MANAGEMENT SCIENCE

Management science is a synonymous with operational research. Operation s research provides a quantitative technique or a scientific approach to the executives for making good decisions for operation under control. It provides a scientific approach to problem solving for executive management.

Operations research

Operations research is the application of methods of science to complex problems arising in the direction and management of large systems of man, machine, material and money in industry, business, government and defense.

Definition

According to T.L Satly " OR is the art of giving bad answers to the problems where otherwise worse answers are given"

Characteristics of Operations research technique

1. Operations research technique is multidisciplinary.
2. It is used to solve complex management problems.
3. It is a continue process.
4. It is a set of mathematical techniques.
5. It is a scientific approach in decision making.
6. It is a team activity

Functions of OR

1.OR is the application of scientific methods to solve the problems connected with human organization

2. OR provide a more accurate description about the cause and effect relationship

3. OR provide solutions for various business problems

4. OR facilitates the process of decision making

5. optimum allocation of limited resources

6. planning, scheduling, controlling large and complex projects

Scope of Operations Research

The main objective of operations research is to solve complex management problems. It is mainly used in decision problem. A multi-disciplinary team used various operations research techniques to solve complex decision problems. The members of the team work together to find a feasible solution which is beneficial for the entire organization. The scope of the operations research involves the following areas.

1. In defense operations: A number of components are involved in military operations. Each component works to achieve maximum gain from its operation. The experts in this field coordinate the entire activities and they utilize their skill to achieve optimum solution.

2. In industry: In an industrial organization there are number of departments. Each department tries to optimize capital investment. HRM department tries to appoint efficient people at minimum cost. There is a conflict between these departments. The application of operations research techniques helps to integrate the activities of various departments to attain the overall objective of the organization. Decision trees, inventory model, linear programming, transportation model, sequencing model, assignment model and replacement model are helpful to the mangers to solve various problems.

3. In agriculture: Operations research techniques are used to select land area for agriculture and the seed of food grains.

4. In traffic control : Queuing theory is used for traffic control.

5. In hospitals: In hospitals we can see lengthy queues. This problem can be solved by the application of operations research techniques.

6. planning: Govt. uses the OR techniques in order to maximize per capita income with minimum sacrifice of time. Govt. can further use OR techniques for framing future

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policies.

7. Research and development: OR techniques can be applied for control of R & D projects, product introduction, product planning etc.

Management uses of OR

The following are the some of the areas of management where tools of OR are used

1.finanance, budgeting and investment

a)Cash flow analysis used to determine long term capital requirements, dividend policies etc.

b) To determine the credit policies of the organization

2. purchasing and procurement

a)To determine the quantity and timing of purchase of raw materials, machineries etc.

b) To decide rules for buying and supplying under different pricing

c) Equipment replacement policies

d)To determine the strategies for exploration of new material sources

3. production management

a).To take decision related with location and size of warehouses, distribution centres etc.

b) To take decision of distribution policy

c) Used in production scheduling, allocation of resources etc.

d) Used to determine optimum production mix

4. Marketing management

a).Used for product selection, timing etc.

b) Used to decide advertising strategy

c) Determine the size of stock to meet future demand

5. personnel management

a)Used to decide recruitment policies and assignment of jobs

b) Selection of suitable employees

Phases of OR

1.formulation of problem

2. set up a mathematical model for the problem

3. deriving solutions from the model

4.Testing the model

5. establishing control over the model

6. implementing the solution

OR models

1.physical model (iconic model) : it include all the form =s of diagrams, graphs and charts. They bring out significant factors and inter-relationship in pictorial form so as to facilitate analysis

2. mathematical model: it is known as symbolic model also. It employs a set of mathematical symbols to represent the decision variable of the system.

3. analogue models : in this model set of properties are used. An organization chart is a common analogue model.

4. by nature of environment:

a).**deterministic model** in which everything is defined and the results are certain.

b) **probabilistic model** in which the input and output variables follow a probability distribution

5. by the extend of generality

a).**general model** : it can be applied in general and does not pertain to one problem only

b) **specific model:** it is applicable under specific condition only.

6. according to procedure

a).**analytical model:** mathematical tools are used to solve a problem

b)**simulation:** numerical solution method which helps to analyze a system to find its optimum solution through trial and error method.

