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Introduction

Investment projects are the fundamental pillar for achieving economic growth and community development, as the successful implementation of development plans is closely linked to the effectiveness of these projects. Feasibility studies play a pivotal role in rationalizing financing and investment decisions; these studies demonstrate a statistical relationship between the quality of economic feasibility assessment and the levels of growth achieved. This correlation fundamentally depends on the analytical efficiency in deploying available resources to maximize economic returns.

This publication aims to shed light on the various concepts associated with investment, investment projects, and feasibility studies, in addition to the different criteria used to evaluate investment projects and prioritize them under all conditions—certainty, uncertainty, and risk. It also covers the application of operations research in project evaluation, specifically business networks and the critical path method.

This publication is among the essential resources required for students across various specializations within the Faculty of Economic and Commercial Sciences and Management Sciences at the University of Médéa, to ensure optimal academic acquisition.

Axis One:

The Theoretical Framework of Feasibility Studies and Investment Projects

Introduction:

Investment projects constitute the cornerstone for achieving economic and social progress for any nation, as the success of development plans is measured by the effectiveness of these projects. Feasibility studies emerge as a pivotal tool in enhancing the efficiency of investment decisions and directing financing towards the most viable projects. Economic evidence demonstrates a clear direct correlation between the quality of feasibility assessment and achieved economic growth levels, which is organically linked to the ability to achieve optimal utilization of available resources according to standards of productive efficiency.

First: The Theoretical Framework of Feasibility Studies

1- Definition of a Feasibility Study:

Investment project feasibility studies are defined as a comprehensive analytical process involving the application of sequential and coherent scientific methodologies to evaluate investment opportunities, starting from the idea formulation stage and leading to the final investment decision (accepting the project, rejecting it, or restructuring it). These studies necessitate conducting multi-dimensional analyses encompassing legal, regulatory, environmental, marketing, technical, and financial aspects, which are executed by a multidisciplinary team comprising academic experts and practitioners from within the entities.[1]

Generally, feasibility studies can be defined as integrated analytical processes based on a systematic evaluation of all fundamental components of investment projects. These studies include a comprehensive examination of the project's technical, financial, marketing, and organizational requirements, aiming to provide an accurate and integrated database that assists decision-makers in assessing the project's suitability and making appropriate investment stances (acceptance, rejection, or restructuring).

2- Characteristics of Feasibility Studies:

2-1- Necessity of Studies for Projects:

These analyses are fundamental for all projects, regardless of their investment or developmental purposes.

[1] Gaber Atef, Abdel Rahim Taha, **Feasibility studies, rooting and practical application**, Alexandria University House, Egypt, 2003, p. 12

2-2- Scope of Studies and Cost:

The scope of these reports and their expenses are proportional to the project's size and the value of capital allocated to it ;

2-3- Interrelation of Study Phases:

The feasibility evaluation process is characterized by the integration of its phases, where the outputs of each stage constitute essential inputs for subsequent phases ;

2-4- The Proactive Model:

A feasibility study represents a prior analytical simulation of the project, aiming to maximize resource use efficiency and avoid their waste ;

Investment environment complexities increase due to the multitude of internal and external variables influencing investor behavior, necessitating the adoption of precise evaluation methodologies to ensure rational decision-making. Feasibility studies emerge in this context as a systematic analytical tool that enables project evaluation under conditions of risk and uncertainty.

However, it is noteworthy that these studies - despite their scientific nature - are subject to the influence of subjective factors, such as the experience of those conducting them and the nature of their objectives, which may sometimes reflect on the reliability of their outputs.

3- The Importance of Feasibility Studies

The strategic importance of feasibility studies lies in supporting the investment decision-making process for various concerned parties as follows:

3-1- For the Individual Investor:

A feasibility study represents a pivotal mechanism to ensure the efficiency of investment decisions, as it allows for the evaluation of available alternatives and the selection of the optimal one given limited resources. It also contributes to mitigating financial risks and preventing capital waste, particularly in large-scale projects. These studies serve as a guiding reference for the investor, in addition to their role in determining the appropriate financing structure that results in calculating the cost of capital, a fundamental criterion in evaluating investment and financial feasibility.

3-2- For Banking Institutions:

A feasibility study enables financial institutions to evaluate the project's operational environment by analyzing available data, market developments, and the project's interaction with them. The added value of these studies lies in reducing the level of risk associated with decisions to grant credit facilities, in addition to enhancing guarantees for loan recovery within the specified timeframe.

3-3- For Government Entities:

Selecting projects of public benefit requires adopting a scientific methodology that allows for the comparison of available alternatives based on objective criteria provided by feasibility studies. Furthermore, official entities stipulate, when granting investment licenses, ensuring the highest rate of societal benefits is achieved while minimizing social costs to the greatest extent possible.

4- Objectives of Feasibility Studies:

Feasibility studies aim to achieve a set of fundamental goals, the most prominent of which are:[2]

- Selecting investment projects that maximize net social benefit, leading to the optimal allocation of limited economic resources. Selected projects should be characterized by operational viability, productive efficiency, scalability, and environmental suitability ;
- Enabling the selection of projects that contribute to addressing economic and social challenges, such as employment, external balance deficits, and wealth distribution disparities, through integrating societal criteria into evaluation mechanisms ;
- Providing the necessary requirements for obtaining official approvals for project establishment, as regulatory authorities require submitting a feasibility study subject to review aimed at measuring the project's economic and social return ;
- Providing institutional guarantees to financing entities (such as banks) regarding the project's investment feasibility, its ability to meet financial obligations, and its operational efficiency.

[2] Bin Shaya Walid, Alamawi Ahmed, bin uthaina bufahs, **Economic feasibility studies as a mechanism for the success of investment projects**, forum Journal for Economic Studies and Research, Vol. 3, No. 2, 2019, P. 138

5- Requirements and Fundamentals of Feasibility Studies:

An investment decision is described as rational when it achieves the specified strategic objectives. To subject the project to objective evaluation, a set of fundamental requirements must be met, based on:[3]

- Availability of all data and information relevant to the project's objectives ;
- Availability of extensive technological and technical expertise for the team of specialized experts conducting the economic feasibility study ;
- The ability to process data electronically ;
- Comprehensive knowledge of the economics of similar projects at the local level and in other countries ;
- Sufficient familiarity with economic policies, investment laws, and those associated with it.

The feasibility analyst must be cognizant of a number of fundamental pillars, the most important of which are:

- **Strategic Flexibility:**
  - Understanding the strategic vision of the project ;
  - The ability to adapt to market variables and potential risks.
- **Defining the Operational Scope:**
  - Precisely controlling the temporal and spatial boundaries of the project ;
  - Inclusivity of all planned operational activities.
- **Management of Investment Alternatives:**
  - Evaluating available technological options ;
  - Analyzing alternatives for equipment and production capacities ;
  - Selecting the optimal choice with justification for the selection.
- **Quality of Data and Information:**
  - Adhering to timeliness and cost standards in data collection ;
  - Ensuring the accuracy and reliability of sources ;
  - Documenting the data collection methodology for reference.

[3] Ibtihal Awad Ahmed Mahfouz**, Economic feasibility study for the success of tourist hotel projects in Yemen (Aden city as a model)**, Rawafed Journal for scientific studies and research in the social sciences and humanities, Vol.8, 2024, P. 470.

6- Difficulties in Conducting an Economic Feasibility Study:

Despite the growing importance of economic feasibility studies, their implementation faces a set of challenges and obstacles for investors, where the most prominent of these difficulties are:[4]

- Unavailability and inaccuracy of information ;
- High costs ;
- Lack of experience, competence, and skill ;
- Complexity in measuring research indicators of an internal nature ;
- Challenges of uncertainty associated with study data ;
- Difficulty in determining optimal evaluation criteria ;
- The level of awareness and conviction regarding the importance of the study.

Secondly: Basic Concepts of the Investment Project

1- Theoretical Framework of Investment

1-1- Concept of Investment:

Investment is defined as expenditure on assets and capacities that will yield a return, and those assets that will generate income in the future are referred to as capital. The human element is no less important than physical capital in the process of producing benefits.[5]

From this, we can say that investment is a current sacrifice for a future return.

1-2- Types of Investment:

Investment can be divided into tangible and intangible investments as follows:

a- Tangible Investments: Divided into two parts:

- **Productive Investments:** These are the means directed towards the production of goods and services.
- **Non-Productive Investments:** Those that do not contribute to the production process, such as: pollution control, work accidents.

[4] Ibtihal Awad Ahmed Mahfouz, **Economic feasibility study as a mechanism for the success of tourist hotel projects in Yemen (Aden city as a model)**,Op.cit, pp. 471, 472.

[5] Sattar Jabbar al-Bayati, Namara Raad Shaker, **Small and medium enterprises**, Dar Al-manahah publishing and distribution, Amman, 2019, P. 50.

b- Intangible Investments:

- **Non-Material Investments:** Such as patents, research and development expenses.

c- Financial Investments:

- Those whose purpose is to obtain financial returns without corresponding production, such as: stocks and bonds.

1-3- Determinants of Investment:

- **Interest Rate:** Represents the cost of invested capital, where an inverse relationship exists between the interest rate and the value of investment.
- **Degree of Risk:** An inverse relationship exists between the degree of risk and investment.
- **Marginal Efficiency of Capital:** This is the expected return from investing a certain amount of funds, and thus a direct relationship exists.

2- Theoretical Framework of the Investment Project:

2-1- Definition of an Investment Project:

An investment project can be defined as an integrated package of planned financial and production operations, which are subject to evaluation, execution, and management within a specific timeframe.[6]

In other words, an investment project is an independent economic unit managed according to specific mechanisms, working to employ production inputs in certain ratios and technical methods, aiming to provide products or services that meet market needs, whether private or public, over a specific period.

2-2- Characteristics of Investment Projects:

- **Investment Objective:** Determining the primary purpose of the project is the cornerstone of its launch, forming the framework that directs all its stages ;
- **Temporal Phases:** The project goes through developmental phases resembling a living organism, starting gradually then accelerating until it reaches peak performance, then declining until the specified term ends ;

[6] Abdul Karim Yacoub, **Project feasibility studies**, Dar Osama publishing and distribution, Amman, Jordan, First Edition, 2008, p.71.

- **Distinctiveness:** Each project possesses a set of unique characteristics that give it a non-repetitive nature compared to similar initiatives ;
- **Competitiveness:** The execution of projects is accompanied by competitive situations aimed at achieving superiority given the limited resources and opportunities available.

2-3 Importance of the Investment Project:

The importance of the investment project lies in:[7]

- Increasing income and achieving welfare for members of society ;
- Providing new job opportunities ;
- Supporting the process of economic and social development ;
- Increasing government revenue from taxes ;
- Developing the state's economy and its prosperity ;
- Increasing national income and gross national product.

2-4 Classification of Investment Projects According to Degree of Economic Interdependence:

- **Independent Projects:** If there is the technical capability to adopt the first project in isolation from the second or to execute them simultaneously, with financial flow independence for each, then the two projects are classified as independent. An illustrative example of this is: constructing a healthcare facility and establishing an educational institution ;
- **Complementary Projects:** Two projects are considered complementary when one contributes to enhancing the financial performance of the other, whether through increasing revenues or reducing expenses. An example of this is: establishing a specialized service unit within a main facility, such as opening a café inside a restaurant ;
- **Contending Projects:** Two projects are classified as contending (or mutually exclusive) when the execution of one causes a decline in the financial performance of the other, whether through decreased revenues or increased costs. An illustrative example of this is: establishing a bus terminal versus constructing a railway line ;
- **Mutually Exclusive Projects:** An exclusive investment choice is defined as the process of selecting a single project from a set of alternatives, where

[7] Al-Siriti, El-Sayed Mohamed Ahmed, **Brief in commercial, economic and social feasibility studies,** Vision Foundation for printing, publishing and distribution, Alexandria, Vol.1, 2008, p. 57.

this choice has no impact on the other projects, but it is impossible to combine them simultaneously ;

- **Interdependent (Contingent) Projects:** This relationship is represented by the interdependence of the two projects, where the execution of the first project is a prerequisite for the realization of the second. Consequently, accepting one necessarily entails accepting the other, and rejecting either one means excluding the associated project.

2-5 Stages of Investment Project Development

Any investment project goes through a series of fundamental stages, starting from the conception as an idea to the actual implementation phase. These stages can be summarized as follows:[8]

✓ First Stage: Pre-Investment Planning Stage

This stage is the most complex and time-consuming, as it ends with a decisive decision to invest or not. This stage includes a set of key procedures, including:

- **Identifying Ideas and Investment Opportunities:** This step involves a comprehensive analysis of the target area for the project establishment, focusing on the availability of production factors, quality of infrastructure, demographic characteristics of the population, and other influencing factors. This is followed by evaluating investment opportunities based on subsectors, estimating the expected size of demand for products or services, and then selecting the most feasible idea.
- **Preliminary Feasibility Study (Pre-Feasibility Studies):** After defining the basic project idea, the process moves to a more in-depth phase involving a preliminary feasibility study. This study aims to assess the practical applicability of the idea and includes the following aspects:
  - **Market Study:** Analyzing the characteristics of the target market for the intended products or services, focusing on: general forecasts of demand volume, potential competition, price trends, studying resources and production inputs ;
  - **Assessing the possibility of obtaining raw materials and essential production elements,** considering: their current availability, future

[8] Drisi Asma, **Lectures on the evaluation of investment projects**, University of Algiers 3, 2016-2017, pp. 17-18.

forecasts of their prices and availability, available alternatives in case of shortage.

- **Detailed (Final) Feasibility Study:**
  - After completing the preliminary feasibility study and deciding to proceed with the project, the process moves to the detailed feasibility study phase. This study is distinguished from its predecessor by the depth and comprehensiveness of the analysis, moving from broad outlines to precise analysis of all aspects of the project ;
  - **Key Characteristics of the Detailed Feasibility Study:** Covers all vital aspects of the project including: environmental and legislative aspects, comprehensive marketing analysis, technical and technological aspects, commercial considerations, financial and economic aspects.

✓ **Second Stage: Implementation Stage (Project Establishment)**

This stage involves transforming the investment idea into a tangible reality and is divided into several key practical steps:

- **Preparation and Engineering Design:** Done by developing detailed technical specifications, preparing engineering plans and drawings, determining infrastructure requirements ;
- **Contracting Phase:** Involves conducting negotiations with suppliers and contractors, concluding legal contracts, securing necessary financing ;
- **Construction Phase:** Involves executing construction works, installing equipment and fittings, monitoring the implementation schedule ;
- **Qualification and Commissioning Phase:** Done through training human resources, conducting operational tests, final project handover ;
- **Final Preparation Phase:** Selecting the factory or facility site, completing internal fittings, preparing full operational conditions.

✓ **Third Stage: Operation Stage**

This stage represents the start of the project's actual operational activities, during which operational problems that may arise in the short and long term are monitored. In the short term, problems usually focus on technical challenges in applying production methods and operating equipment, in addition to workforce efficiency issues. In the long term, challenges revolve around factors of production costs on one hand, and the volume of revenues and sales on the other.

The following table No. 1 shows the main stages of the investment project construction:

Table No. 1: Stages of Building the Investment Project

Pre-Investment Stage	Investment Stage	Project Operation Stage
Identify investment ideas and opportunities ; ↓ Choosing an idea ; ↓ Initial feasibility study ; ↓ Detailed feasibility study ; ↓ Evaluation and decision-making stage.	Negotiation and contracting ; ↓ Construction ; ↓ Training ; ↓ Selection and delivery.	

Source: Drisi Asma, **Lectures on the evaluation of investment projects**, Algiers university3, 2016-2017, P.18

Axis Two:
Evaluation Criteria
for Projects Under Certainty

Introduction:

The concept of the certainty environment refers to the availability of complete and accurate data regarding all proposed investment options, enabling an objective evaluation and comprehensive comparison among them to select the optimal alternative. In this context, the focus centers on identifying the most appropriate metric that aligns with the project's primary objective, relying on precise quantitative methodologies that include mathematical models, statistical tools, and specialized accounting analysis.

First: Terminology for Evaluating Investment Projects

1- Concept of the Investment Project Evaluation Process:

This process involves defining the set of necessary measures and criteria that enable the selection of the optimal investment alternative from a set of proposed options, ensuring the achievement of the outlined objectives based on sound scientific foundations and methodologies.[9]

2- Project Cash Flows:

Implementing any investment project requires cash expenditures that lead to generating either incoming cash flows (e.g., sales revenues) or outgoing cash flows (e.g., investment expenditure and operating costs). The concept of cash flows is based on the cash basis, which focuses on actual revenues received and costs paid during a specific period, without considering accrued revenues or costs until they are collected or paid. This differs from the accrual basis used in determining net profit, which accounts for all revenues and expenses accrued during the period regardless of cash collection. Project evaluation primarily relies on the analysis of these cash flows. They are defined as follows:

2-1- Outgoing Cash Flows:

Include all cash payments made by the project, divided into:

2-1-1- Investment Expenditure:

These are the initial costs required to establish the project.

2-1-2- Operating Expenditure:

Includes annual operating and production costs throughout the project's estimated lifespan, which are determined by the technical study.

[9] Boughaba. A**, Analysis and evaluation of projects**, Algiers, 2005.

2-2- Incoming Cash Flows:

Refer to the annual financial resources generated by the project, represented by the returns from the sales of its products or services, in addition to other cash revenues constituted by the project's net liquidation value at the end of its productive life. The sales volume is estimated based on the findings of the project's marketing study.

3- Basis for Estimating Cash Flows in Investment Projects:

The evaluation of an investment project's cash flows is based on its economic life rather than its productive life, as there is a fundamental difference between the two concepts:

3-1- Project's Productive Life:

- Represents the period during which the project remains capable of production ;
- Continues as long as the assets can be maintained and operated;
- Is not related to profitability or economic feasibility ;
- The project may continue production even in the absence of financial viability.

3-2- Project's Economic Life:

- Refers to the period during which the project achieves economic profitability;
- Ceases when operation becomes financially unviable.

4- Investment Decision:

This investment decision is defined as the process of selecting the most profitable option from several available alternatives, based on a comparative analysis of expected returns, in light of the previously prepared economic feasibility reports for each alternative.[10]

5- Residual Value of the Project:

The residual value, or salvage value/liquidation value, is the estimated value of a fixed asset at the end of its lease period or productive life.

[10] Abdulmutallab Abdulmajid, **Economic feasibility study for investment decision - making**, university house, 2000, p.39.

Secondly: Criteria for Measuring Profitability Discounted and Non-Discounted Under Conditions of Certainty

A set of measures used to evaluate the financial feasibility of projects in certainty environments can be identified, which vary in their levels of complexity and analytical precision.

