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Logistics Network Construction of Hazardous Goods Based on Analytic Hierarchy Process

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Chemical hazardous goods logistics has become a new branch of logistics, but how to choose the location of logistics center and build the logistics network is still an urgent problem to be solved by logistics enterprise. Based on this, this paper studies the logistics enterprise chemical hazardous goods logistics network construction. First of all, construct the logistics center location model of hazardous chemicals, establish decision framework of logistics center location, and give priority weight of each decision criterion; then, this paper uses two stage analysis method to study chemical hazardous goods logistics network logistics construction. In the first stage, the relationship between logistics center, inventory, transportation and service quality are defined; in the second stage, the main task is to adopt analytic hierarchy process (AHP) to determine the evaluation criteria of logistics network used in this study, and design a logistics network construction model of chemical hazardous goods.

1. Introduction

Hazardous chemicals are mostly flammable, explosive, toxic, and corrosive, which leads to the security, environmental protection and other issues in the production, sales, transportation, warehousing and other aspects. Thus, a little negligence will bring about risks and threats to production enterprises, consumers, and social security, and cause great damage to the environment. At present, the chemical hazardous goods logistics in China is still in the preliminary stage of development, and the logistics layout structure also has defects, which result in that chemical transportation accidents frequently occurred in China. In consequence, to establish suitable chemical logistics network is particularly important (Deng et al., 2013). Based on this, this paper, on the basis of analytical hierarchy process, studies the procedures, measures and steps to construct the logistics network of hazardous chemicals, strives to make it clear the relationship between the various factors of the construction of chemical hazardous goods logistics network, and develops and builds a set of logistics network construction process adapt to the development of the logistics enterprises, so as to determine that the logistics network can be good in supply, fast in turnover, and low in consumption, cost, thus ensure production effectively and smoothly carried out.

2. Research contents and methods

2.1 Construction of logistics center location model for chemical hazardous goods

In this paper, the AHP method is adopted as a decision-making model to discuss the importance of the selection of the decision-making criteria for the logistics center of the chemical hazardous goods. The decision model of logistics center location based on AHP is shown in Figure 1.

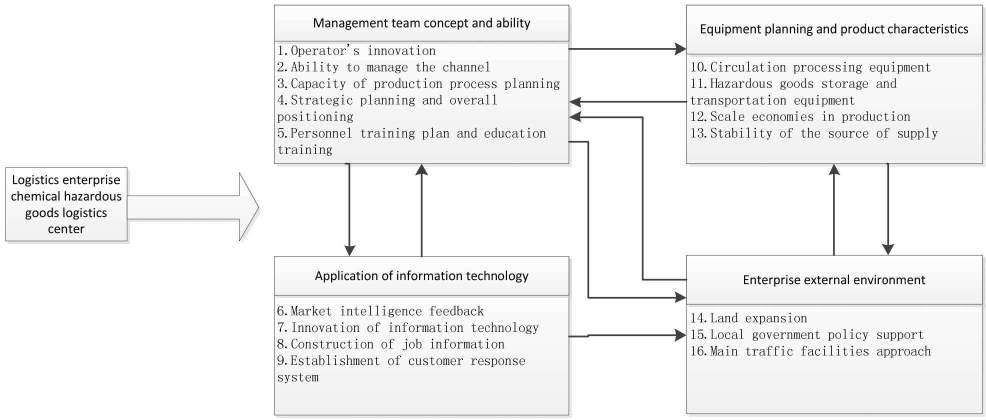

Figure 1: Decision model

After establishing the AHP decision model of the logistics center of chemical hazardous goods, the relative priority weight of each criterion is calculated by the expert to fill in the AHP questionnaire. The pairwise comparison problem in the questionnaire is composed of the texture comparison and the criteria comparison in the SuperDecisions software. Immediately after the experts fill in the questionnaire, the questionnaire data is input into the SuperDecisions software, understand whether each matrix meets the requirement of consistency (C.R.). If do not meet the requirement of consistency (C.R.≦0.1), then after illustrated and discussed with experts, fill a 2-2 value, and at the same time amend its consistent values, to meet the requirements of AHP. Summarize the pair comparison matrix obtained when taking each decision texture and decision criteria as the major considerations, and sort out the priority weight and overall priority weight under various decision criteria textures, as shown in Table 1, in which, items with "*" represent the most important criteria under the texture.

