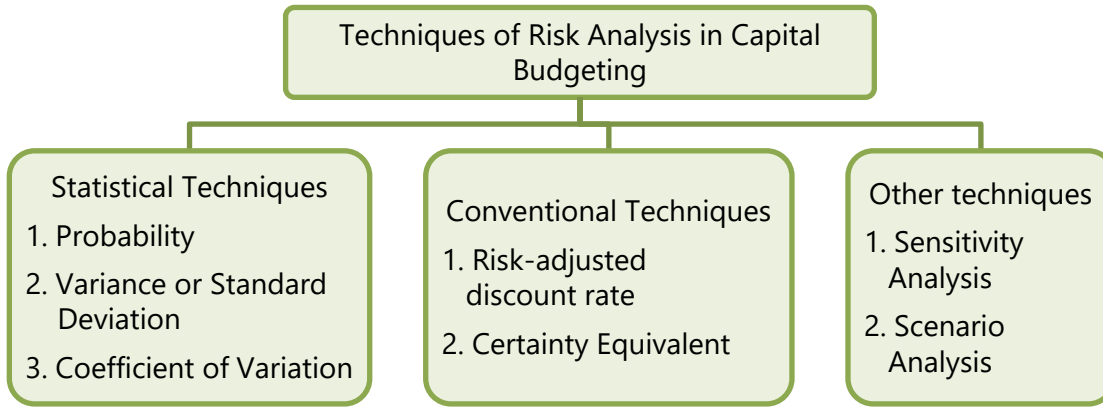
CHAPTER 8

Risk Analysis in Capital Budgeting

LEARNING OUTCOMES

- Discuss the concept of risk and uncertainty in capital budgeting.
- Discuss the sources of risks.
- Understand reasons for adjusting risk in capital budgeting.
- Understand various techniques used in Risk Analysis.
- Discuss concepts, advantages and limitations of various techniques of risk analysis in capital budgeting.

CHAPTER OVERVIEW



8.1 INTRODUCTION TO RISK ANALYSIS IN CAPITAL BUDGETING

While discussing the capital budgeting or investment evaluation techniques in chapter 7, we have assumed that the investment proposals do not involve any risk and cash flows of the project are known with certainty. This assumption was taken to simplify the understanding of the capital budgeting techniques. However, in practice, this assumption is not correct. In-fact, **investment projects are exposed to various degrees of risk.**

There can be three types of decision making:

(i) Decision making under **certainty**: When cash flows are certain.

(ii) Decision making involving **risk**: When cash flows involves risk and probability can be assigned.

(iii) Decision making under **uncertainty**: When the cash flows are uncertain and probability cannot be assigned.

8.1.1 Risk and Uncertainty

Risk is the variability in terms of actual returns comparing with the estimated returns. Most common techniques of risk measurement are Standard Deviation and Coefficient of Variation. There is a thin difference between risk and

uncertainty. In case of risk, probability distribution of cash flow is known. When no information is known to formulate probability distribution of cash flows, the situation is referred as **uncertainty**. However, these two terms are used interchangeably.

8.1.2 Reasons for adjustment of Risk in Capital Budgeting decisions

Main reasons for considering risk in capital budgeting decisions are as follows:

1. There is an opportunity cost involved while investing in a project for the level of risk. Adjustment of risk is necessary to help make the decision as to **whether the returns out of the project are proportionate with the risks borne** and whether it is **worth investing** in the project over the other investment options available.
2. Risk adjustment is required to know the **real value of the Cash Inflows**. **Higher risk** will lead to **higher risk premium** and also **expectation of higher return**.

8.2 SOURCES OF RISK

Risk arises from different sources, depending on the type of investment being considered, as well as the circumstances and the industry in which the organisation is operating. Some of the sources of risk are as follows:

1. **Project-specific risk:** Risks which are related to a particular project and affects the project's cash flows. It includes completion of the project in scheduled time, error of estimation in resources and allocation, estimation of cash flows etc. For example, a nuclear power project of a power generation company has different risks than hydel projects.
2. **Company-specific risk:** Risk which arise due to company specific factors like downgrading of credit rating, changes in key managerial persons, cases for violation of intellectual property rights (IPR) and other laws and regulations, dispute with workers etc. All these factors affect the cash flows of an entity and access to funds for capital investments. For example, two banks have different exposure to default risk.
3. **Industry-specific risk:** These are the risks which effect the whole industry in which the company operates. These risks include regulatory restrictions on industry, changes in technologies etc. For example, regulatory restriction imposed on leather and breweries industries.

4. **Market risk:** The risk which arise due to market related conditions like entry of substitute, changes in demand conditions, availability and access to resources etc. For example, a thermal power project gets affected if the coal mines are unable to supply coal requirements of a thermal power company etc.

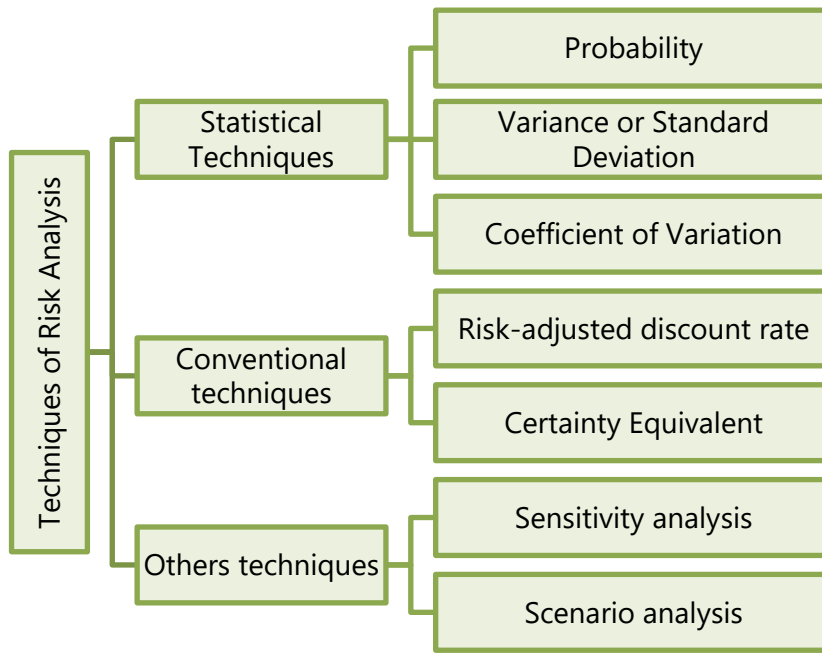
5. **Competition risk:** These are risks related with competition in the market in which a company operates. These risks are risk of entry of rival, product dynamism and change in taste and preference of consumers etc.

6. **Risk due to Economic conditions:** These are the risks which are related with macro-economic conditions like changes in monetary policies by central banks, changes in fiscal policies like introduction of new taxes and cess, inflation, changes in GDP, changes in savings and net disposable income etc.

7. **International risk:** These are risk which are related with conditions which are caused by global economic conditions like restriction on free trade, restrictions on market access, recessions, bilateral agreements, political and geographical conditions etc. For example, restriction on outsourcing of jobs to overseas markets.

8.3 TECHNIQUES OF RISK ANALYSIS IN CAPITAL BUDGETING

Techniques of risk analysis in capital budgeting can be classified as below:



8.4 STATISTICAL TECHNIQUES

8.4.1 Probability

Probability is a measure about the **chances** that an event will occur. When an event is certain to occur, probability will be 1 and when there is no chance of happening an event, probability will be 0.

Example:

Assumption	Cash Flows (₹)	Probability
Best guess	3,00,000	0.3
High guess	2,00,000	0.6
Low guess	1,20,000	0.1

In the above example chances that cash flow will be ₹ 3,00,000, ₹ 2,00,000 and ₹ 1,00,000 are 30%, 60% and 10% respectively.

