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# Designing a Supply Chain Based on Multi-Goal Salesman Style

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**Key words:** Supply chain, travelling salesman problem, goal programming, lingo, factories

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**Abstract:** Transport and distribution is one of the most important elements in the supply chain system which is of great importance in the success of the chain. Al-Rafidain factory, the largest factory in Abu Ghraib was chosen as one of the most productive and diversified factories. Baghdad but lacks a system of distribution based on the scientific and mathematical methods of the work of the processing chain in addition, to the adoption of decision-maker in the system of work on traditional methods and personal experience in two stages, the first is the stage of collecting raw milk from its sources and transfer to the plant and the second is the distribution of the products are based on supermarkets located in the capital Baghdad. On this basis an efficient processing chain was designed based on efficient mathematical and scientific methods that help to find the optimal solutions, namely the problem of the sales traveler problem which works to find the most efficient and efficient the paths of mobility and distribution between cities and as the decision-maker in the factory several goals interspersed the work of the series of processing in the two stages and wants the decision-maker in achieving those goals was used to use the method of programming goals program to build a multi-goal mathematical model finds the best paths in each stage K using the program (lingo) where he showed the results obtained from the solution of these mathematical models the importance of these methods in charting the course of an optimal phase of raw milk collected from its sources and transported to the plant and the stage of the distribution of finished products to the places of disposal and consumption under the multiple goals of the decision maker.

## INTRODUCTION

Business organizations are striving to keep abreast of technological developments in order to meet the major challenges of the business environment including intense competition and shortening the life cycle of products. The researchers in the field of operations management and marketing have given great attention to these developments and the Supply Chain (SC) as the chain of equipment is the network that connects all the parties that deal with the company to deliver its product to the end consumer as well as include suppliers of all components needed by the company and those responsible for the marketing and sale of products on the one hand and (TSP). The method of finding a track is the following: Traversing Salesman Problem (TSP) (N) of the cities, so that, the salesperson visits each city only once before, returning to the city from which it was launched. Therefore, the level of ambition for these sectors and companies will be achieved through the use of the salesman method through which the optimal route is determined at the minimum time or cost, distance or all. The most important challenges facing the decision maker is to choose the appropriate alternative among the alternatives. The decision-making process with multiple goals is one of the most important topics in the management of the processing chain and the Goal Programming method (GP) is a specialized technique used to deal efficiently with multi-and certain priorities which gives the decision-maker a high flexibility in dealing with its goals and understand more deeply what to do in such cases.

A number of researchers have examined a number of studies on these topics. It is one of the methods of selling man traveler which applied this study in Greece which aimed to find an optimal path among several tracks (less time and cost) by using several algorithms to find multiple alternatives and then make a trade-off between alternatives and choose the best alternative, less expensive and time) than the tracks. Liu (2011) designed a Multi-purpose Linear Programming Model (MILP) that can be widely applied and used to solve processing chain problems and aims to identify some of the problems experienced by the processing chain in manufacturing in uncertain conditions. Vivekanadhan *et al*. (2013) conducted a study in the company Lucas in India for the television industry aimed at reducing the total distance traveled by vehicles and directing the work of allocating vehicles to the warehouses through the application of the problem of steering the vehicle and the results of this study is to find the best way to transport in the processing series among several alternatives was obtained by using the simulation method. Yalcin and Erginal (2015) proposed a new algorithm based on multi-goal programming to guide the research of the vehicles used in the process of ceramic transfer and distribution. This algorithm achieved the best results by making the vehicles behave best in the transmission and distribution process, logistics in the industrial ceramics company-Turkey.

Arabzad *et al*. (2017) designed an integrated processing chain using multi-goal linear programming method to find the optimal solution. The results indicated that the model that was built achieves the goals of the establishment and the goals set by the decision maker. O'Neil and Hoffman used the problem of a salesperson traveling with a pick-up car to find the optimal way to receive material from their source and then transfer it to the sales and consumption sources and use graphs to find optimal paths. The results revealed that this method led to the best results and to find the optimal transport plan that can be taken by pick-up truck in the process of receipt and delivery of materials.

In this study, an efficient processing chain was designed based on the travelling salesman problem which works to find the most efficient and efficient routes for urban mobility and distribution. The stage of collecting raw milk from its sources and transferring it to the factory and the stage of distribution of final products to the places of disposal and consumption in light of the multiplicity of goals of the decision-maker.

## MATERIALS AND METHODS

**Research problem:** The general company for food products/Rafidain factory is looking to maximize its profitability and increase its productivity. Many methods have been used to increase its efficiency in order to increase its market share and to create greater benefits for consumers and users but all were limited. Of the following problems:

- There is no effective distribution system for the products and the distribution process is random and is not based on mathematical method
- Reliance on traditional methods and personal experience in the distribution of products to supermarkets in Baghdad

Weak relationship and communication among the chain members (processors, manufacturers, distributors). There are several goals within the chain work that the decision maker wants to achieve in one.

And to design a series of processing the best path in the distribution of products using modern scientific methods of sports and according to the goals desired by the company is trying to search answer the following questions:

- What is the possibility of designing a series of efficient equipment for the company in question?
- Is the use of the salesman's problem method helpful in finding the optimal route for the collection and transport of raw milk and the transfer and distribution of products?
- Is the use of the method of programming goals will contribute to achieve the goals of the company and according to the weights given to it by the decision maker?

**Research goals:** The research aims at the following:

- Designing an efficient processing chain based on efficient scientific sports methods
- Depend on the problem of a salesman's passenger problem to identify and find the optimal path to the process collect raw milk from its sources:
- Transfer and distribution of products to places of consumption
- Use the method of programming goals to implement several goals seek decision-maker to achieve in one
- Draw an optimal road map that can be used at present and in the future in both stages

**Community and sample research:** The company was chosen as the general company for food industries-factories Abogrib Alban as a society for study and was applied this research in the plant Rafidain as a sample of the research which is one of the largest factories Aboograb Alban is one of the most productive factories of various products and produce products on a daily basis.

**Methods and tools used to produce results:**
- The style of the problem of sales man traveler
- Method of programming goals
- Lingo-17.0
- Word-2010

**Mechanism of data collection:** The process of obtaining the data was conducted through field visits to the factories of Abu Ghraib/Rafidain factory and the process of coordination between the specialists of the production and marketing department and also the distributors in the company to obtain the data through personal interviews and access to the company records and follow up daily work and measuring and recording the necessary information.

**Supply chain management/ concept:** The subject of the processing chain has been of great interest to researchers in the field of operations management and marketing management because of the importance of this issue to the organizations of business management because of the developments and challenges facing these organizations at the present time, the most important of which is globalization and fierce competition which led to different views of researchers on the definition of the concept (Beamon, 1998) as an integrated manufacturing process through which raw materials are converted into final products and delivered to customers. The processing chain consists of two integrated processes: process of production planning and inventory control; distribution process; logistics either (Quayle, 2006) Varafha as the term originally used in the military field to describe the organization and the transfer of troops and equipment. It is now applied to any detailed planning process in the organization which requires the distribution or redistribution of resources while (Stevenson, 2012) defined them as the functions or activities and facilities that include the production of the product and delivery to the customer starting from the suppliers of raw materials and ending with the final customer. Including jobs, activities (demand forecasting, procurement, inventory management, information acquisition, quality function, scheduling, production, distribution, delivery and customer service. Facilities include warehouses, factories, production centers, distribution centers and retail channels. Harrison *et al*. (2014) a network of partners who collectively convert the end products to final products that are evaluated by the end customers who manage the revenues at each stage while they know it as a coherent chain of operations inside the company and across the street different cat which produces a product or service to the satisfaction of its customers. More specifically, it is a network of services, materials, cash and information flow that connects the customer's relationship with the company and meets all the requirements of the process and management of relationships with their suppliers and customers.

**Elements of the supply chain:** The processing chain includes all activities that convert raw materials into finished materials (products/services) and deliver them to customers. These activities include suppliers, manufacturers, warehouses, distribution centers, retailers and customers (Liu, 2011). The flow of materials through the supply chain starts from the processors and ends with the customers while the flow of information is in the opposite direction from the customers to the processors (Fig. 1).

As explained by Beamon (1998) that the processing chain consists of two integrated processes namely 1 process of production planning and inventory control 2 distribution process and logistics.

**Supply chain components:** The basic components of the processing chain are:

**Purchasing:** It involves selecting and selecting which of the vendors can negotiate with them and deciding whether to purchase locally or otherwise.

