Unit 5: Decision Making Under Risk and Uncertainty

5.1 The Nature of Decision Making

Making effective decisions, as well as recognizing when a bad decision has been made and quickly responding to mistakes, is a key ingredient in organizational effectiveness. Some experts believe that decision making is the most basic and fundamental of all managerial activities. Decision making is most closely linked with the planning function. However, it is also part of organizing, leading and controlling.

5.1.1 Types of Decisions

Programmed decision is one that is fairly structured or recurs with some frequency (or both). Non programmed decision is one that is unstructured and occurs much less often than a programmed decision.

5.1.2 Decision-Making Conditions

5.1.2.1 Decision Making Under Certainty

A state of certainty exists when a decision maker knows, with reasonable certainty, what the alternatives are and what conditions are associated with each alternative. Very few organizational decisions, however, are made under these conditions. The complex and turbulent environment in which businesses exist rarely allows for such decisions.

5.1.2.2 Decision Making Under Risk

A state of risk exists when a decision maker makes decisions under a condition in which the availability of each alternative and its potential payoffs and costs are all associated with probability estimate. Decisions such as these are based on past experiences, relevant information, the advice of others and one's own judgment. Decision is 'calculated' on the basis of which alternative has the highest probability of working effectively.

5.1.2.3 Decision Making Under Uncertainty

A state of uncertainty exists when a decision maker does not know all of the alternatives, the risks associated with each, or the consequences each alternative is likely to have. Most of the major decision making in today's organizations is done under these conditions. To make effective decisions under these conditions, managers must secure as much relevant information as possible and approach the situation from a logical and rational view. Intuition, judgment and experience always play major roles in the decision-making process under these conditions.

5.2 Meaning of risk and uncertainty

When one is examining the decision-making process under conditions of imperfect information, it is important to distinguish between the closely related concepts of risk and uncertainty. Risky situations involve multiple outcomes (or payoffs), where the probability of each outcome is known or can be estimated. An example of a risky situation is the flipping of a fair coin. The probability that either a head or a tail will result from flipping a fair coin is 50%. Investing in the stock market is another risky situation. While the investor cannot know with certainty the rate of return on the investment, it is possible to estimate an expected rate of return based on a company's past performance.

Definition: Risk involves choices involving multiple possible outcomes in which the probability of each outcome is known or may be estimated.

Uncertainty also involves multiple-outcomes situations. What distinguishes risk from uncertainty, however, is that with uncertainty the probability of each outcome is unknown and cannot be estimated. In many cases, these probabilities cannot be estimated because of the absence of historical evidence about the event. Nevertheless, there is a fine line between decision making under conditions of risk and of uncertainty.

Definition: Uncertainty involves choices involving multiple possible outcomes in which the probability of each outcome is unknown and cannot be estimated.

When one is considering the different ways in which managers deal with uncertain outcomes it is important to distinguish between two types of uncertainty. In situations of *complete ignorance*, the decision maker is unable to make any assumptions about the probabilities of alternative outcomes under different states of nature. In these situations, the decision maker may adopt any of a number of rational criteria to facilitate the decision-making process.

Situations involving partial ignorance, on the other hand, assume that the decision maker is able to assign subjective probabilities to multiple outcomes. Whenever the decision maker is able to use personal knowledge, intuition, and experience to assign subjective probabilities to outcomes, then decision making under uncertainty is effectively transformed into decision making under risk.

The procedures for evaluating outcomes of decisions made under conditions of risk, or uncertainty involving partial ignorance, are identical, the process of evaluating outcomes under conditions of complete ignorance requires alternative approaches to the decision-making process.

5.3 MEASURING RISK: MEAN, VARIANCE AND COEFFICIENT OF VARIATION

MEAN (EXPECTED VALUE)

The manager must know the possible outcomes of a particular event, action or decision. The manager must be aware of the probability of risks in business. (Probability means likelihood that a given outcome will occur)

For example; a purchase of share may lead to three probable results i.e. either the price will increase, decrease or it can be the same. Objective interpretation relies on the frequency with which certain events tend to occur. Out of 100 shares, if 25 have increased and 75 have remained in the same level in the market then the probability of incurring profit is ¼. If there is no past experience then we go for subjective probability and based on our perception of occurrence we may measure the probability. But manager's perceptions differ therefore they make different choices. In general probabilities are measured in two ways they are expected value and variability.

Expected value: The probable payoffs associated with all possible outcomes are called as expected value.