(i) Expected Net Cash Flows

Expected Net Cash flows are calculated as the **sum of the likely Cash flows** of the Project multiplied by the probability of cash flows. Expected Cash flows are calculated as below:

$$E(R)/ENCF = \sum_{i=1}^{n} NCF_i \times P_i$$

Where, E(R)/ENCF = Expected Net Cash flows

P_i = Probability of Cash flows

NCF_i = Net Cash flows

Example:

Assumption (1)	Cash Flows (₹) (2)	Probability (3)	Expected cash flow (₹) (2×3)
Best guess	3,00,000	0.3	3,00,000 × 0.3 = 90,000
High guess	2,00,000	0.6	2,00,000 × 0.6 = 1,20,000

Low guess	1,20,000	0.1	1,20,000 × 0.1 = 12,000
Expected Net cash flow (ENCF)			2,22,000

(ii) Expected Net Present Value

Expected net present value =

$$ENPV = \sum_{t=1}^{n} \frac{ENCF}{(1+k)^t}$$

Where, ENPV = Expected Net Present Value

ENCF = Expected Net Cash Flows(including both inflows and outflows)

t = Period

k = Discount rate.

(a) Expected Net Present Value - Single period

Let us understand the calculation of Expected Net Present Value (ENPV) for a single period through an illustration as follows:

ILLUSTRATION 1

Possible net cash flows of Projects A and B at the end of first year and their probabilities are given below. Discount rate is 10 per cent. For both the projects, initial investment is ₹ 10,000. CALCULATE the expected net present value for each project. STATE which project is preferable?

Possible Event	*Project A*		*Project B*	
	Cash Flow (₹)	*Probability*	*Cash Flow (₹)*	*Probability*
A	*8,000*	*0.10*	*24,000*	*0.10*
B	*10,000*	*0.20*	*20,000*	*0.15*
C	*12,000*	*0.40*	*16,000*	*0.50*
D	*14,000*	*0.20*	*12,000*	*0.15*
E	*16,000*	*0.10*	*8 ,000*	*0.10*

SOLUTION

Calculation of Expected Value for Project A and Project B

Project A				Project B		
Possible Event	Cash Flow (₹)	Probability	Expected Value (₹)	Cash Flow (₹)	Probability	Expected Value (₹)
A	8,000	0.10	800	24,000	0.10	2,400
B	10,000	0.20	2,000	20,000	0.15	3,000
C	12,000	0.40	4,800	16,000	0.50	8,000
D	14,000	0.20	2,800	12,000	0.15	1,800
E	16,000	0.10	1,600	8,000	0.10	800
ENCF			12,000			16,000

The Net Present Value for Project A is (0.909 × ₹ 12,000 – ₹ 10,000) = ₹ 908

The Net Present Value for Project B is (0.909 × ₹ 16,000 – ₹ 10,000) = ₹ 4,544.

(b) Expected Net Present Value- Multiple period

Let us understand the calculation of Expected Net Present Value (ENPV) for multiple periods through an illustration as follows:

ILLUSTRATION 2

Probabilities for net cash flows for 3 years of a project are as follows:

Year 1		*Year 2*		*Year 3*	
Cash Flow (₹)	*Probability*	*Cash Flow (₹)*	*Probability*	*Cash Flow (₹)*	*Probability*
2,000	*0.1*	*2,000*	*0.2*	*2,000*	*0.3*
4,000	*0.2*	*4,000*	*0.3*	*4,000*	*0.4*
6,000	*0.3*	*6,000*	*0.4*	*6,000*	*0.2*
8,000	*0.4*	*8,000*	*0.1*	*8,000*	*0.1*

CALCULATE the expected net present value of the project using 10 per cent discount rate if the Initial Investment of the project is ₹ 10,000.

SOLUTION

Calculation of Expected Value

Year 1			Year 2			Year 3		
Cash Flow (₹)	**Prob.**	**Expected Value (₹)**	**Cash Flow (₹)**	**Prob.**	**Expected Value (₹)**	**Cash Flow (₹)**	**Prob.**	**Expected Value (₹)**
2,000	0.1	200	2,000	0.2	400	2,000	0.3	600
4,000	0.2	800	4,000	0.3	1200	4,000	0.4	1,600
6,000	0.3	1,800	6,000	0.4	2400	6,000	0.2	1,200
8,000	0.4	3,200	8,000	0.1	800	8,000	0.1	800
ENCF		6,000			4,800			4,200

The present value of the expected value of cash flow at 10 per cent discount rate has been determined as follows:

Present Value of cash flow $= \frac{ENCF_1}{(1+k)^1} + \frac{ENCF_2}{(1+k)^2} + \frac{ENCF_3}{(1+k)^3}$

$= \frac{6,000}{(1.1)} + \frac{4,800}{(1.1)^2} + \frac{4,200}{(1.1)^3}$

= (6,000 × 0.909) + (4,800 × 0.826) + (4,200 × 0.751)

= ₹ 12,573

Expected Net Present value = Present Value of cash flow - Initial Investment

= ₹ 12,573 – ₹ 10,000 = ₹ 2,573.

8.4.2 Variance

Variance is a **measurement of the degree of dispersion** between numbers in a data set from its average. In very simple words, variance is the measurement of difference between the average of the data set from every number of the data set. Variance is calculated as below:

$$\text{Variance}(\sigma^2) = \sum_{j=1}^{n} (NCF_j - ENCF)^2 \, P_j$$

Where, NCF_j = Net Cash Flow

ENCF = Expected Net Cash Flow

P_j = Probability

Variance measures the uncertainty of a value from its average. Thus, variance helps an organization to understand the level of risk it might face on investing in a project. A variance value of **zero** would indicate that the cash flows that would be generated over the life of the project would be same. This might happen in a case where the company has entered into a contract of providing services in return of a specific sum. A **large** variance indicates that there will be a large variability between the cash flows of the different years. This can happen in a case where the project being undertaken is very innovative and would require a certain time frame to market the product and enable to develop a customer base and generate revenues. A **small** variance would indicate that the cash flows would be somewhat stable throughout the life of the project. This is possible in case of products which already have an established market.

8.4.3 Standard Deviation

Standard Deviation (SD) is a degree of variation of individual items of a set of data from its average. The **square root of variance** is called Standard Deviation. For Capital Budgeting decisions, Standard Deviation is used to calculate the risk associated with the estimated cash flows from the project.

Importance of Variance and Standard Deviation in Capital Budgeting:

For making capital budgeting decisions, these two concepts are important to measure the volatility in estimated cash flows and profitability in an investment proposal. Both the concepts measures the difference between the expected cash flows and estimated cash flows (mean or average). Variance measures the range of variability (difference) in cash flows data while Standard deviation determines risk in an investment proposal. An investment proposal in which expected cash flows are close to the estimated net cash flow are seen as less risky and has the potential to make profit.

Standard deviation and Variance are two different statistical concepts but are closely interrelated. Standard deviation is calculated as square root of variance, hence, variance is prerequisite for calculation of SD.

