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Optimization Strategies for Modern Transportation and Distribution Network

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Abstract

In the contemporary logistics landscape, it is a challenge to figure out the transportation and distribution problem, especially between the factory and the market. Given the increasing consumer expectation for fast delivery, the need for highly effective distribution strategies is more pressing than ever because the manufacturers and retailers have to minimize costs while maximizing efficiency. This paper aims to devise a method to optimize for costs and efficiency, and has certain reference value for how to reduce costs and improve efficiency in the freight industry. The current approach only considers the cost of products, but does not consider the cost occurring from the transportation distance. Therefore, this paper puts forward a model that considers both transportation distance and costs in optimization.

1. Introduction

Literature review
In the field of transportation, managers face a challenge: how to allocate resources between various factories and stores. J. Reeb and S. Leavengood studied this issue, using linear programming to explore it, this approach has benefited manufacturing, finance, and service industries(Reeb and Leavengood, 2002). In this paper, we will use a numerical model and Python to address and optimize this transportation problem in order to minimize costs. It is a old problem that many researchers are continually optimizing this issue.This issue involves

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economics, manufacturing, and the service industry. Researchers are continuously optimizing transportation problems, which can reduce costs in transportation and promote economic circulation.

This paper proposes a method that solves for the optimal amount of goods transported from factories to retail stores under constraints of the amount available by each factory and the amount required by each retail store. While the locations of the retail stores are fixed, we also find the optimal locations of factories that achieve the minimum costs.

The paper is organized as follows. First, we describe the methodology we used to address the transportation problem at hand. Then, in section 3, we describe our results and in section 4 we offer a discussion and some conclusions.

2. Methodology

We use combinations algorithm to solve the problem and implement it in Python programming language.

This paper based on the python and numerical model, at first, assuming that the location of the factory is fixed and the location of the retail store, the amount of goods available by each factory and the amount of goods required by each retail store are set under the condition of fixed transportation costs, calculate the minimize of the cost.

We use the numerical model and python which can help us illustrate the result clearly. This paper aims to find the minimum cost and satisfy the demand of the

In the first part, we assume two factories and five retail stores, they are all fixed in location, but have different output and demand. The cost of the transportation we assume is each route has a unique price (see Table 1).

In the second part, we assume two factories and three retail stores, we assume random locations for the three retail stores' and random locations for the ten factories, assuming the cost of transportation to each route. Meanwhile, assuming the per unit for the distance cost (see Table 2).

In the first model ,we set up:

F_i	the i-th factory(i=1, 2)
R_j	the j-th retail store(j=1,2,3,4,5)
a_i	the i-the factory output(i=1, 2)
b_j	the j-th retail store demand(j=1,2,3,4,5.)
C_{ij}	the cost of transportation from i to j
n_{ij}	factory i need to transport to the j-th retail store
C	total cost

Table 1: parameter for Transportation Model 1

Let the supply of the first factory be a_1, and the supply of the second factory be a_2, then let the demand of the first retail store be b_1 and the second, third, fourth and fifth retail stores are b_2, b_3, b_4 and b_5. The cost of transportation per unit of goods from factory i to retail store j is c_{ij} (i=1,2 and j=1,2,3,4,5). The total units of goods transported from factory i to retail store j is n_{ij} (i=1,2 and j=1,2,3,4,5). The total cost function is:

$$C=\sum_{i=1,\ j=1} n_{ij}*c_{ij}$$

The objective is to minimize the total cost function. The constraints are:

$$\sum_{j=1} n_{1j} \le a_1$$
$$\sum_{j=1} n_{2j} \le a_2$$
$$\sum_{i=1} n_{i1} \ge b_1$$
$$\sum_{i=1} n_{i2} \ge b_2$$
$$\sum_{i=1} n_{i3} \ge b_3$$
$$\sum_{i=1} n_{i4} \ge b_4$$
$$\sum_{i=1} n_{i5} \ge b_5$$

Typing it into python with specific data, then we can get the solution of this problem.

