QFIIRM Model Solutions
Spring 2014

1. **Learning Objectives:**
3. Understand and be able to apply different approaches to risk measurement.

Learning Outcomes:
(3a) Evaluate a company's or a portfolio's exposures to various risks.

(3b) Explain the advantages and limitations of different risk metrics including value at risk.

Sources:
"Managing Investment Portfolios" by Maginn & Tuttle, Ch 9 "Risk Management, section 5"

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a) Calculate the 5% daily VaR using the following:

   (i) Historical Method.

   (ii) Analytical Method.

   Commentary on Question:
   None

   (i) Given 250 of trading days in a year, there should be 250 returns over the past calendar year.
   5% * 250 = 12.50
   The daily 5% VaR should be average of the worst 12th and 13th return =
   (0.0291 + 0.0280) / 2 = 0.02855
   100 million * 0.02855 = 2.86 million

   (ii) Daily expected return (μ) = 0.135 / 250 = 0.00054
   Daily standard deviation (σ) = 0.244 / = 0.01543
   The daily 5% VaR = μ - 1.645 * σ = 0.00054 – 1.645 * 0.01543 = -0.02484
   100 million * 0.0249 = 2.49 million

1. **Continued**

(b)   Explain which VaR method (Historical, Analytical or Monte Carlo Simulation) is the least appropriate for the following situation:

(i)   Fat tailed distributions.

(ii)   A small company with limited computing resources.

Commentary on Question:
None

(i)   The Analytical Method is the least appropriate because it relies on the normality distribution assumption. Normality is not appropriate for fat tailed distributions.

(ii)   The Monte Carlo Simulation method is the least appropriate because it requires intensive modelling and resources that are least likely to be available for a small company.

(c)   Calculate the Incremental VaR and Incremental CTE for the portfolio at the 99.7th percentile level when the hedge is incorporated.

Commentary on Question:
For IVaR: the candidate should show a formula that indicates that the incremental VAR is the difference between the VAR with and without the hedge to receive full points

For ICTE: the candidate should show a formula that indicates that the incremental CTE is the difference between the CTE with and without the hedge to receive full points.

IVaR = 26 – 20 = 6. For discrete distributions the endpoints for VaR are not clear. By intentionally making the 7th and 8th scenarios identical, the IVaR can be calculated without having to worry about interpolating.

ICTE = (26+32+32)/3 - (20+50+65)/3 =30 – 45 =-15

(d)   Recommend whether to add the hedge to the portfolio based only on the information in part (c).

Commentary on Question:
Candidates often chose CTE but did not explain why. A full answer needed to indicate that CTE was chosen because it was a coherent risk measure. The question also clearly asked the candidate to make a recommendation so if the candidate did not receive points if they did not make an explicit recommendation.

1. Continued

The IVaR is positive meaning the VaR increases when adding the hedge. The ICTE is negative meaning the CTE decreases when adding the hedge. The Bank wants to use a coherent risk measure so they should use CTE and therefore add the hedge.

2. **Learning Objectives:**
1. The candidate will understand the needs and methods of governing investments.

2. The candidate will understand and be able to apply the components of an effective risk management system.

Learning Outcomes:
(1d) Describe governance mechanisms that attempt to address these conflicts.

(1e) Understand the importance of an organizations culture in effectuating governance.

(1f) Explain how governance may be structured to gain competitive advantages and efficiencies.

(2e) Evaluate a company's risk management process.

Sources:
Financial Risk Management, Paul Sweeting, Chapter 20: Case Studies

The 10 Commandments of Operational Due Dilligence, Haslet Chapter 45

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a) Describe four key items you want to include in the template and explain why you want to focus on them.

Commentary on Question:
Candidate should reference any four of the ten items from the 10 Commandments of Due Dilligence note:

- Define the role
- Define the goal – safeguard the assets
- Define the objective – integrate controls consistently and effectively
- Segrate the function
- Do the work
- Document and communicate
- Work Efficiently with investment research
- Remember the fundamentals
- Note the tone at the top
- Be vigilant about red flags

2. **Continued**

(b)   Critique Mr. Salamander's approach to evaluating risk.