ILLUSTRATION 3

CALCULATE Variance and Standard Deviation of Project A and Project B on the basis of following information:

Possible Event	*Project A*		*Project B*	
	Cash Flow (₹)	*Probability*	*Cash Flow (₹)*	*Probability*
A	*8,000*	*0.10*	*24,000*	*0.10*
B	*10,000*	*0.20*	*20,000*	*0.15*
C	*12,000*	*0.40*	*16,000*	*0.50*
D	*14,000*	*0.20*	*12,000*	*0.15*
E	*16,000*	*0.10*	*8,000*	*0.10*

SOLUTION

Calculation of Expected Value for Project A and Project B

	Project A			Project B		
Possible Event	Cash Flow (₹)	Probability	Expected Value (₹)	Cash Flow (₹)	Probability	Expected Value (₹)
A	8,000	0.10	800	24,000	0.10	2,400
B	10,000	0.20	2,000	20,000	0.15	3,000
C	12,000	0.40	4,800	16,000	0.50	8,000
D	14,000	0.20	2,800	12,000	0.15	1,800
E	16,000	0.10	1,600	8,000	0.10	800
ENCF			12,000			16,000

Project A

Variance (σ^2) = $(8,000 - 12,000)^2 \times (0.1) + (10,000 - 12,000)^2 \times (0.2) + (12,000 - 12000)^2 \times (0.4) + (14,000 - 12,000)^2 \times (0.2) + (16000 - 12,000)^2 \times (0.1)$

= 16,00,000 + 8,00,000 + 0 + 8,00,000 + 16,00,000 = 48,00,000

Standard Deviation $(\sigma) = \sqrt{\text{Variance}(\sigma^2)} = \sqrt{48,00,000} = 2,190.90$

Project B:

Variance$(\sigma^{2)}$ = $(24,000 - 16,000)^2 \times (0.1) + (20,000 - 16,000)^2 \times (0.15) + (16,000 - 16,000)^2 \times (0.5) + (12,000 - 16,000)^2 \times (0.15) + (8,000 - 16,000)^2 \times (0.1)$

= 64,00,000 + 24,00,000 + 0 + 24,00,000 + 64,00,000 = 1,76,00,000

Standard Deviation $(\sigma) = \sqrt{\text{Variance}(\sigma^2)} = \sqrt{1,76,00,000} = 4195.23$

8.4.4 The Coefficient of Variation

The standard deviation is a useful measure of calculating the risk associated with the estimated cash inflows from an Investment. However, in Capital Budgeting decisions, the management is several times faced with choosing between many investments' avenues. Under such situations, it becomes difficult for the management to compare the risk associated with different projects using Standard Deviation as each project has different estimated cash flow values. In such cases, the Coefficient of Variation becomes useful.

The Coefficient of Variation calculates the **risk borne for every percent of expected return**. It is calculated as:

$$\text{Coefficient of variation} = \frac{\text{Standard Deviation}}{\text{Expected Return / Expected Cash Flow}}$$

The Coefficient of Variation enables the management to calculate the risk borne by the concern for every unit of estimated return from a particular investment. Simply put, the investment avenue which has a lower ratio of standard deviation to expected return will provide a better risk – return trade off. Thus, when a selection has to be made between two projects, the management would select a project which has a lower Coefficient of Variation.

ILLUSTRATION 4

CALCULATE Coefficient of Variation of Project A and Project B based on the following information:

Possible Event	Project A		Project B	
	Cash Flow (₹)	Probability	Cash Flow (₹)	Probability
A	10000	0.10	26,000	0.10
B	12,000	0.20	22,000	0.15
C	14,000	0.40	18,000	0.50
D	16,000	0.20	14,000	0.15
E	18,000	0.10	10,000	0.10

SOLUTION

Calculation of Expected Value for Project A and Project B

Project A				Project B		
Possible Event	Cash Flow (₹)	Probability	Expected Value (₹)	Cash Flow (₹)	Probability	Expected Value (₹)
A	10,000	0.10	1,000	26,000	0.10	2,600
B	12,000	0.20	2,400	22,000	0.15	3,300
C	14,000	0.40	5,600	18,000	0.50	9,000
D	16,000	0.20	3,200	14,000	0.15	2,100
E	18,000	0.10	1,800	10,000	0.10	1,000
ENCF			14,000			18,000

Project A

Variance (σ^2) = $(10,000 - 14,000)^2 \times (0.1) + (12,000 - 14,000)^2 \times (0.2) + (14,000 - 14000)^2 \times (0.4) + (16,000 - 14,000)^2 \times (0.2) + (18000 - 14,000)^2 \times (0.1)$

= 16,00,000 + 8,00,000 + 0 + 8,00,000 + 16,00,000 = 48,00,000

Standard Deviation (σ) = $\sqrt{\text{Variance}(\sigma^2)} = \sqrt{48,00,000} = 2,190.90$

Project B:

Variance($\sigma^{2)}$ = $(26,000 - 18,000)^2 \times (0.1) + (22,000 - 18,000)^2 \times (0.15) + (18,000 - 18,000)^2 \times (0.5) + (14,000 - 18,000)^2 \times (0.15) + (10,000 - 18,000)^2 \times (0.1)$

= 64,00,000 + 24,00,000 + 0 + 24,00,000 + 64,00,000 = 1,76,00,000

Standard Deviation (σ) = $\sqrt{\text{Variance}(\sigma^2)} = \sqrt{1,76,00,000} = 4195.23$

Projects	Coefficient of variation	Risk	Expected Value
A	$\frac{2,190.90}{14,000} = 0.1565$	Less	Less
B	$\frac{4,195.23}{18,000} = 0.2331$	More	More

In project A, risk per rupee of cash flow is ₹ 0.15 while in project B, it is ₹ 0.23. Therefore, Project A is better than Project B.

8.5 CONVENTIONAL TECHNIQUES

8.5.1 Risk Adjusted Discount Rate

The use of risk adjusted discount rate (RADR) is based on the concept that investors demand higher returns from the risky projects. The required rate of return on any investment should include compensation for delaying consumption plus compensation for inflation equal to risk free rate of return, plus compensation for any kind of risk taken. If the risk associated with any investment project is higher than risk involved in a similar kind of project, discount rate is adjusted upward in order to compensate this additional risk borne. Under this method, NPV is calculated as follows:

$$NPV = \sum_{t=1}^{n} \frac{NCF}{(1+k)^t} - I$$

Where, NCF_t = Net cash flow

k = Risk adjusted discount rate (RADR)

I = Initial Investment

t = Period

A risk adjusted discount rate is a **sum of risk free rate and risk premium**. The Risk Premium depends on the perception of risk by the investor of a particular investment and risk aversion of the Investor.

So,

Risk adjusted discount rate (RADR) = Risk free rate + Risk premium

Risk Free Rate: It is the rate of return on Investments that bear no risk. For e.g., Government securities yield a return of 6% and bear no risk. In such case, 6% is the risk-free rate.

Risk Premium: It is the rate of return over and above the risk free rate, expected by the Investors as a reward for bearing extra risk. For high risk projects, the risk premium will be high and for low risk projects, the risk premium would be lower.

ILLUSTRATION 5

An enterprise is investing ₹ 100 lakhs in a project. The risk-free rate of return is 7%. Risk premium expected by the Management is 7%. The life of the project is 5 years. Following are the cash flows that are estimated over the life of the project:

Year	*Cash flows (₹ in lakhs)*
1	*25*
2	*60*
3	*75*
4	*80*
5	*65*

CALCULATE Net Present Value of the project based on Risk free rate and also on the basis of Risks adjusted discount rate.

SOLUTION

The Present Value of the Cash Flows for all the years by discounting the cash flow at 7% is calculated as below:

Year	Cash flows (₹ in lakhs)	Discounting Factor @ 7%	Present value of Cash Flows (₹ In Lakhs)
1	25	0.935	23.38
2	60	0.873	52.38
3	75	0.816	61.20
4	80	0.763	61.04
5	65	0.713	46.35
Total of Present value of Cash flows			244.34
Less: Initial investment			100.00
Net Present Value (NPV)			144.34

Now, when the risk-free rate is 7% and the risk premium expected by the Management is 7%, then risk adjusted discount rate is 7% + 7% = 14%.

Discounting the above cash flows using the Risk Adjusted Discount Rate would be as below:

Year	Cash flows (₹ in Lakhs)	Discounting Factor @ 14%	Present Value of Cash Flows (₹ in lakhs)
1	25	0.877	21.93
2	60	0.769	46.14
3	75	0.675	50.63
4	80	0.592	47.36
5	65	0.519	33.74
Total of Present value of Cash flows			199.79
Less: Initial investment			100.00
Net present value (NPV)			99.79

Advantages of Risk-adjusted discount rate

1) It is **easy to understand**.

2) It incorporates **risk premium** in the discounting factor.

Limitations of Risk-adjusted discount rate

1) **Difficulty** in finding risk premium and risk-adjusted discount rate.

