Research on the Location selection of Logistics Transshipment Center base on “16+1 Cooperation”

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Abstract—Since the launch of the “16+1 Cooperation”, political mutual trust between China and Central and Eastern Europe Countries (CEECs) has been increasing, and economic cooperation relationship has continued to advance. Aiming at the demand of international strategic development ‘going global’, this paper analyzes the development trend of logistics and establishes a mathematical model for location selection of the logistics transshipment center of Chinese enterprise based on the demand of cargos and the transportation distance. According to the total trade volume of the CEECs from 2013 to 2017, the paper introduces the Artificial Fish Swarm Algorithm (AFSA) to solve the model and finds the optimal logistics transshipment centers under different number of locations. The results show that AFSA is suitable for location selection of the logistics transshipment centers and can provide an important reference for China's logistics enterprises.

1. Introduction

In the mid-to-late 20th century, the drastic changes in Eastern Europe caused profound changes in the politics, economy, and society of Central and Eastern European countries (hereinafter referred to as CEECs). Although CEECs have achieved comprehensive integration with most Western European developed countries, the economic development level of Central and Eastern European is still far behind Western European. As the demand for economic restructuring continues to rise, CEECs begin to value building strategic cooperative relationship with other countries [1].

At the same time, with the rapid economic development, China's international influence has increased year by year. The "Belt and Road" Initiative has demonstrated China's vision for foreign cooperation and exchanges [2]. For the purpose of "complementary advantages and win-win cooperation", the development goals and needs for China and CEECs are in line with each other, and the willingness of both parties to enhance understanding and strengthen economic cooperation has gradually increased. The cooperation between China and CEECs has a long history. In view of the unique natural resources, social forms and geographic location of CEECs, China formally established the "China-Central and Eastern European Countries’ Leaders Meeting" mechanism in 2012.

Under the guidance of the "16+1 Cooperation", the economic cooperation relationship between China and CEECs continues to strengthen, which in turn drives the external demand for international trade in CEECs [3]. The rapid development of trade in CEECs has provided a broad market for the logistics enterprises, and has actively promoted the development of logistics industry. The investment and cooperation of Chinese logistics enterprises in Central and Eastern Europe have shown a positive and
enthusiastic attitude. For example, SF Express signed a strategic cooperation agreement with the Lithuanian Pastas through the Deputy Minister of the Ministry of Transport and Communications of the Republic of Lithuania, and established a comprehensive logistics service center in the European region. STO Express Europe, Budapest Ferenc Liszt International Airport Group and EKOL Logistics (European logistics company) are working together to build the “Belt and Road” Sino-European logistics transshipment center. The transshipment network includes rail transport, air transport and road transport, which optimizes the transshipment efficiency of China-Europe trains and cross-border e-commerce packages. ZTO Express also teamed up with Hungary National Post to establish China Europe Supply Chain Management Co., Ltd., which is committed to opening a cross-border e-commerce express line. In addition, Chinese warehousing companies and door-to-door logistics enterprises such as JD Logistics, Suning Logistics, YT Express, Best Express and Yunda Express are participating in building an international super logistics hub serving eWTP (Electronic World Trade Platform) outside China. All of the above enterprises have played a positive role in promoting China's cross-border express delivery business and the logistics development for CEECs.

Driven by technological progress and governance, modern logistics services have gone far beyond the traditional logistics which usually includes services such as cargos transportation, warehousing or storage [4]. The development of international logistics industry is constantly showing a variety of trends such as diversified functions, personalized service, high-quality services, automation, systematization, globalization and so on. How to rationally arrange and effectively connect all links has become the crucial basics for the development and competition of logistics enterprises.