Table 1: Priority weight for decision criteria

Texture	Decision criteria	The priority weight under the texture	The overall priority weight
I	1. Operator's innovation*	0.43331	0.181113
	2. Sales channel capability	0.08539	0.035714
	3. Capacity of production process planning	0.08087	0.033896
	4. Strategic planning and overall positioning	0.24511	0.103301
	5. Personnel training plan and education training	0.15292	0.063898
II	6. Market intelligence feedback	0.23613	0.061328
	7. Application of information technology	0.12721	0.033050
	8. Construction of job information	0.11782	0.031435
	9. Establishment of customer response system*	0.51604	0.134972
III	10. Circulation processing equipment	0.10325	0.001588
	11. Dangerous goods storage and transportation equipment	0.02517	0.000422
	12. Production scale economies	0.44632	0.006823
	13. Stability of supply source	0.42376	0.006493
IV	14. Land expansion	0.30214	0.093021
	15. Local government policy support *	0.59477	0.182484
	16. Main traffic facilities approach	0.10219	0.031342

From analysis of Table 1, it is known that the first 3 most essential chemical hazardous goods logistics center selection criteria are the local government strategy support (0.1825), operator's innovation (0.1811), and establishment of customer response system (0.1350), whose importance are in more than 9%. At the same time, in the first nine important decision-making criteria, there are four criteria belonging to the texture of "Management team concept and ability", the weight of a total of about 38%, which suggests that the texture is of great importance (Giannetti et al., 2013). The top three key decision criteria are discussed and specifically illustrated combined with the actual situation of establishing a logistics center of hazardous chemicals: 1) The local government strategy support: logistics center building, hazardous goods special storage and transportation equipment, added value and so on facilities construction cost are very expensive, so private companies cannot independently complete the overall construction. Therefore, it is one of the essential factory that enterprise need to consider about that whether can strive for the support of government, acquisition tax incentives, land rent concessions and other government supports in the location of logistics center of chemical hazardous goods. 2) Operators' innovative: mainly refers to that the enterprises need to innovate in technology, products and services, and business model.

2.2 Study on the construction of logistics network of chemical hazardous goods

The purpose of logistics network construction is: to build the logistics network taking pursuing the minimum logistics cost and the maximum customer satisfaction as the starting point, and from the angle of integrating the existing logistics resources. In this section, we first discuss the relationship between logistics center, inventory, transportation and service level, and then design a multi-objective planning model.

2.2.1 Relationship between logistics center, inventory, transportation and service level

The construction of the logistics network is not only to consider the district or number of the logistics center itself, it also needs to consider the relationship between information strategy, inventory strategy and transport strategy, as shown in Figure 2. The transportation cos and inventory management are the most frequently quantitative discussion topics.

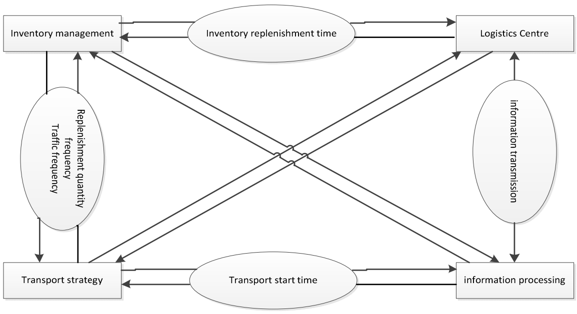

Figure 2: Construction of the relationship between the elements of logistics network

From Figure 2, we can see the relationship between the four kinds of networks. But this study suggests that although the information processing occupies an important position in the logistics network construction, in the actual planning, the information processing mechanism can be included in the setting cost of logistics center to quantify. While the customer service level has a clear response in the logistics network construction cost, and when the decision makers construct the logistics network, the consideration focus is usually on the service level the total cost of logistics and logistics network of customer (Guerin 2015). Therefore, this research mainly aims at the logistics network construction, and then carries on the detailed explanation to the relationship between the logistics center and the inventory network, and that between transportation network and service level.

1) The relationship between logistics center and inventory management

In the case of giving the shortage rate and the total demand, the quantity of safety stock reflects a linear relationship with the quantity of warehouse (DC), so the effect of increasing the warehouse on the average inventory can be shown in Figure 3.

Figure 3. The relationship between average inventory and logistics center warehouse quantity

2) The relationship between the logistics center and the transportation system

Transportation costs often occupies a large proportion in the overall logistics costs, so how to design a most efficient transport system is the problem that enterprises must pay attention to in the logistics network construction. The relationship between transportation cost and warehouse number is shown in Figure 4.

