RESEARCH ON LOGISTICS LOCATION OPTIMIZATION MODEL BASED ON TIME DIMENSIONS

Jiuguo Zhao
School of Economics and Management, Beijing Jiaotong University
No.3 Shang Yuan Cun, Haidian District, Beijing, China

Keywords: Location model, Time-satisfaction, Time cost, Service facility.

Abstract: The classical logistics facility location models seldom lay emphasis on time, which is a critical issue for a company to gain its competitive advantage nowadays. Some scholars study maximal covering location problem based on time-satisfaction, but most of them have not taken the consumption of time cost into account. This paper presents a new location model which incorporates time cost compared with previous approaches of time satisfaction. The model is initially developed based on the integer programming, whose objective function is subject to the maximization of total satisfaction and the minimization of total cost. Finally, it makes precise analysis taking the case of a regional network layout optimization. The computational result proves the feasibility and value of this model in its practical application.

1 INTRODUCTION

The competition advantage in Modern logistics is focused on how to access to consumption with the fastest speed, the shortest distance and lowest cost under the premise of the satisfaction of individual customer needs by distribution channels. So logistics siting problem in logistic distribution centre is an important part of the entire product supply chain optimization.

The economic globalization and international competition augment the frequency of location decisions because of shortened product life cycles. On the other hand, the decisions on the siting problem have a growing impact on competitiveness of enterprises. With the progress of information technology and developing of logistics and supply chain management in recent years, making location decisions has become a corporate capacity trained for business and part of changing tactical decisions. Sometimes it is usually structured to support the organization's daily scientific decision-making. Therefore, the academics and managers pay close attention to how to solve the location problem by analysing, classifying, modelling and calculating (Bo et al, 2008).

Nowadays, time is on the cutting edge. Time will become the next competitive resource advantages. Time-based competition can be a strategic tool to gain success in many industries, especially in logistics industry. Especially in delivery of perishable goods and emergency services, time is even more obvious. For the pursuit of zero-time response to customer demand, siting problem of various service facilities cannot be an overlooked factor. The conventional location models of logistics facilities have a time constraint or use time as the main target elements, but it is still too simplified to define time. Usually enterprises look on time of customers demand from its own perspective, not from the customer itself. It did not fully reflect the importance and differentiation of time required by people in the 2l century.

Based on the background hereinbefore, time is even more obvious. Therefore, time effect should be fully taken into account in the location decision-making process of logistics distribution centre as the key factors. Thus, this paper introduces time into location model of logistics distribution centre. We propose time is not considered in isolation and shortening the time without condition is not scientific. It should define and model time from the perspective of the customer. In this model, we consider not only maximizing total time satisfaction, but also minimizing total cost of time. The time satisfaction mentioned in this article means the customer satisfaction of responding to the needs of the time required. The time cost is the cost consumed by logistics services for customers in order to satisfy their needs.

Zhao J..
RESEARCH ON LOGISTICS LOCATION OPTIMIZATION MODEL BASED ON TIME DIMENSIONS.
DOI: 10.5220/0003580406560661
In *Proceedings of the 13th International Conference on Enterprise Information Systems* (MMLM-2011), pages 656-661
ISBN: 978-989-8425-56-0

2 LITERATURE OVERVIEW

With the growing attention on logistics industry, more and more enterprises are starting to focus on logistics facilities location problem. Logistics facility Location is a very old and classic problem, developing of the foreign research can be divided into three stages with different focus (Brandeau and Chui, 1989).

① Fragmented Research Stage

This stage was from 1909 to 1960. It focused on solving a variety of practical problems in production and daily life. The mainly representatives was the German economist Alfred weber. He considered a single warehouse location problem is to determine the location, so that total transportation distance is the shortest between warehouse and customers. Hotelling proposed location of two competing suppliers in a straight line and built related models in 1929. Then Smithies, Stevens studied this problem in more depth. Regional economist Isard also analysed the choice of industrial location from the perspective of land use, input and output.

② Systemic Research Stage

Hakimi went into more theoretical issues of research on the site in 1964. For selecting for the network location of one or more facilities, he considers it should make the total distance or the distance between facilities minimum. Since then, the location problem was introduced into a broader area. After that, the location problem of Production centre, the transport hub and substation was researched in succession.

③ Uncertainty Research Stage

So far into the 80s of last century, along with great changes in the market, the static and deterministic location model cannot meet the development of location method. Louveaux, Mirchandani, Weaver, Church and other scholars let the transport time and demands as random variables on the issue of uncertainty median. Berman and Odoni, Berman and Leblanc let the time or transportation costs as uncertain system variables to study the traffic problem in random networks (Owen and Daskin, 1998).