**Production:** It manages the conversion of raw materials into commodities or services.

**Distribution:** It manages the process of flow of materials and services from the company to the external customer either directly from the company or a third party to carry out this process.

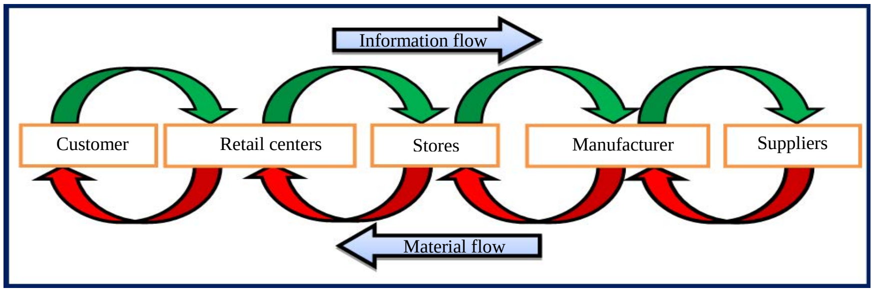


Fig. 1: Supply chain structure (Liu, 2011)

**Supply chain management:** Supply chain management is defined as the management of interconnection between organizations that are connected to each other through upstream and downstream linkages between processes that produce value for the end consumer in the form of products and services (Slack *et al*., 2014; Donato, 2016) SCM is also known by the CSCMP as a process of "Planning and managing all activities involving sources, procurement and manufacturing processes aa logistics management activities (transport) including coordination and cooperation with suppliers and intermediaries (Moussa *et al*., 2017).

**The trouble of a sales traveler problem travling salesman problem**

**Concept of problem mode sales man traveler travling salesman problem:** The TSP is a problem of combanatorail optimaization where the problem consists of the N group (nodes/cities) and the distance is known between any two nodes. The salesman starts from the city of origin and visits all cities exactly once and returns to the city from which he started in such a way that the total distance is the lowest possible. Therefore, the goal of the problem is to find a short tour possible through the group of cities to be visited so that each visit city only once, except for the city of departure, they visit twice (Khan and Maiti, 2019).

It is also known as a scientific mathematical method used to find the path of mobility in the case of a warehouse and a group of cities Khayth must start the sales man from the warehouse and then visit all the selected cities only once and then return to the warehouse, at the lowest cost (Bernardino and Paias, 2018).

**Ways to solve the problem of a sales man traveler problem:** Taha (2007) and Bektas (2006), method of intuition and guessing this method is divided into two branches:

- The nearest neighbor
- The reverse round method
- Branch and bound method
- Cutting methods
- Method of total enumeration
- Computer simulation
- Ant Colony Optimization Algorithm (ACO)
- The algorithm for (Clarke and Wright)
- Solutions in geographically oriented databases

**Traveler Salesman Problem (TSP) type:** In the field of TSP study, two types of methods were addressed. The data matrix of the problem was adopted in determining the type of problem for TSP. The data matrix of the problem is the distance for example or the value adopted between each two nodes in the problem is called Euclidian, meaning the calculated value. Based on this, two types of problem were identified (Khan and Maiti, 2019):

- Symmetric
- Asymmetric

According to this concept, the problem can be represented for the species referred to above as follows:

**Problem symmetric:** This type of problem can be represented as follows:

$$X(i, j) = X(j, i)$$
$$i = 1, 2, ..., m,\ j = 1, 2, ..., n \quad (1)$$

**Problem asymmetric:**

$$X(i, j) \neq X(j, i)$$
$$i = 1, 2, ..., m,\ j = 1, 2, ..., n \quad (2)$$

**Mathematical models of the salesman model with the existence of goals:** Before talking about the general model of the sales man problem, we should point out that the researcher has relied on the type of problem model (TSP) which is defined by the symmetric type and that the essence of the sales man (TSP) is an allocation model. The mathematical model of the subject can be formulated as follows (Bektas, 2006).

**If there is one goal, the model shall be as follows:**

$$\text{Minimize: } Z_1 = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij},\ c_{ij} = 0 \text{ when } i = j \quad (3)$$

s.t:

$$x_{ij}+x_{ji} \leq 1$$
$$\sum_{i=1}^{m} x_{ij} = 1,\ i = 1,\ 2, ..., m\ i \neq j$$
$$\sum_{j=1}^{n} x_{ij} = 1,\ j = 1,\ 2, ..., n\ i \neq j$$
$$x_{ij} \geq 0$$

where, i = 1, 2, ..., m, j = 1, 2, ..., n, i ≠ j, $C_{ij}$ is a variable value for a given measurement unit for a city-to-city-j concept. Symmetric TSP is $c_{ij} = c_{ji}$, n is the number of variable values of the decision variable, m is the number of decision variables and n = m, variable resolution is on two cases.

$$x_{ij} = \begin{pmatrix} 1 & \text{where } i \rightarrow j \text{ is found} \\ 0 & \text{other wise} \end{pmatrix}$$

**If there are several goals to be the model as follows:**

$$\text{Minimize: } Z_1 = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij}c_{ij} = 0 \text{ all } i = j$$
$$\text{Maximize: } Z_2 = \sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}x_{ij}c_{ij} = 0 \text{ all } i = j \quad (4)$$

s.t:

$$x_{ij}+x_{ji} \leq 1,\ i = 1, 2, ..., m$$
$$j = 1, 2, ..., n\ i \neq j$$
$$\sum_{j=1}^{n} x_{ij} = 1,\ j = 1, 2, ..., n\ i \neq j$$
$$\sum_{i=1}^{m} x_{ij} = 1,\ i = 1, 2, ..., m\ i \neq j$$
$$x_{ij} \geq 0$$

($C_{ij} = c_{ji}$), (n) is the number of variable values of the decision variable and m is the number of decision variables (c) (n = m), k represents the number of targets in the subject and $x_{ij}$ represents the decision variable and is:

$$x_{ij} = \begin{pmatrix} 1 & \text{where } i \rightarrow j \text{ is found} \\ 0 & \text{other wise} \end{pmatrix}$$

## Goals Programming (GP)

**Concept of programming goals:** Goal Programming (GP) is an important analytical method for solving many real-world decision problems. The GP model was first developed by Charnes and Cooper and has been applied to many real world problems such as accounting, agriculture, economics, engineering, transport, finance and marketing and the overall goal of GP is to reduce the undesirable deviations between achievement of goals and the corresponding levels of ambition determined by the decision maker (Zhuang and Hocine, 2018). As a mathematical method characterized by flexibility and realism in the process of solving the problems (Inan *et al*., 2018) which is a complex process that takes into account several goals and many variables and constraints.

**Concept of optimization in programming goals:** Programming goals in general is a method that seeks to find the closest and best solutions to the values predetermined by the decision makers for a number of goals by reducing the total deviations from the values of those goals to a minimum as they give efficient solutions (efficient) and not optimal solutions (optimization) of the problems in other words that the programming goals to find solutions that achieve the goals of the model, so that, solutions acceptable or satisfactory to the decision-maker regardless of the subject of optimization and may lead to this failure to find the best solution to doubt in the counting of programming goals of optimization methods. As optimization is in the perm goals are trying to achieve a set of goals and priorities set by the decision-maker, even if those goals are opposite and the best solution remains the ambition and desire of any successful management but the contradictions between growing needs and scarcity of resources remain a difficult problem to reach an optimal solution that satisfies all parties. Thus, the solution in goal programming is a satisfactory satisfactory solution and not necessarily an optimal solution (Taha, 2007).

**Definition of some terms used in the mathematical model**

**Model:** Expresses a system and a real phenomenon and models are abstract ideas (expressions) showing features that have to do with the behavior of the real system under study (Sen and Manish, 2012).

**Positive deviations:** Deviations whose values are higher than the value of the goal and also called higher deviation (Inan *et al*., 2018).

**Negative deviations:** Deviations whose values are less than the goal value and also called lower deviation (Inan *et al*., 2018).

**Goal function:** A function that measures achievement by minimizing undesirable deviation goal variables in the goal programming model (Ignizio and Romero, 2003).

**Targeted constraints:** Goals that are sought to achieve at a certain level (i.e., at the predetermined level of ambition level) (Ignizio and Romero, 2003).

**Variable decision:** It is a variable that represents either an administrative alternative or a product that the decision maker wishes to achieve an optimal value through calculations (Zhuang and Hocine, 2018).

