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Using the shortest path method in analyzing the productive life of the investment

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Abstract:
The objective of this study is how to analyze the useful life of the investment in order to replace it with another investment, which is one of the quantitative mathematical methods and this method depends on calculating the expected costs of investment during future years and then work on analyzing these costs in a way that is the shortest path in the network It was found through the applied study that the institution will buy a machine on 01/01/2019 and the process of using it for two years and then selling it on 31/12/2020, to replace it with another machine on 01/01/2021 and run it during The years 2021, 2022 and 2023 and sold on 31/12/2023.

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JEL Classification Codes : D13 ;C44 ;D85

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1. INTRODUCTION

Investment represents an important part of total spending, so any increase in investment spending is bound to eventually lead to an increase in aggregate demand.

The term investment is one of the commonly used terms, as it is used by the public and specialists alike, but the use of the word investment by each category has a different connotation for each of them, as the public uses the word investment to indicate that they are buying assets that generate a return for them, such as buying a piece of land, buying bonds and shares, or buying a car... etc., and this process does not include the addition of new productive assets to society that lead to supporting the productive capacity of the economy in the future, and therefore it expresses the mere transfer of ownership of these things from one person to another, but when economists use the term investment, they mean those processes that lead to the addition of new productive assets to society, so the decision to buy a piece of land or buy shares and bonds, buy new machines are all within the investment decisions because they represent an addition to productive assets.

In order to analyze the useful life of the investment, several methods can be used, including the method of depreciation of the investment or the method of calculating the present value of it in the future to calculate the expected cash flows from it, or the use of the shortest path method in determining its useful life, and this method is considered one of the quantitative methods that depend on the theory of network analysis in calculating the estimated cost of investment during the coming years, and it depends on a set of methods, including the method of Minty, Ford, Bellman, Danzig.

1.1 The problem of research:

From the above, the problem of research can be raised as follows

How does the shortest path method contribute to the analysis of the useful life of an investment?

1.2 Sub-questions:

Through the main question of the research problem, a set of sub-questions can be posed as follows:

- What are the methods used in analyzing the useful life of the investment?

-How is the minimum cost of investment determined?

–How is the shortest path determined by the projection network for future costs?

1.3 Study assignments

- Quantitative analysis tools help in analyzing the useful life of an investment.
- Network analysis method (shortest path method) is one of the modern methods in analyzing the useful life of investment.
- The network analysis method helps in the forecasting process for future investment renewal.

1.4 Importance of the study

Investment is one of the main pillars in the economy of countries, and in order to carry out the process of replacing it, this process must take place on scientific and mathematical bases so as to help the decision-maker to adopt an effective strategy in renewing investment through the use of quantitative methods.

1.5 Objectives of the study:

- Know the expected costs of investing in the future.
- Know when one investment is replaced by another.

- Determine the shortest way in the process of exploiting the investment and selling it later.

1.6 Study Methodology:

We will rely on the descriptive analytical approach, as this model is considered one of the models with a high ability to describe the investment and determine its types and determinants, and we will also use the quantitative approach by determining the shortest path in the investment analysis process in order to replace it in the future, and we will use in the calculation process the program specialized in quantitative methods, which is the QM program. .

1.7 Study Methodology:

To answer the main problem and sub-questions, this study was divided into the following axes:

The first axis: the conceptual framework of investment (concept, types, determinants)

The second axis: the theory of network analysis.

The third axis: Applied Study

2. The conceptual framework of investment (concept, types, determinants)

2.1 Investment concept: A set of definitions can be presented as follows:

Investment is one of the main elements in any economic system, especially in the capitalist system, where economic decisions are taken by the private sector and are based on individual motives, and investment is considered unlike consumption as a sensitive, active and unstable variable and its lack of stability leads to fluctuations in the level of economic activities and the level of use, and for this reason investment occupies an important part of the theories of economic circles or cycles. (sakhri., 2005, pp. 167-168) .

Investment is defined as an addition to productive assets, which represents a stream of spending on productive assets, such as the purchase of equipment, machinery and means of transportation necessary for productive projects called capital assets, and also represents investment in residential buildings in addition to the changes that occur in the stock of goods, whether raw materials, intermediate or final commodities during a certain period.

The investment contains capital assets (machinery, equipment, means of transportation... etc) It also includes buildings, and since these types have a specific lifespan after which they become unusable, new assets must be replaced by the old ones, in addition to the fact that some assets need repairs and restorations with use, so a part of the total investment is allocated by depreciation of capital allocated for these purposes, and the rest of the total investment after that represents new additions to the existing capital and is called net investment (Bahnchal, 1999, pp. 97-98).

2.2 Types of investment (divisions): Investment can be divided into the following types

A- Total investment: We mean the total additions to the capital balance of machinery, equipment and production capacities to the community, and the total investment is in turn divided into two types:

– Substitutionary investment: It means replacing new capital assets that have been depreciated, and therefore replacement investment does not represent an addition to

the production capacity available to society, but maintains that production capacity until the state's productive capacity decreases.

_ Net investment: Net investment refers to the net increase in the country's capital balance during a certain period, and therefore represents an addition to its productive capacity.

B- Fixed investment: It is an investment that takes the form of establishing factories, installing machinery and equipment, residential buildings, establishing major roads, schools, etc., and the aim of establishing these assets is to use them in the production of consumer goods and services during subsequent periods of time, and fixed investment may lead to an increase in the state's ability to produce as it added new production capabilities to it, and may maintain that ability if new capital assets are replaced by those that have been depreciated.

C- Investment in inventory: where the stock consists of raw materials and goods that are in the stages of production, and finished goods that the facility stores in order to sell them, and the stock that we are interested in here is that stock that is kept to meet the demand for goods in the future, and the establishments keep the inventory and its amount depends on the level of sales, the more the demand for the facility's products is uncertain, the more the stock ratio is affected by the interest rate, because the stock represents an unemployed balance of money and is not exploited, so the stock ratio decreases To sales as the interest rate rises, knowing that the level of inventory fluctuates strongly during economic cycles, a decrease in aggregate demand entails a significant increase in inventory.

D- Financial investment: It means the purchase of shares and bonds in the securities market, knowing that financial investment is followed by real investment, especially if the purchased stocks and bonds are issued for the first time for the purpose of establishing new productive assets in society, but if the financial investment is made in shares and bonds traded for existing projects, it is not considered a real investment, but just a transfer of ownership.

C- Automatic investment: It means that investment that is not affected by the level of income, but is determined by factors other than income such as the expectations of businessmen, interest rate, and technological level.... Etcetera.

