Optimization of E-commerce Logistics Distribution Center Location

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Abstract: With the rapid development of e-commerce, business flow, capital flow and information flow on the Internet happens at any time and any place, but the logistics can not serve customers low costly and high efficiently. Therefore, a reasonable distribution of logistics distribution center is one of the important measures to reduce costs. In this assignment, we improve the model of assigning problems through introducing element of time which impacts the quality of customer service, and we quantify penalty cost to measure the desirability of distribution center, so we can locate the distribution center scientifically. Finally, we use specific example to tell the impact of penalty cost on logistics center location, to provide the effectively quantitative decision-making for management.

Keywords: electronic commerce, logistics distribution center, assignment problem, the penalty cost

1 Introduction

Since the second half of 2008, the global financial crisis exercises a great influence on international logistics; Similarly, China's economy is limited greatly, Chinese economy's dependence on foreign trade meets as high as 60%, Guangdong, is a whopping 150%. 40% of our GDP is driven by export, the financial crisis causes the biggest shift on China's exports, so whether focusing on domestic market or international market, logistics enterprises will face with serious challenges. So China's logistics industry must be restructured and upgraded, its' intensive development must be speeded up, we also need to accelerate the application of modern management methods and information technology, and improve capacity of adjusting the international economic situation which is complicated and volatile. With the popularization of Internet applications, the e-commerce develops rapidly in China. Indeed, with further promotion and application of e-commerce, the importance of logistics and its impact on e-commerce has become increasingly evident. Therefore, logistic operation must be done in a manner of timely, quick and accurate to meet customer requirements, and optimize the location of logistics distribution center, and improve standards of logistics and distribution center's service to customer. At the same time, it will act the warning role to costing.

2 E-Commerce and Distribution Center

2.1 logistics distribution center location
As commodity turnover, sorting, storage, and fortified point in distribution processing and database management, Distribution Center can promote commodity's additional values in accordance with customer value, and overcome time and space barriers occurred in the course of their movement. In the logistics system, the location of logistics center is so important that it is the strategic point in optimization of logistics system [1]. Typically, if logistics distribution center which includes buildings, facilities and information systems is located inappropriately, it will result in some quite serious passive influences and people have to pay for it. Therefore, it is so important that we must conduct a systematic and comprehensive analysis to the location of Logistics Center [2]. A reasonable choice can greatly reduce the construction cost of distribution centers, effectively save transport costs and promote the coordination and cooperation between production and consumption, so as to ensure the balanced development of the logistics system.

2.2 E-Commerce Logistics Distribution Center Location
Development of E-Commerce makes the goods' information flow more quickly, and the flow of goods entity is the ultimate realization of e-commerce. E-commerce on Logistics Distribution Center Location is very important because it can further save the cost of e-commerce and faster e-commerce transactions’ speed, and shorten the cycle of e-commerce transactions. In the E-commerce environment, apart from the factors of general logistics distribution center location, we should pay particular attention to the followings in the process of selecting the location of logistics distribution center:\[3\]

1. To take improving service levels as a guide, we should pay more attention to enhance the delivery speed;
2. Classification of e-commerce logistics center is done through the principle of "economic area" rather than "administrative";
3. To take the special nature of e-commerce’s customer location into main consider, we should locate the distribution center within the metropolitan area.

3 Electronic Commerce Distribution Center Location Model

3.1 Model assumptions
According to features of the logistics distribution under electronic commerce, the following assumptions before the proposed model are proposed.

1. alternative number of distribution centers, address, the largest building capacity are known;
2. The number, location and demand of demand point (the user) is known;
3. It is known that the user has strict requirements on time; This study is delivery problem under time constraints, therefore, time is the stricter requirements.
4. Transport costs and transport capacity is proportional to the distance;
5. A demand point is only supported by the supply of a distribution center, that is, service once can meet the requirements of our customers point;
6. The weight limit of every vehicle in moving does not exceed vehicle capacity; and each vehicle services a loop, starting from the station and eventually back to the station;
7. Other assumptions:
8. Warehouse storage costs are not taken into account, and the speed is constant. Goods in transit are not degenerative, the prevailing situation is not taken into account.