OR techniques

1.probability: the probability concepts try to analyze uncertainties and bring out necessary data with reasonable accuracy for the purpose of decision making

2. Linear Programming: This model is used

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for resource allocation when the resources are limited and there are number of competing candidates for the use of resources. The model may be used to maximize the returns or minimize the costs.

3. Sequencing: When a manufacturing firm has some job orders, which can be processed on two or three machines and the processing times of each job on each machine is known, then the problem of processing in a sequence to minimize the cost or time is known as Sequencing model.

4. Waiting Line Model or Queuing Model: A model used for solving a problem where certain service facilities have to provide service to its customers, so as to avoid lengthy waiting line or queue, so that customers will get satisfaction from effective service and idle time of service facilities are minimized is waiting line model or queuing model.

5. Decision theory: OR technique of Decision theory is applied to select best alternative course of action

6. Game theory: Game theory helps to determine the best course of action for a firm in view of the expected counter moves from the competitors.

7. Transportation problem: The aim of this technique is find out the minimum transportation cost.

8. The assignment problem: This technique is used to assign jobs to efficient and suitable persons at minimum cost.

9. Network analysis: Program evaluation and review technique and critical path method are powerful tools for planning and control of complex jobs involving a large number of complex activities.

10. dynamic programming : this technique deals with the problems that arise in connection with multi period analysis and decisions.

11. simulation: it uses a computerized symbolic model in order to represent actual decision making under certainty for determining alternative course of action based upon facts and assumptions.

12. Replacement theory: this theory suggested the determination of the time when items of plant should be replaced.

13. non linear programming: it is that form of programming in which some or all variables are curvy linear.

14. goal programming : goal programming deals with problems having multiple objectives.

15. markov analysis : it is a method of analyzing the current movement of the same variable in an effort to predict the future movement of same variable.

Limitations of OR

1.huge calculations are required for solving some problems

2. OR provides solution only if the elements are quantified.

3. possibility of having frequent changes in basic data

LINEAR PROGRAMMING PROBLEM LPP

Linear programming is widely used mathematical modeling technique, which is developed to help decision makers in planning and decision making as far as resource allocation is concerned. It is a technique for choosing the best alternatives from a set of feasible alternatives, in situation in which the objective e function as well as constraints can be expressed as linear mathematical functions. Linear programming involves optimization of certain functions called objective function subject to certain constraints. Linear programming technique may be used for solving broad range of problems arising in business, government, industry, hospitals, libraries, etc.

definition

Samulson,Dorfman and Solow stated that LPP as “the analysis of problems in which a linear function of a number of variables is to

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be maximized (or minimized) when these variables are subject to a number of restraints in the form of linear inequalities".

Application areas of LPP

1.industry

a).**product mix problem:** LP is used to select optimal product mix to make best use of machine and man hours available while maximization of profit.

b) **product scheduling:** LP is useful for allocating operators to machines, products, machines.

c).**product smoothening:** with the help of LPP an industrial organization can solve the problem of scheduling its production on the basis of future demand of the products.

d) by using transportation technique of LP, we can decide the distribution system that will minimize the transportation cost from several warehouses to different market locations

e) **problem related with production distribution**: the problem is to minimize cost by deciding what is to be produced at each source and where the goods are to be transported.

f) **communication industry** : LP methods are used to solve problems involving facilities for transportation, relaying etc.

2. management application

a). **Portfolio selection:** This involves the selection of specific investment activity among several activities. The objective function is to find the allocation which maximizes the expected return.

b. Profit planning: It involves the maximization of profit margin from investment in plant facilities and equipment, cash in hand etc.

c. Physical distribution: It determines the most economical and efficient manner of allocating manufacturing plants and distribution centres for physical distribution.

d. staffing problem/ job evaluation: Selection of suitable person for a specified job and evaluation of a job in organization has been done with the help of Linear programming technique.

e. media selection: the LPP is used to select the advertising mix that will maximize the audience exposure.

Merits of LP

1.it helps an organization to study the information through scientific approach

2. the application of LPP helps to consider all possible solutions of a problem and selct the optimal solution

3. LP helps to identify the constraints under which an organization operates.

4. plans can be reevaluated for changing conditions

5. can be used for production problems

Demerits of LP

1.a LP model can only be applied if the constraints and objectives functions can be stated as linear expressions

2. co-efficient in the objective function and the constraints equations must be completely known to create linear equations

3. it may provide fractional valued answers

4. if the management has conflicting multiple goals, the LP will fail to give correct solution

5. LP does not consider the effect of time and uncertainty

Basic requirements of LP

Well defined objective function : a LPP should have a well defined objective function. Objective function may be to maximize profit or minimize cost.

