# Study Guide for Casualty Actuarial Exam 7 on the International Actuarial Association's "A Global Framework for Insurer Solvency Assessment"



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*This is an open-source study guide and may be revised pursuant to suggestions.*

**Source:** International Actuarial Association, "A Global Framework for Insurer Solvency Assessment," a research report of the Insurer Solvency Assessment Working Party, 2004, Chapters 1, 2, 5, 7, 8, and 9; Appendices B, D, E, H, and I.

**Problem S7-IAA-1.** According to the IAA paper, how is the focus of prudential regulation and supervision of financial institutions usually defined? (Chapter 1, Section 1.2, p. 1)

**Solution S7-IAA-1.** The focus of prudential regulation and supervision of financial institutions is usually defined as **the protection of the rights of policyholders and depositors.**

**Problem S7-IAA-2.** What is the primary focus of the IAA paper? (Chapter 1, Section 1.3, p. 1)

**Solution S7-IAA-2.** The primary focus of the IAA paper is **on capital requirements and practices that strengthen the ability of a company to successfully manage its risk in a way to lessen its need for capital.**

**Problem S7-IAA-3.** List any five of the "guiding principles" identified in the IAA paper's Executive Summary. (Chapter 2, Section 2.2, p. 3)

**Solution S7-IAA-3.** Any five of the following will suffice:
- A "three-pillar" approach to supervision
- Principles-based versus rules-based approach
- Total balance-sheet approach
- Degree of protection
- Appropriate time horizon
- Types of risks to be included
- Appropriate risk measures
- Risk dependencies

- Risk management
- Standardized approaches
- Advanced or company-specific models
- Market efficient capital requirements

**Problem S7-IAA-4.** The IAA paper outlines a "three-pillar" approach to supervision. Identify each of the three pillars. (Chapter 2, Section 2.4, p. 3)

**Solution S7-IAA-4.**

**Pillar I:** Minimum financial requirements

**Pillar II:** Supervisory review process

**Pillar III:** Measures to foster market discipline

**Problem S7-IAA-5.** What are the three insurance-specific components of Pillar I (minimum financial requirements), as described in the IAA paper? (Chapter 2, Section 2.5, p. 3)

**Solution S7-IAA-5.**
**Three components of Pillar I:**

**1.** Appropriate technical provisions (policy liabilities);
**2.** Appropriate assets supporting those obligations;

**3.** A minimum amount of capital (developed from a set of available and required capital elements) for each insurer.

**Problem S7-IAA-6.**

**(a)** According to the IAA paper, why is the supervisory review process of Pillar II needed?

**(b)** What two outcomes is Pillar II intended to achieve? (Chapter 2, Section 2.6, p. 4)

**Solution S7-IAA-6.**

**(a)** The supervisory review process of Pillar II is needed **because not all types of risk can be adequately assessed through solely quantitative measures – particularly risks determined using internal models.**

**(b)** Pillar II is intended to achieve the following outcomes:

**1.** Insurers have adequate capital to support all risks in their business.

**2.** Insurers are encouraged to develop and use better risk-management techniques reflective of the insurer's risk profile and in monitoring and managing these risks .

**Problem S7-IAA-7.** According to the IAA paper, how is the "market discipline" of Pillar III intended to be achieved? (Chapter 2, Section 2.7, p. 4)

**Solution S7-IAA-7.** The "market discipline" of Pillar III is intended to be achieved through **disclosure requirements** that are intended to foster industry best practices.

**Problem S7-IAA-8.** According to the IAA paper, how can the actuarial profession assist supervisors with **(a)** Pillar II and **(b)** Pillar III? (Chapter 2, Section 2.8, p. 4)

**Solution S7-IAA-8.**

**(a) Pillar II:** The actuarial profession can provide independent peer review of the following when they entail the use of substantial judgment or discretion:
- Determination of policy liabilities
- Risk management
- Capital requirements
- Current financial position
- Future financial condition

**(b) Pillar III:** The actuarial profession can assist in the design of appropriate disclosure practices to serve the public interest.

**Problem S7-IAA-9.** For each of the three pillars of supervision, the IAA paper identifies areas of difference between insurance and banking. What are these areas of difference by pillar? (Chapter 2, Section 2.10, p. 4)

**Solution S7-IAA-9.**

**Pillar I:** The nature of insurance risks and the techniques needed to assess them

**Pillar II:** The need for multi-period review

**Pillar III:** The definition of relevant information for disclosure purposes

**Problem S7-IAA-10.** Briefly discuss the guidance offered by the IAA paper with respect to the creation of rules derived from the principles of solvency assessment. (Chapter 2, Section 2.11, p. 4)

**Solution S7-IAA-10.** Rules derived from the principles of solvency assessment **should include provisions to allow their adaptation to current or unforeseen circumstances with the prior agreement of the relevant supervisor.**

**Problem S7-IAA-11.** According to the IAA paper, what are three advantages of using a total balance-sheet approach for assessing an insurer's financial strength? (Chapter 2, Section 2.13, p. 4)

**Solution S7-IAA-11.**

**Advantages of total balance-sheet approach:**

**1.** Dependency upon realistic values

**2.** Consistent treatment of both assets and liabilities

**3.** Absence of hidden surplus or deficit

**Problem S7-IAA-12.** Why does the IAA paper not agree with the use of capital requirements for the purpose of totally preventing insurer failures? (Chapter 2, Section 2.14, p. 5)

**Solution S7-IAA-12.** Total prevention of insurer failures is impossible, and if extremely high capital requirements were used, this would discourage the deployment of insurer capital in a jurisdiction.

**Problem S7-IAA-13.** According to the IAA paper, what is a reasonable period for the time horizon of solvency assessment, for the purpose of determining an insurer's current financial position? (Chapter 2, Section 2.16, p. 5)

**Solution S7-IAA-13.** A reasonable period is **about one year.**

**Problem S7-IAA-14.** According to the IAA paper, the amount of required capital must be sufficient for which two purposes? (Chapter 2, Section 2.17, p. 5)

**Solution S7-IAA-14.** The amount of required capital must be sufficient:

**1.** To meet all obligations for the time horizon with a high level of confidence (e.g., 99%)

**2.** To meet the present value at the end of the time horizon of the remaining future obligations, with a moderate level of confidence (e.g., 75%).

**Problem S7-IAA-15.** What two general alternatives does the IAA paper offer for valuing insurer risks over their lifetimes? (Chapter 2, Section 2.18, p. 5)

**Solution S7-IAA-15. Alternative 1.** Value risks using a series of consecutive one-year tests with a very high level of confidence (e.g., 99%) and reflecting management and policyholder behavior (but no new business). **Alternative 2.** Value risks using a single equivalent but lower (e.g., 90%-95%) level of confidence for the entire assessment time horizon.

**Problem S7-IAA-16.** What four risks does the IAA paper recommend be addressed within a Pillar I set of capital requirements? (Chapter 2, Section 2.19, p. 5)

**Solution S7-IAA-16.**

**Risks to be addressed within Pillar I capital requirements:**

**1.** Underwriting risk

**2.** Credit risk

**3.** Market risk

**4.** Operational risk

**Problem S7-IAA-17.** What risk measure does the IAA paper recommend as a superior alternative to Value at Risk (VaR) in many situations? Why is it superior? (Chapter 2, Section 2.20, pp. 5-6)

**Solution S7-IAA-17.** The recommended risk measure is **Tail Value at Risk (TVaR or Conditional Tail Expectation or Policyholders' Expected Shortfall).** It is superior in many cases because risk event distributions are commonly skewed.

**Problem S7-IAA-18.**

**(a)** What are two kinds of risk dependencies?
**(b)** According to the IAA paper, what are two objectives for which it is imperative to find methods or models? (Chapter 2, Section 2.24, p. 6)

**Solution S7-IAA-18.**

**(a)** 2 kinds of risk dependencies are **concentration** and **diversification.**

**(b) Objectives of modeling risk dependencies:**

**1.** To describe dependencies in the absence of reliable data or the presence of scarce data;

**2.** To describe increasing dependence in extreme events (in the tails of the probability distributions which describe the risks).

**Problem S7-IAA-19.**

**(a)** What are four ways, other than the fundamentals of prudent claim management, in which an insurer can manage its risks?

**(b)** According to the IAA paper, what is one caution to keep in mind when selecting a risk-management strategy?
(Chapter 2, Sections 2.26-2.27, p. 6)

**Solution S7-IAA-19.**

**(a) Risk-management techniques** (any four will suffice):
- Risk reduction
- Risk integration
- Risk diversification
- Risk hedging
- Risk transfer
- Risk disclosure

**(b)** One caution is that some risk-management strategies may create additional risk related to the risk-management strategy itself. For example, hedging can create counterparty risk.

**Problem S7-IAA-20.**

**(a)** According to the IAA paper, when are simple risk measures appropriate? Identify two such situations.

**(b)** According to the IAA paper, sophisticated risk measures are appropriate for material risks where one or more of a set of enumerated conditions exist. Identify four of these conditions. (Chapter 2, Sections 2.30-2.31, p. 7)

**Solution S7-IAA-20.**

**(a)** Simple risk measures are appropriate when:
**1.** It is recognized that the risk in question is important from a solvency perspective but there does not exist a generally accepted view of how the risk should be assessed; or

**2.** The risk is of minor importance.

**(b)** Sophisticated risk measures are appropriate when (any four answers will suffice):

**1.** The risk in question is very important from a solvency perspective and cannot be adequately assessed through the use of simple risk measures;

**2.** There is sound technical theory for the risk to be assessed and the risk measure to be used;

**3.** Sufficient technical skills and professionalism are present among the staff;

**4.** Relevant and sufficient data are present or the knowledge about the risks is otherwise reliable;

**5.** The risk is actually managed in accordance with the risk measure used;

**6.** Risk-management practices are evident to a high degree.

**Problem S7-IAA-21.** According to the IAA paper, why can an insurer's risk model be, at best, an approximate representation of reality? (Chapter 2, Section 2.32, p. 7)

**Solution S7-IAA-21.** Many aspects of risk are not well understood in practice – particularly extreme events for which little history exists. The extreme events are the most important in solvency assessment.

**Problem S7-IAA-22.**

**(a)** According to the IAA paper, if capital is the second line of defense for protecting an insurer's solvency, then what is the first line of defense?

**(b)** According to the IAA paper, what should be the case in order for a supervisor to be content with a lower amount of required capital under a company-specific approach?

(Chapter 2, Section 2.33, p. 7)

**Solution S7-IAA-22. (a)** The first line of defense is solid risk management.

**(b)** The supervisor should have assurance that the particular source of risk is under control, its effects are well mitigated, and there is thus a reduced need for the required capital.

**Problem S7-IAA-23.** According to the IAA paper, what is a particular strength of internal capital models? (Chapter 2, Section 2.34, p. 7)

**Solution S7-IAA-23.** A particular strength of internal capital models is their ability to capture the impact of combinations of risks beyond a simple aggregation of individual risk factors that cannot accurately assess risk-interaction effects.

**Problem S7-IAA-24.** Identify five of the elements of the overall management of an insurer, as discussed in the IAA paper. (Chapter 5, Section 5.1, p. 25)

**Solution S7-IAA-24.** Any five of the following would suffice:

1. The design, pricing, marketing, and underwriting of insurance policies;

2. The selection of assets backing the policies;

3. The estimation of the size and volatility of the liabilities associated with the policies;

4. The determination of the insurer's capital needs;

5. Claims management;

6. The updating of all these elements over time as more data and other information becomes available or because the underlying risk processes change;

7. An adequate/sound disclosure/communication process to key stakeholders;

8. Future financial-condition analysis which provides a prospective multi-scenario view of the company as a whole.

**Problem S7-IAA-25.**

**(a)** According to the IAA paper, in an "efficient market", what happens in the insurance sector if additional capital is required, beyond the level needed for all of the appropriate risk factors at an adequate level of confidence?

**(b)** What happens if the capital requirements are insufficient? (Chapter 5, Section 5.4, p. 26)

**Solution S7-IAA-25.**

**(a)** Less capital will be attracted to the insurance sector if the insurance products cannot be priced to recover the additional cost of capital.

**(b)** Insufficient requirements may result in inadequate pricing and increase the exposure of the insurer to insolvency risk over time.

**Problem S7-IAA-26.**

**(a)** What definition of "risk" does the IAA paper utilize? (Chapter 5, Section 5.5, p. 26)

**(b)** What key concept regarding risk is emphasized by the IAA paper? (Chapter 5, Section 5.6, p. 26)

**(c)** What context is required in order for the term "risk" to have meaning? (Chapter 5, Section 5.7, p. 26)

**Solution S7-IAA-26.**

**(a)** Risk is **the chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood.**

**(b)** Risk management is as much about identifying opportunities as avoiding or mitigating losses.

**(c)** Risk only has meaning in the context of a set of objectives or expected results.

**Problem S7-IAA-27.** What four major risk categories does the IAA paper propose for an integrated approach to risk or solvency assessment? (Chapter 5, Section 5.8, p. 26)

**Solution S7-IAA-27.**

**(1)** Underwriting risk

**(2)** Credit risk

**(3)** Market risk

**(4)** Operational risk

**Problem S7-IAA-28.** What did the "Sharma" report conclude about the causes of insurer failures? (Chapter 5, Section 5.9, pp. 26-27)

**Solution S7-IAA-28.** The "Sharma" report concluded that the final cause for a failure is always the realization of some concrete risk, but in most cases the real cause is much earlier and more abstract. There is a causal chain of events leading to failure.

**Problem S7-IAA-29.** Define "underwriting risks". **(**Chapter 5, Section 5.10, p. 27)

**Solution S7-IAA-29.** Underwriting risks are specific insurance risks that are covered by the company through the insurance contracts it sells.

**Problem S7-IAA-30. (a)** What are "free assets"?

**(b)** What does the IAA paper recommend with regard to capital requirements against asset-related risks with respect to free assets, and **(c)** why? **(**Chapter 5, Section 5.11, p. 27)

**Solution S7-IAA-30.**

**(a)** Free assets are those assets which are not supporting the liabilities or the capital requirements themselves.

**(b)** The IAA paper recommends that capital requirements against asset-related risks should ***not*** be determined for free assets.

**(c)** The imposition of capital requirements on free assets discourages insurers from maintaining more capital than absolutely necessary in the insurer. Thus, such requirements are counterproductive to enhancing policyholder protection.

**Problem S7-IAA-31.**

**(a)** What is liquidity risk frequently associated with?

**(b)** In which pillar does the IAA paper recommend that liquidity risk be addressed? (Chapter 5, Section 5.12, p. 27)

**Solution S7-IAA-31.**

**(a)** Liquidity risk is frequently associated with the sale of assets.

**(b)** The IAA paper recommends that liquidity risk be addressed within **Pillar II: Supervisory review process.**

**Problem S7-IAA-32.**

**(a)** What two kinds of risks of loss does the term "operational risk" encompass?

**(b)** In which pillar does the IAA paper recommend that operational risk be addressed?

(Chapter 5, Section 5.13, p. 27)

**Solution S7-IAA-32.**

**(a)** Operational risk includes risk of:
1. Non-underwriting losses internal to the insurer (over which the insurer may have significant control);

2. Losses caused by external non-underwriting risk events (over which the insurer may have little control).

**(b)** The IAA paper recommends that operational risk be addressed in **Pillar I** capital requirements.

**Problem S7-IAA-33.**

**(a)** How does the IAA paper define "volatility"?

**(b)** With respect to volatility, what does it mean for a risk to be diversifiable?

(Chapter 5, Section 5.16, p. 27)

**Solution S7-IAA-33.**

**(a)** Volatility is the risk of random fluctuations in either the frequency or severity of a contingent event.

**(b)** For a diversifiable risk, the volatility of the average claim amount declines as the block of independent insured risks increases.