**Algorithm:** A set of mathematical, logical and sequential steps necessary to solve a problem.

**Algorithm programming goals:** There are two main methods used to solve the problems of programming the goals (Hillier and Lieberman, 2001; Taha, 2007).

- The method of weights
- Method of priorities

The two methods are based on setting multiple targets with one goal. In the weight method, a single goal function is created by the weighted sum of the functions that represent the goals of the problem. The priority method starts with the order of the goals according to their priorities which in turn depends on the importance placed by the decision maker. Optimizing for each goal is not at all detrimental to the priority goal of the most important for the calculation of the least priority goals and the two methods vary because they, generally do not lead to the same solution. Decision: the appropriate model for the problem will not be ready from the first attempt. Therefore, the guidelines for determining priorities and weights are:

- Classification and initial ranking of all goals
- Assemble goals according to priorities or weights
- Allocating weights for each goal within each of the initial levels
- The absolute goals shall be within the highest priority level or the upper weight. The following is an explanation of both methods:

**The method of weights:** In this method, a single goal function is created by the weighted sum of the functions representing the problem goals. In the case that all the goals to be achieved are important for the decision maker, they have the same importance. The choice between them is often difficult, so, this method is used and the weights are determined according to for their relative importance to each goal from the point of view of the decision-maker and to reduce the sum of unwanted deviations (Zhuang and Hocine, 2018). If we assume that the model of programming goals consists of n of the goals (Taha, 2007):

$$\text{Gi}, I = 1, 2, ..., n$$

The goal function of the weights method will be as follows:

$$\text{Min } Z = W_1G_1 + W_2G_2 +, ..., + W_nG_n$$

As $W_i$ represents positive weights and usually reflects the preferences of the decision maker by reference to the importance of each target and the total weights should be equal to 1.

**The priority method:** In most cases, the decision-maker or the project manager faces problems that have multiple goals. In order to overcome these difficulties, priority is placed on the goals. The first goal is to have the highest priority or precedence in implementing it. This is considered the greatest importance of the second goal. Is more important than the third goal and can not be seen in the second goal in the second priority only after the goal is achieved in the first priority and so on the other goals and symbolizes priority (P) for the priority method in the form of irrigation التالي Next (Sen and Manish, 2012):

$$\text{Minimize } Z = \sum_{i=1}^{m} P_j\left(d_i^-, d_i^+\right) \quad (5)$$

s.t:

$$\sum_{j=i}^{n} C_j X_j - di^+ + di^- = g_i$$

$$\sum_{j=1}^{n} a_{ij} X_j = bi$$

$$d_i^+, d_i^-, X_j \geq 0$$

Where:

$$i = 1, 2, 3, ..., m$$

$$i = 1, 2, 3, ..., n$$

Where:

$X_j$ : Decision variables
$C_j X_j$ : variable coefficient in the goal constraint
$a_{ij}X_j$ : Variable coefficient in model i
n : No. of entries

**Number of variables:**

$d_i^+$ : Positive variable positive (above achievement) for goal i
$d_i^-$ : The negative deviation variable (under achievement) of goal i

**The goal value of the goal score:**

$b_i$ : Goal value for model enrollment i

**Realistic example**

**The research community represented by the factories of Abu Ghraib:** The company has been in constant development of all its production lines and the latest technologies. All the products of the company are subjected to bacteriological, chemical and physical tests in the quality control laboratories of the company. The company also has 22 centers for the collection of raw milk. Several provinces are collecting and transporting raw milk to the factories by specialized pelvic cars and stored in factories by tanks designed for this purpose. The company's factories are distributed in three governorates: Baghdad, Nineveh, Diwaniyah:

- Al-Rafidain dairy factory-Baghdad governorate
- Dijla cooked cheese factory-Baghdad governorate
- Al-Furat factory for sterilized milk-Baghdad governorate
- Children's milk factory-Baghdad governorate
- Al-Alban Al-Mosul factory-Ninawa governorate
- Al-Diwaniya dairy factory-Qadisiyah governorate

**Community and research sample:** The factory of Alban Abubraib factories which consists of the study society, contains four factories (Al-Rafidain factory, children's milk factory, tigris factory and Al-Furat factory). The factory was selected in all its sections as a sample of the research being the biggest and largest existing factories and the most productive of various products. Started in 1958 and is one of the largest and largest existing factories and the most productive and effective and diversified products and has large production lines, the factory contains 5 productive sections:

- Production of cream
- Production of butter
- Soft cheese production section
- Department of yoghurt production
- Production of cooked milk

The factory has its own 76 vehicles distributed as follows in Table 1. Which are relied upon in the process of collecting and transporting milk from its sources to the factory and the process of distribution of all products to the distribution areas in addition to transport operations within the factory as a whole.

**Mechanism of the work of the Rafidain Albani:** The Rafidain plant needs about 25 tons of raw milk to produce its various products. The Rafidain plant has four sources of raw milk. It is distributed in the following areas (Radwaniyah, Musayyib, Taji, Tarmiyah) where there are these so-called milk complexes. Raw milk is received daily from farmers farmers (cows and buffaloes) in large quantities to supply the factories with their needs of raw milk, the Rafidain plant has special trucks refrigerated and prepared for the transfer of milk and maintain it and stay fresh, every day. These three trucks where the raw milk is available for collection and transfer to the factory where a truck is allocated for each of these areas and the capacity of the truck (30 tons) was preferred to provide trucks (number 11) of the type of fridge with different capacities to transfer the final products from the factory and distributed to areas sell.

Table 1: Preparation and types of transport available at the Abu Ghraib factory

| Type of transport | Numbers |
|---|---|
| Hino refrigerator | 2 |
| Hyundai refrigerator | 2 |
| Kia refrigerator | 2 |
| Kia | 2 |
| Scania | 5 |
| Drawer | 3 |
| Forklift 3-5 tons | 1 |
| Man firefighter | 7 |
| Tata station | 12 |
| Tata bekeb | 10 |
| Pajero station | 5 |
| Kawasaki operator | 8 |
| Volvo milk container | 6 |
| Ambulance | 11 |

General company for food products-Abu Ghraib dairy industries, technical section, in 2018

**Designing the processing series:** This paragraph consists of two important phases:

**The first stage:** Designing a plan for the collection and transport of raw milk from its sources to the factory and the presence of several targets of specific weights and defined by the decision-maker:

- Get high-fat milk
- Collect and transport milk as low as possible
- Collect and transport milk at the least possible distance
- Collecting and transporting milk at the lowest possible cost of fuel

**Data on the process of designing a plan to collect and transport raw milk from its sources to the plant:** The goal of the factory is to study the research at this stage to achieve five goals and these goals ranked according to, their importance and which were determined by weights by the decision-makers in the factory. These goals are as follows:

**Fat milk density ratio (measured by the quality control department at the plant):** Through the field visits, specialists in the factory determined the percentage of milk fat for the four specific sites as follows:

- Al-Radwaniya complex = 45%
- Musayyib complex = 43%
- Taji complex = 33%
- Tarmiyah complex = 35%

The factory aims to obtain high fat milk because it contributes to the quality of the finished products:

Table 2: The time taken (min) between the factory (Abu Ghraib) and areas providing milk and between the same areas

| Plants | Abu Ghraib | Radwaniyah | Musayyib | Taji | Tarmiyah |
|---|---|---|---|---|---|
| Abu Ghraib | 0 | 45 | 100 | 75 | 100 |
| Radwaniyah | 45 | 0 | 40 | 50 | 75 |
| Musayyib | 100 | 40 | 0 | 70 | 75 |
| Taji | 75 | 50 | 70 | 0 | 15 |
| Tarmiyah | 100 | 60 | 75 | 15 | 0 |

Table 3: The distance traveled (km) between the plant (Abu Ghraib) and the areas of availability of raw milk and between the same areas

| Plants | Abu Ghraib | Radwaniyah | Musayyib | Taji | Tarmiyah |
|---|---|---|---|---|---|
| Abu Ghraib | 0 | 25 | 65 | 60 | 85 |
| Radwaniyah | 25 | 0 | 60 | 55 | 75 |
| Musayyib | 65 | 60 | 0 | 85 | 120 |
| Taji | 60 | 55 | 85 | 0 | 27 |
| Tarmiyah | 85 | 75 | 120 | 27 | 0 |

Table 4: The cost of fuel consumed for trucks used in the collection and transport of raw milk (in dinars) during the process of collection and transport between the factory (Abu Ghraib) and areas of availability and between the same areas

| Plants | Abu Ghraib | Radwaniyah | Musayyib | Taji | Tarmiyah |
|---|---|---|---|---|---|
| Abu Ghraib | 0 | 17000 | 44000 | 40000 | 58000 |
| Radwaniyah | 17000 | 0 | 40000 | 37000 | 50000 |
| Musayyib | 44000 | 40000 | 0 | 58000 | 81000 |
| Taji | 40000 | 37000 | 58000 | 0 | 18000 |
| Tarmiyah | 58000 | 50000 | 81000 | | 0 |

Prepared by the researcher based on the company records as well as personal interviews in addition to see the reality of the work and record data

**Time data:** Min for the collection and transport of milk from areas where raw milk is available as well as the time it takes to go from one area to another as in Table 2.

