QFI IRM Model Solutions
Fall 2016

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

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

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

Sources:
Risk2: Measuring the Risk in Value at Risk by Philippe Jorion
Risk Aggregation Basel Committee on the Developments in Modelling Risk Aggregation
Correlation: Pitfalls and Alternatives - RISK, Vol. 12, No. 5, (May 1999), pp. 69-71

Commentary on Question:
This question is trying to test the candidate's knowledge on the limitations of VaR. The later part of the question aims to test the candidate's ability to practically apply risk aggregation approaches to the dependency structure of default risk of complex assets.

Solution:
(a)   Describe the advantages and disadvantages of using the historical-simulation method to estimate VaR (95).

   Commentary on Question:
   Candidates generally did well in this section.

   Advantages: it is a simple and practical approach to replicate the behaviour of the portfolio using data available from previous days as observations.

   Disadvantages: it requires sufficiently large sample size in order to adequately estimate VaR. Sample variation and data size would also lead to material change in VaR estimates and significant estimation error.

1. **Continued**

(b)   Explain possible reasons for the differences in the estimates.

Commentary on Question:
Candidates generally did well in this section. Most candidates received marks for identifying the variation in the number of data used in VaR calculation and the difference in the approach for data collection.

Statistics used to measure VaR is affected by sampling variation when estimated using historical data. VaR is entailed by estimation risk, which is the risk in value at risk itself. VaR measures are merely estimates and are exact only when the underlying distribution is measured with the same infinite number of observations. In practice, data are available for only a limited time period.

(c)   Recommend two approaches to address the issue of multiple estimates from historical simulation method when reporting VaR.

Commentary on Question:
Candidates generally did poorly in this section. Some candidates only received partial marks by suggesting the improvement in communication to management or using alternative estimates instead of VaR.

The approaches include, but not limited to the following:

Utilizing the standard error of the portfolio, we can report VaR with confidence level, commonly 95% or 99% is chosen. It shows the accuracy of the VaR through a range of VaR values with the level of confidence expected.

We can also perform sensitivity analysis of VaR using different models and compare the VaR results. This requires a deep understanding of the statistical methodology to explain the source of discrepancies arise from different results, whether it comes from fundamental differences in methodologies or sample variation.

We can also improve the acurracy of the VaR measures to minimize the estimation error by selecting a proper statistical methodology. Substantial improvement in precision can be obtained by switching estimation technique. For example, instead of empirical quantile-based VaR, additional precision could be gained by directly measuring the standard deviation, which can be multiplied by an appropriate scaling factor to obtain the desired quantile because standard deviation has lowest standard error. This method leads to substantial efficiency gains relative to using the estimated quantile as standard deviation uses the entire distribution while a quantile uses only the ranking of observations.

1.   Continued

(d)   Identify a family of distributions where using correlation matrix is appropriate.

Commentary on Question:
Most candidates received partial marks by only identifying elliptical distribution without any descriptions.

If the portfolio has an elliptical distribution, it is appropriate to use the correlation matrix to measure the dependency structure of the risks. Multivariate normal, multivariate t distribution are examples of ellipitical distribution Under ellipitical distribution, the density is constant on ellipsoids. In two dimensions, the contour lines of the density surface are ellipses.

(e)   Compare and contrast these three approaches.

Commentary on Question:
Most candidates were able to identify the differences between the three approaches, but only few of the candidates received full marks by identifying the similarities. Instead of identifying the similarities and differences, some candidates lost points by listing the advantages and disadvantages of these three approaches.

- All approaches can be used to measure the dependency of risk factors.
- There are serious drawbacks to use linear correlation if the risk distribution does not follow normal or elliptical distribution, which are uncommon for many risk structures.
- Rank correlation is defined by the relative rank of observation within a data set rather than the actual value of the observation. It is the linear correlation of probability transformed variables. Rank correlation resolves a few deficiencies of linear correlation. Since it is invariant under strictly increasing transformation of the risks, it doesn't require the risks have finite variance. Rank correlation is also attainable in the interval [-1, 1].
- Linear and rank correlation are both simple scalar measurements of dependence. They fail to tell us everything about the dependence structure of risks. Thus, linear correlation or rank correlation are only of very limited use in practice. Instead, Copula allows us to precisely specify the dependency in the areas of the loss distributions that are crucial in determining the level of risk.
- Instead of summarizing dependence with a dangerous single number such as correlation, copula allows us to know the complete relationship of the risk dependency.