3.2 Model
The basic idea of building models is to select a certain number from the candidate sites and determine the distribution centers’ customers according to demand of customers, at last, find the total cost of distribution. Standard assignment problem is a special integer programming problem, which is a special programming problem of 0-1 and special transport problem. Therefore, the assignment revises the standard assignment algorithms so as to be more coincidental with practical problems.

3.2.1 Modificatory assignment algorithm
Distribution Center's address is also subject to time, distance and the distribution center’s construction cost. Therefore, we need amend standard assignment problem, the assignment is mainly on the distribution of time requirements, in order to better optimize distribution center location. The delivery time requirements: shortening the delivery time will increase penalty cost. Penalty cost emerges when customer’s products and services are not delivered or provided within a specified time. For example: Distribution Center in a period of time \(a \ b = t\) (as illustrated 1) provides products and services to customers, only customer accepts the service within the time of \(t\), otherwise, the customer refuses products and services. Within the \(t\) time, in the time \(t2\) it is the most valuable service, and most can satisfy customer requirements, and the penalty cost is the lowest, that is 0; if delivered in advance,
that is, within the time of $t_1 = (ac)$, it will increase the inventory costs, labor costs, the requirements of frozen will produce refrigeration costs, these costs are dominant and relatively small, the costs are a much smaller part of the population in the penalty costs, which can be ignored in order to simplify the calculation. Penalty costs primarily generates in the $(d,b) = t_3$, that is, penalty should be paid for products and services being delivered late, which is the main part of the cost penalty. It is invisible, and it is the primarily focus of distribution centers. Since distribution center will create two implications in the time of $t_3$: first, customers would reduce product and service requirements, or even denial of service requirements, because customer requirements are not supplied timely, accurately and fast, and it will lead to reducing sales of products and services; Second, customers will lose in the long-term, which would result in incalculable losses. So, we should correct the value efficient, the correction function should be increased as follows:

$$f(y) = \begin{cases} 
(y-a) \times c_1 & y \in (a,c) \\
0 & y \in (c,d) \\
(y-d) \times c_1 & y \in (d,b) \\
y \leq a \text{ or } y \geq b & \text{Denial of Service}
\end{cases}$$

Symbols here:
- $C_1 = t_1 / t$: penalty cost rate’s relationship with time under the condition of produces being delivered ahead of time. The penalty cost has a little effect which can be neglected;
- $C_2 = t/t_3$: penalty cost rate’s relationship with time under the condition of produces being delivered late. It will have a main effect.
- Style (1) shows the penalty cost which is the product of the time and penalty cost rate under the condition of produces being delivered ahead of time;
- Style (2) shows that the penalty cost is 0 in the certain time;
- Style (3) shows the penalty cost which is the product of the time and penalty cost rate under the condition of produces being delivered late;
- Style (4) shows the service can not be accepted and should be refused.

In fact, $f(y)$ is a continuous variation number, but in order to simplify the calculation, we take the average of early time, right time and late time, so we assume that $f(y)$ is constant, and the model function should be changed accordingly as follows:

$$\sum_{x_{ij}} f(y) c_{ij} x_{ij}$$

$$\sum_{j=1}^{n} x_{ij} = 1 \quad i = 1,2,\ldots,n$$

$$\sum_{i=1}^{m} x_{ij} = 1 \quad j = 1,2,\ldots,n$$

$$x_{ij} = 0 \text{ or } 1 \quad i,j = 1,2,\ldots,n$$

Model notation here:
- Style (1) shows the minimum objective function under the condition of increasing the penalty cost or time;
- Style (2) shows that each line must have but one distribution center to do;
- Style (3) shows each distribution center must have but one line to transport;
- Style (4) shows it is selected or not checked.

At this point, the available solution matrix is as follows:
Through the above model, we know that optimization of distribution centers location has three states considering the conditions of time: First, the products and services provided at the right time are the most optimal; Second, the supply of products and services in the early state can be considered, but we should try to avoid; Third, if products and services are provided under the late state, it indicates the significant location problem, we should find the cause of increasing cost, and it can act an early warning role.

