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Research on the Location of the Hazardous Chemical Distribution Center under the Supply Chain Environment

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The hazardous chemical is prone to the accidents during the transportation and the storage. At the same time, the characteristics of the hazardous chemical make the hazardous chemical accidents have the very abominable impact on the life, the property and the environment. The reasonable distribution center location for the hazardous chemical can avoid many safety problems fundamentally. Under the modern management idea, the storage and the transportation of the hazardous chemical are all in the supply chain. Therefore, we should consider the selection of the hazardous chemical distribution center under the supply chain environment. The reasonable site selection will have a positive impact on the accident probability, delivery speed and cost etc. In order to make the location problem of the hazardous chemical distribution center fits the trend of the times and the idea of the supply chain management, we propose the location evaluation model of the hazardous chemical distribution center. At the same time, we will use the improved AHP method to evaluate the location problem in order to make the evaluation result more accurate. The experimental results show that the evaluation system of this paper has a good effect on the distribution center location of hazardous chemical under the supply chain environment.

1. Introduction

The hazardous chemical accident has the characteristics of the low probability and the high risk. The hazardous chemical is easy occurring serious consequences during the process of the production, the transportation and the storage. The hazardous chemical accidents cause losses to people's lives and property while causing harm to the surrounding environment. The industrialization of China is speeding up. Therefore, the usage of chemical is also increasing. The production and the transportation of the hazardous chemical are becoming more and more frequent. The storage and transportation safety problem of the hazardous chemical have attracted wide attention.

The location problem of the hazardous chemical distribution center should consider the idea of the supply chain management. The circulation of any goods cannot be separated from the supply chain. When we consider the safety problem of the location of hazardous chemical distribution center, we should consider other supply chain problems, such as costs and transportation etc. Only under the context of the supply chain location, can the hazardous chemical enterprises gain. Otherwise, there are no other issues to speak of.

Many scholars researched the transportation and the location of the dangerous goods. Some scholars applied chaos theory to confirm the best transportation route of the dangerous goods (Mahmoudabadi and Seyedhosseini, 2014). Other scholars have applied the knowledge of the operations research and risk management to study the location of the hazardous chemical logistics center. The scholar used the grey evaluation method synthetically to evaluate the factors of the logistics center location of hazardous chemical. Then they established the qualitative, quantitative combination of the hazardous chemical logistics center location procedures and argued that the key factors for the storage of dangerous goods were the environmental and the socio-economic factors (Zakaria et al., 2013). Other argued that the location model of the hazardous chemical logistics distribution center should take into account the risk characteristics, time attributes, routes, pavement conditions and environmental changes along the route of the hazardous chemical. At the same time, the distribution center construction, operating costs, transportation costs, location

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risk, transportation risk and sensitive target number should be considered as the optimization objective (Yi et al., 2011).
As an evaluation method, the AHP method was proposed by Professor Saaty in 1971 (Bian et al., 2017). After the long-term development, it was applied widely at the plan formulation (Ma et al., 2017), document analysis (Shaher et al., 2017), policy analysis (Lee Jongwon and Lee Heeseok, 2015), and resource allocation (Boukherroub et al., 2017). After entering China, the AHP method played an important role in many fields such as program ranking, economic management (Duan et al., 2016) etc.

2. Establishment of evaluation index

The supply chain network involves many fields and is a complex system (Saban et al., 2017). For enterprises, the optimization of the logistics system can reduce the operating costs of the supply chain (Liao et al., 2017). In the supply chain network, the distribution center is the bridge between the goods and the demand. The location problem of the distribution center is one of the node planning problems in logistics systems, which has great significance to improve the effectiveness of the supply chain systems (Hong et al., 2017).
Under the environment of the supply chain, the selection of the hazardous chemical distribution center has to consider many factors. In this paper, we construct the evaluation index composed of 6 second level indexes and 20 third level indexes. The second indexes mainly consider from the natural environment, infrastructure, economic factors, environmental protection, logistics factors and others.

Table 1: The evaluation indexes of hazardous chemical distribution center

First level index	Second level index	Third level index
Hazardous chemical distribution center	Natural environment	Climatic conditions
		Geological conditions
		Hydrologic condition
		Perennial wind direction
	Infrastructure	Traffic facilities
		Communal facilities
		Fire fighting facilities
	Economic factors	Land price
		Human resources
		Construction cost
		Operating cost
	Environmental protection	Impact on the environment
		Distance from population agglomeration
		Waste disposal
	Logistics factors	Road accident rate
		Sound degree of logistics facilities
		Transportation convenience between upstream and downstream
		Regional industrial structure
	Others	Relevant policy
		Government support

