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Analysis on Location Selection and Path Optimization of Hubei SF Express Logistics Distribution Center

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Abstract. Since its establishment in 1993, SF Express has grown alongside the domestic express delivery industry and private economy. The rise of online and video shopping has further fueled its rapid growth. SF Express's achievements can be attributed to effective cost control, yet improvements in frontline operations are needed. This article first analyzes SF Express's current status in the industry and then explores alternative plans for its Hubei Province distribution center using the Analytic Hierarchy Process (AHP). Leveraging delivery volume data from Hubei outlets, a vehicle routing model is constructed and solved using the Saving Algorithm, yielding an optimized plan for SF Express's logistics in Hubei. This study offers practical optimization suggestions for SF Express and provides valuable reference for third-party logistics enterprises.

Keywords. SF Express; distribution center location; path optimization; hierarchical analysis process; mileage saving method.

1. Introduction

With the vigorous economic development and social progress, the logistics industry has gained increasing importance. The rise of online shopping and improved national consumption levels have further fueled the rapid growth of the express delivery industry. As market competition intensifies, both suppliers and demanders have higher expectations for the timeliness and punctuality of logistics and distribution. However, due to the late start of domestic logistics compared to developed countries, there is still much room for improvement in operational efficiency and time-sensitive logistics products. Additionally, some existing transportation routes and early established distribution centers have high costs. Planning logistics nodes and networks scientifically has become a pressing issue for modern logistics enterprises. This article focuses on SF Logistics, exploring the optimization of its regional distribution centers and transportation routes. Through case studies, it analyzes the deficiencies of the existing

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logistics network and proposes practical optimization solutions. The research aims to provide improvement suggestions for SF Logistics and offer a reference for other logistics enterprises in constructing and optimizing their logistics networks. Ultimately, it hopes to help logistics enterprises improve operational efficiency, reduce costs, better meet market demand, and enhance overall competitiveness [1,2].

2. Analysis of the Current Situation and Problems of the Development of SF Express

2.1. Company Profile

Founded in SHUNDE in 1993, SF has grown into the largest integrated logistics provider in China and Asia, ranking fourth globally by 2022. Operating under direct management, it ensures high quality through unified branch oversight. With a focus on logistics ecosystem, service capabilities, and product systems, SF offers time-delivery, economic express, cold chain, international services, and supply chain solutions. Leveraging technology, SF aims to build a digital supply chain ecosystem and lead in intelligent supply chain globally, while promoting social responsibility [3-5].

2.2. Analysis of the Current Situation and Problems

2.2.1. Situation of Distribution Centers

SF has 12,000 business outlets in China, mainly located in coastal areas and inland transportation hubs, these distribution centers are mainly supplied to the distribution outlets in the city, and at the same time, this layout also facilitates the supply of goods outside the province [6-7]. As with most modern distribution centers, with advanced equipment and systems, to provide customers with a variety of personalized needs, the basic functions shown in Figure 1.

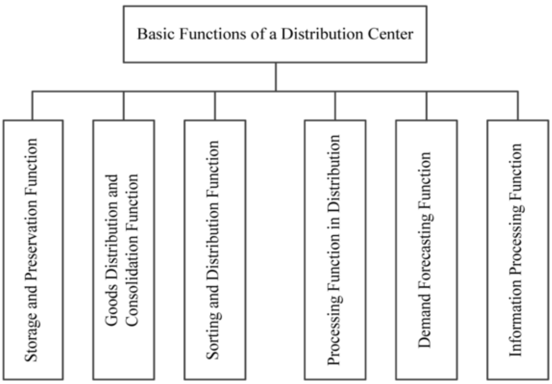

Figure1. Basic Functions of Distribution Center

2.2.2. Situation of Transportation Routes

According to the information given on the official website, SF has set up more than 35,000 self-operated and agency outlets on the mainland, covering more than 300 prefecture-level administrative districts with a coverage rate of 99.7%, as well as more than 2,700 county-level administrative districts with a coverage rate of 97.7%, and more than 120,000 domestic transportation routes [8].