Commentary on Question:
Award all four points for response that cover at least 2 of these points in a clear fashion. Use judgement to determine if candidate covers the points above in similar wording.

- no model can exactly replicate real world
- models should only be treated as guides
- excessive reliance and lack of understanding of limitations of model is an executive shortcoming

(c)   Evaluate the proposed bonus structure.

Commentary on Question:
Candidates needed to indicate all 3 shortcomings listed below to receive full credit. Most candidates only were able to list 1 or 2.

- when significant portion of earnings are paid as bonus if gives emplyees the incentive to take risks with unlimited upside and -0- as downside.
- Bonuses paid on short term results may incent short term profits at the risk of long term profits, expecially if final profitability not know for some period.
- Paying bonuses based on team performance provides little incentive to do anything differenct from the rest of the team.

(d)   Assess Mr. Salamander's recommendation.

Having trading and accounting done by the same team means that a level of internal scrutiny is missing.
The team responsible for back office operations should be different from team responsible for trading

3. **Learning Objectives:**
  2.　　The candidate will understand and be able to apply the components of an effective risk management system.

Learning Outcomes:
  (2b)　Identify and describe the various kinds of risks, including market, credit, operational, etc.

  (2c)　Identify and describe various approaches for managing risks including risk budgeting, position limits, etc.

  (2d)　Explain the features of a best practices enterprise risk management system.

  (2e)　Evaluate a company's risk management process.

Sources:
Managing Investment Portfolios, Maginn & Tuttle, Chapter 9: Risk Management, sections 1-4, 6

Financial Enterprise Risk Management, Paul Sweeting,
  • Chapter 7: Definitions of Risk
  • Chapter 1: An Introduction to Enterprise Risk Management

Haslett Chapter 18: The Sense and Nonsense of Risk Budgeting

Commentary on Question:
Commentary listed underneath question component.

Solution:
  (a)　Define systemic risk.

  Commentary on Question:
  The definition in this part is 1 full exam point, so just stating that "Systemic Risk is risk of failure of a financial system" is insufficient.

  Systemic Risk is risk of failure of a financial system. It occurs when many firms are similarly affected by a particular external risk, either directly or through relationships with each other. The risk of systemic failure is particularly great if all firms follow similar strategies.

  Even if all firms are well-managed individually, an external event resulting in the insolvency of an individual firm could result in failure of the entire financial system.

3. **Continued**

(b)   Identify two types of systemic risk and explain why they are classified as systemic risks.

Commentary on Question:
Any 2 out of the 4 risks described in the model solution below would earn full credit. Candidates who identify/describe more than 2 would not get extra credit. Note that full credit requires identification as well as an explanation of each risk.

1. Financial Infrastructure Risk: arises if a commonly-used system fails, e.g. financial settlement or payment failures of a firm can paralyze the entire financial system; failure of the German Herstatt Bank due to fraud is an example.

2. Liquidity Risk: arises if short-term money market becomes less liquid or there is a run on the bank. Ability of banks to raised capital is reduced; banks are reluctant to provide short-term lending to each other; banks are less able to lend to firms and individuals. System wide fall in funding liquidity leads to damaging the whole economy.

3. Common Market Positions: Exposure to common investment positions can affect individual investments or whole sectors or markets. Resulting risk is known as "feedback risk," the risk that a change in price will result in further changes in the same direction; such movements can be sentiment-driven or behavioral; a fall in price of a risky asset can reduce the solvency of an investor, forcing the investor to sell the asset and buy a risk-free alternative – this forced sale causes a further fall in price, resulting in further solvency problems and even more sales. If this risk extends to a significant proportion of the market, then it can threaten systemic stability.

