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System Optimization on Distribution Center of Retail

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Abstract: Based on reducing cost in logistics system and lowering wasting resources, system optimization on distribution center of retail is carried from a macro point of view. An evaluation indicator system for distribution center of retail is established. A dichotomy model is proposed by using coordinates mapping, fuzzy math, AHP and numerical method. $M_F = M(i \geq d^*) \propto u^{(1)}$ is proved to be the best optimization measure for distribution center of retail.

Keywords: logistics system; resource allocation; fuzzy math; AHP; dichotomy

1 Introduction

In recent years, chain management has been the main choice of the development of retail in China. As researched, distribution center of retail in China would be rapidly developed in the coming years. Optimization analysis is not only of the theory value but also of the realism sense.
Many researches have been done in logistics system. In 2007, Liu Q, et al proposed the theory of genetic algorithm and stochastic-flow network for computing the optimal resource for modern logistics system [1]. In the same year, Fiedler C developed a dynamic resource allocation network on the basis of Petri net by introducing the theory of system dynamics into programming of logistics [2]. Demirag OC and Swann JL presented a model of decentralized logistics network by the theory of mixed integer programming in logistics system [3]. In 2006, Sheu JB gave a novel dynamic resource allocation model for the use of demand-responsive city logistics distribution operations, based on a group of dynamic customers [4]. Yang A and Zhao YF advanced a method to solve the problems of logistics park network gradually in a certain economic zone by the theory of fuzzy clustering in 2007 [5]. Chen JZ proposed the theory of material flow to help the development of the circular economy in modern logistics in 2007 [6]. Ding GL and Chen WY proposed synthetic comments of the ideology principles and key technologies about the main technologies of the resources distribution in modern logistics system in 2007 [7].
In this paper, we introduced the dichotomy of numerical value analysis into logistics system [8] and developed the system optimization theory of programming for distribution center of modern logistics. This research result is helpful in adopting scientific scheme and in saving social resources and reducing cost of investment.

2 Indicators and evaluation system

According to fuzzy math [9-10], we study the system optimization problem on distribution center of retail. Adopting two evaluating indicators, we let the goals set be (*See Tab. 1*)

$$U = \left\{ u^{(1)}, u^{(2)} \right\},$$

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Refining estimating indicators of system programming for distribution center of retail, we let the factors set be (*See Tab. 1*)

$$A = \left\{ a^{(1)}, a^{(2)}, \cdots, a^{(k)} \right\}.$$

Table 1: Evaluating Indicators.

Goals Set U	Factors Set A
	$a^{(1)}$
$u^{(1)}$	$a^{(2)}$
$u^{(2)}$	$\vdots$
	$a^{(k)}$

With AHP ideas in [11-12], we let the weight among $a^{(1)}, a^{(2)}, \cdots, a^{(k)}$ in A be (*See Fig. 1*)

$$\rho(A) = \begin{pmatrix} \rho^{(1)} & \rho^{(2)} & \cdots & \rho^{(k)} \end{pmatrix}.$$

Based on Tab. 1, the evaluation indicators system about system optimization on distribution center of retail can be constructed as Fig. 1.

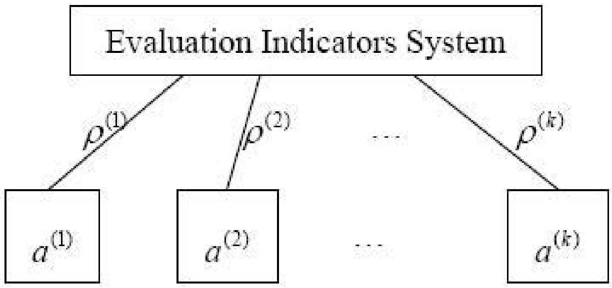

Figure 1: Evaluation Indicators System.

Therefore, we can carry out researches on evaluating indicators$a^{(1)}$,$a^{(2)}$,$\cdots$,$a^{(k)}$ (*See Tab. 1 and Figure 1*) to put forward the final optimized scheme. That is to increase the investment of$a^{(n_1)}$,$a^{(n_2)}$,$\cdots$,$a^{(n_N)}$$(1 \leq n_1$,$n_2$,$\cdots$,$n_N \leq k)$, which are to be determined.

3 Dichotomy Model

We take the following notations. For the ith indicator $a^{(i)}$ of$A$, if $a^{(i)}$is consistent with$u^{(1)}$, then $a^{(i)}$ is said to be advisable and is expressed as$a^{(i)} \propto u^{(1)}$. On the contrary, $a^{(i)} \bar{\propto} u^{(1)}$. For any M $(\exists M)$ in Fig. 1, if M is consistent with $u^{(1)}$, then $M$is considered to be acceptable and is notated as$M \propto u^{(1)}$. Otherwise, $M \bar{\propto} u^{(1)}$.

