Research on Network Location Scheme of Logistics Transfer Station under the Background of COVID-19 Epidemic Situation

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Abstract: The COVID-19 epidemic, which has continued since 2019, has not only caused a huge impact on people's normal production and life, but also brought a severe test to the logistics industry. Facing the outbreak of COVID-19 epidemic, how to carry out emergency rescue quickly and effectively has become the most important thing, and in the process of organizing emergency rescue work, efficient emergency logistics network design is one of the important links. At the same time, in order to avoid the possibility of huge losses, virus infection, an important risk factor, must be considered in the process of location selection of distribution centers. Based on this, under the background of COVID-19 epidemic, this paper systematically and comprehensively analyzes the location problem of logistics distribution center and constructs the location model of logistics transfer station. In order to reduce the influence of single comprehensive evaluation method on the location results due to its subjective factors in index weight distribution and scheme scoring, this paper analyzes the location of express delivery transfer station by using the method of AHP and grey correlation. This method provides a basis for the location decision of express transfer station. At the same time, it has important theoretical and practical significance to study the location of cold chain logistics distribution center under the background of COVID-19 epidemic.

1. Introduction

With the transformation of consumption structure, e-commerce has become an indispensable part of people's production and life. At the same time, as an important supporting industry of e-commerce, express logistics has sprung up everywhere, and e-commerce has accelerated the development momentum of the current express logistics industry, which in turn directly affects the development of e-commerce[1]. At present, with the rapid increase of express delivery volume, the operating pressure of the original express hub gradually reaches or even exceeds the limit, resulting in the blocking of the whole express delivery network[2]. On the other hand, in recent years, all kinds of sudden outbreaks have occurred from time to time in the world, which not only seriously endanger human health and life safety, but also have a significant impact on social and economic development. During the epidemic, the logistics industry should be the most important industry in all industries that needs to be protected. The difference between the early stage and the middle and late stage of the epidemic lies in: in the early stage, more attention was paid to the transportation and delivery of medical protective materials and medical resources, and more importantly, the basic living needs of all people were guaranteed; The problems in the middle and late stages are focused on the demand side[3]. At present, under the background of COVID-19 epidemic, it is of great practical significance to consider the influence of virus infection risk factors when selecting the location of logistics distribution center and determine the location model suitable for the distribution demand under the epidemic.

The epidemic will not only seriously endanger the physical and mental health of the public, but also cause serious losses to national development and social economy[4]. The production activities with high density of people or easily leading to the spread of the epidemic must be stopped, and the development of related industries will be hindered, especially the transportation, catering and tourism industries[5]. Express delivery network is the foundation of the development of express

delivery companies, and the location of nodes in express delivery network is the foundation of express delivery network. The traditional express network structure is generally hub-and-spoke, and different nodes in the network undertake different functions. Faced with the outbreak of all kinds of unconventional outbreaks, how to carry out emergency rescue quickly and effectively has become the most important thing, and in the process of organizing emergency rescue work, efficient emergency logistics network design is one of the important links[6]. The level of express delivery service is closely related to the location of logistics facilities in the distribution network. As a connecting link between the preceding and the following, express delivery transfer station plays an important role in the whole distribution network. Whether the location of transfer station is appropriate or not is directly related to the cost and efficiency of express delivery, thus affecting the level of express delivery logistics service[7]. Under the background of COVID-19 epidemic situation, this paper studies the network location scheme of logistics transfer station.