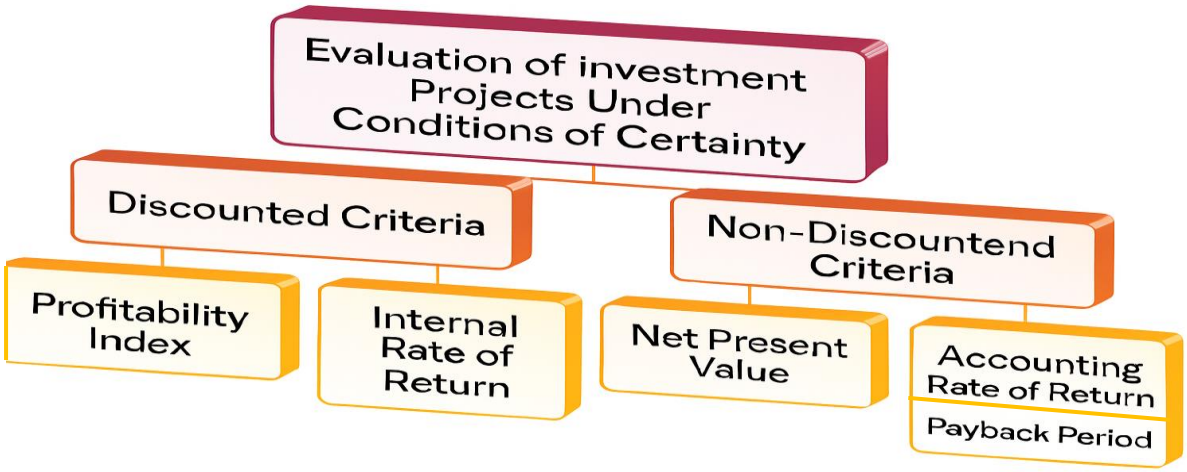
Based on this, the emphasis is on the indicators that are most accepted in academic circles, widespread in practical application and objective in the results.

Commercial profitability criteria under conditions of certainty are divided into:

- Non-Discounted Criteria ;
- Discounted Criteria.

The most important criteria used for evaluation under conditions of certainty can be illustrated through the following Figure No. 1:

Figure No. 1: Project Evaluation Criteria Under Conditions of Certainty



Source: Prepared by the researcher

1- Non-Discounted Criteria:

This category of criteria refers to those that do not consider the time value of money, treating incoming and outgoing financial flows at their nominal value without applying any time discounting. This group of criteria includes:

- Payback Period criterion (the temporal criterion) ;
- Average Rate of Return criterion (the accounting criterion).

We will now attempt to clarify each of these two criteria:

1-1- Payback Period Criterion:

1-1-1-Concept of the Payback Period Criterion and Calculation Methods:

The payback period measure is among the simplest evaluation tools in investment project analysis and has gained widespread adoption in American and European practices. This measure expresses the time period required to recover the expended capital, or the period at which cost cash flows balance with revenue cash flows.

A maximum time limit for capital recovery is typically set, known as the "cut-off period," which represents the maximum acceptable duration for recouping initial investments.

Note: The decision to approve or reject a project is based on comparing the capital recovery duration with the adopted cut-off period. The project is accepted if the recovery duration is less than the specified cut-off period, while it is rejected if the recovery duration exceeds this period. In the context of comparing competing projects, or when needing to prioritize projects, the project with the shortest payback period is given selection priority.

There are several methods for calculating the payback period, including the following:

✓ **First Method (Case of Unequal Annual Cash Flows):**

In this case, the capital recovery period is calculated using the direct accumulation methodology, where cash flows are aggregated annually starting from the first year until reaching the total amount of the initial investments. Here, we distinguish between two cases:

– The Simple Period Case:

$$I_0 = \sum_{t=1}^{n} CF_n t$$

- **Applied Example:** We have the following table representing the net annual cash flows:

Years	0	1	2	3	4	5
Net Cash Flows	(150)	30	50	60	50	30
Cumulative Flows	-	30	80	140	190	220

- To calculate or find the payback period, we computed the cumulative flows starting from Year 1 until reaching the amount of the investment cost ;
- It is clear that recovering the invested capital of 150 million dinars requires a period exceeding 3 years but less than 4 years ;
- During Year 4, a cash flow of 50 million dinars is achieved, while the amount needed to complete the investment recovery does not exceed 10 million dinars, noting that the total cumulative flows after 3 years amount to 140 million dinars.

Therefore, the payback period is as follows:

$$\text{DR} = 3years + \frac{10}{50} \times 360\ days$$

$$\text{DR} = 3years + 2\ \text{months} + 12\ days$$

– The Discounted Payback Period Case:

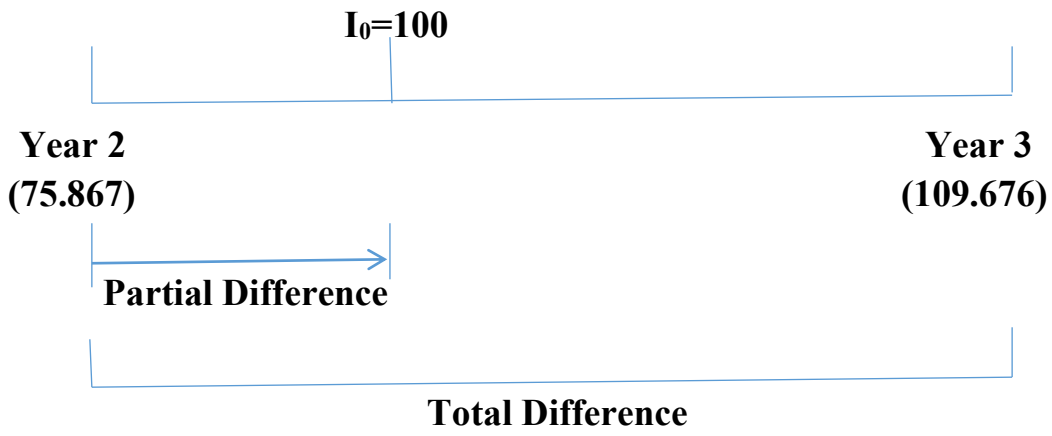
There are no fundamental differences between this methodology and the traditional payback period method in terms of the calculation mechanism, except that it relies on net cash flows discounted to their present time value. Accordingly, the concept of the discounted payback period can be defined as the time required to recover the initial investment cost based on discounted cash flows :

$$I_0 = \sum_{t=1}^{n} \frac{CF_n t}{(1+i)^t}$$

- **Applied Example:** An investment project with a cost of 100 units, as shown in the following table, where the discount rate is estimated at i = 10%:

Years	Net Cash Flow	Discounted Net Cash Flow	Cumulative Discounted Net Cash Flow
1	38	$\frac{38}{(1.1)^{-1}} = 34.545$	34.545
2	50	$\frac{50}{(1.1)^{-2}} = 41.362$	75.868
3	45	$\frac{45}{(1.1)^{-3}} = 33.809$	109.677
4	40	$\frac{40}{(1.1)^{-4}} = 27.32$	136.997
5	20	$\frac{20}{(1.1)^{-5}} = 12.42$	149.417

At the end of Year 3, the firm had accumulated 109.676 units, which covers the investment cost estimated at 100 units. Therefore, the period during which the firm was able to recover the initial investment cost falls between Year 2 and Year 3, calculated as follows:



We have the total difference:

$$33.809 = 109.676 - 75.867$$

The partial difference:

$$24.133 = 100 - 75.867$$

$$DR = \frac{\text{Partial Difference}}{\text{Total Difference}} \times 360\ days + 2\ years$$

$$DR = \frac{24.132}{33.809} \times 360\ days + 2\ years$$

$$DR = 2y\ ears + 256\ years$$

✓ **Second Method (Case of Equal Annual Cash Flows):**

This methodology represents the most widespread and applied approach compared to the previous method, where the capital recovery period is determined based on operational cash flows after accounting for asset depreciation and tax deductions.

This mechanism is considered an effective tool for comparing alternative investment projects, aiming to identify the optimal option with the shortest period for recovering the invested capital.

The payback period is calculated according to this method using the following formula:

$$\textbf{\textit{Payback Period}} = \frac{\textbf{\textit{Initial Investment Cost}}}{\textbf{\textit{Net Annual Cash Flow (Net Annual Return)}}}$$

$$\boldsymbol{DR = \frac{I_0}{CFN}}$$

The best project is considered to be the one that achieves the lowest payback period, which can be illustrated through the following example:

- **Applied Example:** The executive management of a light industries company seeks to acquire an inspection system for finished products before their market release. After conducting and announcing a tender through media channels, the company received three technical and financial offers from leading global specialized firms. as shown in the following table:

Information	Offer (A)	Offer (B)	Offer (C)
Initial Investment Cost	5000	5000	5000
Salvage Value at End of Productive Life	1500	1000	0
Productive Life (Years)	5	5	5
Annual cash flow before tax and depreciation	1500	1200	1100

- **Given that:**

- The company uses the straight-line method for depreciation calculation ;
- Income tax is estimated at 15% of annual profit.

- **Required:**

- Determine which alternative or offer is the best, and why? Use the payback period criterion :
- Rank the alternatives in order of preference.

- **Solution:** The payback period can be calculated using the following formula:

$$\text{Payback Period} = \frac{\text{Initial Investment Cost}}{\text{Net Annual Return}}$$

Regarding the investment cost for each alternative, there is no issue as it is given. The problem lies in calculating the net annual return (CFN).

Therefore, the annual depreciation share for each alternative must first be extracted and then subtracted from the given annual cash flow. Since depreciation represents a cost, to arrive at the annual taxable profit, and after deducting tax, the annual depreciation is added back to achieve balance in the project's final calculations. as shown in the following table:

Information	Alternative (A)	Alternative (B)	Alternative (C)
Annual Depreciation Share ((Investment Cost - Salvage Value) / Productive Life)	$\frac{5000-1500}{5}=700$	$\frac{5000-1000}{5}=800$	$\frac{5000-0}{5}=1000$
Annual Flow Before Depreciation and Tax (Annual Depreciation)	1500 (700)	1200 (800)	1100 (1000)
Annual Flow Subject to Tax (Tax Amount)	800 (800×0.15=120)	400 (400×0.15=60)	100 (100×0.15=15)
Annual Flow After Tax Depreciation Share	680 700	340 800	85 1000
Net Annual Cash Flow (CFN)	1380	1140	1085
Payback Period $=\frac{I_0}{cFn}$	$\frac{5000}{1380}=3.62$	$\frac{5000}{1140}=4.38$	$\frac{5000}{1085}=4.60$
Preference	First	Second	Third

Based on the obtained results, it can be said that Alternative (A) is the best alternative because it achieved the shortest payback period compared to the other alternatives.

1-1-2- Evaluation of the Payback Period Criterion:

Despite the advantages of this criterion, it does face some criticisms, including the following:

a- It ignores additional gains the project may achieve during its productive life:

This means it is necessary to know whether the project ends at the payback period or continues to generate additional returns, what the economic result of its continuation is, and what impact this has on the project's profitability. This can be illustrated with the following example:

- **Applied Example:** If you have the following information about projects A and B:

Information	Project (A)	Project (B)
Initial Investment Cost	100000	100000
Productive Life (Years)	4	4
Annual Cash Flows:		
Year 1	50000	20000
Year 2	50000	30000
Year 3	10000	50000
Year 4	10000	50000

- **Required:** Determine which project is better using the payback period criterion.
- **Solution:**

Based on the payback period criterion, Project (A) is considered better because it can recover its capital in two years, while Project (B) requires three years to recover its capital.

On the other hand, it is noted that Project (A) achieves additional gains during its productive life estimated at 20000, while Project (B) achieves larger additional gains than Project (A), estimated at 50000, after recovering its capital. Therefore, Project (B) is considered better if the profitability criterion is used.

b- It ignores the time value of money:

That is, it ignores the timing of cash flows, leading to significant differences due to the time value of money. This can be illustrated with the following example:

– Applied Example: Assume two projects, A and B, each with an investment cost of 100000 dinars, the same productive life, but differing in the timing of cash flows.

Here is the information as shown in the table:

Information	Project (A)	Project (B)
Initial Investment Cost	100000	100000
Productive Life (Years)	3	3
Net Annual Cash Flows:		
Year 1	50000	20000
Year 2	30000	30000
Year 3	20000	50000

It is observed from the information above that despite both having the same payback period (each project recovered its original capital in 3 years), they are not equally preferable due to the difference in the timing of their annual cash flows. Project (A) is characterized by a faster recovery of its capital (or a larger proportion of its capital early on), as it managed to recover about 80% of its capital in the first two years of its productive life, while Project (B) only recovered about 50% of its capital in the first two years.

Therefore, Project (A) is better than (B), even though they have the same payback period. Consequently, the payback period criterion places both projects at the same level of preference.

On this basis, it can be said that the payback period criterion, despite its widespread use, lacks the conditions necessary for a proper evaluation criterion; meaning it is not a suitable measure of private profitability. However, it can be relied upon, especially for some projects and investments exposed to a certain level of risk.

1-2- Average Rate of Return Criterion (The Accounting Criterion) ARR:

1-2-1- Concept of the Average Rate of Return and its Calculation Method:

This criterion is sometimes called the Accounting Rate of Return (ARR), and it can be defined as "the percentage ratio of the average annual net return to the value of the initial investment costs."

The Average Rate of Return is calculated according to the following relation:

$$\textbf{Average Rate of Return} = \frac{\textbf{Average Annual Net Return}}{\textbf{Initial Investment Cost}} \times 100$$

$$\textbf{Average Annual Net Return} = \frac{\textbf{Sum of Net Annual Returns}}{\textbf{Number of Years}}$$

- **Applied Example:** The investment costs for a specific project were estimated at 50000 dinars, its productive life was estimated at 4 years, and the expected net annual flows were according to the following table:

Year	Expected Net Annual Returns
1	7500
2	7500
3	7500
4	12500

– **Required:** Determine the Average Rate of Return criterion.

– **Solution:**

$$\textbf{Average Annual Net Return} = \frac{12500 + 7500 + 7500 + 7500}{4} = \textbf{8750 dinars}$$

$$\textbf{Average Rate of Return} = \frac{\textbf{Average Annual Net Return}}{\textbf{Initial Investment Cost}} \times \textbf{100}$$

$$= \frac{8750}{50000} \times 100 = \textbf{17.5\%}$$

– **Second Method:** According to the following formula:

$$\textbf{Average Rate of Return} = \frac{\textbf{Average Annual Net Flow}}{\textbf{Average Investment Cost}} \times \textbf{100}$$

Where:

$$\text{Average Investment Cost} = \frac{\text{Investment Cost at the beginning of productive life} + \text{Cost at the end of productive life (Salvage)}}{2}$$

1-2-2- Evaluation of the Average Rate of Return Criterion:

Despite this criterion's advantages of simplicity and ease of use, and its adoption as an evaluation tool, it nevertheless suffers from some weaknesses, the most important of which are:

a- Ignoring the Time Value of Money:

This issue can be illustrated through the following example:

- **Applied Example:** Assume two projects, A and B, each with an initial investment cost of 100000 dinars, the same productive life (5 years), and a salvage value of zero for both. However, they differ in the timing of the realized cash flows, which can be shown in the following table:

Year	Project A	Project B
1	30000	10000
2	30000	10000
3	20000	20000
4	10000	30000
5	10000	30000
Total	**100000**	**100000**

If the requirement is to determine which project is better using the Average Rate of Return criterion, knowing that the prevailing market interest rate is 20%.

- Solution:

Information	Project A	Project B
Average Annual Net Flow	(30000+30000+20000+10000 +10000)/5 = 20000	(10000+10000+20000+30000 +30000)/5 = 20000
Average Investment Cost	100000 / 2 = 50000	100000 / 2 = 50000
Average Rate of Return	(20000 / 50000) × 100 = **40%**	(20000 / 50000) × 100 = **40%**

Based on the obtained results, we find that the Average Rate of Return for both projects is 40%, indicating difficulty in preference and that both are equal. However, despite this, **Project A is better** because it managed to achieve the larger proportion of its returns in the first years of its life (about 80% in the first three years), while Project B only recovered about 40% of its returns in the first three years.

b- Disregard for the Project's Lifespan and Additional Returns Achieved:

This criterion overlooks the temporal considerations of the project's life cycle and the future returns it generates. A long-term project might record a rate of return similar to a short-term project.

This method relies on traditional accounting principles for measuring cash flows, rather than focusing on the project's initial cash flows.

Despite the advantage of simplicity that this criterion enjoys, it suffers from fundamental limitations that exclude it from the requirements of comprehensive evaluation. However, it remains a suitable tool for analyzing

some operational aspects of profitability, especially in the field of dividend distribution to shareholders.

2- Discounted Criteria:

These analytical indicators are characterized by their consideration of the time value of money. The most prominent among them are: the discounted payback period, net present value (NPV), internal rate of return (IRR), and profitability index (PI). Before detailing these criteria, it is worth clarifying the concept of interest, which represents the cash return a lender receives for lending their money for a specific period, or the amount a depositor earns for depositing their funds in banking institutions for a certain period.

As for discounting: We are interested in knowing the present value of an amount we expect to receive in a future period.

2-1 Net Present Value (NPV) Criterion:

This value is defined as the difference between the present time value of the expected net cash flows throughout the project's productive life and the value of the capital invested in the establishment phase.

The NPV methodology is based on converting all net cash flows to their equivalent time value using an appropriate discount rate. The NPV of a project can be expressed by the following mathematical formula:

$$\mathbf{NPV} = \sum \mathbf{PV} - \mathbf{I_0}$$

∑PV: Present Value

I_0: If the capital is invested at the beginning (Year 0).

$$\mathbf{NPV} = \left[\sum_{t=1}^{n} \frac{cFnt}{(1+i)^t}\right] - \left[\sum_{t=0}^{n} \frac{I_t}{(1+i)^t}\right]$$

Where:

i: Discount rate: Internal rate of return of the financing cost.

CF_{nt}: Expected net cash flow in period n ← 1.

I_t: Initial investment cost.