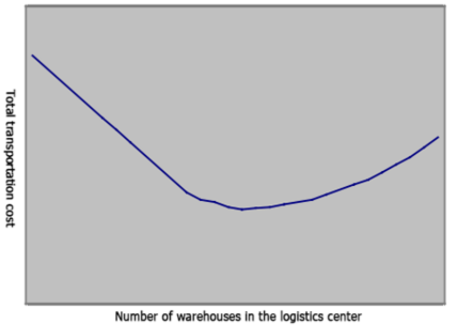

Figure 4: The relationship between transportation cost and the quantity of logistics center warehouse

From the analysis of Figure 4, it is known that, when the enterprise warehouse number is quite small, the customer orders must be processed with direct shipping, so the transportation cost is very high; but if the enterprise increase warehouse number, economic law can be used to combine with shipment and provide logistics services with transportation method. At the same time, the total cost of transportation can be reduced with the increase of warehouse; and when the warehouse number is too much, the number of consolidated shipments will decline to not able to use the scale of transportation economy law, which will lead to excessive increase in the total cost of transportation.

3) The relationship between logistics center and service level

Generally speaking, the relationship between the number of logistics center warehouse and customer service level is shown in Figure 5.

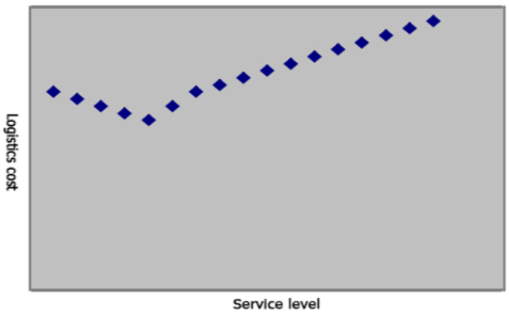

Figure 5: The relationship between the service level and the quantity of the logistics center warehouse

Figure 5 shows that, with the increase of the quantity of the warehouse, the relative cost of logistics also increases, and service level is improved; when the warehouse number is increased to a certain amount, if it continues to increase, the logistics cost will substantially increase for too large scale of logistics center. And once the number of warehouse is too much, it will result in that the transmission of information is not smooth, leading to reduction of customer service level.

2.3.2 Multi-objective programming model construction of logistics network

1) Based on the role of the new Austrian group in the distribution of methanol product, this paper discusses the construction of the logistics network, including the main elements: i methanol processing plant, k customer demand point and j potential logistics center location.

2) The mode of transportation of the product includes the product transporting from the processing factory to the logistics center, and then from the logistics center to the demand points, or directly transporting from the factory to the customer these two kinds.

The goal formula of the model total cost is shown in the Eq (1). Minimize:

$$Z_1 = TC = \sum_j F_j \delta_j + \sum_i F_i \delta_i + \sum_i \sum_j a_{ij} x_{ij} + \sum_j \sum_k b_{jk} y_{jk} + \sum_i \sum_k c_{ik} z_{ik} + \sum_i \sum_j \sum_k u(y_{jk} + z_{ik}) + h \sum_j (S + \Omega \lambda) \delta_j \quad (1)$$

The target function that the customer is satisfied with is shown in Eq (2). Maximize:

$$Z_2 = CSRate = (\sum_i \sum_j y_{jk} w_{jk} + \sum_i \sum_j z_{ik} w_{jk}) \Big/ \sum_k d_k \quad (2)$$

