



STUDY NOTE - 8

RISK MEASUREMENT AND MANAGEMENT

This Study Note includes:

- **Uncertainty and risk**
- **Risk management strategy formulation and implementation**
- **Risk pooling and diversification**
- **Diversification of risk**
- **Probability of ruin**
- **Macro economic factors**

INTRODUCTION

Uncertainty and risk are two terms which are anathema to every manager. To expect the unexpected and handle the same successfully is Hallmark of a Good Manager.

UNCERTAINTY AND RISK

Certainty and uncertainty are the two extremities on a continuous platform and risk is identified somewhere between the two extremes. Uncertainty is a totally indefinable happening and is also unexpected. An uncertain situation is faced when the variables are many and their interaction can be innumerable. For example different people behave and react differently to the same situation and uncertainty arises.

Risk expressed mathematically is the dispersion of a probability distribution: how much do individual outcomes deviate from the expected outcome. A simple measure of dispersion is a range of possible outcomes, which is simply the difference between upper most and the lowest outcomes. This is mathematically measured as standard deviation.

Physically, risk can be identified as an event which has different probabilities of happening, but the time of the event is not known as also the impact of such risk can vary.

Japan has been a country which has suffered many earthquakes over centuries and risk of earthquake is known or it can be said that Japan is earthquake risk prone. However, when an earthquake will take place is not known and to that extent it is uncertain. Again along the Indian Coast, Nagapattinam in Tamilnadu, Ongole in AP, Balasore in Orissa, Chittagong in Bangladesh have suffered through storms and thus this coast along the Bay of Bengal is Storm Risk Prone. In the same manner the uncertainty factor about the storm is the way it builds up or it does not build up and ends up in a low pressure trough needs to be understood in greater detail to face such risk.

While uncertainty cannot be quantified a risk can be quantified through mathematical models, probability models, correlation, etc. and also measured through quantitative models and technological tools.



Objectives of risk management

Objectives can be classified under two heads, namely post-loss objectives and pre-loss objectives.

Pre-loss objectives

1. Understanding environment
2. Fulfillment of external obligations – statutory requirements
3. Reduction in anxiety through preventive measures
4. Social obligations to make people aware of the risks

Post-loss objectives

1. Survival of the organization
2. Continuance of the organization's operations
3. Initiate and improve the income /earnings
4. Obligation to society

RISK MANAGEMENT STRATEGY FORMULATION AND IMPLEMENTATION

Under the pre-loss and post-loss situations it becomes necessary to develop management strategy both on the prevention front as well as containment respectively. Three steps in this direction are as follows:

1. Develop strategy for risk management
2. Develop tools for measurement and evaluation
3. Implement a strategy using tools

1. Develop strategy for risk management

Risk management strategies are seven fold and they are: Avoid Risk, Reduce Risk, Retain Risk, Combine Risks, Transfer Risk, Share Risk and Hedge Risk.

Avoid Risk

Avoid risk is the prevention method and proven method. This method results in complete elimination of exposure to loss due to a specific risk. It may involve avoidance of an activity which is risky. This can be approached in two ways

1. **Do not assume risk:** This means that no risky projects are undertaken. E.g., the Government has clearly mandated that no hazardous chemical industry can be put up near a populated area. This is a proactive avoidance.
2. **Discontinuance of an activity to avoid risk:** While a proactive avoidance follows a sound decision knowing fully the perils of the risk, abandoning a project to avoid risk midway is a decision taken while handling the project. E.g., A PVC plant was being put up on the basis of alcohol as a raw material to be converted to an intermediate product known as ethylene di chloride. Unpredictability of alcohol supplies suddenly



became risk due to a distillery which was supposed to come up in this area did not materialize. So the root of using alcohol was abandoned half way through the PVC product and ethylene-di-chloride was imported to be processed to PVC.

Reducing Risk

Reduction of risk is attempted to decrease the quantum of losses arising out of a risky happening e.g., earthquake, storm, floods, etc. Risk reduction can be achieved through

Loss Prevention and
Loss Control.

