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Comprehensive Evaluation Method of Logistic Location under Electronic Commerce

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Abstract: **The location selection of warehouse and distribution center (DC) is the key step for logistics system optimization. This study establishes the logistic warehouse location model under electronic commerce. Then a numerical example is given to validate the model and compares the results of the traditional logistics warehouse location model with single objective and the new warehouse multi-objective model. It shows the electronic commerce is more economical in selling cost and more efficacies.**

Keywords**: Electronic commerce; logistic location; Comprehensive evaluation.**

I. INTRODUCTION

The facility location decision is critical elements in strategic planning for a wide range of private and public firms. Finding an appropriate solution to this problem is usually a very difficult task, demanding that decision makers account the whole particularity of their problem.

The problem of logistic location facilities is not new in the operation research field, various models in this fields of application have been made, cooper [8] in 1963 is known as first who considered this problem, in 1982, Murtagh and Niwattisya Wong [26] proposed the capa-cited facility location allocation (FLA) their problem is considered to be one of the most important FLA researches focuses on capacity of facility. Over nearly four decades this problem has attracted much research by investigation [1,2]. The field is very active with many interesting problems being investing from problem formulation and algorithmic aspect. In 1994, Liu et al [3] minimizing the total weighted distance from supply center to customers with regards to the rectilinear distances, wich is considered as one of the most important researchers for this location allocation problems.

In the last few years, the facility location problems with supply chain approach and electronic commerce have been considered by researchers [13,14,15,16,17,18,19], because of increasing customer expectations and industry competition[30,31], therefore electronic commerce and the electronization of business process have revoluted many industries, such as the financial services industries and the location problem. As a result the importance of logistics and 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 DC, and improve standards of logistics and DC's service to customer. At the same time it will act the warning road to costing. In line with this subject, there are much work should be done. Little articles have been found in this field and it wills become a hot research[4,5,7,9,10,11,12]. Xu et al [6] proposed a location selection model of two level electronic commerce logistics distribution center, the model has been solved by the software lingo, they only considered two levels logistics distribution mechanism with the principle of the minimum overall cost to satisfy the demands of all the customers. Compared to it, this paper analyzed location selection of three level logistics distribution mechanism with two aims objective cost and time. Bischoff and Dachet [27] compared to traditional search methods for LA problems with the new search methods and studied the effectiveness of these methods to each other. Ding Xiao-dong et al [28] use lingo language to solve the logistics distribution center location, later they discovered that traditional method cannot resolve the complex models. Lu Xiao li et al [29] proposed the research on location model solving logistic distribution center based on matlab, they used this software because they found that the model calculation process of logistics DC are often too complex, therefore they used Matlab language to write the program and to avoid double counting.

However, traditionality, the integration of supply chain network is usually based on deterministic parameters and on limited method, and very simple software like lingo for building and solving mathematical programming problem.

The reminder of this paper is organized as follow: in the next section the mathematical formulation of the problem is presented. Subsequently, solution approaches based on comprehensive evaluation and a numerical experiment are summarized in section three. Finally, our conclusions and future research directions are discussed in the last section.

II. WAREHOUSE LOCATION MODEL UNDER ELECTRONIC COMMERCE

The following assumptions are made for subsequent modeling and optimization: four facility levels including suppliers, customers, warehouses and Distribution center; the whole system is operated steadily; therefore, there is no stock accumulation or depletion, and inventory can be ignored; The distribution center can supply more than one customer's product; An uncertain product demand is considered in the modeling; the requirement of warehouse is known; the storage cost and the fixed expenses of establishing the warehouse can be known; the candidate warehouse have no limitation of flow and capacity; the supplier productive capacity is known; the distribution time condition also known; the transportation expenses of distribution goods are the direct ratio of the transportation cost.