4. Exposure to a Common Counterparty: a relatively small failure can cascade through several layers of investors, to not just those investing in the failed firm, but those investing in institutions that invested in the failed firm, and so on. The losses might stem from a financial relationship or due to a loss of confidence. A contagion effect can cause other types of systemic problems, e.g. anything that reduced the solvency of banks could also reduce their ability to raise capital, leading to a systemic liquidity issues; contagion could also result in wider effects being felt.

(c)   Outline the steps of an Enterprise Risk Management framework and describe how it can be applied to manage the risk associated with the equity indexed annuity block.

3.   Continued

Commentary on Question:
A candidate would only get partial credit for just identifying an ERM framework, but full credit would be awarded if the framework is applied to managing the risks associated with the indexed annuity block.

ERM Framework Outline (typical features):
- Recognize the context (includes understanding the nature of the organization and the interest of the various stakeholders as well as the external environment)
- Develop a consistent risk taxonomy of the risks the block is exposed to Examples of risks associated with the indexed annuity block: credit risk of derivatives issuers, interest rate risk, mortality risk, operational risks
- Identify the risk which the organization is exposed to (divide into those which are quantifiable and those which are not) – how can losses occur and need to understand and quantify the impact to the business
- Assess and compare the risk with the risk appetite/targets – how much is management willing to lose
- Look at the company as a whole - are there offsetting risks in other parts of the business? Determine aggregate risk level of the company considering the block's hedging measures in place, e.g. equity derivatives, reinsurance
- Take action to manage material risks that are beyond the risk targets
- Reporting and monitoring risk management activities

(d)   Explain the risk that is addressed by daily collateral posting.

The daily posting of collateral (usually in the form of cash or highly liquid, low risk securities), sufficient to cover mark-to-market deficiencies, alleviates Credit Risk. Credit risk is the risk of loss caused by a counterparty or debtor's failure to make a payment, and includes default risk, i.e., the risk of loss associated with the nonperformance of a debtor or counterparty.

Since credit risk is risk of loss due to failure of payment by a counterparty and daily posting of margin collateral to cover mark-to-market deficiencies requires settlements at intervals shorter than the full term of the contract, credit risk is reduced to these shorter daily intervals.

(e)   Calculate the collateral movement between the firm and the counterparty.

The market value of the contract = 1000 * ($110 - $107/(1.0325)9/12) = $5,536

Previous collateral held by firm = $4,000

Collateral movement = $5,536 - $4,000 = $1,536

3. **Continued**

(f)   Compare and contrast risk allocation versus asset allocation in the context of risk budgeting.

Both are similar in that both solve optimization problems. Both applied to the same set of asset classes or external managers and same set of inputs.

Asset allocation tries to maximize return and minimize risk.
Risk allocation tries to maximize excess return, and minimize a risk metric, such as tracking error or VAR.

Asset allocation models express results in terms of portfolio weights.
Risk allocation models convert these portfolio weights into tracking error allocations or VAR assignments.

Asset allocation monitoring views sub-portfolios in isolation.
Risk allocation monitoring considers the whole portfolio.

Asset allocation rebalancing involves bringing the weights back in line.
Risk allocation readjusts the risk of the portfolio.

Asset allocation often uses long term historical trends.
For risk allocation, recent history may be more appropriate.

(g)   Assess the overall impact on the risk of the firm given the firm's view of correlation between the two portfolios.

Under the belief that the two portfolio are weakly correlated, the sum of the risk budgets for the individual portfolios ($15M) will typically exceed the risk budget for the combined portfolio because of the impacts of diversification. For example, the VaR of the two portfolios combined might be about $11M, i.e. about 70% of the combined risk allocation for the two desks).

However, if the activities of the two portfolios were highly correlated (i.e., correlation coefficient = 1), their combined VaR = $15M, but the current given profit is still = $50M + $60M = $110M. This represents a higher overall risk position and a poorer risk-adjusted return for the company

(h)   Recommend changes to the allocation of the funds given your assessment in (g).

Commentary on Question:
Full credit would be given for any alternative recommendation, provided it makes sense and is justified by detailed reasons/rationale.