2) Though NPV can be calculated but it is **not possible** to calculate Standard Deviation of a given project.

8.5.2 Certainty Equivalent (CE)

As per CIMA terminology, "Certainty Equivalent is an approach dealing with risk in a capital budgeting context. It involves **expressing risky future cash flows in terms of the certain cashflow** which would be considered, by the decision maker, as their equivalent, that is the decision maker would be indifferent between the risky amount and the (lower) riskless amount considered to be its equivalent."

The certainty equivalent is a guaranteed return that the management would accept rather than accepting a higher but uncertain return. This approach allows the decision maker to incorporate his or her utility function into the analysis. In this approach a set of risk less cash flow is generated in place of the original cash flows.

Steps in the Certainty Equivalent (CE) approach

Step 1: Remove risks by substituting equivalent certain cash flows from risky cash flows. This can be done by multiplying each risky cash flow by the appropriate α_t value (CE coefficient)

$$\alpha_1 = \frac{\text{Certain cash flow}}{\text{Risky or expected cash flow}_t}$$

Suppose on tossing out a coin, if it comes head, you will win ₹ 10,000 and if it comes out to be tail, you will win nothing. Thus, you have 50% chance of winning and expected value is ₹ 5,000 (₹ 10,000 × 0.50) . In such case, if you are indifferent at receiving ₹ 3,000 for a certain amount and not playing then ₹ 3,000 will be certainty equivalent and 0.3 (i.e. ₹ 3,000/₹ 10,000) will be certainty equivalent coefficient.

Step 2: Discounted value of cash flow is obtained by applying risk less rate of interest. Since you have already accounted for risk in the numerator using CE coefficient, using the cost of capital to discount cash flows will tantamount to double counting of risk.

Step 3: After that, normal capital budgeting method is applied except in case of IRR method, where IRR is compared with risk free rate of interest rather than the firm's required rate of return.

Certainty Equivalent Coefficient transforms expected values of uncertain flows into their Certainty Equivalents. It is important to note that the value of Certainty Equivalent Coefficient lies **between 0 & 1**. Certainty Equivalent Coefficient 1 indicates that the cash flow is certain or management is risk neutral. In industrial situation, cash flows are generally uncertain and managements are usually risk averse. Under this method, NPV is calculated as follows:

$$NPV = \sum_{t=1}^{n} \frac{\alpha_t \times NCF_t}{(1+k)^t} - I$$

Where,

α_t = Risk-adjustment factor or the certainly equivalent coefficient

NCF_t = Forecasts of net cash flow for year 't' without risk-adjustment

k = Risk free rate assumed to be constant for all periods

I = Initial Investment

ILLUSTRATION 6

If Investment proposal costs ₹ 45,00,000 and risk free rate is 5%, CALCULATE net present value under certainty equivalent technique.

Year	*Expected cash flow (₹)*	*Certainty Equivalent coefficient*
1	*10,00,000*	*0.90*
2	*15,00,000*	*0.85*
3	*20,00,000*	*0.82*
4	*25,00,000*	*0.78*

SOLUTION

$$NPV = \frac{10,00,000 \times (0.90)}{(1.05)} + \frac{15,00,000 \times (0.85)}{(1.05)2} + \frac{20,00,000 \times (0.82)}{(1.05)3} + \frac{25,00,000 \times (0.78)}{(1.05)4} - 45,00,000$$

= ₹ 5,34,570

Advantages of Certainty Equivalent Method

1. The certainty equivalent method is **simple and easy** to understand and apply.
2. It can **easily be calculated for different risk levels** applicable to different cash flows. For example, if in a particular year, a higher risk is associated with the cash flow, it can be easily adjusted and the NPV can be recalculated accordingly.

Disadvantages of Certainty Equivalent Method

1. There is **no objective** or mathematical method to estimate certainty equivalents. Certainty Equivalents are subjective and vary as per each individual's estimate.
2. Certainty equivalents are decided by the management based on their perception of risk. However, the **risk perception of the shareholders** who are the money lenders for the project is **ignored**. Hence, it is not used often in corporate decision making.

Risk-adjusted Discount Rate Vs. Certainty-Equivalent

Certainty Equivalent Method is superior to Risk Adjusted Discount Rate Method as it does not assume that risk increases with time at constant rate. Each year's Certainty Equivalent Coefficient is based on level of risk impacting its cash flow.

Despite its soundness, it is not preferable like Risk Adjusted Discount Rate Method. It is difficult to specify a series of Certainty Equivalent Coefficients but simple to adjust discount rates.

8.6 OTHER TECHNIQUES

8.6.1 Sensitivity Analysis

As per CIMA terminology, "Sensitivity Analysis a modeling and risk assessment procedure in which changes are made to significant variables in order to determine the effect of these changes on the planned outcome. Particular attention is thereafter paid to variables identifies as being of special significance".

Sensitivity analysis put in simple terms is a modeling technique which is used in Capital Budgeting decisions, to study the **impact of changes in the variables on the outcome of the project**. In a project, several variables like weighted average cost of capital, consumer demand, price of the product, cost price per unit etc. operate simultaneously. The changes in these variables impact the outcome of the project. Therefore, it becomes very difficult to assess, change in which variable impacts the project outcome in a significant way. In Sensitivity Analysis, the project outcome is studied after taking into **change in only one variable.** The more sensitive is the NPV (or IRR), the more critical is that variable. So, Sensitivity analysis is a way of finding impact on the project's NPV (or IRR) for a given change in one of the variables.

Steps involved in Sensitivity Analysis

Sensitivity Analysis is conducted by following the steps as below:

1. Finding variables, which have an influence on the NPV (or IRR) of the project.
2. Establishing mathematical relationship between the variables.
3. Analysing the effect of the change in each of the variables on the NPV (or IRR) of the project.

ILLUSTRATION 7

X Ltd. is considering its new project with the following details:

Sr. No.	*Particulars*	*Figures*
1	*Initial capital cost*	*₹400 Cr.*
2	*Annual unit sales*	*5 Cr.*

3	*Selling price per unit*	*₹ 100*
4	*Variable cost per unit*	*₹ 50*
5	*Fixed costs per year*	*₹ 50 Cr.*
6	*Discount Rate*	*6%*

Required:

1. *CALCULATE the NPV of the project.*
2. *COMPUTE the impact on the project's NPV considering a 2.5 per cent adverse variance in each variable. Which variable is having maximum effect?*

Consider Life of the project as 3 years.

SOLUTION

1. Calculation of Net Cash Inflow per year

	Particulars	Amount (₹)
A	Selling price per unit	100
B	Variable cost per unit	50
C	Contribution per unit (A - B)	50
D	Number of units sold per year	5 Cr.
E	Total Contribution (C × D)	₹ 250 Cr.
F	Fixed cost per year	₹ 50 Cr.
G	Net cash inflow per year (E - F)	₹ 200 Cr.

Calculation of Net Present Value (NPV) of the Project

Year	Year Cash Flow (₹ in Cr.)	PV factor @ 6%	Present Value (PV) (₹ in Cr.)
0	(400.00)	1.000	(400.00)
1	200.00	0.943	188.60
2	200.00	0.890	178.00
3	200.00	0.840	168.00
Net Present Value			134.60

Here, NPV represent the most likely outcomes and not the actual outcomes. The actual outcome can be lower or higher than the expected outcome.

