The Institute of Finance Management
Accounting and Finance Department
Lecture Notes
Decision-Making under an Environment of Uncertainty and Risk

BACC 3 and BAIT 3
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1.1 Introduction

Decision-making is the process through which managers identify organizational problems and attempt to resolve them. There are a variety of environments where the outcome is not known at the time that the decision must be made.

The environment is strategically uncertain if the uncertainty comes from an agent not having perfect information about the choices made by other economic agents (and these choices affect the potential optimality of the decision maker's choice).

Therefore, Managerial decisions are made under conditions of

1. Certainty
2. risk, or
3. Uncertainty

- **Certainty** refers to the situation where there is only one possible outcome to a decision and this outcome is known precisely. For example, investing in Treasury bills leads to only one outcome (the amount of the yield), and this is known with certainty
- **Uncertainty** refers to a situation where there is more than one possible outcome to a decision however no information that can help to assign the probabilities to those states of nature
- **Risk** refers to a situation where there is more than one possible outcome to a decision and the probability of each specific outcome is known or can be estimated.
- A **strategy** refers to one of several alternative courses of action that a decision-maker can take to achieve a goal.
- **States of nature** refer to conditions in the future that will have a significant effect on the degree of success or failure of any strategy, but over which the decision maker has little or no control. For example, the economy may be in boom, normal, or in a recession in the future
- **A payoff matrix** is a table that shows the possible outcomes or results of strategy under each state of nature. For example, a payoff matrix may show the level of profit that would result if the firm builds a large or a small plant and if the economy will be booming, normal, or recessionary in the future.

1.2 Measuring Risk with Probability Distributions

- The concept of probability distributions is essential in evaluating and comparing investment projects.
- In general, the outcome or profit of, an investment project is highest when the economy is booming and smallest when the economy is in a recession.
- If we multiply each possible outcome or profit of an investment by its probability of occurrence and add these products, we get the expected value or profit of the project. That is,

Expected profit = $E(\Pi) = \sum_{i=1}^{n} \Pi i.P$

Where TT, is the profit level associated with outcome i, P, is the probability that outcome will occur, and i' = 1 to n refers to the number of possible outcomes or states of nature

- The expected profit of an investment is a very important consideration in deciding whether or not to undertake the project or which of two or more projects is preferable.

1.3 Absolute Measure of Risk: The Standard Deviation

- It should be that the tighter or the less dispersed a probability distribution, the smaller the risk of a particular strategy or decision.
- The reason is that there is a smaller probability that the actual outcome will deviate significantly from the expected value.
- The measure of the tightness or the degree of dispersion of a probability distribution by the standard deviation, which is indicated by the symbol **δ**,
- Thus, the standard deviation (**δ**) measures the dispersion of possible outcomes from the expected value.
- The smaller the value of (T, the tighter or less, dispersed the distribution, and the lower the risk).
- To find the value of the standard deviation (**δ**) of a particular probability distribution, we follow the three steps outlined below.

1. Subtract the expected value or the mean ($\overline{X}$) of the distribution from each possible outcome (X) to obtain a set of deviations (d) from the expected value. That is,

$di = Xi - \overline{X}$ (1)

2. Square each deviation, multiply the squared deviation by the probability of its expected outcome, and then sum these products. This weighted average of squared deviations from the mean is the variance of the distribution (δ^2), That is,

Variance = $\delta^2 = \sum_{i=1}^{n} (Xi - \overline{X})^2.Pi$

3. Take the square root of the variance to find the standard deviation (o-):

Standard deviation **=**$\delta^2 = \sqrt{\sum_{i=1}^{n} (Xi - \overline{X})^2.Pi}$

1.4 Relative Measure of Risk: The Coefficient of Variation

- The standard deviation is not a good measure to compare the dispersion (relative risk) associated with two or more probability distributions with different expected values or. means.
- The distribution with the largest expected value or mean may very well have a larger standard deviation (absolute measure of dispersion) but not necessarily a larger relative dispersion.
- To measure relative dispersion, we use the coefficient **of variation**
- This is equal to the standard deviation of a distribution divided by its expected value or mean.