**Distance data:** Km for the collection and transport of raw milk from areas where it is available as well as the distance traveled from one area to another as in Table 3.

**Data on the cost of spent fuel:** This is the data on the cost of fuel consumed (dinars) for trucks used for the collection and transport of raw milk from areas available to the plant as well as the cost of fuel consumed for the process of movement between the area and another as in Table 4.

Data on the quantities of demand for raw milk according to each of the sources of access (specified by the factory management). These quantities are determined according to the ratio of fat in each of the availability areas as follows:

- Radwaniya complex = 10 tons of raw milk
- Musayyib complex = 7 tons of raw milk
- Taji complex = 3 tons of raw milk
- Tarmiyah complex = 5 tons of raw milk

Table 5: The matrix of decision variables on which the model will be formulated

| Variables | $X_0$ | $X_1$ | $X_2$ | $X_3$ | $X_4$ |
|---|---|---|---|---|---|
| $X_0$ | 0 | $C_{01}X_{01}$ | $C_{02}X_{02}$ | $C_{03}X_{03}$ | $C_{04}X_{04}$ |
| $X_1$ | $C_{10}X_{10}$ | 0 | $C_{12}X_{12}$ | $C_{13}X_{13}$ | $C_{14}X_{14}$ |
| $X_2$ | $C_{20}X_{20}$ | $C_{21}X_{21}$ | 0 | $C_{23}X_{23}$ | $C_{24}X_{24}$ |
| $X_3$ | $C_{30}X_{30}$ | $C_{31}X_{31}$ | $C_{32}X_{32}$ | 0 | $C_{34}X_{34}$ |
| $X_4$ | $C_{40}X_{40}$ | $C_{41}X_{41}$ | $C_{42}X_{42}$ | $C_{43}X_{43}$ | 0 |

Prepared by the researcher: whereas: $X_0$: Variable resolution refers to plant location (Abu Ghraib); $X_1$: Variable resolution refers to the source of milk (Radwaniyah); $X_2$: Variable resolution refers to the source of milk (Musayyib); $X_3$: Variable resolution refers to milk source (coronary); $X_4$: Variable resolution refers to milk source (Tarmia)

**Building the mathematical model of the first stage:** Based on the available data, the mathematical model is constructed at the stage of collection and transport of raw milk from its sources to the factory and according to the general formula of the problem of the problem of the traveler salesman and the method of programming goals as follows:

A single goal function by the weighted total of functions that represent the goals of the problem and which measure the achievement by reducing the desired deviation variables in the goal programming model:

$$\text{Min } Z = 0.4S_1^- + 0.22S_2^+ + 0.12S_3^+ + 0.15S_4^+ + 0.11S_5^-$$

Variables of the model-divided into two types:

- Basic variables (decision variables)
- Additional variables (negative and positive deviation variables) and Table 3-5 represents the matrix of decision variables

The other decision variables are as follows:

- $X_{ij}$ : Is refers to the variable resolution from site (i) to (j) such as
- $X_{01}$ : Is refers to the variable decision from the factory (Abu Ghraib) to the milk site in Radwaniya and, so, to all variables from the plant (Abu Ghraib) to the location of milk sources
- $C_{ij}$ : Is refers to the coefficient of a decision variable and is either a distance or time or the cost of fuel, ..., etc., between node (i) and node (j)

**The goal limitations of the mathematical model:** The decision-maker seeks to achieve and the level to be achieved for each of them in addition to clarifying the contribution of each decision variable in achieving the specified levels of different goals as well as positive and negative deviations of the goals as a whole.

The first goal limitation the goal of maximizing the density of milk fat/the goal of obtaining (raw milk) high density of fat and aspires the decision-maker to be the proportion of fat in raw milk not <0.45%:

$$\text{Max } Z_1 = 0.45X_{01}+0.43X_{02}+0.33X_{03}+0.35X_{04} \geq 0.45$$

The second goal limitation is the goal of reducing the time it takes to move from the factory to areas providing milk and the regions themselves and here the decision-maker aspires to have the total time for the collection and transfer of milk from sources to the plant is not >210 min day$^{-1}$:

$$\begin{aligned}&\text{Min } Z_2 = 45X_1+100X_2+75X_3+100X_4+45X_{10}+40X_{12}+\\&50X_{13}+60X_{14}+100X_{20}+40X_{21}+70X_{23}+75X_{24}+75X_{30}+\\&50X_{31}+70X_{32}+15X_{34}+100X_{40}+60X_{41}+75X_{42}+15X_{43} \leq 210\end{aligned}$$

The third goal record represents the goal of reducing the distance from the factory to areas providing milk and the regions themselves and the decision maker wants to be the total distance of the process of collecting and transporting raw milk from its sources does not exceed 277 km/h/day:

$$\begin{aligned}&\text{Min } Z_3 = 25X_1+65X_2+60X_3+85X_4+25X_{10}+60X_{12}+\\&55X_{13}+75X_{14}+65X_{20}+60X_{21}+85X_{23}+120X_{24}+60X_{30}+\\&55X_{31}+85X_{32}+27X_{34}+85X_{40}+75X_{41}+120X_{42}+27X_{43} \leq 277\end{aligned}$$

The fourth goal the goal of reducing the cost of fuel for trucks consumed during the process of moving from the plant to areas providing milk and the same areas and return to the plant and wants the decision-maker to obtain the cost of fuel does not exceed 20,000 dinars day$^{-1}$ to complete the collection and transfer of raw milk to the factory:

$$\begin{aligned}&\text{Min } Z_4 = 17000X_1+44000X_2+40000X_3+58000X_4+\\&17000X_{10}+40000X_{12}+37000X_{13}+50000X_{14}+44000X_{20}+\\&40000X_{21}+58000X_{23}+81000X_{24}+40000X_{30}+37000X_{31}+\\&58000X_{32}+18000X_{34}+58000X_{40}+50000X_{41}+81000X_{42}+\\&18000X_{43} \leq 200000\end{aligned}$$

The fifth goal score represents the amount of demand to be obtained (in tons) of raw milk and the decision maker wants to obtain at least 25 tons day$^{-1}$ of raw milk:

$$\text{Max } Z_5 = 10X_1+7X_2+3X_3+5X_4 \leq 25$$

**System limitations:** System constraints are as follows: S. to:

$$\begin{aligned}&X_1+X_2+X_3+X_4 = 1,\ X_{10}+X_{20}+X_{30}+X_{40} = 1\\&X_{10}+X_{12}+X_{13}+X_{14} = 1,\ X_1+X_{21}+X_{31}+X_{41} = 1\\&X_{20}+X_{21}+X_{23}+X_{24} = 1,\ X_2+X_{12}+X_{13}+X_{14} = 1\\&X_{30}+X_{31}+X_{32}+X_{34} = 1,\ X_{03}+X_{13}+X_{23}+X_{24} = 1\\&X_{40}+X_{41}+X_{42}+X_{43} = 1,\ X_{04}+X_{41}+X_{42}+X_{43} = 1\\&X_{01}+X_{10} \leq 1,\ X_{02}+X_{20} \leq 1,\ X_3+X_{30} \leq 1\\&X_{04}+X_{40} \leq 1,\ X_{12}+X_{21} \leq 1,\ X_{13}+X_{31} \leq 1\\&X_{14}+X_{41} \leq 1,\ X_{23}+X_{32} \leq 1,\ X_{24}+X_{42} \leq 1\\&X_{34}+X_{43} \leq 1, \left(0, X_{ij}, 1\right)\end{aligned}$$