The logistic distribution center of multistage model is established under electronic commerce and can be summarized as follows.

$$\text{Min } TT = \sum_{p=1}^{P}\sum_{s=1}^{S}\sum_{j=1}^{J} TT_{psj}Y_{psj} + \sum_{p=1}^{P}\sum_{j=1}^{J}\sum_{l=1}^{L} TT_{pjl}Y_{pjl} + \sum_{p=1}^{P}\sum_{j=1}^{J}\sum_{k=1}^{K} TT_{pjk}Y_{pjk}$$

TT_{psj} : Total transport time of product (p) from the supplier (s) to the warehouse (j)

$$Y_{psj} \begin{cases} 1 & \text{if supplier } s \text{ supplies product } p \text{ to warehouse } j \\ 0 & \text{otherwise} \end{cases}$$

TT_{pjl} : Total transport time of product (p) from warehouse (j) to distribution center (l)

$$Y_{pjl} \begin{cases} 1 & \text{if warehouse } j \text{ supplies product } p \text{ to distribution center } l \\ 0 & \text{otherwise} \end{cases}$$

TT_{pjk} : Total transport time of product (p) from warehouse (j) to customer (k)

$$Y_{pjk} \begin{cases} 1 & \text{if warehouse } j \text{ supplies product } p \text{ to customer } k \\ 0 & \text{otherwise} \end{cases}$$

$$\text{Min } TC = \sum_{p=1}^{P}\sum_{s=1}^{S}\sum_{j=1}^{J} TTC_{psj}Z_{psj} + \sum_{p=1}^{P}\sum_{j=1}^{J}\sum_{l}^{L} TTC_{pjk}Z_{pjk} + \sum_{p=1}^{P}\sum_{j=1}^{J}\sum_{l=1}^{L} TTC_{pjl}Z_{pjl} +$$

$$\sum_{p=1}^{P}\sum_{s=1}^{S}\sum_{j=1}^{J} C_{psj}Z_{psj} + \sum_{j=1}^{J}\sum_{l=1}^{L} R_j C_j + \sum_{p=1}^{P}\sum_{l=1}^{L}\sum_{k=1}^{K} M_{pk}[Max(0, TT_{plk} - T_{pk})]F_{pk}T_{plk}$$

TT_{plk} : Total transportation time from DC to Customer

M_{pk} : The unit of losses of the product (p) for delayed warehouse to customer (k)

T_{pk} : The restricted condition of the distribution time of the customer (k)

T_{plk} : If the distribution center supplies product to customer (k)

F_{pk} : The demand of customer (k)

TTC_{psj} : The transportation price of product (p) from supplier (s) to warehouse (j)

Z_{psj} : The transportation cost of product (p) from the suppliers to the warehouse (j)

TTC_{pjk} : The transportation price of product (p) from warehouse (j) to customer (k)

Z_{pjk} : The transportation cost of product (p) from warehouse (j) to customer (k)

TTC_{pjl} : The transportation price of product (p) from warehouse (j) to distribution center (l)

Z_{pjl} : The transportation cost of product (p) from warehouse (j) to distribution center (l)

C_{psj} : The unit storage costs of product (p) of the warehouse (j)

Z_{psj} : The transportation cost of product (p) from the supplier (s) to the warehouse (j)

$R_j \begin{cases} 1 \text{ the spare dot of the warehouse can be slected} \\ 0 \text{ not selected} \end{cases}$

C_j : The fixed expenses of the product (p) of the warehouse (j)

The restrict equation is following:

$$\sum_{j=1}^{J} Z_{psj} \le A_{ps} \quad \forall\, p, s \in C \;;\;\; j = 1, 2, ..., J$$

Shows that the transportation price of the product (p) supplying to the warehouse by the supplier (s) should be under its producing ability.

C : Number of customer

$\sum_{j=1}^{J} Z_{pjk} = B_{pk}$ $(\forall p \in P \,;\, j \in J \,;\, k \in K)$ Indicate that the warehouse should satisfy the customer

$\sum_{j=1}^{J} Z_{pjl} = F_{pj}$ $(\forall p \in P \,;\, j \in J \,;\, l \in L)$ Means that the warehouse should satisfy the distribution center.