Table 1. SF's logistics and freight forwarding operating costs in the first half of 2023

	Current report		For the same period last year		Year-on-year change	
	Sum	Percentage of income	Sum	Percentage of income	Growth rate (%)	Variable speed as a percentage of revenue
labor cost	49,141,500	40.66%	42,350,198	33.17 %	16.04%	Increase of 7.49 percentage point
transportation costs	39,307,703	32.52%	54,203,466	42.45%	-27.48%	Decrease of 9.93 percentage points
Other operating cost	16,116,677	13.34%	15,132,610	11.85%	6.50%	Increase of 1.49 percentage point

As can be seen from the Table 1, in the first half of 2023, SF's labor and operating costs rose compared to the same period. Despite investing in automation, optimizing operations, and integrating networks to reduce personnel and improve efficiency, SF still faces issues in terminal links, despite operating 1,950 warehouses nationwide and enhancing warehousing functions [9-11].

Firstly, although SF has a large warehouse network system, but no matter the e-commerce warehouse or the cold chain warehouse, its main function is the distribution warehouse mainly for the warehousing, and it lacks the function of the distribution center, so the transportation cost still has the space that can be reduced.

Secondly, in terms of vehicle transportation, SF optimizes the capacity structure to improve the utilization rate of capacity, but this is also limited to self-owned fleet, some routes still need to outsource the fleet to assist in the transport, in the peak of the volume of pieces of the fleet cannot accept the order of the case, the relevant plan is difficult to get the full implementation of the plan, if the lack of path planning will lead to the volume of pieces of the same time as the unloaded volume of the situation is also high.

3. Study on Distribution Center Location Selection Based on Hierarchical Analysis Approach

3.1. Building an Evaluation Indicator System

3.1.1. SF Distribution Center Site selection Evaluation Index Conditions

The location selection of SF's distribution center is a complex and comprehensive process involving multiple evaluation criteria. The following is a detailed analysis of the evaluation criteria for the location selection of SF's distribution center from different dimensions:

1) Cost Minimization: Cost has always been an unavoidable topic, and how to keep

construction costs to a minimum is the key to building a distribution center.

2) Timing and efficiency: enterprises should pay attention to efficiency while reducing costs, and the balance between the two can provide enterprises with a stable foundation in the competition.

3) Systematic and scientific: the construction of the evaluation index system needs to take into account a variety of factors, and has a holistic and correlation, it is best to reflect the role of the distribution center site selection.

3.1.2. Selection of evaluation indicators

Before establishing the evaluation index system, clarify the angles, then select conditions as indexes. The distribution center in Hubei Province considers intra-provincial transportation, incoming shipments, warehousing, and transshipment. Selections are made from social, economic, and enterprise facility aspects.

3.1.3. Analysis and Construction of Evaluation Indicators

From the viewpoint of social factors there are employee treatment, national policies, green environment protection, from the viewpoint of economic factors there are land costs, construction costs, transportation costs, and from the viewpoint of enterprise facility factors there are site facilities, transportation conditions, and service levels. The following is a description of these evaluation indicators:

1) Employee Benefits: Enterprises need to consider whether the location of the workplace is convenient for commuting or whether the site provides living areas.

2) National Policy: The location of the distribution center must comply with relevant national regulations and strictly implement national policies.

3) Green and Environmental Protection: Green logistics cannot be neglected in the development of the industry, as it is related to the future use and reuse rate of resources.

4) Land Cost: Land cost is the most direct expenditure for enterprises in the selection process, which includes not only the purchase price but also taxes, transfer fees, resettlement fees, and other expenses.

5) Construction Cost: This includes expenses for materials, equipment, labor, and a series of costs incurred before completion. Prices for these items may vary across different regions.

6) Transportation Cost: The distance from the distribution center to the destination is the main factor affecting transportation costs, which also include labor costs, fuel costs, and other expenses incurred during vehicle delivery and transportation.

7) Site Facilities: This refers to the hardware equipment in the distribution center, including utilities such as water and electricity, as well as related public facilities.

8) Traffic Conditions: Traffic conditions are important factors affecting distribution costs and logistics efficiency. For express delivery companies, it is preferable to locate their distribution centers near transportation hubs, such as airports, highway exits, and main road intersections, with connections to two or more transportation modes.