The existing literatures mainly consider the location problem of logistics from the perspective of minimizing the cost and the time, but research on location model of logistics facilities and distribution considered by satisfying customer needs is not too much. Logistic is a typical service industry, customer satisfaction must be put in the first place. At the same time, it is an important factor to determine customer satisfaction. The aim of introducing the concept of time satisfaction to location model of logistics distribution centre is to ensure location of services and facilities is consistent with strategic goals and business objectives and the expectations of customers, but few studies take into account the cost of time caused by satisfying customer needs when time satisfaction is considered in the model.

3 OPTIMIZATION MODEL TO LOGISTICS LOCATION PROBLEM

This siting model is formulated to solve location problem of logistics distribution centre, so as to maximize a range of benefits. In this model, we employ the Ma Yun-feng TSBMCLP model to calculate the time satisfaction and establish the frame of the time cost. We formulated model as an integer programming under the goal of maximizing the total satisfaction of customers and minimizing the total cost to the service facility's response time, which builds respectively from the points of cost and benefit (Daskin, 1995). The above-mentioned model is given as follows:

3.1 Notations

t_{ij} The shortest waiting time accepted by customers between the service demand point i and the primary service point j.

c_{ij} Transportation cost per unit between service demand point i and the primary service point j. It is proportional to the shortest distance between two points.

L_i Acceptable maximum waiting time between primary service demand point i and secondary (and lower class) service points when customers feel very satisfied.

U_i The shortest waiting time between service demand point i and secondary (and lower class) services point when customers feel very dissatisfied. $L_i \leq U_i$.

c_j Field processing costs per unit in primary service point j when customers feel satisfied, including the cost of cargo handling, sorting and etc.

h_i Demand of service demand point i.

P Number of primary service points.

λ The ratio of the time and cost, it completes conversion of time and cost. Its value depends on specific situation. For example, if the enterprise is more concerned about customer satisfaction and weaken the concern of cost, λ will be a smaller value.

$f(t_{ij})$ The satisfaction level of response time between the secondary (and lower class) service point i and primary service point j.

The curves of time satisfaction function is of a variety of situations, many functions can be used to represent the satisfaction of time (Yun-feng et al, 2006). In this paper, we use linear function of time-satisfaction, for all $f(t_{ij}) \in [0,1]$.

If $t_{ij} < L_i$, $f(t_{ij}) = 1$; if $t_{ij} > U_i$, $f(t_{ij}) = 0$; if $t_{ij} \in [L_i, U_i]$, $f(t_{ij}) = \dfrac{U_i - t_{ij}}{U_i - L_i}$.

3.2 Formulation of the Model

In a network G (V, A), V is a vertex set, | V | = n; A is an edge set $i \in I$, $j \in J$. We define $I \in V$ is total subscript set for the set of service demand points and $J \in V$ is total subscript set for the set of primary service points, $I \cup J = V$. The model can be formulated as follows:

$$Max\ z = \sum_{i \in I}\sum_{j \in J} h_i f(t_{ij}) Y_{ij} - \lambda \sum_{i \in I}\sum_{j \in J} (c_{ij} + c_j) h_i Y_{ij} \qquad (1)$$

s.t.

$$\sum_{j \in J} Y_{ij} = 1 \qquad \forall i \in I \qquad (2)$$

$$\sum_{j \in J} X_j = p \qquad (3)$$

$$Y_{ij} - X_j \le 0 \qquad \forall i \in I,\ \forall j \in J \qquad (4)$$

$$X_j = 0,1 \qquad \forall j \in J \qquad (5)$$

$$Y_j = 0,1 \qquad \forall i \in I,\ \forall j \in J \qquad (6)$$

$$\lambda \ge 0 \qquad \lambda \in N \qquad (7)$$

The objective function is to maximize actual satisfaction of services demand, while ensure the minimum cost of time. A weight is given to λ relative to the preference of the logistics enterprises. Constraints (2) ensure every demand point is serviced by the only one service point (this service point can provide the best time satisfaction). Constraints (3) ensure number of service point is P . Constraints (4) limit the satisfaction of demand points by establishment of service stations (if service station is not established, the service satisfaction of it is zero). Constraints (5) and (6) are the 0-1 Constraint.