Expected value = P(s) (40/share) + P (f) (20/share)
= ¼(40) + ¾ (20) = 25.

The most commonly used summary measures of risky, random payoffs are the *mean* and the *variance*. These random payoffs may refer to profits, capital gains, prices, unit sales, and so on. In risky situations, the expected value of these random payoffs is called the mean. The mean is the weighted average of all possible random outcomes, with the weights being the probability of each outcome. For discrete random variables, the expected value may be calculated using Equation (5.1)

$$\in(x)= \mu = \sum xipi \qquad (5.1)$$

Where *xi* is the value of the outcome, *pi* is the probability of its occurrence.

When the probability of each outcome is the same as the probability of every other outcome, then the expected value is the sum of the outcomes divided by the number of observations. In this case, the expected value of a set of uncertain outcomes may be calculated using Equation (5.2)

$$\in(x)= \mu = \frac{1}{n}\sum xipi \qquad (5.2)$$

Definition: The mean is the expected value of a set of random outcomes. The mean is the sum of the products of each outcome and the probability of its occurrence. When the

probability of the occurrence of each outcome is the same as the probability of every other outcome, the mean is the sum of the outcomes divided by the number of observations.

Problem 1. Suppose that the chief economist of Silver Zephyr Ltd. believes that there is a 40% ($p1 = 0.4$) probability of a recession in the next operating period and a 60% ($p2 = 0.6$) probability that a recession will not occur. The COO of Silver Zephyr believes that the firm will earn profits of p1 = \$100 in the event of a recession and p2 = \$1,000 otherwise. What are Silver Zephyr's expected profits?

Solution. Silver Zephyr's expected profits are:

$E(\pi) = \sum xipi \;\; = \pi 1p1 + \;\pi 2p2$

$0.4(100) + 0.6(1000)$

40+600 =640

Thus, Silver Zephyr's expected profits for the next operating period are \$640.

VARIANCE (Variability): The extent to which the possible outcomes of an uncertain situation differ. This difference is called as deviation; it means difference between expected outcome and the actual outcome.

The strength of the mean is its simplicity. In a single number, the mean (expected value) summarizes important information about the most likely outcome of a set of random payoffs. Unfortunately, this strength hides other important information that is valuable to the decision maker. For example, suppose that an individual is offered the following fair wager. If the individual flips a coin and it comes up heads, then the individual wins \$10. On the other hand, if the coin comes up tails, then the individual loses \$10.The reader should verify that the expected value of the wager is \$0. Suppose, on the other hand the payoffs were \$1,000 and -\$1,000 for a head and tail, respectively. Once again, the reader will verify that the expected value of the wager is \$0.While the expected values of the two wagers are the same, clearly the wagers themselves are different. While the potential payoff is much greater than in the second scenario, so too is the potential loss. While the individual may be prepared to accept the first bet, that person may not be willing to accept the second because the possibility of such a large loss may be unacceptable. For this individual, the second wager may simply be too risky.

The second wager is riskier because the spread, or dispersion, of the possible payoffs is greater. Each has the same expected value, but the swing between a gain and a loss is considerably greater. It is this dispersion in the possible payoffs that is the distinguishing characteristic of risk. The most commonly used measure of the dispersion of a set of random

outcomes is the variance. The variance is the weighed average of the squared deviations of all possible random outcomes from its mean, with the weights being the probability of each outcome. The variance of a set of random payoffs may be calculated by using Equation (5.3).

$E(x-\mu)^2 = \sigma 2 = E(xi-\mu)^2$ pi (5.3).

When the probability of each outcome is the same, then the variance is simply the sum of the squared deviations divided by the number of outcomes.

$E(x-\mu)^2 = \sigma 2 = \frac{1}{n}E(xi-\mu)^2$ (5.4)

Definition: The variance of a set of random outcomes is the expected value of the squared deviations of an outcome from its mean. The variance is a measure of the dispersion of a data series around its expected value.

The greater this dispersion, the greater the value of the variance. The variance is the sum of the products of the square of the deviation of each outcome from its mean and the probability of the occurrence of the outcome. When the probability of the occurrence of each outcome is the same as the probability of the occurrence of every other outcome, the mean is the sum of the squared deviations divided by the number of outcomes.

