ESSEC

Advanced Master's in Financial Engineering

FINM32227

Financial Risk Management

CLASS HANDOUTS

SESSION 7

Peng Xu

Stress Testing and Operational Risk

Outline

- Stress Testing
- Operational Risk

I. Stress Testing

- Stress testing involves estimating how the portfolio of a financial institution would perform under extreme market moves. Stress testing is an attempt to overcome the backward looking weakness of VaR
- Key Questions
  - How do we generate the scenarios?
  - How do we evaluate the scenarios?
  - What do we do with the results?
- Alternative procedures of generating the scenarios

  1. Stress individual variables

     e.g., a 100-basis-point parallel shift (up or down) in a yield curve; increasing or decreasing all the implied volatilities used for an asset by 20% of current values; increasing or decreasing an equity index by 10%; increasing or decreasing the exchange rate for a major currency by 6%; increasing or decreasing the exchange rate for a minor currency by 20%

2. Choose particularly days when there were big market movements and stress all variables by the amount they moved on those days

   Some historical scenarios are one-day shocks to market variable, while other shock, particular those involving credit and liquidity, can last longer

   It is also important to include volatilities in the market variable.

3. Form a stress testing committee of senior management and use their understanding of markets, world politics, economic environment, and current global uncertainties to develop plausible scenarios that could lead to large losses.

   It is important that senior management and the board of directors understand and recognize the importance of stress testing and take strategic decisions based on the stress-testing results.

   If scenario generated involves only a few “core” variables, regress other “peripheral” variables on the core variables to determine their movements.

Ideally the relationship between peripheral and core variables should be estimated in stressed market conditions

4. Making Scenarios Complete

   Often an adverse scenario has not only an immediate effect on the value of a portfolio but also a “knock on” effect resulting from many different financial institutions being affected by the shock in the same way and responding in the same way

   Scenarios should ideally be dynamic scenarios in which the response of the financial institution doing the stress test to the shock and the response of other financial institutions are all considered

5. Reverse Stress Testing: Use an algorithm to search for scenarios where large losses occur

   This can be a useful input to the stress testing committee. The disadvantage is that the scenarios generated might be totally unreasonable.

- The Basel Committee requires market risk calculations based on a bank's internal VaR model to be accompanied by rigorous and comprehensive stress testing

  Banks using IRB approach to determined credit risk capital are required to conduct stress tests to determine the robustness of their assumptions

  A bank should regularly maintain, update and assess its stress-testing framework

  Regulators require banks to consider extreme scenarios and then make sure they have enough capital for those scenarios. Therefore, the stress testing committee may have an incentive to "water down" the scenarios they consider to avoid more regulatory capital that is likely to be required

  Regulators may provide their own scenarios to be used by all banks. However, if the scenarios are announced in advance, financial institutions may hedge only against the scenarios than the range of risks represented by each stress scenario.

- What to do with the Results?

  If the risk associated with the scenario is not acceptable, managers should investigate what trades they can put on to make the risk more acceptable, or prepare a coping strategy in the extreme condition.

  The stress scenarios can also be integrated with the historical simulation scenarios to produce a composite VaR

  - One idea is to ask the stress testing committee to assign probabilities to scenarios (e.g. 0.05% or 0.2% or 0.5%)
  - The stress scenarios can then be integrated with the historical simulation scenarios to produce a composite VaR

Scenario	Loss ($000s)	Probability	Cumul. Probability
s5	850.000	0.00050	0.00050
s4	750.000	0.00050	0.00100
v494	477.814	0.00198	0.00298
s3	450.000	0.00200	0.00498
v339	345.435	0.00198	0.00696
s2	300.000	0.00200	0.00896
v349	282,204	0.00198	0.01094
v329	277.041	0.00198	0.01292
v487	253.385	0.00198	0.01490
s1	235.000	0.00500	0.01990
v227	217.974	0.00198	0.02188

- Operational risk is the risk of loss resulting from inadequate or failed internal processes, people, and systems, or from external events (Basel Committee Jan 2001)
  - The definition includes people risks, technology and processing risks, physical risks, legal risks, etc
  - The definition excludes reputation risk and strategic risk
- Categorization of Risks
  1. Internal fraud
  2. External fraud
  3. Employment practices and workplace safety
  4. Clients, products and business practices
  5. Damage to physical assets
  6. Business disruption and system failures
  7. Execution, delivery and process management
- Categorization of Business Lines
  1. Corporate finance
  2. Trading and sales
  3. Retail banking

4. Commercial banking
5. Payment and settlement
6. Agency services
7. Asset management
8. Retail brokerage

- In Basel II there is a capital charge for Operational Risk

  Three alternatives:

  - Basic Indicator (15% of annual gross income)
  - Standardized (different percentage for each business line)
  - Advanced Measurement Approach (AMA)

    To use AMA, the bank's operational risk management system must be capable of allocating economic capital for operation risk across business lines in a way that creates incentives to improve operational risk management

    The objective is to produce a probability distribution of losses and capital is assigned to cover *unexpected* loss

    Banks need to estimate their exposure to each combination of type of risk and business line

Ideally this will lead to 7×8=56 VaR measures that can be combined into an overall VaR measure

The confidence level is 99.9% and the time horizon is 1 year

- Loss Severity and Loss Frequency
  - Loss frequency distribution is the distribution of the number of losses observed during the time horizon (e.g., 1 year)

    One possibility is to assume a Poisson distribution:

    Probability of *n* events in time *T* is

    $$e^{-\lambda T}\frac{(\lambda T)^n}{n!}$$

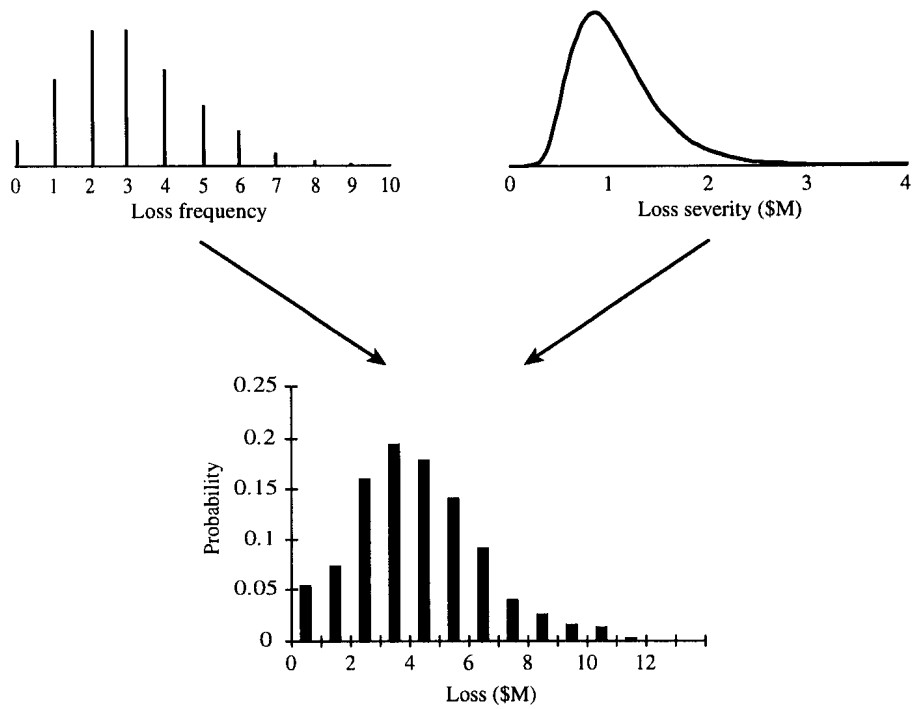
    where λ can be estimated as the average number of loss per unit of time
  - Loss severity distribution is the distribution of the size of a loss given that a loss occurs

    One possibility is to assume a lognormal distribution so that we need only estimate the mean and SD of logarithm of loss.
  - We can combine the loss frequency and severity distribution to determine a total loss distribution.

    The usual assumption is that the loss frequency is independent of the loss severity

On each trial of Monte Carlo simulation:

1) We sample from the loss frequency distribution to determine the number of loss (e.g., $= n$)
2) We sample n times from the loss severity distribution to determine the loss for each loss event ($L_1, L_2 \cdots L_n$)
3) The total loss is $L_1 + L_2 \cdots + L_n$



- Data Issues

There is usually relatively little historical data available within a bank to estimate loss severity and frequency distribution. Important losses are low-frequency high severity-losses.

The loss frequency distribution should be estimated from the banks own data as far as possible.

The loss severity distribution can be estimated with internal and external historical data after adjusted for inflation.

Two sources of external data:

1) data sharing between banks

   A scale adjustment should be made to external data:

$$\text{Estimated Loss for Bank A}$$
$$= \text{Observed Loss for Bank B} \times \left(\frac{\text{Bank A Revenue}}{\text{Bank B Revenue}} \right)^{\alpha}$$

$$\text{Using external data, Shih et al estimate } \alpha = 0.23$$

   Then external data can be merged with bank's own data to obtain a large sample

2) data vendors

   Data from vendors is based on publicly available information and therefore is biased towards large losses

   Data from vendors can therefore only be used to estimate the relative size of the mean losses and SD of losses for different risk categories

- Scenario Analysis

  Aim is to generate scenarios covering all low frequency high severity losses

  Can be based on own experience and experience of other banks

  Assign probabilities

  Aggregate scenarios to provide loss distributions

- Business Environment and Internal Control Factors (BEICFs) should be taken into account when loss severity and loss frequency are estimated. These include

  Complexity of business line

  Technology used

  Pace of change

  Level of supervision

  Staff turnover rates

  etc

- We can also use power law ($Prob(v > x) = Kx^{-\alpha}$) to estimate the tail distribution of operational risk losses. Both internal and external data can be employed.
- Other techniques for operational risk management:
  - Identifying Causal Relationships between decisions taken and operational risk losses
  - Risk Control and Self Assessment (RCSA): asking the managers of business units to identify their operational risks.
  - Key Risk Indicators (KRI): provides an early warning system to track the level of operational risk in the organization and allow remedial action to be taken before losses are incured
  - Allocating operational risk capital to business units in a way that encourages them to improve their operational risk management. E.g., Scorecard approaches
  - It is important for operational risk managers to decide the extent to which operational risks should be insured against. Factors that affect the design of an insurance contract
    - Moral hazard

Deductibles, co-insurance provisions, policy limits

- Adverse selection

  Collect information and charge differently

– Sarbanes-Oxle

  - The board of directors becomes much more involved with day-to-day operations. They must monitor internal controls to ensure that risks are being assessed and handled well
  - SEC has the power to censure the board or give it additional responsibilities
  - Auditors are not allowed to carry out significant non-audit tasks
  - Audit committee of board must be made aware of alternative accounting treatments
  - CEO and CFO must return bonuses in the event financial statements are restated
  - Other rules concerning insider trading, disclosure, personal loans to executives, reporting of transactions by directors