to conduct quantitative analysis of risk margins at the same granular level as used for central-estimate valuation purposes?

Solution RM-13.
Possible Reason 1. The central-estimate valuation portfolios may be too small for credible analysis.
Possible Reason 2. The valuation-portfolio allocation for central-estimate purposes may be at a more granular level than makes practical sense for risk-margin purposes. (Marshall et al., p. 12)

Problem RM-14. ***Fill in the blanks*** (Marshall et al., p. 12): The choice of valuation classes for risk-margin analysis purposes will involve balancing the practical benefits gained from a __________ portfolio allocation and the potential additional benefit and insights gained from a(n) _________ allocation. Consideration should be given to the need to retain as much ___________ as possible between the _______________ methodology and the risk-margin analysis.

Solution RM-14. The choice of valuation classes for risk-margin analysis purposes will involve balancing the practical benefits gained from a **higher-level** portfolio allocation and the potential additional benefit and insights gained from a **more granular** allocation. Consideration should be given to the need to retain as much **consistency** as possible between the **central-estimate** methodology and the risk-margin analysis. (Marshall et al., p. 12)

Problem RM-15. Give two examples of possible ways of segmenting a *home* insurance portfolio into distinct valuation classes. (Marshall et al., pp. 12-13)

Solution RM-15. Possible Segmentation 1. Segment between claims from natural peril events and non-event claims.
Possible Segmentation 2. Segment between home insurance liability claims and other home insurance claims. (Marshall et al., pp. 12-13)

Problem RM-16. Provide three reasons why stochastic modeling techniques do not enable a complete analysis of all sources of uncertainty. (Marshall et al., p. 13)

Solution RM-16.
1. A good stochastic model, in fitting past data well, will fit away most past episodes of external systemic risk and will leave behind largely random sources of uncertainty.
2. If it has not been possible to fit away all past episodes of systemic risk, the outcome of the analysis may be substantially affected by these episodes, and judgment will need to be used to consider whether these past episodes of systemic risk are reflective of that one can expect in the future.
3. The model is unlikely to incorporate uncertainty arising from sources internal to the actuarial valuation process – i.e., internal systemic risk. (Marshall et al., p. 13)

Problem RM-17. Identify five modeling techniques that are used in practice to analyze independent sources of risk and inform on past episodes of external systemic risk. (Marshall et al., p. 13)

Solution RM-17.
1. Mack method
2. Bootstrapping
3. Stochastic chain-ladder methods
4. Generalized linear modeling (GLM) techniques
5. Bayesian techniques
(Marshall et al., p. 13)

Problem RM-18. ***Fill in the blanks*** (Marshall et al., p. 14): Valuation models are designed to predict future claim-cost outcomes based largely on an examination of the ___________ and trends in these _________, as these have been observed in the __________.

Solution RM-18. Valuation models are designed to predict future claim-cost outcomes based largely on an examination of the **key predictors of claim cost** and trends in these **predictors**, as these have been observed in the **past claim experience**. (Marshall et al., p. 14)

Problem RM-19. Identify and describe the three main sources of internal systemic risk. (Marshall et al., p. 15)

Solution RM-19. 1. Specification error: Error that can arise from an inability to build a model that is fully representative of the underlying insurance process.
2. Parameter selection error: Error that can arise because the model is unable to adequately measure all predictors of claim-cost outcomes or trends in these predictors.
3. Data error: Error that can arise due to poor data or unavailability of data required to conduct a credible valuation, as well as inadequate knowledge of the portfolio being analyzed – including pricing, underwriting, and claim-management processes and strategies. (Marshall et al., p. 15)

Problem RM-20. Identify four areas where subjective decisions would need to be made as part of developing a balanced scorecard to assess the internal systemic risk posed by a valuation model. (Marshall et al., p. 15)

Solution RM-20. The following are areas where subjective decisions would need to be made:
1. Risk indicators;
2. Measurement and scoring criteria;
3. Importance (weight) afforded to each risk indicator;
4. Coefficients of variation (CoVs) that map to each score from the balanced scorecard. (Marshall et al., p. 15)

Problem RM-21. Identify four possible risk indicators involved in qualitatively assessing *specification error* within an analysis of internal systemic risk. (Marshall et al., p. 16)

Solution RM-21. Four possible risk indicators involved in qualitatively assessing *specification error* are the following (Marshall et al., p. 16):
1. Number of models used and range of results
2. Reasonableness checks conducted
3. Subjective adjustments required
4. Extent of monitoring and review

Problem RM-22. Identify four possible risk indicators involved in qualitatively assessing *parameter selection error* within an analysis of internal systemic risk. (Marshall et al., p. 16)

Solution RM-22. Possible risk indicators involved in qualitatively assessing *parameter selection error* are the following (Marshall et al., p. 16):
1. Ability to identify and use predictors
2. Extent to which predictors lead rather than lag claim costs
3. Subjective adjustments required
4. Ability to detect trends
5. Stability
6. Uncertainty in superimposed inflation

Any four of the above would suffice.

Problem RM-23. Identify four possible risk indicators involved in qualitatively assessing *data error* within an analysis of internal systemic risk. (Marshall et al., p. 16)

Solution RM-23. Possible risk indicators involved in qualitatively assessing *data error* are the following (Marshall et al., p. 16):
1. Extent, timeliness, and reliability of information from business
2. Access to data
3. Quality of reconciliations
4. Extent of revisions to past data

Problem RM-24. Once qualitative assessments of specification error, parameter selection error, and data error have been conducted, what procedure do Marshall et al. (p. 16) outline for combining the scores?

Solution RM-24. A weighted average combined score for each valuation class is derived. The weights are subjectively selected to reflect the actuary's view of the importance of each of the risk indicators in the context of their own portfolio. (Marshall et al., p. 16)

Problem RM-25. Fill in the blanks pertaining to the mapping of scores pertaining to internal systemic risk to coefficients of variation (CoVs) (Marshall et al., p. 16):
(a) ____________ valuation-class scores should be mapped to CoVs.
(b) Low scores will attract _____ [high or low?] CoVs. High scores will attract _____ [high or low?] CoVs.
(c) CoVs may differ between ________ and _________ portfolios and between _______ and _______ liabilities.
(d) CoVs are derived based on a combination of ________ and ________.