**Solve the mathematical model of the first stage:** The program (Lingo-17.0) was used to solve the multi-goal mathematical model according to the weights method. These weights were determined by the decision maker in the factory by setting one function of the min. Function as follows:

$$\begin{aligned}&\text{Min } Z = 0.4S_2^- +0.22S_2^+ +0.12S_3^+ +0.15S_4^+ +0.11S_5^-\\&0.45X_{01}+0.35X_{02}+0.33X_{03}+0.43X_{04}-\left(S_1^+-S_1^-\right) = 0.45\\&45X_1+100X_2+75X_3+100X_4+45X_{10}+40X_{12}+\\&50X_{13}+75X_{14}+100X_{20}+40X_{21}+70X_{23}+75X_{24}+75X_{30}+50X_{31}+\\&70X_{32}+15X_{34}+100X_{40}+60X_{41}+75X_{42}+15X_{43}-\left(S_2^+-S_2^-\right) = 210\\&25X_1+65X_2+60X_3+85X_4+25X_{10}+60X_{12}+55X_{13}+75X_{14}+\\&65X_{20}+60X_{21}+85X_{23}+120X_{24}+60X_{30}+55X_{31}+85X_{32}+\\&27X_{34}+85X_{40}+75X_{41}+120X_{42}+27X_{43}-\left(S_3^+-S_3^-\right) = 277\end{aligned}$$

$$\begin{aligned}&17000X_1+44000X_2+40000X_3+58000X_4+17000X_{10}+\\&40000X_{12}+37000X_{13}+50000X_{14}+44000X_{20}+\\&40000X_{21}+58000X_{23}+81000X_{24}+40000X_{30}+37000X_{31}+\\&58000X_{32}+18000X_{34}+58000X_{40}+50000X_{41}+81000X_{42}+\\&18000X_{43}-\left(S_4^+-S_4^-\right) = 200000\end{aligned}$$

$$\begin{aligned}&X_{01}+X_{02}+X_{03}+X_{04} = 1,\ X_{10}+X_{20}+X_{30}+X_{40} = 1\\&X_{10}+X_{12}+X_{13}+X_{14} = 1,\ X_1+X_{21}+X_{31}+X_{41} = 1\\&X_{20}+X_{21}+X_{23}+X_{24} = 1,\ X_2+X_{12}+X_{32}+X_{42} = 1\\&X_{30}+X_{31}+X_{32}+X_{34} = 1,\ X_{03}+X_{13}+X_{23}+X_{43} = 1\\&X_{40}+X_{41}+X_{42}+X_{43} = 1,\ X_{04}+X_{14}+X_{24}+X_{34} = 1\\&X_{01}+X_{10} \leq 1,\ X_{02}+X_{20} \leq 1,\ X_3+X_{30} \leq 1\\&X_{04}+X_{40} \leq 1,\ X_{12}+X_{21} \leq 1,\ X_{13}+X_{31} \leq 1\\&X_{14}+X_{41} \leq 1,\ X_{23}+X_{32} \leq 1,\ X_{24}+X_{42} \leq 1\\&X_{34}+X_{43} \leq 1, \left(0, X_{ij}, 1\right)\end{aligned}$$

## RESULTS AND DISCUSSION

**Discussion of phase I results:** The most important results obtained (Appendix 1) were:

- Obtain the optimal path for the milk collection process:

$X_{01}$-$X_{12}$-$X_{24}$-$X_{43}$-$X_{33}$-$X_{01}$

**Abu Ghraib-Radwaniyah-Musayyib-Tarmiyah-Taji-Abu Ghraib:**

- Achieve the first goal by 100%
- Achieve the second goal by 80%
- Achieve the third goal by 71%
- Achieve the fourth goal by 100% in addition to reducing the cost of fuel consumed worth 4000 dinars $day^{-1}$
- Achieve the fifth goal by 60%

The results show that Abu Ghraib, Radwaniyah, Musayyib, Tarmiyah, Taji and Abu Ghraib are the best way to collect milk from places available to the Rafidain plant compared with the transport mechanism used by the factory. Decision maker with savings on the cost of spent fuel for the process.

**Phase II:** Design a plan for the transfer and distribution of products from the Rafidain plant (Abu Ghraib) to the areas of discharge and consumption.

Distribution is a very important process because it has an impact on all other elements starting from the process of fetching milk and then production process which affects and is affected by this process and helps the process in delivering the product to the consumer with high efficiency. The distribution process is through a group of individuals working in which is through which the process of transporting products through trucks (refrigerators) for the factory from the Rafidain plant and distributed to the shopping centers located on both sides of Karkh and Rusafa. The model consists of a set of goals:

- The first goal: to obtain the least time possible for the process of transfer and distribution of products
- The second goal: to obtain the least possible distance for the process of transfer and distribution of products
- The third goal: to obtain the lowest cost of fuel consumed during the process of transporting and distributing products

**Goal function data for the process of designing a plan for the transfer and distribution of products from the plant to the shopping centers:** The goal of the factory in this stage is to achieve three goals. These goals are ranked according to their importance and which were determined by weights by the decision-makers in the factory. These goals are as follows:

**Time data:** The data on the time taken (per minute) for the process of moving from the factory to the shopping centers and between the centers themselves for the transfer and distribution of products (Table 6).

**Distance data:** The data on the distance traveled (km) for the transfer and distribution of products from the factory to the shopping centers as well as the distance traveled from one center to another as in Table 7.

**Data on the cost of fuel:** Data on the cost of fuel consumed (dinars) for trucks used in the transfer of products from the plant and distribution to the sales centers as well as the cost of fuel consumed to move between centers and another as in Table 8.

Table 6: The time taken (per minute) for the transfer of products from the Rafidain plant (Abu Ghraib) and distribution to shopping centers in Baghdad and between the same centers

| Plants | Abu Ghraib | Al-Bayaa | Sédia | Kadhimiya | Rasheed | Al-Shaab | The Ministry of Science and Technology |
|---|---|---|---|---|---|---|---|
| Abu Ghraib | 0 | 45 | 50 | 70 | 60 | 90 | 55 |
| Al-Bayaa | 45 | 0 | 20 | 35 | 20 | 60 | 25 |
| Sédia | 50 | 20 | 0 | 50 | 15 | 50 | 30 |
| Kadhimiya | 70 | 35 | 50 | 0 | 60 | 30 | 50 |
| Rasheed | 60 | 20 | 15 | 60 | 0 | 70 | 45 |
| Al-Shaab | 90 | 60 | 50 | 30 | 70 | 0 | 30 |
| The ministry of Science and Technology | 55 | 25 | 30 | 50 | 45 | 30 | 0 |

Table 7: The distance traveled (km) for the transfer of products from the Rafidain plant and distribution to the shopping centers in Baghdad and between the centers themselves

| Plants | Abu Ghraib | Al-Bayaa | Sédia | Kadhimiya | Rasheed | Al-Shaab | The Ministry of Science and Technology |
|---|---|---|---|---|---|---|---|
| Abu Ghraib | 0 | 30 | 35 | 65 | 40 | 75 | 40 |
| Al-Bayaa | 30 | 0 | 10 | 15 | 12 | 50 | 8 |
| Sédia | 50 | 10 | 0 | 18 | 8 | 40 | 10 |
| Kadhimiya | 65 | 15 | 50 | 0 | 40 | 15 | 17 |
| Rasheed | 40 | 12 | 8 | 40 | 0 | 60 | 20 |
| Al-Shaab | 75 | 50 | 40 | 15 | 60 | 0 | 15 |
| The Ministry of Science and Technology | 40 | 8 | 10 | 50 | 45 | 15 | 0 |

Prepared by the researcher based on the company records as well as personal interviews in addition to see the reality of the work and record data

Table 8: The cost of fuel consumed (dinars) for the transfer of products from the Rafidain plant and distribution to the shopping centers in Baghdad and between the same centers

| Plants | Abu Ghraib | Al-Bayaa | Sédia | Kadhimiya | Rasheed | Al-Shaab | The Ministry of Science and Technology |
|---|---|---|---|---|---|---|---|
| Abu Ghraib | 0 | 20000 | 24000 | 44000 | 27000 | 51000 | 27000 |
| Al-Bayaa | 20000 | 0 | 7000 | 10000 | 8000 | 34000 | 5000 |
| Sédia | 24000 | 7000 | 0 | 12000 | 5000 | 27000 | 7000 |
| Kadhimiya | 44000 | 10000 | 12000 | 0 | 27000 | 10000 | 11000 |
| Rasheed | 27000 | 8000 | 5000 | 27000 | 0 | 41000 | 14000 |
| Al-Shaab | 51000 | 34000 | 27000 | 10000 | 41000 | 0 | 10000 |
| The Ministry of Science and Technology | 27000 | 5000 | 7000 | 11000 | 14000 | 10000 | 0 |