1. **Continued**

- Although copula is well suited for use in aggregating financial risks because it works directly with the percentile measures of the loss distributions, copula is the most complicated approach because the specification of a copula is very abstract and difficult to interpret. Thus, implementing copulas requires a high level of statistical expertise.

(f) Recommend an approach that is most appropriate to model multi-risk factors dependency structure of credit default risk of structured assets and justify your recommendation.

Commentary on Question:
Most candidates did well in this section. In order to receive full credits, candidates should relate the complexity of default risk and tail proprieties of structured asset and explain why copula is the most appropriate approach comparing to linear and rank correlation.

Recommendation: Copula

Due to the complex structure of default risk and heavy tail properties, copula is the best approach to determine the multi-risk factors dependency of default risk for structured assets. Copula approach allows us to precisely specify the dependency in the areas of the loss distributions that are crucial in determining the level of risk. Since default risk is unlikely to follow elliptical (multivariate normal or t distribution) distribution and has heavy tail characteristics, pitfalls of linear correlation apply. Correlation tells us nothing about the degree of dependence in the tail of the underlying distribution. Even though rank correlation has significant improvement compared to linear correlation, ideally, simple scalar measurements of dependence should be avoided because it cannot tell us everything about dependence structure of risks.

2. **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:
Risk Management: Foundations for a Changing World, Haslett, 2012
Ch 2: Practical Issue in Choosing and Applying Risk Management Tools
Maginn & Tuttle: Managing Investment Portfolio's: Section 6

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a)   Compare and contrast the functionality of the Sharpe Ratio and the Sortino Ratio.

> **Commentary on Question**:
> *Candidates generally did well on this section. Most were able to note the differences in the two ratios, but fewer pointed out similarities.*

Similarities:
- Both ratios are used to evaluate the risk adjusted returns of a portfolio
- Both ratios can be inaccurate when applied to portfolio with non-linear risks, such as option positions, since both assume normality in the distributions

Differences:
- Sortino ratio does not penalize portfolio managers for volatility derived from outsized positive performance.
- Sortino ratio is not as well grounded in financial theory or as analytically trackable as Sharpe ratio.

(b)
(i)   Calculate the Sharpe Ratio and Sortino Ratio for each portfolio.

(ii) Evaluate which portfolio's performance is better based on your response from b(i).

> **Commentary on Question**:
> *Most candidates were able to calculate both ratios and give a good recommendation on how to apply the ratios to performance evaluation.*

2. **Continued**

      (i)   Sharpe Ratio = (Mean Portfolio Return – Risk Free Rate)/(Standard Deviation of Portfolio Return)
A = (8%-3%)/29% = 0.17
B = (5%-3%)/5% = 0.4

             Sortino Ratio = (Mean Portfolio Return – MAR)/(Downside Deviation)
A = (8% - 4%)/15% = 0.267
B = (5% - 4%)/5% = 0.2

      (ii)   Portfolio A is the better manager because it has the higher risk adjusted return based on Sortino Ratio. The lower Sharpe ratio is caused by outperformance. The Sortino ratio also includes the minimum acceptable return set by ABC.

(c)   Describe two disadvantages of using tracking error as a risk measure.

Commentary on Question:
Most candidates were able to identify disadvantages of tracking error, some even noting that they have the same shortcomings as VaR or standard deviation.

- Similar to standard deviation, bad deviations from the benchmark are treated the same way as good deviations. This is not representative of the client's asymmetry to performance.
- Extreme events may be ignored in tracking error as the returns of the manager may track closely to the benchmark in such periods.
- The model used to measure tracking error may give different results, based on the parameters used.

(d)   "Since Portfolio B has a lower tracking error, its manager is more effective than Portfolio A's manager."

Critique the above statement.

Commentary on Question:
Most candidates were able to critique the statement and offer observations about the shortcomings of tracking error.

Fund B is more effective as a manager because he has a lower tracking error. This would be true if the S&P500 was considered an appropriate benchmark for the client.
Fund A would be considered more effective if the S&P500 does not closely track the objective of the client's liabilities. If the benchmark is not representative of the client's investment mandates, then tracking error is not a useful metric.

2. Continued

(e)

- A fund manager who achieves $\Omega = 1.5$ is more effective than another fund manager who achieves $\Omega = 1.7$.
- The forecasted tracking error should be lower if the S&P500 is replaced by a more representative index as the benchmark.
- Changing the benchmark will encourage fund managers to execute the investment strategy more effectively.
- David's metric encourages fund managers to maximize risk.

Critique each of the statements.