Solution RM-25.
(a) **Weighted-average** valuation-class scores should be mapped to CoVs.
(b) Low scores will attract **high** CoVs. High scores will attract **low** CoVs.
(c) CoVs may differ between **long-tail** and **short-tail** portfolios and between **outstanding claims** and **premium** liabilities.
(d) CoVs are derived based on a combination of **judgment** and **analysis**.
(Marshall et al., p. 16)

Problem RM-26. What often unrealistic assumption is inherent in using standard quantitative modeling techniques to assess external systemic risk? (Marshall et al., p. 17)

Solution RM-26. The assumption is that the contribution to volatility from future external systemic risk is expected to be similar to that experienced in the past. In reality, for some valuation classes, future external systemic risk will differ from past episodes. (Marshall et al., p. 17)

Problem RM-27. Briefly describe each of the following categories of external systemic risk (Marshall et al., p. 17):
(a) Economic and social risks;
(b) Legislative, political, and claim-inflation risks;
(c) Claim-management process-change risk;
(d) Expense risk;
(e) Event risk;
(f) Latent claim risk;
(g) Recovery risk.

Solution RM-27.
(a) Economic and social risks: Inflation and other social/environmental trends.
(b) Legislative, political, and claim-inflation risks: Known or unknown changes to the legislative or political environment within which each valuation portfolio currently operates, and shifts or trends in the level of claim settlements.
(c) Claim-management process-change risk: Changes to the processes relating to claim reporting, payment, finalization, or estimation.
(d) Expense risk: Uncertainty associated with the cost of managing the run-off of the insurance liabilities or the cost of maintaining the unexpired risk until the date of loss.
(e) Event risk: Uncertainty associated with claim costs arising from natural-peril or man-made events.
(f) Latent claim risk: Uncertainty associated with claims that may arise from a particular source that is currently not considered to be covered.
(g) Recovery risk: Uncertainty associated with recoveries, either reinsurance or non-reinsurance.
(Marshall et al., p. 17)

Problem RM-28.
(a) For property classes, which kinds of external systemic risks are likely to dominate the volatility of the premium liabilities?
(b) For long-tail insurance portfolios, which kinds of external systemic risks are likely to dominate the volatility of both outstanding claim liabilities and premium liabilities?
(Marshall et al., p. 18)

Solution RM-28.
(a) For property classes, **event risk** is likely to dominate the volatility of the premium liabilities.
(b) For long-tail insurance portfolios, **legislative, political, and claims-inflation risks** are likely to dominate the volatility of both outstanding claim liabilities and premium liabilities.
(Marshall et al., p. 18)

Problem RM-29. What assumption can be made with regard to independent risk and correlations with other sources of uncertainty? (Marshall et al., p. 19)

Solution RM-29. Independent risk can be assumed to be **uncorrelated** with any other source of uncertainty, either within a valuation class or between valuation classes. (Marshall et al., p. 19)

Problem RM-30. (a) With which risks can *internal systemic risk* be assumed to be uncorrelated?
(b) What are two key considerations for internal-systemic-risk correlation effects between valuation classes?
(c) What are key considerations for internal-systemic-risk correlation effects between outstanding claim and premium liabilities?
(Marshall et al., p. 19)

Solution RM-30.
(a) Internal systemic risk can be assumed to be uncorrelated with **independent risk** and with each source of **external systemic risk**.
(b) For correlation effects between valuation classes: **(i)** the same-actuary effect and **(ii)** the use of template valuation models across different valuation classes are key considerations.
(c) For correlation effects between outstanding claim and premium liabilities, linkages between the premium-liability methodology and outcomes from the outstanding claim valuation are key considerations. (Marshall et al., p. 19)

Problem RM-31. (a) With which risks can *external systemic risk* be assumed to be uncorrelated?
(b) ***Fill in the blanks*** (Marshall et al., p. 19): For external systemic risk, correlation effects will arise from correlations between __________ or between __________ and __________ liabilities from risks categorized as belonging to ______________.
(c) Give two examples of correlation effects pertaining to external systemic risk.

Solution RM-31.
(a) External systemic risk can be assumed to be uncorrelated with **independent risk** and with each source of **internal systemic risk**.
(b) For external systemic risk, correlation effects will arise from correlations between **classes** or between **outstanding claim** and **premium** liabilities from risks categorized as belonging to **similar risk categories**. (Marshall et al., p. 19)
(c) Two examples given by Marshall et al. (p. 19) are the following:
1. Claims-inflation risk across long-tail portfolios;
2. Event risk across property and motor portfolios.
Other valid examples may be possible.

Problem RM-32. ***Fill in the blanks*** (Marshall et al., p. 19): For practical purposes, the correlation relationship between any two sources of uncertainty or risk can be considered to belong to one of a finite number of __________. One could classify these __________ in categories such as nil, low, medium, high, and full, and assign specific ___________ to each category. However, having more than ________ [give a number] of such __________ could result in spurious accuracy attaching to a largely subjective process.

Solution RM-32. For practical purposes, the correlation relationship between any two sources of uncertainty or risk can be considered to belong to one of a finite number of **assumed correlation bands**. One could classify these **correlation bands** in categories such as nil, low, medium, high, and full, and assign specific **correlation coefficients** to each category. However, having more than **5** of such **categories** could result in spurious accuracy attaching to a largely subjective process. (Marshall et al., p. 19)

Problem RM-33.
(a) Define the term "root dummy variable".
(b) What is another use for dummy variables in assessing correlation effects?
(Marshall et al., pp. 19-20)

Solution RM-33.
(a) A *root dummy variable* is a variable created to be the assumed root source of correlations within a risk category.
(b) Dummy variables can be set up for groupings of valuation classes that belong to the same class of business – e.g., valuations by state within a workers' compensation class of business.
(Marshall et al., pp. 19-20)

Problem RM-34. Marshall et al. (p. 20) describe a hierarchical structure for each systemic-risk category, containing correlations between two aspects of each of three areas. Describe the three areas and the components in each area, between which correlations are considered.

Solution RM-34.
Area 1: For a particular valuation class, correlations between **(i)** premium liabilities and **(ii)** outstanding claim liabilities.
Area 2: Correlations between **(i)** outstanding claim liabilities for individual valuation classes and **(ii)** the relevant class-of-business dummy variables.
Area 3: Correlations between **(i)** class-of-business dummy variables and **(ii)** root dummy variables.