Generally, NPV can be formulated assuming the initial investment cost is a single payment at the project's start ("in Year 0"):

$$\mathbf{NPV} = \left[\sum_{t=0}^{n} \frac{cFnt}{(1+i)^t}\right] - I_0$$

If there is a residual value (V_R) for the investment at the end of the period, NPV can be calculated as follows:

$$\mathbf{NPV} = \left[\sum_{t=1}^{n} \frac{cFnt}{(1+i)^t} + \frac{V_R}{(1+i)^n}\right] - I_0$$

- **Evaluation Method:**
  - **NPV > 0:** Acceptable project, meaning: ∑PV > I_0. For mutually exclusive projects, the principle is to choose the project with the highest positive NPV, excluding other alternatives. For non-interrelated projects, all projects achieving a positive NPV are accepted.
  - **NPV < 0:** Rejected project, meaning: ∑PV < I_0.
  - **NPV = 0:** Rejected project, ∑PV = I_0, Outputs = Inputs.

    Note: When NPV = 0, we resort to the IRR criterion, and the discount rate i is interpreted as the IRR.

- **Applied Example:** We have two projects, (A) and (B). The investment cost for each is estimated at 100000 DZD, the financing cost is 8%, and the net cash flows are shown in the following table:

Years	1	2	3	4	5
Proj (A)	4000	32000	45000	45000	60000
Proj (B)	(3000)	35000	47000	47000	65000

  - **Required:** Evaluate the projects using the Net Present Value method.

  - **Solution:**

Years	Discount Factor (8%)	Project (A)		Project (B)	
		Net Cash Flow	Present Value	Net Cash Flow	Present Value
1	0.92	4000	3703.70	(3000)	(2777.78)
2	0.85	32000	27434.84	35000	30007.00
3	0.79	45000	35722.45	47000	37310.00
4	0.73	45000	33076.34	47000	34346.40
5	0.68	60000	40835.00	65000	44238.00
Total Present Values		**140772.33**		**143,123.62**	

Therefore:

NPV A = 140772.33 - 100000 = **40772.33**

NPV B = 143123.62 - 100000 = **43123.62**

It is concluded from the above analysis that both projects achieve a positive NPV. If the projects are unrelated (independent), accepting both becomes possible. Whereas if they are alternatives (mutually exclusive), the project with the higher NPV is adopted, leading to a preference for Project (B) and the exclusion of Project (A).

The NPV criterion has several advantages and is also subject to several criticisms:

- **Advantages:** Illustrated as follows:
  - Considers the time value of money through the time discounting mechanism ;
  - Includes all cash flows throughout the project's assumed life ;
  - Provides a clear indicator for measuring the project's financial feasibility ;
  - Reflects the true value of the investment using a discount rate equivalent to the cost of capital.
- **Criticisms:** Summarized as follows:
  - Does not provide an accurate comparison between projects with different investment values or lifespans ;
  - Does not show the return on each invested monetary unit ;
  - Does not take into account risk and uncertainty elements affecting project performance.

Note: When NPV = 0, the project's incoming and outgoing cash flows are equal; in this case, we resort to the Internal Rate of Return (IRR) criterion.

2-2 Internal Rate of Return (IRR):

Considered one of the most important criteria used by companies and institutions to decide on the long-term feasibility of an investment decision.

The basic idea of this criterion is to find the discount rate at which the initial investment (I_0) equals the present value of the cash flow throughout the project's life. In other words, it is the discount rate that gives the project a net present value of cash flow equal to zero, usually interpreted as the expected profits generated by the investment decision.

The Internal Rate of Return is determined by the following equation:

$$I_0 = \sum_{t=1}^{n} \frac{CFN_t}{(1 + \text{IRR})^t}$$

Or through the trial-and-error method. The project's validity is decided when the discount rate is less than the internal rate of return. To save time and avoid the trial-and-error approach, cash flows can be discounted using two chosen discount rates; the required discount rate must lie between them and is determined using the following formula:

$$\mathbf{IRR} = I_1 + \frac{(I_2 - I_1) \times NPV_1}{|NPV_1| + |NPV_2|}$$

Where:

IRR: Internal Rate of Return

I_1: Lower discount rate used

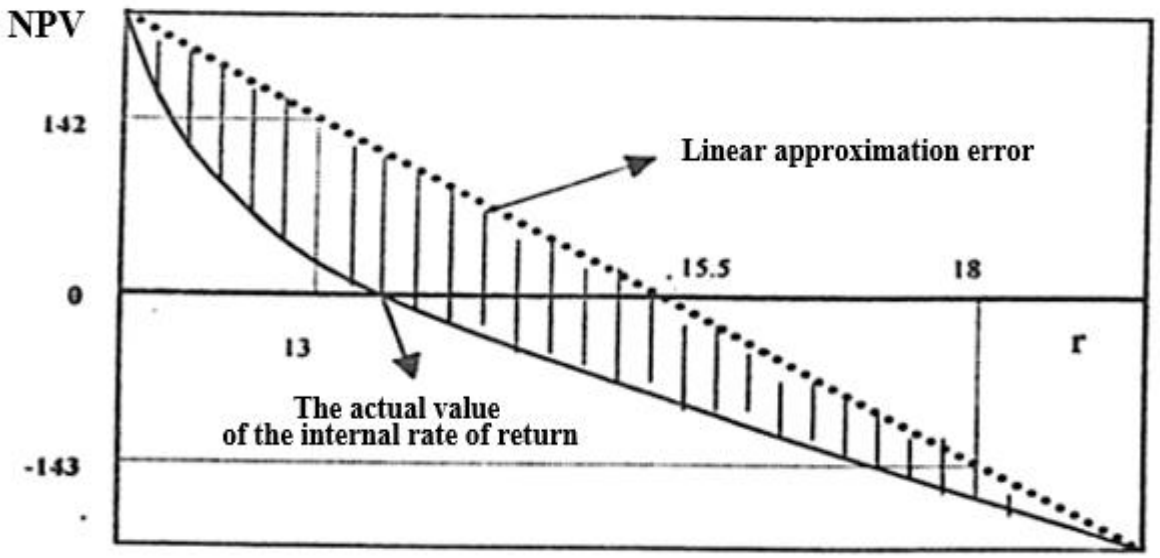
I_2: Higher discount rate used

NPV_1: Net Present Value using discount rate I_1

NPV_2: Net Present Value using discount rate I_2

This formula assumes that the relationship between the discount rate and the net present value is linear. However, in practical reality, this relationship may be non-linear, which means that this method may involve a type of error called approximation error. The approximation error can be illustrated using the following Figure No. 2, where the shaded area represents the linear approximation error:

Figure No. (2): Linear Approximation Error in Estimating the Internal Rate of Return.



Source: Abdelkader Mohamed Abdelkader Al-Atya, **Commercial, Economic, and Social Feasibility Studies with BOT Projects**, University House, Alexandria, 2008, 2nd Edition, p. 224.

According to this methodology, a project is accepted when its internal rate of return exceeds the minimum required rate of return or the cost of capital. This rule applies in two main cases:

- For independent projects: All projects achieving an internal rate of return higher than the benchmark rate are accepted.
- For mutually exclusive projects: The project achieving the highest internal rate of return is selected.

- **Applied Example:** Assume that for a discount rate of 14.7%, the Net Present Value (NPV) of a project is VAN = +1.014, and for a discount rate of 14.8%, the NPV of the same project is VAN = -0.121.

To find the Internal Rate of Return (IRR) in this case, we use the linear approximation formula as follows:

$$\mathbf{IRR} = 14.7 + \frac{1.014(14.8 - 14.7)}{1.014 + 0.121}$$

$$\mathbf{IRR} = 14.7893\% \approx \mathbf{14.79\%}$$

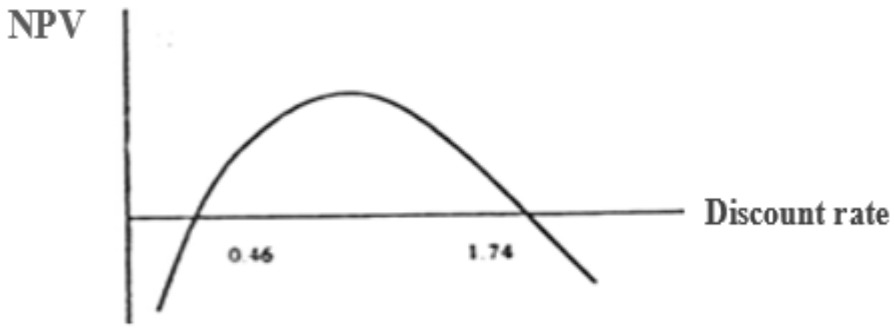
2-3 Special Cases of the Internal Rate of Return:

These are represented in the following cases:

✓ **First Case:**

This involves the case of having two internal rates of return. The relationship between the discount rate and the NPV takes the form shown in the following Figure No. 3:

Figure No. (3): The case of two internal rates of return.

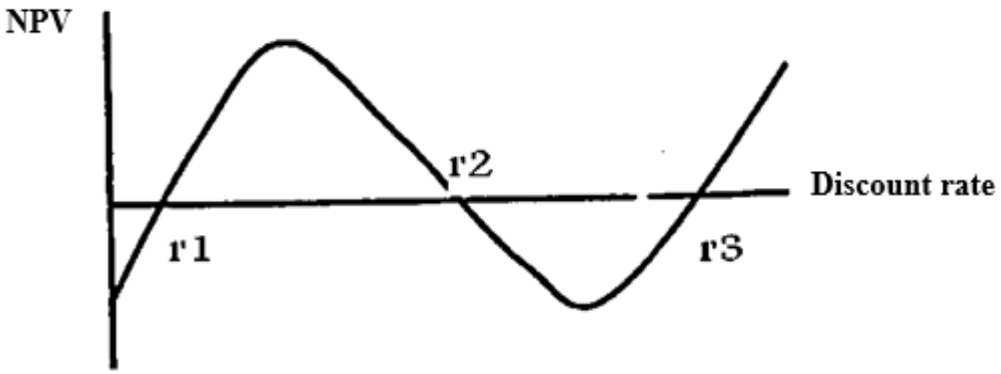


Source: Abdelkader Mohamed Abdelkader Al-Atya, **Commercial, Economic, and Social Feasibility Studies with BOT Projects**, University House, Alexandria, 2008, 2nd Edition, p. 226.

✓ **Second Case: The case of more than two internal rates of return:**

This occurs when the net cash flows of the project, starting from the construction period, are negative, then positive, then negative, and so on. The relationship between the discount rate and NPV takes the form shown in the following Figure No. 4:

Figure No. (4): The case of three internal rates of return



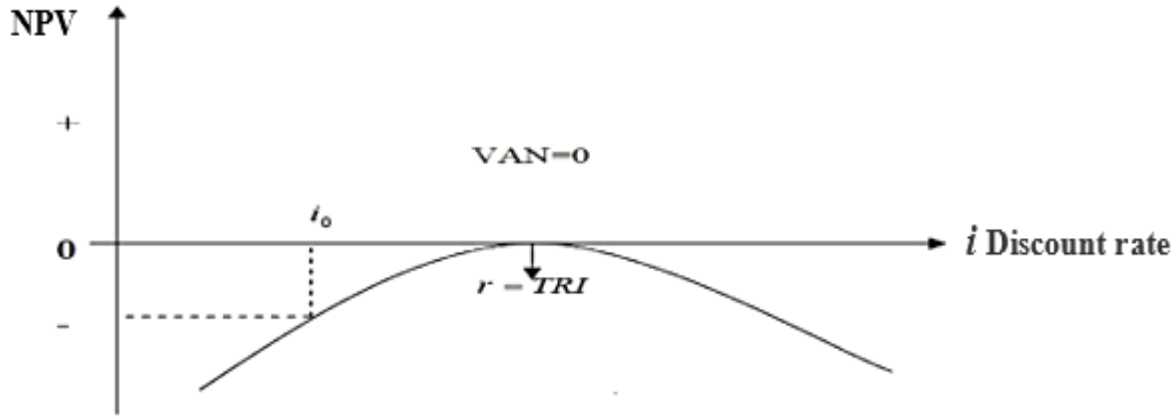
Source: Abdelkader Mohamed Abdelkader Al-Atya, **Commercial, Economic, and Social Feasibility Studies with BOT Projects**, University House, Alexandria, 2008, 2nd Edition, p. 226.

It is observed from this figure that there are three rates, r_1, r_2, r_3, corresponding to the change in the path of the Net Present Value of cash flows as a function of the discount rate, where each point of intersection with the horizontal axis indicates NPV = 0, meaning the existence of an internal rate of return.

✓ **Third Case: The case of an internal rate of return with a negative net present value**

This is as illustrated in the following Figure No. 5:

Figure No. (5): The case of an internal rate of return with a negative net present value.



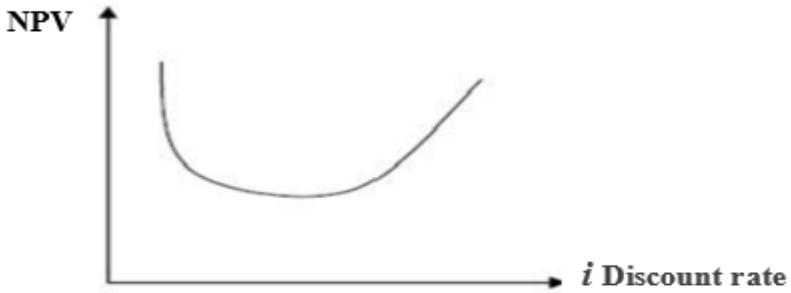
Source: Abdelkader Mohamed Abdelkader Al-Atya, **Commercial, Economic, and Social Feasibility Studies with BOT Projects**, University House, Alexandria, 2008, 2nd Edition, p. 226.

In this case, the project is accepted according to the internal rate of return criterion because $i_0 < r_0$, despite the negative net present value.

✓ **Fourth Case: The case of no internal rate of return**

This is as illustrated in the following Figure No. 6:

Figure No. (6): The case of no internal rate of return



Source: Abdelkader Mohamed Abdelkader Al-Atya, **Commercial, Economic, and Social Feasibility Studies with BOT Projects**, University House, Alexandria, 2008, 2nd Edition, p. 226.

It is observed from Figure No. 5 above that there is no internal rate of return. This is because the net present value is positive at all discount rates. The internal rate of return criterion has several advantages and has also been subject to numerous criticisms:

- **Advantages:** These are as follows:
  - It enjoys high reliability as a precise indicator for measuring financial feasibility ;
  - It is used as a ranking tool for investment projects according to their profitability rates ;
  - It integrates the time value of money into the economic evaluation process ;
  - It presents results in percentage form, facilitating monitoring and comparison ;
  - It shows the safety margin through the difference between the return and the cost of capital ;
  - It eliminates the need to determine external discount rates.
- **Criticisms:** These are as follows:
  - It assumes the reinvestment of cash flows at the same internal rate of return, a theoretical assumption difficult to achieve in practice ;
  - It does not fully address elements of risk and uncertainty, although this limitation has a limited impact in practical applications ;
  - In the case of mutually exclusive projects, the net present value criterion is preferred for comparison ;
  - Despite these observations, the criterion's effectiveness in investment decision-making remains high.

2-5 Profitability Index (IP) Criterion

This indicator is also known as the "benefit-cost ratio." The profitability index is defined as the measure that evaluates a project's efficiency in generating profits. It is calculated by the ratio of the present value of incoming cash flows to the total initial investments. This indicator measures the relationship between project inputs and outputs as a percentage, unlike the net present value criterion, which expresses results in absolute values. The profitability index is expressed by the following mathematical formula:

$$IP = \frac{\sum_{t=1}^{n} \frac{CFt}{(1+i)^t} + \frac{VR}{(1+i)^n}}{I}$$

This is if I (initial investment) is made in Year 0. If I is distributed over several years, the formula is as follows:

$$IP = \frac{\sum_{t=1}^{n} \frac{CFt}{(1+i)^t} + \frac{VR}{(1+i)^n}}{\sum_{t=0}^{m} \frac{It}{(1+i)^t}}$$

Where :

m: represents the construction and completion period,

m+1 : to n represents the production period (i.e., post-completion).

This criterion can also be expressed by the following formula:

$$\mathbf{IP} = \frac{\text{NPV}}{\text{I}} + 1$$

The application of this criterion yields three main possibilities:

- If the index exceeds the benchmark (IP > 1): Indicates economic feasibility of the project, reflects profitable investment capacity, and necessitates acceptance and implementation.
- If the index is below unity (IP < 1): Indicates financial infeasibility, reflects potential loss, and thus requires rejection.
- If equal to unity (IP = 1): Indicates the break-even point, does not achieve additional profit, and is usually rejected.

For comparing multiple projects, the following rules apply:

- Independent projects: Every project achieving (IP > 1) is accepted, and any project not meeting this condition is rejected.
- Mutually exclusive projects: The project with the highest profitability index (IP > 1) is selected, and other projects are excluded.

• **Applied Example:** We have two investment projects (A) and (B). Their investment costs are estimated at 100000 DZD and 130000 DZD, respectively. The discount factor is 14%, and the cash flows are as follows:

Years	**1**	**2**	**3**	**4**	**5**
Proj (A)	25000	(10000)	30000	40000	70000
Proj (B)	10000	50000	40000	60000	80000

- **Required:** Evaluate the projects using the Profitability Index method.
- **Solution:**

Years	**Discount Factor 14%**	**Project (A)**		**Project (B)**	
		Cash Flow	**Present Value**	**Cash Flow**	**Present Value**
0	1.000	(100000)	(100000)	(130000)	(130000)
1	0.877	25000	21925	10000	8770
2	0.769	(10000)	(7690)	50000	38450

3	0.674	30000	20220	40000	26960
4	0.592	40000	23680	60000	35520
5	0.519	70000	36330	80000	41520
Total PV		**-5535**		**21220**	

Therefore:

$$\mathbf{IP\ (A)} = \frac{50\ 616}{100\ 000} = 0.5$$

$$\mathbf{IP\ (B)} = \frac{1\ 333\ 680}{130\ 000} = 1.02$$

Project (B) is economically acceptable because its profitability index is greater than one. Project (A) is economically rejected because its profitability index is less than one.

The profitability index criterion has several advantages and has also been subject to criticisms, including:

- **Advantages:** These are as follows:
  - A measure of investment efficiency, as it measures the net return per invested monetary unit ;
  - A weighting tool, used as a complement to the NPV criterion for ranking projects, especially when initial investment sizes and project lifespans differ ;
  - Considers the time dimension by taking into account the time value of money ;
  - A ranking tool that allows for ordering investment alternatives according to their degree of feasibility.
- **Criticisms:** These are as follows:
  - Does not address risk, as it does not consider the uncertainty elements accompanying cash flows ;
  - Sensitivity to the discount rate, as the accuracy of the results depends on choosing an appropriate discount rate; any error in its estimation negatively affects the quality of the investment decision.

Despite these limitations, the profitability index remains an important analytical tool for comparing projects, especially when used with other evaluation criteria to enhance the accuracy of the investment decision.