A transshipment center refers to the function, which assumes that cargos transfer between various modes of transportation. A distinguished transshipment center is supposed to undertake secondary transportation within a larger area. Therefore, the location selection of a transshipment center is very important, since it can affect the core competitiveness, resource integration ability and comprehensive innovation ability of a logistics enterprise. Hence, the research on the location selection of transshipment center is very significant. The location selection of transshipment center is subject to a series of problems such as resource constraints and transportation efficiency. A reasonable location selection of a transshipment center can determine the delivery speed, responsiveness to market demand, service costs and so on. Mathematical model and algorithm are the core for logistics enterprises to select the optimal location. Solving algorithms effectively is an important research content of model optimization.

Under the background of "16+1 Cooperation", this paper analyzes the location advantages of CEECs, a mathematical model of transshipment center location selection is established based on the demand of cargos and transportation distance which can directly affect the efficiency of transshipment center. The AFSA algorithm is used to optimize the variables. Finally, the optimization results of the logistics transfer centers in the sixteen countries of Central and Eastern Europe are compared and analyzed.

2. Mathematical model of location selection for logistics transshipment center
The core of "16+1 Cooperation" is to accelerate and enhance the cooperation between regions through interconnection, equipment manufacturing, finance and agriculture. No matter which kind of cooperation, it will be achieved through the exchange of technology, materials or capital, especially the huge material exchange. All of this will increase the demand for the logistics and promote the development of the logistics industry. Whether a transshipment center can work efficiently and maximize the value of internal and external activities depends on its geographic location. Scientifically selecting the location of transshipment center can effectively integrate and allocate the resources of all links in the supply chain [5-6]. By optimizing the selection of the transshipment center location, it can gather the scattered materials in the supply chain to improve the efficiency of warehousing, loading and unloading, handling, storage and so on. Therefore, logistics enterprises can only achieve the purpose of low cost and high turnover of logistics by optimizing the location of the transshipment center.
2.1. Objective function

The logistics transshipment center is an important bridge for connecting suppliers and customers. Its location directly determines the logistics distribution distance and distribution mode, which in turn affects the efficiency of the entire logistics system. The location selecting model of logistics transshipment center is a nonlinear planning problem solving with complex constraints. It is assumed that the scale and capacity of a logistics transshipment center is determined by the total demand for cargos within its distribution range, and there is only one logistics transshipment center in each city. The location of the logistics transshipment center needs to find $M$ logistics transshipment centers from $N$ cities and distribute cargos to each city. The objective function is the sum of the total cargos demand and the minimum distance from the logistics transshipment center to other cities. The mathematical expression is as follows:

$$\min F = \sum_{i \in N} \sum_{j \in M} c_i d_{ij} H_{ij}$$ \hspace{1cm} (1)

In the Equation (1), $c_i$ represents the demand for cargos in city $i$; $d_{ij}$ represents the distance between city $i$ and logistics transshipment center $j$. $H_{ij}$ represents the transshipment distribution relationship. When city $i$ is delivered by logistics transshipment center $j$, $H_{ij}$ is 1, otherwise $H_{ij}$ is 0.

2.2. Constraints

Constraints for solving the objective function of the location model of the logistics transshipment center include:

$$\sum_{j \in M} H_{ij} = 1$$ \hspace{1cm} (2)

Equation (2) ensures that there is only one logistics transshipment center in each city.

$$H_{ij} \in \{0,1\}$$ \hspace{1cm} (3)

Equation (3) ensures that the transshipment distribution relationship $H_{ij}$ is 0 or 1.

$$d_{ij} \leq s$$ \hspace{1cm} (4)

In the Equation (4), $s$ represents the upper limit of the distance between a city and a logistics transshipment center. It ensures that each city is within the optimal distribution range of a logistics transshipment center.