3. **Continued**

If the activities of the two portfolios were highly correlated (i.e., correlation coefficient = 1), particularly if correlation is expected to continue to remain strong, it is recommended that the FI desk be closed down and its capital and risk budget be reallocated to the FX trading desk.

Current returns on capital:
FX return on capital = 50/200 = 25%; FI return on capital = 60/400 = 15%

If the firm closed down the FI desk and reallocated capital and risk budget to the FX desk, the firm will generate 0.25($200M + $400M) = $150M of return, on the daily VaR of $15M. This is better than the previous total return of $110M on the same daily VaR of $15M (since there are no diversification benefits).

4. **Learning Objectives:**
1.   The candidate will understand the needs and methods of governing investments.

Learning Outcomes:
(1a)   Compare the interest of key stakeholders

(1b)   Explain principal versus agent conflict.

(1c)   identify sources of unethical conduct and explain the role of a fiduciary.

(1d)   Describe governance mechanisms that attempt to address these conflicts.

(1e)   Understand the importance of an organizations culture in effectuating governance.

(1g)   Demonstrate understanding of how ethics relates to business decision-making, and relate ethics in business to personal ethics.

Sources:
Hill & Jones, Strategic Management: An Integrated Approach, p. 381-406

Financial Enterprise Risk Management, Paul Sweeting, Chapter 1: An Introduction to Enterprise Risk Management

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a)   Describe the interests of the following stakeholders with respect to the company's current profitability and profit growth:

   (i)   Stockholders

   (ii)   CEO

   (iii)   Customers

   Commentary on Question:

   The candidate should describe the interests of each of the stakeholders, and comment on how current profitability and profit growth promote those interests.

   (i)   Stockholders want to maximize share value, through price appreciation and dividends. Their focus would be on profit growth.

4. **Continued**

        (ii)   The CEO needs a balance between current profitability and profit growth to meet the claims of multiple stakeholders (stockholders, creditors, employees, customers, etc.)

        (iii)   Customers want to company to be profitable to continue to provide products and product support, but not to maximize prices at their expense

(b)   Explain whether each of the following relationships involves a principal-agent conflict.

        (i)   CEO – Stockholders

        (ii)   Bondholders – Stockholders

        (iii)   Senior Management – mid level managers

Commentary on Question:

The candidate should be able to apply principal – agent conflict concepts to real-life situations.

        (i)   CEO – Stockholders (A principal-agent conflict exists)

              The CEO acts as an agent for the stockholders (the principal) to run the company, but may not always act in the best interest of the stockholders if incentives are misaligned

        (ii)   Bondholders – Stockholders (A principal-agent conflict does not exist)

              Stockholders and bondholders may have conflicting interests, but stockholders are not technically the agents who are making the decision in running the company.
              The appropriate agent where bondholders are the principal is the company's management

        (iii)   Senior Management – mid level managers (A principal-agent conflict exists)

              Senior Management is the principal and mid-level managers are their agents. If there are conflicting interests, mid-level managers may not act in the best interest of senior management. For example, abusing company resources that increase expenses, but improve the mid-level manager's work environment.

4. Continued

(c)   Identify the unethical behavior(s) present if Widgets 'R Us were to proceed with the outsourcing and explain what may be causing Otto to ignore ethical considerations.

Commentary on Question:
The model provides 2 potential rationales; other rationales would also earn credit.

Substandard working conditions

Environmental degradation

Otto may lack personal ethics.

Pressure from top management (i.e. the CEO said to 'do what it takes') to meet performance goals that are unrealistic and can only be attained by acting in an unethical manner.

(d)   Recommend 4 ways to promote the consideration of ethical issues when making business decisions for Widget "R Us.

Commentary on Question:
Again the model provides four potential recommendations; other recommendations would also earn credit.

- Favor hiring and promoting people with a strong personal ethics
- Require people to consider the ethical dimension of business decisions
- Build an organizational culture that supports ethics.
- Use ethics officers

(e)   Critique the current board structure and recommend changes that would improve the effectiveness of Widgets 'R Us' Board in governing the company.