Commentary on Question:
Some candidates were able to apply tracking error to the adjusted metric. The key observation is that the anticipated tracking error can be adjusted to account for inappropriateness of the benchmark chosen.

- Statement 1: If a portfolio manager is effective, their realized tracking error will be as close to the anticipated tracking error as possible. Therefore, the fund manager with the lower omega is more effective. The metric is a risk adjusted metric that evaluates performance while including a risk tolerance in the tracking error allowed by each manager.
- Statement 2: This would only be true if the representative index chosen tracks the fund manager's returns closer to the client's objective than the S&P500.
- Statement 3: This would only be true if the anticipated tracking error is revised to the new benchmark accordingly.
- Statement 4: The metric allows for risk tolerance to be included in the anticipated tracking error. Therefore, the portfolio manager can maximize risk based on the anticipated tracking error set by the client. The ratio is a measure of the portfolio manager's efficiency at converting potentially higher risk into lower realized volatility.

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

Learning Outcomes:
(2a) Explain the importance of risk culture in an investment firm.

(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.

Sources:
Haslett Chp 9

"Managing Investment Portfolios section 1-4, 6" by Maginn & Tuttle Chp 9,

"Advances in Risk Management and Risk Governance" by Leslie Rahl
Sweeting Chp 8

Commentary on Question:
This question covered various components of a risk management system. It progressed from identifying coping mechanisms and identification tools to application of monitoring risk.

Solution:
(a) List two ways FundPro might cope with these accounting risks.

Commentary on Question:
Candidates performed well on this section. Many candidates were able to identify that hiring experts would help mitigate accounting risk, while some candidates listed only one or described the first mechanism in a different manner.

Hire personnel with the latest accounting knowledge for internal positions or as external consultants.

Lobby and communicate actively with the appropriate regulators to try and modify rules in a direction more favorable for FundPro

(b) Describe three risk identification tools that will help identify other emerging risks.

Commentary on Question:
Candidates performed well on this section. Most candidates could identify three tools correctly and some provided a thorough description to earn full credit. Some candidates described the risk techniques instead of identification tools.

3. **Continued**

SWOT Analysis: identify strengths, weaknesses, opportunities and threats of potential risks. Strengths and weaknesses are internal risks while opportunities and threats are external risks.

Risk Prompt Lists: identify a broader range of risks and within specific risk categories: political, economic, social, technological, environmental, legal and industrial.

Risk Taxonomy: full list and description of all risks that FundPro may face with each risk fully categorized.

(c)   Identify and explain two biases that you might bring into your new role in the investment fund industry based on your past experience.

Commentary on Question:
Candidates performed as expected on this section. Many candidates were able to identify short term bias and conservative bias. Some candidates incorrectly listed general biases for a manager entering a new job (such as anchoring). In order to receive full credit, candidates must explain the bias and how it would impact FundPro.

Bank risk managers are focused on losses from individual transactions and not the risk profile of the entire portfolio. One might be biased towards short term transactions instead of longer term investments in order to keep the risk low and collect fees.

Bank risk managers are also very conservative when assessing the risk of a big loss. As a result, one may bring a conservative bias to the industry and purposely overstate the potential for a large loss.

d)   Critique FundPro's risk culture based on these characteristics.

Commentary on Question:
Candidates performed well on this question. Many candidates were able to explain why it is unhealthy to avoid losses entirely and how policies and procedures are healthy as long as they are clear and effective. Some candidates did not state the importance of providing risk management training to all employees. Candidates needed to take a side and provide support in order to receive full credit.

3. Continued

Avoiding losses entirely is not healthy. In a healthy risk culture, risks are well understood and risk-reward tradeoffs are considered when decisions are made. Risks must be properly understood. Investors cannot make money without taking risks.

A significant amount of policies and procedures is healthy as long as policies are clear and effective. A healthy risk culture begins with policies and procedures. Without effective policies, it is not clear what is expected of employees.

Providing training to managers but not employees is not healthy. In a risk conscious culture, employee education is critical. It is essential that everyone in the organization understands the role that he or she has in risk awareness and management.

(e) Explain the importance to risk management of making real-time daily Net Asset Values (NAV) widely available.

Commentary on Question:
Candidates performed as expected on this question. Most candidates explained the how making NAV widely available would help the risk management staff understand trends in the market. Some candidates focused solely on the timeliness of the data without explaining the important of understanding NAV.

The risk management staff would develop an understanding of how the portfolio responds to changes in financial markets and how much risk exists in the portfolio.

Managers could start to develop an intuition for profits that can be taken and profits that do not exist.