2. Sensitivity Analysis considering 2.5 % Adverse Variance in each variable

	Particulars	Base	Initial capital cost increased to ₹ 410 crore	Selling Price per Unit Reduced to ₹ 97.5	Variable Cost Per Unit increased to ₹ 51.25	Fixed Cost Per Unit increased to ₹ 51.25	Units sold per year reduced to 4.875 crore
		(₹)	(₹)	(₹)	(₹)	(₹)	(₹)
A	Selling price per unit	100	100	97.5	100	100	100
B	Variable cost per unit	50	50	50	51.25	50	50
C	Contribution per unit (A - B)	50	50	47.5	48.75	50	50
		(₹ in Cr.)	(₹ in Cr.)	(₹ in Cr.)	(₹ in Cr.)	(₹ in Cr.)	(₹ in Cr.)
D	Number of units sold per year (units in Crores)	5	5	5	5	5	4.875
E	Total Contribution (C × D)	250	250	237.5	243.75	250	243.75
F	Fixed cost per year	50	50	50	50	51.25	50
G	Net Cash Inflow per year (E - F)	200	200	187.5	193.75	198.75	193.75
H	PV of Net cash Inflow per year (G × 2.673)	534.60	534.60	501.19	517.89	531.26	517.89
I	Initial capital cost	400	410	400	400	400	400
J	NPV (H - I)	134.60	124.60	101.19	117.89	131.26	117.89
K	Percentage Change in NPV	-	-7.43%	-24.82%	-12.41%	-2.48%	-12.41%

The above table shows that by changing one variable at a time by 2.5% (adverse) while keeping the others constant, the impact in percentage terms on the NPV of the project can be calculated. Thus, it can be seen that the change in selling price has the maximum effect on the NPV by 24.82%.

Advantages of Sensitivity Analysis:

Following are the main advantages of Sensitivity Analysis:

(1) **Critical Issues**: This analysis identifies critical factors that impinge on a project's success or failure.

(2) **Simplicity**: It is a simple technique.

Disadvantage of Sensitivity Analysis

Following are the main disadvantages of Sensitivity Analysis:

(1) **Assumption of Independence**: This analysis assumes that all variables are independent i.e. they are not related to each other, which is unlikely in real life.

(2) **Ignore probability**: This analysis does not look to the probability of changes in the variables.

8.6.2 Scenario Analysis

Although sensitivity analysis is probably the most widely used risk analysis technique, it does have limitations. Therefore, we need to extend sensitivity analysis to deal with the probability distributions of the inputs. In addition, it would be useful to vary more than one variable at a time so we could see the combined effects of changes in the variables.

Scenario analysis provides answer to these situations of extensions. This analysis brings in the probabilities of changes in key variables and also allows us to **change more than one variable at a time.**

This analysis begins with base case or most likely set of values for the input variables. Then, go for worst case scenario (low unit sales, low sale price, high variable cost, etc.) and best case scenario (high unit sales, high sale price, low variable cost, etc.). Alternatively, Scenarios analysis is possible where some factors are changed positively and some factors are changed negatively.

So, in a nutshell Scenario analysis examine the risk of investment, to analyse the **impact of alternative combinations of variables**, on the project's NPV (or IRR).

ILLUSTRATION 8

XYZ Ltd. is considering a project "A" with an initial outlay of ₹ 14,00,000 and the possible three cash inflow attached with the project as follows:

(₹ '000)

Particulars	Year 1	Year 2	Year 3
Worst case	450	400	700
Most likely	550	450	800
Best case	650	500	900

Assuming the cost of capital as 9%, DETERMINE NPV in each scenario. If XYZ Ltd is certain about the most likely result in first two years but uncertain about the third year's cash flow, ANALYSE what will be the NPV expecting worst scenario in the third year.

SOLUTION

The possible outcomes will be as follows:

Year	PVF @ 9%	Worst Case		Most likely		Best case	
		Cash Flow	PV	Cash Flow	PV	**Cash Flow**	PV
		(₹ '000)	**(₹ '000)**	**(₹ '000)**	**(₹ '000)**	**(₹ '000)**	**(₹ '000)**
0	1	(1,400)	(1,400)	(1,400)	(1,400)	(1,400)	(1,400)
1	0.917	450	412.65	550	504.35	650	596.05
2	0.842	400	336.80	450	378.90	500	421.00
3	0.772	700	540.40	800	617.60	900	694.80
NPV			-110.15		100.85		311.85

If XYZ Ltd. is certain about the most likely result in first two years but uncertain about the third year's cash flow, then, NPV expecting worst case scenario is expected in the third year will be as follows:

$$= -₹\ 14,00,000 + \frac{₹\ 5,50,000}{(1+0.09)} + \frac{₹\ 4,50,000}{(1+0.09)^2} + \frac{₹\ 7,00,000}{(1+0.09)^3}$$

= − ₹ 14,00,000 + ₹ 5,04,587 + ₹ 3,78,756 + ₹ 5,40,528 = ₹ 23,871

Scenario Analysis Vs Sensitivity Analysis

Sensitivity analysis and Scenario analysis both help to understand the impact of the change in input variable on the outcome of the project. However, there are certain basic differences between the two.

Sensitivity analysis calculates the impact of the change of a **single** input variable on the outcome of the project viz., NPV or IRR. The sensitivity analysis thus enables to identify that single critical variable which can impact the outcome in a huge way and the range of outcomes of the project given the change in the input variable.

Scenario analysis, on the other hand, is based on a **scenario**. The scenario may be recession or a boom wherein depending on the scenario, all input variables change. Scenario Analysis calculates the outcome of the project considering this scenario where the variables have changed simultaneously. Similarly, the outcome of the project would also be considered for the normal and recessionary situation. The variability in the outcome under the three different scenarios would help the management to assess the risk a project carries. Higher deviation in the outcome can be assessed as higher risk and lower to medium deviation can be assessed accordingly.

Scenario analysis is far more **complex** than sensitivity analysis because in scenario analysis all inputs are changed simultaneously, considering the situation in hand while in sensitivity analysis, only one input is changed and others are kept constant.

Miscellaneous Illustrations

ILLUSTRATION 9

Shivam Ltd. is considering two mutually exclusive projects A and B. Project A costs ₹ 12,000 and project B ₹ 11,000. You have been given below the net cash flow (NCF) probability distribution for each project.

Project A		Project B	
NCF estimates (₹)	Probability	NCF estimates (₹)	Probability
15,000	0.4	15,000	0.3
12,000	0.3	12,000	0.5
10,000	0.2	10,000	0.1
8,000	0.1	8,000	0.1

(i) COMPUTE the expected net cash flows (ENCF) of projects A and B.

(ii) COMPUTE the risk attached to each project i.e. standard deviation of each probability distribution.

(iii) COMPUTE the profitability index of each project.

(iv) IDENTIFY which project do you recommend? State with reasons.

SOLUTION

(i) Computation of expected net cash flow of Projects A and B

Project A			Project B		
NCF Estimate (₹)	Probability	ENCF (₹)	NCF Estimate (₹)	Probability	ENCF (₹)
15,000	0.4	6,000	15,000	0.3	4,500
12,000	0.3	3,600	12,000	0.5	6,000
10,000	0.2	2,000	10,000	0.1	1,000
8,000	0.1	800	8,000	0.1	800
ENCF		12,400			12,300

(ii) Computation of Standard deviation of each project

Project A

P	ENCF	NCF	(NCF – ENCF)	P (NCF – ENCF)^2
0.4	12,400	15,000	2,600	27,04,000
0.3	12,400	12,000	-400	48,000
0.2	12,400	10,000	-2,400	11,52,000
0.1	12,400	8,000	-4,400	19,36,000
Variance				58,40,000

Standard Deviation of Project A = $\sqrt{58,40,000}$ = 2416.61

Project B

P	ENCF	NCF	(NCF – ENCF)	P (NCF – ENCF)^2
0.3	12,300	15,000	2,700	21,87,000
0.5	12,300	12,000	-300	45,000
0.1	12,300	10,000	-2,300	5,29,000
0.1	12,300	8,000	-4,300	18,49,000
Variance				46,10,000

Standard Deviation of Project B = $\sqrt{46,10,000}$ = 2147.09

(iii) Computation of profitability index of each project

$$\text{Profitability index} = \frac{\text{Discounted cash inflows}}{\text{Cash outlay}}$$

Project A

$$PI = \frac{12,400}{12,000} = 1.033$$

Project B

$$PI = \frac{12,300}{11,000} = 1.118$$

(iv) Recommendation of the project

ENCF of both the projects is almost same but Standard deviation (risk) is lower in Project B as compared to Project A. Also, profitability index of Project B is higher than that of Project A. So, Project B is preferable because of lower risk and higher profitability index.