Problem RM-35. In the stage of consolidation of analysis into a risk-margin calculation, which four types of assumptions would need to be consolidated and converted into a risk margin for the whole portfolio? (Marshall et al., p. 20)

Solution RM-35. The assumptions that would need to be consolidated are the following:
1. Coefficients of variation (CoVs) for *independent risk* for each valuation portfolio, separately for outstanding claim and premium liabilities;
2. Coefficients of variation (CoVs) for *internal systemic risk* for each valuation portfolio, separately for outstanding claim and premium liabilities;
3. Coefficients of variation (CoVs) for each potential category of *external systemic risk*, separately for outstanding claim and premium liabilities;
4. *Correlation coefficients* between each source of uncertainty, risk category, valuation portfolio, and outstanding claim/premium liability combination.

Problem RM-36.
(a) What type of correlation dependency do Marshall et al. (p. 20) propose to allow for the various correlation effects?
(b) For what situations of risk-margin assessment would Marshall et al. consider this correlation dependency structure to be reasonable?
(c) Give examples of two types of situations where alternative dependency structures would need to be considered.

Solution RM-36.
(a) Marshall et al. propose a **simple linear correlation dependency**.
(b) Marshall et al. consider this dependency structure to be reasonable for assessment of risk margins where the **probability of adequacy is 90% or less**.
(c) Alternative alternative dependency structures need to be considered:

(i) For extreme probabilities of adequacy (greater than 90%);
(ii) Portfolios in run-off;
(iii) When parametrizing reserve risk for Dynamic Financial Analysis (DFA) modeling purposes. (Marshall et al., p. 20)

Any two of the above would suffice.

Problem RM-37. ***Fill in the blank*** (Marshall et al., p. 22): When creating any correlation matrix, it is important to include a check that the matrix is __________.

Solution RM-37. When creating any correlation matrix, it is important to include a check that the matrix is **positive definite**. (Marshall et al., p. 22)

Note: A matrix [B] is positive definite if, for all nonzero vectors [x], $[x]^T*[A]*[x] > 0$, where $[x]^T$ is the transpose of [x]. (For more details, see "Positive Definite Matrix" at Wolfram MathWorld.)

Problem RM-38. In what situations can the use of a lognormal distribution result in risk margins that appear unreasonable, and how does this tendency manifest itself? (Marshall et al., p. 23)

Solution RM-38. The use of a lognormal distribution result in risk margins that appear unreasonable for **particularly high coefficients of variation (CoVs)**. As the CoV increases, lognormal risk margins can be reduced significantly as a percentage of the CoV, to the extent that the risk margin could actually decline as the CoV increases. (Marshall et al., p. 23)

Problem RM-39. What happens to a risk margin derived via a Normal distribution as the coefficient of variation (CoV) increases? (Marshall et al., p. 23)

Solution RM-39. A risk margin derived via a Normal distribution **remains unchanged as a percentage of the CoV**. In other words, as the CoV increases, the risk margin increases proportionally, but remains at the same fraction of the total CoV.

Problem RM-40. Describe the conceptual essence of **sensitivity testing** in the context of analyzing risk margins. (Marshall et al., p. 23)

Solution RM-40. Sensitivity testing is performed by varying each of the key assumptions and seeing how the outcome is affected. It is meant to evaluate the sensitivity of final outcomes to key assumptions. Marshall et al. recommend that each of the coefficients of variation (CoVs) and correlation coefficients for independent risk, internal systemic risk, and external systemic risk be varied and the impact on the risk margins for each valuation class and the claims portfolio be examined. (Marshall et al., p. 23)

Problem RM-41. Describe the conceptual essence of **scenario testing** in the context of analyzing risk margins. (Marshall et al., p. 24)

Solution RM-41. In scenario testing, some key assumptions adopted for central-estimate purposes would be strengthened, and the outstanding claim liabilities and premium liabilities would be aligned with the provisions that include risk margins. A number of scenarios would be tested, and outcomes – including projected ultimate claim frequencies, average claim sizes, and loss ratios – would be compared in each scenario against the central-estimate basis.

Problem RM-42. Describe the conceptual essence of **internal benchmarking** in the context of analyzing risk margins. (Marshall et al., p. 24)

Solution RM-42. Internal benchmarking involves comparing coefficients of variations (CoVs) *between* valuation classes for outstanding claim liabilities, premium liabilities, and total insurance liabilities. Also, comparisons should be made between outstanding claim liability CoVs and premium liability CoVs *within* valuation classes. (Marshall et al., p. 24)

Problem RM-43. For independent risk, what are the two main dimensions that should be considered in internal benchmarking? (Marshall et al., p. 24)

Solution RM-43.
Dimension 1. Portfolio size
Dimension 2. Length of claim run-off
(Marshall et al., p. 24)

Problem RM-44.
(a) ***Fill in the blank*** (Marshall et al., p. 24): The larger the claim portfolio, the __________ [higher or lower?] the volatility arising from random effects.
(b) ***Fill in the blank*** (Marshall et al., pp. 24-25): The longer a portfolio takes to run off, the ______ [more or less?] time there is for random effects to have an impact.

Solution RM-44.
(a) The larger the claim portfolio, the **lower** the volatility arising from random effects. (Marshall et al., p. 24)
(b) The longer a portfolio takes to run off, the **more** time there is for random effects to have an impact. (Marshall et al., pp. 24-25)

Problem RM-45. ***Fill in the blanks*** (Marshall et al., p. 25): For independent risk, outstanding-claim liability coefficients of variation (CoVs) for short-tailed portfolios are likely to be __________ [higher or lower?] than for similarly sized long-tailed portfolios and ______________ [provide a comparative term] than much smaller long-tailed portfolios.

Solution RM-45. For independent risk, outstanding-claim liability coefficients of variation (CoVs) for short-tailed portfolios are likely to be **lower** than for similarly sized long-tailed portfolios and **substantially lower** than much smaller long-tailed portfolios. (Marshall et al., p. 25)

Problem RM-46. ***Fill in the blanks*** (Marshall et al., p. 25): For independent risk, premium liability coefficients of variation (CoVs) for *long-tailed portfolios* would normally be _______ [higher or lower?] than outstanding-claim liability CoVs for the same portfolios. This is primarily due to ____________. The extent of the difference will depend on the _________________, with the difference being __________ [greater or smaller?] for small portfolios, which will have ______________ [higher or lower?] independent-risk components than for large portfolios, which will have ______________ [higher or lower?] independent-risk components.