Prepared by the researcher based on the company records as well as personal interviews in addition to see the reality of the work and record data

Table 9: The matrix of decision variables on which the model will be formulated

| Variables | $X_0$ | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_6$ |
|---|---|---|---|---|---|---|---|
| $X_0$ | 0 | $C_{01}X_{01}$ | $C_{02}X_{02}$ | $C_{03}X_{03}$ | $C_{04}X_{04}$ | $C_{05}X_{05}$ | $C_{06}X_{06}$ |
| $X_1$ | $C_{10}X_{10}$ | 0 | $C_{12}X_{12}$ | $C_{13}X_{13}$ | $C_{14}X_{14}$ | $C_{15}X_{15}$ | $C_{16}X_{16}$ |
| $X_2$ | $C_{20}X_{20}$ | $C_{21}X_{21}$ | 0 | $C_{23}X_{23}$ | $C_{24}X_{24}$ | $C_{25}X_{25}$ | $C_{26}X_{26}$ |
| $X_3$ | $C_{30}X_{30}$ | $C_{31}X_{31}$ | $C_{32}X_{32}$ | 0 | $C_{34}X_{34}$ | $C_{35}X_{35}$ | $C_{36}X_{36}$ |
| $X_4$ | $C_{40}X_{40}$ | $C_{41}X_{41}$ | $C_{42}X_{42}$ | $C_{43}X_{43}$ | 0 | $C_{45}X_{45}$ | $C_{46}X_{46}$ |
| $X_5$ | $C_{50}X_{50}$ | $C_{51}X_{51}$ | $C_{52}X_{52}$ | $C_{53}X_{53}$ | $C_{54}X_{54}$ | 0 | $C_{56}X_{56}$ |
| $X_6$ | $C_{60}X_{60}$ | $C_{61}X_{61}$ | $C_{62}X_{62}$ | $C_{63}X_{63}$ | $C_{64}X_{64}$ | $C_{65}X_{65}$ | 0 |

Prepared by the researcher: Indicates $X_0$: Variable resolution refers to plant location (Abu Ghraib); $X_1$: Variable resolution refers to the Baya shopping center; $X_2$: Variable resolution refers to Sédia shopping center; $X_3$: Variable resolution refers to Kadhimiya shopping center; $X_4$: Variable resolution refers to Rasheed shopping center; $X_5$: Variable resolution refers to the Al-shaab shopping center; $X_6$: Variable resolution refers to the shopping center object at the headquarters of The Ministry of Science and Technology

**Construct the mathematical model for the second stage:** Based on the available data, the mathematical model is built in the stage of the transfer and distribution of products to the shopping centers and according to the general formula of the problem of the problem of the traveler salesman and the method of programming goals as follows: The goal function is a min. Minimization function as follows:

$$\text{Min } Z = 0.28\, S_1^- + 0.24\, S_2^+ + 0.48\, S_3^+$$

**Variables of the model; Divided into two types:**

- Basic variables (decision variables)
- Additional variables (negative and positive deviation variables) and Table 9 represents the matrix of decision variables

The remaining decision variables are defined as follows:

- $X_{ij}$: Is refers to the variable resolution from site (i) to (j) such as:
- $X_{01}$: Is refers to the variable decision from the factory (Abu Ghraib) to the shopping center Bayaa and so to all variables from the factory (Abu Ghraib) to shopping centers
- $C_{ij}$: Is refers to the coefficient of a decision variable and is (measured and calculated) either distance or time or cost of fuel, ..., etc., between node (i) and node (j)

**Goals of the mathematical model of the second phase:** The first goal limit the goal of reducing the time it takes to move from the factory to the shopping centers and return to the center and here the decision maker wants to increase the total time spent for the distribution of products on the mall for 205 min day$^{-1}$:

$$\begin{aligned} \text{Min } Z_1 = {} & 45X_1+50X_2+70X_3+60X_4+90X_5+55X_6+ \\ & 45X_{10}+20X_{12}+35X_{13}+20X_{14}+60X_{15}+25X_{16}+50X_{20}+ \\ & 20X_{21}+50X_{23}+15X_{24}+50X_{25}+30X_{26}+70X_{30}+35X_{31}+ \\ & 50X_{32}+60X_{34}+30X_{35}+50X_{36}+60X_{40}+20X_{41}+15X_{42}+ \\ & 60X_{43}+70X_{45}+45X_{46}+90X_{50}+60X_{51}+50X_{50}+30X_{53}+ \\ & 70X_{54}+30X_{56}+55X_{60}+25X_{61}+30X_{62}+50X_{63}+45X_{64}+ \\ & 30X_{65} \le 205 \end{aligned}$$

The second goal limit represents the goal of reducing the distance from the factory to the shopping centers and return to the factory and wants the decision maker to complete the distribution of products on shopping malls with a total distance of not >137 km day$^{-1}$:

$$\begin{aligned} \text{Min } Z_2 = {} & 30X_1+35X_2+65X_3+40X_4+75X_5+40X_6+30X_{10}+ \\ & 10X_{12}+15X_{13}+12X_{14}+50X_{15}+8X_{16}+50X_{20}+10X_{21}+18X_{23}+ \\ & 8X_{24}+40X_{25}+10X_{26}+65X_{30}+15X_{31}+50X_{32}+40X_{34}+15X_{35}+ \\ & 17X_{36}+40X_{40}+12X_{41}+8X_{42}+40X_{43}+60X_{45}+20X_{46}+75X_{50}+ \\ & 50X_{51}+40X_{52}+15X_{53}+60X_{54}+15X_{56}+40X_{60}+8X_{61}+10X_{62}+ \\ & 50X_{63}+45X_{64}+15X_{65} \le 137 \end{aligned}$$

The third goal limit the goal of reducing the cost of fuel for trucks consumed during the process of moving from the factory to the shopping centers and return to the factory and be the decision-maker's goal to obtain the cost of fuel for the whole process of transporting and distribution of products to the sales centers >88000 dinars day$^{-1}$:

$$\begin{aligned}&\text{Min } Z_3 = 20000X_1+24000X_2+44000X_3+27000X_4+\\&51000X_5+27000X_{06}+20000X_{10}+7000X_{12}+10000X_{13}+\\&8000X_{14}+34000X_{15}+5000X_{16}+24000X_{20}+7000X_{21}+\\&12000X_{23}+5000X_{24}+27000X_{25}+7000X_{26}+44000X_{30}+\\&10000X_{31}+12000X_{32}+27000X_{34}+10000X_{35}+11000X_{36}+\\&27000X_{40}+8000X_{41}+5000X_{42}+27000X_{43}+41000X_{45}+\\&14000X_{46}+10000X_{56}+27000X_{60}+51000X_{61}+7000X_{62}+\\&11000X_{63}+14000X_{64}+10000X_{65}\leq 88000\end{aligned}$$

**System limits;** The system limits the following:
S.to

$$\begin{aligned}&X_1+X_2+X_3+X_4+X_5+X_6=1\\&X_{10}+X_{12}+X_{13}+X_{14}+X_{15}+X_{16}=1\\&X_{20}+X_{21}+X_{23}+X_{24}+X_{25}+X_{26}=1\\&X_{30}+X_{31}+X_{32}+X_{34}+X_{35}+X_{36}=1\\&X_{40}+X_{41}+X_{42}+X_{43}+X_{45}+X_{46}=1\\&X_{50}+X_{51}+X_{52}+X_{53}+X_{54}+X_{56}=1\\&X_{60}+X_{61}+X_{62}+X_{63}+X_{64}+X_{65}=1\\&X_{10}+X_{20}+X_{30}+X_{40}+X_{50}+X_{60}=1\\&X_1+X_{21}+X_{31}+X_{41}+X_{51}+X_{61}=1\\&X_2+X_{12}+X_{32}+X_{42}+X_{52}+X_{62}=1\end{aligned}$$

$$\begin{aligned}&X_{03}+X_{13}+X_{23}+X_{43}+X_{53}+X_{63}=1\\&X_{04}+X_{14}+X_{24}+X_{34}+X_{54}+X_{64}=1\\&X_{05}+X_{15}+X_{25}+X_{35}+X_{55}+X_{65}=1\\&X_{06}+X_{16}+X_{26}+X_{36}+X_{56}+X_{66}=1\\&X_{01}+X_{10}\leq 1,\ X_{02}+X_{20}\leq 1,\ X_3+X_{30}\leq 1\\&X_{04}+X_{40}\leq 1,\ X_{05}+X_{50}\leq 1, X_{06}+X_{60}\leq 1\end{aligned}$$

$$\begin{aligned}&X_{12}+X_{21}\leq 1,\ X_{13}+X_{31}\leq 1, X_{14}+X_{41}\leq 1\\&X_{15}+X_{51}\leq 1,\ X_{16}+X_{61}\leq 1,\ X_{23}+X_{32}\leq 1\\&X_{24}+X_{42}\leq 1,\ X_{25}+X_{52}\leq 1,\ X_{26}+X_{62}\leq 1\\&X_{34}+X_{43}\leq 1, X_{35}+X_{53}\leq 1,\ X_{64}+X_{46}\leq 1\\&X_{45}+X_{54}\leq 1,\ X_{46}+X_{64}\leq 1,\ X_{56}+X_{65}\leq 1\\&\left(X_{ij},1,0\right)\end{aligned}$$