**Problem S7-IAA-34.** According to the IAA paper, what would happen in "fully efficient" markets in terms of volatility? How are actual insurance markets different? (Chapter 5, Section 5.17, p. 27)

**Solution S7-IAA-34.** In a "fully efficient" market, volatility would not be valued in the calculation of the fair value of a set of projected future cash flows; capital would absorb the fluctuations arising from volatility risk. Investors can diversify the risks in their own portfolios, and the efficient-market theory takes the viewpoint of such hypothetical investors. However, in real insurance markets, the assumptions of the "fully efficient" market do not hold. Policyholders cannot diversify away their risk, and can be subject to an insurer's bankruptcy as a result of diversifiable risk.

**Problem S7-IAA-35.**

**(a)** How does the IAA paper define "uncertainty"?

**(b)** Is uncertainty risk diversifiable? Why or why not? (Chapter 5, Section 5.18, p. 28)

**(c)** In what common way does uncertainty risk exist among insurers? (Chapter 5, Section 5.19, p. 28)

**Solution S7-IAA-35.**

**(a)** Uncertainty is the risk that the models used to estimate the claims or other relevant processes are misspecified or that the parameters within the models are misestimated.

**(b)** Uncertainty risk is **non-diversifiable**, because it cannot be reduced by increasing portfolio size.

**(c)** Insurers often have unique underwriting standards and market niches – and therefore unique parameters that might not be grasped in a more general industry model of risk. The experience of the entire population of insurers may not be applicable to a particular specialized insurer.

**Problem S7-IAA-36.** Briefly describe *three key elements* of uncertainty. (Chapter 5, Section 5.20, p. 28)

**Solution S7-IAA-36.**

**1. Model-error risk:** The model itself may be incorrect, and no parameters may exist to make the model an adequate description of reality.

**2. Parameter risk:** Risk of error in the estimation of parameters; may exist because of limited number of observations, short observation period, volatility of observation, lack of consideration of calamitous events, and/or contaminated data.

**3. Structural risk:** The parameters (risk structure) can change over time or be uncertain for other reasons – e.g., emerging events that change the nature of the risk.

**Problem S7-IAA-37.** Briefly describe three general ways in which extreme events differ from typical kinds of risk in their effects on an insurance company. (Chapter 5, Section 5.22, p. 28)

**Solution S7-IAA-37.**

**1.** Extreme events can cause fluctuations to be much greater than what that might be expected to arise from normal (modeled) fluctuations.

**2.** Extreme events cannot be extrapolated from more common events, and it is thus difficult to specify a loss value or amount of capital to hold.

**3.** An extreme event can occur, which has an extremely low probability of occurrence and so may not be anticipated.

**Problem S7-IAA-38.** Briefly describe four of the eight subsets of underwriting risk mentioned in the IAA paper. (Chapter 5, Section 5.24, p. 29)

**Solution S7-IAA-38.** Any four of the following will suffice:

**1. Underwriting Process Risk:** Risk from exposure to financial losses related to the selection and approval of risks to be insured.

**2. Pricing Risk:** Risk that the prices charged by the company for insurance contracts will be ultimately inadequate to support the future obligations arising from those contracts.

**3. Product-Design Risk:** Risk that the company faces exposures under its insurance contracts that were unanticipated in the design and pricing of the insurance contract.

**4. Claims Risk:** Risk that many more claims occur than expected or that some claims that occur are much larger than expected claims, resulting in unexpected losses.

**5. Economic Environment Risk:** Risk that social conditions will change in a manner that has an adverse effect on the company.

**6. Net-Retention Risk:** Risk that higher retention of insurance loss exposures results in losses due to catastrophic or concentrated claims experience.

**7. Policyholder Behavior Risk:** Risk that the insurance company's policyholders will act in ways that are unanticipated and have an adverse effect on the company.

**8. Reserving Risk:** Risk that the provisions held in the insurer's financial statements for its policyholder obligations will prove to be inadequate.

**Problem S7-IAA-39.**

**(a)** How does the IAA paper define "credit risk"?

**(b)** Briefly describe four of the seven subsets of credit risk mentioned in the IAA paper. (Chapter 5, Section 5.26, pp. 29-30)

**Solution S7-IAA-39.**

**(a)** Credit risk is the risk of default and change in the credit quality of issuers of securities, counter-parties, and intermediaries, to whom the company has an exposure.

**(b)** Any four of the following will suffice:

**1. Direct-Default Risk:** Risk that a firm will not receive the cash flows or assets to which it is entitled because a party with which the firm has a bilateral contract defaults on one or more obligations.

**2. Downgrade or Migration Risk:** Risk that changes in the possibility of future default by an obligor will adversely affect the present value of the contract with the obligor today.

**3. Indirect Credit or Spread Risk:** Risk due to market perception of increased risk.

**4. Settlement Risk:** Risk arising from the lag between the value and settlement dates of securities transactions.

**5. Sovereign Risk:** Risk of exposure to losses due to the decreasing value of foreign assets or increasing value of obligations denominated in foreign currencies.

**6. Concentration Risk:** Risk of increased exposure to losses due to concentration of investments in a geographical area or other economic sector.

**7. Counterparty Risk:** Risk of changes in values of reinsurance and contingent assets and liabilities.

**Problem S7-IAA-40.**

**(a)** How does the IAA paper define "market risk"?

**(b)** Briefly describe four of the eight subsets of market risk mentioned in the IAA paper. (Chapter 5, Section 5.29, pp. 30-31)

**Solution S7-IAA-40.**

**(a)** Market risk arises from the level or volatility of market prices of assets and involves the exposure to movements in the level of stock prices, interest rates, exchange rates, or commodity prices – as well as the exposure of options to movements in the underlying asset price or exposure to other unanticipated movements in financial variables.

**(b)** Any four of the following will suffice:

**1. Interest-Rate Risk:** Risk of exposure to losses resulting from fluctuations in interest rates.

**2. Equity and Property Risk:** Risk of exposure to losses resulting from fluctuation of market values of equities and other assets.

**3. Currency Risk:** Risk that relative changes in currency values decrease values of foreign assets or increase the value of obligations denominated in foreign currencies.

**4. Basis Risk:** Risk that yields on instruments of varying credit quality, liquidity, and maturity do not move together, thus exposing the company to market-value variation that is independent of liability values.

**5. Reinvestment Risk:** Risk that the returns on funds to be reinvested will fall below anticipated levels.

**6. Concentration Risk:** Risk of increased exposure to losses due to concentration of investments in a geographical area or other economic sector.

**7. Asset/Liability Mismatch Risk:** Risk that occurs to the extent that the timing or amount of the cash flows from the assets supporting the liabilities and the liability cash flows are different (or can drift apart).

**8. Off-Balance-Sheet Risk:** Risk of changes in values of contingent assets and liabilities, such as swaps that are not otherwise reflected on the balance sheet.

**Problem S7-IAA-41.**

**(a)** For capital purposes, how is “operational risk” defined? (Chapter 5, Section 5.31, p. 31)

**(b)** Identify one kind of risk that the term “operational risk” includes, and three kinds of risks that it excludes. (Chapter 5, Section 5.32, p. 31)

**Solution S7-IAA-41.**

**(a)** Operational risk is the risk of loss resulting from inadequate or failed internal processes, people, or systems – or from external events.

**(b)** Operational risk includes legal risks and excludes strategic, reputational, and systemic risk.

**Problem S7-IAA-42.** Within which pillar of insurer solvency assessment does the IAA paper recommend including operational risk? What are the limitations of this recommendation? (Chapter 5, Section 5.39, p. 32)

**Solution S7-IAA-42.** The IAA paper recommends including operational risk within **Pillar I: Minimum financial requirements**. However, there can be no experience-based Pillar I requirement for insurers because of lack of sufficient insurer quantitative data and the unique nature of the insurance basis. The IAA paper recommends an interim, non-experience-based Pillar I requirement, accompanied by incentives for companies to demonstrate sound management of operational risk.

**Problem S7-IAA-43.** According to the IAA paper, what is a challenge for insurers in assessing operational risk? (Chapter 5, Section 5.41, p. 32)

**Solution S7-IAA-43.** A challenge for insurers in assessing operational risk is to separate this risk from the loss-experience data typically collected for the other underwriting, credit, and market risks.

**Problem S7-IAA-44.**

**(a)** Define “liquidity risk” in an insurance context.

**(b)** Identify two situations in which an insurer might experience liquidity risk. (Chapter 5, Sections 5.43-5.44, pp. 32-33)

**Solution S7-IAA-44.**

**(a)** Liquidity risk in an insurance context is the exposure to loss in the event that insufficient liquid assets will be available, from among the assets supporting the policy obligations, to meet the cash-flow requirements of the policyholder obligations when they are due.

**(b)** An insurer might experience liquidity risk in the following situations (any two will suffice):

1. Early termination of insurance contracts;

2. Unexpected need to borrow money or sell assets for an unanticipated low price;

3. Need to pay claim settlements earlier than expected and therefore to liquidate invested assets prematurely or on unfavorable terms.

**Problem S7-IAA-45. (a)** Identify three different levels of liquidity management. **(b)** Which of these is typically not covered by actuarial opinions or normal measures of risk-based capital? (Chapter 5, Section 5.45, p. 33)

**Solution S7-IAA-45.**

**(a)** Three levels of liquidity management:

1. Day-to-day cash management

2. Ongoing cash-flow management (monitoring cash needs for the next 6-24 months)

3. Stress-liquidity management, focused on catastrophic risk.

**(b)** Stress-liquidity management is typically not covered by actuarial opinions or normal measures of risk-based capital.

**Problem S7-IAA-46.** Identify four possible triggers of an unexpected demand for liquidity. (Chapter 5, Section 5.47, p. 33)

**Solution S7-IAA-46.** Any four of the following will suffice:

**1.** Cash calls following major loss events;

**2.** A credit-rating downgrade;

**3.** Negative publicity, justified or not;

**4.** Deterioration of the economy;

**5.** Reports of problems of other companies in the same or similar lines of business;

**6.** Extent of reliance on and performance of secured sources of funding and their terms;

**7.** Breadth of funding and accessibility/liquidity of capital markets.

**Problem S7-IAA-47.** Give four examples of company-specific characteristics that can contribute to liquidity risk exposure. (Chapter 5, Section 5.48, pp. 33-34)

**Solution S7-IAA-47.** Any four of the following will suffice:

**1.** A single contract holder or a few contract holders controlling large sums of money;

**2.** Limited access to capital markets due to size of company (either very small or very large);

**3.** Short supply of cash to meet immediate demands for cash payments;

**4.** Unpredictable deferred or deferrable demands on cash;

**5.** Insufficient ability to borrow short-term through bank lines of credit or commercial paper.

**6.** Lack of diversity or fungibility in either the liability or the asset portfolio when analyzed by product, region industry, or creditor – leading to over-concentration of illiquid assets.

**7.** Crisis in the capital markets, including extreme volatility of market prices.

**Problem S7-IAA-48.** Fill in the blanks: (Chapter 5, Section 5.51, p. 34)

A risk measure is a function of the _____. It is used to determine either the _____ (based on the _____) or a(n) _____ (based on the _____).

**Solution S7-IAA-48.** A risk measure is a function of the **probability distribution of losses**. It is used to determine either the **total capital requirement** (based on the **aggregate distribution of losses**) or an **indicated capital requirement for a component** (based on the **loss distribution of the component risk only**).

**Problem S7-IAA-49.** Briefly describe the following basic risk measures in verbal terms: (Chapter 5, Section 5.53, p. 35)

**(a)** Value-at-Risk (VaR)

**(b)** Standard Deviation

**(c)** Tail-Value-at-Risk (TVaR)

**Solution S7-IAA-49.**

**(a)** Value-at-Risk (VaR): A quantile of the distribution (e.g., the Xth percentile).

**(b)** Standard Deviation: A measure of the degree of uncertainty relative to the mean.

**(c)** Tail-Value-at-Risk (TVaR): Quantile VaR plus the average exceedence of that quantile if such exceedence occurs.

**Problem S7-IAA-50.**

**(a)** Why are skewed “fat tail” distributions superior to the Normal distribution for modeling insurance risks?

**(b)** Why is TVaR a superior measure to VaR and the standard deviation for the purpose of solvency assessment? (Chapter 5, Section 5.54, pp. 35-36)

**Solution S7-IAA-51.**

**(a)** Skewed distributions with fat tails reflect a higher probability of infrequent but sizable losses (such as catastrophes) than the Normal distribution. Many insurance risks are indeed subject to such losses.

**(b)** TVaR, unlike VaR and the standard deviation, indicates the amount of catastrophic losses above a certain confidence level. It is thus useful in assessing the impact of extreme events.

**Problem S7-IAA-52.** To what risk does the presence of a reinsurance contract expose the ceding insurer? (Chapter 5, Section 5.57, p. 36)

**Solution S7-IAA-52.** The presence of a reinsurance contract exposes the ceding insurer to the risk of **counter-party default.**

**Problem S7-IAA-53.** What two caveats are important to recognize in evaluating the financial implications of reinsurance contracts? (Chapter 5, Section 5.59, p. 37)

**Solution S7-IAA-53.**

1. Where the liabilities are held may not fully indicate which party has the risk.

2. Some types of reinsurance (financial or finite reinsurance) involve minimal transfer of real risk and are structured to provide financing by reinsurers to direct writers.

**Problem S7-IAA-54.** What are the two conditions that the IAA paper proposes should accompany the granting of credit within a capital requirement to an insurer that has passed on some of its risks through reinsurance? (Chapter 5, Section 5.60, p. 37)

**Solution S7-IAA-54.**

**1.** Verification that real risk transfer has taken place.

**2.** Recognition in the capital credit of the counterparty risk being assumed by the direct writer.

**Problem S7-IAA-55.**

**(a)** How can hedging transactions by insurers result in a net reduction in risk?

**(b)** What risk is assumed in a hedging transaction?

**(c)** What is a "natural" hedge? (Chapter 5, Section 5.61, p. 37)

**Solution S7-IAA-55.**

**(a)** In a hedging transaction, the insurer assumes an offsetting risk to the original risk, therefore reducing risk on net.

**(b)** A **counter-party default risk** is assumed in a hedging transaction.

**(c)** A natural hedge is "a row of bushes or small trees planted close together, especially when forming a fence or boundary" (definition from Dictionary.com) – just kidding ☺. **Serious answer:** A "natural" hedge occurs when a company can offset risks in different lines of business.

**Problem S7-IAA-56.**

According to the IAA paper, what are three of the criteria that a supervisor should use before granting credit for financial hedging in a capital requirement? (Chapter 5, Section 5.63, p. 37)

**Solution S7-IAA-56.**

Any three of the following will suffice:

**1.** The hedging program should be well-formulated.

**2.** The hedging program should be consistent with financial economic theory.

**3.** The hedging program should effectively provide the desired hedge.

**4.** There should be assurance that financial markets offer a sufficient supply of the required derivative instruments.

**5.** The company's personnel executing the hedging strategy should be competent and knowledgeable regarding financial economics.

**Problem S7-IAA-57.**

**(a)** Briefly describe the concept of participating insurance. (Chapter 5, Section 5.64, p. 37)

**(b)** What two criteria does the IAA paper recommend for granting some credit within a capital requirement for risks that are shared with policyholders through participating insurance? (Chapter 5, Section 5.66, p. 38)

**(c)** Why does the IAA paper consider it inappropriate to allow complete credit for risk generated through participating or adjustable policies? (Chapter 5, Section 5.67, p. 38)

**Solution S7-IAA-57.**

**(a)** Participating insurance involves the sharing of the insurer's experience with respect to a block of business with policyholders through the payment of a policyholder dividend or bonus.