D- Subsidiary investment: It means that type of investment that depends on the level of income as it changes with the change of income, and the relationship between income and investment is a direct relationship (Shehab., 2019, pp. 161-164)

2.3 Determinants of Investment: Economists point to a set of factors that affect the volume of investment and push towards stimulating it:

_ The size of the current demand for products: If demand increases, the facility increases its production depending on its existing production apparatus, but if the demand continues to increase, it will be motivated to expand its production apparatus

by building new production lines and new stores to meet the increasing demand for its products.

– **Future expectations**: As the motivation for investment for businessmen depends on foreseeing the future, if their expectations are pessimistic about it, they refrained from it and slowed down in implementing their investment plans, but if their expectations were optimistic, they rushed towards it and increased in its size, meaning that optimistic expectations constitute an incentive to invest, while pessimistic expectations are a deterrent to it.

_**Interest rate**: As the interest rate determines the cost of the alternative opportunity, the cost of this opportunity rises and decreases with its decrease, which constitutes an incentive for investment, and although the sensitivity of investment to the demand for goods and services produced is greater than its sensitivity to the interest rate, the latter remains a basic determinant of investment (Younis, 2017, p. 81).

3. Grid Analysis Theory

3.1 The concept of quantitative methods (operations research): It is a set of tools and methods (Méthods) that are used by the decision maker to address a specific problem or to rationalize the administrative decision to be taken regarding a particular case, and it is assumed in this case that there is sufficient data related to the problem, and its application and use also requires the identification of hypotheses and factors affecting directly or indirectly. (Al-Fadl, 2010, p. 22) .

Some have defined it as those mathematical or quantitative models through which all the vocabulary of the problem is absorbed and expressed based on mathematical relationships (equations or invariants) as a first step towards addressing and solving it. Mathematical models are supported by the necessary data, some of which are characterized by being constants and others variables in proportion to the nature of the problem studied. (al-Salami, 2019, pp. 4-5) .

The British Operations Research Association has defined operations research as the application of science methods to complex issues that appear in the direction and management of large systems of people, in mechanisms, materials, and finance in industry, in business, government and defense, it is the distinct comparison, which is the development of a scientific model of the system, including measurements of factors such as luck and risk, and with them is achieved to predict and compare the results of alternative strategic or control decisions, and the goal is to help the administration to determine its policy and methods of work and action scientifically, and this definition has been adopted by most specialists in operations research.

The American Operations Research Association (AIARC) provided a shorter but similar definition, noting that operations research is concerned with the scientific report on how to obtain the best design and operation of machine and human systems in conditions that usually require the allocation of scarce resources. (Bani Hani, 2013, p. 15).

3.2 Statement theory: It is also called graph theory, and this theory is in fact nothing but the theory of relationships, in which symmetrical relationships are often represented by undirected drawings and asymmetric relationships by directed drawings, and due to the spread of the circle of problems that fall under this definition of graphic theory, this theory has played and plays a major role in addressing many problems in operations research, however, the directed drawings or drawings are sometimes not sufficient to express a system or A specific case, where we must associate numerical values with the set of points or the set of lines that make up the drawing or drawing directed to express costs, distances, possibilities, accidents... This kind of graphics is called networks (al-Balkhi, 2003, p. 316).

The first to study the theory of the statement as a mathematical concept is the mathematician Uller 1736, and at the beginning of the twentieth century witnessed this branch of science a wide breakthrough made it one of the sciences that took its place in the latter half of the last century, the importance of the theory of the statement is reflected in the effectiveness of this science in various fields and branches of other sciences as well as in practical and applied life, such as communications, electrical networks, computer science, planning and management, economics, transportation, concentration and control, theory of dependencies, chemistry and engineering. (Suhai, 2011, p. 10) .

3.3 The concept of networks: The work networks are one of the methods of the quantitative approach in business management that are used in the field of planning and control for the implementation of productive projects, and service, whether medium and large size, and it is one of the quantitative methods of operations research. (Al-Fadl M. , 2009, p. 317) .

The networks are those graphic and engineering forms that express a specific problem in reality, and networks are designed mostly through stocks and known as activity, and points of acquaintance or what is known as events, and these networks are used in various fields in practice, whether constructional, productive, scientific, service, etc., as the design and study of large and complex projects that are characterized by the phased implementation requires the development of maps and preliminary studies that explain the development of the project in terms of the sequence of work Structural or productive, commensurate with the proposed and appropriate time stages of work, as the idea of the economic concept of labor networks focuses on how to use scarce or specific resources to achieve the goals of different organizations. (Al-Obaidi, 2005, p. 132).

Business networks can be expressed through different formulas, methods and models that can be illustrated as follows:

–Shortest route models: These models are used when it is required to determine the shortest route between two points, the shortest route between a given point and all

other points in the business network, or the shortest route between every two points in the business network.

_Maximum flow models: This type of model is similar to what is presented in the first model, except that it is used to determine the maximum flow of profits or financial resources that can be achieved through the application of business networks.

_Business network models (times): These models aim to determine the sequential and parallel times of different projects, as well as determine the time for each activity and identify critical paths in the project business network. (Al-Fadl M. A., 2010, p. 132) .

3.4 Shortest path model concept: The shortest path model refers to the set of lines (branches) connecting several points that form the shortest path between the source point, i.e. the initial point in the network and the destination point, i.e. the last point in the network.

This model aims to determine the shortest route between the source point and the access point, i.e. determine the path that connects the source and the access point so that the sum of the time, time or distance for this path is as little as possible. (Saber, 2009, p. 97) .

The shortest path method can be solved in the following ways:

-Minty method in the case of low only.

-Ford method

-Bellman method

-Dantzig method

4. Applied study

4.1 Definition of the National Corporation for Electrochemical Products in Tiaret Sougueur Unit: The National Corporation for Electrochemical Products is a national public company established in 1986under the command economy and was independent in 1989 As it has witnessed a gradual development in its economic situation, which led to the creation of several units, including the Samar unit for dry batteries and the Sougueur unit for wet savings, which is replaced

Training Where the Sougueur unit was established in 1992in order to produce insulators used by the units of Setif and Oued Smar along with private institutions, and also established a partnership with Qatar and Germany, the National Corporation for Electrochemical Products in Sougueur is located 1200 m from the city in the industrial zone of Tosnina Road, and its area is estimated at 10.1227hectares, a public institution with shares established by Executive Decree No. 383of January 22, 1983with a capital of 31500000000 DZD Head Office in Setif "parent company" This unit is of an industrial and commercial nature according to what is included in the production processes Produces wet or wet savings, known under the name of a saver

Persians, which are eight types:

43 ha/50ha/85ha/55ha/60ha/70ha/90ha/110ha/70ha/90ha/110ha.