3. Artificial Fish Swarm Algorithm

Figure 1 shows the flowchart of AFSA. The position of artificial fish is described as $X$. The food concentration of the artificial fish is described as $Y$. The main steps of AFSA can be described as follows: firstly, the parameters of AFSA are assigned, including the number of the fish swarm, the variation range of parameters, the fish visual range. Secondly, the original status of fish swarm is initialized randomly. Thirdly, with means of foraging behavior, huddling behavior, following behavior, and random behavior, the state of the fish swarm is updating. Then, the state of the artificial fish is evaluated by the fitness function. Finally, the best state of the artificial fish is selected and outputted as the optimal parameters [7-8].
4. Examples
In the location selection planning of the logistics transshipment center, a comprehensive analysis should be made on the conditions, principles, and influencing factors of the location selection of the logistics transshipment center. A detailed location selection proposal is made based on those analyses. Generally speaking, the location selection of a logistics transshipment center is mainly affected by customers, market, geographic location, transportation and policy environment.
Taking into account principles of economy, transportation convenience, strategy and overall planning, we believe that the capital is the best location for each country. Therefore, the logistics transshipment center in this paper is only the capital cities of the regional country. Considering that the total trade volume can truly represent the total logistics flow of a country, we collected the total trade volume of sixteen Central and Eastern European countries from 2013 to 2017, as shown in Table I. The logistics transshipment centers are chosen from the capitals of sixteen countries.

The shape of the earth is close to an ellipsoid, and the distance between every two cities can be measured by latitude and longitude. \( \text{Dist} \) refers to the distance between cities and is calculated as follows:

\[
\begin{align*}
C_i &= \sin \frac{\pi \cdot \text{Lat}_A}{180} \cdot \sin \frac{\pi \cdot \text{Lat}_B}{180} \\
C_j &= \cos \frac{\pi \cdot \text{Lat}_A}{180} \cdot \cos \frac{\pi \cdot \text{Lat}_B}{180} \cdot \cos \frac{\pi \cdot (\text{Lon}_A - \text{Lon}_B)}{180} \\
\text{Dist} &= R \cdot \arccos(C_i + C_j)
\end{align*}
\]

In the above equation, \( R \) is the average radius of the earth, taking 6371.004km; \( \text{Lon}_A \) and \( \text{Lat}_A \) are the longitude and latitude of city \( A \); \( \text{Lon}_B \) and \( \text{Lat}_B \) are the longitude and latitude of city \( B \).

| Country                  | Capital    | Trade Volume (billions of dollars) |
|--------------------------|------------|-----------------------------------|
|                          |            | 2013  | 2014  | 2015  | 2016  | 2017  |
| Albania                  | Tirana     | 72    | 77    | 67    | 66    | 80    |
| Bosnia and Herzegovina   | Sarajevo   | 160   | 169   | 141   | 145   | 168   |
| Bulgaria                 | Sofia      | 638   | 641   | 550   | 55    | 640   |
| Croatia                  | Zagreb     | 347   | 368   | 334   | 355   | 402   |
| Czech Republic           | Prague     | 3041  | 3275  | 2979  | 3044  | 3451  |
| Estonia                  | Tallinn    | 385   | 377   | 296   | 297   | 327   |
| Hungary                  | Budapest   | 2064  | 2167  | 1911  | 1951  | 2177  |
| Latvia                   | Riga       | 301   | 304   | 253   | 251   | 288   |
| Lithuania                | Vilnius    | 674   | 676   | 536   | 524   | 603   |
| Montenegro               | Podgorica  | 28    | 28    | 24    | 26    | 30    |
| Poland                   | Warsaw     | 4095  | 4311  | 3842  | 3850  | 4393  |
| Romania                  | Bucharest  | 1393  | 1478  | 1305  | 1382  | 1559  |
| Serbia                   | Belgrade   | 352   | 355   | 316   | 341   | 391   |
| Slovakia                 | Bratislava | 1665  | 1673  | 1480  | 1527  | 1675  |
| Slovenia                 | Ljubljana  | 580   | 606   | 525   | 543   | 570   |
| Macedonia                | Skopje     | 109   | 123   | 109   | 115   | 134   |

Data source: from UN Comtrade Data
5. Result analysis

5.1. The influence of optimal number of location on the optimization goal

Based on the total trade volume of the sixteen CEECs in 2017, this article uses AFSA to search for logistics transshipment centers. Figure 2 shows the optimization results of logistics transshipment centers under different locations.