**(b) 1.** The supervisor should be satisfied that the insurer has in place a policy and practice of reducing the dividend or bonus scale or adjusting policy elements in its favor when it is subject to adverse loss experience.

**2.** The supervisor should be satisfied that the constraints placed upon insurers by the concept of "policyholders' reasonable expectations" with respect to participating policies, or the limits within adjustable policies, do not interfere with the company's ability to share unfavorable experience with policyholders consistently with its policies and past practices.

**(c)** It may take a significant amount of time to determine an unfavorable shift in experience, and insurers have historically been reluctant to quickly reduce bonus or dividend scales.

**Problem S7-IAA-58.** According to the IAA paper, what is a key difference between a bank's exposure to risk and an insurer's exposure to risk – such that certain standardized approaches in the Basel Accord cannot be followed for insurers? (Chapter 7, Section 7.4, p. 60)

**Solution S7-IAA-58.** For banks, the Basel Accord prescribes certain non-discretionary standard accounting conventions to measure the banks' exposure to risk. This cannot be done for an insurer, because many measures of an insurer's exposure to risk are related to actual policy liabilities, which cannot be perfectly known in advance and must be estimated using actuarial techniques.

**Problem S7-IAA-59.** Provide the IAA paper's definitions of the following:
**(a)** Company-specific approach

**(b)** Standardized approach

(Chapter 7, Section 7.5, p. 60)

**Solution S7-IAA-59.**

**(a) Company-specific approach:** A method of determining an insurance company's capital requirement with respect to a particular source of risk that measures the intensity of the risk in relation to the company's own experience or the structure of its portfolio of business.

**(b) Standardized approach:** A method based upon standardized factors that measure the intensity of risk, applied to measures of the company's exposure to risk, or is based upon differing measures of the company's exposure to that risk.

**Problem S7-IAA-60.**

**(a)** Fill in the blank: When a company calculates the component of required capital with respect to a specific source of risk by means of a company-specific approach, it is to be expected that the result will be _____ (more or less?) than the value for that component that would result from a (more conservative) standardized approach.

**(b)** What two sets of conditions does the IAA paper suggest are needed to a supervisor to be comfortable with this result? (Chapter 7, Section 7.6, p. 61)

**Solution S7-IAA-60.**

**(a)** When a company calculates the component of required capital with respect to a specific source of risk by means of a company-specific approach, it is to be expected that the result will be **less** than the value for that component that would result from a (more conservative) standardized approach.

**(b) 1.** Appropriateness and accuracy of the particular approach taken by the company;

**2.** Actions of the company to manage and mitigate that particular risk.

**Problem S7-IAA-61.** With regard to satisfying the supervisor as to the integrity of the company's data used in the calculations of internal models, identify two areas of concern mentioned in the IAA paper. (Chapter 7, Section 7.7, p. 61)

**Solution S7-IAA-61.** Any two of the following will suffice:

**1.** The data's sufficiency and credibility

**2.** The statistical methods used to organize and analyze the data

**3.** The qualifications of the insurer's personnel associated with this approach

**Problem S7-IAA-62.**

**(a)** Under the Basel II proposal, on what two elements does a bank's capital requirement for credit risk depend?

**(b)** What two company-specific approaches does the Basel II proposal offer? (Chapter 75, Section 7.10, p. 61)

**(c)** Which of these two approaches is expected to be utilized by only the largest and "most technically sophisticated" banks? (Chapter 7, Section 7.11, p. 62)

**Solution S7-IAA-62.**

**(a) 1.** The frequency of asset defaults

**2.** The severity distribution of the amount of loss, given that default has occurred

**(b) Approach 1:** A bank may use frequencies of default based upon its own asset-quality ratings and frequencies of default, while using standardized severity distributions.

**Approach 2:** The bank may also use its own severity distributions.

**(c) Approach 2** (using the bank's own severity distributions) is expected to be utilized by only the largest and "most technically sophisticated" banks, because a bank would need to experience a much larger number of asset defaults in order to derive a credible severity distribution, than would be needed to derive a credible frequency distribution.

**Problem S7-IAA-63.** According to the IAA paper, why are advanced approaches with respect to credit risk generally more important for banks than for insurers? (Chapter 7, Section 7.12, p. 62)

**Solution S7-IAA-63.** Banks originate many of their assets through their lending activities, and these assets can only be assigned a quality or credit rating through use of a bank's own rating system. Insurers, on the other hand, invest mostly in publicly traded assets that have been rated by recognized rating agencies and so often do not require a company-specific rating approach.

**Problem S7-IAA-64.**

**(a)** For risk pass-through products, why does the IAA paper suggest that recognition given in the calculation of required capital to the reduction of risk to the company should be a company-specific matter? (Chapter 7, Section 7.13, p. 62)

**(b)** What is the supervisor's primary concern in allowing an insurer to reflect its risk-sharing mechanisms in the determination of capital requirements? (Chapter 7, Section 7.15, p. 62)

**(c)** Identify three areas that the IAA paper recommends for the supervisor to examine in order to address the primary concern in part (b) above. (Chapter 7, Section 7.15, p. 62)

**Solution S7-IAA-64.**

**(a)** The risk-sharing mechanism will necessarily depend upon the company's specific product design and the methods the company employs to administer the business and operate a risk-sharing mechanism.

**(b)** The supervisor's primary concern in allowing an insurer to reflect its risk-sharing mechanisms in the determination of capital requirements is **to ensure that the insurer will actually be able and willing to reflect unfavorable experience in policyholder dividends or bonus scales.**

**(c)** Any three of the following will suffice:
**1.** The insurer's dividend or bonus policy

**2.** The insurer's history of administering its dividend or bonus policy

**3.** The effects of any smoothing mechanism that may be in place

**4.** The insurer's competitive position

**5.** The perceived effect on the part of company management and the supervisor that a reduction in dividends or bonus due to unfavorable experience would have on the company's position

**6.** Whether the concept of policyholders' reasonable expectations would inhibit or restrict the company's ability to pass on unfavorable experience to its policyholders

**Problem S7-IAA-65.**

**(a)** Describe the difference between retrospective and prospective risk-sharing mechanisms.

**(b)** How could prospective risk-sharing mechanisms be reflected in a standardized approach? (Chapter 7, Section 7.18, p. 63)

**Solution S7-IAA-65.**

**(a)** Retrospective risk-sharing mechanisms enable a company to share its past experience with policyholders. Prospective mechanisms allow companies to adjust future premiums in anticipation of expected unfavorable experience. However, they do not provide any relief to a company that has already experienced significant losses.

**(b)** In a standardized approach, a capital requirement may be linked to the period for which future premium rates are guaranteed, with longer-term guarantees requiring increased capital. Prospective risk-sharing mechanisms should be reflected as reductions in the length of premium-rate-guarantee periods.

**Problem S7-IAA-66.**

**(a)** According to the IAA paper, what condition should be required in order for a reduction in capital to be granted with respect to a contract where retrospective rating is employed?

**(b)** What provision would need to be made in this situation? (Chapter 7, Section 7.19, p. 63)

**Solution S7-IAA-66.**

**(a)** The contract wording should legally bind the policyholder to pay for case deficits arising from unfavorable experience.

**(b)** An appropriate provision for counterparty risk would need to be made.

**Problem S7-IAA-67.** If an insurer holds a policyholder's funds on deposit in order to have available funds to make up for a case-specific experience-rating deficit, then what caveat exists with respect to recognizing an offset or reduction in required capital? (Chapter 7, Section 7.20, p. 63)

**Solution S7-IAA-67.** The recognition should only be granted on a policy-by-policy basis, since deposits attributable to one policy could not be used to offset unfavorable experience arising from another policy.

**Problem S7-IAA-68.** Identify three general characteristic of an insurer's internal capital model. (Chapter 7, Section 7.22, p. 64)

**Solution S7-IAA-68.**

**1.** The internal models are computer models of a specific line of business or segment of a company's activity.

**2.** The models are usually stochastic in nature and directed to determining the amount of capital that will be sufficient to guarantee the success of that portion of the company's business to a high degree of probability.

**3.** The models depend upon scenario generators that can produce a wide variety of scenarios that can affect the future course of the company's business.

**Problem S7-IAA-69.**

**(a)** When a company constructs its internal model, what three general aspects of the company should be reflected in the model?

**(b)** What two aspects are the prerogative of the supervisor to determine?

(Chapter 7, Section 7.23, p. 64)

**Solution S7-IAA-69.**

**(a)** The model should reflect:

**1.** The company's specific product designs

**2.** The company's administrative policies and procedures

**3.** Other practices, including investment policy and claim settlement

**(b)** The supervisor's role is to determine:

**1.** The level of probability that is to be tested

**2.** The length of the future period over which future model projections are carried out

**Problem S7-IAA-70.**

**(a)** According to the IAA paper, in many cases, what will be the primary stochastic element in the scenario generator of an insurer's internal model?

**(b)** According to the IAA paper, in what two respects should the supervisor be satisfied with the scenario generator?

**(c)** Is the scenario generator, in the case from the answer to part (a) above, expected to vary significantly from one company to another, in the same jurisdiction and operating in the same economic environment?

**(d)** In models that depart from the answer to part (c) above, what could the scenario generator be used for – particularly in the case of non-life insurance?

**(e)** If the scenario generator is used for the purpose described in the answer to part (d) above, then with what aspect of the scenario generator would the supervisor need to be satisfied?

(Chapter 7, Section 7.24, p. 64)

**Solution S7-IAA-70. (a)** In many cases, the primary stochastic element in the scenario generator of an insurer's internal model will be **the performance of some set of economic indices, such as interest rates or equity market averages, over time.**

**(b)** The supervisor should be satisfied that the generator:
**1.** Is consistent with the theory of financial economics; and

**2.** Is appropriate for use in the practical application.

**(c)** No.

**(d)** For non-life insurance, the scenario generator may be used to generate **claims experience.** In this case, the generator could be specific to the company and the types of business it conducts.

**(e)** The supervisor would need to be satisfied that the generator captures the range of possible claims that the company could experience.

**Problem S7-IAA-71.** Fill in the blanks (Chapter 7, Section 7.27, p. 65):

To be valid for use in the supervision of insurance, an internal model needs to be demonstrably capable of meeting a number of criteria in respect of _____, _____, and _____.

**Solution S7-IAA-71.** To be valid for use in the supervision of insurance, an internal model needs to be demonstrably capable of meeting a number of criteria in respect of **prudence**, **comparability**, and **consistency within the supervisor's jurisdiction**.

**Problem S7-IAA-72.**

**(a)** According to the IAA paper, what are three minimum prudential requirements for an insurer's internal model?
**(b)** Identify three qualitative criteria that follow from these prudential requirements.

(Chapter 7, Section 7.28, p. 65)

**Solution S7-IAA-72.**

**(a)** Minimum prudential requirements for an internal model:
**1.** Conceptually sound risk-management environment

**2.** Risk-management environment supported by adequate resources

**3.** Risk-management environment supported by appropriate audit and compliance procedures

**(b)** Any three of the following will suffice:

**1.** The insurer should have an independent internal risk-management unit, responsible for the design and implementation of the risk-based capital model.

**2.** The insurer's Board and senior management should be actively involved in the risk-control process, which should be demonstrated as a key aspect of business management.

**3.** The model should be closely integrated with the day-to-day management processes of the insurer.

**4.** An independent review of the model should be carried out on a regular basis, and the evolution of modeling capabilities is to be encouraged.

**5.** Operational risks should be considered.

**Problem S7-IAA-73. (a)** Fill in the blanks with regard to comparability and consistency requirements for an insurer's internal model: The model's output needs to fit closely with the supervisor's view of key _____, such as _____ and other important measures of financial soundness.

**(b)** Identify two qualitative criteria that follow from these requirements of comparability and consistency. (Chapter 7, Section 7.29, p. 65)

**Solution S7-IAA-73.**

**(a)** The model's output needs to fit closely with the supervisor's view of key **minimum performance criteria**, such as **probability of default** and other important measures of financial soundness.

**(b) 1.** A requirement for the model to calculate the capital needed to keep the annual probability of default below a certain level or levels

**2.** An ability for calculating the likely spread of economic costs relating to a range of potential outcomes for the business

**Problem S7-IAA-74.** Identify four key risk factors that an insurer's internal model should have the ability to specify. (Chapter 7, Section 7.30, p. 65)

**Solution S7-IAA-74.** Any four of the following will suffice:

**1.** Measurement of cash flows for both assets and liabilities

**2.** The risk of changes in outstanding-claims valuation due to changes in economic, environmental, or experience-related factors

**3.** The risk of changes to the adequacy of premium rates due to changes in economic, competitive, or environmental factors

**4.** Catastrophe concentration risk

**5.** Expense risk

**6.** The reinsurance security risk and risk of reinsurance-cost variability

**Problem S7-IAA-75.** Fill in the blanks (Chapter 7, Section 7.31, p. 65): An insurer's internal model should include a facility to enable comparability of _____ between risk classes, as well as a system of _____ and other _____ examinations.

**Solution S7-IAA-75.** An insurer's internal model should include a facility to enable comparability of **correlation effects** between risk classes, as well as a system of **stress testing** and other **scenario-based** examinations.

**Problem S7-IAA-76. (a)** According to the IAA paper, in which situation is the Total Balance Sheet approach particularly appropriate with regard to setting capital requirements?

**(b)** In this situation, what can two aspects can be determined using the same probability distribution?

**(c)** What requirement does this approach help to satisfy?

(Chapter 7, Section 7.33, p. 66)

**Solution S7-IAA-76.**

**(a)** The Total Balance Sheet approach is particularly appropriate in a situation where the present value of the insurer's future cash flows can be treated as a random variable whose distribution is derived using an internal model.

**(b)** Using the same distribution, it is possible to determine (i) policy liabilities and (ii) the sum of liabilities and required capital.

**(c)** This approach helps to satisfy the requirement that an internal model should be closely integrated with the day-to-day management processes of the insurer and should not be used solely for the calculation of required capital.

**Problem S7-IAA-77.**

**(a)** What possible solution does the IAA paper recommend with regard to capital modeling for jurisdictions where the insurance industry is not in a state of technological readiness for all insurance companies to use internal models?
**(b)** According to the IAA paper, what bias should exist in this approach?

(Chapter 7, Section 7.34, p. 66)

**Solution S7-IAA-77.**

**(a)** A possible solution is to apply a generic model to data collected across the industry. The result of these calculations could be used to determine standardized factors that could be applied to various companies' measures of exposure to the particular risk.

**(b)** The IAA paper recommends a **conservative** bias to the generic approach in order to provide insurers an incentive to seek approval for their own internal models.

**Problem S7-IAA-78.** According to the IAA paper, what are the two main objectives of purchasing reinsurance? (Chapter 8, Section 8.3, p. 67)

**Solution S7-IAA-78.** Two main objectives of purchasing reinsurance:

**1.** Genuine risk transfer with the goal of risk mitigation

**2.** Risk transfer for the purposes of managing/spreading risk over time or achieving strategic business objectives

**Problem S7-IAA-79.** What are two genuine risk-transfer reasons for purchasing reinsurance – and what reinsurance products are generally appropriate for eachj? (Chapter 8, Section 8.4, p. 67)

**Solution S7-IAA-79.** Genuine risk-transfer reasons for purchasing reinsurance:

**1.** Limiting large or catastrophic claims: Appropriate reinsurance generally provides for the reinsurer to pay claims in excess of a certain limit, subject to a minimum number of claims and a maximum amount of reinsurance per event.