It is a modern product that agrees with all conditions, which helped to acquire the Algerian market, and it is looking forward to the homeland and Africa due to its direct use, after acquisition, it does not need electric charging or acid filling, and it also has high technologies, as it consists of thin sheets, pockets and insulation produced in the unit.

4.2 Estimation of network costs: In order to estimate the costs of the network, we will choose one of the machines in which a certain type of battery is manufactured and we calculate the forecasts related to the purchase price of this machine, which is new, and its selling price as a percentage of its purchase price and operating costs per year, during the next five years, and the following table shows that.

Table 1. Represents the purchase price, the resale price as a percentage and operating costs

Years	**1920**	**2020**	**2021**	**2022**	**2023**
Machine purchase price	720000	730000	740000	750000	760000
Resale price as a percentage of the purchase price	80%	70%	60%	50%	40%
Annual operating costs of the machine	80000	100000	140000	190000	220000

Source: Authored by researchers

To prepare the expected costs for the five years, we follow the following rule:
Cost of this procedure = loss of the sale of the machine after one year of operation + operating costs of the machine during the year 2020

Table 2. Projected commissioning calculation for the next five years

Machine purchase history	**Machine Sale Date**	**Expected cost**
01/01/2019	31/12/2019	80000+720000×0.20=224000 DZD
01/01/2019	31/12/2020	80000+100000+720000×0.3=396000 DZD
01/01/2019	31/12/2021	80000+100000+140000+720000×0.40=608000 DZD
01/01/2019	31/12/2022	80000+100000+140000+190000+720000×0.50=870000 DZD
01/01/2019	31/12/2023	80000+100000+140000+190000++220000+720000×0.60=1162000 DZD
01/01/2020	31/12/2020	80000+730000×0.20=226000 DZD
01/01/2020	31/12/2021	80000+100000+730000×0.3=399000 DZD
01/01/2020	31/12/2022	80000+100000+140000+730000×0.40=612000 DZD
01/01/2020	31/12/2023	80000+100000+140000+190000+730000×0.50=875000 DZD
01/01/2021	31/12/2021	80000+740000×0.20=228000 DZD
01/01/2021	31/12/2022	80000+100000+740000×0.3=402000 DZD
01/01/2021	31/12/2023	80000+100000+140000+740000×0.40=616000 DZD
01/01/2022	31/12/2022	80000+750000×0.20=230000 DZD
01/01/2022	31/12/2023	80000+100000+750000×0.3=405000 DZD

01/01/2023	31/12/2023	80000+760000×0.20=232000 DZD

Source: Authored by researchers

After calculating the various expected costs for the five years can be unloaded in the following table

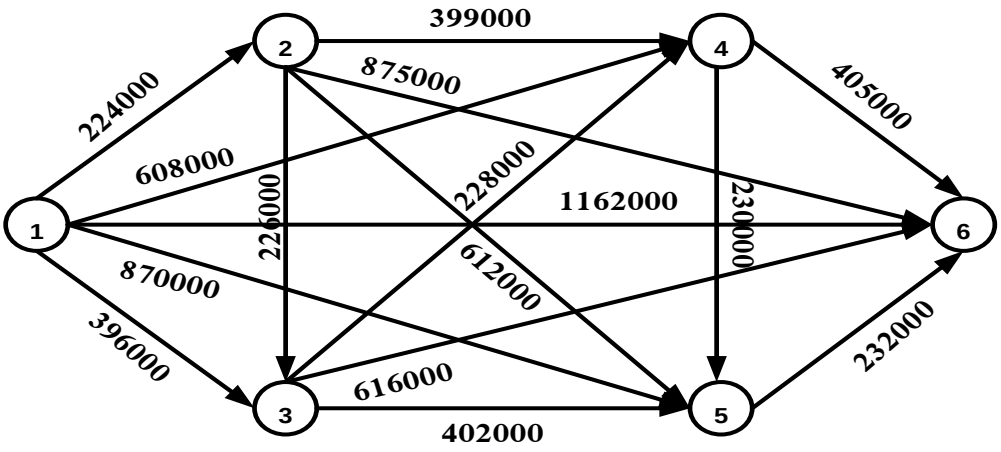
Table 3. Estimated Costs of the Machine during the Next Five Years Unit: DZD

	2019	**2020**	**2021**	**2022**	**2023**
2019	224000	396000	608000	870000	1162000
2020	-------	226000	399000	612000	875000
2021	-------	---------	228000	402000	616000
2022	-------	---------	---------	230000	405000
2023	-------	---------	---------	---------	232000

Source: Authored by researchers

4.3 Drawing of the network of expected costs for the five years: Based on Table (03), the network of expected costs can be drawn as follows:

Fig.1. Expected five-year adaptation network



Source: Authored by researchers

4.4 Find the shortest path in the expected adaptive network: The shortest path can be extracted through the following methods:

4.4.1 Minty method: This method, which bears the name of its owner, is based on the Minty algorithm, noting that it is used only in networks where closed loops do not appear.

-Solution steps: depend on the following steps

The first Stage: All vertices are numbered Xi with i variable from 0 to n-1 with n being the number of values.

The second stage: we give a value of 0 to the asset and put this value in a square.

The third stage: we look for the top that all previous peaks have a square and give it the value of λ_j where

$\lambda_j = \lambda_i + L(X_i, X_j)$ In the case that the arc ends at one peak, but if more than one arc reaches one peak, the following relationship is applied $\lambda_j = MIN\left[\lambda_i + L(X_i, X_j)\right]$

The Fourth stage: To determine the shortest path, we start from the last peak of the grid and keep only the peaks that guarantee the following equation $\lambda_i = \left[\lambda_j - L\left(X_i, X_j\right)\right]$ (Hirsch, 2012, pp. 192-196) .

According to the steps above, we will determine the shortest path in the expected cost network according to this method as follows:

Stage I and II: Numbering all peaks from 0 to n-1 giving the value 0 to the original.