$\sum_{s=1}^{S} Z_{psj} = \sum_{k=1}^{K} Z_{pjk} + \sum_{d=1}^{D} Z_{pjl}$ $(\forall p \in P \,;\, j \in J \,;\, s \in S \,;\, k \in K \,;\, 1 \in L)$ Means the entering and going transportation cost of the warehouse should be equal.

$1 \le \sum_{j=1}^{J} R_j \le P$ $(\forall j \in J)$ Shows that the maximum amount of warehouse should be more than one and less than the maximum amount P ; P : The maximum amount of warehouse

R_j : The spare dot of warehouse j selecting

$\sum_{j=1}^{J} R_j Z_{psj} \ge 1$ $(\forall p \in P \,;\, j \in J \,;\, s \in S)$ Means each supplier at least provide goods to one warehouse

$\sum_{j=1}^{J} R_j Z_{pjl} \ge 1$ $(\forall p \in P \,;\, j \in J \,;\, l \in L)$ Means each distribution center must satisfied at least by one warehouse

$\sum_{j=1}^{J} R_j Z_{pjk} \ge 1$ $(\forall p \in P \,;\, j \in J \,;\, k \in K)$ Means each customer must satisfied by one warehouse.

$R_j \le \sum_{p=1}^{P} \sum_{l=1}^{L} Z_{pjl} + \sum_{p=1}^{P} \sum_{k=1}^{K} Y_{pk}$ $(\forall p \in P \,;\, j \in J \,;\, l \in L ; k \in K)$ Show if the warehouse is selected.

$Z_{psj} \le Y_{psj}$ $(\forall p \in P \,;\, s \in S \,;\, j \in J)$ Means if the supplier supplies product to warehouse

$Z_{pjk} \le Y_{pjk}$ $(\forall p \in P \,;\, j \in J \,;\, k \in K)$ Shows if the warehouse supplies product to customer

$Z_{pjl} \le Y_{pjl}$ $(\forall p \in P \,;\, j \in J \,;\, l \in L)$ Shows if the warehouse supplies product to distribution center

$Y_{pjl} \le R_j$ $(\forall p \in P \,;\, j \in J \,;\, l \in L)$ Shows if the warehouse is selected can provide service to distribution center

$\sum_{\forall s} Q_{sjt}^{p} = \sum_{\forall l} Z_{jlt}^{p}$ $(\forall j, t)$ The total flow of product by supplier must be equal to the total rate of the product from the warehouse to all DC.

$IQ_{st}^{p} = \sum_{\forall j} Q_{sjt}^{p}$ $(\forall i, t)$ The actual note of product by a supplier must equal the total flow of the product to all warehouses.

$\sum_{\forall j} Z_{jlt}^{p} = \sum_{\forall k} Q_{lkt}^{p}$ $(\forall l, t)$ The total flow of product from all warehouses to a DC must equal to the total flow of the product from the DC to all customer zones.

$\sum_{\forall l} Q_{lkt}^{p} = FCD_{kt}^{p}$ $(\forall k, t)$; $IQ_{pi}^{t} \ge 0$ $(\forall p, i)$

The total flow of production from all DCs to a customer zone must equal to the forecast customer Demands.

In summary the mid-term supply chain-planning model can be constructed as a multi-objective mixed integer linear program (MILP). Notably, all objectives expressed below are set to a maximum for simplifying the discussion. The feasible searching space Ω is a composite of all constraints shown below.

$$\max_{x\in\Omega}\left(O_1(x),\cdots,O_M(x)\right)=\left(-TC,-TT\right) \qquad O_m\text{ :objectives}$$