Constraints: there are limited restrictions on resources, which are to be allocated to various activities. These limited resources are expressed as constraints or restrictions

Decision variable and their relationship: the decision variables are activity variables such as products, services etc. these variables are usually interrelated in terms of utilization of resources. The relationship among the variables should be linear.

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Alternative course of action : there should be alternative course of action for selecting the best course of action.

Non negative restrictions : all decisions variables must assume non negative values. The negative values of physical quantities are impossible.

Assumptions

Linearity: the basic assumption is that the objectives and constraints governing it should be linear in form. Both must be expressed in terms of linear equation or inequalities.

Finiteness: the activities and constraints must be finite in number

Additivity: sum of the resources used by different activities must be equal to the total quantity resources used by each activity individually.

Certainty: all model coefficient like unit profit contribution of each product are assumed to be known with certainty. It is also assumed that these are not changing under the period of study.

Divisibility: the solution of LPP need not be in integers(whole numbers). The solution figures are divisible and may take any fractional value.

Deterministic: we assume that condition of certainty exist with each problem. That means the coefficient in the objective function and constraints are completely known.

Formulation of Mathematical Model to Linear Programming Program

Formulation of Linear Programming model involves the following steps.

1. Identification of the problem and setting up of objectives.

2. Establish the interrelationship between the variables of the situation.

3. Identification of alternative variables

4. Specification of constraints.

5. Summarizing the problem in a mathematical form.

Graphical method

Graphical method is used to solve linear programming problem. It involves two variables. Each line is represented by each constraint.

Steps

1. Formulate the problem.

2. All constraints may be written as equality.

3. Draw the curve.

4. Find out the feasible region.

Feasible solution :

Any combination of activity levels which satisfies all constraints, including non negative restrictions, is known as feasible solution to the problem

Meaning of project

A project simply refers to any investment opportunity which is to be exploited for profit. It may consist of a new product, new service, new organization, new business.

NETWORK ANALYSIS

A project is composed of jobs, activities or functions that are related to one another and all these should be completed in order to complete the project. These activities are arranged in logical sequence in the form of network. Network is a combination of activities & events of a project. Network analysis is a system which plans projects by analyzing the project activities.

Objectives of network analysis

1.powerful tool for planning, scheduling and control of projects

2. it shows a simple way of the inter-relationship of the various activities consulting a project.

3. to minimize the total cost of the project

4. Helps to minimize time of the completion of the project

5. it leads to optimal use of resources

6. it avoids production delays

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Managerial application of network analysis

1.planning

2. research and development

3. installation of a complex new equipment

4. market penetration programme

5. construction of building, bridges, factories etc

6. preparation of inventory plans

7. market strategies

8. launching of new products

Terms related with network analysis

1).Network diagram- it is a diagram showing the activities & events of a project, their sequence & relationship.

2).Activity- it is a job or task or item of work to be completed in specific time.

3).Event- it represent start or end of an activity(represent by circle called node)

4).Dummy activity- it is an imaginary activity included in the activity. It does not consume time.

Methods of network analysis

Critical path method (CPM)

It is a network technique involving the preparation of the network in the form of arrow diagram and its analysis to identify the critical path.

Terms related with CPM

1).Critical path- it is the longest path in the network

Critical activities- these are the activities lying on the critical path

2).Preceding activities(predecessor)- activities must be completed immediately prior to the start of another activity are called preceding activity

3).Succeeding activity(successor)- activities that cannot be started until one or more of the activities are completed are called succeeding activity.

4).Concurrent activities- activities which can be accomplished concurrently or simultaneously are known as concurrent activities.

5).Earliest start time(EST)- it is the earliest time an activity can begin.

6).Latest start time(LST)- it is the difference between latest finish time the estimated time for the activity.

7).Earliest finish time(EFT)- EST + activity time duration.

8).Latest finish time(LFT)- it is the latest possible time an activity can finish without delaying the project.

9).Float- float means amount of excess or spare time up to which an activity can be delayed without affecting the project. Float may be two type – free float & independent float.

10).Free float: free float is that portion of the total float within which an activity can be manipulated without affecting the float of subsequent activities

11).Independent float: it is that portion of total float within which an activity can be delayed for start without affecting floats of the preceding activities.