Stage Three: Forward Calculations

We do the front calculations as follows

$\lambda_0 = 0$

$\lambda_1 = \lambda_0 + L\left(X_0, X_1\right) \Rightarrow \lambda_1 = 0 + 224000 = 224000$

$\lambda_2 = MIN\left[\lambda_0 + L\left(X_0, X_2\right); \lambda_1 + L\left(X_1, X_2\right)\right] \Rightarrow$

$\lambda_2 = MIN\left[0 + 396000; 224000 + 226000\right]$

$\lambda_2 = MIN\left[396000; 450000\right] \Rightarrow \lambda_2 = 396000$

$\lambda_3 = MIN\left[\lambda_0 + L\left(X_0, X_3\right); \lambda_1 + L\left(X_1, X_3\right); \lambda_2 + L\left(X_2, X_3\right)\right] \Rightarrow$

$\lambda_3 = MIN\left[0 + 608000; 224000 + 399000; 396000 + 228000\right]$

$\lambda_3 = MIN\left[608000; 623000; 624000\right] \Rightarrow \lambda_3 = 608000$

$\lambda_4 = MIN\left[\lambda_0 + L\left(X_0, X_4\right); \lambda_1 + L\left(X_1, X_4\right); \lambda_2 + L\left(X_2, X_4\right); \lambda_3 + L\left(X_3, X_4\right)\right] \Rightarrow$

$\lambda_4 = MIN\left[870000; 836000; 798000; 838000\right] \Rightarrow \lambda_4 = 798000$

$\lambda_5 = MIN\left[\lambda_0 + L\left(X_0, X_5\right); \lambda_1 + L\left(X_1, X_5\right); \lambda_2 + L\left(X_2, X_5\right); \lambda_3 + L\left(X_3, X_5\right); \lambda_4 + L\left(X_4, X_5\right)\right]$

$\lambda_5 = MIN\left[1162000; 1099000; 1012000; 1013000; 1030000\right] \Rightarrow \lambda_5 = 1012000$

Fourth Stage: **Background Accounts**

$\lambda_5 = 1012000$

$\lambda_4 = \left[\lambda_5 - L\left(X_4, X_5\right)\right] \Rightarrow \lambda_4 = \left[1012000 - 232000\right] \Rightarrow \lambda_4 = 780000$

$\lambda_3 = \left[\lambda_5 - L\left(X_3, X_5\right), \lambda_4 - L\left(X_3, X_4\right)\right] \Rightarrow$

$\lambda_3 = \left[1012000 - 405000; 780000 - 230000\right]$

$\lambda_3 = \left[607000; 550000\right] = 550000$

$\lambda_2 = \left[\lambda_3 - L\left(X_2, X_3\right); \lambda_4 - L\left(X_2, X_4\right); \lambda_5 - L\left(X_2, X_5\right)\right] \Rightarrow$

$\lambda_2 = \left[550000 - 228000; 780000 - 402000; 1012000 - 616000\right]$

$\lambda_2 = \left[322000; 378000; 396000\right] \Rightarrow \lambda_2 = 396000$

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$$\lambda_1 = \left[\lambda_2 - L\left(X_1, X_2\right); \lambda_3 - L\left(X_1, X_3\right); \lambda_4 - L\left(X_1, X_4\right); \lambda_5 - L\left(X_1, X_5\right)\right] \Rightarrow$$

$$\lambda_1 = [396000 - 226000; 550000 - 399000; 780000 - 612000; 1012000 - 875000]$$

$$\lambda_1 = [170000; 151000; 168000; 137000] \Rightarrow \lambda_1 = 137000$$

$$\lambda_0 = \left[\lambda_1 - L\left(X_0, X_1\right); \lambda_2 - L\left(X_0, X_2\right); \lambda_3 - L\left(X_0, X_3\right); \lambda_4 - L\left(X_0, X_4\right); \lambda_5 - L\left(X_0, X_5\right)\right] \Rightarrow$$

$$\lambda_1 = [-87000; 0; -58000; -90000; -150000] \Rightarrow \lambda_1 = 0$$

The shortest route is $5-2-0$ at an estimated cost of 1,012,000 DZD

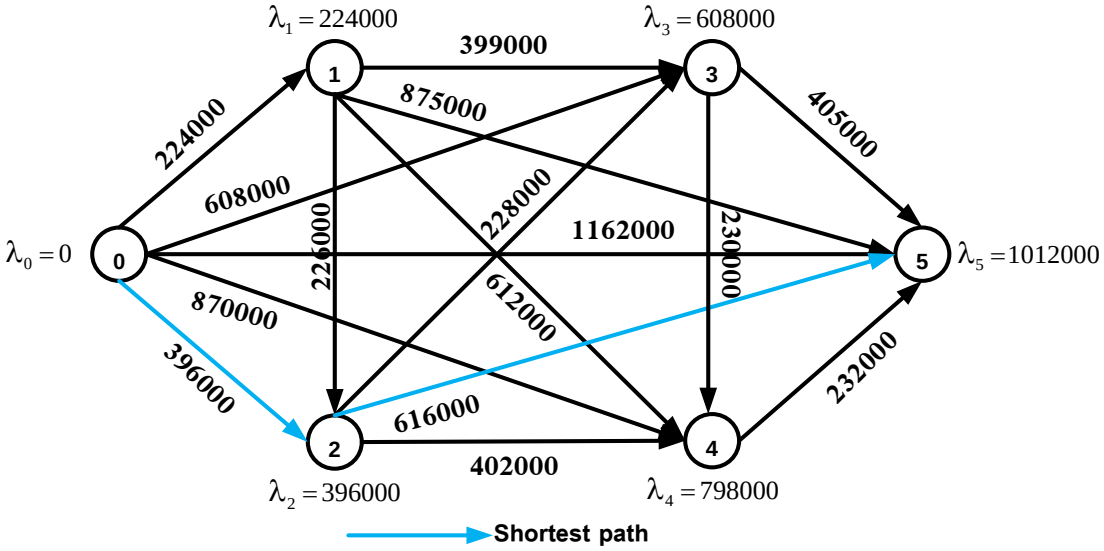
The shortest path reached can be explained as follows:

- Buying the machine on 01/01/2019 and operating it during that year and the following year 2020 and then selling it on 31/12/2020.

-Buying the machine on 01/01/2021 and operating it during the years 2021, 2022 and 2023 and then selling it at the end of the year 31/12/2023

This can be illustrated by the following network:

Fig.2. Shortest path using Minty method



Source: Authored by researchers

4.4.2 Ford method: It is named after the first to use it, and it will be used whether in the case of searching for the shortest route or for the longest lane.

In order to search for the shortest path, we follow the following steps

We rename the peaks of the statement as follows, tee peak $\mathbf{X_0}$ and next high $\mathbf{X_1}$ and so on until the peak of reaching the end is $\mathbf{X_{n-1}}$ where the total number of peaks is **n**.

-Next to the top $\mathbf{x_0}$ we put $\lambda_0 = 0$, next to the rest of the vertices $\mathbf{X_i}$ where $i \neq 0$ We put the value $\lambda_i = \infty$

-We assume that $L\left(X_i, X_j\right)$ is the load of the bow

- The calculation process is carried out in two stages, the home and away phase.

-In the going phase

-At every peak **Xj** you are in $\left(\lambda_j-\lambda_i\right)>L\left(X_i,X_j\right)$ ‘, if the condition is met, we substitute λ_j As follows

$$\lambda_j=\lambda_i+L\left(X_i,X_j\right)$$

-We continue the process until it is impossible to change any of the λ_j

-But if $\left(\lambda_j-\lambda_i\right)<L\left(X_i,X_j\right)$ The value of λ_j

It remains as it was before.