Loss Prevention: Prevention of loss is the most insignificant of dealing with the risk, prevention systems like fire sprinkler systems, burglar alarms, etc., are typical prevention measures to reduce the risk of fire burglary. Other measures are the understanding of the risk or the comprehension of the risk arising out of an activity is environment and relationship between the activity and the environment. This will help in the following way:

Modify the risk involved in the activity itself through improved design or technology;

Tailor the surroundings where the risky activity is to take place by isolation or notification or proper layout;

Identify the linkage between the activity and the environment and institute suitable safe guards through training of people, safety devices and providing knowledge and institute mock exercises, etc.

Loss Control: Is accomplished through measures which will douse the fire in the case of fire accident, e.g. using fire hydrants, fire extinguishers. Loss control is also accomplished by on line process control which operates in the event of a risky happening, e.g., Gas leaks fires.

Retain Risk

Risk retention is adopted when it cannot be avoided, reduced or transferred. It can be a voluntary or involuntary action. When it is voluntary it is retained through implied agreements, involuntary retention ensures when the organization is unaware of the risk and faces it when it come up.

Combine Risks

When the business faces two or three risks the over all risk is reduced by a combination. This strategy is prevalent mainly in the area of financial risk. Different financial instruments being negative risk return of co relation like Bonds and Shares are taken in a single port folio to reduce the risk. A physical risk of non-availability of a particular material is often solved by having more than one supplier.

Transfer Risk

Normally in projects assignments or multifaceted exercises, execution is fought with risks. Different agencies work together and these agencies take care to transfer risk in their areas to another agency which is better equipped to take care of a risk for a consideration. Here the concept of core competence curves in and whenever a particular agency, individual or a firm finds that it is dealing in a area where it does not have the core competence to deal



with it seeks the help of another agency which has the specific core competence to transfer its own risk. The risk may be in the form of loss of reputation or sub quality performance and this risk is taken care of through transfer.

Sharing Risk

Insurance is a method of sharing risk for a consideration, viz., premium insurance loss, undertakes to share the risk with the companies and share their own risk through re-insurance with other companies. Some times big conglomerates share risk among their own group of companies in proportion to their risk bearing strengths by creating a corpus instead of paying premium to insurance companies.

Hedging Risk

Exposures of funds to fluctuations in foreign exchange rates, interest rates, prices, etc. bring about financial risks resulting in losses or gains. The downside risk is often taken care of by hedging. Hedging is done by an agency taking over the risk for a consideration for a period and select band of fluctuation.

Risk optimization

Risk optimization means utilizing information on risk to compute precisely what types and combinations of risk to take. It also develops the precise trade off between risk and reward and the corresponding appropriate product pricing to reflect the risk taken.

2. Develop tools for measurement and evaluation

Tools for measurement can be identified based on the type of risk.

Types of Risk

Mark Dorfman has defined “risk management as the logical development and execution of a plan to deal with potential losses”. The risk can include both upside and downside. Potential risk management often refers to reducing downside potential and enhances the returns on topside.

Risks are of many types as follows:

1. **Physical Risk** like natural calamities: fire, tsunami, floods, earthquake, etc.
2. **Business Risk** which is inherent to a business due to its nature and susceptibility to environment, e.g., change of fashion, business cycles, conflicts like war, insurgency, cross border terrorism, technological obsolescence, etc.
3. **Financial Risk** arising out of the nature of financial transactions and conduct of business and investment.

Measurement of risk

Physical Risk

Physical risks are measured by the application of technological tools. Earthquakes are measured in the Richter scale. Floods are measured through level monitoring and marking danger levels. Risk of fire is often monitored through measurement of flash point, fire point, ignition temperatures and propulsion temperatures. Spontaneous ignition temperatures are



yet another measurement to identify fire risk, e.g., coal dumps, oil installations, explosive godowns, etc.