The parameters of decision variables are set as follows (Hao, et al., 2015):
x_{ij} suggests the transport volume of processing factory i to logistics center j; y_{jk} indicates the transport volume from logistics center j to customer k; z_{ik} refers to the transport volume directly transported from the processing plant to the customer k; δ_j represents binary variables for whether logistics center j is open, and δ_j=1 indicates open, while δ_j=0 suggests not open; δ_i represents binary variables for whether the processing factory i opens direct transportation, δ_i=0 indicates open, and δ_i=1 suggests not open; w_{jk} is the service level rate of customer k served by the logistics center j; w_{ik} suggests the service level rate of customer k served by the factory i.
The parameters of this research model are set as follows:
S_i suggests the supply of the processing plant i; d_k is customer k demand; w_j indicates the minimum shipments of logistics center j; W_j is the maximum capacity of logistics center j; W_i is the minimum shipments of the processing factory i; W_i represents the maximum capacity of the processing plant i; F_j is the setup cost of logistics center j; Fi suggests the setup cost of the processing plant setting up direct distribution; u is the unit handling cost for goods transported to customers (Netro, et al., 2016); u said the unit treatment cost; a_{ij} is the unit transportation cost of the processing plant i to logistics center j; b_{jk} indicates the unit transportation cost from logistics center j to the customer k; c_{ik} suggests the unit transportation cost form the processing plant to the customer k. S is the logistics center safety inventory, Ω is the average inventory holding rate, λ is the demand for a market, and the number of logistics center inventory is $S+\Omega\cdot\lambda$.
This study only takes the network and environment two qualitative criteria as the second stage evaluation criteria. The main reason for planning in the first stage of planning, is to consider the quantified criteria in the model. As a result, do not consider the cost criterion. This study adopted logistics network evaluation criteria is shown in Table 2.

Table 2: Logistics network qualitative factor evaluation criterion

	Evaluation criteria	Explanation
Network	Transportation speed (time)	The time it takes to transport to the point demanded.
	Transportation stability	It refers to the time difference for transporting same quantity goods to the same demanded point.
	Traffic convenience	It suggests the road traffic condition of the place where the facilities are located in.
	Market proximity	It indicates whether the place where the facilities are located in is close to the demand side or the supply side.
	Rationality of the scope of service	It is the rationality of districts where the facilities are responsible for service.
	Inter facility mutual support	It is the degree that facilities support each other.
Environment	Time difference of information	It represents the speed of information transmission.
	Applicability of laws and regulations	It is the degree of overall planning in line with laws and regulations.

3. Research results and discussion

This research aims at the problem of logistics network construction, and puts forward the planning method of two stages. In this two stage method, it includes qualitative and quantitative criteria so that the overall planning is more in line with the needs of enterprises. In the first phase, for the criteria quantified, use multi-objective programming method to solve the advantages and disadvantages of several groups; in the second stage, based on the combination of the above solution, add the needed to consider qualitative criteria for multi-criteria evaluation. Sort the various programs so as to select the best plan. The new Austrian group chemical hazardous goods logistics center project is in the planning stage. According to the development of enterprises and the progress of the project, design chemical hazardous goods logistics network construction flow chart of the new Austrian group, as shown in Figure 6.

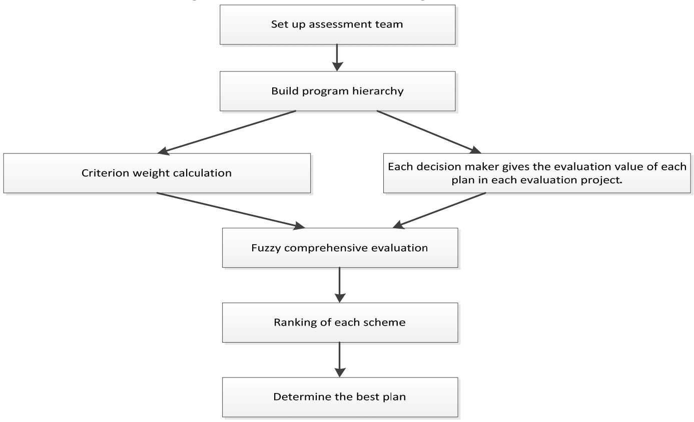

Figure 6: Evaluation flow chart

4. Conclusion

The site selection of logistics center and the construction of logistics network is a new problem in the study of logistics in China. But the accident of hazardous goods distribution is a typical "low probability while serious consequence" event. Once it occurs, the loss of life and property and the environmental impact are very serious. Therefore, the AHP decision model is taken as decision model, to select decision criteria affecting logistics center location of hazardous chemical, and then construct the AHP decision framework of logistics center location, so as to find out the decisive factors which should be noticed in the determination of logistics center location (Qian et al., 2015). And then, taking to determine the location of logistics center as the premise, analyze the relationship between logistics center, inventory transportation and service level, and design multi-objective programming model for logistics equipment construction. Combined with the actual requirements of the construction of the logistics network of the chemical hazardous goods, sort out the qualitative factors evaluation criteria, design model of chemical hazardous goods logistics network logistics enterprises, to provide support for the possibility of future logistics network construction of hazardous chemical, which has certain practical significance.

Acknowledgments

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