That is, the Coefficient of variation =v= $\frac{\delta}{\overline{X}}$

1.5 Decisions Making Environment

- Virtually all decisions are made in an environment of at least some uncertainty. However, the degree will vary from relative certainty to great uncertainty.
- There are certain risks involved in making decisions. Therefore, the decision to be made by the management will depend on the decision environment, because the environment depends on the context of information available to the managers.
- So, it is important for managers to understand the decision environment as it assists in choosing the appropriate management technique corresponding to the environment under consideration. Normally there are three decision environments, which are explained below;

1.5.1 Decisions Making under the Environment of Uncertainty

- Uncertainty exists where the future is unknown and so the decision-maker has no previous experience and no statistical evidence on which to base predictions.
- Therefore, the environment of uncertainty is characterized by many decision alternatives to consider many states of nature, apart from that the management has no information that can help to assign the probabilities to those states of nature
- Under this environment there are three criteria that the manager can use to make a decision, these criteria are

(i) Maximax Criteria

The maximax criterion suggests that a decision-maker should select the alternative that offers the highest possible return. This means that the decision-maker would choose the opportunity that maximizes the maximum profit. Thus under this criterion, the following steps should be followed;

1. Prepare the pay-off table
2. Select the maximum pay-off under each decision alternative
3. Take that decision that corresponds to the highest payoff among those listed in step 2 above

(ii) Maximin Criterion

The maximin criterion suggests that a decision maker should select the alternative that offers the least unattractive worse outcome. The decision maker assumes that the worst possible outcome will always occur and therefore he should select the largest payoff under these situations. This means that the manager would select the opportunity that maximizes the minimum profit. Thus the following steps should be followed when this criteria is used;

1. Prepare the pay-off table
2. Select the minimum payoff under each decision alternative
3. Take that decision that corresponds to the highest payoff among those listed in step 2 above

(iii) The minimax regret approach

Sometimes known simply as 'Regret', this approach decides today based upon how the trader might feel at the end of tomorrow's market (CIMA). Hence, under this decision rule, the manager seeks to minimize the maximum regret that there would be from selecting a particular alternative.

Therefore, under this criterion it is essential to construct an opportunity loss table sometimes called a regret matrix table based on the payoff table given in the problem, the regret is the opportunity loss from taking one decision given that a certain contingency occurs. The procedure for deciding to use this approach is as follows;

1. With the help of the payoff table develop an opportunity loss table i.e. regret matrix
2. Select the maximum regret value under each decision under consideration
3. The decision to take is the one that corresponds to the minimum regret value among those listed in Step 2 above

1.5.2 Reasons for Uncertainty in Decisions Making

Uncertainty arises largely because of changes in the external environment over which a company will sometimes have little control. Reasons include:

1. Customers may decide to buy more or less goods or services than originally forecast. For example, if a major customer goes into liquidation, this has a huge effect on a company and could also cause them to go into liquidation.
2. Competitors may strengthen or emerge and take some business away from a company. On the other hand, a competitor's position may weaken leading to increased business for a particular company.
3. Technological advances may take place which lead a company's products or services to become outdated and therefore less desirable.
4. The workforce may not perform as well as expected, perhaps because of time off due to illness or maybe simply because of a lack of motivation.
5. Materials may increase in price because of global changes in commodity prices.
6. Inflation can cause the price of all inputs to increase or decrease.

1.6Decisions Making under the Environment of Risk

Risk implies a degree of uncertainty and an inability to fully control the outcomes or consequences of such an action. Risk or the elimination of risk is an effort that managers employ. However, in some instances, the elimination of one risk may increase some other risks. Effective handling of a risk requires its assessment and its subsequent impact on the decision process. The decision process allows the decision-maker to evaluate alternative strategies before making any decision. The process is as follows:

- The problem is defined and all feasible alternatives are considered. The possible outcomes for each alternative are evaluated.
- Outcomes are discussed based on their monetary payoffs or net gain about assets or time.
- Various uncertainties are quantified in terms of probabilities.
- The quality of the optimal strategy depends upon the quality of the judgments.

The decision maker should identify and examine the sensitivity of the optimal strategy concerning the crucial factors

- Hence, the environment of risk is that environment that has many decision situations and also many states of nature, however, there is also some information that can assist the manager in assigning the probabilities to all states of nature
- Risk exists where the decision-maker knows, probably due to previous experience, that several alternative outcomes are possible. Previous experience enables the decision-maker to describe the probability of the occurrence of each alternative

1.6.1 Probability distribution and expected value

It should be noted by the management that, the presentation of probability distribution for each alternative course of action can provide useful additional information to management for decisions making under the environment of risk. The probability distribution enables the management to consider not only possible profits from each opportunity but also the amount of uncertainty, which applies to each opportunity.

Under the decision environment of risk, the manager can make decisions by using various approaches; the most common approaches that help the manager to decide in this environment are illustrated as follows;

1.6.2 The Expected Monetary Value (EMV) Approach

- Under this approach where the probabilities are assigned to various possible outcomes, it is common to evaluate the worth of the decision as an expected value, or weighted average, of these outcomes.
- The expected value of an opportunity is equal to the sum of the probabilities of the outcome occurring multiplied by the return expected if it does not occur.
- Meaning that, for each type of decision, the decision maker will calculate a single figure that represents all of the possible outcomes for that decision and their respective probability distribution.