2. Background of COVID-19 Epidemic

With the worsening of air pollution and climate warming, coupled with the continuous evolution of microorganisms and the increasing frequency of population movements, it is often difficult to effectively control the regional epidemic after a sudden outbreak, and then it will evolve into a global epidemic. This will bring serious harm to public health safety, world economy and human health. Among them, the COVID-19 epidemic that suddenly broke out at the end of 2019 can be called the once-in-a-century catastrophe of mankind[8]. It makes the global disaster response system face great challenges. Since the first case was found, the number of cases has increased exponentially, and COVID-19 epidemic has spread rapidly across 34 provincial administrative regions in China and 200 countries and regions around the world. Its severe symptoms and strong infectivity make it one of the most difficult viruses in human history. According to statistics, COVID-19 epidemic has killed more than 160,000 people and confirmed more than 2.32 million people, which has exerted great influence on all countries in the world including China[9]. It makes the world press the pause button and damages the global supply chain. At the same time, under the COVID-19 epidemic situation, the community closed management has greatly promoted the consumption of fresh products, and the cold chain logistics is the key guarantee link of the fresh product supply chain. After the outbreak of the epidemic, the cold chain logistics industry has been greatly affected. COVID-19 virus has been found continuously in the cold chain packaging of imported food in China, which has caused some public concern.

Because the COVID-19 epidemic happened suddenly, it was difficult to determine the scale and duration of its spread in the first time, which made it impossible for decision makers to arrange rescue according to the demand of emergency materials in different areas in time[10]. Therefore, timely and accurate prediction of the demand for emergency supplies is one of the most important links in emergency rescue work, the premise and foundation of emergency supplies collection and dispatch, and the necessary condition for people in epidemic areas to maintain normal life and treatment. Facing the outbreak of COVID-19 epidemic, how to carry out emergency rescue quickly and effectively has become the most important thing. In the process of organizing emergency rescue work, a reasonable and effective emergency logistics network design directly determines the support ability of emergency materials, which is an important support for the prevention and control of COVID-19 epidemic. The difference between the early stage and the middle and late stage of the epidemic lies in: in the early stage, more attention was paid to the transportation and delivery of medical protective materials and medical resources, and more importantly, the basic living needs of all people were guaranteed; The problems in the middle and late stages are focused on the demand side. The Ministry of Transport of China requires relevant logistics enterprises and relevant departments to strengthen quarantine control of all kinds of products and take measures to kill viruses; COVID-19 virus should not be allowed to spread along the transportation channels, and the life safety of consumers should be ensured. In view of the sudden epidemic situation, it is necessary not only to discover it in time, to monitor and control its source, but also to provide emergency materials quickly and carry out emergency rescue in time after the outbreak. In the organization

process of emergency rescue, the efficiency and effect of rescue are very important goals, and the efficient design of emergency logistics network is one of the important links.

3. Establishment of Logistics Transfer Station Location Model

3.1 Logistics Design

Logistics is a collection of interrelated organizations and facilities in the process of resource flow, which ensures the stable development of the whole supply chain. According to supply chain value theory, supply chain value can be divided into three parts: financial value, customer value and social value. The location of logistics facilities can be divided into single objective and multi-objective location according to the number of objectives. Single-objective site selection generally considers minimizing total cost, maximizing demand satisfaction or minimizing distance. For multi-objective location, different location models can be established from different angles. Among them, the location of logistics transfer station needs to meet a number of principles at first, which is also one of the necessary conditions for the location of logistics facilities, including the principles of adaptability, coordination, economy and sustainable development. Starting from the unique nature of the logistics supply chain, consider its special requirements for temperature, transportation time, benefits of upstream and downstream enterprises, customers' requirements for logistics service quality and supply chain cost minimization. Taking these conditions that need to be considered as the basis for selection, a logistics transfer station location model is constructed. The network structure of the hub can be summed up as a three-tier network structure, including one hub station, J hubs and L outlets, as shown in Figure 1.
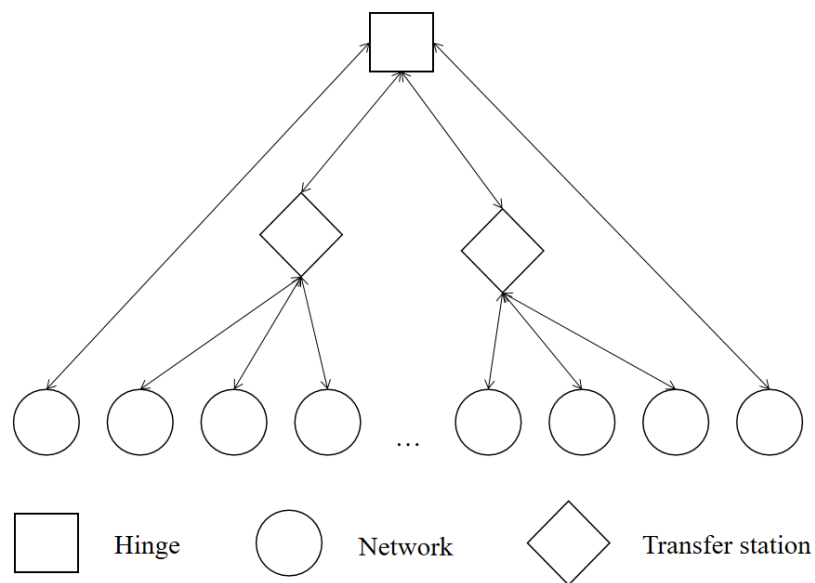