We realign $a^{(i)} (i = 1, 2, \cdots, k)$ to $A = \{a_1, a_2, \cdots, a_k\}$ according to the increasing order of the sequence $\rho^{(i)}$. Now the weight of factors in A is

$$\left\{ \begin{array}{l} \rho(A) = (\rho_1, \rho_2, \cdots, \rho_k) \\ \sum\limits_{i=1}^{k} \rho_i = 1 \\ \rho_1 \leq \rho_2 \leq \cdots \leq \rho_k \end{array} \right. .$$

Let the weight of a_i and A with respect to U be

$$\widetilde{R}_i = \begin{pmatrix} x_i & 1 - x_i \end{pmatrix}_{1 \times 2}.$$

and

$$R\left(A,U\right)=\left(\ \widetilde{R}_i\right)_{k\times 2}=\begin{pmatrix} x_1 & 1-x_1 \\ x_2 & 1-x_2 \\ \vdots & \vdots \\ x_k & 1-x_k \end{pmatrix}_{k\times 2}, \quad i=1,2,\cdots,k.$$

respectively. It is sure that $a^{(i)} \propto u^{(1)}$ if and only if $x_i > 0.5$. We map $\rho_i(i = 1, 2, \cdots, k)$ into *a reference frame* (*See Fig. 2*). Among $1, 2, \cdots, k$, there is a dichotomy point $d = \left[\frac{k+1}{2}\right]$,where $[\cdot]$ means taking the integer part of d. Assume that

$$\begin{cases} a_i \propto u^{(1)}, d \le i \le k \\ a_i \bar{\propto} u^{(1)}, 1 \le i \le d-1 \end{cases},$$

So x_i, the first component of $\widetilde{R}_i$, must satisfy the following (*See Fig. 3*)

$$\begin{cases} x_i > 0.5, d \le i \le k \\ x_i \le 0.5, 1 \le i \le d-1 \end{cases}.$$

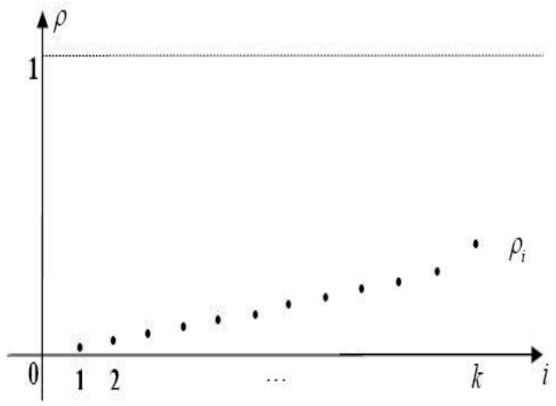

Figure 2: Mapped ρ_i.

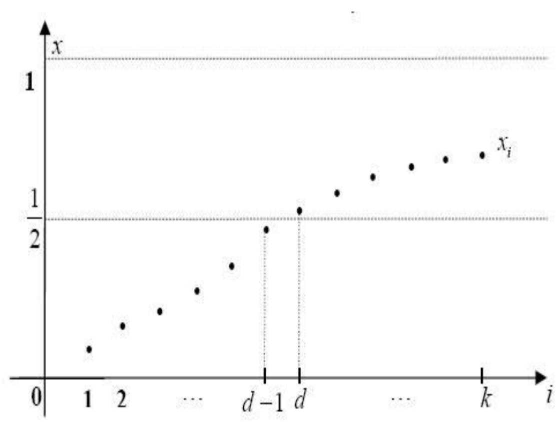

Figure 3: Distributing of x_i.

Based on AHP[11-12], we obtain the final evaluated results as $B = \rho\left(A\right)\cdot R\left(A,U\right) = \left(\ b_1 \quad b_2\ \right)$,where $b_1 = \sum_{i=1}^{k} \rho_i x_i, \quad b_2 = \sum_{i=1}^{k} \rho_i\left(1-x_i\right)$. So

$$b_2 = \sum_{i=1}^{k} \rho_i\left(1-x_i\right) = \sum_{i=1}^{k}\left(\rho_i - \rho_i x_i\right) = \sum_{i=1}^{k}\rho_i - \sum_{i=1}^{k}\rho_i x_i,$$

for

$$\sum_{i=1}^{k}\rho_i = 1,$$

we can obtain

$$b_2 = 1 - b_1.$$

From the above analysis , we can obtain the final evaluated results as $B = \left(\ b \quad 1-b\ \right)$,where $b = \sum_{i=1}^{k}\rho_i x_i$. Therefore, $M\left(i \ge d\right) \propto u^{(1)}$ if and only if $b > 0.5$. The above analysis can be described in a flow chart (*See Fig. 4*).