Application of CPM

- Construction of dams or canals
- Construction of building or highway
- Communication networks
- Production planning
- Maintenance of oil refinery & aero planes

Advantages of CPM

- Makes better & detail planning
- Helps in ascertaining the time schedule
- Control become easy
- Identify critical elements
- Optimum utilization of resources

Disadvantages

- Based on assumptions
- Rigidity
- Not a panacea for all ills

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PERT(Programme Evaluation & Review Technique)

It is a network technique of scheduling & controlling the project where activity times cannot be precisely estimated.

Terms related with PERT

- **Optimistic time**-
  shortest possible time in which an activity can be completed.
- **Pessimistic time**-
  maximum possible time in which an activity can be completed.
- **Most likely time**-
  normal time an activity would take.
- **Slack**-
  it is similar to float but associated with event and used in PERT.

Advantages of PERT

- Reduces cost & time
- Effective control
- Handles uncertainties
- Provide updated project information

Disadvantages

- Difficult to develop clear & logical network
- All activities cannot be clearly identified in some projects
- Not suitable in certain projects
- Error in time estimation

Application of PERT

- Construction of industry
- Installation of plant & machinery
- Maintenance & major repairs of ships, aircrafts etc.
- Administration
- Managing accounts
- Defense projects
- Research & development projects

Difference between CPM & PERT

CPM	PERT
Activity oriented	Event oriented
Deterministic model	Probabilistic model
Single time estimate	3 time estimate
Concerned with time only	Consider both time & cost
It does not reveal critical & non critical activities	It reveal critical & non critical activities
Critical path is determined on the basis of float	Critical path is determined on the basis of slack
It used in construction & industrial projects	Mainly used in defence & Research &development project
Dummy activities are not compulsory	Compulsory

CHAPTER 4

DECISION THEORY

The decision theory is a technique used for decision making in uncertain conditions or situations. It provides a framework and methodology for rational decision making when the outcomes are uncertain. Decision making may be defined as a process which results on the selection from a set of alternative course of actions which is considered to meet the objectives of the decision problem more satisfactory than others judged by decision makers.

Elements common to all decisions

1. Course of action: - There is finite number of decision alternatives available to the decision maker at each point in time when a decision is made. The number and type of such alternatives may depend upon the previous decisions. These alternatives are called course of action.

2. State of nature: - These are future conditions that are not under the control of

decision maker. A state of nature may be the state of economy, a weather condition, a political development, etc.

3. Pay off: It is the outcome resulting from each possible combination of alternatives and states of nature. The pay off values is always conditional values because of unknown states of nature.

Payoff table: it is also known as pay off matrix. This depicts the tabular form of pay off of various alternative course of action vs states of nature.

Opportunity loss table / regret table: Opportunity loss of an act is the difference between the payoff of that act or action and payoff of the best act which has foregone.

Decision making environments

- Decision making under certainty
- Decision making under uncertainty
- Decision making under risk
- Decision making under competition

Decision making under certainty

Certainty refers to an environment in which the decision maker is in a position to know exactly what will happen by his decision during the period in which such a decision is made. That means it is the situation in which the decision maker knows the consequences of every action and option available to him in taking decision.

Decision making under uncertainty

In decision making under pure uncertainty, the decision maker has absolutely no knowledge, not even about the likelihood of occurrence for any state of nature. In such situations, the decision maker's behavior is purely based on his/her attitude toward the unknown.

There are different **criteria** of decision making under this situation.

1. Optimism criterion

2. Pessimism criterion

3. Equal probabilities

4. Regret criterion.

Optimism (maximax or minimax) criterion: As per this criterion the decision maker ensures that he should not miss the opportunity to achieve the largest possible profit. In the maximax criterion the decision maker selects the decision that will result in the maximum of maximum payoffs; known as an optimistic criterion.

2. Pessimism (maximin or Minimax) criterion: In this criterion the decision maker ensures that he would earn no less than some specified amount. The decision maker selects the alternative that represents the maximum of minima pay off in case of profits. This criterion is also known as Wald's criterion.

3. Laplace criterion: We don't know the states of nature. Hence it is assumed that all states of nature will occur with equal probability.