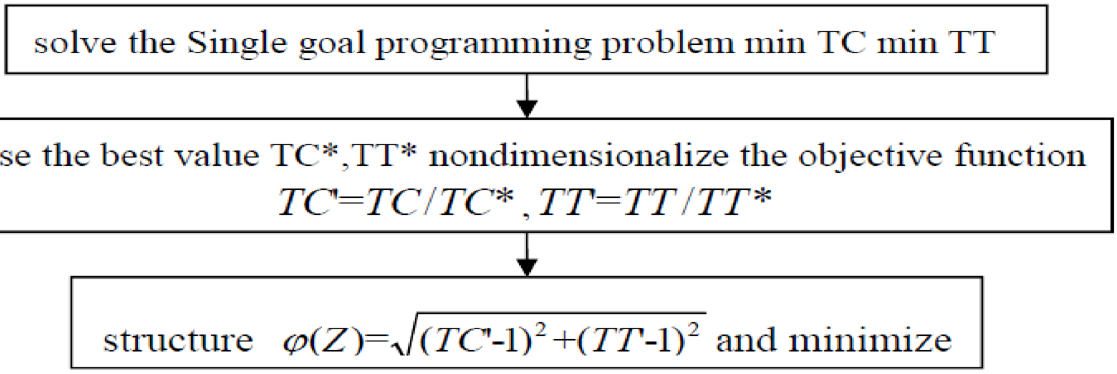
III. LOGISTIC LOCATION MODEL UNDER COMPREHENSIVE EVALUATION

The solution method in this paper is as below; we calculate first the problem by Matlab after we make comparison with Lingo software [32, 33].

The problem of this paper is a multiple objective programming problem. The basic ideas to solve Multi-objective linear programming are transforming the multi-objective problem into single-objective planning. The ideal point method will be introduced below and applied to this problem.

As everyone knows, we can't get the optimal value at the same generally. But we can solve each Single goal programming problem first. For example, to the goal TC, suppose the optimal solution is TC*， and to the goal TT is TT*.We define the ideal point (TC*,TT*),so, under some expected measurement, if we find the nearest point away from the ideal point, that the best solution achieved.

Three steps to achieve the goal by Matlab[20,21,22,23,24,25,34]. See the flow diagram below.



Additional remark: To deal with Rj, assume [R1,R2,R3]=[1,1,1],[1,1,0],[1,0,1],[1,0,0],[0,1,1], [0,1,0], [0,0,1] by the method of exhaustion, if the solutions conform to the corresponding situation, the [R1,R2,R3] is right.

Another method for solving this problem also carries out with the name of linear weighted method. In that case, the structural function will be another form.

$$\varphi(Z)=\omega_1 TC'+\omega_2 TT'$$

IV. NUMERICAL EXAMPLES

There is a logistic enterprise wants to build secondary warehouse. Our method, can be illusltrated through an example application; The typical supply chain consists of three suppliers, three candidate warehouses, five distribution centers, 10 customer zones, and three products.

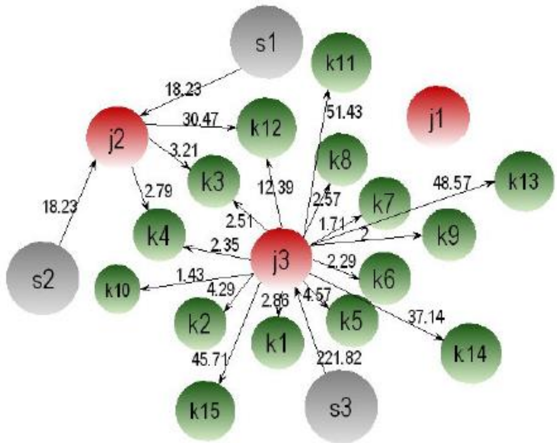
The data include, supplier capacity (Tons/day), warehouse unit storage cost and fixed cost (RMB/Month/m2), shipping costs from supliers to the warehouse ($/vehicle 35T),shipping time from supplier to warehouse (Day), shipping cost from warehouse to customer and distribution center($/vehicle 35 T); shipping time from warehouse to distirbution center and customer (day), demand constraint of customer and distirbution cneter, time constraint of customer (day) and unit losses of delayed distirbution. Now it needs to make the selecting decision.

To solve this problem, the decision-maker can choose the appropriate weight values according to their own expectation.

