Introduction to Quantitative Risk Analysis

Week 2 Risk Management

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Purpose of Today's Study

Purpose of Today's Study focuses on understanding key concepts in risk management and measurement:

1. **Objectives and Common Errors in Risk Management:**
   - Understand the primary objectives of risk management within organizations.
   - Analyze common errors that occur in risk management practices.

2. **Difference Between Risk Management and Risk Measurement:**
   - Compare and contrast risk management and risk measurement, and understand the importance of both.

Overview of Financial Risk Management

Overview of Financial Risk Management

Financial risk management is the process by which financial risks are identified, assessed, measured, and managed to create economic value.

- ▶ Some risks can be quantified using statistical tools, creating a probability distribution of profits and losses.
- ▶ Other risks, though not easily measurable, are still crucial and require judgment in management.
- ▶ The role of the risk manager is to evaluate risks using both quantitative tools and qualitative judgment.

Importance of Risk Management:

- ▶ As financial markets have grown, effective risk management has become increasingly important.
- ▶ The goal is not to minimize risk entirely but to take calculated, smart risks.

Risk Management Process

1. Identification

- ▶ The first step involves identifying potential risks that could affect the organization's objectives.
- ▶ This includes both internal and external risks, such as market fluctuations, operational failures, legal liabilities, and technological changes.
- ▶ Effective risk identification requires a thorough understanding of the business environment and the ability to foresee possible challenges.

Risk Management Process

2. Assessment

- ▶ Once risks are identified, they must be assessed in terms of their potential impact and likelihood.
- ▶ This step involves quantitative and qualitative analysis to prioritize risks based on their severity and the organization's risk tolerance.
- ▶ Tools such as risk matrices, scenario analysis, and stress testing are commonly used for risk assessment.

Risk Management Process

3. Monitoring

- ▶ Continuous monitoring of identified risks is essential to detect any changes in their status or impact.
- ▶ This step ensures that risk management strategies remain effective and are adjusted as needed in response to new information or changing circumstances.
- ▶ Regular risk reporting and review meetings are critical components of effective risk monitoring.

Risk Management Process

4. Control or Mitigation

- ▶ The final step involves implementing strategies to control or mitigate the impact of risks.
- ▶ This could include risk avoidance, risk transfer (e.g., through insurance), risk reduction, or acceptance (if the risk is within acceptable limits).
- ▶ Effective risk mitigation requires a balanced approach, ensuring that the costs of risk management are justified by the benefits.

Types of Financial Risks by Risk Categories

- **Market Risk:**
  - The risk of losses due to changes in the market prices of assets. This includes fluctuations in stock prices, interest rates, exchange rates, and commodity prices.
- **Credit Risk:**
  - The risk of financial loss due to a borrower's failure to meet their obligations. This can occur when a counterparty defaults on a loan or other financial agreement.
- **Operational Risk:**
  - The risk of loss resulting from inadequate or failed internal processes, people, systems, or external events. Examples include fraud, system failures, and natural disasters.
- **Liquidity Risk:**
  - The risk that an entity will be unable to meet its short-term financial obligations due to an inability to convert assets into cash without significant loss in value.

Types of Financial Risks by Impact

Systemic (Systematic) Risk:

- ▶ **Definition:** Systemic risk, also known as systematic risk, refers to the risk inherent to the entire market or an entire market segment. It is the risk of a breakdown or failure in an entire system, market, or economy.
- ▶ **Characteristics:**
    - ▶ Affects a large number of assets or the entire market.
    - ▶ Cannot be eliminated through diversification.
    - ▶ Examples include recessions, interest rate changes, and natural disasters.

Types of Financial Risks by Impact

Idiosyncratic Risk:

- ▶ **Definition:** Idiosyncratic risk, also known as unsystematic risk, is the risk that is specific to a single asset or a small group of assets. It is not correlated with the market as a whole.
- ▶ **Characteristics:**
    - ▶ Affects individual assets or companies.
    - ▶ Can be reduced or eliminated through diversification.
    - ▶ Examples include management decisions, product recalls, and individual company earnings.

Example 1.1

- **Scenario:** A financial institution holds a significant portfolio of equities. Sudden market downturns due to Covid-19 lead to sharp declines in stock prices.
- **Impact:** The institution's portfolio loses value rapidly, potentially resulting in substantial financial losses.
- **Mitigation:** Diversification of the portfolio across various asset classes and regions, as well as the use of hedging strategies such as options or futures to reduce exposure to market volatility.