9) Service Level: As an integral part of the distribution center's operations, service level includes on-time delivery, accuracy, delivery speed, feedback handling, and so on [12-14]. Excellent service can further enhance customer experience, increase business revenue, and

elevate the corporate brand image [15].

Combined with the above description, the evaluation index system suitable for the location of Hubei SF distribution center is constructed, as shown in Figure 2.

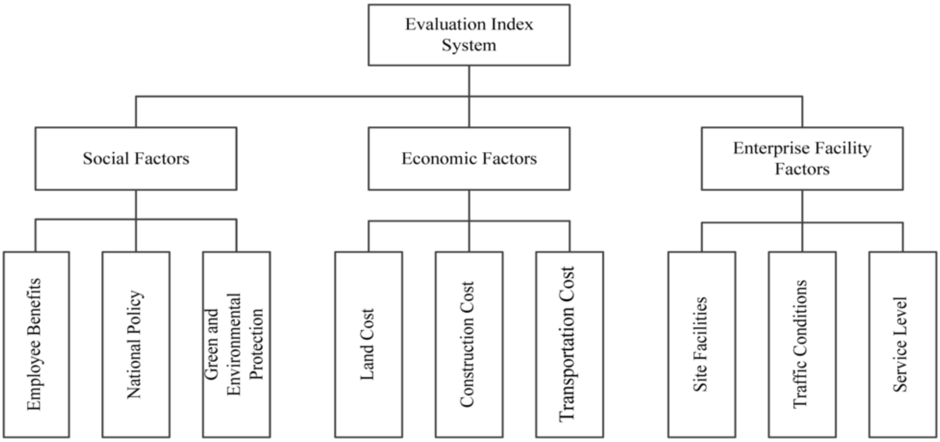

Figure 2. Distribution Center Site Selection Evaluation Center System

3.1.4. Determination of site selection options

Based on the analysis of various condition factors and considering regional differences within Hubei as the site selection range, we have identified four options for distribution point locations.

1) Option A is an existing SF warehouse with an intelligent warehousing system, convenient main road access, staff living quarters, and no nearby residential areas, suitable for immediate use as a distribution center.

2) Option B is located far from the city's main road but close to major transportation routes, with a reference land price of 157 yuan per square meter. It is distant from the airport and railroad and lacks residential areas or other equipment.

3) Option C is situated close to the city's main road and railroad system, with a reference price of 338 yuan per square meter. It is surrounded by residential areas and schools, has convenient transportation, but does not provide staff dormitories.

4) Option D is located away from the city center, near the main road and railroad, with a rental reference price of 650 yuan per square meter. It has supporting infrastructure, subsequent utility fee discounts, and complete living facilities.

3.2. Distribution Center Site Selection Based on Hierarchical Analysis

3.2.1 Hierarchical Site Selection Analysis

After the establishment of the evaluation index system, it is necessary to determine the weight between the factors, the use of 1-9 scale method to compare the factors, based on the scale for the comparison of the relative weight of the indicators, the importance of the scale and the meaning of the Table 2 shows. Based on the established evaluation index system, relevant information inquiry and summary of SF's distribution center site selection in different regions are conducted, and the importance comparison results are obtained by scoring each layer that is the index, as shown in Table 3, Table 4, Table 5 and Table 6 below.

Table 2. Importance scales and meanings

Scale	Connotation
1	Two elements are of equal importance compared to each other
3	Two elements compared,the former is slightly more important than latter
5	Two elements compared, the former is significantly more important than the latter
7	Two elements compared, the former is more strongly important than the latter
9	Two elements compared, the former is more extremely important than the latter
2,4,6,8	The median value of the above judgment
Reciprocal	The importance of the latter over the former is the reciprocal of the importance of the latter over the former

Table 3. Comparison of main indicators

	A Social factor	B Economic factor	C Enterprise facility factor
A Social factor	1	1/2	1/3
B Economic factor	2	1	3
C Enterprise facility factor	3	1/3	1

Table 4. Comparison of secondary indicators of social factors

	A1 Employee Treatment	A2 State policies	A3 Green environment protection
A1 Employee Treatment	1	1/3	1/2
A2 State policies	3	1	1
A3 Green environment protection	2	1	1