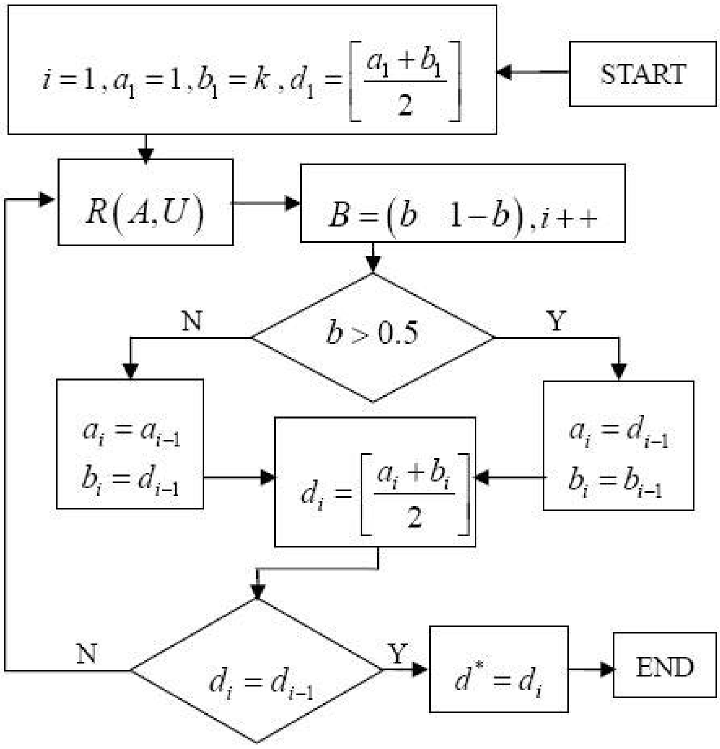

Figure 4: Flow Chart

According to Fig. 4, the final dichotomy point d^* can be obtained. And we can make sure that

$$a_i\,(i \geq d^*) \propto u^{(1)},$$

We can also obtain the optimized programming scheme as

$$M_F = M\,(i \geq d^*) \propto u^{(1)}.$$

That is to increase the investment of $a_i\,(i \geq d^*) \propto u^{(1)}$ which have been determined.

4 Application

Based on the ideas mentioned above, we study a system optimization problem for a distribution retail center.

4.1 Evaluating indicators system

According to AHP and fuzzy math, we obtain the Indicator Evaluation System (*See Tab. 2*).

4.2 Dichotomy Model

By Tab. 2, we realign $a^{(j)}$ to $A = \{a_i\}$ in the increasing order of sequence $\rho^{(j)}$ (*See Tab. 3*).

On the bases of Tab. 2 and Tab. 3, the weight of a_i in A is $\rho\,(A) = (\rho_i)$, $i = 1, 2, \cdots, 28$(*See Fig. 5*).

And we can also make sure that (*See Fig. 5*)

$$\sum_{i=1}^{28} \rho_i = \sum_{j=1}^{28} \rho^{(j)} = 1.$$

We let (*See Fig. 6*)

$$\begin{cases} x_i = 0.7, & d^* \leq i \leq k \\ x_i = 0.3, & 1 \leq i \leq d^* - 1 \end{cases}.$$

According to Fig. 3, the value of d_i can be obtained (*See Tab. 4*).

Table 2: Indicator Evaluation System.

		Indicator	Evaluation	System	
j	$a^{(j)}$	$\rho^{(j)}$	j	$a^{(j)}$	$\rho^{(j)}$
1	$a^{(1)}$	0.0011	15	$a^{(15)}$	0.0315
2	$a^{(2)}$	0.0715	16	$a^{(16)}$	0.0547
3	$a^{(3)}$	0.0568	17	$a^{(17)}$	0.0179
4	$a^{(4)}$	0.1254	18	$a^{(18)}$	0.0238
5	$a^{(5)}$	0.0357	19	$a^{(19)}$	0.0113
6	$a^{(6)}$	0.0514	20	$a^{(20)}$	0.0101
7	$a^{(7)}$	0.0325	21	$a^{(21)}$	0.0109
8	$a^{(8)}$	0.0435	22	$a^{(22)}$	0.0201
9	$a^{(9)}$	0.0897	23	$a^{(23)}$	0.0213
10	$a^{(10)}$	0.0543	24	$a^{(24)}$	0.0139
11	$a^{(11)}$	0.0785	25	$a^{(25)}$	0.0074
12	$a^{(12)}$	0.0584	26	$a^{(26)}$	0.0098
13	$a^{(13)}$	0.0123	27	$a^{(27)}$	0.0172
14	$a^{(14)}$	0.0135	28	$a^{(28)}$	0.0255