Risk Management Failures

Understanding Failures:

- ▶ A large loss is not necessarily a failure if it was a known risk and properly communicated—this could reflect bad luck rather than mismanagement.
- ▶ Failures occur when risks go unrecognized, are mismeasured (due to model risk, liquidity risk, or distribution errors), or when risk limits are not enforced.
- ▶ Risk management also fails when it does not effectively communicate risks to decision-makers.

Example 2.1

Scenario: Based on the risk assessment of the CRO, Bank United's CEO decided to make a large investment in a levered portfolio of Collateralized Debt Obligation (CDOs). The CRO had estimated that the portfolio had a 1% chance of losing $1 billion or more over one year, a loss that would make the bank insolvent. At the end of the first year, the portfolio lost $2 billion, and the bank was closed by regulators.

Which of the following statements is correct?

1. The outcome demonstrates a risk management failure because the bank did not eliminate the possibility of financial distress.

2. The outcome demonstrates a risk management failure because the fact that an extremely unlikely outcome occurred means that the probability of the outcome was poorly estimated.

3. The outcome demonstrates a risk management failure because the CRO failed to go to regulators to stop the shutdown.

4. Based on the information provided, one cannot determine whether it was a risk management failure.

Example 2.1

Correct Answer: 4. Based on the information provided, one cannot determine whether it was a risk management failure. Explanation:

▶ The scenario describes an outcome that was within the range of possibilities (a 1% chance of losing $1 billion or more). The loss of $2 billion, though severe, does not in itself indicate a failure in risk management.

▶ A low-probability event occurring does not necessarily mean that the risk was poorly estimated. It could simply be an instance of bad luck within the predicted risk parameters.

▶ The key point is that the occurrence of a rare, adverse outcome does not automatically indicate a flaw in the risk assessment process unless further information suggests that the probability of the event was incorrectly estimated or ignored.

Risk Measurement VS Risk Management

The Importance of Risk Measurement

Risk measurement is crucial for effective risk management, serving as the specialized task of quantifying and communicating risk within an organization.

Key Points:

- ▶ In the financial industry, risk measurement has evolved into a specialized quantitative discipline, often organized into an independent department.

- ▶ Risk measurement is essential for uncovering, understanding, and communicating risks faced by a portfolio or firm.

- ▶ A major function of the risk measurement process is to estimate the distribution of future profits and losses.

The Importance of Risk Measurement

Goals of Risk Measurement:

1. **Uncovering Known Risks:** Identifying risks that can be understood through analysis and study, even if they are not immediately apparent.

2. **Making Risks Visible and Understandable:** Effectively displaying and reporting risks in a simple and transparent manner. Tools like Value at Risk (VaR) are commonly used for this purpose.

3. **Understanding Unknown Risks:** Attempting to uncover risks that are not easily anticipated, possibly because they have not been experienced before by the firm or industry.

Risk Measurement

- Risk that can be measured can be managed better.
- Tools like Value at Risk (VaR) help balance risk against return by providing a centralized, forward-looking risk assessment.

Historical Context:

- Centralized risk management tools, like VaR, were developed in the early 1990s.
- The concept of measuring risk at the top level of the portfolio was influenced by Harry Markowitz's work in 1952, emphasizing the importance of risk measurement in a total portfolio context.

Some Risk Measure: Value at Risk

Mathematical Definition:

- Value at Risk (VaR) at a confidence level α (e.g., 95% or 99%) is the maximum potential loss over a specified time period (e.g., one day, one week) that will not be exceeded with a probability of $1 - \alpha$.

- Formally, for a given time horizon t and confidence level α, VaR is defined as:

$$\text{VaR}_\alpha = \inf \{ l \mid P(L > l) \leq 1 - \alpha \}$$

where L is the loss in value of the portfolio.

Some Risk Measure: Value at Risk

Intuitive Definition:

▶ Value at Risk (VaR) is a measure of the worst expected loss over a specified time period under normal market conditions at a given confidence level.

▶ Intuitively, VaR answers the question: "What is the maximum loss I could expect to occur with a certain probability over a given time frame?"

▶ For example, a daily VaR of $1 million at 99% confidence level means that there is only a 1% chance that the portfolio will lose more than $1 million in one day.