Fig.1 Network Structure of Hub Area

Goods to be sent by customers are collected through outlets, transported to hub stations through transfer stations or directly delivered to hub stations from outlets. The goods to be received by customers will be sent from the hub station to the outlets through the transfer station, which will send them to customers or directly from the hub station to the outlets. According to the basic principles of site selection of transfer stations, the evaluation index system of site selection is constructed. In this paper, an evaluation system with nine indicators including basic conditions, economic benefits and social impact is established. When choosing the location of logistics distribution center under the disaster situation of COVID-19 epidemic, we should also consider other influencing factors such as demand, fresh product corruption rate, virus transmission risk, and establish mathematical models according to different needs. In logistics network design, location allocation is a strategic planning problem, which plays a very important role in decision-making.

3.2 Network Site Selection Scheme of Transfer Station

The single evaluation method is greatly influenced by the subjective evaluation of the individual in the determination of the index weight and the evaluation score of alternative schemes. In order to reduce the influence of single comprehensive evaluation method on the location results due to the subjective factors in index weight distribution and scheme scoring, this paper adopts the comprehensive evaluation method combining sub-analysis and grey relational analysis to study the location of express transfer station. In addition to the rental cost, when constructing the location model of logistics transfer station, this paper also comprehensively considers five kinds of costs, such as freight and transfer station related expenses, and brings all kinds of costs into the research category. Before the mathematical model is established, the definition of total cost is given. Including the transportation cost between transfer station and hub, network point to transfer station and network point to hub station, staff salary cost and site rental cost. Among them, the transportation cost needs to be doubled because it is a round trip, and different models correspond to different single kilometer costs. In the logistics distribution center location model, the most common objective function is to minimize the total cost. In site selection, the first cost to be paid attention to is the fixed cost and the later operating cost of the distribution center. Then, according to the geographical location and area of the selected logistics distribution center, the construction scale will be determined, resulting in corresponding construction costs and transportation expenses.

The following formulas are used to calculate the correlation coefficient between the k th index and the corresponding optimal index in the i th scheme:

$$\varepsilon_{ik} = \frac{\min\limits_{i}\min\limits_{k}\left|X'_{0k}-X'_{ik}\right| + \xi \max\limits_{i}\max\limits_{k}\left|X'_{0k}-X'_{ik}\right|}{\left|X'_{0k}-X'_{ik}\right| + \xi \max\limits_{i}\max\limits_{k}\left|X'_{0k}-X'_{ik}\right|} \quad (1)$$

Among them, $\min\limits_{i}\min\limits_{k}\left|X'_{0k}-X'_{ik}\right|$ represents the minimum value of the difference sequence; $\max\limits_{i}\max\limits_{k}\left|X'_{0k}-X'_{ik}\right|$ represents the maximum value of the difference sequence. Combined with the weight of each indicator obtained by the AHP:

$$W = [w_1, w_2, w_3, \ldots, w_n] \quad (2)$$

Then the final weighted gray correlation degree of the candidate point i is:

$$R_i = \sum_{j=1}^{n} \varepsilon_{ij} w_j, i = 1,2,3,\ldots,m \quad (3)$$

When the weighted grey correlation degree of each transfer station is determined, the transfer stations can be sorted according to the grey correlation degree according to the actual situation, and the site selection process of the transfer stations can be completed.