Figure 2a is the optimization results when the logistics transshipment centers are located in two cities. It can be seen that the most preferred locations are Warsaw (Poland) and Bratislava (Slovakia). The reason why Warsaw (Poland) became the most preferred location is because Poland's economic development level is much higher than most Central and Eastern Europe counties. The specific data can be seen from Table I, from 2013 to 2017, Poland's foreign trade volume ranked first for five consecutive years, far surpassing neighboring countries. Although the trade volume of Czech and Hungary in the northern region is greater than Bratislava (Slovakia), the difference is not as great as in Poland and the Baltic counties. In addition, our most preferred location is selected based on both the demand of cargos and the distance between cities. When the demand for cargos in a country is exceptionally large, the influence of the cargos demand will exceed the influence of the distance between cities. Similarly, when the difference in demand for cargos in not obvious and the difference in distance is large, the influence of the distance between cities will exceed the influence of cargos. Based on the calculation of the joint effect of the distance between cities and the demand for cargos, when we selected two locations, Warsaw (Poland) and Bratislava (Slovakia) are the most preferred transshipment centers.

When we chose three locations as the transshipment centers, the optimization locations are Warsaw (Poland), Bratislava (Slovakia) and Bucharest (Romania) as shown in Figure 2b. At this time, Warsaw and Bratislava are still the most preferred transshipment centers. We believe that the reason why Galest (Romania) replaced Prague (Czech Republic) and Budapest (Hungary) as the third location of transshipment center is because Galest has the smallest distances between other cities in north Central and Eastern Europe countries, such as Albania, Macedonia, Serbia, Montenegro, in the case of relatively small differences in demand for cargos.
Figure 2 shows the optimization results when the logistics transshipment centers are four. It can be seen that the optimization results of the four most preferred selections are Warsaw (Poland), Prague (Czech Republic), Budapest (Hungary), and Bucharest (Romania). The difference between Figure 2a and
Figure 2b is not obvious, but the difference between Figure 42a and Figure 2c is very large. The analysis shows that when the location number of transshipment centers increases, the optimal locations are different. Because of the large gap in the economic development level of CEECs, the impact of differences in demand for goods is far greater than the impact of distance differences overall. In terms of foreign trade volume in 2017, the top five countries in terms of demand for cargos are Poland, Czech Republic, Hungary, Slovakia, and Romania (the total demand for cargos from these five countries are 13,255 million US dollars) which accounts for 78% of the total trade volume of sixteen CEECs. Among them, the trade volume of the Czech Republic ($3451 billion) is close to other eleven countries. At this time, because the demand for cargos in Albania, the Baltic countries, Montenegro, and Bosnia and Herzegovina, is too small to be the optimal location of the transshipment center.

6. Conclusion
On April 12, 2019, the 8th China-Central and Eastern European Countries’ Leaders Meeting was held in Dubrovnik, Croatia. Obviously, the leaders of both regions attach great importance to the “16+1 Cooperation” which plays a significant role in promoting economic cooperation and mutual political trust between China and CEECs. Encouraged by government, trade volume between the two regions has risen rapidly, which in turn has increased the demand for logistics service. As a result, Chinese logistics enterprises find a broad market in Central and Eastern European region. Studies have shown that location selection is the core factor that determines whether the efficiency of a logistics transshipment center can be maximized. Therefore, the research on the location of the logistics transshipment center is very crucial. This paper analyzes the location advantages of the sixteen countries in Central and Eastern Europe. Based on the demand of cargos and transportation distance, the paper uses AFSA to solve the mathematical model of the logistics transshipment center selection. The research results prove that AFSA is suitable for the location selection optimization. We hope this study can provide reference for Chinese logistics enterprises to “going global”.

ACKNOWLEDGMENT
This research was financially supported by “Research on the Reform and Innovation of State-owned Enterprises Supervision System of the National Social Science Fund of China” (Grant No. 17ZDA087).

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