Table 5. Comparison of secondary indicators for economic factors

	B1 Land costs	B2 Construction costs	B3 Transportation costs
B1 Land costs	1	3	1/3
B2 Construction costs	1/3	1	1/4
B3 Transportation costs	3	4	1

Table 6. Comparison of secondary indicators for the enterprise facility factors

	C1 Site facilities	C2 Transportation conditions	C3 Service levels
C1 Site facilities	1	1/2	2
C2 Transportation conditions	2	1	3
C3 Service levels	1/2	1/3	1

3.2.2 Comprehensive Evaluation Analysis

Through the analysis of the impact of SF distribution center site selection, the factors of each influencing factor were obtained, and the weights of the primary indicators are shown in Table 7, and the weights of the secondary indicators are shown in Table 8, Table9, and Table 10.

Table 7. Primary indicators weights

Primary indicator	Weight
A Social factor	0.16
B Economic factor	0.54
C Enterprise facility factor	0.30

Table 8. Secondary indicators of social factors weights

Secondary indicator	weight
A1 Employee treatment	0.17
A2 State policies	0.44
A3 Green environment protection	0.39

Table 9. Secondary indicators for economic factors weights

Secondary indicator	weight
B1 Land costs	0.27
B2 Construction costs	0.12
B3 Transportation costs	0.61

Table 10. Secondary indicators for the enterprise facility factors weights

Secondary indicator	weight
C1 Site facilities	0.30
C2 Transportation conditions	0.54
C3 Service levels	0.16

After calculating the weights, we obtained the weights for level 1 and level 2 indicators. The composite indicator weights were derived by multiplying the level 2 weights with their corresponding level 1 weights, as seen in Table 11.

Based on the expert scoring data (Appendix 1), combined with the total weights of the evaluation indicators, a weighted average was used to score the site locations, resulting in the scores for each site option as shown in Table 12.

Utilizing the hierarchical analysis method, with Hubei Province as the focus, this section evaluates four potential locations for the SF distribution center. By selecting and establishing an evaluation indicator system, we determine the importance and weight of each indicator. Using these weights, we calculate the total weight and obtain scores through expert evaluation. By comparing the weighted average scores, Option A emerges as the top choice for the distribution center, effectively reducing distribution center layout costs and minimizing regional logistics expenses.

Table 11. Total weight of evaluation indicators

	Primary indicator		Secondary indicator		Combined weights
Evaluation Indicator System	Social factor	0.16	Employee treatment	0.17	0.03
			State policies	0.44	0.07
			Green environment protection	0.39	0.06
	Economic factor	0.54	Land costs	0.27	0.15
			Construction costs	0.12	0.06
			Transportation costs	0.61	0.33
	Enterprise facility factor	0.30	Site facilities	0.30	0.09
			Transportation conditions	0.54	0.16
			Service levels	0.16	0.05

Table 12. Programmatic scores

	Combined weights	Option A	Option B	Option C	Option D
Employee treatment	0.03	88	58	82	92
State policies	0.07	80	72	84	86
Green environment protection	0.06	72	78	58	80
Land costs	0.15	92	74	60	50
Construction costs	0.06	86	60	84	82
Transportation costs	0.33	84	70	84	86
Site facilities	0.09	92	70	80	82
Transportation conditions	0.16	82	56	76	78
Service levels	0.05	82	64	78	92
Weighted average score		84.74	67.72	76.84	78.84

4. Distribution Path Optimization Scheme Based On Mileage Saving Method

According to the regional data given by SF, it can be summarized that the business characteristics of SF, the characteristics of large business volume, more categories, more batches, fewer batches, coupled with the regional differences in the volume of the pieces, the full load rate of the transport vehicle is difficult to meet the company's standards. This paper models the distribution routes of seven primary outlets of SF located in Hubei Province, and optimizes the path problem through the mileage saving method.

4.1. Problem Description and Mathematical Modeling

Assuming that SF's warehouse A needs to distribute goods to seven outlets B, C, D, E, F, G, and H. The distribution diagram is shown in Figure 3.

The distance from Warehouse A to each outlet is shown in Table13, and the demand for goods assigned to each outlet is shown in Table 14. The distribution tasks of all seven outlets are performed by trucks with a load capacity of 9 tons, and the maximum distance traveled by each truck is 600 km. The lowest cost distribution planning is calculated using the total distribution distance as the cost.