Steps

1. Assign equal probability value to each state of nature.

2. Compute the expected or average pay off for each alternative by adding all the payoff and dividing by the number of possible states of nature. (Probability of state of nature *j) x (pay off value for the combination of alternative i and state of nature j.)*

3. Select the best expected pay off

4. Criterion of realism (Hurwicz criterion): As per this criterion a rational decision maker is neither completely optimistic nor pessimistic. Hurwicz introduced coefficient of optimism. The Hurwicz alpha is a criterion for decision making under complete uncertainty that represents a compromise between the Maximin and Maximax criteria. The alpha is a number between 0 and 1. In the special case where it is one, the criterion reduces to Maximin and in the special case where it is zero the criterion reduces to Maximax. The decision maker can set alpha to a number between zero and one according to his or her level of optimism. H (criterion of realism) =

∝ ( ) + (1 -∝) (minimum in column). Select an alternative with best anticipated weighted average pay off value.

Decision making under risk

It is a probabilistic situation. Here more than one state opt nature exists. The decision maker has sufficient information to assign probability values to the likely occurrence of each of these states. On the basis of knowing the probability distribution of the states of nature, the best decision is to select the course of action which has the largest expected pay off value. There are mainly **three methods** used to find decisions under risk.

a) Expected Monetary Value

b) Expected opportunity loss criterion

c) Expected value of regrets

Expected monetary value (EMV): It is the weighted sum of possible pay off for each alternative. EMV = conditional profits or losses× corresponding probability of each state of nature.

Expected Value of perfect information: If the decision maker is able to acquire perfect information about the occurrence of various states of nature, then he will be able to select a course of action that yields the desired pay off for whatever state of nature actually happens. The expected value of perfect information is the expected outcome with perfect information.

EVPI = Expected value with perfect information – maximum EMV.

Expected value with perfect information = (best outcome for consequence for first state of nature ×probability of first state of nature) + best outcome for consequence for second state of nature ×probability of second state of nature)

Expected value of regrets or expected opportunity loss (EOL): As per the criterion, the decision is to select the strategy with minimum expected opportunity loss.

Decision making under competition or conflict(game theory)

Game theory is a study of strategic decision making. More formally, it is "the study of mathematical models of conflict and cooperation between intelligent rational decision-makers. Game theory is a branch of mathematics that deals with the analysis of games (i.e., situations involving parties with conflicting interests). It is concerned with decision making in organizations where the outcome depends upon decisions of two or autonomous players**,** one of which may be nature itself and where no single decision maker has full control over the outcomes. It aims to find optimal solutions to situations of conflict and cooperation under the assumption that players are instrumentally rational and act in their best interests. The basic constituents of any game are its participating, autonomous decision makers called players. A game must have two players. The total number of players may be large, but must be finite, and must be known. Each player must have more than one choice.

Decision trees

A **decision tree** is a decision support tool that uses a tree-like graph or model of decisions and their possible consequences, including chance event outcomes, resource costs, and utility. It is one way to display an algorithm. Decision trees are commonly used in operations research, specifically in decision analysis, to help identify a strategy most likely to reach a goal. It is a schematic tree-shaped diagram used to determine a course of action or show a statistical probability. Each branch of the decision tree represents a possible decision or occurrence. The tree structure shows how one choice leads to the next, and the use of branches indicates that each option is mutually exclusive. A decision tree consists of 3 types of **nodes:**

1. **Decision nodes** - commonly represented by squares. It indicates places where a

decision maker must make a decision.

2. **Chance nodes** - represented by circles. It is point at which decision maker will discover the response to his decision.

3. **End nodes** - represented by triangles

CHAPTER5

TRANSPORTATIONMODEL

The transportation problem involves determining a minimum-cost plan for shipping from multiple sources to multiple destinations. A transportation model is used to determine how to distribute supplies to various destinations while minimizing total cost. The main objective of a transportation problem is to satisfy the demand destination requirements within the plant capacity constraints at minimum transportation cost.

Special terms related to transportation problem

Feasible solution: Feasible solution to a transportation problem is a set of non-negative allocations ($X_{ij} > 0$) which satisfies the row and column sum restrictions.

Basic feasible solution: A feasible solution is a basic solution if the number of non-negative allocations is equal to m+n -1, where 'm' is the number of rows and 'n' is the number of columns in a transportation problem.

Optimal solution: A feasible solution is said to be an optimal solution, if it minimizes the transportation cost.

Non degenerate basic feasible solution: A feasible solution to a transportation problem is said to be non degenerate if it contains m+n -1 and each allocation is independent.