Denoting a win and a loss as *x*1 and *x*2, respectively, the variances of the two wagers, $\sigma 2i \; and \; \sigma 2ii \; are$

$\sigma 1^2 = E(x-\mu)^2 pi = 0.5(10-0)^2 + 0.5(-10-0)^2 = 100$

$\sigma 2^2 = E(x-\mu)^2 pi = 0.5(1000-0)^2 + 0.5(-1000-0)^2$

$0.5(1{,}000{,}000) + 0.5(1{,}000{,}000) = 1{,}000{,}000$

$\sigma 2^2 > \sigma 1^2$, then the second wager is riskier than the first.

An alternative way to express the riskiness of a set of random outcomes is the *standard deviation*. The standard deviation is simply the square root of the variance, s.

Definition: The standard deviation is the square root of the variance

For the foregoing wagers the standard deviations are $\sigma 1 = \sqrt{100} = 10 \; and \; \sigma 2 = \sqrt{1{,}000{,}000} = 1{,}000.$ since the standard deviation is a monotonic transformation of the variance, the ordering of relative risks of the wagers is preserved. Thus, since $\sigma 2 > \sigma 1$ the second wager is riskier than the first.

COEFFICIENT OF VARIATION (CV)

Unfortunately, neither the variance nor the standard deviation can be used to compare the riskiness involving two or more risky situations with different expected values. The reason for this is that neither measure is independent of the units of measurement. To measure the relative riskiness of two or more outcomes, we may use the coefficient of variation, which may be calculated by using Equation (14.6). The coefficient of variation allows us to compare the riskiness of alternative projects by "normalizing" the standard deviation of each by its expected value.

$$Cv= \frac{\sigma}{\mu} \qquad (14.6)$$

Definition: The coefficient of variation is a dimensionless number that is used to compare risk involving two or more outcomes involving different expected values. It is calculated as the ratio of the standard deviation to the mean.

Problem 2. Suppose that capital investment project A has an expected value of $\mu A =$ \$100,000 and a standard deviation of σA = \$30,000. Additionally, suppose that project B has an expected value μB = \$150,000 and a standard deviation of σB = \$40,000.Which is the relatively riskier project?

Solution. From Equation (14.6) the relative riskiness of projects A and

B are

$$CVA= \frac{\sigma}{\mu} = \frac{30000}{100000} = 0.3$$

$$CVB= \frac{\sigma}{\mu} = \frac{40000}{150000} = 0.267$$

Thus, although project B has the larger standard deviation, it is the relatively less risky project.

5.4 Types of Risks

Economic risk: Choice of loss due the fact that all possible outcomes and their probability of occurrence are unknown.

Uncertainty: When the outcomes of managerial decisions cannot be predicted with absolute accuracy but all possibilities and their associated probabilities of occurrence are known.

Business risk: Chance of loss associated with a given managerial decision.

Market risk: Chance that a portfolio of investments can lose money due to volatility in the financial market.

Inflation risk: A general increase in the price level will undermine the real economic value of any legal agreement that involves a fixed promise to pay over an extended period.

Interest rate risk: The changing interest rates affect the value of any agreement that involves a fixed promise to pay over a specified period.

Credit risk: May arise when the other party fails to abide by the contractual obligations.

Liquidity risk: Difficulty of selling corporate assets and investments.

Derivative risk: Chance that volatile financial derivatives could create losses on investments by increasing price volatility.

Cultural risk: Risk may arise due to loss of markets differences due to distinctive social customs.

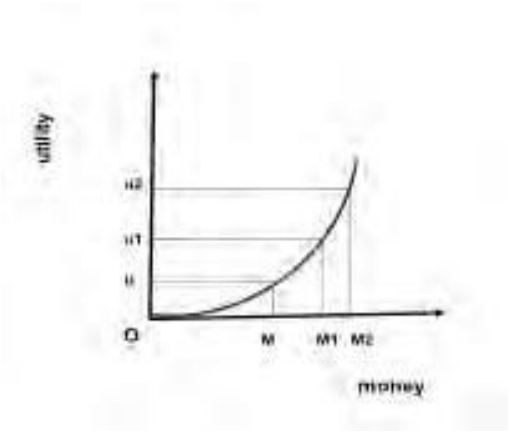
Currency risk: Is the probable loss due to changes in the domestic currency value in terms of expected foreign currency.

Government policy risk: Chance of loss because of domestic and foreign government policies.