Solution RM-46. For independent risk, premium liability coefficients of variation (CoVs) for long-tailed portfolios would normally be **higher** than outstanding-claim liability CoVs for the same portfolios. This is primarily due to **the law of large numbers**. The extent of the difference will depend on the **size of the premium liability and outstanding claim liability**, with the difference being **greater** for small portfolios, which will have **higher** independent-risk components than for large portfolios, which will have **lower** independent-risk components. (Marshall et al., p. 25)

Problem RM-47. ***Fill in the blanks*** (Marshall et al., p. 25): For independent risk, premium liability coefficients of variation (CoVs) for *short-tailed portfolios* would normally be _______ [higher or lower?] than outstanding-claim liability CoVs for the same portfolios. This is primarily due to ____________. Where it is material, __________ risk is likely to mean that the independent-risk profiles of premium liabilities and outstanding claim liabilities are different. This is likely to offset the benefit that premium liabilities gain from their _______.

Solution RM-47. For independent risk, premium liability coefficients of variation (CoVs) for *short-tailed portfolios* would normally be **lower** than outstanding-claim liability CoVs for the same portfolios. This is primarily due to **the law of large numbers**. Where it is material, **event** risk is likely to mean that the independent-risk profiles of premium liabilities and outstanding claim liabilities are different. This is likely to offset the benefit that premium liabilities gain from their **greater size**. (Marshall et al., p. 25)

Problem RM-48. ***Fill in the blanks*** (Marshall et al., p. 25): For internal systemic risk, coefficients of variation (CoVs) can be compared in the context of each __________. One would expect CoVs to be similar between __________ if ___________ are used for similar portfolios. The underlying process and its key drivers are likely to be more complicated in __________ portfolios as compared to _________ portfolios, leading to higher internal-systemic-risk CoVs for the ________ portfolios.

Solution RM-48. For internal systemic risk, coefficients of variation (CoVs) can be compared in the context of each **valuation class**. One would expect CoVs to be similar between **classes** if **template models** are used for similar portfolios. The underlying process and its key drivers are likely to be more complicated in **long-tailed** portfolios as compared to **short-tailed** portfolios, leading to higher internal-systemic-risk CoVs for the **long-tailed** portfolios. (Marshall et al., p. 25)

Problem RM-49. ***Fill in the blanks*** (Marshall et al., p. 25): The main sources of external systemic risk are likely to be more significant for _________ portfolios, with the exception of _______ risk for property classes and _______ risk for home classes.

Solution RM-49. The main sources of external systemic risk are likely to be more significant for **long-tailed** portfolios, with the exception of **event** risk for property classes and **liability** risk for home classes. (Marshall et al., p. 25)

Problem RM-50. According to Marshall et al. (p. 25), what would be an inappropriate use of external benchmarking, when it comes to risk margins derived from previously published papers? What would be a superior approach?

Solution RM-50. An inappropriate approach would be to simply derive the risk margins from the previous papers, with no consideration as to whether this approach is reasonable in the context of a particular portfolio. A superior approach is to thoroughly analyze a particular claims portfolio and then benchmark the adopted risk margins with those derived in the prior papers. (Marshall et al., p. 25)

Problem RM-51. (a) For what situations could external benchmarking be of benefit, and especially for analyzing *which* type of risk?
(b) Rather than being the entire basis of the risk-margin assessment, what role should the use of benchmarking have? (Marshall et al., pp. 25-26)

Solution RM-51. (a) External benchmarking could be of benefit where **little information is available for analysis purposes**, especially for analyzing **independent risk.**
(b) Benchmarking should be used as a **sanity check**, instead of being the entire basis of the risk-margin assessment.
(Marshall et al., pp. 25-26)

Problem RM-52. ***Fill in the blanks*** (Marshall et al., p. 26): Hindsight analysis involves comparing __________ of outstanding claim liabilities and premium liabilities against the __________ of the equivalent liabilities. Movements can be analyzed and converted to a ___________ reflective of the actual ________ observed in the past.

Solution RM-52. Hindsight analysis involves comparing **past estimates** of outstanding claim liabilities and premium liabilities against the **latest view** of the equivalent liabilities. Movements can be analyzed and converted to a **coefficient of variation** reflective of the actual **volatility** observed in the past.

Problem RM-53. According to Marshall et al. (p. 26), what are two reasons why care needs to be taken in the interpretation of any hindsight analysis?

Solution RM-53. Reasons why care needs to be taken in the interpretation of any hindsight analysis:
1. The models may have changed/improved since previous valuations were conducted.
2. Future external sources of systemic risk may differ materially from past such episodes of systemic risk. (Marshall et al., p. 26)

Problem RM-54. ***Fill in the blanks*** (Marshall et al., p. 26): Hindsight analysis is particularly useful for ________ valuations where there is little _________ between consecutive valuations. Hindsight analysis is somewhat less valuable for ___________, where there is usually significant ___________ between consecutive valuations.

Solution RM-54. Hindsight analysis is particularly useful for **short-tail** valuations where there is little **serial correlation** between consecutive valuations. Hindsight analysis is somewhat less valuable for **long-tail portfolios**, where there is usually significant **serial correlation** between consecutive valuations.

Problem RM-55.
(a) Describe the essence of *mechanical hindsight analysis.* (Marshall et al., p. 26)
(b) How can mechanical hindsight analysis be used to analyze *independent risk*? (Marshall et al., p. 27)
(c) How can mechanical hindsight analysis be used to analyze *internal systemic risk*? (Marshall et al., p. 27)

Solution RM-55.
(a) Mechanical hindsight analysis takes a mechanical approach to estimating the outstanding claim liabilities and premium liabilities, systematically removing the most recent claims experience. (Marshall et al., p. 26)
(b) Mechanical hindsight analysis can be used to analyze independent risk by focusing the analysis on periods where there was a degree of stability in the experience, with few or no systemic trends. (Marshall et al., p. 27)
(c) Mechanical hindsight analysis can be used to analyze internal systemic risk by applying this technique using a range of actuarial methods (preferably those used for central-estimate valuation purposes) and observing the differences in volatility outcomes. (Marshall et al., p. 27)

Problem RM-56. According to Marshall et al. (p. 27), at least how frequently should a full application of a risk-margin analysis framework be performed?