3. AHP

The basic principle is as follows. We assume that there are n object A_1, A_2, …, A_n. The weights are w_1, w_2, …, w_n. And the sum of the weight is 1. Now, we compare the two objects and get the judgment matrix.
wis the feature vector of the judgment matrix A. n is a feature value of A. According to the matrix theory, n is the only nonzero eigenvalue. And it is also the largest eigenvalue of A.
Obviously, $a_{ij}=1/a_{ji}$,$a_{ii}=1$, $a_{ij}=a_{ik}/a_{jk}$

$$A = \begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & \frac{w_n}{w_n} \end{bmatrix} = (a_{ij})_{n\times n} \quad (1)$$

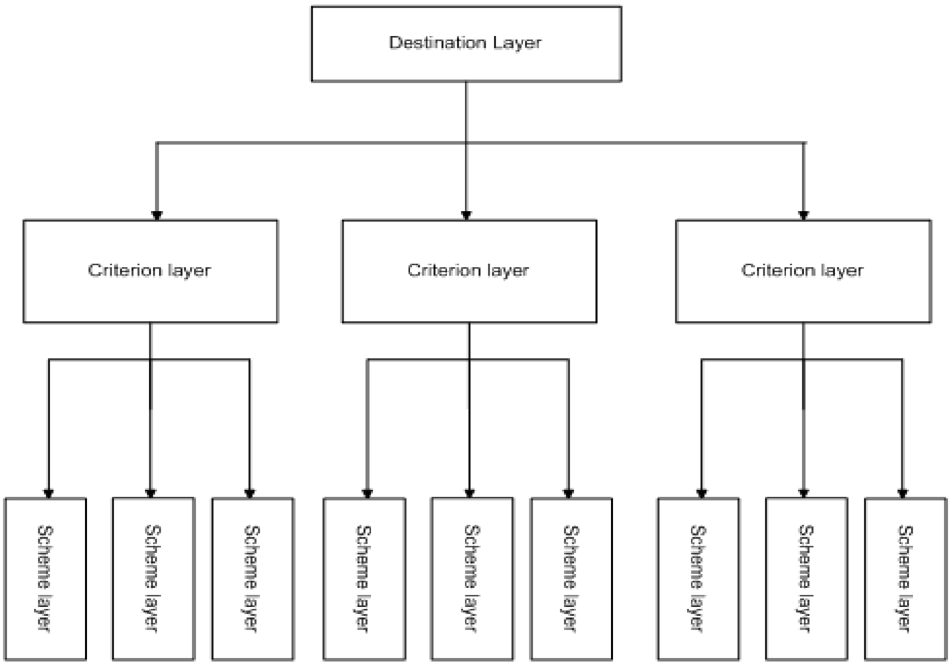

Figure1: AHP structure diagram of three layers

The steps are as follows.
The first step is to establish the hierarchical structure.
The second step is to construct the judgment matrix and it satisfies

$$a_{ij} > 0, \frac{1}{a_{ij}} = a_{ji}, a_{ii} = 1, a_{ii} = 1 \quad (2)$$

The third step is to normalize the judgment matrix A.

$$a_{ij} = a_{ij} \Big/ \sum_{k=1}^{n} a_{kj} \ (i = 1, 2, \cdots, n) \ , \quad (3)$$

The fourth step is to normalize ω_i.

$$w_i = w_i \Big/ \sum_{i=1}^{n} w_i \ (i = 1, 2, \cdots, n) \quad (4)$$

Where,

$$w_i = \sum_{j=1}^{n} a_{ij} (i = 1, 2, \cdots, n) \quad (5)$$

The fifth step is to calculate the characteristic roots and eigenvectors.

$$Aw = \lambda_{\max} w \tag{6}$$

The sixth step is to check the consistency.
We define,

$$CI = \frac{\lambda_{\max} - n}{} n - 1 \tag{7}$$

When CI=0, the judgment matrix is completely consistent. Conversely, the bigger the CI is, the poorer the consistency of the judgment matrix is.

4. The improved AHP

The AHP method has been applied in many fields. The key of the AHP method is to determine the judgment matrix. Then it calculates the sorting vector. Therefore, it is a very important problem that whether the given judgment matrix has satisfactory consistency or not. In this paper, in order to study the location of the hazardous chemical distribution center in the supply chain environment, we propose an improved AHP method.
The judgment matrix is as follows.

$$A = (a_{ij})_{n\times n} , B = (b_{ij})_{n\times n} \tag{8}$$

Where,

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}} \tag{9}$$

$$\beta_j = (b_{1j}, b_{2j}, \cdots, b_{nj})^T \tag{10}$$

β_i is the normalized vector at j column vector of the judgment matrix A. We make $w_i = \frac{1}{n}\sum_{j=1}^{n} b_{ij}$.

$$c_{ij} = \frac{b_{ij}}{w_i}, i, i = 1, 2, \cdots, n , B = (b_{ij})_{n\times n} \tag{11}$$

Therefore, the matrix $\mathrm{C} = (c_{ij})_{n\times n}$ is the induced matrix of the judgment matrix A.