If the index of the right side of the stock is (i) greater than the index of the final party (j) i> j, (i = j) must be placed and recalculated from the value of i

-Return phase

In order to determine the path with the minimum value, it is sufficient to determine, from the end of the grid, the arrow whose vertices are the difference between the values of $\left(\lambda_j-\lambda_i\right)$ and the length of the accompanying value $L\left(X_i,X_j\right)$ Equal. (Ratoul, 2006, pp. 247-248).

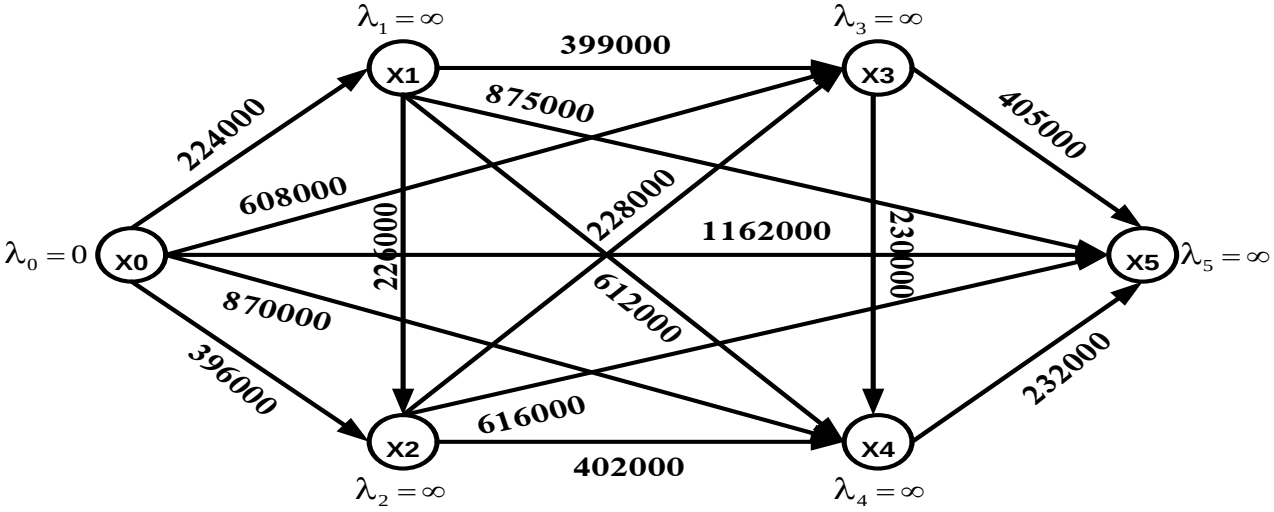
According to this method, we will determine the shortest path in the network of expected costs as follows:

We rename the peaks of the statement as follows, tee peak X_0 and next high X_1 and so on until the peak of reaching the end is X_{n-1} where the total number of peaks is n.

-Next to the top X_0 we put $\lambda_0=0$, next to the rest of the vertices X_i where $i\neq 0$ We put the value $\lambda_i=\infty$

The following figure illustrates this.

Fig.3. Working principle of the Ford method



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Source: Authored by researchers

After that, we calculate according to the round-trip stage as follows

-Go Phase

- Brackets that start from $X_0(X_0,X_1),(X_0,X_2),(X_0,X_3),(X_0,X_4),(X_0,X_5)$هي

-At the top X1 we find

$\lambda_1-\lambda_0=\infty-0=\infty>224000$

$\lambda_1=\lambda_0+L(X_0,X_1)\Rightarrow\lambda_1=0+224000=224000$

-At the top X2 we find $\lambda_2-\lambda_0=\infty-0=\infty>396000$

$\lambda_2=\lambda_0+L(X_0,X_2)\Rightarrow\lambda_2=0+396000=396000$

-At the top X3 we find $\lambda_3-\lambda_0=\infty-0=\infty>664680$

$\lambda_3=\lambda_0+L(X_0,X_3)\Rightarrow\lambda_3=0+608000=608000$

-At the top X4 we find $\lambda_4-\lambda_0=\infty-0=\infty>87000$

$\lambda_4=\lambda_0+L(X_0,X_4)\Rightarrow\lambda_4=0+870000=870000$

-At the top X5 we find $\lambda_5-\lambda_0=\infty-0=\infty>1162000$

$\lambda_5=\lambda_0+L(X_0,X_5)\Rightarrow\lambda_5=0+1162000=1162000$

-The parentheses that run from X1 are $(X_1,X_2),(X_1,X_3),(X_1,X_4),(X_1,X_5)$

-At the top X2 we find $\lambda_2-\lambda_1=396000-224000=172000<226000$

So λ_2 remains unchanged.

-At the top X3 we find

$\lambda_3-\lambda_1=608000-224000=384000<399000$

So λ_3 remains unchanged.

-At the top X4 we find

$\lambda_4-\lambda_1=870000-224000=646000>612000$

$\lambda_4=\lambda_1+L(X_1,X_4)\Rightarrow\lambda_4=224000+612000=836000$

-At the top X5 we find $\lambda_5-\lambda_1=1162000-224000=938000>875000$

$\lambda_5=\lambda_1+L(X_1,X_5)\Rightarrow\lambda_5=224000+875000=1099000$

- The parentheses that run from X2 are $(X_2,X_3),(X_2,X_4),(X_2,X_5)$

-At the top X3 we find

$\lambda_3-\lambda_2=608000-396000=212000<228000$

So λ_3 remains unchanged.

-At the top X4 we find $\lambda_4-\lambda_2=836000-396000=440000>402000$

$\lambda_4=\lambda_2+L(X_2,X_4)\Rightarrow\lambda_4=396000+402000=798000$

-At the top X5 we find $\lambda_5-\lambda_2=1099000-396000=703000>616000$

$\lambda_5=\lambda_2+L(X_2,X_5)\Rightarrow\lambda_5=396000+616000=1012000$

-The parentheses that run from X3 are $(X_3,X_4),(X_3,X_5)$

-At the top X4 we find $\lambda_4-\lambda_3=798000-608000=190000<230000$

So λ_4 remains unchanged.

-At the top X5 we find

$\lambda_5-\lambda_3=1012000-608000=404000<405000$

So λ_5 remains unchanged.