Figure.1 show the result of the single goal TT and TC when transport product PP. [R1, R2, R3] =[0,1, 1].The best value TT*=871.71d. Figure 1 also show the result of the single goal TC when transport product PP. [R1,R2,R3]=[0,1, 1].The best value TC*= 4281900¥.It doesn't consider that Zs are integers because we can do each product firstly and then combine all the results when will discuss the integer problem.

Result.1 indicates that we should try to take delivery of the goods from the supplier 3 as far as possible to the warehouse 3 if we want to realize the optimal total time.

Result.2 indicate that we should try to take delivery of the goods from the supplier 2 as far as possible to the warehouse 2 if we want to realize the optimal total cost.


Result of single min TT

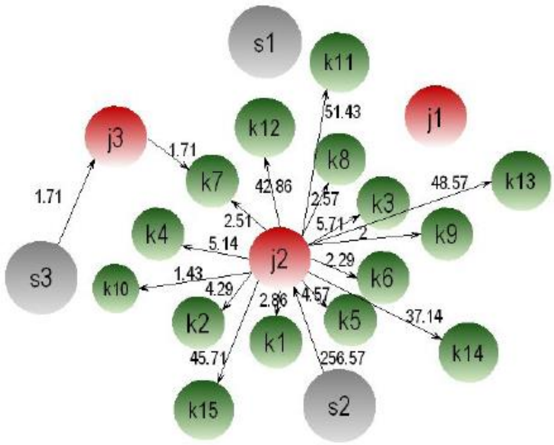

Result of single min TC

Figure. 1 Result of Single min

Table. 1 Corresponding Code

s1	Inner Mongolia wuhai chemical co.	k6	Choosing HaoChuan Chemical co.,
s2	Guangxi tiandong jin cheng chemical co.	k7	Shandong better xiang plastic co.
s3	Shanghai tianwu chemical international trade co.	k8	Shijiazhuang city east chemical industry co.
j1	Center warehouse	k9	Wuhan fuhua era trade co.
j2	Second warehouse	k10	Wisewin chemical co.Of zhengzhou city
j3	Delivery warehouse	k11	East China distribution center
k1	Hangzhou damei plastic co.	k12	South China distribution center
k2	Haining ShenHui decoration co.	k13	Southwest distribution center
k3	Dongguan xin shun plastic products co.	k14	Northeast distribution center
k4	Zhongshan Yang plastic packaging materials co.	k15	Central China distribution center
k5	Chengdu green peace trading co.		

%The numbers on the arrow line means the times trucks should transport and arrow shows the direction.
Through the analyze above, we can predict that the solution of this multiple objective programming problem must be between the two extreme solutions. And the selected warehouse is warehouse 2&3.

With the method of the ideal point method, TT= 987.43d and TC=4852800¥, at this situation, result 1 of figure 1 show the transport plan. With the method of linear weighted method, taking the weight value w1=w2=0.5, TT= 978.29d and TC= 896500¥ and the best φ (Z)= 0.18815, result 2 of figure 2 show the transport plan. Comparing the two results, there is little a difference between them in which warehouse is responsible for the PP to k4.