**2.** Limiting total claims: Stop-loss reinsurance, limiting the aggregate amount of claims in a year, is appropriate.

**Problem S7-IAA-80.** Identify and briefly describe three strategic or financial objectives of reinsurance. (Chapter 8, Section 8.5, p. 67)

**Solution S7-IAA-80.**

**1. Increasing new-business capacity:** Enabling the insurer to issue policies with larger coverage limits or amounts than it could prudently issue on its own; protecting the insurer from insolvency if several large claims occur in a short time period.

**2. Investment-risk transfer:** Insurers may reinsure a block of business to effect a transfer of investment risk from the insurer. This can avoid a large concentration of assets in a single product.

**3. Financial-results management:** Insurers can utilize the financial-reporting impact of reinsurance agreements to optimize the insurer's earnings and surplus objectives and minimize taxes.

**Problem S7-IAA-81.** Identify three reinsurance purposes that represent a mixture of risk-transfer and strategic/financial objectives. (Chapter 8, Section 8.6, pp. 67-68)

**Solution S7-IAA-81.**

**1.** Gaining product expertise from the reinsurer

**2.** Acquiring underwriting and product-design advice from the reinsurer

**3.** Divesting a product line by transferring a loss portfolio to a reinsurer

**Problem S7-IAA-82.** In what way can reinsurance be crucial to the viability of smaller companies? (Chapter 8, Section 8.7, p. 68)

**Solution S7-IAA-82.** Small companies use reinsurance as a diversification and risk-reduction tool, enabling them to compete effectively against large diversified companies.

**Problem S7-IAA-83.** What effect does quota-share reinsurance have on a primary insurer's risk profile? (Chapter 8, Section 8.9, p. 68)

**Solution S7-IAA-83.** Quota-share reinsurance compresses a primary insurer's risk profile by reducing each loss to the insurer by a fixed percentage.

**Problem S7-IAA-84.** What effect does excess-of-loss reinsurance have on a primary insurer's risk profile? (Chapter 8, Section 8.11, p. 69)

**Solution S7-IAA-84.** Excess-of-loss reinsurance truncates the cedant's loss distribution at the attachment point of the excess-of-loss treaty. The distribution up to the attachment point is the same as without the treaty, but at the attachment point there is a mass point in the distribution.

**Problem S7-IAA-85.**

**(a)** At the mean of a loss distribution, does a quota-share reinsurance contract or an excess-of-loss reinsurance contract achieve greater risk reduction?

**(b)** At the 99$^{th}$ percentile of a loss distribution, does a quota-share reinsurance contract or an excess-of-loss reinsurance contract achieve greater risk reduction? (Chapter 8, Section 8.13, p. 69)

**Solution S7-IAA-85.**

**(a)** At the mean of a loss distribution, the **quota-share** reinsurance contract achieves greater risk reduction.

**(b)** At the 99$^{th}$ percentile of a loss distribution, the **excess-of-loss** reinsurance contract achieves greater risk reduction.

**Problem S7-IAA-86.** Fill in the blanks (Chapter 8, Section 8.15, p. 69): Non-proportional reinsurance eliminates all or part of the _____ coming from the _____ of the distribution.

**Solution S7-IAA-86.** Non-proportional reinsurance eliminates all or part of the **volatility** coming from the **tail** of the distribution.

**Problem S7-IAA-87. (a)** Is reinsurance more effective at reducing the standard deviation or at reducing the Tail Value at Risk (TVaR)?

**(b)** What does the answer above suggest with regard to capital requirements?

(Chapter 8, Section 8.17, p. 70)

**Solution S7-IAA-87. (a)** Reinsurance is more effective at reducing the TVaR.

**(b)** In reducing the TVaR, reinsurance reduces the amount at risk for the company in the case of extreme events. Therefore, less solvency capital is needed for a company whose reinsurance arrangements significantly protect against extreme losses.

**Problem S7-IAA-88.** Identify four general reasons why it is difficult to assess the impact of reinsurance on a ceding company's risk profile. (Chapter 8, Sections 8.19-8.23, pp. 70-71)

**Solution S7-IAA-88. 1.** There is tremendous diversity in the types of reinsurance contracts.

**2.** Many reinsurance contracts do not bear a linear relationship with the underlying risks.

**3.** Not all reinsurance warrants a reduction in the capital requirement, in particular when it is inadequate.

**4.** Reinsurance recoverable may be highly correlated with the cedant's net risk exposures.

**Problem S7-IAA-89.** Give three examples of diversity in reinsurance contracts. (Chapter 8, Section 8.20, p. 71)

**Solution S7-IAA-89.** Any three of the following will suffice:

**1.** Typical reinsurance arrangements comprise both proportional and non-proportional covers.

**2.** Some contracts have variable rating terms, such as sliding scales or loss corridors for a proportional reinsurance treaty, and reinstatements or contingent commissions for an excess-of-loss treaty.

**3.** Some contracts cover just one line of business, others cover multiple lines of business, and others cover single loss events only.

**4.** Some contracts are on an aggregate basis, with aggregate deductibles and aggregate limits.

**5.** Some financial reinsurance contracts cover a hybrid of underwriting and financial risks.

**Problem S7-IAA-90.** Give three reasons why a reinsurance program might not warrant a reduction in the cedant's capital requirement. (Chapter 8, Section 8.22, p. 71)

**Solution S7-IAA-90.**

**1.** If improperly designed, a reinsurance program may be inefficient in reducing the total risk to the cedant.

**2.** Some reinsurance contracts do not contain significant risk transfer and are mainly used for some specific accounting or tax effects.

**3.** Some reinsurance contracts may have credit-risk exposures – i.e., the loss recoverable may be non-collectable in cases of contract dispute or reinsurance failure.

**Problem S7-IAA-91.** According to the IAA paper, what are the two general methods of evaluating the amount of risk transfer in a reinsurance contract? (Chapter 8, Section 8.25, p. 71-72)

**Solution S7-IAA-91.**

**1.** Judging the amount of risk transfer for a reinsurance contract by analyzing whether the cedant has transferred (reduced) risk on an enterprise-wide basis.

**2.** Judging the amount of risk transfer for a reinsurance contract by focusing on a stand-alone single transaction as defined in the contract.

**Problem S7-IAA-92.**

**(a)** According to the IAA paper, for what kinds of reinsurance contracts is it "practically impossible" to assess individual contracts on a per-risk or line-of-business basis?

**(b)** For what kinds of reinsurance contracts is it possible to evaluate agreements on an approximate basis?

**(c)** Fill in the blanks: A whole-account stop-loss limits the _____ of the underwriting result and thus, assuming the reinsurance and thus, assuming the reinsurance performs, the _____ can be quantified. (Chapter 8, Section 8.26, p. 72)

**(d)** Fill in the blanks: Except in the case of a stop-loss arrangement, a risk-based solvency assessment is impossible in the absence of _____ and _____. In this situation, a prudent supervisory approach would b e to give _____ for the purchase of reinsurance. (Chapter 8, Section 8.27, p. 72)

**Solution S7-IAA-92.**

**(a)** Excess-of-loss contracts

**(b)** Proportional contracts

**(c)** A whole-account stop-loss limits the **maximum downside** of the underwriting result and thus, assuming the reinsurance and thus, assuming the reinsurance performs, the **maximum capital at risk** can be quantified.

**(d)** Except in the case of a stop-loss arrangement, a risk-based solvency assessment is impossible in the absence of **reliable aggregate loss-distribution data** and **exposure information**. In this situation, a prudent supervisory approach would b e to give **no credit** for the purchase of reinsurance.

**Problem S7-IAA-93.** According to the IAA paper, for property lines of reinsurance, what could be used as a proxy for the insurer's risk profile? (Chapter 8, Section 8.28, p. 72)

**Problem S7-IAA-93.** A combination of exposure profiles for multiple lines (especially when compared to industry data) can achieve an approximate total company profile.

**Solution S7-IAA-94.** What should an adequate enterprise-wide internal risk model be able to accomplish in terms of evaluating the effects of reinsurance? (Chapter 8, Section 8.29, p. 72)

**Problem S7-IAA-94.** An adequate enterprise-wide internal risk model should be able to evaluate the total capital requirement on a gross basis (without reflecting reinsurance) and then on a net basis (net of reinsurance. The model should reflect all the intricacies of the reinsurance contract terms.

**Problem S7-IAA-95. (a)** For the assessment of the risk transfer under a particular reinsurance contract, what can one do without referring to a full enterprise-wide model? (Chapter 8, Section 8.31, p. 72)

**(b)** Give three general steps in the approach described in the answer to part (a).

**(c)** What are two challenges in utilizing this approach? (Chapter 8, Section 8.32, p. 72)

**Solution S7-IAA-95. (a)** For the assessment of the risk transfer under a particular reinsurance contract, one can perform the risk modeling of the cash flows between two parties based on the contract terms.

**(b) 1.** The risk characteristics can be described by segmenting the underlying contracts into homogeneous "risk buckets" – describing the exposure of the underlying risks in terms of insured value, retention, policy limit, and maximum loss/PMI.

**2.** The data can be used to derive a gross risk profile of the portfolio to be insured, using frequency and severity/expected-loss information.

**3.** The gross loss distributions can be used to adequately apply proportional reinsurance transactions, including loss-sensitive features as appropriate.

**(c)** With regard to non-proportional reinsurance contracts, the proper evaluation of the risk-reducing impact is not possible without **(i)** relatively complex mathematical transformations, or **(ii)** the use of simulations.

**Problem S7-IAA-96. (a)** According to the IAA paper, what is the most adequate assessment of the risk-transfer capability of a reinsurance contract? (Chapter 8, Section 8.33, p. 73)

**(b)** What issue does this approach *not* resolve? (Chapter 8, Section 8.34, p. 73)

**Solution S7-IAA-96. (a)** The most adequate assessment of the risk-transfer capability of a reinsurance contract is through the description of risk using detailed loss and exposure data. From this information, possibly blended with industry data, the company can derive specified and validated loss distributions.

**(b)** This approach does not resolve the aggregation of the individual risk profiles into a total company profile, since such resolution would need to consider dependencies between risks, such as concentration or diversification.

**Solution S7-IAA-97. (a)** The IAA paper recommends that a factor $\theta$ be applied to the full amount of capital relief derived from having a reinsurance arrangement in place. Based on what four aspects might $\theta$ vary? (Chapter 8, Section 8.37, p. 73)

**(b)** Fill in the blanks: $\theta$ should be in line with the charge for _____ with similar _____. (Chapter 8, Section 8.38, p. 73)

**Problem S7-IAA-97. (a)** Aspects affecting $\theta$:

**1.** The financial stability of the reinsurer

**2.** The amount of collateral being posted

**3.** The nature of the reinsurance (e.g., short versus long tail)

**4.** Concentration risk (number of reinsurers)

**(b)** θ should be in line with the charge for **bond defaults** with similar **default frequencies**.

**Problem S7-IAA-98.** Let X be the aggregate loss and let ρ be the risk measure applied.

Let $X_{net}$ and $X_{ceded}$ be the net and ceded losses, respectively. Give two equivalent expressions for the net capital requirement for the ceding company in terms of the above variables and θ. (Chapter 8, Sections 8.39-840, p. 74)

**Solution S7-IAA-98.**

**Expression 1:** $\rho(X) - (1- \theta)*\rho(X_{ceded})$

**Expression 2:** $\rho(X_{net}) + \theta*\rho(X_{ceded})$

**Problem S7-IAA-99.**

**(a)** Define "concentration risk".

**(b)** How does concentration risk affect capital requirements in practice?

(Chapter 9, Section 9.1, p. 75)

**Solution S7-IAA-99.**

**(a)** Concentration risk is the risk of having higher-than-normal relative risk exposure in a single risk.

**(b)** In practice, concentration risk can result in increased capital requirements.

**Problem S7-IAA-100.** How does diversification affect capital requirements in practice?

(Chapter 9, Section 9.2, p. 75)

**Solution S7-IAA-100.**

**(a)** Diversification reduces total relative capital required when combining two risks. It should be encouraged by being reflected in a capital formula.

**Problem S7-IAA-101.** Explain how risk correlations can affect capital requirements. (Chapter 9, Section 9.3, p. 75)

**Solution S7-IAA-101.** For positively correlated risks, more capital would be required than if the risks were independent. Negatively correlated risks function as natural hedges and usually require less capital than if the risks were independent.

**Problem S7-IAA-102.** Why, according to the IAA paper, might it not be possible to identify all sources of interaction among risks and build them into an internal model, or even estimate their correlations or related measures of interaction? (Chapter 9, Section 9.4, p. 75)

**Solution S7-IAA-102.** For some risks that are separate from financial markets, there is very little historical data to detect and quantify the real relationship between risk factors.

**Problem S7-IAA-103.** Identify and briefly describe two general types of dependencies from which comovement of risks can result. (Chapter 9, Section 9.5, p. 75)

**Solution S7-IAA-103.**

**Structural dependencies:** Due to known relationships, which can be accounted for in a modeling exercise; include situations where loss variables are driven by common variables, such as general economic inflation or shocks.

**Empirical dependencies:** Simply observed, without any known relationships or relationships capable of being modeled.

**Problem S7-IAA-104.** Give two examples of situations where the degree of dependency of insurance risks leading to comovement may increase in extreme outcomes of the risk.

(Chapter 9, Section 9.6, p. 76)

**Solution S7-IAA-104.**

**1. Major terrorist attack:** Could affect aviation, property, business interruption, workers' compensation, life, personal accident, and other insurance simultaneously.

**2. Major natural catastrophe on a weekday morning:** Could affect property and workers' compensation insurance.

Other valid answers are possible.

**Problem S7-IAA-105.** Fill in the blanks (Chapter 9, Section 9.7, p. 76): Structural dependencies can be modeled directly in _____ and reflected appropriately in _____.

**Solution S7-IAA-105.** Structural dependencies can be modeled directly in **internal models** and reflected appropriately in **factor-based formulas**.

**Problem S7-IAA-106.**

**(a)** For what two circumstances does the IAA paper consider it necessary to find methods and models to describe dependencies?

**(b)** What is a likely alternative to modeling dependencies directly if their nature is well-understood?

**(c)** What theory, according to the IAA paper, provides a comprehensive modeling tool to assist in reflecting dependencies?

(Chapter 9, Section 9.9, p. 76)

**(d)** Is this theory from part (c) more appropriate for modeling structural dependencies or empirical dependencies? (Chapter 9, Section 9.10, p. 76)

**Solution S7-IAA-106.**

**(a) 1.** Absence of reliable data

**2.** Increasing dependency in extreme events

**(b)** A likely alternative is to construct dependency models that reflect observed and expected dependencies without formalizing the structure of those dependencies with cause-effect models.

**(c)** The theory of **copulas** provides a comprehensive modeling tool to assist in reflecting dependencies.

**(d)** Copulas are more appropriate for modeling **empirical** dependencies.

**Problem S7-IAA-107.** What are the two sources from which an insurer's assets, needed to support the insurer's capital requirement, originate? (Appendix B, Section 1.4, p. 109)

**Solution S7-IAA-107.**

**1. Policyholders** (after the provisions for the various reserves and expenses are removed)

**2. Investors** (through either a direct contribution to capital or retained earnings from prior years of operation)

**Problem S7-IAA-108.** How does the IAA paper define the risk-based capital charge, with respect to the TVaR evaluated at the 99% level? (Appendix B, Section 1.5, p. 109)

**Solution S7-IAA-108.**

Risk-Based Capital Charge = $TVaR_{99\%}$ – Expected Net Losses on Current Business – Net Loss Reserve

**Problem S7-IAA-109.** What action could an insurer take to provide a more conservative estimate of reserves? (Appendix B, Section 1.6, p. 109)

**Solution S7-IAA-109.** The insurer could remove the discount for the time of value of money and utilize the higher, undiscounted reserves.