Decision variable is seen as follows:

$$X_j = \begin{cases} 0 & \text{not set up a service at point j} \\ 1 & \text{set up a service at point j} \end{cases} \qquad \forall j \in J$$

$$Y_{ij} = \begin{cases} 0 & \text{customers at point i don't accept the service from point j} \\ 1 & \text{customers at point i accept the service from point j} \end{cases} \qquad \forall i \in I,\ \forall j \in J$$

3.3 Solving the Model

The specific target of this model is to maximize total satisfaction of secondary (and lower class) service points covered by primary service points, while reducing the cost of it. The relevant algorithm is proposed to solve the problem. With the introduction of time satisfaction function, location model will be more flexible and effective (Gen-gui and Yan-fei, 2008). At the same time, it will increase the complexity of the algorithm. According to adjusting classical algorithm of current location model, the time-based location model can be solved. The greedy algorithm, Ant colony algorithm, genetic algorithm, tabu search algorithm, artificial neural networks method and simulated annealing method can be adjusted to solve such problems. linear programming software can also be used for solving of Small-scale problems, such as lindo and lingo (Yong, 2008).

4 APPLICATION TO A CASE STUDY

4.1 The Case

In order to verify the feasibility of modeling, we apply this model to solve and optimize an actual location problem. Company A is a large private express delivery companies. It forces on customer-oriented strategy, which pays close attention to customer service and level of customer satisfaction. A has three primary services points in East China (respectively in Shanghai, Wuxi, Hangzhou) and twenty-four secondary service points. Its annual throughput of 591,000 tons is also the forefront of all regions. According to the above analysis, there is an obvious and typical site layout problem in the region of East China. We number twenty-seven service points, and the defined number and Throughputs of twenty-seven service points in East China are given in Table 1:

Table 1: The defined number and Throughputs of primary and secondary service points in East China.

Name of Service point	Number	Throughput s(h_i)
		kiloton
Shanghai (primary)	1	24
Hangzhou (primary)	2	120
Wuxi (primary)	3	23
Minhang	4	7
Qingpu	5	28
Pudong	6	14
Zhuanqiao	7	8
Huzhou Wuxing	8	5
Nanhu	9	22
Ningbo Gaoqiao	10	33
Yuyao Lanjiang	11	15
Wenzhou Ouhai	12	44
Suzhou Wuzhong	13	22
Nantong Yongxing	14	8
Wuxi Shuofang	15	13
Jindong	16	23
Yiwu Heye Tang	17	14
Huangyan	18	11
Keqiao	19	4
Zhuji	20	1
Shaoxing Donghu	21	25
Xiaoshan	22	64
Xiacheng	23	10
Changzhou Hengshan Bridge	24	22
Nanjing Guanghua	25	13
Zhenjiang Danyang	26	9
Huaian Wangying	27	11

4.2 Solving of Case

① Numbering

In the given network G (V, A), | V | = n = 27. Shanghai, Hangzhou, Wuxi are three original primary service points among them, so their current handling capacity ranks first in major cities in East China. After considering the fixed costs of set up a new primary service point, carrying capacity of cities and distribution of airports, we assume Shanghai, Hangzhou and Wuxi are candidate primary service points. X_j is set as follows:

X_1: Primary service point in Shanghai;
X_2: Primary service point in Hangzhou;
X_3: Primary service point in Wuxi;

Actually, A Company has realized two location problems: ①the layout of three primary service points mentioned above is not suitable; ②the scope of their distribution is not unreasonable because the relatively distance between them is short. Therefore, we reduce number of primary service points. We assume p = 2.

② Time-satisfaction Function $f(t_{ij})$

If V is the average speed and S_{ij} is the distance between two service points, $t_{ij} = \frac{S_{ij}}{v}$. The time can be figured out by the linear distance between two service points. S_{ij} is showed in Table 2:

Table 2: The distance between primary service point i and secondary service point j.

Distance S_{ij} km	Shanghai X_1	Hangzhou X_2	Wuxi X_3
Shanghai (primary)	—	166.9	120.3
Hangzhou (primary)	166.9	—	188.7
Wuxi (primary)	120.3	188.7	—
Minhang	15.6	151.1	113.7
Qingpu	34.2	136.4	90.1
Pudong	32.5	171.1	121.8
Zhuanqiao	17.8	149.0	117.0
Huzhou Wuxing	134.6	78.7	120.2
Nanhu	85.8	81.6	105.9
Ningbo Gaoqiao	286.6	126.7	312.7
Yuyao Lanjiang	250.5	93.8	270.6
Wenzhou Ouhai	444.6	306.7	466.7

Table 2: The distance between primary service point i and secondary service point j (cont.).