Solution RM-56. A full application of a risk-margin analysis framework be performed at least once **every three years.** (Marshall et al., p. 27)

Problem RM-57.
(a) At what times would Marshall et al. (p. 28) recommend conducting a less comprehensive review of the risk-margin analysis framework?
(b) During a more frequent, less comprehensive review of the risk-margin analysis framework, key assumptions of the framework should be examined in the context of which three changes? (Marshall et al., p. 28)

Solution RM-57.
(a) Marshall et al. (p. 28) would recommend conducting a less comprehensive review of the risk-margin analysis framework **at the times when central-estimate valuations of insurance liabilities are conducted.**

(b) Key assumptions of the framework should be examined in the context of:
1. Any emerging trends;
2. Emerging systemic risks;
3. Changes to valuation methodologies.
(Marshall et al., p. 28)

Problem RM-58. ***Fill in the blanks*** (Marshall et al., p. 29): In the application of most techniques for identifying independent risk, one is attempting to fit a model to __________ and _______ and to analyze the ____________ once these _________ and __________ have been fitted away. The better the model fit is, the more likely it is that the ____________ observed reflects random effects alone.

Solution RM-58. In the application of most techniques for identifying independent risk, one is attempting to fit a model to **past systemic episodes** and **trends** and to analyze the **residual volatility** once these **episodes** and **trends** have been fitted away. The better the model fit is, the more likely it is that the **residual volatility** observed reflects random effects alone. (Marshall et al., p. 29)

Problem RM-59. What three aspects should be considered in making a decision with regard to which techniques to use to assess independent risk pertaining to each valuation class? (Marshall et al., p. 29)

Solution RM-59. The following aspects should be considered:
1. Extent to which the independent risk for a particular valuation class is material to the overall claim-portfolio risk margin;
2. Contribution to uncertainty from internal systemic risk and external systemic risk;
3. Cost and effort associated with applying the techniques.
(Marshall et al., p. 29)

Problem RM-60. What approach could be pursued in situations where the available data are too limited or volatile to enable a credible split between past episodes of systemic risk and past independent risk? (Marshall et al., p. 29)

Solution RM-60. A model could be used that does not attempt to fit away the past systemic risk. This analysis should be supplemented with additional allowances for external systemic risk that is considered to differ from the past, as well as internal systemic risk, which cannot be modeled using standard quantitative modeling techniques. (Marshall et al., p. 29)

Problem RM-61. ***Fill in the blanks*** (Marshall et al., p. 30): Generalized linear modeling (GLM) techniques can be used to model ________ claims or _________ claims. GLM techniques can be used for reserving purposes to identify the __________ that have contributed to past claim-cost outcomes.

Solution RM-61. Generalized linear modeling (GLM) techniques can be used to model **individual** claims or **aggregate** claims. GLM techniques can be used for reserving purposes to identify the **key factors** that have contributed to past claim-cost outcomes. (Marshall et al., p. 30)

Problem RM-62. ***Fill in the blanks*** (Marshall et al., p. 30): Bootstrapping techniques offer __________ [more or less?] flexibility than generalized linear modeling techniques. Bootstrapping techniques can be adapted to help in ______________. This is done by calculating bootstrap residuals for ____________ and using these residuals as part of the bootstrapping process.

Solution RM-62. Bootstrapping techniques offer **less** flexibility than generalized linear modeling techniques. Bootstrapping techniques can be adapted to help in **assessment of random effects**. This is done by calculating bootstrap residuals for **past periods largely unaffected by systemic episodes** and using these residuals as part of the bootstrapping process. (Marshall et al., p. 30)

Problem RM-63. Using a bootstrapping technique, what three plots of residuals could be used to identify periods that have been affected by past systemic episodes? (Marshall et al., p. 30)

Solution RM-63. The following plots of residuals could be used:
1. Plots by accident period;
2. Plots by development period;
3. Plots by experience period. (Marshall et al., p. 30)

Problem RM-64. ***Fill in the blanks*** (Marshall et al., p. 30): Where a loss-ratio approach to projecting premium liabilities is used, allowance should be made for ________ in ________ levels, as well as _______.

Solution RM-64. Where a loss-ratio approach to projecting premium liabilities is used, allowance should be made for **systemic shifts** in **past premium** levels, as well as **claim costs**. (Marshall et al., p. 30)

Problem RM-65. When large claims are extracted for separate analysis of independent risk, observations could be made regarding what kind of distinction? (Marshall et al., p. 30)

Solution RM-65. Observations could be made regarding the aspects of past experience that represent systemic episodes versus those that are purely random. (Marshall et al., p. 30)

Problem RM-66. What are two ways in which standard triangulation methods are likely to represent a simplified view of the insurance process? (Marshall et al., p. 31)

Solution RM-66. Standard triangulation methods **(i)** will normally analyze predictors that have been aggregated to a reasonably high level or **(ii)** lag rather than lead the underlying drivers of the insurance process. (Marshall et al., p. 31)

Problem RM-67. ***Fill in the blanks*** (Marshall et al., p. 31): The assessment of internal systemic risk must be conducted in the context of the actual approach used to ____________. The strengths or weaknesses associated with that approach would be considered and scored with a view to determining an appropriate _____________ for internal systemic risk.

Solution RM-67. The assessment of internal systemic risk must be conducted in the context of the actual approach used to **assess the central estimate of outstanding claim and premium liabilities**. The strengths or weaknesses associated with that approach would be considered and scored with a view to determining an appropriate **allowance in risk margins** for internal systemic risk. (Marshall et al., p. 31)

Problem RM-68. Provide the three general steps of the *balanced scorecard* approach for evaluating internal systemic risk. (Marshall et al., pp. 31-32)

Solution RM-68.
Step 1. For each of the specification, parameter, and data risk components, conduct a qualitative assessment of the modeling infrastructure, considering a range of risk indicators and scoring these indicators on a scale of 1 to 5 (where 5 represents best practice).
Step 2. Apply weights to each risk indicator, reflecting its relative importance to the overall modeling infrastructure, and calculate a weighted-average score representing an objective view of the quality of the modeling infrastructure for each valuation class.
Step 3. Calculate the weighted-average score derived to a coefficient of variation (CoV) for internal systemic risk. Development of appropriate CoVs would involve substantial judgment, perhaps supplemented by quantitative analysis. (Marshall et al., pp. 31-32)

Problem RM-69. What is the essence of the alternative approach for assessing the level of internal systemic risk, described by Brett Riley and Bruce Watson? (Marshall et al., p. 32)

Solution RM-69. The Riley/Watson approach specifies High and Low scenarios that represent the endpoints of a reasonable range of central estimates based on alternative interpretations of all available information. (Marshall et al., p. 32)

Problem RM-70. In the scorecard approach presented by Marshall et al. (p. 33) for potential risk indicators for internal systemic risk, what are the requirements for a high score with regard to the following risk components of **specification error**?
(a) Number of independent models used;
(b) Extent to which models separately analyze different claim/payment types;
(c) Range of results produced by models.