ILLUSTRATION 10

From the following details relating to a project, ANALYSE the sensitivity of the project to changes in initial project cost, annual cash inflow and cost of capital:

Initial Project Cost (₹)	*1,20,000*
Annual Cash Inflow (₹)	*45,000*
Project Life (Years)	*4*
Cost of Capital	*10%*

IDENTIFY which of the three factors, the project is most sensitive, if the variable is adversely affected by 10%? (Use annuity factors: 10% = 3.169 and 11% = 3.103).

SOLUTION

Calculation of NPV through Sensitivity Analysis

	(₹)
PV of cash inflows (₹ 45,000 × 3.169)	1,42,605
Initial Project Cost	(1,20,000)
NPV	22,605

Situation	NPV	Changes in NPV
Base (present)	₹ 22,605	-
If initial project cost is varied adversely by 10% i.e. it becomes ₹ 1,32,000 (₹ 1,20,000 x 1.10).	(₹ 1,42,605 - ₹ 1,32,000) = ₹ 10,605	(₹ 22,605 – ₹ 10,605)/ ₹ 22,605 = (53.08%)
If annual cash inflow is varied adversely by 10% i.e. it becomes ₹ 40,500 (₹ 45,000 x 0.9).	[₹ 40,500 × 3.169) – (₹ 1,20,000)] = ₹ 8,345	(₹ 22,605 – ₹ 8,345) / ₹ 22,605 = 63.08%
If cost of capital is varied adversely by 10% i.e. it becomes 11%.	(₹ 45,000 × 3.103) – ₹ 1,20,000 = ₹ 19,635	(₹ 22,605 – ₹ 19,635) / ₹ 22,605 = 13.14%

Conclusion: Project is most sensitive to 'annual cash inflow'.

ILLUSTRATION 11

PNR Ltd. is considering a project with the following Cash flows:

Year	*Cost of Plant (₹)*	*Running Cost (₹)*	*Savings (₹)*
0	*12,00,00,000*	-	-
1	-	*4,00,00,000*	*12,00,00,000*
2	-	*5,00,00,000*	*14,00,00,000*
3	-	*6,00,00,000*	*11,00,00,000*

The cost of capital is 12%. Measure the sensitivity of the project to changes in the levels of plant cost, running cost and savings (considering each factor at a time) such that the NPV becomes zero. The P.V. factors at 12% are as under:

Year	*0*	*1*	*2*	*3*
PV factor @12%	*1*	*0.892*	*0.797*	*0.711*

DETERMINE the factor which is the most sensitive to affect the acceptability of the project?

SOLUTION

Calculation of Net Present value (NPV)

Particulars	Year 0	Year 1	Year 2	Year 3
Cost of Plant	(12,00,00,000)	-	-	-

Running cost	-	(4,00,00,000)	(5,00,00,000)	(6,00,00,000)
Savings	-	12,00,00,000	14,00,00,000	11,00,00,000
Net cash inflow	(12,00,00,000)	8,00,00,000	9,00,00,000	5,00,00,000
PV factor	1	0.892	0.797	0.711
PV of Cash Flows	(12,00,00,000)	7,13,60,000	7,17,30,000	3,55,50,000

NPV = ₹ (- 12,00,00,000 + 7,13,60,000 + 7,17,30,000 + 3,55,50,000)

= ₹ 5,86,40,000

Determination of the most Sensitive factor:

(i) Sensitivity Analysis w.r.t. Plant cost:

NPV of the project would be zero when the cost of the plant is increased by ₹ 5,86,40,000.

$$\therefore \text{ Percentage change in the plant cost } = \frac{₹\,5,86,40,000}{₹\,12,00,00,000} \times 100 = 48.87\%$$

(ii) Sensitivity Analysis w.r.t. Running cost:

NPV of the project would be zero when the Running cost is increased by ₹ 5,86,40,000.

∴ Percentage change in the Running cost

$$= \frac{₹\,5,86,40,000}{(0.892 \times 4,00,00,000) + (0.797 \times 5,00,00,000) + (0.711 \times 6,00,00,000)} \times 100$$

$$= \frac{₹\,5,86,40,000}{3,56,80,000 + 3,98,50,000 + 4,26,60,000} \times 100 = \frac{₹\,5,86,40,000}{₹\,11,81,90,000} \times 100 = 49.61\%$$

(iii) Sensitivity Analysis w.r.t. Savings:

NPV of the project would be zero when the savings is decreased by ₹ 5,86,40,000.

∴ Percentage change in the savings

$$= \frac{₹\,5,86,40,000}{(0.892 \times 12,00,00,000) + (0.797 \times 14,00,00,000) + (0.711 \times 11,00,00,000)} \times 100$$

$$= \frac{₹\,5,86,40,000}{10,70,40,000 + 11,15,80,000 + 7,82,10,000} \times 100 = \frac{₹\,5,86,40,000}{29,68,30,000} \times 100 = 19.75\%$$

The **Savings factor** is the most sensitive as only a change beyond 19.75% in savings makes the project unacceptable.

ILLUSTRATION 12

DETERMINE the risk adjusted net present value of the following projects:

	X	Y	Z
Net cash outlays (₹)	*2,10,000*	*1,20,000*	*1,00,000*
Project life	*5 years*	*5 years*	*5 years*
Annual Cash inflow (₹)	*70,000*	*42,000*	*30,000*
Coefficient of variation	*1.2*	*0.8*	*0.4*

The Company selects the risk-adjusted rate of discount on the basis of the coefficient of variation:

Coefficient of Variation	Risk-Adjusted discount rate	P.V. Factor 1 to 5 years at risk adjusted discount rate
0.0	*10%*	*3.791*
0.4	*12%*	*3.605*
0.8	*14%*	*3.433*
1.2	*16%*	*3.274*
1.6	*18%*	*3.127*
2.0	*22%*	*2.864*
More than 2.0	*25%*	*2.689*

SOLUTION

Statement showing the determination of the risk adjusted net present value

Project	Net cash outlays	Coefficient of variation	Risk adjusted discount rate	Annual cash inflow	PV factor 1-5 years	Discounted cash inflow	Net present value
	(₹)			(₹)		(₹)	(₹)
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii) = (v) × (vi)	(viii) = (vii) – (ii)
X	2,10,000	1.20	16%	70,000	3.274	2,29,180	19,180
Y	1,20,000	0.80	14%	42,000	3.433	1,44,186	24,186
Z	1,00,000	0.40	12%	30,000	3.605	1,08,150	8,150

SUMMARY

- **Risk:** Risk denotes variability of possible outcomes from what was expected. Standard Deviation is perhaps the most commonly used tool to measure risk. It measures the dispersion around the mean of some possible outcome.
- **Risk Adjusted Discount Rate Method (RADR):** The use of risk adjusted discount rate is based on the concept that investors demand higher returns from the risky projects. The required return of return on any investment should include compensation for delaying consumption equal to risk free rate of return, plus compensation for any kind of risk taken on.

  Risks adjusted discount rate = Risk free rate + Risk premium
- **Certainty Equivalent Approach:** This approach allows the decision maker to incorporate his or her utility function into the analysis. In this approach, a set of risk less cash flow is generated in place of the original cash flows.
- **Sensitivity Analysis:** Also known as "What if" Analysis. This analysis determines how the distribution of possible NPV or IRR for a project under consideration is affected consequent to a change in one particular input variable. This is done by changing one variable at one time, while keeping other variables (factors) unchanged.
- **Scenario Analysis:** This analysis is based on scenario. A scenario can be recession or a boom, wherein depending on the scenario, all input variables changes. This analysis brings in the probabilities of changes in key variables and also allows us to change more than one variable at a time. It examines the risk of investment by analysing the impact of alternative combinations of variables, on the project's NPV (or IRR).

