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Optimizing Logistic Problem in Automotive Corporations by Linear Programming

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***Abstract*— In today's modern global market, companies make efforts to sell their products in a vast territory. According to usual long distance between production plants and target markets, in addition to the variety of methods for transferring products to customers' place, deciding about logistic strategies is very important. Since the main goals of each organization depend on its appropriate use of resources, tools, and abilities, a thoughtful manager should take time, cost and risk into consideration. In new economic models of industrial corporations, like automotive ones, the inter-transportation system is considered as an important factor alongside production, knowledge, budget, and human resource. In this article an approach for solving logistic problem in an automotive corporation has been developed by means of a multi-objective linear programming model. The main question is the optimized way of delivering sold cars by trucks to customers who are scattered in different parts of the country, and in various cities. The aim of this article is to propose an answer in order to minimize the transfer costs and also the customers' time of receiving their new car, and each car has a priority to be delivered to a customer. Like all linear programming models, there is more than one dominant answer in most of multi-objective optimization problems and finally the managers are forced to select among a collection of efficient answers.**

Keywords-component; formatting; Linear Programming, Multi-objective optimization, Logistic planning

I. Introduction

We face to multi-objective optimization in real world decision making and in our model we minimize transfer costs according to the priority of sending cars [2,3]. To solve this problem we use Lexicographical method; we divide the whole country in definite number of zones by taking a glance on our present trajectory network of whole country and also the geographical place of the target cities; Our purpose is omitting irrational answers of model, making the process of problem solving faster, and also minimizing the scope of problem. It is necessary to mention that solving the problem by increasing the number of zones makes the process easier but it lasts longer. After all these done, by sending up cars to the zones with the highest priorities which is calculated by summing up the priorities of the cars which are assumed to be send to that zone, we allocate full trucks to that zone to transfer our soled cars. Car priorities are as a direct function of delay time of delivering the cars and also special comments of managerial board[4]. Cars with longer delay time have the most important priorities to be send. It is possible that managers emphasize on sending some cars sooner. In this case the priority of those cars will increase. Our aim is to send the trucks in routes which minimize our logistic costs. In the next stage we will minimize the number of trucks which deliver cars in several cities for each trip [5].

II. Linear Programming and Logistic Management: A Literature Review

Linear programming is the process of taking various linear inequalities relating to some situation, and finding the best value obtainable under those conditions. Logistic management is a typical example that takes the limitations of cost, capacity and length, and then determines the best transformation path under those conditions [10].

In real life, linear programming is part of a very important area of mathematics called "optimization techniques". This field of study, or at least the applied results of it, is used every day in the organization and allocation of resources. These "real life" systems can have dozens or hundreds of variables, or more.

The general process for solving linear-programming problems is to graph the inequalities, called the "constraints", to form a walled-off area on the x,y-plane, called the "feasibility region". Then you figure out the coordinates of the corners of this feasibility region; that is, you find the intersection points of the various pairs of lines, and test these corner points in the formula, called the "optimization equation", for which you are trying to find the highest or lowest value.

On the other hand, logistics optimization has become increasingly an important component of supply chain management for the improvement of business efficiency in agile and global manufacturing. Logistics optimization problems are mainly focused on strategic decision making, and they reveal a scarcity of models that capture simultaneously many aspects relevant to real-world applications, emphasizing an increasing need for extensive studies.

Noticing a similarity to the hierarchy of decision levels in production planning, which are commonly classified as long-term, middle-term and short term plans, we can address the logistics network design problem more reliably and adequately.

Taking into account tactical decisions, in addition to the conventional strategic one, we can give more operational and practical insights and provide innovative resolutions to logistics problems. After presenting some preliminary statements, we provide a general formulation and propose a solution procedure. Finally, the validity of the proposed method is shown through numerical experiments.

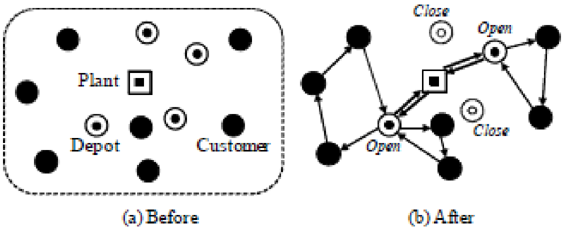

Fig 1. Solution image for the problem considered

III. PROBLEM DEFINITION

The proposed logistic model includes some objectives: using maximum capacity of trucks for transferring sold cars and also minimizing the length of routes which a truck traverse in, especially when a truck runs through several cities. The direct relation between these items and the automotive corporation's logistic cost is assumed [6]. First, the country will be divided into definite zones according to the latest map of roads which connects different cities to each other in a country. By increasing the number of zones the answer of the model will be more precise, but it lasts more time and the number of operations will increase rapidly. It is obvious that by supposing the whole country as a united zone, we will face the most general model [11].

The priority of loading cars to trucks depends on time and managerial view points. Cars which are waiting in the queue delivering for more time have more priority; Besides it is possible to send some cars sooner by managerial commands according to social and political conditions. Priority of the cars not loaded to trucks today will increase the next day and the probability of sending them tomorrow will be added. By supposing this matter, the average and the maximum time of delivering cars to customers will increase after a long time [7-9].