Thirdly: Special Cases for Project Evaluation Under Certainty Conditions

1- Case of Inflation:

The prevailing inflation rate in the market must be considered because it affects cash flows and also affects the discount rate. Therefore, there are two solution methods:

✓ **First Method:** Adjust the annual real cash flows to nominal annual cash flows according to the following relationship:

$$\mathbf{CFN} = CFR \times (1 + TI)^n$$

Where:

CFN : Nominal annual cash flows

CFR : Real annual cash flows

TI : Inflation rate

✓ **Second Method:** Adjust the nominal discount rate to a real discount rate according to the following relationship:

$$\mathbf{IR} = \frac{1 + IN}{1 + TI} - 1$$

Where:

IR: Real discount rate

IN: Nominal discount rate

TI: Inflation rate

Then we proceed to evaluate the project using one of the previous criteria.

- **Applied Example:** An investment project with an initial investment cost estimated at 1000 monetary units. The net annual cash flows were respectively: 200, 300, 500, 400. The discount rate (i) was estimated at 10%, and the inflation rate (TI) was estimated at 5%.
- **Required:** Is the project economically acceptable using the Net Present Value criterion?
- **Solution:**

According to the first method (adjusting cash flows):

$$CFN1 = 200 \times (1+0.05)^1 = 210$$

$$CFN2 = 300 \times (1+0.05)^2 = 330.75$$

$$CFN3 = 500 \times (1+0.05)^3 = 578.8125$$

$$CFN4 = 400 \times (1+0.05)^4 = 486.2025$$

After adjusting the flows from real to nominal, we now calculate NPV to evaluate the project:

$$\mathbf{PV} = 210(1.1)^{-1} + 330.75(1.1)^{-2} + 578.8125(1.1)^{-3} + 486.2025(1.1)^{-4}$$

$$\mathbf{PV} = \mathbf{1232.4}$$

$$\mathbf{NPV} = PV - I = 1232.4 - 1000 = \mathbf{232.4}$$

The NPV is positive, therefore the project is economically acceptable.

According to the second method (adjusting the discount rate):

$$\mathbf{IR} = \frac{1 + IN}{1 + TI} - 1$$

$$IR = \frac{1 + 0.1}{1 + 0.05} - 1$$

$$IR = 4.7\%$$

Calculate NPV:

$$\mathbf{PV} = 200(1.0476)^{-1} + 300(1.0476)^{-2} + 500(1.0476)^{-3} + 400(1.0476)^{-4}$$

$$\mathbf{PV} \approx \mathbf{1232.8}$$

$$\mathbf{NPV} = PV - I = 1232.8 - 1000 = \mathbf{232.8}$$

The NPV is positive, therefore the project is economically acceptable.

2- Case of Inflation with Salvage Value:

Since a salvage value (VR) exists, it affects the depreciation charge. Therefore, we follow these steps:

- Convert annual real cash flows to nominal annual cash flows ;
- Convert the real salvage value to a nominal salvage value ;
- Account for the salvage value ;
- Evaluate the project using a specific method.

- **Applied Example:** An investment project with an initial investment cost estimated at 40000 monetary units. Its economic life is 5 years, and the residual value at the end of its productive life is estimated at VR = 5000 monetary units. The annual cash flows before tax and depreciation were respectively: 15000, 17000, 20000, 15000, 10000. The discount rate (i) is estimated at 5%, the income tax rate is 40%, and the capital gains tax rate is 30%. Note that the country is experiencing an annual inflation rate of 10%.

- **Required:** Evaluate the project using the NPV method?

– **Solution:**

- **Convert real flows to nominal:**

$$CFN1 = 15000 \times (1.1)^{1} = 16500$$
$$CFN2 = 17000 \times (1.1)^{2} = 20570$$
$$CFN3 = 20000 \times (1.1)^{3} = 26620$$
$$CFN4 = 15000 \times (1.1)^{4} = 21960$$
$$CFN5 = 10000 \times (1.1)^{5} = 16100$$

- **Convert real salvage value to nominal:**

$$\mathbf{VRN} = VRr \times (1 + TI)^{n} = 5000 \times (1.1)^{5} = 8052.55$$

- **Calculate depreciation:**

$$\mathbf{AM} = \frac{40000 - 5000}{5} = 7000$$

- **Calculate salvage value after tax:**

$$\mathbf{VR'} = VRN - (VRN - VRr) \times T$$

Where:

T: Capital gains tax rate (30%)

$$\mathbf{VR'} = 8052.55 - (8052.55 - 5000) \times 0.3 = 7135$$

Let's calculate the after-tax and after-depreciation cash flows according to the following table:

Information	Year 1	Year 2	Year 3	Year 4	Year 5
Nominal Cash Flow	16500	20570	26620	21960	16100
(Depreciation)	(7000)	(7000)	(7000)	(7000)	(7000)
Cash Flow After Depreciation & Before Tax	9500	13570	19620	14960	9100
(Tax Amount @40%)	(3800)	(5428)	(7848)	(5984)	(3640)
Cash Flow After Tax	5700	8142	11772	8976	5460
+ Add Back Depreciation	+7000	+7000	+7000	+7000	+7000
Net Nominal Cash Flow	**12700**	**15142**	**18772**	**15976**	**12460**

We now evaluate the project using Net Present Value (NPV):

$$\mathbf{PV} = [12700(1.05)^{-1}] + [15142(1.05)^{-2}] + [18{,}772(1.05)^{-3}] + [15{,}976(1.05)^{-4}] + [12460(1.05)^{-5}] + [7135(1.05)^{-5}]$$
$$= 12095.24 + 13739.23 + 16216.19 + 13144.16 + 9762.37 + 5592.70$$
$$\mathbf{PV} \approx \mathbf{70550}$$
$$\mathbf{NPV} = 70550 - 40000 = \mathbf{30550}$$

We find that the Net Present Value is positive, therefore the project is economically acceptable.

3- Case of Investment Replacement Timing:

A company needs to replace some machines it deems obsolete due to technological advancements. The decision is made by comparing the present value of the old machine for each year with the Net Present Value (NPV) of the new machines for all years. If the former is less than or equal to the latter, replacement should be decided.

- **Applied Example:** We have an old machine that is operational and generates a net cash flow after taxes and before depreciation each year as follows: 9000, 7500, 3000, after which it becomes permanently inoperable. Meanwhile, a new machine costs 25000 to purchase and produces a net cash flow estimated at 12000 each year for 3 years.
- **Required:** When should the old machine be replaced with the new one, given a discount rate of 10%?
- **Solution:**

Calculate NPV for the new machine as follows:

$$\mathbf{PV} = [12000(1.1)^{-1}] + [12000(1.1)^{-2}] + [12000(1.1)^{-3}]$$

$$= 10909.09 + 9917.36 + 9015.78$$

$$\mathbf{PV} = \mathbf{29842.23}$$

$$\mathbf{NPV} = 29842.23 - 25000 = \mathbf{4842.23}$$

Now calculate the Present Values for the old machine:

$$\mathbf{PV1} = 9000(1.1)^{-1} = \mathbf{8181.81}$$

$$\mathbf{PV2} = 7500(1.1)^{-2} = \mathbf{6198.35}$$

$$\mathbf{PV3} = 3000(1.1)^{-3} = \mathbf{2253.94}$$

The old machine should be replaced with the new one at the beginning of **Year 3** because its third-year present value (2253.94) is less than the NPV of the new machine (4842.23).

4- Case of Decision to Start Project Implementation in Case of Project Growth:

For example, some projects may have a negative Net Present Value initially; this does not mean they won't be viable in the future, such as agricultural and livestock projects. There are two solution methods

4-1- Present Value Method: Calculate the present value of the project's future net cash flows for each year, then choose the year in which the project begins to achieve the highest present value (PV).

4-2- Growth Rate (GR) Method:

Calculate the growth rates of the Net Present Value each year using the following formula:

Growth Rate = (Subsequent Cash Flow Value - Previous Cash Flow Value) / Previous Cash Flow Value

Then compare these rates to the desired discount rate and choose the year where the growth rate becomes equal to or less than the desired discount rate.

- **Applied Example:** We have information about an investment project: initial investment cost is 160, and it produces net cash flows each year respectively: 200, 230, 256, 274, 290, 296. The desired discount rate is 10%.
  - **Required:** In which year is it best to start exploiting this project?
  - **Solution:**

We will use the Growth Rate method as follows:

$$GR1 = \frac{200 - 160}{160} \times 100 = 25\%$$

$$GR2 = \frac{230 - 200}{200} \times 100 = 15\%$$

$$GR3 = \frac{256 - 230}{230} \times 100 = 11.3\%$$

$$GR4 = \frac{274 - 256}{256} \times 100 = 7.03\%$$

$$GR5 = \frac{290 - 274}{274} \times 100 = 5.83\%$$

$$GR6 = \frac{296 - 290}{290} \times 100 = 2.06\%$$

Here, we choose **Year 4** because the growth rate (7.03%) becomes less than the desired discount rate (10%). Therefore, we conclude that Year 4 is the best year to start exploiting this project.

5- Case of Unequal Project Productive Lives:

In the case of unequal project productive lives, it is necessary to find the Least Common Multiple (LCM) of their lives. For projects with shorter lives, we extend their lives by replicating their cash flow patterns until the LCM is reached.

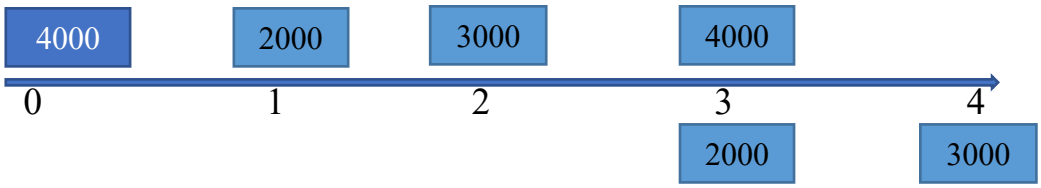
- **Applied Example:** You have the following table:

Information	Project A	Project B
I0	4000	4000
Net Annual Flows:		
Year 1	2000	3000
Year 2	3000	2000
Year 3	-	1500
Year 4	-	1000

- **Required:** Which project is better using the Net Present Value criterion, given a discount rate of 10%?

- **Solution:**

First, the Least Common Multiple must be found, which in this case is 4. Therefore, Project A's cash flow becomes as follows:



Calculation of the NPV for Project A is as follows:

$$\textbf{V.A} = 2000(1+0.1)^{-1} + 3000(1+0.1)^{-2} + 2000(1+0.1)^{-3} + 3000(1+0.1)^{-4}$$

$$= \textbf{7849.18}$$

$$\textbf{I0} = 4000 + 4000(1+0.1)^{-2} = 7305.78$$

$$\textbf{NPV.A} = 7849.18 - 7305.78 = 543.4$$

Calculation of the NPV for Project B is as follows:

$$\textbf{V.B} = 3000(1+0.1)^{-1} + 2000(1+0.1)^{-2} + 1500(1+0.1)^{-3} + 1000(1+0.1)^{-4}$$

$$\textbf{V.B} = \textbf{6190.18}$$

$$\textbf{NPV.B} = 6190.18 - 4000 = 2190.18$$

– **Project Evaluation:** Both projects achieved a positive net present value. If the project types are independent, then both are economically acceptable.

However, if the projects are mutually exclusive, then we accept Project B and reject Project A because we choose the project with the highest positive net present value.

Fourth: Solved Exercises on Project Evaluation under Certainty Conditions

1- Exercise One :

If you have the following information on three projects according to the table below :

Information	Project A	Project B	Project C
Initial Investment Cost	60000	60000	60000
Productive Life (Years)	4	4	4
Salvage Value	15000	10000	14000
Additional Capital	5000	6000	9000
Annual Cash Flow before Depreciation and Tax	25000	15000	20000

If you know that the company uses the straight-line method for calculating annual depreciation, and the income tax is estimated at 20% of the annual flow.

- **Required :** Determine which project is economically acceptable using the payback period criterion.

- Solution :

Information	Project A	Project B	Project C
Total Investment Cost	60000+5000=65000	60000+6000=66000	60000+9000=69000
Depreciation	$\frac{65000-15000}{4}=12500$	$\frac{66000-10000}{4}=14000$	$\frac{69000-14000}{4}=13750$
Cash Flow (Depreciation)	25000 (12500)	15000 (14000)	20000 (13750)
Annual Taxable Cash Flow Tax (20%)	12500 (12500 × 0.2 = 2500)	1000 (1000 × 0.2 = 200)	6250 (6250 × 0.2 = 1250)
Cash Flow after Tax + Depreciation	1000 12500	800 14000	5000 13750

Net Cash Flow (CFN)	13500	14800	18750
Payback Period $= \frac{I_0}{cFn}$	**65000 / 13500 ≈ 4.81**	**66000 / 14800 ≈ 4.46**	**69000 / 18750 = 3.68**

The economically acceptable project is Project C because it achieved the shortest payback period of 3 years and 8 months.

2- Exercise Two:

The head of studies at a production company, as part of efforts to increase the company's production capacity, reached two types of equipment, resulting in the following table:

Years / Elements	German Equipment			English Equipment		
	0	**1**	**2**	**0**	**1**	**2**
Raw Materials	...	2000	2500	...	1700	1900
Maintenance	...	4000	2000	...	1000	3600
Wages	...	900	900	...	1000	900
Acquisition Cost	16000	...	...	16000	...	...
Revenues	...	9000	6000	...	8800	7600
Depreciation	...	2000	2000	...	1000	1000

- **Required:** Which is the better project using the net present value criterion, knowing the discount rate is 11% and the tax rate is 20%?

- **Solution:**

✓ **First: German Equipment**

We have : $I_0 = 16000$

Now we find the salvage value (VR) from the relation:

$$\mathbf{AM} = \frac{I0 - VR}{n}$$

Thus: **VR** = I_0 - (AM × n)

VR = 16000 - (2000 × 2)

VR = 12000

Now we find the Net Cash Flows (CFN):

- **Year 1:**

CF1 = 9000 - (2000 + 4000 + 900)

CF1= 2100

CFN1 = (2100 - 2000) - (100 × 0.2) + 2000

CFN1= 2080

- **Year 2:**

$$\mathbf{CF2} = 6000 - (2500 + 2000 + 900)$$

$$\mathbf{CF2 = 600}$$

Since CF2 is less than the depreciation value, in this case it is the same as CFN2, meaning:

$$\mathbf{CFN2 = 600}$$

Now we calculate NPV_1 :

$$NPV_1 = [CFN1(1+i)^{-1} + CFN2(1+i)^{-2}] - I_0$$

$$NPV_1 = [2080(1+0.11)^{-1} + 600(1+0.11)^{-2}] - 16000$$

$$\mathbf{NPV_1 = -13639.16}$$

✓ **Second: English Equipment**

We have: $I_0 = 16000$

Now we find the salvage value (VR) from the relation:

Thus:

$$\mathbf{AM} = \frac{I0 - VR}{n}$$

$$\mathbf{VR} = 16000 - (1000 \times 2)$$

$$\mathbf{VR = 14000}$$

Now we find the Net Cash Flows (CFN):

- **Year 1:**

$$CF1 = 8800 - (1700 + 1000 + 1000)$$

$$\mathbf{CF1 = 5100}$$

$$CFN1 = (5100 - 1000) - (4100 \times 0.2) + 1000$$

$$\mathbf{CFN1= 4280}$$

- **Year 2:**

$$CF2 = 7600 - (1900 + 3600 + 900)$$

$$\mathbf{CF2 = 1200}$$

$$CFN2 = (1200 - 1000) - (200 \times 0.2) + 1000$$

$$\mathbf{CFN2 = 1160}$$

Now we calculate NPV_2

$$NPV_2 = [CFN1(1+i)^{-1} + CFN2(1+i)^{-2}] - I_0$$

$$NPV_2 = [4280(1+0.11)^{-1} + 1160(1+0.11)^{-2}] - 16000$$

$$\mathbf{NPV_2 = -11203.15}$$

Both projects are economically rejected because they achieved a negative net present value.

3- Exercise Three:

If you have the following information on two projects (A-B):

Information	Project (A)	Project (B)
Initial Investment Cost	3000	3000
Productive Life (Years)	3	3
Annual Net Cash Flows:		
Year 1	1500	1000
Year 2	2000	3000
Year 3	1000	2000

- **Required:** Determine which alternative is better? Using the Internal Rate of Return (IRR) criterion, knowing that discount rates of 10% and 15% were used for Project A, and 8% and 10% for Project B, and that the prevailing market interest rate is 12%.

- **Solution:**

✓ **For Project A**

Information	Project A at 10%		Project A at 15%	
	CFN	VA	CFN	VA
Year 1	1500	1363.63	1500	1304.34
Year 2	2000	1652.89	2000	1512.27
Year 3	1000	751.31	1000	657.51
$\sum_{k=1}^{3}$ **VA**	3767.83		3474.12	
NPV	767.83		474.12	

- Calculate IRR :

$$\mathbf{IRR} = I_1 + \frac{(I_2 - I_1) \times NPV_2}{|NPV_1| + |NPV_2|}$$

$$\mathbf{IRR} = 10 + \frac{(15 - 10) \times 767.83}{|767.83| + |474.12|}$$

$$\mathbf{IRR} = 13.09\%$$

✓ **For Project B**

Information	Project B at 8%		Project B at 10%	
	CFN	VA	CFN	VA
Year 1	1000	925.92	1000	909.09
Year 2	3000	2572.01	3000	2479.33
Year 3	2000	1587.66	2000	1502.62
$\sum_{k=1}^{3} \mathbf{VA}$	5085.59		4891.04	
NPV	2085.59		1891.04	

- Calculate IRR :

$$\mathbf{IRR} = I_1 + \frac{(I_2 - I_1) \times NPV_2}{|NPV_1| + |NPV_2|}$$

$$\mathbf{IRR} = 8 + \frac{(10 - 8) \times 2085.59}{|2085.59| + |1891.04|}$$

$$\mathbf{IRR} = 9.04\%$$

We note that Project A is economically acceptable because its IRR is greater than 12% (the prevailing market interest rate).

Whereas Project B is economically rejected because its IRR is less than 12%(the prevailing market interest rate).

4- Exercise Four:

An investor wants to choose one of two projects A and B where the residual value is zero. Knowing that the discount rate is 4%, and the annual cash flows at their present values were as follows:

Years	0	1	2	3	4	5	6
Projct A	30000	19259.25	25720.16	11907.48	0	0	0
Project B	30000	9629.62	12860.08	0	-	-	-

– **Required:** What is the better project, using the net present value criterion if the discount rate is 8%?