Solution RM-70.
(a) Many different modeling approaches should be considered. Each approach should add value by considering different dimensions of claims experience.
(b) Relevant homogeneous claim or payment types should be modeled separately.
(c) There should be low variations between different models in terms of past performance, if results are appropriately compared. (Marshall et al., p. 33)

Problem RM-71. In the scorecard approach presented by Marshall et al. (p. 33) for potential risk indicators for internal systemic risk, what are the requirements for a high score with regard to the following risk components of **specification error**?
(a) Checks made on the reasonableness of results;
(b) Confidence in assessment of model goodness of fit;
(c) Number and importance of subjective adjustments to factors.

Solution RM-71.
(a) Significant reasonableness checks should be conducted, including reconciliation of movement in liabilities, diagnostic checks on valuation outcomes, acceptance of results by business, expert peer review, and benchmarking against the industry.
(b) Actual and expected results should be close. There should be few difficulties in selecting parameters. Relevant sensitivities should yield small variances in results.
(c) There should be few subjective adjustments. Relevant subjective factor sensitivities should yield low variances. The subjective adjustments should be regularly monitored and reviewed. (Marshall et al., p. 33)

Problem RM-72. In the scorecard approach presented by Marshall et al. (p. 33) for potential risk indicators for internal systemic risk, what are the requirements for a high score with regard to the following risk components of **specification error**?
(a) Extent of monitoring and review of model and assumption performance;
(b) Ability to detect trends in key claim-cost indicators;
(c) Sophistication and performance of superimposed inflation analysis;
(d) Ability to model using more granular data, such as unit record data.

Solution RM-72.
(a) Model and assumption performance should be monitored continuously and reviewed regularly.
(b) Models should have performed well in detecting trends in the past.
(c) Detailed analysis should be performed of past sources of superimposed inflation. Each past source should be quantified.
(d) Unit record data should be available and used to further analyze and better understand key predictors and trends in those predictors. (Marshall et al., p. 33)

Problem RM-73. In the scorecard approach presented by Marshall et al. (p. 33) for potential risk indicators for internal systemic risk, what are the requirements for a high score with regard to the following risk components of **parameter selection error**?
(a) Identification of best predictors;
(b) Stability of best predictors;
(c) Value of predictors used.

Solution RM-73.
(a) Best predictors should have been analyzed and identified, including internal and external variables that show strong correlation with claims experience.
(b) Predictors should be stable over time, should stabilize quickly, and should respond well to process changes.
(c) Predictors should be close to best predictors, lead rather than lag claim-cost outcomes, and be modeled rather than subjectively allowed for, and be unimpaired by past systemic events. (Marshall et al., p. 33)

Problem RM-74. In the scorecard approach presented by Marshall et al. (p. 33) for potential risk indicators for internal systemic risk, what are the requirements for a high score with regard to the following risk components of **data error**?
(a) Knowledge of past processes affecting predictors;
(b) Extent, timeliness, consistency, and reliability of information from business;
(c) Appropriate data reconciliations and quality control.

Solution RM-74.
(a) There should be good and credible knowledge of past processes, including changes to processes.
(b) There should be regular, complete, and proactive two-way communication between the valuation actuary and claims staff/portfolio managers who understand key valuation predictors and how changes may impact or invalidate these.
(c) Reconciliations against other sources should be conducted for all data sources and types. Checks should be conducted throughout the data-processing steps. Reconciliations against the previous valuation should be conducted. The data and differences should be well-understood.
(Marshall et al., p. 33)

Problem RM-75. In the scorecard approach presented by Marshall et al. (p. 33) for potential risk indicators for internal systemic risk, what are the requirements for a high score with regard to the following risk components of **data error**?
(a) Robustness and replicability of processes for obtaining and processing data;
(b) Frequency and severity of past mis-estimation due to revision of data;
(c) Extent of current data issues and possible impact on predictors.

Solution RM-75.
(a) There should be no past instances of poor data understanding. There should be no potential or low potential for miscoding of claim types.
(b) There should be no past instances of data revision.
(c) There should be no known current data issues.
(Marshall et al., p. 33)

Problem RM-76. In assessing internal systemic risk, in addition to the indicators considered for outstanding claim liabilities, what two indicators could be considered for premium liabilities? (Marshall et al., p. 34)

Solution RM-76. The following two indicators could be considered for premium liabilities:
1. Whether the outstanding claim liabilities are used as an input in the premium liability assessment;
2. Whether credible portfolio-level pricing analysis is used as an input in the premium liability assessment. (Marshall et al., p. 34)

Problem RM-77. Give an example of a situation for a short-tail portfolio where a risk indicator for outstanding claim liabilities may not be as relevant for premium-liability purposes. (Marshall et al., p. 34)

Solution RM-77. If there is a large variance in the outstanding claim liabilities, this might only affect the most recent accident periods and have a relatively small impact on the projected ultimate claim frequency or average claim size, therefore not being as material in the context of a premium-liability assessment. (Marshall et al., p. 34)

Problem RM-78. According to Marshall et al. (p. 35), what could be done with regard to developing a scale of coefficients of variation (CoVs) for internal systemic risk, in situations where more than one methodology has been deployed in the past?

Solution RM-78. Hindsight analysis could be used to study the actual past performance of each method and the extent to which multiple models can improve the performance of the whole modeling infrastructure. (Marshall et al., p. 35)

Problem RM-79. (a) According to Marshall et al. (p. 35), even in a "perfect" model, the minimum internal-systemic-risk coefficient of variation (CoV) is unlikely to be much less than *what* percentage?
(b) Why would the internal-systemic-risk CoV be unlikely to be substantially lower than this percentage?
(c) In the context of a single, aggregated model with limited data or information to populate the model, few identified predictors, and significant subjective assumptions required, what ranges of internal-systemic-risk CoVs are reasonable and why?