Physical risk arising out of Social, Political, Economic and Legal Environments are often identified through the performance of lead indicators. In the Social arena lead indicators can be pestilence, expedencies, social upheavals, etc., measurement of these social risk are done on the basis of the impact on the Society, i.e., increase in crimes, violence and accidents, etc.

Political risk is often identified with the change in Government policy capitalistic, democratic or totalitarian and can be measured by the impact of such government policy on the economic activity, e.g., Government Industrial Policy and Labor Policy.

Economic risk may arise out of commercial transactions, foreign exchange currency variation, capital market fluctuations, trade cycles, etc. The lead indicators risks are like variation in GDF, IIP, Balance of Payments, Stock Market Indices, etc.

Legal Risk arises out of the implication of various statutes affecting business, Anti Trust Bills, Factory Acts, Industrial Disputes Act, and Foreign Exchange Management Act (FEMA).

Business Risk

Business risks refers to variations in earnings due to demand variability, price variability, variability for input prices, etc, that are essentially external and are market driven. Measurement of this type will be discussed in greater detail under Corporate Risk Management section latter.

Financial Risk

Financial risk arises out of financial leverage. Capital structure having a high degree of financial leverage will have greater proportion of debt, increasing the financial commitment of the company. Such companies are exposed to the financial risk which is normally measure as a capability to repay loans and service the loans. Measurement of this type will be discussed in greater detail under Corporate Risk Management section latter.

Risk Evaluation

Risk evaluation helps in quantifying the possible consequences of risk in value terms or in other words physical measurement can be translated into value. Risk evaluation is based on two steps:

1. Developing a benchmark in relation to the importance of the risk to the company
2. Apply this yard stick for evaluation of all risks

The effect of consequences of a risk is computed in terms of variable as well as fixed costs. For example, wherever an exposure to risk involves a loss as in the case of a break down in a factory, the direct cost as a result of the breakdown will have to be calculated. At the same time, if the factory comes back to production only after a period, the standing charges during the period of shutdown will be the fixed cost not recovered.

Mathematical models as well as statistical analysis have been helpful in risk assessment. While applying statistical analysis, two concepts are applied for assessment of risk:



1. Measures of Central Tendency and
2. Measures of Variation

Measures of Central Tendency

Aim of this concept is to arrive at one single value that will denote the characteristics of the total data collected. Such a value is known as the Central Value or Average and can be expressed as Mean, Median and Mode according as the nature of risk being measured.

Measures of Variation

From the Central Tendency or the average is to study the dispersion or scatteredness. The statistical analysis is based on following methods (a) Range (b) Mean deviation (c) Standard deviation (d) Variance (e) Co efficient of variation.

Mathematical models

As risks are of different types, probabilistic models have been used for obtaining expected values, e.g., launching of a new product with uncertain demand, launching of a product in a known area where competition is keen with penetration prices, etc.

Frequency distribution of a random variable can be discrete or continuous. When the random variable is discrete the probability function is known as *probability mass function* and its distribution is known as *discrete probability distribution*. If the random variable is continuous, then its probability function is known as *probability density function* and distribution as *continuous probability distribution*.

Distribution can be classified as follows:

1. Binomial Distribution
2. Poisson Distribution
3. Normal Distribution.

Binomial Distribution is a probability distribution which identifies the probability of success or failure. Bernoulli Process is applied in this case.

Poisson distribution is a discrete probability distribution which is applied when a chance of an individual event being a success is minimal. This distribution is used to delineate the behavioral events like number of accidents which are rare.

Normal Distribution is useful for understanding continuous random variables.

Financial model

Time Value of Money

Conversion of the above values can relate to different points of time in the future and as such cannot be given the same credence in terms of value. For this discounted cash flows have been computed for ascertaining the present value of such future losses or earnings. This type of computation is known as *time value of money*.