– **Solution:**

✓ **For Project A:**

- Calculate CFN1:

$$CFN1 = VA1(1+i)^1$$

$$CFN1 = 19259.25(1+0.04)^1$$

CFN1= 20029.62

$$CFN2 = VA2(1+i)^2$$

$$CFN2 = 25720.16(1+0.04)^2$$

CFN2= 27818.92

$$CFN3 = VA3(1+i)^3$$

$$CFN3 = 11907.48(1+0.04)^3$$

CFN3= 13394.29

- Now we calculate NPV at an 8% discount rate:

Find VA:

$$VA1 = CFN1 \times (1+i)^{-1} = 20029.62(1+0.08)^{-1}$$

VA1= 18545.94

$$VA2 = CFN2 \times (1+i)^{-2} = 27818.92(1+0.08)^{-2}$$

VA2 = 23850.24

$$VA3 = CFN3 \times (1+i)^{-3} = 13394.29(1+0.08)^{-3}$$

VA3= 10632.81

VA4 = 0

VA5 = 0

VA6 = 0

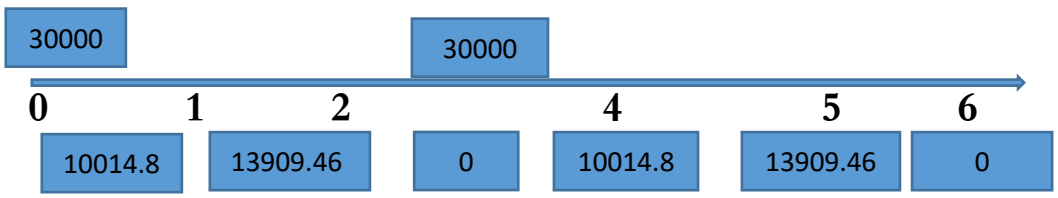
Calculation of NPV for Project A is as follows

NPV = (18545.94 + 23850.24 + 10632.81) - 30000

NPV = 23028.99

✓ **For Project B:**

First, the Least Common Multiple must be found, which in this case is 6. Therefore, Project B's cash flow becomes as follows:



Calculate CFN:

$CFN1 = VA1(1+i)^1 = 9629.62(1+0.04)^1$

CFN1= 10014.80

$CFN2 = VA2(1+i)^2 = 12860.08(1+0.04)^2$

CFN2 = 13909.46

$CFN3 = VA3(1+i)^3 = 0(1+0.04)^3$

CFN3 = 0

CFN4 = 10014.80

CFN5 = 13909.46

CFN6 = 0

- Now we calculate NPV at an 8% discount rate:

Find VA:

VA1 = CFN1 × (1+i)^(-1) = 10014.80 × (1+0.08)^(-1)

VA1 = 9272.96

VA2 = CFN2 × (1+i)^(-2) = 13909.46 × (1+0.08)^(-2)

VA2= 11925.12

VA3 = CFN3 × (1+i)^(-3)

VA3= 0

VA4 = CFN4 × (1+i)^(-4) = 10014.80 × (1+0.08)^(-4)

VA4 = 7361.17

VA5 = CFN5 × (1+i)^(-5) = 13909.46 × (1+0.08)^(-5)

VA5= 9466.54

VA6 = CFN6 × (1+i)^(-6)

VA6 = 0

Calculation of NPV for Project B is as follows:

VA = 9272.96 + 11925.12 + 0 + 7361.17 + 9466.54 + 0

VA = 38025.79

I0 = 30000 + 30000(1+0.08)^(-3) = 53814.96

NPVB = 38025.79 - 53814.96

NPVB = -15789.17

Project A is economically acceptable, while Project B is economically rejected.

Axis Three:
Criteria for Evaluating Projects Under Uncertainty

Introduction:

Investing significant sums, whose returns materialize over an extended period in an environment of risk and uncertainty, requires a meticulous methodology based on precise analytical tools. This methodology aims to enhance the quality of investment decisions and mitigate the severity of risks associated with uncertainty. In this context, a variety of analytical tools are used to evaluate projects and prioritize them in uncertain environments. These tools vary in their precision (ranging from simple to complex techniques) and nature (differing between theoretical models and practical applications). Among these techniques are the following:

1- Decision Tree Approach:

A decision tree is an analytical tool used to visually represent the decision-making process, facilitating the identification of stages and available choices. This method is used particularly for addressing complex or multi-stage problems, as it allows for a systematic analysis of alternatives and the potential consequences of each option. Unlike decision matrices, which are only suitable for simple problems, decision trees are capable of handling both simple and complex issues, making them a comprehensive tool for improving the quality of decisions made.[11]

The decision tree methodology is a fundamental analytical tool for addressing composite, sequential decisions that occur across multiple time stages. This quantitative technique represents an analytical approach integrated with the evaluative theories of investment projects. The nomenclature derives from the structural framework of decisions, which takes the form of a central, pivotal main decision and branching sub-decisions that together form a structure resembling a tree and its branches. This methodology relies on precise numerical data (calculations, revenues), probabilistic estimates, as well as an analysis of the interrelationships between main and sub-decisions. From an application perspective, the decision is represented by a graphical quantitative model that illustrates the potential outcomes of the problem's constituent elements and the interactive relationships between them, within the context of evaluating and selecting projects under conditions of risk and uncertainty.

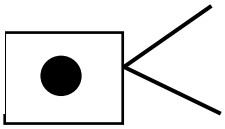
The basic elements of a decision problem are expressed through nodes, which are of two types:

[11] Ahmed al-Tarawneh, Suleiman Obeidat, **Introduction to operations research**, Dar Al-Masirah publishing and distribution, Amman, Jordan, 2009, p.39.

a- Alternatives:

Also referred to as strategies, these constitute the totality of means available to confront challenges that appear in practical reality in the form of different states of nature. Alternatives are represented by the following symbol:

Decision point
"a station or location for making"

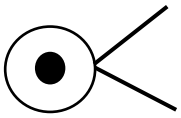


b- Available States of Nature:

Refers to the potential financial outcomes that the decision-maker seeks to achieve, represented by specific numerical values. These values may materialize as expected revenues, potential investment returns, estimated costs, or potential losses resulting from the adoption of specific decision alternatives and particular operational strategies.

The states of nature are represented by the following symbol:

Probability



The decision tree method is characterized by its ability to clarify choices, risks, monetary gains, objectives, and the information required by management that is involved in the investment problem.

Decision tree analysis involves two main stages:

- **Calculating the expected value (return or cost) for each alternative:**

This is done by multiplying the values associated with each alternative by the probabilities of the potential scenarios occurring, then summing the products to determine the expected value, which is recorded at the connection points in the tree.

- **Comparing expected values and making a decision:**

The calculated results are compared to select the optimal alternative (the one with the highest return or lowest cost), and the chosen value is then fixed at the decision point.

c. In the case of multiple decision points:

For large and complex problems on a decision tree, it is necessary to apply the previous steps and then make appropriate decisions regarding them. This means that the decision tree can serve as a tool to help eliminate poor alternatives, retain good ones, compare them, and select the best.

The following illustrates how to use decision trees in making decisions and comparing alternatives through the following examples:

- **Practical example:** If you have the following decision matrix, which represents the returns realized from investing in three areas (bonds, stocks, deposits) under three states of nature (three different economic conditions). The matrix includes the following information:

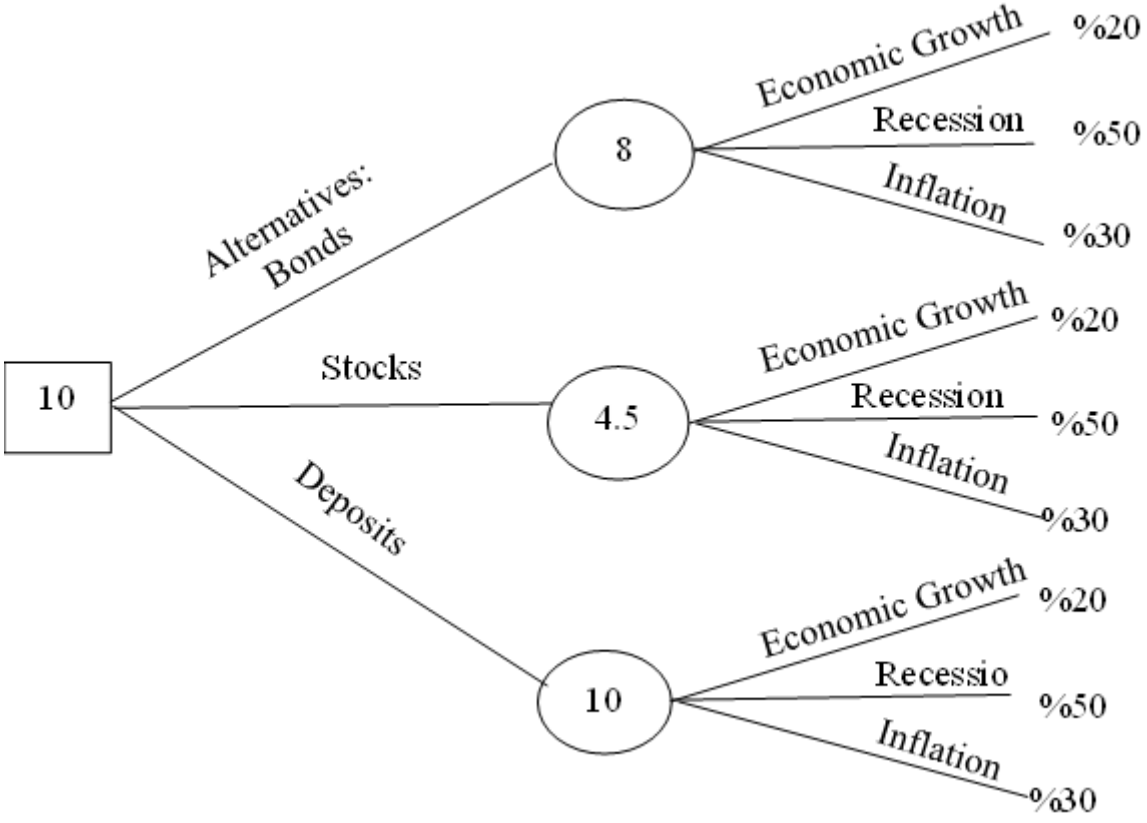
- **Decision Matrix**

Probabilities	**20%**	**50%**	**30%**
Natural states / Alternatives	**Economic Growth**	**Economic Recession**	**Inflation**
Bonds	14	8	4
Stocks	16	5	-4
Deposits	10	10	10

- **Required:** Determine the best alternative or investment opportunity using the decision tree method.

To answer, the following steps must be followed:

1. Draw the decision tree: Based on the given information, as follows:



2. The given information is represented on the decision tree.
3. The information provided in the decision matrix is analyzed, and the expected values for each alternative and the three probabilities are calculated as follows:
   - Expected value for Bonds return:(14 × 0.20)+(8 × 0.50)+(4×0.30)= 8
   - Expected value for Stocks return:(16×0.20)+(5×0.50)+((-4)×0.30)= 4.5
   - Expected value for Deposits return:(10×0.20)+(10×0.50)+(10×0.30) =10
4. The expected values for each alternative are recorded at the connection points on the decision tree.
5. The results recorded at the connection points are compared to determine the optimal investment choice. The alternative with the greatest return (highest recorded value) is selected in the case of a return matrix, and this choice is then indicated at the decision point on the tree.

This means the best alternative among the available investment opportunities is investing in Deposits, as it achieves the highest return compared to the other alternatives.

2- Sensitivity Analysis Method:

Sensitivity analysis refers to assessing the degree to which a proposed project is affected by potential changes in the key variables influencing its evaluation.

This analysis aims to measure the sensitivity of feasibility indicators (such as Net Present Value) to changes in various factors.[12]

Through this analysis, the decision-maker can determine :

- The extent to which expected returns are affected when any of the fundamental variables change ;
- The degree of the project's flexibility in the face of uncertainty ;
- The most stable projects in the face of fluctuations.

When conducting sensitivity analysis, the following points must be considered:[13]

- **Identifying critical variables:** Selecting the main factors that directly affect the project's evaluation criteria ;

[12] Ramash Hajer, **Publication entitled: Project Evaluation**, Constantine University 2, Abdul Hamid Mehri, 2017-2018, P.44.

[13] Ihab Mokabalah, **feasibility study and project evaluation**, Center of Excellence for non-governmental organizations, 2003, p. 22.

- **Modeling mathematical relationships:** Defining the formulas and quantitative relationships linking these variables to the evaluation criteria ;
- **Defining ranges of change:** Estimating the potential values of the variables, focusing on the most optimistic values and the most pessimistic values ;
- **Evaluation under uncertainty:** Calculating feasibility indicators (such as NPV) under different scenarios to measure the project's flexibility.

2-1- Methods of Using Sensitivity Analysis in Evaluating Investment Projects:

2-1-1- Percentage Method:

This method is one of the most commonly used sensitivity analysis techniques in practical applications due to its simplicity. It focuses on assessing the impact of changes in specified input variables on output values by measuring the effect of a specific change (either an increase or decrease) in input values on the model's results.

For example, the net cash flows of an investment project are calculated based on forecasts of revenue volume, product prices, operating costs, expected productive life, and capital investments. The role of traditional sensitivity analysis is highlighted in assessing the impacts resulting from a 10% increase in capital costs above the expected level, or a 5% decrease in incoming cash flows below planned values. Through this analysis, the variables that most affect the target rate of return can be identified in case of deviations from initial estimates.

2-1-2- Sensitivity Index:

The sensitivity index is an important tool for the investment decision-maker, as it helps determine the extent to which changes in fundamental variables (such as costs or revenues) affect financial evaluation criteria, like profitability or return on investment. This index is used particularly when there are simultaneous changes in several influencing factors, providing a clear view of the elements most sensitive and impactful on the project's performance.[14]

[14] Shaqiri Nuri Musa, Osama Azmi Salam**, Economic feasibility study and evaluation of investment projects** ،Dar Al-Maysara, Amman, Jordan, 2009, p.182.

A sensitivity index is prepared for each element of the investment project's operating economics. The index expresses the changes in the Internal Rate of Return (IRR) relative to changes in each element, as follows:

$$\textbf{Sensitivity Index} = \frac{\Delta(\text{IRR}) \times \text{initial value}}{(\text{final value} - \text{initial value})100}$$

$$\textbf{SI} = \frac{\Delta(\text{IRR}) \times L_0}{(L_1 - L_0)100}$$

- **Δ(IRR):** The absolute change in the Internal Rate of Return;
- **L_0:** The initial value of the element under analysis;
- **L_1:** The final value of the element under analysis.

The higher the sensitivity index, the greater the sensitivity of the Internal Rate of Return to changes in the element under analysis.

2-1-3- Sensitivity Coefficient:

Referred to by an absolute number denoted as theta (θ), where the sensitivity coefficients of the model's input elements are compared on a standard basis to determine how they affect the dependent variable (Internal Rate of Return).

Theta coefficients are calculated using the following formula:

$$\boldsymbol{\theta} = \frac{\Delta m}{m} \times \frac{L}{\Delta L}$$

Where:

- **m:** Dependent variable;
- **L:** Independent variable;
- **Δ:** Magnitude of change in a variable;
- **Δm / m:** Relative change in the output-related variable;
- **L /ΔL:** Relative change in the input-related variable.

Generally, sensitivity elements are identified through several rules:

- **If θ = 1:** This means that a specific percentage change in the independent variable results in an equal percentage change in the dependent variable ;
- **If θ > 1:** This means the dependent variable is sensitive to changes in the independent variable; a given change in input data results in a proportionally larger change in the output ;
- **If 0 < θ < 1:** This means the dependent variable is relatively insensitive to changes in the independent variable; a given rate of change in the

independent variable results in a lower rate of change in the dependent variable ;

– **If θ = 0:** This means the dependent variable is absolutely insensitive to changes in the independent variable; a specific change in the value of the independent variable results in no change in the value of the dependent variable.

- **Practical Example:**

Assume a specific project is being studied for its economic feasibility. Its initial investment cost under certainty conditions was estimated at 100000 dinars, with half spent in Year 0 and the other half at the end of Year 1. The present value of cash flows under the same conditions reached 200000 dinars, based on a discount rate of 7%, resulting in a Net Present Value (NPV) of 100000 dinars.

Also assume that, due to uncertainty regarding machinery needs and their prices, the initial investments were estimated at 80000 dinars and 150000 dinars for optimistic and pessimistic conditions, respectively.

- **Required:** Test the sensitivity of the project's Net Present Value under conditions of uncertainty?

- **Solution:** To answer, the following must be considered:
  - ✓ The value of initial investments under uncertainty can be considered as 80000 dinars (optimistic estimate) and 150000 dinars (pessimistic estimate) ;
  - ✓ Calculate the NPV for the initial investments under the optimistic estimate first.

which can be done through the following table:

Year	Investment Value	Discount Factor 7%	Present Value
0	80000/2 = 40000	1	40000
1	40000	1/(1.07) ≈ 0.9346	40000 / 1.07 ≈ 37383
Total PV of Initial Investments			**77383**

Therefore, the project's NPV under the optimistic estimate for initial investments equals the difference between the present value of cash flows and the present value of investments:

200000 - 77383 = **122617 dinars**

✓ **Calculate the project's NPV under the pessimistic estimate for the initial investment value** according to the following table:

Year	Investment Value	Discount Factor 7%	Present Value
0	150000/2 = 75000	1	75000
1	75000	1/(1.07) ≈ 0.9346	75000 / 1.07 ≈ 70093
Total PV of Initial Investments			**145093**

Therefore, the project's NPV under the pessimistic estimate for initial investments equals the difference between the present value of cash flows and the present value of initial investments:

200000 - 145,093 = **54,907 dinars**

On this basis, we find that the Net Present Value of this project is sensitive to changes in the value of initial investments, and this sensitivity ranges between 122617 dinars under the optimistic estimate and 54907 dinars under the pessimistic estimate.

Nevertheless, the Net Present Value remains positive under the worst potential conditions regarding initial investments. However, it must be taken into account that this project faces a high degree of risk.

3- Break-Even Point Method:

Focuses on studying the relationship between revenues, costs, and profits at different levels of production or sales. The break-even point expresses the minimum production or sales the project must achieve to ensure its financial survival without making profits or losses. This point can be expressed as the number of units produced (if the project produces a single good), as a percentage of production capacity, or as a sales value.