Solution RM-79. (a) A CoV is unlikely to be much lower than **5%.**
(b) Even a "perfect" model will not be able to completely replicate the true underlying insurance process or identify every possible predictor of claim-cost outcomes.
(c) For models with these limitations, CoVs of **20% or higher** are reasonable, because it is possible that internal systemic risk is the main contributor to overall uncertainty. (Marshall et al., p. 35)

Problem RM-80. Give a reason why a scale of selected internal-systemic-risk coefficients of variation (CoVs) might not be linear with respect to the scores from a balanced scorecard approach. (Marshall et al., p. 36)

Solution RM-80. It is possible that the marginal improvement between poor and fair modeling infrastructures is greater than the marginal improvement between fair and good modeling infrastructure. This means that the selected CoV would decrease more rapidly as a very low score improves, but would decrease more gradually as a moderately good score improves to a very good score. (Marshall et al., p. 36)

Problem RM-81. Give two reasons why internal-systemic-risk coefficients of variation (CoVs) would be larger for long-tail portfolios than for short-tail portfolios. (Marshall et al., p. 36)

Solution RM-81. Any two of the reasons below would suffice. (Marshall et al., p. 36)
Reason 1. For long-tail portfolios, it is generally more difficult to develop a modeling approach that is representative of the underlying insurance process.
Reason 2. Key predictors are often less stable for long-tail portfolios.
Reason 3. Past episodes of systemic risk are more likely to impair the ability to fit a good model.

Problem RM-82.
(a) Give a possible argument for why internal-systemic-risk coefficients of variation (CoVs) might be greater for *premium liabilities* than for outstanding claim liabilities.
(b) Give a possible argument for why internal-systemic-risk coefficients of variation (CoVs) might be greater for *outstanding claim liabilities* than for premium liabilities.
(Marshall et al., p. 36)

Solution RM-82.
(a) CoVs for premium liabilities might be larger if they include additional uncertainty associated with the estimation of exposure or premium relating to undisclosed or contractually bound future business.
(b) For stable short-tail classes, it may be that the difference between using a single aggregate model and multiple disaggregated models could have a greater effect on estimates of outstanding claim liabilities than on estimates of premium liabilities. (Marshall et al., p. 36)
Problem RM-83. The assessment of *what* major risk category would pick up the risk associated with the actuarial modeling infrastructure potentially being unable to identify emerging risks? (Marshall et al., pp. 36-37)

Solution RM-83. This risk would be picked up by an assessment of **internal systemic risk**, since it pertains to the capabilities of the actuarial modeling infrastructure.

Problem RM-84. ***Fill in the blanks*** (Marshall et al., p. 37): Certain ________ quantitative approaches may be used to gain insights into _______ and ________ sources of external systemic risk. These insights, together with those gained from _________ analysis, will provide useful intelligence on the types of risks that can emerge in each valuation portfolio, if those risks also __________.

Solution RM-84. Certain **stochastic** quantitative approaches may be used to gain insights into **past** and **emerging** sources of external systemic risk. These insights, together with those gained from **central-estimate** analysis, will provide useful intelligence on the types of risks that can emerge in each valuation portfolio, if those risks also **emerged in the past**. (Marshall et al., p. 37)

Problem RM-85. What shortcoming do stochastic quantitative analyses have when it comes to capturing sources of external systemic risk? How can this shortcoming be remedied? (Marshall et al., p. 37)

Solution RM-85. Stochastic quantitative analyses can only capture past and emerging sources of external systemic risk, but one cannot assume that the future external systemic risks will be the same as those occurred in the past. This shortcoming can be remedied by considering each of the possible future sources of external systemic risk, using a number of sources of information. (Marshall et al., p. 37)

Problem RM-86. Marshall et al. (p. 37) point out that some categories of external systemic risk are more open to quantitative analysis than others. What approach do Marshall et al. recommend for categories where quantitative analysis is more difficult?

Solution RM-86. For such categories, **sensitivity analysis** could be performed, perhaps in conjunction with business management, to shed light on the range of possible outcomes. (Marshall et al., p. 37)

Problem RM-87. Why is it important to consider the shape of the entire distribution when assessing coefficients of variation (CoVs) for each external-systemic-risk category? Give an example. (Marshall et al., p. 37)

Solution RM-87. It is important to consider the shape of the entire distribution, because some risks will demonstrate characteristics reflecting of a highly skewed distribution and may not be substantial at a lower percentile but might be more relevant for higher probabilities of adequacy. An example would be a latent risk which has a very low probability of emerging but could have extreme consequences if/when it does. (Marshall et al., p. 37)

Problem RM-88. Marshall et al. (p. 38) recommend an approach of ranking individual external systemic risks for each valuation class in order of importance, separately for outstanding claim and premium liabilities. What two benefits could this approach provide?

Solution RM-88.
Benefit 1. This approach could identify a small number of key risks and allow efforts to be focused accordingly.
Benefit 2. This approach might provide justification for excluding certain risk categories that are deemed immaterial in terms of their contribution to the overall coefficient of variation (CoV).

Problem RM-89.
(a) What is a key consideration when determining external-systemic-risk categories for a particular valuation class?
(b) How could the consolidation of the analysis of external systemic risk be substantially simplified?
(c) What may need to be done in order for such simplified consolidation to be a valid approach? (Marshall et al., p. 38)

Solution RM-89.
(a) A key consideration is **whether there is any correlation between categories**.
(b) The consolidation could be simplified **if one can assume that each of the risk categories is independent**.
(c) It may be necessary to **combine certain risk categories** to ensure that the assumption of independence is valid.
(Marshall et al., p. 38)

Problem RM-90.
(a) Give four examples of sources of economic and social external systemic risk.
(b) What should any external-systemic-risk analysis of past levels of inflation consider?
(Marshall et al., p. 38)

Solution RM-90.
(a) Examples of sources of economic and social external systemic risk:
1. Levels of standard inflation;
2. General economic conditions (unemployment rates, GDP growth, interest rates, asset returns);
3. Fuel prices;
4. Driving patterns;
5. Potential systemic shifts in claim frequency for short-tail valuation portfolios.
Any four of the above would suffice.