Loops in transportation problem: A ordered set of four or more cells can be formed as a loop, of any of the two adjacent cells in the ordered set lie either in the same row or in the same column. A feasible solution to a transportation problem is basic if the corresponding cells in the transportation table do not contain a loop.

Solution to a transportation problem

The following are the **steps** to solve a transportation problem.

1. Define the objective function. That is minimization of cost.

2. Set up a transportation table with 'm' rows and 'n' columns

3. Develop an initial feasible solution.

4. Verify the initial feasible solution is optimum or not.

5. If the solution is not optimal, then modify the allocation.

6. Repeat step and six till we get an optimal solution.

Methods to find out initial feasible solution

1. North West corner method (NWCM)

2. Least cost method (LCM)

3. Vogel's approximation method

North West corner method

It is a simple method to obtain an initial solution. This method does not take into account the cost of transportation on any route of transportation.

Steps

1. Start with the cell at the North West corner of the transportation matrix and allocate commodity equal to the minimum of the rim values for the first row and first column.

2. If allocation done in step I is equal to the supply available at first source, then move vertically down to the cell (2,1) in the second row and first column.

3. Apply step one again for next allocation.

4. If allocation made in step 2 is equal to the supply available at second source, then move vertically down to the cell (3,1).

5. Continue the procedure till an allocation is made in the south east corner cell of the transportations table.

Least cost method

In this method allocations are made in the

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cells with the smallest unit cost. It reduces the computation as well as the amount of time necessary to arrive at the optimal solution

Steps

1 . Select the cell with the lowest transportation cost among all the rows or columns of the transportation table,

2. If there are more than two lowest same cost, we can select the cell for allocation arbitrarily, among the lowest cost cells.

3 . Assign maximum units in the lowest cost cell. Then we can exhaust either a row total or a column on the basis of allocation. Eliminate that column or row.

4 . Consider the reduced matrix table and select another lowest cost cell. Then allocate the maximum units in that cell. On the basis of that we can exhaust either a row or column.

5 . Continue the process till all the available quantities are exhausted.

3. Vogel's Approximation Method

Vogel's method is based on the concept of opportunity cost. Opportunity cost is the cost incurred for forgone opportunities or penalties.

Steps

1 . Find the penalty cost namely the difference between the smallest and next smallest costs in each row and column.

2 . Among the penalties found in step (1), select the maximum penalty. If there is a tie relate with maximum penalties, select any one arbitrarily.

3 . From the selected column or row (as per step 2) fin d out the cell which is having lowest cost. As much as quantity must be allocated to this cell by considering the demand and supply .

4 . The column or row which is exhausted, is to be deleted. The above steps is to be continued till an initial feasible solution is attained. It should be noted that if column is exhausted, then there will be a change in row penalty and vice versa.

Finding the optimal solution

Once the initial basic feasible solution has been computed, the next step is to determine whether the solution obtained is optimum or not. To perform optimality test, we can discuss the modified distribution method (MODI).

Steps in MODI method or U.V method

1.Find the initial basic feasible solution of transportation problem by using one of the three methods described earlier.

2. determine a set of numbers for each row and each column. That is U1 and V1 for each row and column satisfying U1 + V! = Cij for each occupied cell.

3. then calculate cell evaluation known as dij values for unoccupied cells. That is dij = Cij (U1=V1)

4.if all dij values are positive, the solution is optimal and an unique solution exists. If at least one of them is zero and other are positive, the solution is optimum but alternative solution exist. If at least one dij is negative, the solution is not optimal.

5. reallocation are to made, If the solution is not optimal. Give maximum allocation to the cell for which dij is negative making one of the occupied cell is empty.

6. select empty having the most negative value Cij.

7. draw a closed path or loop for unoccupied cell selected in step 6. Assign +ve and –ve alternatively and find the minimum allocation cell having –ve sign. The allocation should be added to the allocation having positive sign and subtract from the allocations having negative sign.

8. repeat from the step 2 till an optimum basic solution is obtained.

Degeneracy in transportation problem

Some times the number of non negative independent allocation is less than m+n-1, in transportation problem. It may happen either at the initial stage or at subsequent

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iteration. It is called degeneracy.

Unbalanced transportation problem

To obtain a feasible solution, it is necessary that the total supply must equal to total demand. In unbalanced transportation problem it is not equal. This unbalanced problem is to be converted into a balanced transportation problem. For this fictitious destination or source which will provide the surplus supply or demands to be added.

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