Employees at all levels will participate in the risk management process. This participation will strengthen the risk culture at FundPro.

(f) Assess the reasonableness of the fund NAV for each scenario.

Commentary on Question:
Candidates performed well on this section. Many candidates were able to assess that nothing seemed wrong with scenario 1. For scenarios 2 and 3 where something seemed wrong, candidates needed to describe why something seemed wrong in order to gain full credit.

3. **Continued**

Based on historical information, change in NAV is positively correlated with S&P 500 return.

#1) Daily S&P Return: -1.26%, Daily Change in NAV: -1.12%. Nothing seems wrong, as the S&P return and change in NAV are of about the same magnitude in the same direction.

#2) Daily S&P Return: 0.71%, Daily Change in NAV: 2.62%. This scenario seems suspicious. While both metrics are moving in the same direction, the magnitude of the change in the fund's NAV is much greater than the S&P return.

#3) Daily S&P Return: -0.38%, Daily Change in NAV: 0.47% This scenario also seems suspicious since the fund and the S&P 500 are moving in opposite directions and the historical data suggests positive correlation.

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.

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

Sources:
QFII-101-14: Chapter 11 of Strategic Management: An Integrated Approach, Hill & Jones

Commentary on Question:
This question tested a candidate's understanding of many of the issues facing companies, beginning with the needs of its stakeholders. It then challenged the candidate to consider the importance of communication between the CEO and stockholders in particular. The next section tested a candidate's understanding of the principal-agency problem. Finally, it asked candidates to apply their knowledge of the above components in a real-world application.

Overall, candidates did very well on this question and on each section, when attempted.

Solution:
(a) List the key steps of a stakeholder impact analysis.

   Commentary on Question:
   Candidates performed well for this section. Most were able to earn full credit by clearly identifying each step. Candidates who did not earn full credit usually omitted one or more steps, or provided steps that were not applicable to this question.

   Identify stakeholders' interests and/or concerns.
   Identify the claims likely made to organization.
   Prioritize stakeholders by importance.
   Identify resulting strategic challenges.

(b) Categorize the above stakeholders into internal and external stakeholders.

   Commentary on Question:
   Candidates performed well on this section. Nearly all who attempted this section were able to earn full credit by listing at least one internal and one external stakeholder. Candidates who did not earn full credit did not attempt to answer this question.

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4. Continued

Internal: one of stockholders, managers, employees
External: one of customers, suppliers, bondholders

(c)   Assess the importance of current profitability and future profit growth for each of the stakeholders above.

Commentary on Question:
Candidates performed as expected on this section. Those who earned full credit were able to distinguish between current profitability and future profitability in the eyes of each stakeholder, with sufficient supporting details. Those who earned less than full credit failed to distinguish between the two, or did not provide sufficient support for their answer.

Stockholders – both are important, as they want strong dividends and stock price growth
Bondholders – both are important, as this will ensure sufficient debt payment ability
Managers – both are important, to balance salaries with continued benefits
Suppliers – future profitability is more important, to ensure company's ability to continue to provide goods and/or services
Customers – future profitability is more important, to be present for after-sales support
Employees – both are important, to support bonuses, salaries, and benefits

(d)   Identify 2 additional stakeholders of XYZ and explain how they would have an interest or stake in the company.

Commentary on Question:
Candidates performed well on this section. Most who earned full credit were able to list 2 from the list below, else provide support for any stakeholders not listed below, with sufficient support. Few candidates earned less than full credit if they omitted an answer, or did not provide sufficient details pertaining to current and future profitability.

Local communities/General Public – want company to have good future growth to provide jobs; also want strong current profits to pursue any philanthropic investments

Creditors – balance between current and future, to ensure debts will continue to be paid

4. Continued

Governments – balance needed, as they want company to continue to contribute to the economy via taxes; excessive profitability may indicate foul play or non-adherence to regulations

Unions – future important, as they want company to provide jobs; excessively high profitability may indicate they should be paying more to employees

Board members – need balance, as performance may be linked to pay

(e) Assess the statement: "There is nothing good about information asymmetry between the CEO and stockholders so we have nothing to lose by completely opening information channels between the firm's management and our stockholders."

Commentary on Question:
Candidates performed well on this section. Most who earned full credit discussed both the advantages and disadvantages of the statement. Those who earned less than full credit did not consider both the pros and cons.

In general, information asymmetry isn't preferred, as it helps the Board and stockholders assess the decisions of the CEO. However, some will be necessary to protect the competitive position, is less costly, and protects sensitive information relating to future strategic plans.