Risk adjusted performance measurement (RAPM)

The best practice recommendation on risk management was enunciated in the G30 report on derivatives. The recommendations have been considered very sound and are very much in use currently. They include:



- a. Involve senior management
- b. Establish independent risk managers for market and credit risk
- c. Market to Market on a daily basis with consistent valuation measures
- d. Measure and limit market and credit risk rating using value at risk (VaR) techniques to estimate probable loss over a period of time
- e. Strengthen operational controls, systems and training
- f. Make investment and funding forecasts
- g. Identify revenue sources and next conduct stress testing

The above recommendations ensure that adequate information could be available for the management to manage risk and avoid nasty surprises. RAPM framework brings together and measures the trade off between risks and rewards. This is discussed in greater detail under financial risk measures in risk insurance chapter.

3. Implement strategy using tools

Data collection and analysis will have to be selectively exercised and quantification of risk is done in the following manner:

1. Using entire probability distributions
 - a. Normal Distributions
 - b. Monte Carlo simulation of distributions
2. Correlation analysis
3. Discounted cash flow analysis

Using probability distributions (Loss distributions)

Often analysts focus on characteristics of loss distributions, such as

1. Expected Loss
2. Standard Deviation of loss
3. Maximum probable loss

Sometimes information about the entire probability distribution is available and useful. Two main approaches for probability distribution are:

1. Approximate loss distribution assuming losses are normally distributed
2. Use Monte Carlo simulation to approximate the loss distribution

Approximate loss distribution assuming losses are normally distributed

Most Loss distributions are not normal; however, from the central limit theorem using the normal distribution will nevertheless be appropriate when

1. Number of exposures is large
2. Losses across exposures are independent



For example, where a firm has large number of employees and workers suffer injury losses and firms having large fleets of cars suffering automobile accident losses.

If Losses are normally distributed with

$$\text{Mean} = m$$

$$\text{Standard deviation} = s$$

Then Probability (Loss < $m + 1.645 s$) = 0.95

$$\text{Probability (Loss < } m + 2.33 s) = 0.99$$

For example, worker compensation losses for a steel company

Sample mean loss per worker = Rs.300

Sample standard deviation per worker = Rs. 20,000

Number of workers = 10,000

Assume losses are independent

It is reasonable to assume that total losses are normally distributed. Find what is the expected total loss and standard deviation of total loss?

Total loss = $\sum L_i$, where L_i = loss due to worker i

Expected total loss = $\sum E(L_i) = \text{Rs.}300 \times 10,000 = \text{Rs.}3 \text{ million}$

$$\begin{aligned} \text{Standard deviation of total loss} &= [\text{Var}(\sum L_i)]^{1/2} \\ &= [10,000 \times \text{Rs.}20,000]^{1/2} \\ &= \text{Rs.}2 \text{ million} \end{aligned}$$

The expected value and standard deviation can then be used to find the maximum probable loss at the 95 per cent level:

$$\text{Rs.}3 \text{ million} + 1.645 (\text{Rs.}2 \text{ million}) = \text{Rs.}6.3 \text{ million}$$

Use Monte Carlo simulation to approximate the loss distribution

The following steps are to be taken to quantify the total cost of loss:

- Make assumptions about distributions relating to the severity and the frequency of the individual losses
- Draw samples randomly from each distribution and compute the company's total losses under alternative risk management strategies
- Iterate a number of times to obtain a distribution for total losses under each of the alternative strategies
- Compare the distributions

Correlation analysis

Develop correlation coefficient between X and Y variables.

$$\text{Correlation coefficient between X and Y} = \text{Cov}(X, Y) / \text{STD}(X) \text{ STD}(Y)$$



Correlation is always between -1 and +1.