-The parentheses that run from X4 are (X_4,X_5)

-At the top X5 we find $\lambda_5-\lambda_4=1012000-798000=214000<232000$

So λ_5 remains unchanged

-Return phase

-The brackets that reach the top X5 are

$(X_0,X_5),(X_1,X_5),(X_2,X_5),(X_3,X_5),(X_4,X_5)$

We have $\lambda_5=1012000$

$\lambda_5-\lambda_4=1012000-798000=214000\notin(X_4,X_5)$

$\lambda_5-\lambda_3=1012000-608000=404000\notin(X_3,X_5)$

$\lambda_5-\lambda_2=1012000-396000=616000\in(X_2,X_5)$

$\lambda_5-\lambda_1=1012000-224000=788000\notin(X_1,X_5)$

$\lambda_5-\lambda_0=1012000-0=1012000\notin(X_0,X_5)$

-The arcs that reach the top X4 are $(X_0,X_4),(X_1,X_4),(X_2,X_4),(X_3,X_4)$

$\lambda_4-\lambda_3=798000-608000=190000\notin(X_3,X_4)$

$\lambda_4-\lambda_2=798000-396000=402000\in(X_2,X_4)$

$\lambda_4-\lambda_1=798000-224000=574000\notin(X_1,X_4)$

$\lambda_4-\lambda_0=798000-0=798000\notin(X_0,X_4)$

-The parentheses that reach the top of X3 are $(X_0,X_3),(X_1,X_3),(X_2,X_3)$

$\lambda_3-\lambda_2=608000-396000=212000\notin(X_2,X_3)$

$\lambda_3-\lambda_1=608000-224000=384000\notin(X_1,X_3)$

$\lambda_3-\lambda_0=608000-0=608000\in(X_0,X_3)$

-The parentheses that reach the top X2 are $(X_0,X_2),(X_1,X_2)$

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$\lambda_2 - \lambda_1 = 396000 - 224000 = 172000 \notin (X_1, X_2)$

$\lambda_2 - \lambda_0 = 396000 - 0 = 396000 \in (X_0, X_2)$

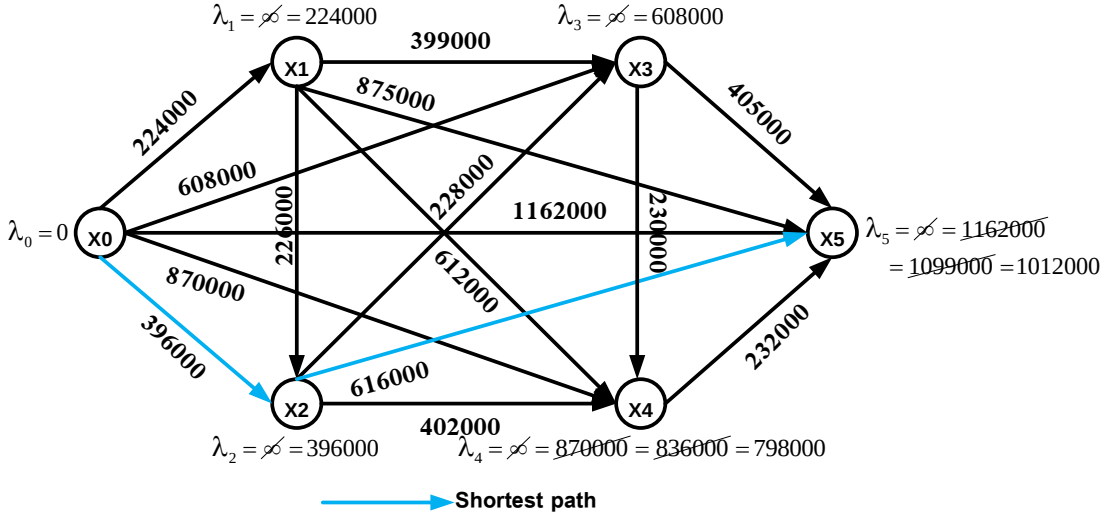
-The parentheses that reach the top X1 are (X_0, X_1)

$\lambda_1 - \lambda_0 = 224000 - 0 = 224000 \in (X_0, X_1)$

The shortest path is $X_0 - X_2 - X_5$

at an estimated cost of 1,012,000 DZD and the previously calculated results can be viewed through the following network

Fig.4. Shortest path using Ford method



Source: Authored by researchers

4.4.3 Bellman method: The Bellman algorithm natively addresses the question of the shortest path from source S in a non-circuit-bearing network to downstream D in this network. This algorithm gives Implicitly the shortest path from upstream Sto any node of the network and we will demonstrate how this algorithm works by finding the shortest path between Sand Din the grid N given in the following figure, (note that the network does not have circuits) The numbers given on the parentheses represent the weights of these parentheses. (al-Balkhi, Introduction to Operations Research, 2003, p. 347).

The principle of this method is as follows:

-We number the network headers sequentially from 01 to n.

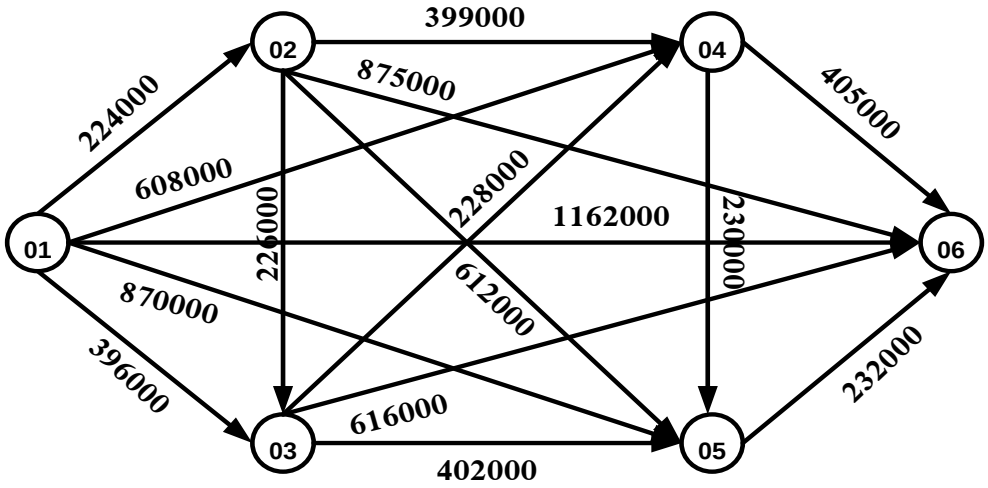
-We put on the headers of the network the values λ_j

-We start calculating the values of λ_j Starting from the back of the end of the network . (Ali, 2016, p. 163).