**Problem S7-IAA-110.** According to the IAA paper, along with underwriting risk, what two types of risk should a complete risk-based capital formula consider? (Appendix B, Section 1.7, p. 109)

**Solution S7-IAA-110.**

**1.** Asset risk

**2.** The risk of premium deficiency (risk that the market will not allow adequate premiums)

**Problem S7-IAA-111.** Identify and briefly describe the three criteria that the IAA paper recommends for a factor-based formula prescribed by a regulator for risk-based capital analysis. (Appendix B, Section 1.9, pp. 109-110)

**Solution S7-IAA-111.**

**1. Simplicity:** The formula can be put on a spreadsheet. There may be some complexity in the formulas, as long as their objective is clear.

**2. Input Availability:** The inputs needed for the formula are either readily available, or can be reasonably estimated with the help of the appointed actuary.

**3. Conservatism:** When there is uncertainty in the values of the parameters, the parameters should be chosen to yield a conservative estimate of the required capital.

**Problem S7-IAA-112. (a)** In Appendix B, the IAA paper presents a factor-driven risk-based capital formula. To what four attributes is this formula sensitive? (Appendix B, Section 3.1, p. 111)

**(b)** What underlying aggregate loss distribution does the model assume? (Appendix B, Section 3.3, p. 111)

**Solution S7-IAA-112. (a) 1.** The volume of business in each line of business

**2.** The overall volatility of each line of insurance

**3.** The reinsurance provisions

**4.** The correlation, or dependency structure, between each line of business

**(b)** The model assumes a **lognormal** aggregate loss distribution.

**Problem S7-IAA-113.** Given the mean and variance of an insurer's aggregate loss distribution, it is possible to calculate $TVaR_{\alpha}(X)$ (at the $\alpha$ percentile) using four steps. What are those steps? (Appendix B, Section 3.7, p. 112)

**Solution S7-IAA-113.**

**1.** Calculate the parameters of the lognormal distribution that has the same mean and variance as the insurer's aggregate loss distribution.

**2.** Calculate $VaR_\alpha(X)$ (the α percentile) of the lognormal distribution.

**3.** Calculate the limited expected value $E[X \wedge VaR_\alpha(X)]$ for the lognormal distribution.

**4.** Find $TVaR_\alpha(X) = VaR_\alpha(X) + (E[X] - E[X \wedge VaR_\alpha(X)])/(1- \alpha)$.

**Problem S7-IAA-114.** Qualitatively describe the manner in which the model presented in the IAA paper's Appendix B improves upon introductory treatments of insurance mathematics, which make the assumption that there are n identical insurance policies, each with independent and identically distributed loss random variables. (Appendix B, Sections 3.9-3.13, p. 112)

**Solution S7-IAA-114.** In the introductory treatments, as n increases, the variance of the loss ratio decreases and approaches zero, implying that a very large insurance company can write insurance with minimal risk. A more realistic approach involves a positive lower bound on the variance of the loss ratio. The IAA paper's Appendix B model sets this lower bound at $b_i + c_i + b_ic_i$, utilizing the parameters $b_i$ and $c_i$ for each line of insurance i. This attempts to account for the uncertainty of writing policies in a changing economic environment. The b parameters affect correlations among lines of business, while the c parameters affect correlations among individual insurance policies within a line of business.

**Problem S7-IAA-115.** Use the IAA paper's Appendix B model to derive the parameters $b_i$ and $c_i$ using the following hypothetical information about line of insurance i.

(Appendix B, Section 3.14, p. 113)

- The standard deviation of the loss ratio can be no smaller than 30%, regardless of the size of the insurer.
- The standard deviation of inflationary effects is 18%.

**Solution S7-IAA-115.**

The lower bound on the variance of the loss ratio is $0.3^2 = 0.09 = b_i + c_i + b_ic_i$.

$b_i$ is the variance due to inflationary effects, or $0.18^2 = \mathbf{b_i = 0.0324}$.

This means that $0.09 = 0.0324 + c_i + 0.0324*c_i \rightarrow$

$0.0576 = 1.0324*c_i \rightarrow$

$c_i = 0.0576/1.0324 = \mathbf{c_i = 0.0557923286}$.

**Problem S7-IAA-116.**

**(a)** Fill in the blanks (Appendix B, Section 4.1, p. 113): To utilize the IAA paper's Appendix B model to calculate risk-based capital, the regulators, in consultation with the insurers, must determine four parameters, before application of the reinsurance, of the loss model for each _____ for both _____ and _____.

**(b)** What are these four parameters?

**(c)** Briefly describe the five subsequent steps needed to arrive at the risk-based capital required. (Appendix B, Sections 4.3-4.8, p. 113-115)

**Solution S7-IAA-116.**

**(a)** To utilize the IAA paper's Appendix B model to calculate risk-based capital, the regulators, in consultation with the insurers, must determine four parameters, before application of the reinsurance, of the loss model for each **line of insurance** for both **current business** and **unsettled claims for past business**.

**(b)** The four parameters are **(1)** the expected value of the lognormal claim-severity distribution, **(2)** the coefficient of variation, $CV_i$, of the lognormal claim-severity distribution, **(3)** $b_i$, and **(4)** $c_i$.

**(c) 1.** Calculate the parameters $\mu_i$ and $\sigma_i$ (mean and standard deviation) or no reinsurance and for each reinsurance option.

**2.** Provide estimates for expected claim counts, $\lambda_i$, for each line of insurance by dividing the expected losses for each line of insurance by $\mu_i$ (mean loss amount).

**3.** Aggregate the expected loss and standard deviation figures for each line of business to arrive at the mean and variance of the aggregate loss distribution.

**4.** Using the aggregate loss distribution, calculate the TVaR at the desired percentile $\alpha$.

**5.** Calculate the risk-based capital (incorporating catastrophic risk by adding a catastrophe probable maximum loss), using the following formula:

**$TVaR_{\alpha}$ – Expected Net Loss on Current Business – Net Loss Reserve + Catastrophe PML**.

**Problem S7-IAA-117.** The IAA paper identifies four ways in which its sample internal risk-management formula in Appendix B model differs from the previously presented factor-based model. What are these four ways? (Appendix B, Section 5.2, p. 116)

**Solution S7-IAA-117.**

**1.** The choices of the claim-severity distributions were not conservative. The internal model uses claim distributions derived from the insurer's own analysis of claim severity.

**2.** The structure of the model is "richer". Random multipliers applied to the claim-count distributions across lines allow for a relaxation of the conservative assumption that each correlation of coefficient is equal to 1 across all lines of business.

**3.** The model calculates the aggregate loss distribution directly, rather than approximate the aggregate loss distribution with the first two moments.

**4.** The catastrophe model was incorporated directly into the internal risk-management model.

**Problem S7-IAA-118.**

**(a)** What is the practical effect of the Provision for Adverse Deviation (PAD) on the insurer's assets, liabilities, and capital? (Appendix B, Section 6.4, p. 117)

**(b)** What is a general formula for a PAD calculated at the 80% level, and how is this PAD incorporated afterward into the calculations of expected loss and the loss reserve?

**Solution S7-IAA-118.**

**(a)** Total assets for the insurer remain the same. The PAD shifts a portion of the capital over to the insurer's liabilities.

**(b)** PAD at the 80% level is equal to ($TVaR_{80\%}$ - Expected loss for the reserve in that line of insurance).

This value is **added** to the expected loss and loss reserve as a way of accounting for reserves being larger than expected.

**Problem S7-IAA-119. (a)** Fill in the blanks (Appendix D, Section 1.1, p. 130): Market risk results from the _____ and _____ inherent in the market value of future _____ from insurer assets and liabilities. Market risk is thus driven by exposure to _____.

**(b)** Identify four types of assets that are considered with respect to market risk.

**Solution S7-IAA-119.**

**(a)** Market risk results from the **volatility** and **uncertainty** inherent in the market value of future **cash flows** from insurer assets and liabilities. Market risk is thus driven by exposure to **movements in the level of financial variables**.

**(b)** Any four of the following will suffice:
**1.** Stock prices

**2.** Interest rates

**3.** Exchange rates

**4.** Commodity prices

**5.** Exposure of options in either the assets or liabilities to movements in underlying pricing variables

**Problem S7-IAA-120.** Fill in the blanks (Appendix D, Section 1.2, p. 130): Liquidity risk is the risk that various events will require the insurer to attempt to _____ (do what?) _____ (in what manner?).

**Solution S7-IAA-120.** Liquidity risk is the risk that various events will require the insurer to attempt to **liquidate various asset holdings prematurely, on short notice and under unfavorable terms.**

**Problem S7-IAA-121.**

**(a)** In addition to the volatility of market risk affecting the net market value of the insurer's assets, what are two ways in which market risk may affect the liabilities and net surplus position of the insurer?

**(b)** What are three categories of "interest" profit sharing within the global insurance market? (Appendix D, Section 1.3, p. 130)

**(c)** What could all three of these types of profit sharing include? (Appendix D, Section 1.4, p. 130)

**Solution S7-IAA-121.**

**(a) 1.** Changing asset yields will affect the market value of the liabilities through their effect on the rate(s) used to explicitly or implicitly discount the liability cash flows.

**2.** Changing asset returns (yields) may affect the amount and/or timing of future liability cash flows.

**(b)** Three types of "interest" profit sharing:
**1.** Profit sharing that is fully based on objective indicators of the performance of the capital market, e.g., an indicator of the actual interest-rate level that is calculated nad published periodically by a government agency, or a stock-market index.

**2.** Profit sharing that is somehow related to the actual performance of the company, particularly with respect to the company's investments.

**3.** Profit sharing that is related to the actual performance of the assets that are "locked-in" at the policyholders' discretion.

**(c)** All three types of profit sharing could include certain types of guarantees offered by the insurer, such as a bonus rate that will never be negative or a minimum level of the maturity benefit.

**Problem S7-IAA-122.** Fill in the blanks (Appendix D, Section 1.5, p. 130): Changes in asset returns in the external market may affect the amount and/or timing of future liability cash flows by inducing policyholders to _____ by _____ or _____.

**Solution S7-IAA-122.** Changes in asset returns in the external market may affect the amount and/or timing of future liability cash flows by inducing policyholders to **arbitrage the external returns with those available in the policy** by **surrendering the policy** or **paying additional premiums**.

**Problem S7-IAA-123.** According to the IAA paper, what three aspects should be taken into account when considering market risk? (Appendix D, Section 1.6, p. 131)

**Solution S7-IAA-123.**

**1.** Market risk applies to all assets and liabilities.

**2.** Market risk must recognize the profit-sharing linkages between the asset cash flows and the liability cash flows (e.g., liability cash flows are based on asset performance).

**3.** Market risk includes the effect of changed policyholder behavior on the liability cash flows due to changes in market yields and conditions.

**Problem S7-IAA-124.** According to the IAA paper, to appropriately measure market risk, the market values of both assets and liabilities.

**(a)** How can the market values of assets generally be arrived at?

**(b)** How can the market values of liabilities generally be arrived at? (Appendix D, Section 2.2, p. 131)

**Solution S7-IAA-124.**

**(a)** Market values of assets can generally be deduced from listings in the various securities markets.

**(b)** Market values of liabilities can be approximated through evolving market/fair-value techniques, due to lack of a market for insurance liabilities.

**Problem S7-IAA-125.** According to the IAA paper, it is common risk-management practice for insurers to explicitly or implicitly allocate their assets for one of three purposes. What are these purposes? (Appendix D, Section 2.3, p. 131)

**Solution S7-IAA-125.**

**1.** To support insurance contract liabilities

**2.** To represent economic capital

**3.** To represent free surplus

**Problem S7-IAA-126.** Describe what the IAA paper terms **(a)** Type A market risk and **(b)** Type B market risk. (Appendix D, Sections 2.4-2.5, p. 132)

**Solution S7-IAA-126.**

**(a) Type A market risk** applies to cases where it is possible to select assets whose cash flows can provide a very close match to the liability cash flows. It focuses on the volatility of the market value of the actual assets held and the market value of the replicating portfolio of assets and the ability of the insurer to manage that volatility. It also includes the effect of volatility on an insurer's stand-alone surplus or economic capital assets.

**(b) Type B market risk** includes the reinvestment risk that occurs when the insurer's assets are not of

as long a duration as the insurer's liabilities. This involves the risk that reinvestment rates may be lower in the future. Also, life-insurance contracts may contain various complex, long-term options and/or guarantees for which replicating market positions may not currently exist.

**Problem S7-IAA-127.** Give three reasons why the IAA paper recommends a risk-measurement time horizon of one year for insurer market risks. (Appendix D, Section 3.1, p. 132)

**Solution S7-IAA-127.**

**1.** One year recognizes the generally less active trading environment of insurers with respect to their asset and liability cash flows.

**2.** One year reflects a conservative view of the time required by a supervisor to assume control of the affairs of a weakened insurer.

**3.** One year reflects a conservative view of the time required for an insurer to rebalance a mismatched portfolio of assets and liabilities.

**Problem S7-IAA-128.**

**(a)** Is Type A market risk diversifiable? If so, to what extent? If not, why not? (Appendix D, Section 3.2, p. 132)
**(b) )** Is Type B market risk diversifiable? If so, to what extent? If not, why not? (Appendix D, Section 3.3, p. 132)

**Solution S7-IAA-128.**

**(a)** Type A market risk is **diversifiable** to the extent that the asset/liability-mismatch risk can be immediately eliminated through rebalancing the portfolio.

**(b)** Type B market risk is **not diversifiable** to some extent due to the limited availability of the replicating-asset portfolio or uncertainty about its composition.

**Problem S7-IAA-129.** What two possible conditions does the IAA paper discuss with regard to the confidence level for measuring market risk and setting required capital? (Appendix D, Section 4.1, p. 133)

**Solution S7-IAA-129.**

**1.** There should be a very high (e.g., 99%) confidence level that the assets of the insurer would be sufficient in one year's time to provide for the policy liabilities determined one year later at a moderate (e.g., 75%) level.

**2.** If the present value of the policy liabilities determined at time zero for all future durations at a fairly high (e.g., 90-95%) confidence level is greater, then this amount should be held.

**Problem S7-IAA-130.** Fill in the blanks (Appendix D, Section 5.3, p. 133): Market risk should include a provision for both _____ risk (for example, _____) and _____ risk (for example, _____).

**Solution S7-IAA-130.** Market risk should include a provision for both **specific** risk (for example, **as implied by the credit spread inherent in the yield of securities offered by the issuer**) and **general market** risk (for example, **general sensitivity to future rates of return**).

**Problem S7-IAA-131.**

**(a)** According to the IAA paper, in situations where the insurer has a block of insurance contracts which exhibit only Type A market risk, the insurer may choose to conduct what sort of modeling?

**(b)** What three aspects should such modeling reflect? (Appendix D, Section 5.5, p. 133)

**Solution S7-IAA-131.**

**(a)** The insurer may conduct integrated modeling of the projected future cash flows resulting from the insurance contracts and their matching assets.