Some Risk Measure: Value at Risk
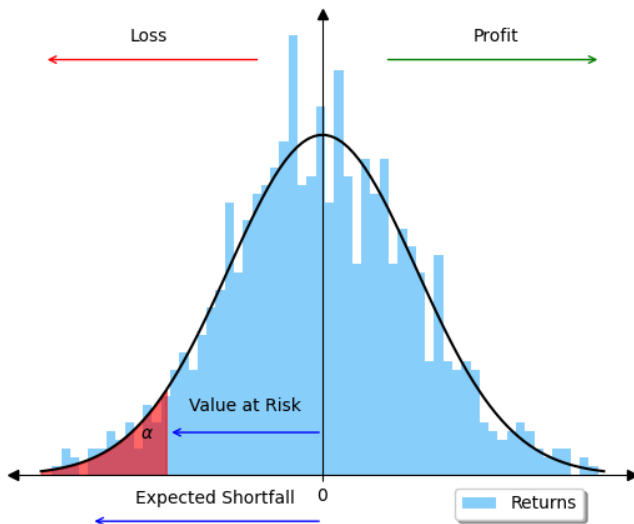
From: RCVaR: an Economic Approach to Estimate Cyberattacks Costs using Data from Industry Reports

Example 2.2

Example: U.S. Equities Portfolio

Consider a portfolio with $100 million invested in U.S. equities. The investor seeks profit, but the portfolio carries inherent risk.
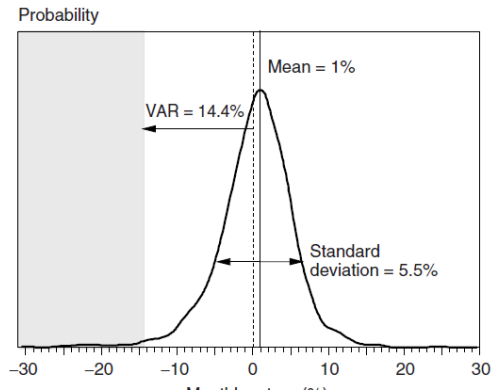

Figure: Monthly return (%)

Example 2.2

Key Concept:

- ▶ The trade-off between expected profit and assumed risk is crucial.
- ▶ A risk manager constructs the distribution of potential profits and losses to guide investment decisions.
- ▶ The profit or loss P over a fixed horizon (e.g., the coming month) is the product of the initial investment and the future rate of return R_P.

Risk Distribution:

- ▶ Historical data can be used to produce a distribution of total returns, as shown in the example based on the S&P 500 index since 1925.
- ▶ The vertical axis represents the probability of a gain or loss, and the horizontal axis indicates the size of the gain or loss.

Example 2.2

Key Observations:

▶ Most of the probability mass is centered, indicating small gains or losses are most likely.

▶ The tails of the distribution have less weight, but the downside tail shows a 3

Risk Assessment:

▶ If the 3% risk of losing 10% or more in a month is too high, reducing exposure (e.g., shifting some investment to cash) might be necessary, albeit with lower expected returns.

Example 2.2

Summary Statistics:

- **Mean Return (μ):** Approximately 1% per month.
- **Standard Deviation (σ):** Approximately 5.5%, representing volatility.
- **Value at Risk (VaR):** At a 99% confidence level, the VaR is 14.4%, indicating the cutoff point for the worst 1% of losses.

Example 2.3

Absolute Risk:

- ▶ Measured by the dispersion of dollar returns, or in absolute terms.
- ▶ Typically involves shortfall relative to the initial value of the investment or an investment in cash.
- ▶ The standard deviation (σ) is used as the risk measure.
- ▶ Formula: $\sigma(\Delta P) = \sigma(\Delta P/P) \times P = \sigma(R_P) \times P$

Relative Risk:

- ▶ Measured relative to a benchmark index (e.g., S&P 500 for U.S. equities).
- ▶ The deviation from the benchmark return $e = R_P - R_B$ is known as the tracking error.
- ▶ The risk is measured as the tracking error volatility (TEV).
- ▶ Formula: $\sigma(e) \times P = [\sigma(R_P - R_B)] \times P = TEV \times P$

Example 2.3

Example - Active Equity Portfolio Manager:

- **Year 1:** The active portfolio returns -6%, while the benchmark drops by -10%.
    - Absolute return: -6% (negative performance).
    - Relative return: $e = -6\% - (-10\%) = 4\%$ (positive performance relative to the benchmark).