The lower the break-even point, the greater the project's chances of making profits and the lower the probability of losses. The difference between total production capacity and the break-even point forms the margin of safety, which provides flexibility for the project. It is advisable to use data from a normal operating year when calculating the break-even point to ensure the accuracy of the results.[15]

[15] Medhat Al-Quraishi, **Feasibility studies and evaluation of economic projects**, Wael publishing and distribution house, Oman, Jordan, 2009, pp 176-177.

3-1- Assumptions of Break-Even Analysis:

The break-even analysis method relies on the following assumptions:[16]

- Linearity of variable costs: Variable costs remain directly proportional to the volume of production within a specified range (a relevant range of production quantities) ;
- Stability of fixed cost elements within the specified production levels ;
- Stability of the variable cost per unit and stability of operating costs regardless of production levels or the time factor;
- Ability to accurately determine production levels and measure outputs quantitatively;
- Focus on a single product, with the necessity of maintaining constant production ratios in the case of multiple products;
- Assumption of a linear relationship between production capacity on one hand, and costs, prices, and profit margins on the other;
- Homogeneity of revenues at the per-unit level.

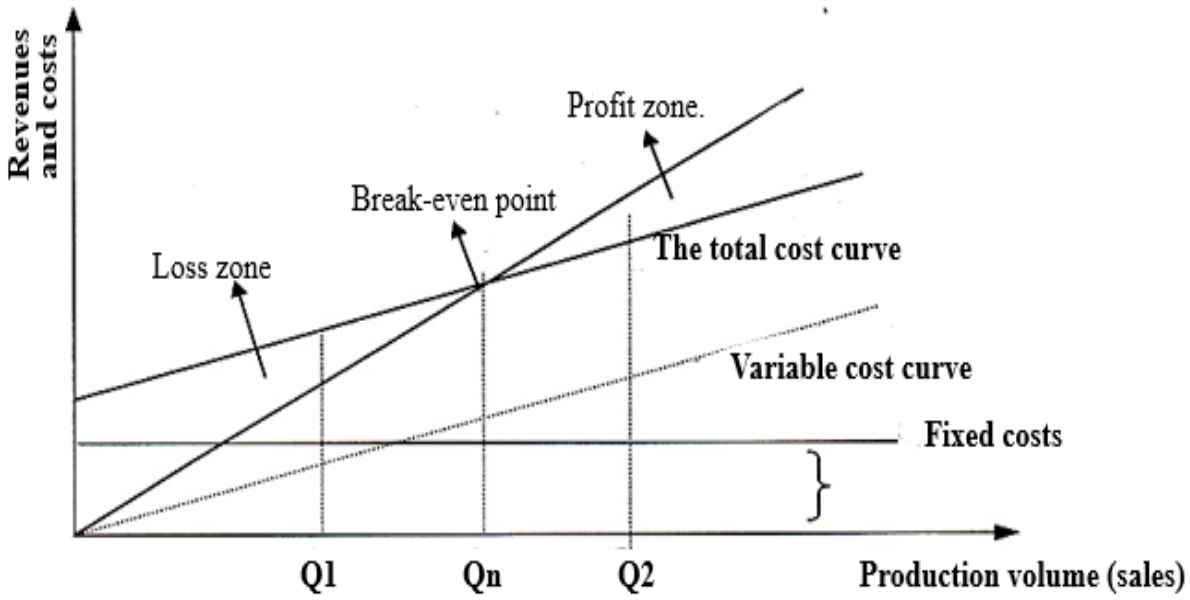
3-2- Graphical Method for Break-Even Analysis:

The break-even point is determined by representing revenues and costs on the vertical axis, and the volume of production or sales on the horizontal axis. Three main curves are drawn:

- Total Revenue curve: Where each point represents the expected revenue at different production levels ;
- Total Cost curve: Reflects the total costs (fixed and variable) at each production level ;
- Fixed and Variable Cost curves: Shows the distribution of costs between fixed and variable across different production levels.

The break-even point is located at the intersection of the Total Revenue curve and the Total Cost curve, where revenues equal costs :

[16] Hakim bojto, Mohamed Malouh, **Using the method of tie analysis to choose the location of industrial enterprises-an applied study of the Cordoba institution for carpentry and technical furniture-,** Journal of economic, management and Business Sciences, Volume 12, Issue 2, 2019, P. 469.



Source: Naim Nimar Dawood, **Economic Feasibility Study**, Dar Al-Bidaya, Amman, 2011, p. 181

3-3- Algebraic Method for Break-Even Analysis:

In this area, we can use three algebraic equations for break-even analysis as follows:

- **Break-Even Analysis by Quantity:**

Break-Even Point (in units sold) =Fixed Costs / (Selling Price per Unit Variable Cost per Unit)

- **Break-Even Analysis by Value:**

Break-Even Point (in sales value) = Fixed Costs / (1 - (Variable Cost per Unit ÷ Selling Price per Unit))

- **Break-Even Analysis as a Percentage of Maximum Production Capacity:**

Project's Production Capacity Utilization Rate = Total Costs / (Total Revenues - Variable Costs) × 100

The final equation determines the production capacity utilization rate for the project under analysis and defines what is known as the Margin of Safety - the range between the actual production level and the break-even point.

Logically, a wider range reduces the degree of risk associated with the project :

- ✓ If the production volume required by the study is less than the break-even volume, this means we are in the loss zone, and therefore theproject should be rejected ;
- ✓ If the opposite is true, this means we are in the profit zone, and therefore the project should be accepted.

- **Practical Example:** The following data is extracted from the records of an establishment: Selling price per unit is 25 dinars, variable cost per unit equals 15 dinars, total fixed costs are 100000 dinars, and the production capacity is estimated at 20000 units.

– **Required:**

- ✓ Find the break-even quantity.
- ✓ Find the break-even quantity as a ratio of production capacity.
- ✓ Find the break-even value.

– **Solution:**

- ✓ **Calculate the break-even quantity?**

We have :

Break-Even Quantity = Fixed Costs / (Selling Price per Unit Variable Cost per Unit)

Break-Even Quantity = 100000 / (25 - 15)

Break-Even Quantity = 10000 units

This means the project reaches its break-even point when its production capacity reaches 10000 units. At this production level, it makes neither profit nor loss.

- ✓ **Calculate the break-even quantity as a ratio of production capacity?**

Break-Even Quantity as a ratio of production capacity = (Break-Even Quantity / Production Capacity) × 100

Break-Even Quantity as a ratio of production capacity= (10000 / 20000)× 100

Break-Even Quantity as a ratio of production capacity = 50%

This means the project's break-even point, as a percentage of production capacity, is achieved when the project operates at 50% of its total production capacity. At this utilization level, it makes neither profit nor loss.

✓ **Calculate the break-even value**

Break-Even Value = 100000 / (1 - (15 / 25))

Break-Even Value = 250000 dinars

This means the project reaches its monetary break-even point when it produces output worth 250000 dinars. At this level of production value, it makes neither profit nor loss.

The monetary break-even value as a ratio of the project's total capacity

= 250000 / (20000 × 25) = **50%**

This means the project breaks even when it operates at half of its production capacity.

Axis Four:
Criteria for Evaluating Projects Under Risk

Introduction:

We previously discussed evaluation methodologies in environments of certainty and uncertainty, omitting the factor of risk, which fundamentally affects the financial flows of investment projects. These flows are susceptible to fluctuations due to changing economic conditions, necessitating the consideration of these variables, as they may lead to variations in financial estimates.

Although evaluation under conditions of certainty represents an ideal theoretical model, it lacks realism in practical application, potentially producing inaccurate or questionable results. Therefore, it has becomeessential to integrate the element of risk into the project evaluation process, which requires the availability of accurate statistical and economic data for each potential economic scenario, in addition to determining the probabilities of each of these future states occurring.

This reality calls for the application of specialized statistical methodologies. In this section, we will review the different criteria for evaluation in environments involving varying degrees of risk.

1- Definition of Risk:

Risk is a measure of the probability of not achieving the objectives of the investment project as planned beforehand, and the consequent repercussions. Risk arises from environmental uncertainty, where risk consists of the inability to know future events accurately. Risk involves two main elements: the first is the probability of its occurrence, and the second is its impact on outcomes. Factors that cause a difference between the actual return and the expected return are also considered sources of risk.[17]

2- Stages of Evaluating Investment Project Risk:

Risk management in investment projects refers to the structured methodology that includes the necessary procedures and mechanisms for identifying, studying, addressing, and documenting potential hazards. This process is divided into four sequential stages: risk initiation and preparation, risk analysis and assessment, implementation of remedial solutions, and finally, risk monitoring and control.

[17] Bindawdiya Wahiba, **Publication entitled: Project Evaluation**, Introduction to third-year students Specialization of financial management, Hassiba bin Buali University-Al-shalaf-, 2019-2020, P 131.

3- Methods for Evaluating Projects Under Risk:

3-1 Expected Value of Net Present Value (NPV):

In risk-laden work environments, the Net Present Value is not a fixed and specific number; rather, its value varies depending on changing conditions associated with specific probabilities for each potential scenario.

The expected value of the Net Present Value of cash flows can be expressed by the following relationship:

$$\mathbf{E(NPV)} = \sum_{J=1}^{n} NPV_J P_J$$

Where:

- **NPVj:** The Net Present Value of cash flows under each circumstance;
- **E(NPV):** The Expected Value of the Net Present Value of cash flows.
- **n:** The number of possible probabilities;
- **Pj:** The probability of occurrence.

For evaluation and comparison based on this method, we find two cases:

- **Case One: A Single Project:**
  - If E(NPV) > 0, the project is acceptable;
  - If E(NPV) < 0, the project is rejected.
- **Case Two: Multiple Projects:**
  - If there is more than one project presented to the decision-maker, they choose the project with the highest expected value of net cash flows, E(NPV). The rate of the expected value of net cash flows can be calculated by dividing the expected value of net cash flows by the initial investment cost :

$$\mathbf{Rate\ of\ E(NPV)} = \frac{E(NPV)}{I}$$

Since the criterion of the expected value of net cash flows may lead to incorrect selection due to the non-objectivity of probability distributions of risk or their dispersion, and the differing probability ratios associated with different conditions, it is preferable to be guided by the standard deviation criterion, especially if the expected values of net cash flows are equal.

3-2 Standard Deviation:

The size of the standard deviation in a probability distribution indicates the level of risk, where a higher value reflects a higher degree of risk, and vice versa. To calculate this measure, the following steps are followed: calculate the differences between the expected value of net cash flows and their actual values under each potential scenario, then multiply the squares of these deviations by their probabilities of occurrence, and finally, extract the square root of the sum of these weighted values. The standard deviation can be found using the following equation:

$$\boldsymbol{\delta(NPV)} = \sqrt{\sum_{j=1}^{n} Pj\,[(NPVj) - E(NPV)]^2}$$

Where: **δ(NPV):** Standard Deviation.

The lower the value of this statistical measure, the lower the level of risk, which is a positive indicator. As mentioned earlier, this dispersion criterion is an essential tool for comparing investment opportunities, especially when their expected values of net financial flows are equal.

3-3 Coefficient of Variation (CV):

This criterion is based on the ratio of the standard deviation to the expected value, selecting the project that shows the smallest coefficient of variation (lowest risk). The coefficient of variation is calculated as follows:

$$\mathbf{CV} = \frac{\delta(NPV)}{E(NPV)}$$

The coefficient of variation is noted to be superior to the standard deviation in the case of differing expected values of net cash flows for the projects under evaluation and selection. This is because the latter (standard deviation) considers the absolute figure of the deviation in the expected value of net cash flows, while the former (coefficient of variation) represents a relative measure of risk relative to the expected value of net cash flows.

- **Applied Case:** A financial institution has the opportunity to invest an amount of 60000 dinars in one of two projects (A, B). The institution has managed to establish probabilistic estimates of the Net Present Value of expected cash flows as a percentage of the initial investment, and the expected probabilities of achieving these flows based on the general economic condition, as shown in the table:

Economic Condition	Probability of Occurrence (Pj)	NPV(A)	NPV(B)
Boom	30%	90%	20%
Normal Conditions	40%	15%	15%
Recession	30%	-60%	10%

- **Solution:**

We have:

$$\mathbf{E(NPV)} = \sum_{J=1}^{n} \mathrm{NPVj\ Pj}$$

- **E(NPV)_A** = (0.9 × 0.3) + (0.15 × 0.4) + (-0.6 × 0.3) = 0.15 = **15%**
- **E(NPV)_B** = (0.2 × 0.3) + (0.15 × 0.4) + (0.1 × 0.3) = 0.15 = **15%**

It is noted that the expected value of the Net Present Value for both projects is equal and amounts to 15% of the initial investment value. Therefore, we resort to calculating the standard deviation.

We have:

$$\boldsymbol{\delta} = \sqrt{\sum_{J=1}^{n} P_J[\mathrm{NPV} - \mathrm{E(NPV)}]^2}$$

- $\boldsymbol{\delta_A} = \sqrt{(0.9-0.15)^2 \times 0.3 + (0.15-0.15)^2 \times 0.4 + (-0.6-0.15)^2 \times 0.3}$

$$\boldsymbol{\delta_A} = 0.581 = \mathbf{58.1\%}$$

- $\boldsymbol{\delta_B} = \sqrt{(0.2-0.15)^2 \times 0.3 + (0.15-0.15)^2 \times 0.4 + (0.1-0.15)^2 \times 0.3}$

$$\boldsymbol{\delta_B} = 0.116 = \mathbf{11.6\%}$$

It is noted that $\boldsymbol{\delta_A} > \boldsymbol{\delta_B}$, meaning the risk of Project A is greater than the risk of Project B.

Calculate the Coefficient of Variation (CV) for projects (A, B):

$$\mathbf{CV} = \frac{\delta}{\mathrm{E(NPV)}}$$

$$\mathbf{CV_A} = \frac{\delta_A}{\mathrm{E(NPV)_A}} = \frac{0.581}{0.15} = 3.873 = \mathbf{387.3\%}$$

$$\mathbf{CV_B} = \frac{\delta_B}{\mathrm{E(NPV)_B}} = \frac{11.6}{0.15} = 0.773 = \mathbf{77.3\%}$$

From the above, we find that Project A has higher risk than Project B, even though the expected Net Present Value for both is equal. Therefore, we choose to finance or invest in Project B.

3-4- Using the Risk-Adjusted Discount Rate:

Using a discount rate that is relatively higher than the cost of obtaining funds serves as a way to confront risk conditions. The value of the risk-adjusted discount rate can be found using the following equation:

$$\mathbf{K = i + \lambda_1 + \lambda_2}$$

Where:

- **K:** Risk-adjusted discount rate;
- **i:** Risk-free rate of return;
- **λ_1:** Risk premium;
- **λ_2:** Adjustment for increase or decrease from normal risks.

It can be said that determining the increase in the discount rate according to the different types of risk is not an easy task. If the risk expected from the investment is equivalent to the type of risk prevailing in the type of activity the project undertakes, then the cost of capital represents the appropriate discount rate, meaning the sum of i and λ_1 is the weighted average cost of capital (WACC). However, if the proposed investment project is believed to be less or more risky than the prevailing risk level, then the discount rate must be adjusted, either increased or decreased from the cost of capital, by λ_2.

It is worth noting that the risk premium is related to the coefficient of variation (CV) and is directly proportional to it. This allows the use of different discount rates for each type of investment rather than different discount rates for each investment project. The Net Present Value can be determined using the risk-adjusted discount rate according to the following formula:

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

4- Exercises on Project Evaluation under Uncertainty and Risk Conditions

- **Exercise One:**

We have the net cash flows for projects A and B according to the following table:

Project	Net Present Value	Net Cash Flows		
		Boom	Stable	Recession
Project A	**NPV_A**	70000	60000	30000
Project B	**NPV_B**	45000	40000	25000
Probability		0.5	0.3	0.2

– **Required:** Which is the better project using a decision tree.

- **Exercise Two:**

Assume an establishment is studying two investment options, each requiring an amount of 2000 dinars, and both have a productive life of three years with no salvage value at the end of the term. Each option is expected to generate annual cash gains of 1000 dinars, assuming a discount rate of 10%.

But suppose the establishment is uncertain about the economic conditions that might prevail during the productive life of the options. In this case, the investment decision must be reassessed to determine if the options will retain the same degree of preference under the new conditions. To do this, the establishment must follow these steps:

Assume expected states of nature (economic conditions): To simplify the analysis, the focus will be on three main states: recession, stability, boom.

– **Required:** Calculate the expected cash gains for each of these states. The following table shows the estimated cash flows for each scenario:

Economic Condition	Alternative 1	Alternative 2
Recession	800	0
Stability	1000	1000
Boom	1200	2000

- **Exercise Three:**

Assume the initial investment for a project is 15000 MU, and the expected annual cash flows and their probabilities over the project's expected life of 3 years (knowing the discount rate is 10%) are as follows:

Year 1		Year 2		Year 3	
CF_1	P_I	CF_2	P_I	CF_3	P_I
4500	0.1	3000	0.1	1500	0.1
6000	0.25	4500	0.25	3000	0.25
7500	0.3	6000	0.3	4500	0.3
9000	0.25	7500	0.25	6000	0.25
10500	0.1	9000	0.1	7500	0.1

- **Required:** Can the project be accepted using the expected value of Net Present Value criterion?

- **Exercise Four:**

An institution intends to invest in a new project worth 250000 MU. Previous studies enabled the estimation of the cash flows resulting from its operation during its economic life, which were as follows:

Year 1		Year 2	
CF1	P1	CF2	P2
15000	0.45	17000	0.45
16500	0.45	15000	0.35
18000	0.1	12000	0.2

- **Required:** If the cash flows are independent of each other and the discount rate is 10%, calculate both E(NPV) and δ(NPV)? Would you advise the institution to invest in the project?

- **Exercise Five:**

If the present value of a set of cash flows for a project is 500 dinars, based on a selling price per unit of 50 dinars. Forecasts indicate a probability that the selling price per unit will increase to 70 dinars. When calculating the present value of cash flows at the new price, the present value was 750 dinars.

- **Required:** Find the sensitivity index.

- **Exercise Six:**

We want to make a decision to choose a project from between two projects:

- ✓ **Project One:** Cost 5000000, life 10 years, whereby:
  - If demand is high, it achieves a return of 1000000 ;
  - If demand is low, it achieves a return of 300000.

- ✓ **Project Two:** Cost 2000000, life 10 years, whereby:
  - In the first two years, it achieves a return of 250000 if demand is high ;
  - If demand is low, it achieves a return of 200000 ;
  - After two years, we want to undertake development; it continues to operate for 8 years after development. If we do this development, the development cost is 4200000 ;
  - After development, if demand is high, it achieves a return of 900000, and if demand is low, the return is 200000 ;
  - The probability of high demand is 75% and the probability of low demand is 25%.