4. Conclusions

There is usually no sign or it is difficult to detect an outbreak before it happens, and it is difficult for the public to predict the time, place, scope and intensity of the outbreak. Once the epidemic breaks out, the relevant health and public safety departments are often difficult to make adequate preparations because of the sudden incident. It can be predicted that after the COVID-19 epidemic, the global economy and industrial structure will undergo great changes. China's logistics supply chain should build a brand-new logistics supply chain system by combining the technological innovation of the whole system brought about by the changes from informatization, networking to digital age, whether it is competing for the international logistics channel market or reducing costs and increasing efficiency of domestic logistics industry. At the same time, under the background of COVID-19 epidemic, it is necessary to effectively control the internal epidemic rebound and prevent external virus input; We must not let logistics become the transmission chain of viruses. We need to improve the efficiency of logistics distribution centers and ensure the safety of logistics distribution. Under the background of COVID-19 epidemic situation, this paper systematically and comprehensively analyzes the location problem of logistics distribution center and constructs the

location model of logistics transfer station. In order to reduce the influence of single comprehensive evaluation method on the location results due to its subjective factors in index weight distribution and scheme scoring, this paper analyzes the location of express delivery transfer station by using the method of AHP and grey correlation. At present, the importance of the logistics industry is becoming more and more prominent, and logistics and supply chain have become national strategies related to national security or industrial upgrading in many countries. The model in this paper can play a certain role and be operable in the field of logistics distribution center location. Therefore, this model has certain reference significance for the location of logistics distribution center under the epidemic situation.

Acknowledgement

References

[1] Chen Jingyu, Zhang Li. Research on construction of distribution center location model in emergency cold chain logistics of new land-sea corridor under epidemic situation [J]. Logistics Science and Technology, 2020, 43(7):4.

[2] Liu Chengcheng, Li Yetong, Li Congcong, et al. Location selection of smart express cabinets in contactless distribution mode under the new crown pneumonia epidemic [J]. Logistics Technology, 2021, 40(9):6.

[3] Li Shuyuan, Zheng Jingheng, Yan Xingchen. The impact of the new coronavirus epidemic on the recent development and direction of the logistics industry [J]. Logistics Engineering and Management, 2020, 42(4):3.

[4] Dai Yan, Chen Ning. Location optimization model for urban solid waste transfer station [J]. Logistics Technology, 2019(2):4.

[5] Chen Jie. The new value of logistics under the epidemic [J]. Knowledge Economy. China Direct Selling, 2020(4):3.

[6] Liu Lianhua, Chen Xiu, Ping Hai. The impact of the new crown pneumonia epidemic on the logistics industry and countermeasures [J]. Supply Chain Management, 2021, 2(1):10.

[7] Wang Yan. Research on the development of the logistics industry in the post-epidemic environment [J]. Research on Economic and Social Development, 2020(15):1.

[8] Gu Feng. Reflections on the improvement of urban emergency logistics facilities system in the post-epidemic era [J]. Small and Medium Enterprise Management and Technology, 2021, 000(021):108-109.

[9] Wang Sijing. Location selection of pharmaceutical cold chain logistics distribution center [J]. Logistics Technology, 2019, 38(3):5.

[10] Gan Bin, Li Haidong, Gong Hao, et al. Visualized logistics distribution optimization location simulation under big data [J]. Computer Simulation, 2018, 35(8):5.