IV. PROBLEM SOLVING APPROACH

Our solving approach for solving the implied logistic problem is using Lexicographical method. The most preferable consignments must be delivered at first. The goal is to maximize the sum of loaded cars to trucks which are going to be delivered in different cities and according to logistic limitations in an automotive corporation, the number of allocated trucks and the cars supposed to be delivered to each region will be specified in this stage. In next stage minimizing the length of routes by trucks will occur [8].

V. MATHEMATICAL MODEL

For the model systematically, some sets are assumed;

- Number of Regions: $k \in \{1, 2, ..., K\}$
- Number of Roads in each Region: $r \in \{1, 2, ..., R\}$
- Number of Cars: $i \in \{1, 2, ..., I\}$
- Number of Cities: $j \in \{1, 2, ..., J\}$

In addition, suppose that we have **n** trucks with the capacity **c**. We also define three zero-one functions [1]:

- $$target(i,j) = \begin{cases} 1, & \textit{if the target of car } i \textit{ is city } j \\ 0, & \textit{otherwise} \end{cases} \quad (1)$$
- $$road(j,r) = \begin{cases} 1, & \textit{if the city } j \textit{ is on road } r \\ 0, & \textit{otherwise} \end{cases} \quad (2)$$
- $$region(j,k) = \begin{cases} 1, & \textit{if the city } j \textit{ belongs to region } k \\ 0, & \textit{otherwise} \end{cases} \quad (3)$$

In addition assume that function length(r) denotes the length of route r and priority(i) is the priority of car i.

Now consider the formula of the priority of regions for allocating trucks. We calculate the average priority of cars which must be delivered in each region:

$$\overline{priority}(k) = \frac{\textit{sum of priorities of cars delivered in region } k}{\textit{sum of number of cars delivered in region } k} \quad (4)$$

.

So the average of priorities will be calculated as follows:

$$\overline{priority}(k) = \frac{\sum_j [region(j,k) * \sum_i target(i,j) * priority(i)]}{\sum_j [region(j,k) * \sum_i target(i,j)]} \quad (5)$$

For initializing the parameters we suppose the number of not allocated trucks to all the regions names **rest** which is **n**, the total number of trucks, at first. We choose the region with the highest priority to allocate trucks to it. The number of trucks which should be assigned to region **k** is as follows:

$$assign(k) = \min\left\{ \left[\frac{\textit{region } k\textit{'s car}}{\textit{truck capacity}} \right], \textit{rest trucks} \right\} \quad (6)$$

Consider that we use the absolute value of the number of region's car to trucks capacity in order to send full trucks not partially filled trucks to their destination. Usually a truck can carry 6 cars, so its capacity is 6. The most advantage of this formula is the complete usage of our truck capacities. According to our functions,

$$assign(k)=\min\left\{\frac{\sum_j[region(j,k)*\sum_i target(i,j)]}{c}, rest\right\} \quad (7).$$

After finding the number of needed trucks for each region k, the parameter named rest must be updated. New rest will be the number of previous rest, which was the number of all trucks we have, minus assign(k). Now we calculate the number of cars that can be carried to each region according to assign(k). That is enough to multiply c to assign(k). If there is a gap between the number of carried cars and the number of cars which must be delivered the rest of the cars will enter the cycle of calculating the priorities again and will wait in the queue of allocating trucks. This cycle will continue till there is no unloaded car. The problem of using the complete capacity of whole trucks is finished now and it will lead to decrease costs.

The next problem is finding the optimized trajectories between automotive factory and customers' cities. This trajectory must be selected in a way that the length of the road between the factory and the cities became minimized. Since cost depends on length directly, by optimizing the length of trajectories, the cost will be optimized too. So we continue the problem by minimizing the length of roads according to constraints. Our decision making parameters will be:

- $$X(t,r) = \begin{cases} 1, & if\ truck\ t\ goes\ on\ road\ r \\ 0, & otherwise \end{cases} \quad (8)$$
- $$Y(i,t) = \begin{cases} 1, & if\ truck\ t\ carries\ car\ i \\ 0, & otherwise \end{cases} \quad (9)$$

So the Linear Programming Model for region k will be as follows:

$$Min\ Z=\sum_v[\sum_r length(r)*X(v,r)] \quad (10)$$

$s.t.$

$$\sum_v Y(i,v)=1 \qquad \forall i \qquad (i)$$

$$\sum_i Y(i,v)\le c \qquad \forall v \qquad (ii)$$

$$Y(i,v)\le\sum_r X(v,r)*[\sum_j target(i,j)*road(j,r)] \qquad \forall i,v \qquad (iii)$$

$$Y(i,v)\in\{0,1\}\ ,\forall i,v \qquad (iv)$$

$$X(v,r)\in\{0,1\}\ ,\forall v,r \qquad (v)$$

Constraint (i) implies that each of cars can be carried just by one truck; Constraint (ii) is the constraint of trucks' capacity, for example 6 cars; Constraint (iii) says that car i will be carried by truck t when truck t goes across the city in which car I must be delivered.

VI. CONCLUSION

In this article we solved a problem that most of automotive corporations face with it in real world. A comprehensive model based on linear programming is proposed in this research. The model is formulating in mathematical programming whit objective function of minimizing the whole path which sold cars are carried on, subject to various operational constraints. Therefore, we present a Linear Programming Model which can offer an answer by means of most mathematical softwares very fast and in a rational time. For future studies we suggest Dynamic Programming with more objectives.

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