If Correlation = 0 it means that there is no relationship between X and Y

If Correlation = 1 it means that X and Y always move together and are fully correlated

If Correlation = -1 it means that X and Y always move in opposite directions and are negatively correlated

Discounted cash flow (DCF) analysis

This financial tool computes the present value of future cash flows over multiple periods using a discount factor. The formula for net present value of alternative decisions can be computed as below:

$$NPV = \sum_{t=0}^n \frac{E(NCF_t)}{(1+r)^t}$$

Where

E (NCF_t) = Expected net cash flow in year t

r = opportunity cost of capital (reflects the risk of the cash flows)

For example, consider a compound wall's

Upfront cost = Rs.1,50,000

Compound will reduce theft loss by Rs.55,000 each year for 3 years

Security expenses will be reduced by Rs.15,000 each year for 3 years

Discount rate = 10%

NPV = (1, 50, 00 – [1x 70,000 + 0.909 x 70,000 + 0.826 x 70,000]) = +12936

Thus NPV is positive.

RISK POOLING AND DIVERSIFICATION

Whether it is the individual, an insurance company or insurer or a corporate, which necessarily has to insure all its risks, the proper way to look at the exigencies is to pool the risk. The concept of pooling risk is the process of identification of separate risks and put them all together in a single basket, so that the monitoring, combining, integrating or diversifying risk can be implemented.

Monitoring becomes easier when the specific agency put in charge knows that all the risks have been identified and they are being monitored according to the system drawn up to quantify the total risk through pooling and with a control figure. i.e., plan the way to monitor, actually monitor, and then check whether there are variations from the monitoring exercise and then act to correct the deviation. This correction act can be combining risks or integrating risks or diversifying risks.

For example, whenever a project is put up insurance (Marine insurance) is taken for shipping the various plant and machinery from the manufacturers to the port near the project site. The logistics from the port to the project site is taken care of by the carrier and he insures (transit insurance) the risk for that segment. The material is received at site and stored until erection



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(storage insurance). During erection of different plant and machinery, mechanical, electrical, etc, risk is covered (erection insurance). The erected plant and machinery is then tested and trial runs are taken for guarantee purposes on continuous run as per the contract. The risk during this period is covered as risks for commercial run. All these risks put together is pooling and each separate policy has a risk value and premium and conditions attached there to by the insurer and insured has to carry out those obligations. This is the process of monitoring. To reduce risk after pooling it can be combining through a comprehensive policy for the plant and machinery Freight on Board (FOB) to the completion of final commercial guarantee run. Integrating risks will take care of all the foreign shipments together, inland transit risks together so that these risks which are similar are taken together.

DIVERSIFICATION OF RISK

This involves identifying that fraction, which is systematic and the remaining unsystematic. Systematic risk is that inherent and peculiar to the type of business or the organization and can be reduced or diversified by acting within the organization, which is through functional level strategy. The unsystematic risk, which is the market risk is external to an organization and is also termed as market risk. The identification of characteristics of market risk through statistical correlation “Beta”, which is a measure of market risk, lends itself for manipulation through portfolio management.

PROBABILITY OF RUIN

Probability of ruin is essentially a study of risk of insolvency for a company with multiple business activity facing heavy claims from creditors. For this purpose, the company is permitted to transfer resources between business lines. But such transfers are restricted by transaction costs. Insolvency or ruin occurs when the negative positions in one or more business lines cannot be compensated by capital transfers. Such problems are normally solved on the basis of intermittent or continuous process. Mathematically, actuarial calculations are involved in such exercise. A clear expression of Laplace transformation of the finite type, for computing ruin probability is one such method. Another model developed by Clayton Levy Copulas takes into consideration the interdependence of components of risk.

IMPACT OF MACRO ECONOMIC FACTORS AND RISK

Relationship between risk and return can never be over emphasized, higher the risk the return needs to be higher and the computation of the risk premium has always been a million dollar question. However, risk perceptions of investors tend to be different with the onset of business cycles. In recession, investors tend to be conservative as their appetite for risk is reduced and they go after growth sectors which have lower risk. In a security market, low risk growth sector have always been the biggest gainers in terms of returns. This explains that onset of recession upsets the risk return balance.

Macro economic factors like change in interest rates, inflation, money supply and index of industrial production have a big impact on the investors risk perception. Analysis has shown that in a regime of high interest rates and high inflation low risk sectors perform better than high risk stocks. As the interest rates and inflation decline the high risk sectors tend to do better.