**(b) 1.** Actual asset allocation of the insurer

**2.** Reinvestment policies of the insurer

**3.** Practices of the insurer for that business

**Problem S7-IAA-132.**

**(a)** According to the IAA paper, what is the appropriate time horizon for measuring Type B market risk?

**(b)** According to the IAA paper, how can the general Type B market-risk component best be measured at an advanced level? (Appendix D, Section 6.3, p. 134)

**Solution S7-IAA-132.**

**(a)** The appropriate time horizon is the entire duration of the liability cash flows.

**(b)** The general Type B market-risk component can best be measured at an advanced level through modeling of the insurer's actual reinvestment policies and practices.

**Problem S7-IAA-133.**

**(a)** According to the IAA paper, with what does the modeling process for Type B market risks begin?

**(b)** In this first step, what in particular, according to the IAA paper, must be understood?

**(c)** What needs to occur for this understanding to be possible?

**(d)** What is a subsequent step in this process?

**(e)** If the market risk for the liabilities is to be determined separately from the actual assets used to support them, then what concept would need to be employed?

**(f)** The IAA paper recommends that the combined asset and liability future cash flows would be modeled in an integrated manner to allow for what four types of information?

(Appendix D, Section 6.4, p. 134)

**Solution S7-IAA-133.**

**(a)** The modeling process begins with an identification of the assets and liabilities to be modeled.

**(b)** In particular, the process for generating the future cash flows under varying economic scenarios must be understood.

**(c)** For this understanding to be possible, the primary risk factors affecting market risk must be identified and defined for their impact on policyholder and company behaviors and strategies.

**(d)** The risk factors and their impact must be modeled as part of an integrated set of economic scenarios.

**(e)** The concept of a **replicating portfolio of assets** would need to be employed.

**(f) 1.** Asset/liability linkages

**2.** Pass-through of risks to policyholders

**3.** Reinvestment strategy and practices

**4.** Impact of economic scenarios on policyholder behavior.

**Problem S7-IAA-134.** According to the IAA paper, the difference between market-risk determinations for general market interest-rate risk for two sets of future cash flows, one slightly shorter than the replicating-portfolio horizon and the other slightly longer, will be minimized in what circumstances? (Appendix D, Section 6.9, p. 135)

**Solution S7-IAA-134.** This difference will be minimized the more accurately the investment practices of the insurer can be modeled.

**Problem S7-IAA-135.** What definition of a “replicating portfolio” does the IAA paper propose, in recognition of the fact that liability cash flows are subject to certain risks that cannot be hedged by financial instruments? (Appendix D, Section 6.11, p. 135)

**Solution S7-IAA-135.** The replicating portfolio only replicates the liability cash flows that are risk-adjusted for the systematic non-financial risks, while volatility due to diversifiable non-financial risks (e.g., volatility risk as a consequence of mortality) is fully ignored.

**Problem S7-IAA-136.**

**(a)** What effect do guarantees from the insurer to policyholders have on the market value of the insurer's liabilities, and why?

**(b)** Theoretically, the market value of the insurer's guarantees is equal to what? (Appendix D, Section 6.14, p. 135)

**(c)** What is the effect of embedded options which can be exercised by the insurer on the market value of the insurer's liabilities? (Appendix D, Section 6.16, p. 136)

**Solution S7-IAA-136.**

**(a)** Guarantees always **increase** the market value of the insurer's liabilities. They always offer additional value to the policyholders, since they indicate, implicitly or explicitly, that certain risks are transferred to the insurer.

**(b)** Theoretically, the market value of the insurer's guarantees is equal to the market value of the financial instruments that are necessary to hedge these guarantees.

**(c)** Embedded options which can be exercised by the insurer always **reduce** the market value of the insurer's liabilities.

**Problem S7-IAA-137.** When financial instruments to hedge the investment-return guarantees in life insurance are not amply available or non-existent, what two general ways does the IAA paper recommend to approximate their market values? (Appendix D, Section 6.17, p. 136)

**Solution S7-IAA-137.**

**1.** Option-pricing theory

**2.** Stochastic simulation using a combination of currently available financial instruments

**Problem S7-IAA-138.**

**(a)** Describe and give an example of "soft" liabilities of an insurer. (Appendix D, Section 6.18, p. 136)

**(b)** How can the present value of the liability cash flows for very long-term insurance liabilities be determined? (Appendix D, Section 6.19, p. 136)

**Solution S7-IAA-138.**

**(a)** "Soft" liabilities are those where an insurer has expressed the intention, but not the guarantee, to cover certain risks or to provide a certain minimum level of profit sharing.
**Examples** (any one will suffice):

**1.** Some life insurance benefits are conditionally indexed for price or wage inflation.

**2.** Some performance-linked contracts may offer positive bonus rates if the financial condition of the company, as assessed by management, allows for the extra pay-outs.

**(b)** The present value of very-long-term liability cash flows can be determined through modeling of the reinvestment policies and practices of the insurer into the future using currently available financial instruments.

**Problem S7-IAA-139.** For each of the following economic scenarios, identify three desirable modeling characteristics, as listed in the IAA paper (Appendix D, Section 6.20, pp. 136-137):

**(a)** Interest rates

**(b)** Equity returns

**(c)** Inflation

**Solution S7-IAA-139.**

**(a) Interest rates** (any three will suffice):

**1.** Nominal yields must remain positive and not increase indefinitely.

**2.** Interest rates are subject to mean reversion, but the reversion target is not constant.

**3.** Rate volatility decreases with maturity.

**4.** Higher volatility occurs with higher rates.

**5.** High correlation between maturities

**6.** Distinctive yield-curve shapes

**(b) Equity returns** (any three will suffice):

**1.** Negative skewness

**2.** Fat tails over short periods

**3.** Volatility clustering

**4.** Exogenous shocks

**5.** Markov property: Only the current state is important.

**6.** Market correlations increase under extreme conditions.

**7.** Price appreciation versus dividend income.

**(c) Inflation** (any three will suffice):

**1.** Non-persistence of extremely high or low inflation

**2.** Realized inflation may equal expected inflation plus exogenous shock.

**3.** Mean reversion exists, but target does not appear to be constant.

**4.** Volatility clustering

**5.** Various forms of inflation

**6.** Relationship to other economic factors

**Problem S7-IAA-140. (a)** According to the IAA paper, under what two assumptions can the discount rates for the cash flows of a replicating portfolio be set equal to the actual "risk-free" spot yields?

**(b)** What two results does this approach have? (Appendix D, Section 6.21, p. 137)

**Solution S7-IAA-140.**

**(a)** The following two assumptions would be made:
**1.** The cash flows of the replicating portfolio correspond with the liability cash flows that are adjusted for the systematic non-financial risks.

**2.** The diversifiable non-financial risks are ignored.

**(b) 1.** This approach implicitly provides for the specific risk of the issuer of the cash flows.

**2.** This approach allows the liquidity-premia preferences in market yields to emerge over the life of the cash flows.

**Problem S7-IAA-141. (a)** Give the formula for the Nelson-Siegel approach of estimating the spot yield $r_t^{spot}$, using the parameters $\beta_0$, $\beta_1$, $\beta_2$, and $\tau$.

**(b)** According to the IAA paper, what are the "nice" characteristics of this approach?

(Appendix D, Sections 6.22-6.23, p. 137)

**Solution S7-IAA-141.**

**(a)** $r_t^{spot} = \beta_0 + (\beta_1 + \beta_2)*\tau*[1-\exp(-t/\tau)]/t - \beta_2* \exp(-t/\tau)$.

**(b) 1.** The specification is reasonably parsimonious.

**2.** The spotyield for the very short duration is equal to $\beta_0 + \beta_1$.

**3.** The estimated spotyields for the long term converge to $\beta_0$.

**Problem S7-IAA-142.** According to the IAA paper, what are the six essential ingredients required to assess Type A market risk? (Appendix D, Section 7.4, p. 138)

**Solution S7-IAA-142.**

**1.** Projected future cash flows

**2.** Nature of embedded options

**3.** Time horizon

**4.** Confidence level

**5.** Current economic scenario

**6.** Series of adverse scenarios

**Problem S7-IAA-143.**

**(a)** Describe three approximation approaches with regard to the essential ingredients of assessing market risk. (Appendix D, Sections 7.5-7.8, p. 138)

**(b)** Identify four considerations that need to be balanced in the supervisor's selection of the approximation approach. (Appendix D, Section 7.9, p. 138)

**Solution S7-IAA-143.**

**(a) Approach 1:** Use option-adjusted durations to represent the price-sensitivity of cash flows, the current market value of future cash flows, and a set of investment-return shocks. The shocks would need to be designed to reflect the time horizon and confidence level desired as well as the possible pattern of adverse scenarios.

**Approach 2:** Group future cash flows into various term "buckets". The sum of the cash flows in these "buckets" would be multiplied by factors to produce the capital requirement. These factors would represent a combination of the essential ingredients.

**Approach 3:** Simply multiply the balance-sheet value of insurer assets and liabilities by a table of factors reflecting the presumed presence and size of Type A risk.

**(b)** Any four of the following will suffice:

**1.** Objectivity

**2.** Ease of calculation

**3.** High accuracy

**4.** Complexity

**5.** Overall impact of method on the management of market risk by insurers

**6.** Overall impact of method on the products offered in the marketplace

**Problem S7-IAA-144.** According to the IAA paper, what is a possible concern in designing approaches for modeling market risk which allow judgment to be used by the insurer? (Appendix D, Section 7.10, p. 138)

**Solution S7-IAA-144.** A concern is that the results might be less transparent, since there may be opportunities for the insurer to manipulate the resulting solvency requirement.

**Problem S7-IAA-145.** According to the IAA paper, what are the two relevant properties of fixed-income investments with regard to assessing their risk? (Appendix D, Section 7.13, p. 139)

**Solution S7-IAA-145. 1. Duration:** Sensitivity against an interest-rate increase

**2. Rating:** Matters for assessing the credit risk

**Problem S7-IAA-146.** Fill in the blanks (Appendix D, Section 7.14, p. 139): The market risk for fixed-income investments is dominated by the risk of _____. When the relevant interest rates (or the whole yield curve) increase by one percent, the value of a bond portfolio _____ (increases or decreases?) by _____. The duration can either be exactly computed from the _____ and the _____, or it can be approximately assessed as _____.

**Solution S7-IAA-146.** The market risk for fixed-income investments is dominated by the risk of **increasing interest rates**. When the relevant interest rates (or the whole yield curve) increase by one percent, the value of a bond portfolio **decreases** by **the amount of duration times 1%**. The duration can either be exactly computed from the **cash flows of the bond** and the **current zero-coupon yield curve**, or it can be approximately assessed as **80% of the mean time to maturity**.

**Problem S7-IAA-147.** According to the IAA paper, what are three drawbacks of the Macaulay duration analysis? (Appendix D, Section 7.15, p. 139)

**Solution S7-IAA-147.**

**1.** The duration approach requires a fair degree of complex modeling by the company.

**2.** The duration approach is based on a first-order Taylor approximation of the interest sensitivity of the present value. This approach is not very good for larger interest changes.

**3.** The duration approach assumes a parallel shift of the spot-yield curve, while non-parallel shifts are equally possible and possibly even more dangerous for the company.

**Problem S7-IAA-148.**

**(a)** Is the variance of interest-rate changes higher for long maturities or for short maturities?

**(b)** Is the variance of interest-rate changes higher for currencies with a high interest level or those with a low interest level?

**(c)** Give an approximate formula for $\sigma_{bond}$, the standard deviation of the yearly value change.
(Appendix D, Section 7.16, pp. 139-140)

**Solution S7-IAA-148.**

**(a)** The variance of interest-rate changes is higher for **short maturities.**

**(b)** The variance of interest-rate changes is higher for **currencies with a high interest level.**

**(c)** $\sigma_{bond} \approx$ (Mean time to maturity)*(Asset value)/100

**Problem S7-IAA-149. (a)** Fill in the blanks (Appendix D, Section 7.18, p. 140): Changes in bond yields may be caused by changes in the _____, changes in the _____, or changes in _____.

**(b)** Which of these changes only affect the market value of the actual assets available?
**(c)** Which of these changes only affect both the market value of the assets available and the market value of the replicating portfolio (liabilities)?

**Solution S7-IAA-149.**

**(a)** Changes in bond yields may be caused by changes in the **underlying risk-free rates**, changes in the **spreads that reflect the liquidity risk and credit risk of the asset**, or changes in **both components simultaneously**.

**(b) Changes in spreads** only affect the market value of the actual assets available.

**(c) Changes in risk-free rates** affect both the market value of the assets available and the market value of the replicating portfolio (liabilities).

**Problem S7-IAA-150.**

**(a)** Give an approximate formula for $\sigma_{FX}$, the volatility of the foreign-exchange rate for a bond denominated in a foreign currency. (Appendix D, Section 7.19, p. 140)

**(b)** Given an approximate formula for $\sigma_{ForeignBond}$, the volatility of a foreign bond that combines the components $\sigma_{bond}$ and $\sigma_{FX}$. (Appendix D, Section 7.21, p. 140)

**(c)** According to the IAA paper, what assumption regarding correlation is conservative in case of the formula in part (b)? (Appendix D, Section 7.22, p. 140)

**(d)** In what case might the true risk be smaller? (Appendix D, Section 7.23, p. 140)

**Solution S7-IAA-150.**

**(a)** $\sigma_{FX} \approx 0.1*(\text{Asset Value})$

**(b)** $\sigma_{ForeignBond} \approx \sqrt{(\sigma_{bond}^2 + \sigma_{FX}^2)} \approx \sqrt{([\text{Mean Time to Maturity}]^2/10000 + 0.01)}$.

**(c) Zero correlation** is a conservative assumption in this case.

**(d)** The true risk might be smaller if there exists asset-liability matching.

**Problem S7-IAA-151.**

**(a)** Fill in the blanks (Appendix D, Section 7.24, p. 140): Equity and property positions are subject to Type A market risk when these assets are used to fund _____ or represent _____. In these situations, market risk results from _____ volatility in the _____.

**(b)** Is the volatility of equity returns higher or lower than for bonds? (Appendix D, Section 7.25, p. 140)

**Solution S7-IAA-151.**

**(a)** Equity and property positions are subject to Type A market risk when these assets are used to fund **similarly performing policyholder liabilities** or represent **free surplus**. In these situations, market risk results from **short-term** volatility in the **market value of the underlying assets**.

**(b)** The volatility of equity returns is **higher** than for bonds.

**Problem S7-IAA-152.** For a hypothetical equity denominated in a foreign currency, the volatility (standard deviation) of the yearly value change of the equity itself is 0.35. The volatility of the foreign-exchange rate is 0.25. Using the approximation formula in the IAA paper, what is the total volatility of the foreign equity? (Appendix D, Section 7.26, p. 141)

**Solution S7-IAA-152.** We use the formula $\sigma_{ForeignEquity} \approx \sqrt{(\sigma_{equity}^2 + \sigma_{FX}^2)}$.

Here, $\sigma_{equity} = 0.35$, and $\sigma_{FX} = 0.25$. Thus, $\sigma_{ForeignEquity} \approx \sqrt{(0.35^2 + 0.25^2)} =$ **0.4301162634.**

**Problem S7-IAA-153. (a)** If assets needed to hedge embedded options in an insurance contract are not actually available, what kind of mismatch might arise?

**(b)** According to the IAA paper, what should a solvency requirement pertaining to this mismatch be equal to? (Appendix D, Section 7.31, p. 141)

**Solution S7-IAA-153.**

**(a)** A mismatch might arise between the options that are embedded in liabilities and the derivative assets that are intended to cover them.

**(b)** The solvency requirement pertaining to this mismatch should be equal to a conservative estimate of the possible change of the difference between the market values of the options embedded in the liabilities and the derivative assets. The mismatch buffer only needs to cover the possible change of this difference within the limited time period under consideration (e.g., a year).