After that, we add a new variable d_{ij} into the model, and change the number of retail stores to be 3. In the second model ,we set up:

F_i	the i-th factory(i=1, 2)
R_j	the t-th retail store(j=1,2,3)
a_i	the i-the factory output(i=1, 2)
b_j	the j-th retail store demand(j=1, 2, 3)
C_{ij}	the cost of transportation from i to j
n_{ij}	the quantity of the factory i transport the products to retail store j
d_{ij}	the distance of the factory i from the retail store j
C	total cost

Table 2: parameter for Transportation Model 2

The variable d_{ij} means the distance between the factory i and the retail store j. So, the model becomes:

$$C=\sum_{i=1,j=1} n_{ij}*d_{ij}*c_{ij}$$

C means the total cost, and c_{ij} becomes the cost of transportation per unit of goods transported from factory i to retail store j per km. The definition of dij is :

$$d_{ij}=[(x_i - x_{ij})\hat{}2+(y_i - y_{ij})\hat{}2]\hat{}½$$

The variable x_i means the horizontal coordinate of factory i, the variable y_i means the vertical coordinates of factory i. And the variable x_{Rj} means the horizontal coordinates of retail store j, the variable y_{Rj} means the vertical coordinates of retail store j (see figure 1). The constraints of the new model are as same as before. The location of the retail stores are randomly determined using python. And the location of the factory is uncertain before the problem is solved.

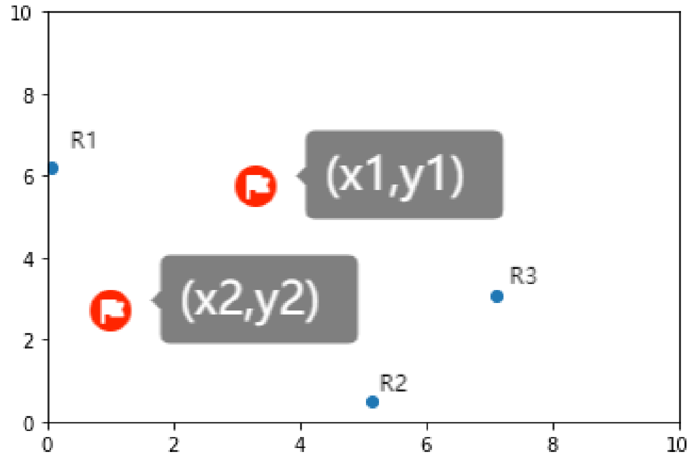

Figure 1: the location of factories and retail stores

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3. Results

3.1 Transportation Model 1

All the specific data we assume based on the assumption of real situation.
The parameters used in this model are shown in Table 2.

A1=8, A2=4
B1=4, B2=1, B3=3, B4=2, B5=2
C11=1, C12=1, C13=2, C14=3, C15=3, C21=2, C22=2, C23=3, C24=4, C25=5

Table 3: parameter choice for Transportation Model 1 (TM1)

The schematic diagram of TM1 is shown in Figure 2.

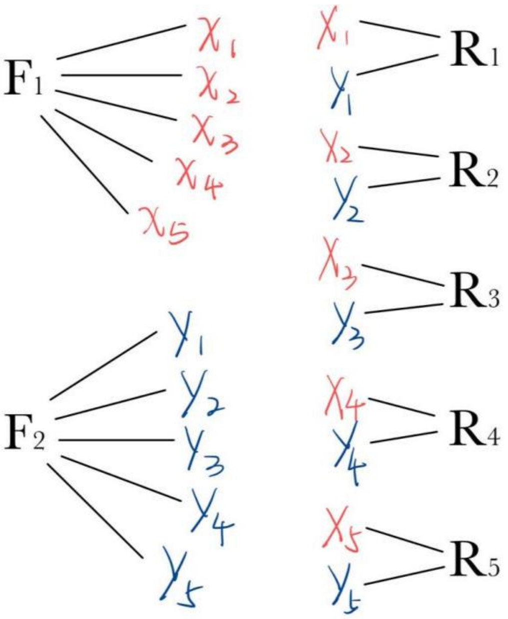

Figure 2: schematic diagram of TM1

We find that the optimal set of production amounts is shown in figure 3

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Optimal values: x1=4, x2=1, x3=2,x4=1,x5=0,y1=0,y2=0,y3=1,y4=1,y5=2,cost=29
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Figure 3: optimal production load for each factory for TM 1

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We find the each retail store demand and the minimum cost

Describe some of your results: F1 produces double than F2. Is that important in TM1?in these data, we assume the F1 output is double F2, but compare the result, we find it is not important in these model.