- **Year 2:** The portfolio returns $+6\%$, but the benchmark goes up by $+10\%$.
    - Absolute return: $+6\%$ (positive performance).
    - Relative return: $e = 6\% - 10\% = -4\%$ (underperformance relative to the benchmark).

Key Takeaway:

- A portfolio's performance must be evaluated both in absolute terms and relative to a benchmark to gain a full understanding of its risk and return profile.

Contrasting Risk Management and Risk Measurement

Key Distinction:

- ▶ **Risk Management:** Involves understanding, managing, and making decisions to control risks.
- ▶ **Risk Measurement:** Involves the specialized task of quantifying and communicating risk.

Misconception:

- ▶ The term "risk management" is often misused to describe "risk measurement," which can dilute the responsibility of managers to actively manage risks.

Contrasting Risk Management and Risk Measurement

Organizational Structure:

▶ Risk measurement should be organized into a separate department with specialized expertise, independent from the main risk-taking units.

▶ Managing risk, however, should be treated as a core competence of the firm and its managers, not delegated to a separate department.

Evaluation of Risk Measurement

▶ **Known Knowns** are risks that have been properly identified and measured. These are risks that are understood and can be quantified based on available data and models.

▶ Example: A portfolio's exposure to the stock market where the risk is quantified using measures like Value at Risk (VaR).

Evaluating Known Knowns:

▶ Risk Quantification:
  ▶ Use statistical tools like VaR to quantify the risk. For example, a 99% VaR of 14.4% means that in 99% of cases, losses will not exceed 14.4%.

▶ Monitoring for Model Accuracy:
  ▶ Regularly monitor performance against the model's predictions. If actual losses exceed the predicted VaR significantly or frequently, it may indicate a flawed model.
  ▶ Backtesting: Use backtesting techniques to compare predicted risks against actual outcomes, ensuring the model's validity.

Evaluation of Risk Measurement

Definition:

- ▶ **Known Unknowns** are risks arising from model weaknesses that are either known or should be known, but are not properly measured by risk managers.
- ▶ Examples include:
  - ▶ Ignored risk factors that should have been considered.
  - ▶ Inaccurate measurement of risk factors, including volatilities and correlations.
  - ▶ Errors in the mapping process, where positions are replaced with exposures on risk factors (model risk).

Evaluation of Risk Measurement

Evaluating Known Unknowns:

- ▶ Stress Testing:
  - ▶ Apply stress tests to shock financial variables or models beyond typical ranges to assess potential vulnerabilities.
  - ▶ Example: UBS's $19 billion loss in 2007 due to overreliance on simplified models and credit ratings for structured credit securities.
- ▶ Liquidity Risk Assessment:
  - ▶ Evaluate the liquidity of assets under different market conditions.
  - ▶ Consider the intrinsic liquidity of assets and the size of positions relative to normal trading activity.
  - ▶ Example: Large positions in less liquid assets may require accepting significant price drops to execute trades.
- ▶ Model Risk Management:
  - ▶ Continuously review and update risk models to ensure they accurately reflect current market conditions and risk factors.
  - ▶ Avoid overreliance on historical data and ratings that may give a biased view of true risks.

Evaluation of Risk Measurement

- **Unknown Unknowns** refer to risks that are completely outside the scope of most scenarios and are extremely difficult to anticipate or measure.
- Examples include:
  - Regulatory Risks: Sudden changes in regulations, such as restrictions on short sales, which can disrupt hedging strategies.
  - Structural Changes: Major shifts in the financial industry, such as the conversion of investment banks to commercial banks, leading to accelerated deleveraging.
  - Counterparty Risk: The complex web of counterparty exposures, where the failure of one institution can have cascading effects through the financial network (e.g., Lehman Brothers).
  - Liquidity Risk in Illiquid Markets: The impact of forced sales when similar traders are selling at the same time, which can lead to severe market disruptions.

Evaluation of Risk Measurement

Challenges:

- These risks, often referred to as Knightian Uncertainty, are inherently immeasurable.
- Financial institutions cannot carry enough capital to withstand such massive, systemic risks.
- In these situations, central banks or governments act as the "risk managers of last resort," stepping in to stabilize the system.