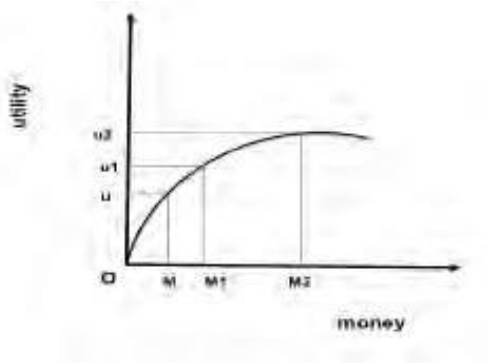
The above listed various types of risks are involved in business. Therefore it is essential for the manager to understand the type of risk and strategies to overcome the same.

Manager's attitudes toward risk affect the decision making. The preference towards risk is classified as, risk loving, risk aversion and risk neutral.

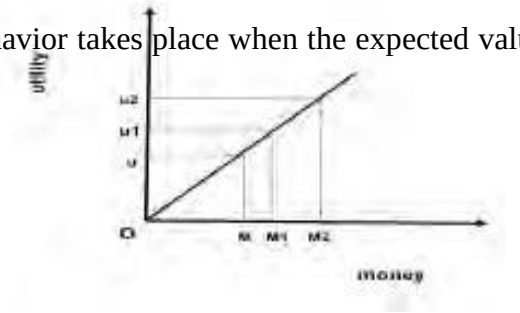
Risk loving: Arises when the payoff is greater than the expected value.



Risk Aversion: Is the behavior of the mangers when the payoff is less than the expected value.



Risk neutral: Behavior takes place when the expected value is equal to the payoff.



Decision under Uncertainty:

1. **The maximax rule:** Deals with selecting the best possible outcome for each decision and choosing the decision with the maximum payoff for all the best outcomes.
2. **The Maximin rule:** Deals with selecting a worst outcome for each investment decision and choosing the decision with the maximum worst payoff.
3. **The Minimax rule:** Deals with determining the worst potential regret associated with each, decision, then choosing the decision with the minimum worst potential regret.

5.5 DECISION MAKING UNDER UNCERTAINTY WITH COMPLETE IGNORANCE

It was mentioned earlier that whenever the decision maker is able to use personal knowledge, intuition, and experience to assign subjective probabilities to outcomes, decision making under uncertainty is transformed into decision making under risk. These situations were described as decision making under conditions of uncertainty with partial ignorance. When managers are unable to assign probabilities to alternative outcomes, some other rational decision-making criteria must be used. As mentioned earlier, this is referred to as decision making under conditions of uncertainty with complete ignorance. In this section we will examine four such rational decision criteria: the *Laplace criterion*, the *Wald* (*maximin*) *criterion*, the *Hurwicz criterion*, and the *Savage* (*minimax regret*) *criterion*. No single decision rule is appropriate for all decision-making situations. The choice of the criterion should be appropriate to the circumstances and consistent with organizational objectives and philosophy.

LAPLACE DECISION CRITERION

Before examining in detail the Laplace decision criterion for selecting among alternative strategies under conditions of complete ignorance, consider the situation depicted in Figure 5.1. This figure summarizes the payoffs from three possible pricing strategies given three different states of the economy: economic expansion, stability, and contraction. The payoffs in the matrix represent the firm's expected rates of return.

Under conditions of risk or partial ignorance, however, the decision maker may be able to assign objective or subjective probabilities to the different states of the economy. These probabilities (in parentheses), and the expected values of the payoffs from each strategy, $E(Si) = \mu$, are summarized in Figure 5.2. As in the Slumlords' Dilemma, if management decides to adopt the pricing strategy with the highest expected rate of return, then the best strategy is to "raise price."

The most significant draw- back of this decision is that it fails to consider management's attitude toward risk.

		Expansion	Stability	Contraction
Strategy	Raise price	25	15	-10
	No change	15	20	-5
	Lower price	15	0	5

Fig. 5.1 Payoff matrix for pricing strategies under alternative state of nature

If the manager estimates the probability of the occurrence of expansion, stability and contraction of the economy as 35%, 50% and 15% respectively, then the μ, σ as follows

		Economy				
		Expansion	Stability	Contraction	μ	σ
Strategy	Raise price	25(0.35)	15(0.5)	-10(0.15)	14.75	11.34
	No change	15(0.35)	20(0.5)	-5(0.15)	9.5	9.86
	Lower price	15(0.35)	0(0.5)	5(0.15)	6	6.8

Fig. 5.2 Decision making under risk: expected values and standard deviations of returns for each pricing strategy with different probabilistic outcomes.