Table 3: Realigned Factors Set.

a_i	a_1	a_2	a_3	a_4	a_5	a_6	a_7
$a^{(j)}$	$a^{(1)}$	$a^{(25)}$	$a^{(26)}$	$a^{(20)}$	$a^{(21)}$	$a^{(19)}$	$a^{(13)}$
a_i	a_8	a_9	a_{10}	a_{11}	a_{12}	a_{13}	a_{14}
$a^{(j)}$	$a^{(14)}$	$a^{(24)}$	$a^{(27)}$	$a^{(17)}$	$a^{(22)}$	$a^{(23)}$	$a^{(18)}$
a_i	a_{15}	a_{16}	a_{17}	a_{18}	a_{19}	a_{20}	a_{21}
$a^{(j)}$	$a^{(28)}$	$a^{(15)}$	$a^{(7)}$	$a^{(5)}$	$a^{(8)}$	$a^{(6)}$	$a^{(10)}$
a_i	a_{22}	a_{23}	a_{24}	a_{25}	a_{26}	a_{27}	a_{28}
$a^{(j)}$	$a^{(16)}$	$a^{(3)}$	$a^{(12)}$	$a^{(2)}$	$a^{(11)}$	$a^{(9)}$	$a^{(4)}$

4.3 Optimized scheme

By Tab. 4, $d^* = d_7 = d_6 = 22$, so $a_i\,(i \geq 22) \propto u^{(1)}$. So we can obtain the optimized programming scheme as

$$M_F = M\,(i \geq 22)\,.$$

And by Tab. 3, we can make sure that $a^{(j)} \propto u^{(1)}\,(j = 16, 3, 12, 2, 11, 9, 4)$. So the optimized programming scheme is

$$M_F = M\,(j = 2, 3, 4, 9, 11, 12, 16)\,.$$

That is to increase the investment of $a^{(j)} \propto u^{(1)}\,(j = 2, 3, 4, 9, 11, 12, 16)$ which have been determined.

Table 4: Value of d_i.

i	1	2	3	4	5	6	7
d_i	14	21	24	22	23	22	22

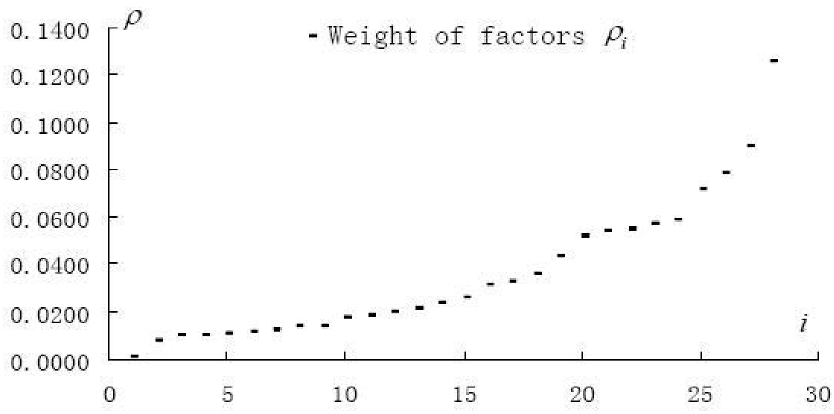

Figure 5: Distributing of ρ_i.

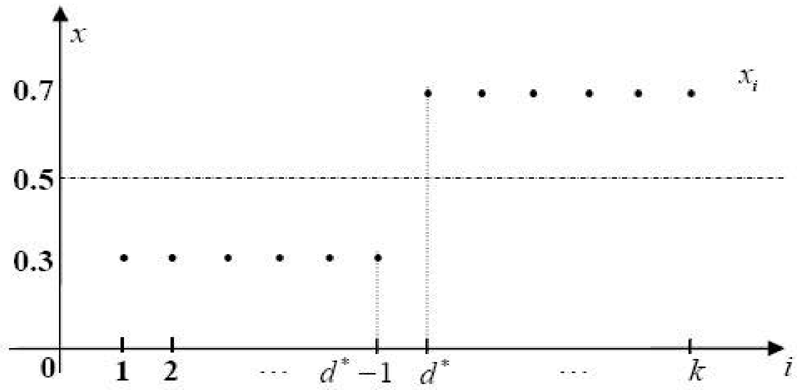

Figure 6: Distributing of x_i.

5 Conclusion

By constructing the evaluating indicators system and introducing the dichotomy model, we conclude that the best measure of optimal programming for distribution center of retail is $M\,(i \geq d^*)$. As shown in the example, the number of evaluating indicators which need to be determined is a quarter of the entire indicators.

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