- **Required:** Make the decision by drawing a decision tree.

Axis Five:
The Use of Operations Research in Evaluation

Introduction:

Operations Research involves the use of scientific methods, techniques, and tools to solve problems related to the operations of any project, with the aim of providing optimal solutions to the problems faced by those managing the project.[18]

First: The PERT/CPM Method

The functions of planning and controlling project execution are among the most important in managing projects across various enterprises. Planning is the fundamental first step in project management, and network diagrams (one of the effective planning techniques) are used for planning and monitoring project execution.

Before the emergence of the PERT/CPM technique, the process of planning and monitoring project execution used Gantt charts. However, with the evolution of projects, their increasing size, and the complexity of activities, this method became unsuitable for large and complex projects. Therefore, it became necessary to use more efficient methods, with the PERT/CPM method being considered the best.

1- Basic Stages of Building the Project Network:

The process of creating a project network involves four main stages, which can be presented as follows:

1-1 Identifying the Project's Basic Activities:

This stage is fundamental in planning, where the following is done:

- Breaking down the project into main and sub-activities ;
- Ensuring these activities are logically and sequentially interconnected ;
- Defining the start and end points for each activity.

1-2 Determining the Logical Sequence of Activities:

In this stage, the following is done:

- Analyzing the logical relationships between activities ;
- Determining the correct chronological order for execution ;
- Building the network structure from the project's start to its finish ;
- Ensuring the correct ordering of dependencies between tasks.

[18] Shafiq Al-Atoum, **Operations research**, First edition, Curriculum House ،Amman, Jordan, 2005, p 13.

1-3 Estimating Time and Required Resources:

This stage includes:

- Calculating the expected duration for each activity ;
- Identifying the necessary resources (human, material, financial) ;
- Studying the impact of these estimates on: the overall schedule, the total project cost ;
- Ensuring estimates are realistic according to available capabilities.

1-4 Drawing the Project Network

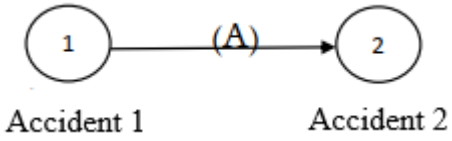
The project network is a graphical model that illustrates the logical relationships between the various activities of the project. It consists of the following elements:

- **Event:** Represented by a numbered circle, it indicates a start or end point of an activity and requires no time or resources ;
- **Activity:** Represented by an arrow between two events, it contains: a specific time duration, resources required for execution.
- **Types of Activities in the Network:**
  - **Real (Actual) Activities:** These require time for execution and need resources (human/financial/material). Consequently, they have an actual presence in project execution ;
  - **Dummy Activities:** These consume no time, require no resources, and their function is purely organizational to ensure: the logical sequence of activities, the correct order of events, avoiding overlap in relationships.

1-5 Rules for Preparing the Network

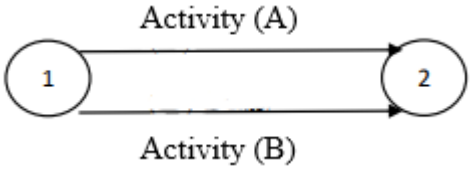
These are as follows:[19]

- The project network starts from a single event and ends at a single event only ;
- Each activity is represented by a single arrow, and the direction of the arrow indicates the flow of work. The length or shortness of the arrow does not represent the completion duration ;
- Every activity must begin and end with an event, as follows:

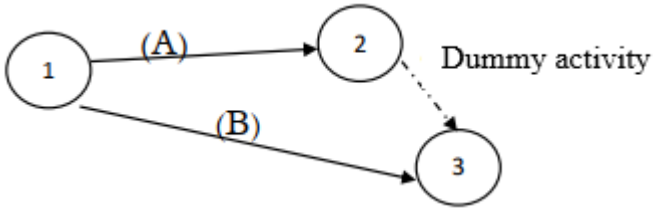


[19] Eslimani Muhammad, **Quantitative methods in management - exercises and solved issues-,** Al-mutanabi printing and publishing house ،The liquid ،Algeria ،2024.

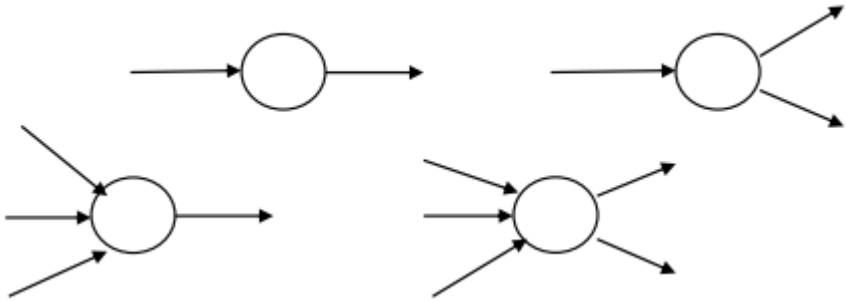
- No two activities can start from the same incident and end at the same incident.



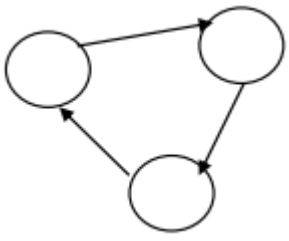
- To handle this situation, a dummy activity is used as follows:



- An incident that is in the middle of the project network can trigger one or several activities, as well as one or several activities can be injured or received :



- Before the start of the activity or activities emanating from a specific event, all activities entering that event must be completed. That is, the execution of activities or a specific activity cannot begin unless the execution of the preceding activity or activities has been completed ;
- Event numbers must not be repeated ;
- The network cannot contain a closed path or a closed loop (cycle).



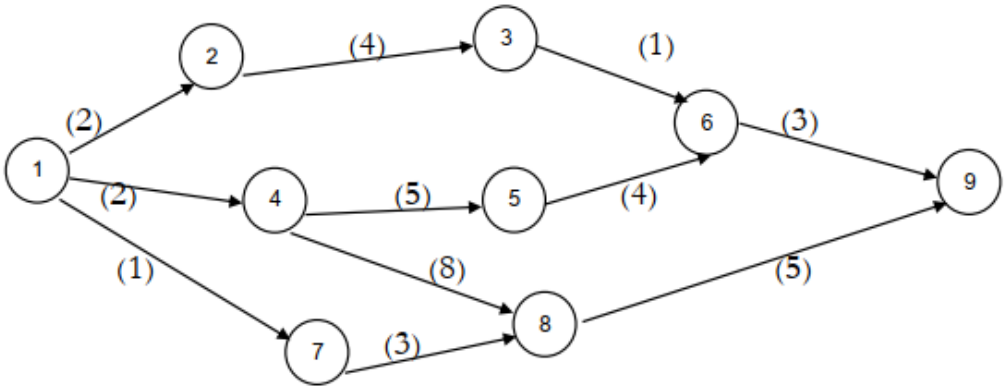
- **Applied Example:**

The following table represents the activities constituting a project:

Activity & Duration	A(2)	B(2)	C(1)	D(4)	E(5)	F(8)	G(3)	H(5)	I(4)	J(1)	K(3)
Immediate Predecessor	-	-	-	A	B	B	C	F-G	E	D	J-I

- **Required:** Construct the project network?

- **Solution:**



2- Calculating the Critical Path:

Building and drawing the project network or work network is a schematic diagram showing the logical sequence of activities. Subsequently, the element of time must be incorporated into the network. Project timing or scheduling is an essential step to determine the project's duration, its completion date, and how to monitor the execution of its constituent activities. Every project network consists of multiple paths, and one of these paths is called the critical path. The critical path is simply the longest path through the network, and it determines the project's execution duration.[20]

To calculate the critical path, calculations can be performed either from the start of the network (called the Forward Pass) or from the end of the network (called the Backward Pass).

[20] Islimani Muhammad, Op cit, P 197

2-1 Forward Pass:

It is necessary to address the following terms:

- Earliest Time of an Event, denoted by **ESj** (Earliest Start for event **j**).
- Earliest Start Time of an Activity (from event **j** to **z**), denoted by **ESjz**.
- Earliest Finish Time of an Activity (**jz**), denoted by **EFjz**.
- Duration of Activity (**jz**), denoted by **Djz**.
- The earliest start time of the initial starting event is zero: **ES1 = 0**.
- The earliest start time of event z is: **ESz = max(ESj + Djz)** for all activities ending at **z**.
- The earliest start time of activity **(jz)** is: **ESjz = ESj.**
- The earliest finish time of activity **(jz)** is: **EFjz = ESj + Djz**.

2-2 Backward Pass:

This is done according to the following steps:

- Latest Time of an Event, meaning the latest start time for an event, say j, denoted by **LSj** (Latest Start for event **j**).
- Latest Start Time of an Activity **(jz)**, denoted by **LSjz**.
- Latest Finish Time of an Activity **(jz)**, denoted by **LFjz.**
- Duration of Activity, denoted by **Djz**.
- The latest start time of the final event equals its earliest start time: **LSZ = ESZ**.
- The latest start time of event **j** is: **LSj = min(LSz - Djz**) for all activities starting from j.
- The latest start time of activity **(jz)** is: **LSjz = LSz - Djz**
- The latest finish time of activity **(jz)** is: **LFjz = LSz**.

3- Critical Path Method (CPM):

An activity belongs to the critical path if it does not have any time reserve (whether total or free), meaning that any delay in its implementation will directly lead to a delay in the completion of the project as a whole.

It is noteworthy that: Every project network contains at least one critical path, where the critical path extends continuously from the first event (start) to the last event (end), and the sum of the times of the critical activities represents the total duration for the completion of the project. Non-critical paths differ in that they contain time margins (time reserves).

Consequently, determining the critical path is a matter of utmost importance for project management, as it helps focus management's efforts on

the most impactful activities, clarifies the minimum time for project implementation, and reveals the activities that cannot tolerate any delay:

- **Total Float (Total Reserve Time):**

Symbolized by TF, it is the time by which we can delay the start of or extend the duration of the implementation of this activity without affecting the time or date of the end of the project as a whole. Therefore, if the activity consumes its total float, the activities that come after it can become critical, and it can be calculated as follows:

$$\mathbf{TF = LCjz - ECjz}$$

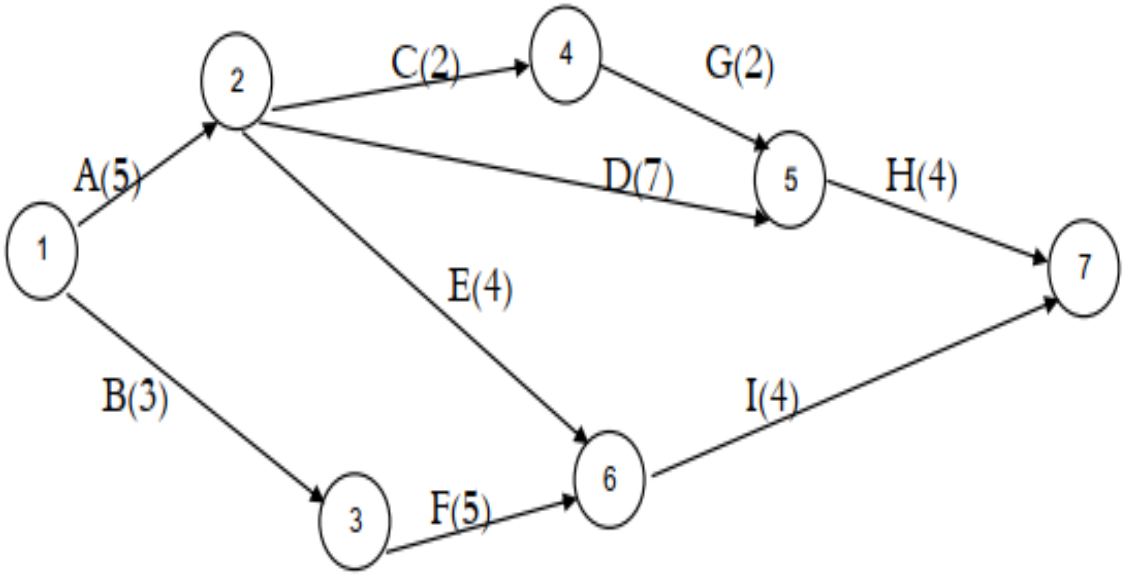
- **Free Float (Free Reserve Time):**

Symbolized by FF, it is the maximum duration by which we can or are able to delay the completion of an activity without affecting the early start of the event that comes after it, and it is calculated as follows:

$$\mathbf{FF = ESz - Ecjz}$$

- **Applied Example:**

The following is the network of activities



- **Required:** Find the critical path.

- **The Solution:**

- **First: We perform the forward pass calculation.**
  - **Calculation of Early Start for events:**

$ES_1 = 0$

$ES_2 = \max(ES_1 + D_{12}) = 0 + 5 = 5$

$ES_3 = \max(ES_1 + D_{13}) = 0 + 3 = 3$

$ES_4 = \max(ES_2 + D_{24}) = 5 + 2 = 7$

$ES_5 = \max(ES_4 + D_{45}, ES_2 + D_{25}) = \max(7 + 2, 5 + 7) = 12$

$ES_6 = \max(ES_2 + D_{26}, ES_3 + D_{36}) = \max(5 + 4, 3 + 5) = 9$

$ES_7 = \max(ES_5 + D_{57}, ES_6 + D_{67}) = \max(12 + 4, 9 + 4) = 16$

  - **Calculation of Early Start for activities:**

$ES_{12} = ES_1 = 0$ $ES_{13} = ES_1 = 0$ $ES_{24} = ES_2 = 5$

$ES_{25} = ES_2 = 5$ $ES_{26} = ES_2 = 5$ $ES_{36} = ES_3 = 3$

$ES_{45} = ES_4 = 7$ $ES_{57} = ES_5 = 12$ $ES_{67} = ES_6 = 9$

  - **Calculation of Early Finish for activities:**

$EC_{12} = ES_1 + D_{12} = 0 + 5 = 5$

$EC_{13} = ES_1 + D_{13} = 0 + 3 = 3$ $EC_{24} = ES_2 + D_{24} = 5 + 2 = 7$

$EC_{25} = ES_2 + D_{25} = 5 + 7 = 12$ $EC_{26} = ES_2 + D_{26} = 5 + 4 = 9$

$EC_{36} = ES_3 + D_{36} = 3 + 5 = 8$ $EC_{45} = ES_4 + D_{45} = 7 + 2 = 9$

$EC_{57} = ES_5 + D_{57} = 12 + 4 = 16$ $EC_{67} = ES_6 + D_{67} = 9 + 4 = 13$

- **Second: We perform the backward pass calculation.**
  - **Calculation of Late Start for events:**

$LS_7 = ES_7 = 16$

$LS_6 = \min(LS_7 - D_{67}) = 16 - 4 = 12$

$LS_5 = \min(LS_7 - D_{57}) = 16 - 4 = 12$

$LS_4 = \min(LS_5 - D_{45}) = 12 - 2 = 10$

$LS_3 = \min(LS_6 - D_{36}) = 12 - 5 = 7$

$LS_2 = 5$

$LS_1 = 0$

  - **Calculation of Late Start for activities:**

$LS_{12} = LS_2 - D_{12} = 0$ $LS_{13} = LS_3 - D_{13} = 4$ $LS_{24} = LS_4 - D_{24} = 8$

$LS_{25} = LS_5 - D_{25} = 5$ $LS_{26} = LS_6 - D_{26} = 8$ $LS_{36} = LS_6 - D_{36} = 7$

$LS_{45} = LS_5 - D_{45} = 10$ $LS_{57} = LS_7 - D_{57} = 12$ $LS_{67} = LS_7 - D_{67} = 12$

  - **Calculation of Late Finish for activities:**

$LC_{12} = LS_2 = 5$ $LC_{13} = LS_3 = 7$ $LC_{24} = LS_4 = 10$

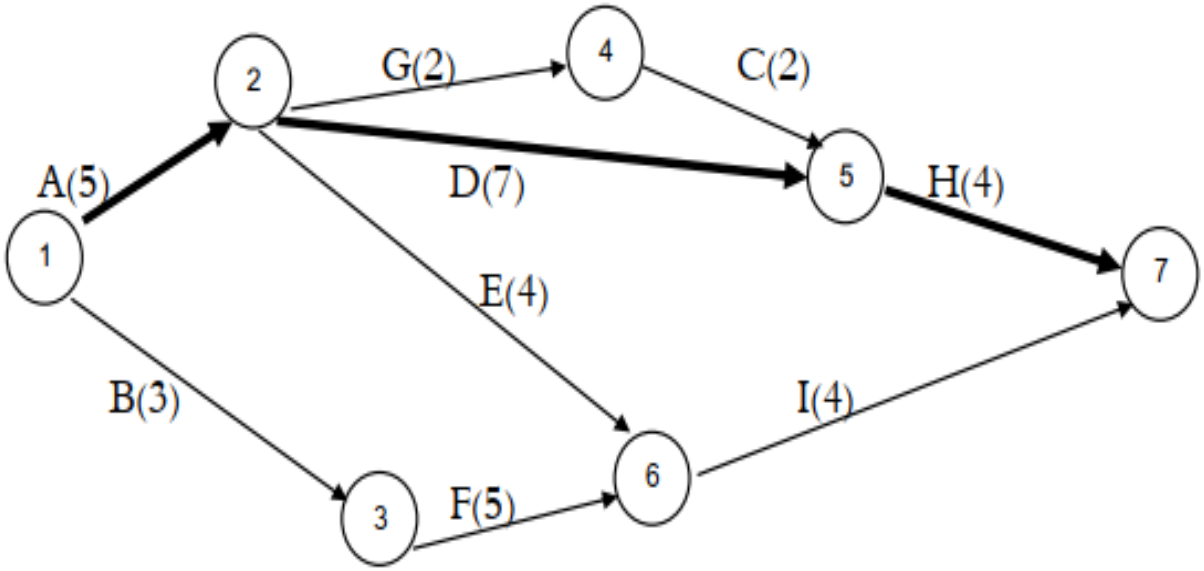
$LC_{25} = LS_5 = 12$ $LC_{26} = LS_6 = 12$ $LC_{36} = LS_6 = 12$