3.2 Transportation Model 2

A1=8,A2=4
B1=5.B2=3,B3=4
C11=1,C12=3,C13=2,C21=2,C22=4,C23=3

Table 4: parameter choice for Transportation Model 2 (TM2)

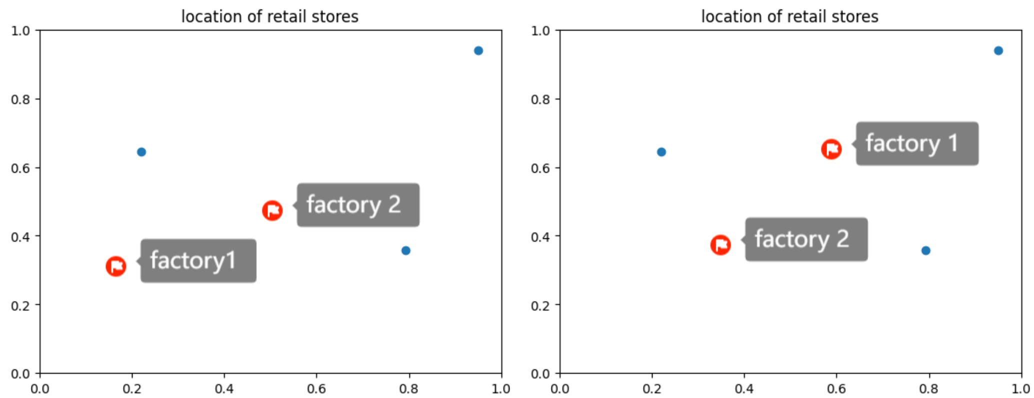

Figure 4: different locations of factories

	x1	y1	x2	y2	n11_opt	n12_opt	n13_opt	n21_opt	n22_opt	n23_opt	cost
0	9.676893	0.955739	9.215001	5.283399	1	3	4	4	0	0	158.072779
1	0.308410	3.132713	1.591786	7.800096	5	3	0	0	0	4	165.836079
2	8.542153	7.036393	7.524664	4.771549	1	3	4	4	0	0	135.336577
3	0.079248	1.077150	8.034676	8.723056	5	3	0	0	0	4	142.779166
4	0.589574	6.699188	2.155923	9.029207	1	3	4	4	0	0	195.531285
...	...	...	...	...	...	...	...	...	...	...	...
95	5.644541	2.318482	1.370712	2.280802	1	3	4	4	0	0	68.572548
96	2.839462	1.295145	3.160824	7.359675	1	3	4	4	0	0	144.427000
97	7.608395	4.875066	9.473480	3.350088	1	3	4	4	0	0	117.372757
98	7.128681	5.503818	4.946672	4.182201	1	3	4	4	0	0	90.888400
99	8.249905	7.939116	9.439283	0.896670	1	3	4	4	0	0	166.016816

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We random 100 different factories' locations and use python to calculate every cost and demand that the retail stores demand. We can find the optimize cost in the table. And the process is repeated multiple times until the optimal position no longer changes.

4. Discussion and Conclusions

Contributions

By optimizing the relationship between transportation costs and freight volume, it is possible to more accurately predict excessive inventory and stock shortages at retail stores, allowing for the effective distribution of goods produced by factories and improving resource utilization. Using this model, operators may be better able to adapt to dynamic market demands and complex supply chain challenges. Based on mathematical models and Python, our research provides greater precision and more relevance to real-life situations than calculations conducted with formulas alone.

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