**Solve the mathematical model of the second stage:** After the formulation of the multi-goal mathematical model, the program (Lingo-17.0) was used to solve the mathematical model according to, the weights method. These weights were determined by the decision maker in the factory by placing one function:

$$\begin{aligned}&\text{Min } Z = 0.28\ S_1^- + 0.24\ S_2^+ + 0.48\ S_3^+\\&45X_{01}+50X_{02}+70X_{03}+60X_{04}+90X_{05}+55X_{06}+45X_{10}+\\&20X_{12}+35X_{13}+20X_{14}+60X_{15}+25X_{16}+50X_{20}+20X_{21}+\\&50X_{23}+15X_{24}+50X_{25}+30X_{26}+70X_{30}+35X_{31}+50X_{32}+\\&60X_{34}+30X_{35}+50X_{36}+60X_{40}+20X_{41}+15X_{42}+60X_{43}+\\&70X_{45}+45X_{46}+90X_{50}+60X_{51}+50X_{52}+30X_{53}+70X_{54}+\\&30X_{56}+55X_{60}+25X_{61}+30X_{62}+50X_{63}+45X_{64}+30X_{65}-\\&(S_1^- - S_1^+) = 205\end{aligned}$$

:

$$\begin{aligned}&30X_{01}+35X_{02}+65X_{03}+40X_{04}+75X_{05}+40X_{06}+30X_{10}+10X_{12}+\\&15X_{13}+12X_{14}+50X_{15}+8X_{16}+50X_{20}+10X_{21}+18X_{23}+8X_{24}+\\&40X_{25}+10X_{26}+65X_{30}+15X_{31}+50X_{32}+40X_{34}+15X_{35}+\\&17X_{36}+40X_{40}+12X_{41}+8X_{42}+40X_{43}+60X_{45}+20X_{46}+\\&75X_{50}+50X_{51}+40X_{52}+15X_{53}+60X_{54}+15X_{56}+40X_{60}+\\&8X_{61}+10X_{62}+50X_{63}+45X_{64}+1530X_{65}-(S_2^- - S_2^+)=137\end{aligned}$$

$$\begin{aligned}&20000X_{01}+24000X_{02}+44000X_{03}+27000X_{04}+51000X_{05}+\\&27000X_{06}+20000X_{10}+7000X_{12}+10000X_{13}+8000X_{14}+\\&34000X_{15}+5000X_{16}+24000X_{20}+7000X_{21}+12000X_{23}+\\&5000X_{24}+27000X_{25}+7000X_{26}+44000X_{30}+10000X_{31}+\\&12000X_{32}+27000X_{34}+10000X_{35}+11000X_{36}+27000X_{40}+\\&8000X_{41}+5000X_{42}+27000X_{43}+41000X_{45}+14000X_{46}+\\&51000X_{50}+34000X_{51}+27000X_{52}+10000X_{53}+41000X_{54}+\\&10000X_{56}+27000X_{60}+5000X_{61}+7000X_{62}+11000X_{63}+\\&14000X_{64}+10000X_{65}-(S_3^- - S_3^+) = 88000\\&\left(0, X_{ij}, 1\right)\end{aligned}$$

**Discussion of the results of the second phase:** The most important results obtained (Appendix 2) were:

- Getting the best route for the transfer and distribution of products on the shopping centers and return to the factory which is as follows:

$$X_{01}\leftarrow X_{13}\leftarrow X_{35}\leftarrow X_{56}\leftarrow X_{64}\leftarrow X_{42}\leftarrow X_{20}\leftarrow X_{01}$$

- Abu Ghraib-Bayaa-Kadhimiya-Al-Shaab the Ministry of Science and Technology Al-Rasheed-Saidia-Abu Ghraib
- Achieve the first goal by 100% and get an abundance of time 45 min day$^{-1}$ when using this path
- Achieve the second goal by 100% and get an abundance of distance by 41 km day$^{-1}$ when using this path
- Achieve the third goal by 100% and get a reduction of the cost of 5000 dinars/day when using this path

The results show that the track (Abu Ghraib-Bayaa-Kadhimiya-Al Shaab Ministry of Science and Technology Rasheed-Sidiya-Abu Ghraib) is the best way to transfer the finished products from the Rafidain factory to the shopping centers located in Baghdad in the event that there are several goals for the decision-maker, when this course of action in the transfer and distribution of these centers will achieve these goals by 100% with the savings in time and distance and the cost of fuel consumed.

## CONCLUSION

The most important conclusions reached are: the use of the methods of the problem of sales man traveling and programming goals which are the methods of mathematical sports task which worked through the program ((Lingo to find the optimal solutions in the design of the processing series of the plant Rafidain in the first phase and the second stage achieved the best results under the multi-goals decision-maker.

With regard to the first stage, the design of a plan for the collection and transport of raw milk from its sources to the plant and the existence of several targets of specific weights and determined by the decision-maker, the results achieved through the application of these methods led to better results in terms of selection of high-density crude milk and reduce the cost and distance and the lowest possible cost of fuel for the track (Abu Ghraib-Radwaniyah-Musayyib-Tarmiyah-Taji-Abu Ghraib) which takes place when the collection and transfer of milk in reality.

With regard to the second stage, the design of a plan for the transfer and distribution of products from the Rafidain plant (Abu Ghraib) to the areas of discharge and consumption and the presence of several targets of specific weights and determined by the decision-maker and through the results found that the track (Abu Ghraib-Bayaa-Kadhimiya-Al Shaab-Ministry of Science and technology-Al-Rasheed-Al-Sayyidiya-Abu Ghraib) is the best way to transfer the final products in the presence of several goals for the decision makers is to reduce the time taken to move, reduce the distance and reduce the cost of fuel trucks consumed during the process of transition from the plant to the centers of settlement and return to the factory.

The adoption of modern scientific methods based on mathematical methods and modern software in determining the optimal paths in both stages and in the multiple goals of the decision-maker has had the effect of increasing the quality of finished products and make them compete with other local and foreign products similar to them.

## APPENDIX

**Appendix 1; results of the first stage using the Lingo program; Global optimal solution found:**

| | |
|---|---|
| Goal value: | 16.60000 |
| Infeasibilities: | 0.000000 |
| Total solver iterations: | 20 |
| Elapsed runtime seconds: | 0.33 |
| Model class: | LP |
| Total variables: | 32 |
| Nonlinear variables: | 0 |
| Integer variables: | 0 |
| Total constraints: | 26 |
| Nonlinear constraints: | 0 |
| Total nonzeros: | 142 |
| Nonlinear nonzeros: | 0 |