  Thus the expected value will be calculated by the following formula

  Expected Monetary Value (EMV) = $E(\Pi) = \sum_{i=1}^{n} \Pi i.P$

Where *i* is the monetary value of each outcome and p is the associated probability

In deciding, under this approach, the decision-maker will select the alternative that corresponds with the highest expected monetary value than the other alternative decisions.

Thus, the actual outcome will not equal the expected value. What you get is not what you expect, i.e. the “Great Expectations!”

- For each action, multiply the probability and payoff, and then,
- Add up the results by row,
- Choose the largest number and take that action.

1.6.3 The Expected Opportunity Loss (EOL) Approach

- Under this approach with the help of the pay off table the decision-maker will be required to prepare the opportunity loss table then the expected opportunity loss equal to the sum of the probabilities of the outcome occurring multiplied by the return expected opportunity loss.
- The following procedures can be followed to compute the expected opportunity loss (EOL);

1. With the help of the payoff table, the decision maker should develop a regret matrix (opportunity loss) table

2. To compute the expected opportunity loss for each decision alternative

3. The optimal decision to take is the one that corresponds to that alternative resulting in the least expected opportunity loss.

In short, the steps of this method are as follows:

- Set up a loss payoff matrix by taking the largest number in each state of nature column (say L), and subtracting all numbers in that column from it, L - Xij,
- For each action, multiply the probability and loss then add up for each action,
- Choose the action with the smallest EOL.

1.7 Expected Value of Perfect Information

- The **Expected Value of Perfect Information (EVPI)** is the price that one would be willing to pay to gain access to perfect information
- EVPI helps to determine the worth of an insider who possesses perfect information.
- Recall that EVPI is equal to EOL.
- The computation of EVPI involves the following steps
    1. Take the maximum payoff for each state of nature,
    2. Multiply each case by the probability for that state of nature and then add them up (EV with perfect information (PI)
    3. Subtract the expected payoff from the number obtained as Expected Payoff (Expected Value without information-EMV)
- The expected value of perfect information is the difference between these two quantities,
    - EVPI = EV (PI) – EMV

Illustration 1.1 (Comprehensive Worked Example)

Twiga Cement Co is a company specializing in the manufacture of cement, a product used in the building industry. The company has found that when weather conditions are good, the demand for cement increases since more building work can take place. Last year, the weather was so good, and the demand for cement was so great, that Cement Co was unable to meet demand. Cement Co is now trying to work out the level of cement production for the coming year to maximize profits. The company doesn't want to miss out on the opportunity to earn large profits by running out of cement again. However, it doesn't want to be left with large quantities of the product unsold at the end of the year, since it deteriorates quickly and then has to be disposed of. The company has received the following estimates about the probable weather conditions and corresponding demand levels for the coming year:

Weather	Probability	Demand

Good	25%	350,000 bags
Average	45%	280,000 bags
Poor	30%	200,000 bags

Each bag of cement sells for Shs 9,000 and costs Shs 4,000 to make. If cement is unsold at the end of the year, it has to be disposed of at a cost of Shs 500 per bag.
Cement Co has decided to produce at one of the three levels of production to match forecast demand. It now has to decide which level of cement production to select.

REQUIRED:
(a) Construct a payoff table to show all the possible profit outcomes.
(b) Decide the level of cement production the company should choose, based on the following decision rules:
- Maximax
- Maximin
- Minimax regret
- Expected Value (EMV)
- Expected Opportunity Loss (EOL)

(c) Calculate the Expected Value of Perfect Information (EVPI)

Solution

(a) Payoff table

Pay off Table (Shs 000)

Decisions	States of nature (Demands)		
Production	Good (0.25) 350,000	Average (0.45) 280,000	Poor (0.3) 200,000
350,000	1,750,000	1,085,000	325,000
280,000	1,400,000	1,400,000	640,000
200,000	1,000,000	1,000,000	1,000,000

Note: The calculation of the payoff in the first low

Sales Revenues =	350,000 bags x Shs 9,000 =	shs 3,150,000,000
Cost of to make=	350,000 bags x Shs 4,000=	shs 1,400,000,000
Pay off		Shs 1,750,000,000

Sales Revenues =	280,000 bags x Shs 9,000 =	shs 2,520,000,000
Cost of to make=	350,000 bags x Shs 4,000=	shs 1,400,000,000
Cost of disposal =	70,000 bags x Shs 500	Shs 35,000,000
Pay off		Shs 1,085,000,000