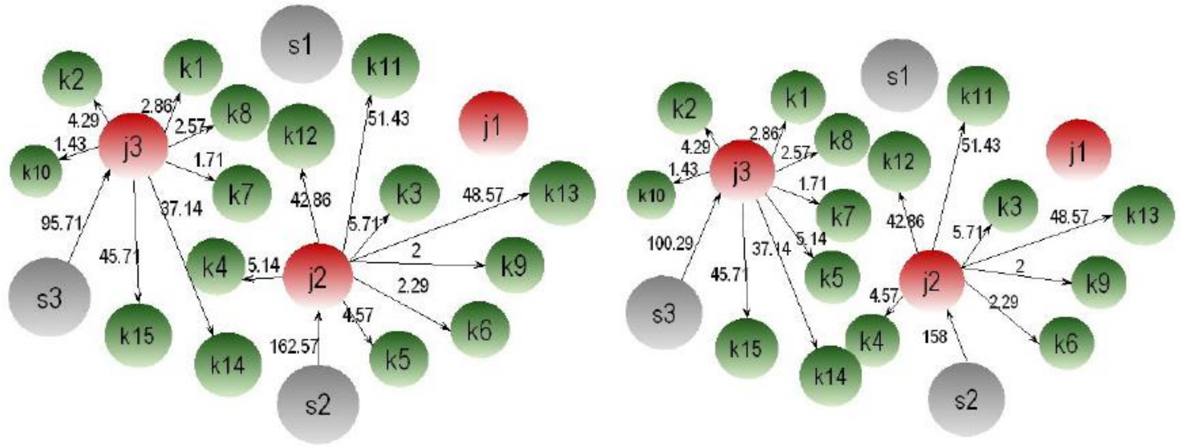


Figure. 2: Result of the ideal point method Result of linear weighted method (w1=w2=0.5)

The result above is for discussing the transportation of product PP.Changing the initial data and run the program in the same way can get the corresponding results.Finishing as follows.

Table.2: transportation plan

times	PP	PVC	PE	Sum	times	PP	PVC	PE	Sum
Z22	162.6	181.3	58.6	402.4	Z215~	0	17	0	17
Z33	95.7	88.7	25.3	209.7	Z31~	2.9	4.3	1.4	8.6
Z23~	5.7	7.1	2.3	15.1	Z32~	4.3	2.9	2	9.1
Z24~	5.1	5.7	2.9	13.7	Z35~	0	5.7	3.4	9.1
Z25~	4.6	0	0	4.6	Z36~	0	4.3	0	4.3
Z26~	2.3	0	2.9	5.1	Z37~	1.7	2.9	1.7	6.3
Z29~	2	2.9	2	6.9	Z38~	2.6	3.7	1.4	7.7
Z211~	51.4	57.1	22.9	131.4	Z310~	1.4	2	1	4.4
Z212~	42.9	48.6	14.3	105.7	Z314~	37.1	57.1	8.6	102.9
Z213~	48.6	42.9	11.4	102.9	Z315~	45.7	5.9	5.7	57.3
		PP		PVC		PE		Sum	
Total Time/d		987.4		1018.5		319.3		2325.2	
Total Cost/p.d		4852800		5140600		1471600		11465000	

%(note)Zsj has no "~" on the top right conner.Zjk has the "~" on the top right conner.

Through the transportation plan table 11,we can easily read, not only the times of the trucks (35t) should bring from the suppliers to warehouse or warehouse to customers per day, but also the types of products. Under its guidance, it is possible to bring two or three products in one trucks.

For example, from warehouse 3 to customer 2, the loads just in one truck can be 10.5 tons of PP, 10.5 tons of PVC and 14 tons of PE.

Besides, All the results are checked by lingo. Input the data in lingo to calculate the minimum logistics costs.

From the result showed above we can see, the multi-objective model increases logistics costs and improves the efficiency of distribution time, that's mean our model is more comprehensive and more consideration.

V. CONCLUSION

In this article, we have presented a new mathematical model under comprehensive evaluation method to establish the logistic warehouse location model under electrotonic commerce. In addition, we have designed principles of the ideal point method and linear weighted method to solve the proposed model because of its complexity. Finally, we have solved numerous examples to compare the results of lingo and matlab, we use matlab and lingo just to check the result and to

Illustrate the numerical example, we can find from the result showed above, the multi-objective model increases logistics costs and improves the efficiency of distribution time.

According to the comparing between the traditional model properties and the new multi-objective model, we can discover that the new model is more suitable and more applicable and has better result, and using the electronic commerce factors in this paper, shows that electronic commerce is more economical in selling cost and more efficacious.

Actually, to solve the location problem under electronic commerce, many other factors except cost and time need to be consider. Such as inventory cost, public satisfaction, social benefit, etc. Therefore our future work, is to concentrate on new solution methodology based on fuzzy method, this method can be developed to obtain new optimal solutions for the multi-objective location problem, and the effectiveness of the methodology can be investigated.

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