Distance S_{ij}	Shanghai X_1	Hangzhou X_2	Wuxi X_3
km			
Suzhou Wuzhong	79.3	144.8	45.7
Nantong Yongxing	115.8	237.6	127.7
Wuxi Shuofang	112.1	170.2	13.4
Jindong	298.8	133.5	326.2
Yiwu Heye Tang	256.3	93.5	261.3
Huangyan	233.4	70.5	248.5
Keqiao	184.6	38.5	211.3
Zhuji	217.4	55.3	241.5
Shaoxing Donghu	201.2	47.6	225.8
Xiaoshan	165.8	17.5	187.7
Xiacheng	167.4	25.0	183.2
Changzhou HengshanBridge	142.0	188.2	28.1
Nanjing Guanghua	271.6	248.4	158.5
Zhenjiang Danyang	197.7	228.5	82.7
Huaian Wangying	356.4	423.4	271.6

Data is measured by Google Maps

③ The Cost

The value of cost parameters c_j and c_{ij} is given by the actual data analysis. c_j =34.3 and c_{ij} =35.4.

We assume customers can accept service provided by primary service points and secondary service points in East China. So the time-satisfaction is not zero. According to customer-focused strategic analysis of private express delivery companies, we give same weight to time and cost. $\lambda = 0.014$.

4.3 Illustrative Results and Analysis

We solve this model based on the branch and bound algorithms and lingo software. The lingo result showed as follows:

① $Max\ z = 36.234$

② The site selection resulting of primary service point is A transit output is X_2 , X_3 . The final selection is Hangzhou and Wuxi. Shanghai is changed into secondary service point. The specific service scope is showed in Figure 1.

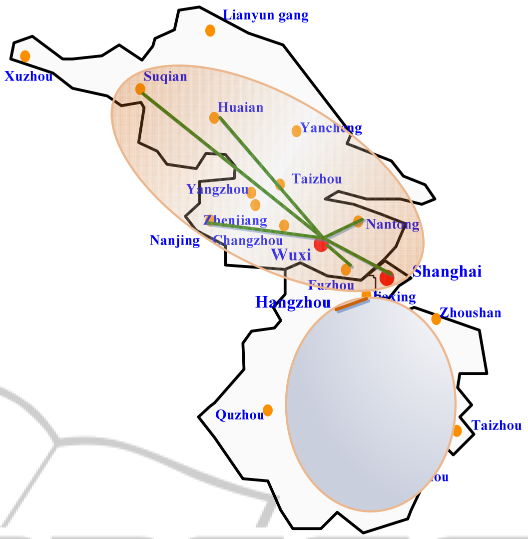

Figure 1: The optimized layout of regional network.

This result shows an optimized layout of regional networks. It reselects two primary service points: Hangzhou and Wuxi, and reorganizes the regional scope. The new program can not only meet growing business needs, but also improve the relatively dense layout. It achieves a high level of customer satisfaction because customers can obtain service in shorter time. Company A can gain competitive advantages by improving time-satisfaction, while cost of services is deceased.

5 CONCLUSIONS

This paper discusses location model of logistics distribution and service centre based on time dimensions. The main value added of this study is the development of the new location model, in which, both time satisfaction and time cost are taken into account. We formulated the model as an integer programming under the goal of maximizing the total satisfaction and minimizing the total cost. According to analysing the optimized layout of regional networks which is solved by this model, we confirm the model has usage value for the location problem of logistics facility. Nevertheless, a more research is needed to develop the model. The following step of this research could be to replace a part or all of relevant expressions about transportation cost with time cost accurately in objective function or constraints. At the same time, more factors need to be considered in this model so as to reflect actual situation.

REFERENCES

Qu Bo, Yang Chao, Ma Yun-feng, Weng Ke-rui, 2008. Time-satisfaction-based covering location problem and the application of Hybrid Genetic Algorithm. *Industrial Engineering and Management.*

Brandeau ML, Chui SS, 1989. An overview of representative problems in location research. Management Science, 35(6), 645-674.

Susan Hesse Owen, Mark S. Daskin, 1998. Strategic facility location: A review. *European Journal of Operation Research,* 111, 423-447.

Mark S. Daskin, 1995. *Network and discrete location: models, algorithms and applications*. New York, Wiley Interscience.

Ma Yun-feng, Yang Chao, Zhang Min, Hao Chun-yan, 2006. Time-satisfaction-based maximal covering location problem. *Chinese Journal of Management Science,* 2 (14).

Zhou Gen-gui, Hen Yan-fei, 2008. Research on logistics siting problem in logistic distribution center based on time satisfaction. *Journal of Zhejiang University of Technology*, 4 (36).

Liu Yong, Ma Yun-feng, Yang Chao, 2008. Study on the telecom business outlet location optimization model Based on the Time-Satisfaction. *Industrial Engineering and Management.*