Sales Revenues =	200,000 bags x Shs 9,000 =	shs 1,800,000,000

Cost of to make=	350,000 bags x Shs 4,000=	shs 1,400,000,000
Cost of disposal =	70,000 bags x Shs 500	Shs 75,000,000
Pay off		Shs, 325,000,000

Note: Other lows can be calculated in the same ways

(b) Cement production the company should choose, based on the following decision rules:

Maximax Criteria

Production decision	**Pay off (Shs)**
350,000 bags	325,000,000
280,000 bags	640,000,000
200,000 bags	1,000,000,000

This would lead to select production of 350,000 bags with the highest possible profit of Shs 1,750,000,000

Maximin Criteria

Production decision	**Pay off (Shs)**
350,000 bags	1,750,000,000
280,000 bags	1,400,000,000
200,000 bags	1,000,000,000

This would lead to select production of 200,000 bags

The Minimax Regret Approach

With the help of the pay off table, the opportunity loss table will be developed as follows

Opportunity loss Table (Shs 000)

Decisions	States of nature (Demands)		
Production	Good (0.25) 350,000	Average (0.45) 280,000	Poor (0.3) 200,000
350,000	0	315,000	675,000
280,000	350,000	0	360,000
200,000	750,000	400,000	0

Production decision	**Pay off (Shs)**
350,000 bags	675,000,000
280,000 bags	360,000,000
200,000 bags	750,000,000

Select the alternative which has the minimum regret value for the this case above select 280,00 bags which has the minimum value of regret i.e. Shs 360,000,000

Expected Value (EMV)

EMV = $E(\Pi) = \sum_{i=1}^{n} \Pi i.P$

EMV (350, 000 bags) = 1,750,000,000 *0.25 + 1,085,000,000 *0.45 + 325,000,000 *0.3
= Shs 1,031,350,000

EMV (280, 000 bags) = 1,400,000,000 *0.25 + 1,400,000,000 *0.45 + 640,000,000 *0.3
= Shs 1,172,000,000

EMV (200, 000 bags) =1,000,000,000 *0.25 + 1,000,000,000 *0.45 + 1,000,000,000 *0.3
= Shs 1,000,000,000

The decision to produce 280,000 bags which has the highest EMV of Shs 1,172,000,000

Expected Opportunity Loss (EOL)

EOL (350, 000 bags) = 0 *0.25 + 315,000,000 *0.45 + 675,000,000 *0.3
= Shs 344,250,000

EOL (280, 000 bags) = 350,000,000 *0.25 + 0 *0.45 + 360,000,000 *0.3
= Shs 195,500,000

EOL (200, 000 bags) =750,000,000 *0.25 + 400,000,000 *0.45 + 0 *0.3
= Shs 367,500,000

The decision to produce 280,000 bags which has the lowest EOL of Shs 195,500,000

The Expected Value of Perfect Information (EVPI)

EV (PI)= 1,750,000,000 *0.25 + 1,400,000,000 *0.45 + 1,000,000,000 *0.3
= Shs 1,367,500,000

EMV= Shs 1,172,000,000

EVPI= Shs 1,367,500,000 - Shs 1,172,000,000
= Shs 195,500,000

Note: EVPI = EOL

1.7 Other Methods used in Decision Making to Assess Risk.

- Market research: This can be desk-based (secondary) or field-based (primary). Desk-based is cheap but can lack focus. Field-based research is better in that you can target your customers and your product area, but can be time consuming and expensive. The internet

is bringing down the cost and speeding up this type of research, email is being used to gather information quickly on the promise of free gifts etc.

- Simulation. Computer models can be built to simulate real life scenarios. The model will predict what range of returns an investor could expect from a given decision without having risked any actual cash. The models use random number tables to generate possible values for the uncertainty the business is subject to. Again, computer technology is assisting in bringing down the cost of such risk analysis.
- Sensitivity analysis. This can be used to assess the range of values that would still give the investor a positive return. The uncertainty may still be there, but the affect that it has on the investor's returns will be better understood. Sensitivity calculates the % change required in individual values before a change of decision results. If only a (say) 2% change is required in selling price before losses result an investor may think twice before proceeding. Risk is therefore better understood.
- Calculation of worst- and best-case figures. An investor will often be interested in range. It enables a better understanding of risk. An accountant could calculate the worst-case scenario, including poor demand and high costs whilst being sensible about it. He could also calculate best-case scenarios including good sales and minimum running costs. This analysis can often reassure an investor. The production of a probability distribution to show an investor the range of possible results is also useful to explain the risks involved. A calculation of standard deviation is also possible