CEO is the chairman of the board. The Board of Directors needs to monitor/control management's actions.

The CEO and chairman position should be held by different individuals.

While Company officers can provide detailed information on the Company's activity and results, the current board lacks sufficient independence. This is worsened by having the CEO nominate directors.

There should be an increase in outside directors and/or a reduction in Company officers on the board. The nomination process should be opened to the Board and/or shareholders.

4. Continued

Independence is particularly important for the Audit and Compensation Committees, 50% and 25% internal directors is not appropriate.

The Audit and Compensation Committees should be comprised of entirely external directors

5. **Learning Objectives:**
3.   Understand and be able to apply different approaches to risk measurement.

Learning Outcomes:
(3d)   Analyze and evaluate risk aggregation techniques, including the use and misuse of correlation, integrated risk distributions and copulas.

Sources:
Correlation: Pitfalls and Alternatives

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a)   List 4 problems of linear correlation as a dependency measure.

- Correlation is simply a scalar measure of dependency; it cannot tell us everything we would like to know about dependence structure of risks.
- Possible values of correlation depend on the marginal distributions of the risks. All values between -1 and 1 are not necessarily attainable.
- Perfect positively dependent risks do not necessarily have a correlation of 1. Perfectly negative risks do not necessarily have a correlation of -1.
- A correlation of zero does not indicate independence of risks.
- Correlation is not invariant under transformations of the risks. For example $\log(x1)$ and $\log(x2)$ generally do not have the same correlation as x1 and x2.
- Correlation is only defined when the variances of the risks are finite. It is not an appropriate dependence measure for very heavy tailed risks where variances appear infinite.

(b)   Critique each statement.

Commentary on Question:
For each statement, award 1 point for stating whether or not the statement is correct. The remaining points are awarded for an explanation similar to the one in the rows above.

For the first statement, the candidate must identify the fact that the credit risk does not follow an elliptical distribution to get full points (worth 2 point), with 1 additional point for another reasonable statement.

The first statement is not correct. For elliptical distributions this is true, but credit losses do not generally follow elliptical distributions. There can be infinite joint distributions for non-elliptical distributions. The marginal distributions and correlation do not uniquely identify the joint distribution.

5. **Continued**

The second statement is not correct. Correlation tells us nothing about dependence in the tail. Said another way, two distributions with the same correlation coefficient can have vastly different tail dependencies.

The third statement is correct. In an elliptical distribution, the densities are constant on an ellipsoid, so in this special case the correlation matrix is sufficient to determine dependence.

(c)   Propose an approach to modeling the dependency structure of each risk class.

Commentary on Question:
This was a 4 point questions, requiring time needed to develop a complete answer, yet most candidates did not write out a detailed response and thus earned limited points.

For the operational risk class, the copula approach is most appropriate. Marginal lognormal distributions mean that the the multivariate distribution is unlikely to be jointly normal. This means that the pitfalls of correlation apply. Since the specified complexity level is high, we can use the copula approach. Copula modeling involves incorporating an aggregation function, which is significantly more complex than simply using correlation. In addition, marginal conditional probability analysis is only possible when the aggregation function is continuously defined, as in a copula.

For the mortality risk class, the linear correlation approach is adequate. Multivariate t distribution is an example of a distribution which has a density constant on ellipsoids. This means that linear correlation is an appropriate statistic to define dependency structure. Linear correlation also fits the requirement for low complexity. The statistic is adequate for building a Value at Risk modeling framework.

For the equity risk class, the rank correlation metric is most appropriate. Lognormal marginals can prove difficult to fit a linear correlation dependency structure to (a specified joint distribution may not even exist). Rank correlation is less complex than copula dependency structure, so this approach is preferable here given the client's specification. Finally, a heavy tailed multivariate distribution lends itself poorly to a linear correlation approach, as tail dependence should be structured to be a more severe probability function in the tail (rank correlation is better at meeting this objective).