(f)
 (i) Evaluate the advantages and disadvantages of partly compensating senior managers by granting them stock options.

 (ii) Describe two other governance mechanisms that would mitigate agency problems.

Commentary on Question:
For both sections i and ii, candidates performed well. Most were able to demonstrate a good understanding of the main issues for section i. Those who earned less than full credit usually did not provide sufficient details for section ii.

 (i) Advantage – aligns interests as senior managers will aim to increase the share price, which will increase the value of their options
  Disadvantages – less motivation to hedge/more motivation to take on excess risk, may lead to dilution of equity, strike price may be set so low as to nearly guarantee profit

4. **Continued**

        (ii)   Board of Directors can review manager performance relative to goals and objectives
                Financial statements need to be signed off
                Takeover constraints and/or threat of getting fired can motivate managers to perform well

(g)   Assess the CEO's proposal.

        Commentary on Question:
        Candidates performed well on this section. Those who earned full credit considered both the economic benefit as well as the negative ethical issues. Candidates who earned less than full credit usually did not address the primary economic advantage of moving the company operations to a developing country to reduce costs.

        There is a clear economic benefit, i.e., lower costs, to moving the company. However, this is more than offset by the lack of ethics, including substandard working conditions and deterioration of the environment, which leads to reputation risk and threatens the company's long-term viability.

5. **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.

(2a)   Explain the importance of risk culture in an investment firm.

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

Sources:
Risk Management: Haslett, Ch 45: The Ten Commandments of Operational Due Diligence

Financial Enterprise Risk Management, Sweeting Ch 7: Definitions of Risk

Miller and Lawton: The Top Ten Operational Risks: A Survival Guide for Investment Management Firms and Hedge Funds

Financial Enterprise Risk Management, Sweeting Ch 20: Case Studies

Commentary on Question:
Commentary listed underneath question component.

Solution:
(a)   Define the following risks and describe two examples of each:

(i)   Market risk

(ii)   Operational risk

Commentary on Question:
Most candidates did well on this section. They were able to explain both risks and giving examples on each.

5. **Continued**

    (i)   Market risk is the risk inherent from exposure to capital markets. This can relate directly to the financial instruments held on the assets side (equities, bonds, etc.) and also to the effect of these changes to the valuation of liabilities (long-term interest rates and their effect on life insurance and pensions liabilities).

        Examples of these include interest rate risk, credit risk, liquidity risk, foreign exchange risk, etc.

        Interest rate risk is a type of market risk that rises from unanticipated changes in interest rates of various terms such as changes in overall level of interest rates, shape of yield curve, etc.

    (ii)   Operational risk is the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events. It covers a group of risks which impact the way in which a firm carries on business.

        Examples include people risks, technology risk, model risk, data risk, legal risk, business continuity risk, etc.

        Model risk is the risk that financial models used to assess risk, to determine trades or otherwise to help make financial decisions are flawed.

(b)   Recommend three potential improvements to the hedge fund's operations.

Commentary on Question:
A number of candidates were able to offer at least two improvements to the hedge fund operations. However, some candidates only mentioned the problems with the current operations without recommending improvements explicitly.

    (i)   The trading and accounting functions should be separated to catch trade errors and prevent rogue traders.

    (ii)   The documentation should help to facilitate an ongoing evaluation, so it should be done more regularly than every few years.

    (iii)   Reduce key person risk by training other personnel to do the work (avoid reliance on a single competent employee)

5. **Continued**

(c)

    (i)   Describe two operational failures that occurred at LTCM and led to their near collapse.

    (ii)   Recommend what LTCM could have done to address each of these two operational failures.

Commentary on Question:
Although a number of candidates demonstrated knowledge of the case study, the focus of the failures were focused on the financial aspect of the LTCM study rather than the operational failures. As such, the recommendations were focused on financial changes rather than operational changes.

(i)

- Complacency (trivializing and disregarding risks). The fund managers were very well respected in the industry that many people did not question their investing methods.
- Naïve reliance on technology (downside of automation). Models were used to make decisions at LTCM rather than simply inform them. Over reliance on models at the expense of good judgment can be damaging.

(ii)

- Complacency solutions. Managers at the company or clients should have questioned more the switch to more risky bond trading instead of trusting the partners. There should have been better assessment of the returns available from the strategies that were advertised.
- Naïve reliance on technology solutions. Models should be used to provide information and not to make decisions. Assumptions should have been questioned and more thoroughly reviewed.