(b) Any analysis of past levels of inflation should consider the **extent to which past volatility is random** and **the extent to which it has been impacted by systemic events**. Analysis of external systemic risk is only concerned with the latter. (Marshall et al., p. 38)

Problem RM-91.
(a) Why are legislative, political, and claims-inflation risks combined into a single risk category by Marshall et al. (p. 39)?
(b) For what valuation classes is the legislative, political, and claims-inflation risk category likely to be much more material?
(c) The analysis conducted to justify coefficients of variation (CoVs) for legislative, political, and claims-inflation risk can be used to justify *which* assumptions for central-estimate valuation purposes? (Marshall et al., p. 39)

Solution RM-91.
(a) These risks are **often correlated** and have therefore been combined into a single category.
(b) This risk category is likely to be much more material for **long-tail valuation classes.**
(c) The CoV analysis for legislative, political, and claims-inflation risk can be used to justify **superimposed inflation assumptions** for central-estimate valuation purposes. (Marshall et al., p. 39)

Problem RM-92. Give three examples of sub-groups of risk that would be encompassed under legislative, political, and claims-inflation risk for *long-tail valuation classes*. (Marshall et al., p. 39)

Solution RM-92. The following are examples of sub-groups of this risk for long-tail valuation classes:
1. Impact of recent legislative amendments, including possibility of the erosion of the amendments' intent through changes in court interpretation;
2. Potential for future legislative amendments with retrospective impacts;
3. Precedent-setting in courts;
4. Changes to costs of medical technology;
5. Changes to legal costs;
6. Systemic shifts in large-claim frequency and severity.
(Marshall et al., p. 39)

Problem RM-93. Give three examples of sub-groups of risk that would be encompassed under legislative, political, and claims-inflation risk for *short-tail valuation classes*. (Marshall et al., p. 39)

Solution RM-93. The following are examples of sub-groups of this risk for short-tail valuation classes:
1. Risk that claim inflation will increase at a level different from that adopted for central-estimate purposes;
2. Risk from standard inflation;
3. Claim-management process risk.
(Marshall et al., p. 39)

Problem RM-94.
(a) What are two areas which discussions with claim managers should address in order to gain an understanding of claim-management process-change risk?
(b) What four aspects of claim management should be considered in the course of such discussions? (Marshall et al., pp. 39-40)

Solution RM-94. (a) Discussions with claim managers should address:
1. The claim-management philosophy, the process that underpins that philosophy, and current or potential future changes to that process;
2. Past systemic episodes that may have been impacted by the claim-management process.
(b) Aspects of claim management that should be considered:
1. Reporting patterns;
2. Payment patterns;
3. Finalization and reopening rates;
4. Case-estimation processes. (Marshall et al., pp. 39-40)

Problem RM-95. (a) Is claim-management process-change risk likely to be more relevant for *outstanding claim liabilities* or for *premium liabilities*?
(b) Is claim-management process-change risk likely to be more material for *short-tailed* valuation classes or for *long-tailed* valuation classes?
(c) Why is claim-management process-change risk most relevant for the liabilities and valuation classes from parts (a) and (b)?
(Marshall et al., p. 40)

Solution RM-95. (a) Claim-management process-change risk is likely to be more relevant for ***outstanding claim liabilities***.
(b) Claim-management process-change risk is likely to be more material for ***short-tailed* valuation classes**.
(c) Claim-management process-change risk would impact the pattern of emergence of credible claim estimates, which is most important for outstanding claim liabilities for short-tailed valuation classes. (Marshall et al., p. 40)

Problem RM-96.
(a) Is *expense risk* generally expected to be a large contributor or a small contributor to total external systemic risk?
(b) What are two analyses that can be combined to form a reasonable view as to the range of possible claim-cost outcomes arising from expense risk?
(c) What kinds of claims can have a material impact on the level of claim-handling expenses?
(Marshall et al., p. 40)

Solution RM-96.
(a) Expense risk is generally expected to be a **small** contributor to total external systemic risk.
(b) The following two analyses can be combined:
1. Sensitivity testing around the key drivers, preferably conducted in association with informed business and process experts; and
2. Analysis of past expense levels with a view to identifying past systemic effects.
(c) Event claims (e.g., natural-disaster claims) can have a material impact on the level of claim-handling expenses. (Marshall et al., p. 40)

Problem RM-97. Give four examples of valuation classes where **event risk** could be material. (Marshall et al., p. 40)

Solution RM-97. Valuation classes where event risk could be material:
1. Property
2. Motor/Automobile
3. Medical malpractice
4. Builders' warranty
(Marshall et al., p. 40)

Problem RM-98. ***Fill in the blanks*** (Marshall et al., pp. 40-41): For outstanding claim liabilities, the approach to assessing event risk will be defined by __________, which should be analyzed __________, if they exist. The range of __________ for ___________ may also influence the view on uncertainty.

Solution RM-98. For outstanding claim liabilities, the approach to assessing event risk will be defined by **the extent to which there are material outstanding events**, which should be analyzed **separately**, if they exist. The range of **development patterns** for **previous events** may also influence the view on uncertainty. (Marshall et al., pp. 40-41)

Problem RM-99. What are three possible sources of information available to help in the quantification of event risk for premium liabilities? (Marshall et al., p. 41)

Solution RM-99. The following are possible sources of information:
1. Past experience for event claims;
2. Output from proprietary catastrophe modeling;
3. Models from reinsurance intermediaries for natural perils and some man-made perils, that can be used to model perils not covered by proprietary catastrophe models.
(Marshall et al., p. 41)

Problem RM-100.
(a) For what two valuation classes could *latent claim risk* be considered material?
(b) What is latent claim risk one of the most difficult risks to quantify? (Marshall et al., p. 41)

Solution RM-100.
(a) Latent claim risk could be considered material for **(i)** workers' compensation and **(ii)** liability classes.
(b) The probability of events pertaining to latent claim risk is low, but their impact could be substantial if they occur.
(Marshall et al., p. 41)

Problem RM-101.
(a) What is a type of valuation class for which *recovery risk* could be substantial?
(b) For non-reinsurance recovery risk, what two approaches could help form a view as to the range of possible systemic outcomes?
(c) For reinsurance recovery risk, what kinds of events would have a low probability of occurring, but would have high severity if they happen? Give two examples.

(Marshall et al., p. 42)

Solution RM-101.
(a) Motor/automobile valuation classes often involve considerable third-party recoveries, so recovery risk could be substantial for them.
(b) For non-reinsurance recovery risk, the following two approaches are helpful:
1. Analysis of past non-reinsurance recovery rates and patterns;
2. Discussions with claim management around current trends in recovery management and any current or planned future initiatives that may impact recovery levels.
(c) Such low-probability, high-severity events would be **material shifts in reinsurance market conditions** that significantly affect the ability to recover from reinsurers. Examples include **(i)** global-scale catastrophic events or **(ii)** a downturn in asset returns. (Marshall et al., p. 42)