TEST YOUR KNOWLEDGE

MCQs based Questions

1. Risk arises from various sources such as:

   (a) Market Risk

   (b) Competition Risk

   (c) International Risk

   (d) All of the above

2. Expected cash flows are calculated as:
   (a) Sum of likely cash flow of the project.
   (b) Sum of likely cash flow of project multiplied by probability of cash flow.
   (c) Sum of likely cash flow of project divided by probability of cash flow.
   (d) None of the above
3. Variance measures:
   (a) How far each number in the set is from the mean
   (b) The mean of a given data set
   (c) Return on Investment
   (d) Level of risk borne for every percent of expected return
4. Certainty Equivalent approach is:
   (a) Guaranteed return from an investment after adjusting for certainty equivalent coefficient.
   (b) Return that is expected over the lifetime of a project.
   (c) Equivalent to Net Present Value.
   (d) An important component in Decision Tree Analysis.
5. The firm expects an NPV of ₹ 10,000 if the economy is exceptionally strong (30% probability), an NPV of ₹ 4,000 if the economy is normal (40% probability), and an NPV of ₹ 2,000 if the economy is exceptionally weak (30% probability). Expected Net present value is _____.
   (a) ₹ 5,200
   (b) ₹ 6,000
   (c) ₹ 5,000
   (d) ₹ 6,200
6. Risk Premium is:
   (a) Extra rate of return expected by the Investors as a reward for bearing extra risk.
   (b) Equivalent to the rate of Government Securities.

(c) Return provided to equity shareholders.

(d) Risk free rate of return.

7. Calculation of Coefficient of Variance depends on:

(a) Standard Deviation

(b) Expected Return

(c) Expected cash flow

(d) All of the above

8. Scenario Analysis is considered under scenarios such as:

(a) Worst Case Scenario

(b) Base Case Scenario

(c) Best Case Scenario

(d) All of the above

9. Sensitivity analysis is useful in decision making because:

(a) It shows the probabilities associated with each outcome.

(b) It tells the user how much critical each input is for the Output value.

(c) It allows to calculate the probable results under different scenarios.

(d) The results of Sensitivity Analysis are reliable.

10. When the risk is high, the cash flow under certainty equivalent coefficient is:

(a) Higher

(b) Lower

(c) No impact

(d) None of the above

Theoretical Questions

1. EXPLAIN Certainty Equivalent Approach.
2. EXPLAIN Risk Adjusted Discount rate.
3. EXPLAIN Scenario Analysis.
4. EXPLAIN the different scenarios under which Scenario Analysis is considered.

5. STATE the two approaches to Sensitivity Analysis.
6. EXPLAIN what is Sensitivity Analysis used for?
7. DISTINGUISH between Scenario Analysis & Sensitivity Analysis.

Practical Problems

1. Giri Ltd. is using Certainty Equivalent approach in the evaluation of risky proposals. The following information regarding a new project is as follows:

Year	Expected Cash flow (₹)	Certainty equivalent quotient
0	(4,00,000)	1.0
1	3,20,000	0.8
2	2,80,000	0.7
3	2,60,000	0.6
4	2,40,000	0.4
5	1,60,000	0.3

Riskless rate of interest on the government securities is 6 per cent. DETERMINE whether the project should be accepted?

2. Following information have been retrieved from the finance department of Corp Finance Ltd. relating to Project X, Y and Z:

Particulars	X	Y	Z
Net cash outlays (₹)	42,00,000	24,00,000	20,00,000
Project life	5 years	5 years	5 years
Annual Cash inflow (₹)	14,00,000	8,40,000	6,00,000
Coefficient of variation	2.0	0.8	1.6

You are required to DETERMINE the risk adjusted net present value of the projects considering that the Company selects risk adjusted rate of discount on the basis of the coefficient of variation:

Coefficient of Variation	Risk Adjusted discount rate	P.V. Factor for 1 to 5 years at risk adjusted discount rate
0.0	8%	3.992

0.4	10%	3.790
0.8	12%	3.604
1.2	14%	3.433
1.6	16%	3.274
2.0	20%	2.990
More than 2.0	22%	2.863

3. The Textile Manufacturing Company Ltd. is considering one of two mutually exclusive proposals, Project M and N, which require cash outlays of ₹ 8,50,000 and ₹ 8,25,000 respectively. The certainty equivalent (C.E) approach is used in incorporating risk in capital budgeting decisions. The current yield on government bonds is 6% and this is used as the risk free rate. The expected net cash flows and their certainty equivalents are as follows:

Project M			Project N	
Year-end	**Cash Flow (₹)**	**C.E.**	**Cash Flow (₹)**	**C.E.**
1	4,50,000	0.8	4,50,000	0.9
2	5,00,000	0.7	4,50,000	0.8
3	5,00,000	0.5	5,00,000	0.7

Present value factors of ₹ 1 discounted at 6% at the end of year 1, 2 and 3 are 0.943, 0.890 and 0.840 respectively.

Required:

(i) ANALYSE which project should be accepted?

(ii) If risk adjusted discount rate method is used, IDENTIFY which project would be appraised with a higher rate and why?

4. A&R Ltd. has under its consideration a project with an initial investment of ₹ 90,00,000. Three probable cash inflow scenarios with their probabilities of occurrence have been estimated as below:

Annual cash inflow (₹)	20,00,000	30,00,000	40,00,000
Probability	0.2	0.7	0.1

The project life is 5 years and the desired rate of return is 18%. The estimated terminal values for the project assessed under the three probability alternatives, respectively, are ₹ 0, ₹ 20,00,000 and ₹ 30,00,000.

You are required to:

(i) CALCULATE the probable NPV.

(ii) CALCULATE the worst case NPV and the best case NPV.

(iii) STATE the probability occurrence of the worst case, if the cash flows are perfectly positively correlated over time.

5. SG Ltd. is considering a project "Z" with an initial outlay of ₹ 7,50,000 and life of 5 years. The estimates of project are as follows:

	Lower Estimates	Base	Upper Estimates
Sales (units)	4,500	5,000	5,500
	(₹)	(₹)	(₹)
Selling Price p.u.	175	200	225
Variable cost p.u.	100	125	150
Fixed Cost	50,000	75,000	1,00,000

Depreciation included in Fixed cost is ₹ 35,000 and corporate tax is 25%.

Assuming the cost of capital as 15%, DETERMINE NPV in three scenarios i.e worst, base and best case scenario.

PV factor for 5 years at 15% are as follows:

Years	1	2	3	4	5
P.V. factor	0.870	0.756	0.658	0.572	0.497

6. New Projects Ltd. is evaluating 3 projects, P-I, P-II, P-III. Following information is available in respect of these projects:

	P-I	P-II	P-III
Cost	₹ 15,00,000	₹ 11,00,000	₹ 19,00,000
Inflows-Year 1	6,00,000	6,00,000	4,00,000
Year 2	6,00,000	4,00,000	6,00,000
Year 3	6,00,000	5,00,000	8,00,000

Year 4	6,00,000	2,00,000	12,00,000
Risk Index	1.80	1.00	0.60

Minimum required rate of return of the firm is 15% and applicable tax rate is 40%. The risk free interest rate is 10%.

REQUIRED:

(i) Find out the risk-adjusted discount rate (RADR) for these projects.

(ii) Which project is the best?