$LC_{45} = LS_5 = 12$ $LC_{57} = LS_7 = 16$ $LC_{67} = LS_7 = 16$

- **Third: Finding the Critical Path:**

Activity	Duration (Djz)	ECjz	Early		Late		Total Float (TF)	Free Float (FF)
			ES_{jz}	ECjz	LS_{jz}	LC_{jz}		
1-2	5	5	0	5	0	5	0	0
1-3	3	3	0	3	4	7	4	0
2-4	2	7	5	7	8	10	3	0
2-5	7	12	5	12	5	12	0	0
2-6	4	9	5	9	8	12	3	0
3-6	5	9	3	8	7	12	4	1
4-5	2	12	7	9	10	12	3	3
5-7	4	16	12	16	12	16	0	0
6-7	4	16	9	13	12	16	3	3

Now the critical path can be illustrated through the network :



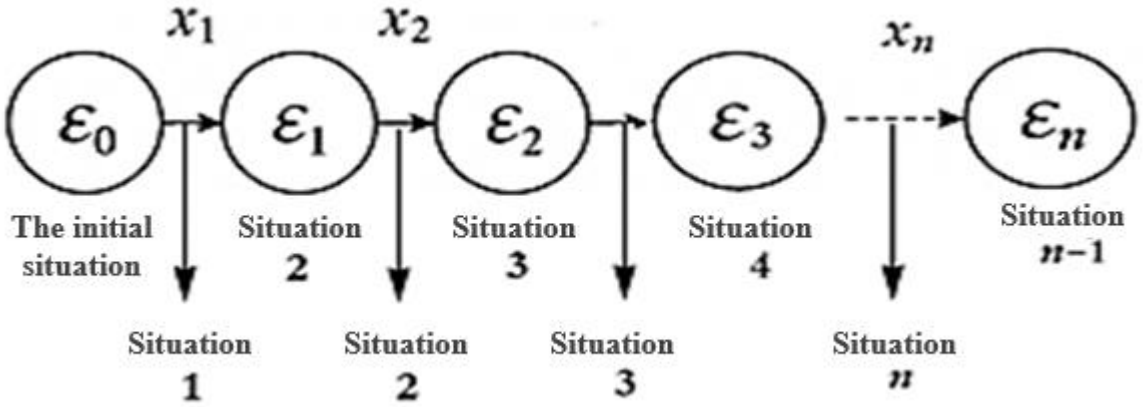
Second: The Dynamic Method

Dynamic programming helps us find the optimal solution by dividing the decision-making process into several stages, where the final solution is the result of the multiple stages (the specific solutions for each stage). It is also considered a part of mathematical programming in general.[21]

$\varepsilon_0 \longrightarrow \varepsilon_n$

Elementary posture Final position

To apply this approach, it is assumed that we can partition the phenomenon under study into n stages :

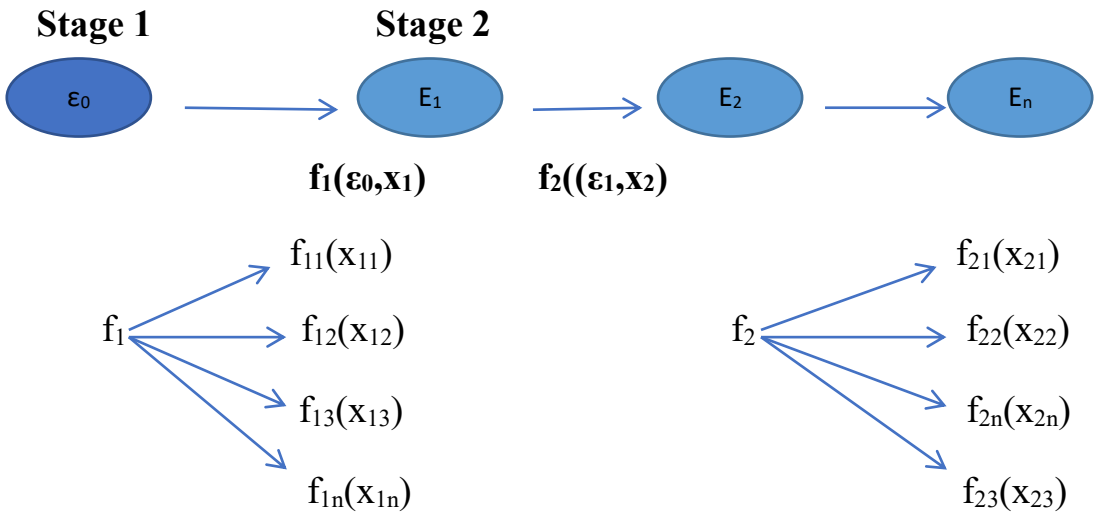


- xk is the stage variable ;
- The value of the state variable at the end of each stage k (εk-1) depends on the value of the previous state variable (εk-1) and the variable of this stage, which is xk ;
- Objective function: It is known that every phenomenon has a general objective function, which is divided into several partial objective functions specific to each stage individually.
- The objective function specific to stage k (meaning the partial function) is:

FK = fk(εk-1, xk)

- The objective function for each stage (fk) takes successive values according to the values taken by the variable of the concerned stage k, meaning each value taken by xk gives a corresponding value to the objective function ;
- The optimal solution for the stage objective function is: Taking the maximum value or the minimum value of these previous values

[21] Makid Ali, **Operations research**, Quantitative techniques of conducting, Lectures ،2009-2010



– **The Principle of Optimality (Bellman)**, its added value, implies that partial solutions must be viewed differently; the partial solution must be optimal for the previous stage and simultaneously prepare the conditions for the subsequent stage.

• **Applied Example:**

A company wants to invest an amount of available financial resources (ε_0) across four of its subsidiaries (E_1, E_2, E_3, E_4) to finance their investment activities, aiming to obtain the maximum possible profit from the activity of these subsidiaries.

– **Required:**

Determine how to distribute the available initial investment amount to finance the activities of the four subsidiaries in order to obtain the largest possible return from their activities, based on the condition that the remaining amount (surplus) from the activity of subsidiary (k) is used to finance the activity of subsidiary (k+1). The available initial amount is 200.

– **Solution:** Find the solution based on the following data:

Expected profit function for subsidiary 4 / **Financial Resources x_i**	**$f_1(x_1)$**	**$f_2(x_2)$**	**$f_3(x_3)$**	**$f_4(x_4)$**
40	8	6	3	4
80	10	9	4	6
120	11	11	7	8
160	12	13	11	13
200	18	15	18	16

We divide the company's investment activity into four stages: each stage consists of the investment activity of one subsidiary. Stage 1 is the investment activity of the first subsidiary, Stage 2 of the second subsidiary, and so on...

- **Stage 1:** Subsidiary (1) The amount available to it:
  The initial amount $\varepsilon_0 = 200$. It takes the amount it needs for its investment activity, x_1. The remainder from this amount is ε_1, where $\varepsilon_1 = \varepsilon_0 - x_1$. This remainder is for the other subsidiaries ;
- **Stage 2:** Subsidiary (2) The amount available to it:
  is ε_1. It takes the amount it needs for its investment activity, x_2. The remainder from this amount is ε_2, where $\varepsilon_2 = \varepsilon_1 - x_2$. This remainder is for the other subsidiaries, and so on until the fourth subsidiary.

Subsidiary	Initial Amount Available for Subsidiary's Activity	Amount Used by It	Remaining Amount Surplus from Its Activity
1	ε_0	X_1	$\varepsilon_1 = \varepsilon_0 - X_1$
2	ε_1	X_2	$\varepsilon_2 = \varepsilon_1 - X_2$
3	ε_2	X_3	$\varepsilon_3 = \varepsilon_2 - X_3$
4	ε_3	X_4	$\varepsilon_4 = \varepsilon_3 - X_4$

$Z_1(x_1)$, $Z_1(x_1)$, $Z_2(x_2)$, $Z_3(x_3)$, $Z_4(x_4)$
max, max, max, max, max
The optimal solution
for the entire problem.

	Initial Amount Available for Subsidiary's Activity	Amount Allocated to It	Remaining Amount for Distribution	Value of the Stage's Objective Function	Value of Profits Obtained in Subsequent Stages	Value of Maximum Profit Obtained in Stages 4 + Profit from This Stage	Maximum Total Profit for the Company in This Stage
Stage 4 Subsidiary 4	ε_3	X_4	$\varepsilon_4 = \varepsilon_3 - X_4$	$f_4(x_4)$	$Z_5^{max}(x_5, \varepsilon_4)$	$f_4(x_4) + Z_5^{max}(x_5)=0$	$Z_4^{max}(x_4)$
Stage 3 Subsidiary 3	ε_2	X_3	$\varepsilon_3 = \varepsilon_2 - X_3$	$f_3(x_3)$	$Z_4^{max}(x_4, \varepsilon_3)$	$f_3(x_3) + Z_4^{max}(x_4)=0$	$Z_3^{max}(x_3)$
Stage 2 Subsidiary 2	ε_1	X_2	$\varepsilon_2 = \varepsilon_1 - X_2$	$f_2(x_2)$	$Z_3^{max}(x_3, \varepsilon_2)$	$f_2(x_2) + Z_3^{max}(x_3)=0$	$Z_2^{max}(x_2)$
Stage 1 Subsidiary 1	ε_0	X_1	$\varepsilon_1 = \varepsilon_0 - X_1$	$f_1(x_1)$	$Z_2^{max}(x_2, \varepsilon_1)$	$f_1(x_1) + Z_2^{max}(x_2)=0$	$Z_1^{max}(x_1)$

Maximum Profit Value Obtained in Stage 4	Profit Value Obtained in Stage 4	Maximum Profit Value Obtained Up to the Subsequent Stage	Objective Function for the Fourth Stage $f_4(x_4)$	Remaining Amount for the Next Stage $\varepsilon_4 = \varepsilon_3 - x_4$	Amount Possible to Invest in This Stage x_4	Remaining Amount at the Start of the Stage ε_3
0	0	0	0	0	0	0
4	4+0=4	0	4	0	40	40
6	6+0=6	0	6	0	80	80
8	8+0=8	0	8	0	120	120
13	13+0=13	0	13	0	160	160
16	16+0=16	0	16	0	200	200
Z_3^{max}	F_3	Z_4^{max}	F3	ε_3	X_3	Stage 4 Subsidiary 3, ε_2
0	0	0	0	0	0	0
4	0+4=4 3+0=3	4 0	0 3	40 0	0 40	40
7	0+6=6 3+4=7 4+0=4	6 4 0	0 3 4	80 40 0	0 40 80	80
9	0+8=8 3+6=9 4+4=8 7+0=7	8 6 4 0	0 3 4 7	120 80 40 0	0 40 80 120	120
13	0+13=13 3+8=11 4+6=10 7+4=11 11+0=11	13 8 6 4 0	0 3 4 7 11	160 120 80 40 0	0 40 80 120 160	160
18	0+16=16 3+13=16 4+8=12 7+6=13 11+4=15 18+0=18	16 13 8 6 4 0	0 3 4 7 11 18	200 160 120 80 40 0	0 40 80 120 160 200	200
Z_2^{max}	F2 + Z_3^{max}	Z_3^{max}	$f_2(x_2)$	ε_2	X_2	Stage 2, Subsidiary2, ε_1
0	0	0	0	0	0	0
6	0+4=4 6+0=6	4 0	0 6	40 0	0 40	40
10	0+7=7 6+4=10 9+0=9	7 4 0	0 6 9	80 40 0	0 40 80	80

13	0+9=9 6+7=13 9+4=13 11+0=11	9 7 4 0	0 6 9 11	120 80 40 0	0 40 80 120	120
16	0+13=13 6+9=15 9+7=16 11+4=15 13+0=13	13 9 7 4 0	0 6 9 11 13	160 120 80 40 0	0 40 80 120 160	160
19	0+18=18 6+13=19 9+9=18 11+7=18 13+4=17 15+0=15	18 16 9 7 4 0	0 6 9 11 13 15	200 160 120 80 40 0	0 40 80 120 160 200	200
Z_1^{max}	**$f_1(x_1)$**	**$f_1(x_1)+ Z_2^{max}$**	**$f_1(x_1)$**	**ε_1**	**X_1**	**Stage 1, Subsidiary1, ε_0**
24	19 24 23 21 18 18	19 16 13 10 6 0	0 8 10 11 12 18	200 160 120 80 40 0	0 40 80 120 160 200	200

Stage	Remaining Amount at the Start of the Stage	Maximum Profit in This Stage	Amount Invested in This Stage	Optimal Value of the Objective Function in This Stage	Remaining Amount for the Next Stage
1	200	24	40	8	160
2	160	16	80	9	80
3	80	7	40	3	40
4	40	4	40	4	0
			∑200	**∑24**	

Axis Six :
Accounting-Financial Approach

First: Accounting Evaluation

Management relies fundamentally on information to perform its tasks and make its decisions, as it is difficult to achieve effective decisions without the presence of accurate and relevant data. The quality of decisions is directly proportional to the quality of the information they are based on. In this context, management accounting provides analytical information that supports decisions in multiple aspects such as: pricing policies, investment planning, make-or-buy decisions, and solving administrative problems related to choosing optimal alternatives.

Among the most prominent decisions that management accounting contributes to studying are:

- Analyzing the feasibility of in-house manufacturing of parts versus purchasing them from suppliers ;
- Evaluating the introduction of new products to the current production line ;
- Determining the feasibility of continuing to produce a specific product or discontinuing it ;
- Analyzing special sales orders at reduced prices ;
- Optimizing the product mix to maximize profitability ;
- Evaluating decisions to replace and renew fixed assets.

These functions represent the core contribution of management accounting to enhancing managerial effectiveness and making sound decisions.

Second: The Ratio Method and Return on Investment

Ratio analysis is one of the most prominent and oldest analytical tools for evaluating the financial position of firms and measuring their operational efficiency. Financial ratios are defined as mathematical relationships with an economic basis that link different items of financial statements, aiming to derive indicators that signal the evolution of financial performance.

It is noteworthy that:

- The financial system includes an unlimited number of potential ratios ;
- Effective analysis requires selecting a balanced and integrated set of ratios ;
- Isolated ratios lose their analytical value unless compared to standards or other ratios ;

- The effectiveness of ratios lies in comparing them to historical ratios or industry standards.

This analytical method aims to:

- Evaluate profitability and investment efficiency;
- Measure liquidity and the ability to meet obligations;
- Analyze the financing structure and financial leverage;
- Evaluate the efficiency of asset management.

Financial ratios gain their importance from their ability to simplify complex financial data and transform it into comparable and analyzable indicators, which contributes to making sound financial decisions.[22]

The financial ratio method involves establishing relationships between balance sheet items or the income statement. Financial analysts, especially those working in the banking sector, have heavily relied on this method. In the context of investment analysis, financial ratios are used to assess the project's efficiency in generating profits and the effectiveness of managing invested funds. For these ratios to be effective and have clear significance, they must be tracked over different time periods, compared with each other, and interconnected. It is also necessary to have standard ratios used as a reference for comparison with ratios derived from other projects operating in the same field or belonging to the same sector.

Financial ratios are classified into four main categories: financial structure ratios, liquidity ratios, activity ratios, and profitability ratios.[23]

1- Financial Structure Ratios:

These ratios are used to analyze the financial composition of the project, measuring its reliance on debt and its ability to meet its financial obligations. The most prominent of these ratios are:

1-1- Permanent Financing Ratio:

This ratio reflects the balance between permanent resources (such as capital and reserves) and fixed investments in the project, and is calculated as follows:

Permanent Assets ÷ Net Fixed Assets

[22] Zghaib Malika, Bushgir Miloud, **Financial management according to the new official program**, Bureau of university publications, Algeria, P. 37

[23] Ramash Hagar, **Project evaluation**, Opcit.

If the result is greater than 1, it indicates that the project has a sufficient financial safety margin to finance its needs, meaning the net working capital (FR) is positive.

1-2- Self-Financing Ratio:

This ratio measures the project's ability to finance its fixed assets using its own funds (without relying on loans), calculated by the following equation:

Own Funds ÷ Net Fixed Assets

The higher the result is above 1, the more it indicates a surplus in own working capital, enhancing the project's financial stability.

1-3- Working Capital Ratio:

This ratio measures the ability of working capital to cover current assets, calculated by the following equation:

Working Capital ÷ Current Assets

1-4- Financial Autonomy Ratio:

This ratio assesses the degree of the project's reliance on self-financing compared to debt, calculated as follows:

Own Funds ÷ Total Debt

According to banking standards, if the ratio exceeds 1, it indicates:

- Low debt risk ;
- The project's ability to meet its obligations or obtain additional financing.

1-5- Solvency Ratio (Debt Ratio):

Used to measure the project's ability to repay its debts in case of financial distress, it estimates the relationship between debt and total assets. It is calculated as follows:

Total Debt ÷ Total Assets

It is preferred that this ratio remains below 0.5, because exceeding this value may indicate:

- High bankruptcy risk ;
- The need to liquidate assets to repay debts during financial crises.

2- Liquidity Ratios:

These ratios are used to measure the entity's ability to meet its short-term financial obligations. The most important of these ratios are:

2-1- General Liquidity Ratio (Current Ratio):

This ratio measures the adequacy of current assets to cover current liabilities, calculated by the following equation:

Current Assets ÷ Short-Term Liabilities

- If the ratio is greater than (1): It indicates a surplus of current assets over current liabilities, meaning the entity has a positive net working capital ;
- If the ratio is less than (1): It indicates that the entity may face difficulties in meeting its short-term obligations.

2-2- Quick Ratio (Acid-Test Ratio):

This ratio measures the entity's ability to repay its short-term obligations using immediately liquid assets (cash and equivalents), calculated as follows:

(Receivables + Marketable Securities + Cash and Equivalents) ÷ Short-Term Liabilities

The ratio is considered acceptable when it is greater than 0.5.

2-3- Cash Ratio:

Measures the entity's ability to repay its short-term obligations using immediately available cash, calculated as follows:

Cash and Equivalents ÷ Short-Term Debt

- Preferably ranges between 0.2 to 0.3 ;
- A lower ratio indicates weak cash liquidity ;
- A higher ratio may reflect poor management of excess cash.

3- Activity Ratios:

Measure how effectively management uses its assets to generate revenue. Key ratios include: Inventory Turnover Ratio, Customer Collection Period (Days Sales Outstanding), Supplier Payment Period (Days Payable Outstanding), Capital Turnover Ratio.

4- Profitability Ratios:

These ratios aim to assess the efficiency of resource management and the project's ability to generate profits. The most important are:

4-1- Net Profit Margin:

This ratio measures the percentage of net profit to total revenue, calculated as follows:

Net Profit ÷ Total Sales

4-2- Return on Assets (ROA):

Measures the efficiency of using assets to generate profits, calculated by the equation:

Net Profit ÷ Total Assets

4-3- Return on Equity (ROE):

Measures the return generated from the owners'investment, calculated as follows:

Net Profit ÷ Total Equity

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