Using the savings method, the number of miles saved between outlets was calculated, and based on the results, the miles saved were ranked to obtain the corresponding savings odometer, as shown in Table 15.

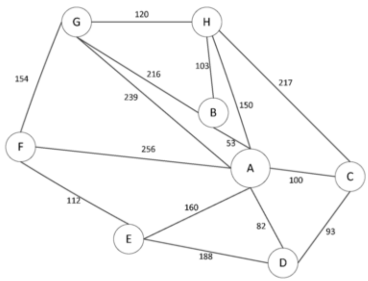

Figure 3. Network Distribution Modeling

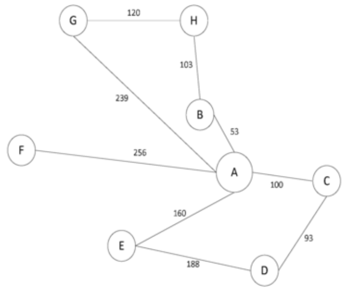

Figure 4. Distribution route optimization diagram

4.2. Model Calculation Solution

Based on the data obtained from the above savings odometer, combined with the vehicle loading capacity and the maximum transportation limit, the routes with many miles are combined to determine the final distribution path, as shown in Figure 4.

Determine the final distribution path based on the results of the optimization map:

Route 1: *A-G-H-B-A*

Volume of deliveries: $Q_1=Q_G+Q_H+Q_B=3.8+2.1+1.2=7.1$

Mileage savings: $S_1=269+100=369$

Route 2: *A-C-D-E-A*

Volume of deliveries: $Q_2=Q_C+Q_D+Q_E=2.5+1.7+3.2=7.4$

Mileage savings: $S_2=89+54=143$

Route 3: *A-F-A*

Volume of deliveries: $Q_3=Q_F=2.7$

Mileage savings: $S_3=0$

The final route was planned using three 9-ton delivery vans, saving a total distance of 512 kilometers. This section analyzes the seven distribution outlets of S.F. Hubei, focusing on vehicle path planning. By establishing a model to mark transportation distance, applying the mileage-saving method, and considering carrier limitations, we aim to reduce total transportation time and cost. The optimal path scheme is obtained, and unified distribution routes facilitate vehicle management and scheduling. This approach addresses the issue of increased total distance and cost of transportation caused by low load factor and irrational vehicle allocation in vehicle transportation.

Table 13. Distance Matrix (Unit: kilometer)

	A	B	C	D	E	F	G	H
A	-	53	100	82	160	256	239	150
B		-	153	135	213	309	216	103
C			-	93	260	356	337	217
D				-	188	300	321	232
E					-	112	266	310
F						-	154	274
G							-	120
H								-

Table 14. Requirements by Outlet (Unit: tons)

Location	B	C	D	E	F	G	H
Requirements	1.2	2.5	1.7	3.2	2.7	3.8	2.1

Table 15. Table of mileage savings

Number	Trails	Mileage savings (kilometers)	Number	Trails	Mileage savings (kilometers)
1	F--G	341	8	B--G	76
2	E--F	304	9	D--E	54
3	G--H	269	10	D--F	38
4	F--H	132	11	C--H	33
5	B--H	100	12	B--C	0
6	C--D	89	13	B--D	0
7	E--G	79	......	......	......

5. Conclusion

The express delivery industry in China is undergoing rapid and complex changes. To compete effectively, optimizing distribution center locations and vehicle path management are crucial for reducing end-of-pipe delivery costs, making them key industry focuses. This paper examines SF Express's development in Hubei, focusing on distribution center location strategies. It considers various influencing factors and establishes a comprehensive evaluation index system. Through hierarchical analysis, factors are carefully assessed and compared, ultimately selecting Option A as the optimal location. This choice reduces both initial construction and operational transportation costs, lowering overall expenses. Additionally, the paper addresses SF's cost challenges in establishing functional distribution centers by integrating sorting centers and warehouses. Furthermore, it studies SF's seven regional distribution outlets, constructing an efficient path model. Considering vehicle constraints, it optimizes distribution routes to create a practical and efficient path planning. This planning ensures high vehicle load rates and facilitates vehicle management and scheduling.

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