4 Case Study

Suppose distance between the four distribution centers and four lines is as table 4_1 show, the goods are delivered fresh and frozen which should be sent within 5 hours, otherwise, products are rejected; if the goods are required to be signed two hours before, this will increase the inventory, refrigeration cost, etc. If the freight unit is the same one, the optimal solution is as following:

Table 14_1

<table>
<thead>
<tr>
<th>route</th>
<th>address</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>M₁</td>
<td></td>
<td>100</td>
<td>90</td>
<td>90</td>
<td>120</td>
</tr>
<tr>
<td>M₂</td>
<td></td>
<td>85</td>
<td>110</td>
<td>120</td>
<td>125</td>
</tr>
<tr>
<td>M₃</td>
<td></td>
<td>95</td>
<td>125</td>
<td>95</td>
<td>90</td>
</tr>
<tr>
<td>M₄</td>
<td></td>
<td>110</td>
<td>95</td>
<td>120</td>
<td>95</td>
</tr>
</tbody>
</table>

The first one kind of solution without regard to time-sensitive: solution is solved through Hungarian method, the key to the Hungarian Method is to use the following nature of assignment problem's Optimal Solution: if a line’s (or a column’s) elements of the assignment’s coefficient matrix minus a constant k, it will get a new matrix. The 2 coefficient matrix’s assigned problems comes the same optimal solution. The coefficient matrix’s change does not affect the constraint equations of the mathematical model, for the objective function values reduce the constants k only. Therefore, the optimal solution does not change. So the optimal solution is as follows:

Table 14_2

<table>
<thead>
<tr>
<th>route</th>
<th>address</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>M₁</td>
<td></td>
<td>10</td>
<td></td>
<td>(0)</td>
<td>30</td>
</tr>
<tr>
<td>M₂</td>
<td></td>
<td>(0)</td>
<td>25</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>M₃</td>
<td></td>
<td>5</td>
<td>35</td>
<td>5</td>
<td>(0)</td>
</tr>
<tr>
<td>M₄</td>
<td></td>
<td>15</td>
<td>(0)</td>
<td>25</td>
<td>0</td>
</tr>
</tbody>
</table>

The optimal assignment program which corresponds to the result is: M₁ --- C, M₂ ---- A, M₃-D, M₄ --- B, the shortest path is 360, that is, transport cost is 360.

The second method with regard to the time: here is simplification of the principle. Three identical major
states are calculated regardless of mixed state. Take the average time of every period as follows:
Ahead of time: $t_1 = \frac{2}{2} = 1$, $c_1 = \frac{2}{5}$, that is: $f_1(y) = 1 \times \left(\frac{2}{5}\right) = 0.4$;
Time period: that is: $f_2(y) = 0$;
Delay time: $t_2 = \frac{1}{2} = 0.5$, $c_2 = 5 / 1$ that is: $f_3(y) = 0.5 \times \left(\frac{5}{1}\right) = 2.5$;
Put these data into the formula and get three results: (1) all of the penalty costs ahead of time are: $360 \times 0.4 = 144$, total cost $z = 200 + 144 = 344$; (2) All the time cost does not change, that is the ideal state $z = 360$; (3) All penalty cost of the time delay: $360 \times 2.5 = 900$, total cost $z = 900 + 200 = 1100$. From the data, we can find: (1) Penalty costs arise primarily in the late stage; The penalty cost of lead time sometimes can be ignored; (2) 0 --- 344 penalty cost is acceptable, indicating that the design of distribution center addresses are reasonable, in 344 --- 1100, delivery location is able to accept in a short time, distribution centers must be on site redesign in the long-term, so the cost penalty can be reduced to an acceptable range, and thus early warning can be indicated.

5 Conclusion

We revise assignment problem to optimize the distribution center location, so as to provide effective decision-making on logistics location. But there are many shortcomings, the penalty cost coefficient is entirely decided by time, whether there is a better combination of distance, time, construction cost of the distribution center to determine the penalty factor. These issues should be deserved further study.

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References