**Problem S7-IAA-154.** Fill in the blanks (Appendix D, Section 7.36, p. 142): Dependencies between asset market prices/yields of different asset types, particularly fixed-interest, equity, and property (but excluding derivatives), are generally ____. It may therefore be reasonable to assume _____ correlation between all these asset types in a factor-based approach. Consequently, the total solvency requirement for market risks can be set equal to the _____.

**Solution S7-IAA-154.** Dependencies between asset market prices/yields of different asset types, particularly fixed-interest, equity, and property (but excluding derivatives), are generally **low**. It may therefore be reasonable to assume **zero** correlation between all these asset types in a factor-based approach. Consequently, the total solvency requirement for market risks can be set equal to the **square root of the sum of squared requirements for these individual asset classes**.

**Problem S7-IAA-155.** Fill in the blanks (Appendix D, Section 7.38, p. 142): Correlations within individual asset categories are generally _____. Implicitly, this is taken into account by _____, instead of _____. Any "extra" correlations due to possible concentrations within categories can be _____.

**Solution S7-IAA-155.** Correlations within individual asset categories are generally **high**. Implicitly, this is taken into account by **defining and summing different solvency requirements for different asset categories**, instead of **defining and summing them for individual assets**. Any "extra" correlations due to possible concentrations within categories can be "**penalized" by adding solvency requirements for concentration risks**.

**Problem S7-IAA-156. (a)** For fixed-interest securities, verbally summarize the four steps of the approach described in the IAA paper, intended to allow for non-parallel shifts in the spot-yield curve. (Appendix D, Section 7.39, pp. 142-143)

**(b)** Fill in the blanks (Appendix D, Section 7.40, p. 143): This approach assumes that each of the individual spot yields may either rise or fall within the next year. In this respect, _____ correlation between individual spot yields is assumed. However, by simply summing the resulting individual solvency requirements, we implicitly assume correlations to be equal to _____.

**Solution S7-IAA-156. (a) 1.** Select a number of modified duration bands with corresponding median durations and corresponding actual risk-free spot yields, according to the actual risk-free spot-yield curve.

**2.** Define "maximum" potential absolute changes of spot yields that may occur within the first next year, for each of the individual spot yields individually.

**3.** Allocate the cash flows of the available fixed-interest securities and liabilities respectively to the different duration bands, calculate actual the market values as well as their balance per duration band, and define the solvency requirement for each duration band as the absolute value of the product of the median duration, the maximum absolute potential change in the spot yield, and the balance of the market value in that duration band.

**4.** Define the total solvency requirement for fixed-interest securities as the sum of the requirements for the individual duration bands.

**(b)** This approach assumes that each of the individual spot yields may either rise or fall within the next year. In this respect, **zero** correlation between individual spot yields is assumed. However, by simply summing the resulting individual solvency requirements, we implicitly assume correlations to be equal to **one**.

**Problem S7-IAA-157.** What approaches does the IAA paper recommend for assessing Type B market risk for **(a)** long-term interest guarantees in life insurance and annuity products, and **(b)** complex options? (Appendix D, Section 8.2, p. 143)

**Solution S7-IAA-157.**

**(a) Long-term interest guarantees in life insurance and annuity products:** The present value of future liability cash flows must be determined on the presumption that long-term reinvestment returns revert to a conservative view of historical long-term averages.

**(b) Complex options:** Appropriately conservative factors must be derived based on rigorous stochastic modeling of industry-wide data to adequately capture the tail of the loss distribution for the confidence level required.

**Problem S7-IAA-158.**

**(a)** State the IAA paper's definition of "credit risk". (Appendix E, Section 1.1, p. 145)

**(b)** Fill in the blanks (Appendix E, Section 1.2, p. 145): Credit risk has been traditionally associated with _____. However, it can exist with respect to any _____. Credit risk might even be considered to exist in regard to the _____ resulting from the _____. This latter aspect of credit risk is controversial, as it suggests the value of _____ diminishes as the credit risk of the insurer declines. The IAA paper recommends that insurer capital requirements for credit risk _____ [do or do not?] reflect the potential ability of the insurer to default on its own cash flows.

**(c)** Fill in the blanks (Appendix E, Section 1.3, p. 145): Credit risk can be reflected in the present value of a set of cash flows either implicitly via a _____ or via explicit _____.

**Solution S7-IAA-158.**

**(a)** Credit risk is the inability or unwillingness of a counterparty to fully meet its on- and/or off-balance-sheet contractual financial obligations. The counterparty could be an issuer, a debtor, a borrower, a broker, a policyholder, a reinsurer, or a guarantor.

**(b)** Credit risk has been traditionally associated with **assets**. However, it can exist with respect to any **set of projected future cash flows**. Credit risk might even be considered to exist in regard to the **projected future cash flows** resulting from the **policyholder obligations**. This latter aspect of credit risk is controversial, as it suggests the value of **policyholder obligations** diminishes as the credit risk of the insurer declines. The IAA paper recommends that insurer capital requirements for credit risk **do not** reflect the potential ability of the insurer to default on its own cash flows.

**(c)** Credit risk can be reflected in the present value of a set of cash flows either implicitly via a **credit-risk spread incorporated in the discount rate** or via explicit **modeling of the cash flows themselves**.

**Problem S7-IAA-159.** The market value of a stream of projected future cash flows reflects the current market view of the credit risk of the provider of the cash flows. Identify three elements that such a market view might consider, as discussed in the IAA paper. (Appendix E, Section 1.4, p. 145)

**Solution S7-IAA-159.** Any three of the following will suffice:

**1.** The current financial position of the issuer

**2.** The current economic environment

**3.** The possibility of the issuer slipping in its ratings (i.e., ability to pay)

**4.** The probability of default of the issuer

**5.** The amount of loss given that default occurs

**Problem S7-IAA-160.**

**(a)** According to the IAA paper, the allocation of assets to support specific policy liabilities is especially important for what kinds of insurance products?
**(b)** If credit toward the insurer's credit-risk capital requirement is granted with respect to these insurance products, what two elements should that credit take into account, according to the IAA paper? (Appendix E, Section 2.3, p. 146)

**Solution S7-IAA-160.**

**(a)** The allocation of assets to support specific policy liabilities is especially important for insurance products whose performance depends directly on the performance of the underlying assets.

**(b)** The following two elements should be taken into account:

**1.** Policyholders' reasonable expectations of sharing in the asset performance

**2.** The insurer's practices in sharing such experience with policyholders

**Problem S7-IAA-161.** Define **(a)** Type A credit risk and **(b)** Type B credit risk. (Appendix E, Section 2.4, p. 146)

**Solution S7-IAA-161.**

**(a) Type A credit risk:** In situations where it is possible to select assets whose cash flows can provide a very close match to the liability cash flows, credit risk focuses on the actual assets held and the ability of the insurer to manage its credit-loss position within the replicating-portfolio horizon.

**(b) Type B credit risk:** In situations where the long-term duration of some insurance liabilities requires the consideration of long-term reinvestment of existing assets – since a replicating portfolio of assets of sufficient duration may not be currently offered in the market – credit risk focuses not only on current assets but also on the credit risk involved with future reinvested assets.

**Problem S7-IAA-162.** Identify and describe four of the key drivers of credit risk discussed in the IAA paper. (Appendix E, Section 3.1, pp. 146-147)

**Solution S7-IAA-162.** Any four of the following will suffice:
**1. Credit quality:** Probability that the issuer will meet all contractual obligations. One of the most common measurements used to assess credit quality is the rating assigned to the issuer by a variety of ratings agencies.

**2. Maturity:** The longer the term to maturity of an investment, the longer even a high-quality issuer has to potentially deteriorate.

**3. Concentration by industry:** Conditions that trigger credit events have a tendency to impact the entire economy simultaneously, but the impact varies among sectors of the economy. The sector-specific impact should be considered.

**4. Concentration by geography:** Credit risk has high geographic contagion. Periods of relatively few credit events are followed by periods where default experience is extremely high. Economically depressed regions tend to produce high levels of default experience in comparison with more prosperous areas.

**5. Size of expected loss:** Can vary widely, from loss of some or all of the return on an investment to loss of some, or all, of the inherent principal. Losses can also occur from a delay in the timing of a scheduled payment, causing a loss of return during the deferral period and/or a reduction in available reinvestment rate during the deferral period.

**Problem S7-IAA-163.** Identify three hedging strategies for offsetting credit risk, listed in the IAA paper. (Appendix E, Section 4.2, p. 147)

**Solution S7-IAA-163.** Any three of the following will suffice:

**1.** Letters of credit

**2.** Contingency deposits

**3.** Securitization of mortgages (mortgage-backed securities)

**4.** Securitization of other assets (asset-backed securities)

**5.** Credit derivatives

**Problem S7-IAA-164. (a)** Briefly describe **default models** of credit risk in qualitative terms. (Appendix E, Section 5.2, p. 148)

**(b)** Using the default model described in the IAA paper (Appendix E, Section 5.3, p. 148), calculate the current value of a cash flow under the following conditions:

- A $1530 cash flow is expected one year from now.
- The issuer's probability of default is 30%.
- If the issuer defaults, the expected recovery is 45% of the full amount due.
- The risk-free one-year interest rate is 0.5%.

**Solution S7-IAA-164.**

**(a)** In default models, the rates of default are recovery are modeled explicitly. Present values are taken using the risk-free interest-rate curve, and different cash flows under assumptions of default or non-default are valued using probabilities.

**(b)** We use the formula Current Value = [C*(1-p) + C*p*R]/(1+i), where C is the expected future cash flow, p is the issuer's probability of default, R is the probability of recovery in the event of default, and i is the risk-free one-year interest rate:
Current Value = [1530*(1-0.3) + 1530*0.3*0.45]/(1.005) = **1271.19403**.

**Problem S7-IAA-165. (a)** What are the only two states considered by default models?

**(b)** In addition to the risk of default, what do **credit-migration models** consider? (Appendix E, Section 5.5, p. 148)

**(c)** What is the basic premise behind Merton's **asset models**? (Appendix E, Section 5.6, p. 148)

**(d)** With what can an asset model be combined to produce a portfolio-level risk-management model? (Appendix E, Section 5.7, p. 148)

**Solution S7-IAA-165.**

**(a)** The only two states considered by default models are "in default" and "not in default".

**(b)** Credit-migration models also consider the risk that an investment will lose or gain value due to changes in the corporation's credit rating.
**(c)** The basic premise behind Merton's asset models is that a firm will go into default if the value of its assets becomes less than the value of its debts, so the firm's debt can be modeled as an option against its assets.

**(d)** An asset model can be combined with a **model of correlations between obligors** to produce a portfolio-level risk-management model.

**Problem S7-IAA-166.**

**(a)** What is the time horizon recommended by the IAA paper for determining credit risk?

**(b)** What are three reasons the IAA paper gives for selecting this time horizon? (Appendix E, Section 7.1, p. 148)

**(c)** With respect to Type B credit risk, what should be considered beyond the one-year time frame? (Appendix E, Section 7.2, p. 149)

**Solution S7-IAA-166.**

**(a)** The recommended time horizon is **one year.**

**(b) 1.** One year recognizes the generally less active trading environment of insurers with respect to their asset and liability cash flows.

**2.** One year reflects a conservative view of the time required by a supervisor to assume control of the affairs of a weakened insurer.

**3.** One year reflects a conservative view of the time required for an insurer to address the credit risk in its assets.

**(c)** The full term of all the assets and obligations of the insurer should be considered. Type B credit risk involves systematic, undiversifiable risk due to the limited availability of parts of the replicating-asset portfolio or uncertainty about its composition. These risks should be assessed for the full remaining term of the liabilities.

**Problem S7-IAA-167.** What limitation does the IAA paper recommend with regard to supervisory credit-risk assessment guidelines? (Appendix E, Section 8.6, p. 149)

**Solution S7-IAA-167.** A supervisory credit-risk assessment guideline should be designed in a way not to demand the use of commercial software packages or services. The proposed guideline should provide a formula that is compatible to the multivariate normal framework of the base-line approach.

**Problem S7-IAA-168.** Let $p_T$ be the probability of default on a bond over time period T. **(a)** Give a simple formula for the theoretical value of this bond, in terms of the bond principal amount and $p_T$.

**(b)** Give a simple formula for $\sigma^2_{credit}(T)$, the variance of the value change of this bond due to credit risk, in terms of the bond principal amount and $p_T$. (Appendix E, Section 8.7, pp. 149-150)

**(c)** Assume that, for a bond, $p_T = 43\%$, and the principal is \$5000. Using the formulas in parts (a) and (b), what is the theoretical value of the bond and the variance due to credit risk?

**(d)** What is the nature of the distribution function implied by these formulas? **(**Appendix E, Section 8.8, p. 150)

**Solution S7-IAA-168.**

**(a)** Asset Value $\approx (1- p_T)$*Principal

**(b)** $\sigma^2_{credit}(T) = p_T$*(Asset Value)$^2$

$\mathbf{\sigma^2_{credit}(T) = p_T*(1- p_T)^2*(Principal)^2}$

**(c)** Asset Value $\approx (1- p_T)$*Principal = (1-0.43)*5000 = **\$2850**.

$\sigma^2_{credit}(T) = p_T$*(Asset Value)$^2 = 0.43*2850^2 =$ **3492675**.

**(d)** The distribution function is **binomial**.

**Problem S7-IAA-169.** Comment on the accuracy of a default-only model with respect to estimating the variance due to credit risk. **(**Appendix E, Section 8.9, p. 150)

**Solution S7-IAA-169.** A default-only model **underestimates** the variance due to credit risk. Fluctuations in the rating of the issuer have to be included to arrive at sufficiently large estimated standard deviations.

**Problem S7-IAA-170.** What are the two assumptions that the model of credit risk in the IAA paper makes with regard to rating fluctuations? **(**Appendix E, Section 8.10, p. 150)

**Solution S7-IAA-170.**

**Assumption 1:** There is a rating scale on which the rating fluctuation can be described as a Brownian motion in a sufficiently good approximation.

**Assumption 2:** There is a minimum value on this scale that corresponds to a default and serves as an absorbing state of the Brownian motion.

**Problem S7-IAA-171.** Let N(.) be the cumulative standard normal distribution with unit variance. Let $\Phi(.) = 2N(.) - 1$, and let k be a constant that depends on the initial credit rating of the issuer.

**(a)** Provide the formula used by the IAA paper to determine $p_T$, the probability of default on a bond over time period T. **(**Appendix E, Section 8.11, p. 150)

**(b)** Provide the formula used by the IAA paper to relate $p_T$ to $p_1$, the default probability over one year. **(**Appendix E, Section 8.12, p. 150)

**(c)** Provide the formula used by the IAA paper to approximate $\sigma^2_{credit}(T)$, the yearly variance of returns due to credit risk (Appendix E, Section 8.13, p. 151)

**Solution S7-IAA-171.**

**(a)** $p_T = 1 - \Phi(k/\sqrt{(T)})$.

**(b)** $p_T = 1 - \Phi[\sqrt{(1/T)}*\Phi^{-1}(1- p_1)]$.

**(c)** $\sigma^2_{credit}(T) = (1/T)*p_T = (1/T)*\Phi[\sqrt{(1/T)}*\Phi^{-1}(1- p_1)]$ .

**Problem S7-IAA-172.** According to the IAA paper, what limits the diversification effects for a portfolio of different corporate bonds, and how does this relate to the volatility level of default frequencies? (Appendix E, Section 8.15, p. 151)

**Solution S7-IAA-172.** The diversification effects are limited by correlations among defaults. Default frequencies depend on worldwide economic cycles, and the geographical and economic proximity of different issuers may affect the correlations. Some defaults may lead to chain reactions. As a result, default frequencies exhibit a higher volatility level than would be suggested by a purely stochastic, Poisson-like model.