ANSWERS/SOLUTIONS

Answers to the MCQs based Questions

1. (d) **2.** (b) **3.** (a) **4.** (a) **5.** (a) **6.** (a)
7. (d) **8.** (d) **9.** (b) **10.** (b)

Answers to the Theoretical Questions

1. Please refer paragraph 8.5.2

2. Please refer paragraph 8.5.1

3. Please refer paragraph 8.6.2

4. Please refer paragraph 8.6.2

5. Please refer paragraph 8.6.1

6. Please refer paragraph 8.6.1

7. Please refer paragraph 8.6.2

Answers to the Practical Problems

1. Determination of Net Present Value (NPV)

Year	Expected Cash flow (₹)	Certainty equivalent quotient	Adjusted Cash flow (₹)	PV factor @ 6%	Total PV (₹)
	(1)	(2)	(3)=(1)×(2)	(4)	(5)=(3)×(4)
0	(4,00,000)	1.0	(4,00,000)	1.000	(4,00,000)
1	3,20,000	0.8	2,56,000	0.943	2,41,408

2	2,80,000	0.7	1,96,000	0.890	1,74,440
3	2,60,000	0.6	1,56,000	0.840	1,31,040
4	2,40,000	0.4	96,000	0.792	76,032
5	1,60,000	0.3	48,000	0.747	35,856
NPV					2,58,776

As the Net Present Value is positive the project should be accepted.

2. Statement showing the determination of the risk adjusted net present value

Project	Net cash outlays	Coefficient of variation	Risk adjusted discount rate	Annual cash inflow	PV factor 1-5 years	Discounted cash inflow	Net present value
	(₹)			(₹)		(₹)	(₹)
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii) = (v) × (vi)	(viii) = (vii) – (ii)
X	42,00,000	2.0	20%	14,00,000	2.990	41,86,000	-14,000
Y	24,00,000	0.8	12%	8,40,000	3.604	30,27,360	6,27,360
Z	20,00,000	1.6	16%	6,00,000	3.274	19,64,400	-35,600

3. (i) Statement Showing the Net Present Value of Project M

Year end	Cash Flow (₹)	C.E.	Adjusted Cash flow (₹)	PV factor at 6%	Present value (₹)
	(a)	(b)	(c) = (a) × (b)	(d)	(e) = (c) × (d)
1	4,50,000	0.8	3,60,000	0.943	3,39,480
2	5,00,000	0.7	3,50,000	0.890	3,11,500
3	5,00,000	0.5	2,50,000	0.840	2,10,000
Total PV of cash inflows					8,60,980
Less: Initial Investment					8,50,000
Net Present Value					10,980

Statement Showing the Net Present Value of Project N

Year end	Cash Flow (₹)	C.E.	Adjusted Cash flow (₹)	PV factor at 6%	Present value (₹)
	(a)	(b)	(c) = (a) × (b)	(d)	(e) = (c) × (d)
1	4,50,000	0.9	4,05,000	0.943	3,81,915
2	4,50,000	0.8	3,60,000	0.890	3,20,400
3	5,00,000	0.7	3,50,000	0.840	2,94,000
Total PV of cash inflows					9,96,315
Less: Initial Investment					8,25,000
Net Present Value					1,71,315

Analysis: Since the net present value of Project N is higher, it should be accepted.

(ii) Certainty Equivalent (C.E.) Co-efficient of Project M i.e. 2.0 (0.8 + 0.7 + 0.5) is lower than that of Project N i.e. 2.4 (0.9 + 0.8 + 0.7). This means Project M is riskier than Project N as "higher the riskiness of a cash flow, the lower will be the CE factor". If risk adjusted discount rate (RADR) method is used, Project M would be appraised with a higher rate because of high risk.

4. (i) Calculation of probable Net Present Value (NPV)

Year	Prob. = 0.2		Prob. = 0.7		Prob. = 0.1		Total		
	Cash flow	Probable cash flow	Cash flow	Probable cash flow	Cash flow	Probable cash flow	Cash flow	PVF @ 18%	PV
	(₹)	(₹)	(₹)	(₹)	(₹)	(₹)	(₹)		(₹)
0	-	-	-	-	-	-	(90,00,000)	1.000	(90,00,000)
1-5	20,00,000	4,00,000	30,00,000	21,00,000	40,00,000	4,00,000	29,00,000	3.125	90,62,500
5	0	0	20,00,000	14,00,000	30,00,000	3,00,000	17,00,000	0.437	7,42,900
Net Present Value (NPV)									**8,05,400**

(ii) Worst and Best case is the case where expected annual cash inflows are minimum and maximum respectively.

Calculation of Worst Case and Best Case NPV

Year	PVF@ 18%	Worst case		Best Case	
		Cash flows (₹)	PV of Cash flows (₹)	Cash flows (₹)	PV of Cash flows (₹)
0	1.000	(90,00,000)	(90,00,000)	(90,00,000)	(90,00,000)
1 - 5	3.125	20,00,000	62,50,000	40,00,000	1,25,00,000
5	0.437	0	0	30,00,000	13,11,000
NPV			**(27,50,000)**		**48,11,000**

Worst case NPV = ₹ (27,50,000)

Best Case NPV = ₹ 48,11,000

(iii) If the cash flows are perfectly positively correlated over time, it means cash flow in first year will be the cash flows in subsequent years. In the worst case, cash flow is ₹ 20,00,000 and its probability is 20%, thus, possibility of worst case is 20% or 0.2.

5. (i) Calculation of Yearly Cash Inflow

In worst case: High costs and Low price (Selling price) and volume(Sales units) are taken.

In best case: Low costs and High price(Selling price) and volume(Sales units) are taken.

	Worst Case	Base	Best Case
Sales (units) (A)	4,500	5,000	5,500
	(₹)	(₹)	(₹)
Selling Price p.u.	175	200	225
Less: Variable cost p.u.	150	125	100
Contribution p.u. (B)	25	75	125
Total Contribution (A x B)	1,12,500	3,75,000	6,87,500
Less: Fixed Cost	1,00,000	75,000	50,000
EBT	12,500	3,00,000	6,37,500
Less: Tax @ 25%	3,125	75,000	1,59,375

EAT	9,375	2,25,000	4,78,125
Add: Depreciation	35,000	35,000	35,000
Cash Inflow	44,375	2,60,000	5,13,125

(ii) Calculation of NPV in different scenarios

	Worst Case	Base	Best Case
Initial outlay (A) (₹)	7,50,000	7,50,000	7,50,000
Cash Inflow (c) (₹)	44,375	2,60,000	5,13,125
Cumulative PVF @ 15% (d)	3.353	3.353	3.353
PV of Cash Inflow (B = c x d) (₹)	1,48,789.38	8,71,780	17,20,508.13
NPV (B - A) (₹)	(6,01,210.62)	1,21,780	9,70,508.13

6. (i) The risk free rate of interest and risk factor for each of the projects are given. The risk adjusted discount rate (RADR) for different projects can be found on the basis of CAPM as follows:

Required Rate of Return = I_{Rf} + (ke-I_{RF}) Risk Factor

For P-I : RADR = 0.10 + (0.15 – 0.10) 1.80 = 19%

For P-II : RADR = 0.10 + (0.15 – 0.10) 1.00 = 15 %

For P-III : RADR = 0.10 + (0.15 – 0.10) 0.60 = 13 %

(ii) The three projects can now be evaluated at 19%, 15% and 13% discount rate as follows:

Project P-I

Annual Inflows	₹ 6,00,000
PVAF (19 %, 4)	2.639
PV of Inflows (₹ 6,00,000 x 2.639)	₹ 15,83,400
Less: Cost of Investment	₹ 15,00,000
Net Present Value	₹ **83,400**

Project P-II

Year	Cash Inflow (₹)	PVF (15%,n)	PV (₹)
1	6,00,000	0.870	5,22,000
2	4,00,000	0.756	3,02,400

3	5,00,000	0.658	3,29,000
4	2,00,000	0.572	1,14,400
Total Present Value			12,67,800
Less: Cost of Investment			11,00,000
Net Present Value			**1,67,800**

Project P-III

Year	Cash Inflow (₹)	PVF (13%,n)	PV (₹)
1	4,00,000	0.885	3,54,000
2	6,00,000	0.783	4,69,800
3	8,00,000	0.693	5,54,400
4	12,00,000	0.613	7,35,600
Total Present Value			21,13,800
Less: Cost of Investment			19,00,000
Net Present Value			**2,13,800**

Project P-III has highest NPV. So, it should be accepted by the firm.