Definition: The Laplace decision criterion transforms decision making under complete ignorance to decision making under risk by assuming that all possible outcomes are equally likely.

		Expansion	Stability	Contraction	μ	σ
Strategy	Raise price	25(0.333)	15(0.333)	-10(0.333)	10	14.71
	No change	15(0.333)	20(0.333)	-5(0.333)	10	10.79
	Lower price	15(0.333)	0(0.333)	5(0.333)	6.67	6.23

Fig. 5.3 Laplace decision criteria: expected values and standard deviations for each pricing strategy assuming equal probabilistic outcomes.

Definition: The Wald (maximin) decision criterion is a decision-making approach in the presence of complete ignorance that involves the selection of the largest payoff from among the worst possible payoffs.

The Wald decision criterion represents an extremely risk-averse approach to decision making in the presence of complete ignorance. In essence, the Wald decision criterion attempts to maximize management's feelings of security; in Figure 5.4 the indicated solution is a "lower price" strategy with

a maximin payoff of 0, which stands in contrast to the selection of a "no change" pricing strategy obtained by using the Laplace decision criterion.

Strategy		Expansion	Stability	Contraction	m	M
	Raise price	25	15	-10	-10	25*
	No change	15	20	-5	-5	20
	Lower price	15	0	5	0*	15

Fig. 5.4 Wald(maxmin) decision criterion

While the maximin strategy represents an extremely pessimistic approach to the decision-making process, a maximax strategy by contrast is extremely optimistic. Managers who use this approach will select as optimal that strategy that promises the best of the best of all possible outcomes.

In the situation depicted in Figure 5.4, the decision to raise price represents one such maximax strategy. But, how likely is it that this, or any, firm would knowingly adopt such a strategy? The selection of a maximax strategy suggests that managers are risk lovers who are willing to gamble with the firm's assets in the hope of a big payoff, which in Figure 5.4 occurs with economic expansion. Under the other two phases of the business cycle, this firm will earn the lowest possible payoff. Since managers are ultimately responsible to the shareholders, it is very unlikely that such a strategy would ever be adopted. So why is it presented here? Minimax and maximax decision criteria are two extreme examples of the Hurwicz decision criteria.

The Savage decision criterion, which is sometimes referred to as the *minimax regret criterion*, is based on the opportunity cost (or regret) of selecting an incorrect strategy. In this instance, opportunity costs are measured as the absolute difference between the payoff for each strategy and the strategy that yields the highest payoff from each state of nature. Once these opportunity costs have been estimated, the manager will select the strategy that results in the minimum of all maximum opportunity costs.

Definition: The Savage decision criterion is used to determine the strategy that results in the minimum of all maximum opportunity costs associated with the selection of an incorrect strategy.

Figure 5.5 illustrates the calculations of the opportunity costs for the payoffs summarized in Figure 5.1 For example; the maximum possible payoff during an economic expansion is 25 for a "raise price" strategy. The absolute difference between the maximum payoff and the payoffs from each strategy during an economic expansion are calculated and summarized in each cell of the matrix. Figure 5.5 summarizes the maximum regret (opportunity cost) from each strategy. The minimum of these maximum opportunity costs, which is identified with an asterisk, is the strategy that will be selected by means of the Savage decision criterion.

Neither overly optimistic nor overly pessimistic, the Savage decision criterion is most appropriate when management is interested in earning a satisfactory rate of return with moderate levels of risk over the long term.

Thus, the Savage decision criterion may be more appropriate for long-term capital investment projects.

Strategy		Expansion	Stability	Contraction	*Maximum Regret*
	Raise price	$\|25-25\|=0$	$\|15-20\|=5$	$\|-10-5\|=15$	15
	No change	$\|15-25\|=10$	$\|20-20\|=0$	$\|-5-5\|=10$	10*
	Lower price	$\|15-25\|=10$	$\|0-20\|=20$	$\|5-5\|=10$	20

Fig. 5.5 Savage regret matrix

There are four ways to manage the risk and uncertainty:

1. Insurance (Business risks are transferred through Insurance Policies)
2. Hedging is a mechanism whereby the expected loss is to be offset by an expected profit from another contract.
3. Diversification is a method of managing the risk where the risk is spread to various investments and thus the risk is minimized to each investment.
4. Adjusting risk is the mechanism whereby the provision is made to offset the expected loss.