We will determine the shortest path in the network of expected costs according to this method as follows:

The following figure shows the principle of action of the Pillman method

Fig.5. The principle of action of the Pillman method



Source: Authored by researchers

Based on the previous network, we calculate to determine the shortest path as follows:

$$\lambda_6 = 0$$

$$\lambda_5 = \lambda_6 + L(X_5, X_6) \Rightarrow \lambda_5 = 0 + 232000 = 232000$$

$$\lambda_4 = \left(\begin{array}{c}\text{Min}\\ j=5,6\end{array}\right)\left(\lambda_5 + L(X_4, X_5), \lambda_6 + L(X_4, X_6)\right) \Rightarrow \lambda_4 = \text{Min}(232000 + 230000; 0 + 405000) \Rightarrow$$

$$\lambda_4 = \text{Min}(462000{,}10; 405000) \Rightarrow \lambda_4 = 405000$$

$$\lambda_3 = \left(\begin{array}{c}\text{Min}\\ j=4,5,6\end{array}\right)\left(\lambda_4 + L(X_3, X_4); \lambda_5 + L(X_3, X_5); \lambda_6 + L(X_3, X_6)\right) \Rightarrow$$

$$\lambda_3 = \text{Min}(405000 + 228000; 232000 + 402000; 0 + 616000) \Rightarrow$$

$$\lambda_3 = \text{Min}(633000; 634000; 616000) \Rightarrow \lambda_3 = 616000$$

$$\lambda_2 = \left(\begin{array}{c}\text{Min}\\ j=3,4,5,6\end{array}\right)\left(\lambda_3 + L(X_2, X_3); \lambda_4 + L(X_2, X_4); \lambda_5 + L(X_2, X_5); \lambda_6 + L(X_2, X_6)\right) \Rightarrow$$

$$\lambda_2 = \text{Min}(616000 + 226000; 405000 + 399000; 232000 + 612000; 0 + 875000)$$

$$\lambda_2 = \text{Min}(842000; 804000; 844000; 875000) \Rightarrow \lambda_2 = 804000$$

$$\lambda_1 = \left(\begin{array}{c}\text{Min}\\ j=2,3,4,5,6\end{array}\right)\left(\begin{array}{l}\lambda_2 + L(X_1, X_2); \lambda_3 + L(X_1, X_3); \lambda_4 + L(X_1, X_4);\\ \lambda_5 + L(X_1, X_5); \lambda_6 + L(X_1, X_6)\end{array}\right) \Rightarrow$$

$$\lambda_1 = \text{Min}\left(\begin{array}{l}804000 + 224000; 616000 + 396000; 405000 + 608000;\\ 232000 + 870000; 0 + 1162000\end{array}\right) \Rightarrow$$

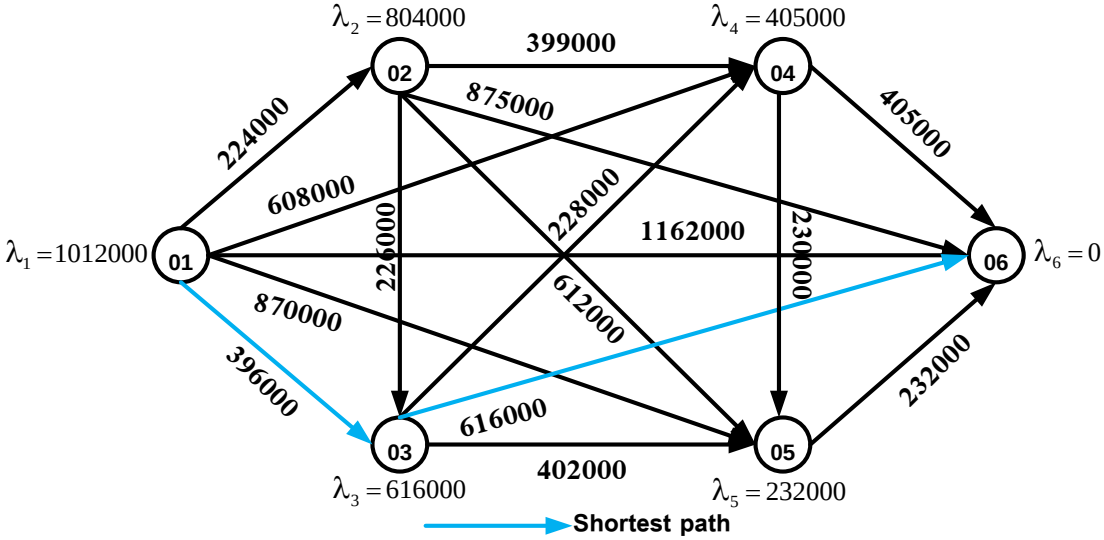
$$\lambda_1 = \text{Min}(1028000; 1012000; 1013000; 1102000; 1162000) \Rightarrow \lambda_1 = 1012000$$

Therefore, the shortest route is 01-03-06

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All previous calculations and findings can be illustrated through the following network:

Fig.6. Shortest path using the Pillman method



Source: Authored by researchers

4.4.4 Danzig method: To find the path with the lowest value in the network, we follow these steps:

-We number the network headers a specific sequential number from 01 to n.

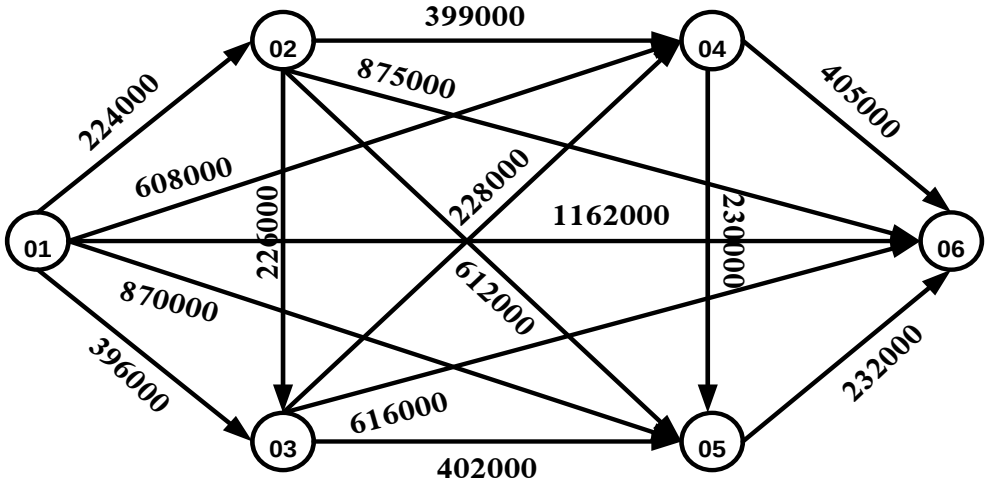
-We put on the headers of the network the values λ_i

-We start calculating the values of λ_i Starting from the front (from the beginning of the grid). (Ali, 2016, p. 165).