TOPSIS method is a multi-attribute decision making method proposed by Hwang and Yoon in 1981. The method is also called as approximation ideal point method. After improving the consistency test of the judgment matrix, we combine AHP with TOPSIS. Then we propose an improved AHP method. The specific steps are as follows.
Step1. Order the consistency test. If passes, turns 3. Otherwise, it turns 2.
Step2. Improve the order consistency and turns 1.
Step3. Calculate the normalized vector β_j(j=1, 2, L, n) of each column vector and the sort vector w=(w_1, w_2, L, w_n)^T.
Step4. Calculate the introduce matrix $\mathrm{C} = (c_{ij})_{n\times n}$.
Step5. Find the i, j which makes the $|c_{ij} - 1|$(i,j=1, 2, L, n) biggest. And we remind it as k,l.
Step6. If c_{kl}>1 or c_{kl} >1, we adjust a_{kl}.
Step7. Make $a'_{lk} = \frac{1}{a'_{kl}}, a'_{ij} = a_{ij}$.
Step8. If $\mathrm{A}' = (a'_{ij})_{n\times n}$ has the satisfactory consistency, we stop the improvement. Or else, we use A' to instead of A, then turn to the first step to improve until getting the judgment matrix of the satisfactory consistency.
Step9. Get the weights and calculate the evaluation matrix.
Step10. Standardize the evaluation matrix and calculate the weighted normalization matrix.

$$V=(w_jP_{ij})_{mn}\,,V=(v_{ij})_{mn}=\begin{pmatrix} w_1P_{11} & w_1P_{21} & \cdots & w_1P_{m1} \\ w_2P_{12} & w_2P_{22} & \cdots & w_2P_{m2} \\ \vdots & \vdots & \ddots & \vdots \\ w_nP_{1n} & w_nP_{2n} & \cdots & w_nP_{mn} \end{pmatrix} \tag{12}$$

Step11. Calculate the positive and negative ideal point.

$$V^{+}=\left\{(\max_{1\le j\le m} v_{ij}\,\middle|\, j\in J_1),(\min_{1\le j\le m} v_{ij}\,\middle|\, j\in J_2)\right\} \tag{13}$$

$$V^{-}=\left\{(\min_{1\le j\le m} v_{ij}\,\middle|\, j\in J_1),(\max_{1\le j\le m} v_{ij}\,\middle|\, j\in J_2)\right\} \tag{14}$$

J_1 is the benefit index and J_2 is the cost index.

5. Experiment

Under the supply chain environment, we will study the location of the hazardous chemical distribution center. Before the alternatives are evaluated, we should determine the weights of each index firstly. We use the improved AHP method to calculate the weight of each index firstly. The weights of each index are shown in the following table.

Table 2: The weights of indexes of hazardous chemical distribution center

First level index	Second level index	Weights	Third level index	Weights
Hazardous chemical distribution center	Natural environment	0.27	Climatic conditions	0.28
			Geological conditions	0.21
			Hydrologic condition	0.25
			Perennial wind direction	0.26
	Infrastructure	0.17	Traffic facilities	0.39
			Communal facilities	0.29
			Fire fighting facilities	0.32
	Economic factors	0.19	Land price	0.20
			Human resources	0.17
			Construction cost	0.28
			Operating cost	0.35
	Environmental protection	0.16	Impact on the environment	0.39
			Distance from population agglomeration	0.33
			Waste disposal	0.28
	Logistics factors	0.17	Road accident rate	0.35
			Sound degree of logistics facilities	0.24
			Transportation convenience between upstream and downstream	0.41
	Others	0.04	Regional industrial structure	0.38
			Relevant policy	0.29
			Government support	0.33

After that, we sort the alternatives. The closeness of the 3 alternatives is as follows.
$d_1^+ = 0.1438, d_1^- = 0.1231, d_2^+ = 0.1174, d_2^- = 0.1092, d_3^+ = 0.0847, d_2^- = 0.1175.$
The relative closeness are as follows.
C_1=0.4612; C_2=0.4819; C_3=0.5811
We can see that scheme 3 has the highest degree of relative closeness. Therefore, we select the distribution center of 3 as the distribution center of the hazardous chemical under the supply chain environment.

6. Conclusion

In order to reduce the probability of the occurrence of hazardous chemical, it is very important to choose an ideal distribution center for the hazardous chemical. At the same time, in order to adapt to the trend of modern enterprise management, the selection of the distribution center should take into consideration the relevant factors of the supply chain. In this paper, we combine the idea of supply chain and apply the improved AHP method to study the selection of the hazardous chemical distribution center. The main work of this paper is as follows. Firstly, we introduce the background. Secondly, we establish the evaluation system. Thirdly, we introduce the AHP method. Fourthly, we propose the improved method. Finally, we make the experiments. We order the sort the alternatives and achieve the excellent effect.

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