**Problem S7-IAA-173.**

**(a)** For all individual standard deviations of credit risk, $\sigma_{credit,i}$, what is an expression for the maximum possible variance due to credit risk, in the case of full dependence? (Appendix E, Section 8.16, p. 151)

**(b)** What is the expression for variance due to credit risk, in the case of no dependence? (Appendix E, Section 8.17, p. 151)

**(c)** According to the "conservative" assumption of the IAA paper, what is the correlation coefficient that "best" approximates diversification?

**(d)** What is the formula for credit risk for a bond portfolio, resulting from the correlation coefficient in part (c)? Let $\alpha$ = the estimated degree of diversification (Appendix E, Section 8.18, p. 152)

**Solution S7-IAA-173.**

**(a) Full dependence:** $(\sigma_{credit,max})^2 = (_i\sum\sigma_{credit,i})^2$, i.e., the square of the sum.

**(b) No dependence:** $(\sigma_{credit,total})^2 = _i\sum(\sigma_{credit,i}^2)$, i.e., the sum of the squares.

**(c)** The IAA paper recommends a correlation coefficient of **0.5**.

**(d)** $\sigma_{credit,total}^2 = (\alpha/2)*_i\sum(\sigma_{credit,i}^2) + (1- \alpha/2)*(_i\sum\sigma_{credit,i})^2$, i.e., a weighted average with a weight of $\alpha/2$ assigned to the sum of the squares.

**Problem S7-IAA-174. (a)** Fill in the blank (Appendix E, Section 8.19, p. 152): Chain reactions in case of defaults may lead to a _____ of the true overall credit risk.

**(b)** Provide the IAA paper's formula of combining the market and credit risk of a fixed-income portfolio. What assumption does this formula make? (Appendix E, Section 8.20, p. 152)

**Solution S7-IAA-174.**

**(a)** Chain reactions in case of defaults may lead to a **fat tail** of the true overall credit risk.

**(b)** $\sigma_{FixedIncome} = \sqrt{(\sigma_{bond,market}^2 + \sigma_{credit}^2)}$. This formula assumes independence between bond markets and downgrades/defaults.

**Problem S7-IAA-175.**

**(a)** According to the IAA paper, how can the present-value amount of the provision for Type B credit risk be estimated?
**(b)** What are two areas in which care should be exercised in estimating such a provision? (Appendix E, Section 9.3, p. 152)

**Solution S7-IAA-175.**

**(a)** The present-value amount of the provision for Type B credit risk can be estimated through determination of the credit spread inherent in future investment returns.

**(b)** Care must be exercised to:

**1.** Avoid double-counting the credit-risk provision for Type A credit risk in both the liabilities and via direct reference to the current assets;

**2.** Ensure that an appropriate provision for Type B credit risk has been made and that the provision is sufficient for solvency purposes.

**Problem S7-IAA-176.** What are the three standardized approaches to assessing Type B credit risk, recommended by the IAA paper? (Appendix E, Section 11.2, p. 153)

**Solution S7-IAA-176.**

**Approach 1:** Where it is not possible to directly compute the present value of future liability cash flows, provision for Type B credit risk can be made approximately by applying a factor to the policy liabilities of long-term business. These factors would need to be tailored to the circumstances of an individual supervisor and their financial reporting structure for these liabilities.

**Approach 2:** Where it is possible to estimate the duration of long-term business, provision for Type B risk can be made approximately by applying a credit-risk spread to the duration (beyond that of the current assets) and policy liabilities for long-term business.

**Approach 3:** Where it is possible to directly compute the present value of future liability cash flows, provision for Type B credit risk can be made through use of a credit-risk spread.

**Problem S7-IAA-177.**

**(a)** Given random variable X, give the expression for the cumulant generating function of x, $\varphi_x(t)$.
(Appendix H, Section 1.2, p. 166)

**(b)** Let $\kappa_n$ be the nth cumulant of the distribution – e.g., $\kappa_1 = \mu$: the mean, and $\kappa_2 = \sigma^2$, the variance. Give the series expansion of the cumulant generating function of x, $\varphi_x(t)$, using summation notation.
(Appendix H, Section 1.3, p. 166)

**(c)** Give the cumulant generating function for the Normal distribution. (Appendix H, Section 1.4, p. 166)

**(d)** How does the cumulant generating function for the Normal distribution relate to the cumulant generating function of the "true" probability distribution of a random variable? (Appendix H, Section 1.5, p. 166)

**Solution S7-IAA-177.**

**(a)** $\varphi_X(t) = \ln[E(e^{tX})]$.

**(b)** $\varphi_X(t) = {}_{n=1}^{\infty}\Sigma[(\kappa_n * t^n)/n!]$.

**(c)** For the Normal distribution: $\varphi_X(t) = \mu t + (\sigma^2 * t^2)/2$.

**(d)** The Normal distribution's cumulant generating function has all cumulants $\kappa_3$ and higher equal to zero. Hence, its cumulant generating function is the first two terms of the generic cumulant generating function. The Normal distribution can be viewed as a first-order approximation of the "true" probability distribution.

**Problem S7-IAA-178.** Qualitatively describe the method mentioned in the IAA paper for examining the error in the Normal approximation to the probability distribution of a random variable. (Appendix H, Section 1.7, p. 166)

**Solution S7-IAA-178.** The method is to obtain upper bounds on the error of key quantities, such as risk measures when the mean and variance are fixed but the higher cumulants are unknown. The upper bounds are useful for a supervisor in evaluating maximum possible error in adopting a relatively simple model as a baseline model.

**Problem S7-IAA-179.** For n random variables $X_1$ through $X_n$, let $\rho_{i,j}$ be the correlation between the ith and jth components, let $\sigma_i$ be the standard deviation of the ith component, and let $\sigma_j$ be the standard deviation of the jth component. Give the formula for $\sigma$, the standard deviation of the aggregate distribution. (Appendix H, Sections 1.9-1.10, p. 167)

**Solution S7-IAA-179.** $\sigma = \sqrt{({}_{i,j=1}^{n}\Sigma[\rho_{i,j} * \sigma_i * \sigma_j])}$.

**Problem S7-IAA-180. (a)** According to the IAA paper, what are two major sources of error that need to be recognized when using the Normal model as a baseline capital model? Describe each source in a moderate level of detail. (Appendix H, Section 1.12, p. 167)

**(b)** What are two ways the IAA paper recommends for a supervisory framework to recognize these sources of errors? (Appendix H, Section 1.13, p. 167)

**Solution S7-IAA-180. (a) 1.** The true probability distributions associated with particular risks may be quite different from the Normal distribution. Observed extreme events suggest that a heavier tail of the probability distribution exists in reality. Typical risk measures, such as standard deviation or VaR can seriously underestimate the true risk if the true model is significantly different from the Normal distribution.

**2.** When the marginal distributions of the various risks are combined into a multivariate distribution, the linear correlation used in the Normal distribution may not be well-suited to combining interactions in the extreme tails of the distribution, since normal correlation describes the degree of linearity of the relationship between two risks over the entire range of the distributions, and does not focus mainly on the tails.

**(b)** The supervisory framework could:

**1.** Require a multiple (e.g., 150%) of the capital indicated by using a specific model. This provides a cushion for model error.

**2.** Incorporate directly some conservative elements into assumptions, parameters, and correlations in the base-line model.

**Problem S7-IAA-181.** Identify three common criticisms of risk measures based on the Normal distribution. (Appendix H, Section 2.5, p. 168)

**Solution S7-IAA-181.** Risk measures based on the Normal distribution
**1.** May fail to differentiate between the upside and downside for risks with skewed and fat-tail distributions;

**2.** May fail to reflect non-linear correlation (e.g., higher-tail correlations);

**3.** May violate some of the "consistency" rules for a coherent risk measure.

**Problem S7-IAA-182.**

**(a)** Give the formula for the Wang Transform F*(x) of a loss distribution with cumulative distribution function F(x). Let N(.) be the cumulative normal distribution function.

**(b)** Describe the characteristics (nature, meanm and standard deviation) of the distribution which results from applying the Wang Transform to a Normal distribution with mean $\mu$ and standard deviation $\sigma$. What special function can the mean of the transformed distribution serve? (Appendix H, Section 2.7, p. 168)

**Solution S7-IAA-182.**

**(a)** $F^*(x) = N[N^{-1}(F(x))-\lambda]$.

**(b)** The transformed distribution is also Normal and has mean $\mu+\lambda\sigma$ and standard deviation $\sigma$. The mean can serve the function of the risk measure or the required capital.

**Problem S7-IAA-183.** According to the IAA paper, one can consider the insurer capital C as a function of the exposure levels of each of the component risks. What are three simple proxies for exposures? (Appendix H, Section 3.1, p. 168)

**Solution S7-IAA-183.** Three simple proxies for exposures are (1) amounts-at-risk, (2) premiums, and (3) reserves.

**Problem S7-IAA-184. (a)** The IAA paper describes a process of approximating any power of the capital requirement C using a Taylor expansion. Let $(e_1, \ldots, e_n)$ describe the various exposures faced by the insurer, and let the specific points $(e_1^0, \ldots, e_n^0)$ describe the "target mix" of exposures. Give the general formula for the Taylor expansion of $C^m$, the mth power of the estimated capital requirement, utilizing the "target mix" of exposures. (Appendix H, Section 6.1, p. 170)

**(b)** What important flexibility is gained over the baseline multivariate Normal model when using this approximation approach? (Appendix H, Section 7.1, p. 170)

**Solution S7-IAA-184.**

**(a)** $C^m(e_1, \ldots, e_n) = (1/m!)*_{i\_1,\ldots,i\_m}\Sigma([\partial^m(C^m)/(\partial e_{i\_1}{}^0*\ldots*\partial e_{i\_m}{}^0)]*[e_{i\_1}*\ldots*e_{i\_m}]) +$ terms of order (m+1) and higher.

**(b)** The results of this approximation approach permit the use of any distribution and any risk measure, not just the Normal distribution and measures such as TVaR and standard deviation.

**Problem S7-IAA-185.** What are two ways in which insurance claim data show the shortcomings of the assumption that each risk component for an insurer follows a Normal distribution? (Appendix I, Section 1.3, p. 171)

**Solution S7-IAA-185.**

**1.** Loss distributions are usually skewed and heavy-tailed.

**2.** Dependency between risks usually increases in the tails – including dependency among various lines of business.

**Problem S7-IAA-186.**

**(a)** Fill in the blanks (Appendix I, Section 1.6, p. 171): An n-dimensional copula is an n-dimensional _____ with uniform _____ distributions.

**(b)** Fill in the blanks (Appendix I, Section 1.6, p. 171): For random variables $X_1$ through $X_n$, the dependence structure is described by C if the distribution function F of $X_1$ through $X_n$ is given by $F(x_1, \ldots, x_n) =$ _____, where $F_j$ denotes the _____ of $X_j$.

**(c)** Fill in the blanks (Appendix I, Section 2.2, p. 174): A copula is a function that associates the _____ of one random variable to the _____ of another random variable.

**Solution S7-IAA-186.**

**(a)** An n-dimensional copula is an n-dimensional **distribution function** with uniform **marginal** distributions.

**(b)** For random variables $X_1$ through $X_n$, the dependence structure is described by C if the distribution function F of $X_1$ through $X_n$ is given by $F(x_1, \dots, x_n) = \mathbf{C(F_1(x_1), \dots, F_n(x_n))}$, where $F_j$ denotes the **marginal distribution function** of $X_j$.

**(c)** A copula is a function that associates the **quantiles** of one random variable to the **quantiles** of another random variable.

**Problem S7-IAA-187.** Fill in the blank (Appendix I, Section 2.4, p. 175): Suppose that the dependence among random variables $X_1$ through $X_n$ can be adequately represented by a model (i.e., we know the marginal distribution functions $F_j$). Furthermore, assume that we have an algorithm to simulate independent random vectors $(u_1^k, \dots, u_n^k)$, k = 1, 2, … from C. Then _____ are independent random samples of X, and in this way we have obtained a model for X.

**Solution S7-IAA-187.** Suppose that the dependence among random variables $X_1$ through $X_n$ can be adequately represented by a model (i.e., we know the marginal distribution functions $F_j$). Furthermore, assume that we have an algorithm to simulate independent random vectors $(u_1^k, \dots, u_n^k)$, k = 1, 2, … from C. Then $\mathbf{F_1^{-1}(u_1^k) + \dots + F_n^{-1}(u_n^k)}$ are independent random samples of X, and in this way we have obtained a model for X.

**Problem S7-IAA-188.**

**(a)** Complete the sentence (Appendix I, Section 2.8, p. 175): Suppose that C is a copula for $X_1, \dots, X_n$. If $\varphi_1, \dots, \varphi_n$ are non-decreasing functions, then C is _____.

**(b)** What are two uses of this property in the insurance industry? (Appendix I, Section 2.9, p. 175)

**Solution S7-IAA-188.**

**(a)** Suppose that C is a copula for $X_1, \dots, X_n$. If $\varphi_1, \dots, \varphi_n$ are non-decreasing functions, then C is **also a copula for $\varphi_1(X_1), \dots, \varphi_n(X_n)$**.

**(b) 1.** If there exist sensitive data that is not intended to be disclosed, the data could be transformed by an increasing function without losing the information needed for estimating copulas. Copulas are a potential tool for making otherwise sensitive data available to public use without violating

confidentiality.

**2.** A reinsurance structure in a certain line of business typically is a non-decreasing function of the underlying losses. Hence, the copula for the gross losses can reliably be assumed to be the same for the net losses.

**Problem S7-IAA-189.**

**(a)** Give the formula for the Gauss copula using the following definitions (Appendix I, Section 3.1, p. 176):
$\Phi$ = distribution function of the standard normal distribution;

$\Phi_n^R$ = the n-variate standard normal distribution function with correlation matrix R;

$C_R^{Gauss}(u_1, \ldots, u_n)$ = the n-dimensional Gauss copula with correlation matrix R.

**(b)** What is a shortcoming of Gauss copulas, and how do t-copulas overcome this shortcoming? (Appendix I, Sections 3.3-3.4, p. 176)

**Solution S7-IAA-189.**

**(a)** $C_R^{Gauss}(u_1, \ldots, u_n) = \Phi_n^R(\Phi^{-1}(u_1), \ldots, \Phi^{-1}(u_n))$.

**(b)** A shortcoming of Gauss copulas is that they are not suitable to model the tail of X. If the random variables are not perfectly correlated, the tail dependencies are zero. To overcome this shortcoming, t-copulas employ one additional parameter $\nu$ to control the tail dependencies, with $\nu = \infty$ corresponding to the Gauss copula.

**Problem S7-IAA-190.**

**(a)** Briefly describe what a *comonotonic copula* is and what it signifies for insurers. (Appendix I, Section 3.9, p. 177)

**(b)** Fill in the blanks (Appendix I, Section 3.10, p. 177): In general, any dependency at a single point in the multivariate distribution can be described as a linear combination of the _____ copula and the _____ copula (the latter obtained by _____).

**Solution S7-IAA-190.**

**(a)** A comonotonic copula ensures that risks always move in the same direction. This is a "worst case" for insurers, and its results provide an upper bound on the capital requirement.

**(b)** In general, any dependency at a single point in the multivariate distribution can be described as a linear combination of the **comonotonic** copula and the **independent** copula (the latter obtained by **multiplying marginal distributions together**).