We will determine the shortest path in the network of expected costs according to this method as follows:

The following figure shows the principle of action of the Danzig method

Fig.7. Working principle of the Danzig method



Source: Authored by researchers

Based on the previous network, we calculate to determine the shortest path as follows:

$$\lambda_1 = 0$$

$$\lambda_2 = \lambda_1 + L(X_1, X_2) \Rightarrow \lambda_2 = 0 + 224000 = 224000$$

$$\lambda_3 = \begin{pmatrix} \text{Min} \\ j=1,2 \end{pmatrix} (\lambda_1 + L(X_1, X_3), \lambda_2 + L(X_2, X_3)) \Rightarrow \lambda_3 = \text{Min}(0 + 396000; 224000 + 226000) \Rightarrow$$

$$\lambda_3 = \text{Min}(396000; 450000) \Rightarrow \lambda_3 = 396000$$

$$\lambda_4 = \begin{pmatrix} \text{Min} \\ j=1,2,3 \end{pmatrix} (\lambda_1 + L(X_1, X_4); \lambda_2 + L(X_2, X_4); \lambda_3 + L(X_3, X_4)) \Rightarrow$$

$$\lambda_4 = \text{Min}(0 + 608000; 224000 + 399000; 396000 + 228000) \Rightarrow$$

$$\lambda_4 = \text{Min}(608000; 623000; 624000) \Rightarrow \lambda_4 = 608000$$

$$\lambda_5 = \begin{pmatrix} \text{Min} \\ j=1,2,3,4 \end{pmatrix} (\lambda_1 + L(X_1, X_5); \lambda_2 + L(X_2, X_5); \lambda_3 + L(X_3, X_5); \lambda_4 + L(X_4, X_5)) \Rightarrow$$

$$\lambda_5 = \text{Min}(0 + 870000; 224000 + 612000; 396000 + 402000; 608000 + 230000)$$

$$\lambda_5 = \text{Min}(870000; 836000; 798000; 838000) \Rightarrow \lambda_5 = 798000$$

$$\lambda_6 = \begin{pmatrix} \text{Min} \\ j=1,2,3,4,5 \end{pmatrix} \begin{pmatrix} \lambda_1 + L(X_1, X_6); \lambda_2 + L(X_2, X_6); \lambda_3 + L(X_3, X_6); \\ \lambda_4 + L(X_4, X_6); \lambda_5 + L(X_5, X_6) \end{pmatrix} \Rightarrow$$

$$\lambda_6 = \text{Min} \begin{pmatrix} 0 + 1162000; 224000 + 875000; 396000 + 616000; \\ 608000 + 405000; 798000 + 232000 \end{pmatrix} \Rightarrow$$

$$\lambda_6 = \text{Min}(1162000; 1099000; 1012000; 1013000; 1030000) \Rightarrow$$

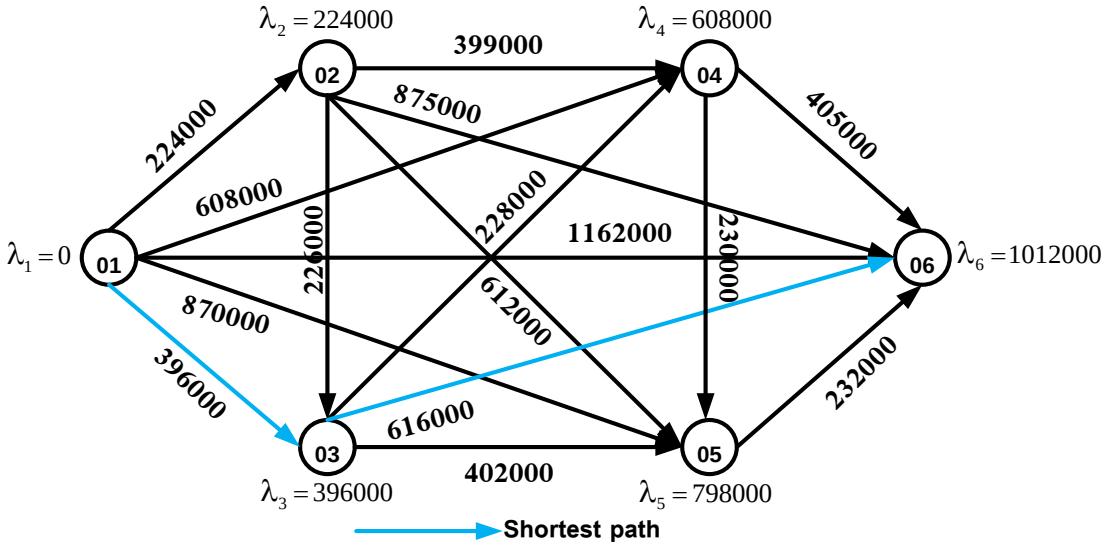
$$\lambda_6 = 1012000$$

Therefore, the shortest route is **01-03-06**

All previous calculations and findings can be illustrated through the following network:

Fig.8. Shortest path using Danzig method

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Source: Authored by researcher

5. CONCLUSION

Through the applied study that took place in the National Corporation for Electrochemical Products in Tiaret and the Sougueur unit, in order to analyze the useful life of the investment replacement by determining the expected cost of the five years of this investment, the network of expected costs has been drawn in order to determine the shortest path through a set of quantitative mathematical methods and these methods are (Minty method, Ford, Belman, Danzig) and we have reached through the application of all these methods that the shortest path in the network of expected costs of investment during the next five years It is the same path for all roads and at a minimum cost of 1,012,000 DZD, meaning that those in charge of the institution have to buy the investment on 01/01/2020 and exploit it for two years, then sell it on 31/12/2021 and replace it with another investment by buying it on 01/01/2022 and exploiting it for three years and selling it at the end of 12/31/2024.

Results of the study:

- The method of replacing one investment with another is one of the most effective ways to renew the company's investments.

The shortest path method is one of the quantitative methods used in the investment substitution process.

This method of analyzing the useful life of the investment depends on the expected costs for years to come with the identification of the network of different paths for these forecasts.

- The shortest path method helps in the optimal utilization of investment.

The same route was reached using the four routes (Minty, Ford, Belman and Danzig).

05-02 Recommendations & Suggestions

- Training of the tires of the National Corporation for Electrochemical Products in the tires of the Sougueur unit in the use of quantitative methods.

–There are several ways to determine the shortest path, including the matrices method and the cycle method.

- Conducting a comparison in the analysis of the useful life of the investment between several mathematical methods, including the present value method and the shortest path method in making the optimal decision.

- The use of specialized programs in determining the shortest path, including the win Qsb program and the QM program .

Specialized programs help save time and effort when future cost projections are long, i.e. more than five years.

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