Appendix 1: Continue

| Variables | Values | Reduced cost |
|---|---|---|
| $Y_1$NEG | 0.000000 | 0.000000 |
| $Y_2$POS | 40.00000 | 0.000000 |
| $Y_3$POS | 65.00000 | 0.000000 |
| $Y_4$PO | 0.000000 | 0.1500000 |
| $Y_5$NEGS | 0.000000 | 0.1100000 |
| $X_{01}$ | 1.000000 | 0.000000 |
| $X_{02}$ | 0.000000 | 0.000000 |
| $X_{03}$ | 0.000000 | 0.4000000E-01 |
| $X_{04}$ | 0.000000 | 3.232000 |
| $Y_1$POS | 0.000000 | 0.4000000 |
| $X_{10}$ | 0.000000 | 0.000000 |
| $X_{12}$ | 1.000000 | 0.000000 |
| $X_{13}$ | 0.000000 | 7.700000 |
| $X_{14}$ | 0.000000 | 7.000000 |
| $X_{20}$ | 0.000000 | 0.000000 |
| $X_{21}$ | 0.000000 | 0.8000000E-02 |
| $X_{23}$ | 0.000000 | 0.000000 |
| $X_{24}$ | 1.000000 | 0.000000 |
| $X_{30}$ | 1.000000 | 0.000000 |
| $X_{31}$ | 0.000000 | 7.708000 |
| $X_{32}$ | 0.000000 | 0.000000 |
| $X_{34}$ | 0.000000 | 0.000000 |
| $X_{40}$ | 0.000000 | 3.200000 |
| $X_{41}$ | 0.000000 | 0.000000 |
| $X_{42}$ | 0.000000 | 7.008000 |
| $X_{43}$ | 1.000000 | 0.000000 |
| $Y_2$NEG | 0.000000 | 0.2200000 |
| $Y_3$NEG | 0.000000 | 0.1200000 |
| $Y_4$POS | 0.000000 | 0.000000 |
| $Y_4$NEG | 4000.000 | 0.000000 |
| $Y_5$POS | 0.000000 | 0.000000 |
| $Y_5$NEG | 15.00000 | 0.000000 |
| **Row** | **Slack or surplus** | **Dual price** |
| 1 | 16.60000 | -1.000000 |
| 2 | 0.000000 | -0.4000000 |
| 3 | 0.000000 | 0.2200000 |
| 4 | 0.000000 | 0.1200000 |
| 5 | 0.000000 | 0.000000 |
| 6 | 0.000000 | 0.000000 |
| 7 | 0.000000 | -5.736000 |
| 8 | 0.000000 | 7.892000 |
| 9 | 0.000000 | -7.808000 |
| 10 | 0.000000 | -1.708000 |
| 11 | 0.000000 | -7.008000 |
| 12 | 0.000000 | -21.99200 |
| 13 | 0.000000 | -8.184000 |
| 14 | 0.000000 | -23.89200 |
| 15 | 0.000000 | -17.79200 |
| 16 | 0.000000 | -23.09200 |
| 17 | 0.000000 | 1.200000 |
| 18 | 1.000000 | 0.000000 |
| 19 | 0.000000 | 0.000000 |
| 20 | 1.000000 | 0.000000 |
| 21 | 0.000000 | 0.000000 |
| 22 | 1.000000 | 0.000000 |
| 23 | 1.000000 | 0.000000 |
| 24 | 1.000000 | 0.000000 |
| 25 | 0.000000 | 0.000000 |
| 26 | 0.000000 | 18.26000 |

**Appendix 2; phase II results using the Lingo program; Global optimal solution found:**

| | |
|---|---|
| Goal value: | 0.000000 |
| Infeasibilities: | 0.000000 |
| Total solver iterations: | 20 |
| Elapsed runtime seconds: | 0.18 |
| Model class: | LP |
| Total variables: | 48 |
| Nonlinear variables: | 0 |
| Integer variables: | 0 |
| Total constraints: | 39 |
| Nonlinear constraints: | 0 |
| Total nonzeros: | 261 |
| Nonlinear nonzeros: | 0 |

| Variables | Values | Reduced cost |
|---|---|---|
| $Y_1$POS | 0.000000 | 0.2800000 |
| $Y_2$POS | 0.000000 | 0.2400000 |
| $Y_3$POS | 0.000000 | 0.4800000 |
| $X_{01}$ | 1.000000 | 0.000000 |
| $X_{02}$ | 0.000000 | 0.000000 |
| $X_{03}$ | 0.000000 | 0.000000 |
| $X_{04}$ | 0.000000 | 0.000000 |
| $X_{05}$ | 0.000000 | 0.000000 |
| $X_{06}$ | 0.000000 | 0.000000 |
| $X_{10}$ | 0.000000 | 0.000000 |
| $X_{12}$ | 0.000000 | 0.000000 |
| $X_{13}$ | 1.000000 | 0.000000 |
| $X_{14}$ | 0.000000 | 0.000000 |
| $X_{15}$ | 0.000000 | 0.000000 |
| $X_{16}$ | 0.000000 | 0.000000 |
| $X_{20}$ | 1.000000 | 0.000000 |
| $X_{21}$ | 0.000000 | 0.000000 |
| $X_{23}$ | 0.000000 | 0.000000 |
| $X_{24}$ | 0.000000 | 0.000000 |
| $X_{25}$ | 0.000000 | 0.000000 |
| $X_{26}$ | 0.000000 | 0.000000 |
| $X_{30}$ | 0.000000 | 0.000000 |
| $X_{31}$ | 0.000000 | 0.000000 |
| $X_{32}$ | 0.000000 | 0.000000 |
| $X_{34}$ | 0.000000 | 0.000000 |
| $X_{35}$ | 1.000000 | 0.000000 |
| $X_{36}$ | 0.000000 | 0.000000 |
| $X_{40}$ | 0.000000 | 0.000000 |
| $X_{41}$ | 0.000000 | 0.000000 |
| $X_{42}$ | 1.000000 | 0.000000 |
| $X_{43}$ | 0.000000 | 0.000000 |
| $X_{45}$ | 0.000000 | 0.000000 |
| $X_{46}$ | 0.000000 | 0.000000 |
| $X_{50}$ | 0.000000 | 0.000000 |
| $X_{51}$ | 0.000000 | 0.000000 |
| $X_{52}$ | 0.000000 | 0.000000 |
| $X_{53}$ | 0.000000 | 0.000000 |
| $X_{54}$ | 0.000000 | 0.000000 |
| $X_{56}$ | 1.000000 | 0.000000 |
| $X_{60}$ | 0.000000 | 0.000000 |
| $X_{61}$ | 0.000000 | 0.000000 |
| $X_{62}$ | 0.000000 | 0.000000 |
| $X_{63}$ | 0.000000 | 0.000000 |
| $X_{64}$ | 1.000000 | 0.000000 |
| $X_{65}$ | 0.000000 | 0.000000 |
| $Y_1$NEG | 45.00000 | 0.000000 |
| $Y_2$NEG | 41.00000 | 0.000000 |
| $Y_3$NEG | 5000.000 | 0.000000 |

Appendix 2: Continue

| Row | Slack or surplus | Dual price |
|---|---|---|
| 1 | 0.000000 | -1.000000 |
| 2 | 0.000000 | 0.000000 |
| 3 | 0.000000 | 0.000000 |
| 4 | 0.000000 | 0.000000 |
| 5 | 0.000000 | 0.000000 |
| 6 | 0.000000 | 0.000000 |
| 7 | 0.000000 | 0.000000 |
| 8 | 0.000000 | 0.000000 |
| 9 | 0.000000 | 0.000000 |
| 10 | 0.000000 | 0.000000 |
| 11 | 0.000000 | 0.000000 |
| 12 | 0.000000 | 0.000000 |
| 13 | 0.000000 | 0.000000 |
| 14 | 0.000000 | 0.000000 |
| 15 | 0.000000 | 0.000000 |
| 16 | 0.000000 | 0.000000 |
| 17 | 0.000000 | 0.000000 |
| 18 | 0.000000 | 0.000000 |
| 19 | 0.000000 | 0.000000 |
| 20 | 0.000000 | 0.000000 |
| 21 | 1.000000 | 0.000000 |
| 22 | 1.000000 | 0.000000 |
| 23 | 1.000000 | 0.000000 |
| 24 | 1.000000 | 0.000000 |
| 25 | 1.000000 | 0.000000 |
| 26 | 0.000000 | 0.000000 |
| 27 | 1.000000 | 0.000000 |
| 28 | 1.000000 | 0.000000 |
| 29 | 1.000000 | 0.000000 |
| 30 | 1.000000 | 0.000000 |
| 31 | 0.000000 | 0.000000 |
| 32 | 1.000000 | 0.000000 |
| 33 | 1.000000 | 0.000000 |
| 34 | 1.000000 | 0.000000 |
| 35 | 0.000000 | 0.000000 |
| 36 | 1.000000 | 0.000000 |
| 37 | 1.000000 | 0.000000 |
| 38 | 0.000000 | 0.000000 |
| 39 | 0.000000 | 0.000000 |

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