

Optimisation and Application of Entropy Weight Method-TOPSIS Model for Ranking the Importance of Urban Express Sites

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Abstract: With the rapid development of e-commerce, the importance of express delivery network in the modern logistics system is becoming more and more prominent. In order to scientifically assess the importance of urban express sites, this paper proposes a multi-objective decision-making method based on entropy weight method and TOPSIS model. The entropy weight method is objectively assigned by analysing the data dispersion of indicators, and the TOPSIS model is used to rank urban sites by calculating their distance from ideal and negative ideal solutions. In this paper, we firstly processed the data with multiple interpolation to ensure its accuracy, and selected four key indicators, namely, shipping volume, receiving volume, correlation and growth trend of express delivery volume. The results show that the entropy weight method-TOPSIS model can effectively assess the importance of each city site, provide a scientific basis for optimising the express delivery network, and have a wide range of application potential.

Keywords: Entropy Weight Method; TOPSIS Model; City Express Site; Multi-Objective Decision-Making; Logistics Network Optimisation.

1. Introduction

In the modern logistics system, express delivery network has become an important part of supporting urban economic development. With the rapid development of e-commerce and logistics industry, how to effectively assess and optimise the layout and importance of urban express site has become particularly critical. Different cities express site in the logistics network in different roles, some bear a large number of express transport tasks, and some in the logistics links between cities play a hub role. In order to ensure the efficient operation of the logistics network, it is necessary to scientifically assess the importance of each site, in order to provide a decision-making basis for future resource allocation, capacity adjustment and network optimization [1].

In this context, many multi-objective decision-making methods are widely used in the evaluation of express networks. These methods include hierarchical analysis, fuzzy comprehensive evaluation method, grey system theory, etc. However, when facing the complex multi-indicator problem, the results of these methods may be affected by the interference of subjective factors or the complexity of calculation. In order to solve this problem, TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method has gradually become an effective tool for the evaluation of the importance of urban courier sites due to its advantages of easy calculation, reasonable results and flexibility [2]. TOPSIS is used to evaluate the importance of urban courier sites by measuring the relationship between each evaluation object and the Ideal Solution and Negative Ideal Solution to rank them, which makes the comprehensive evaluation results more intuitive. At the same time, entropy weighting method, as an objective assignment method, can automatically calculate the weights according to the degree of data dispersion of each index, thus avoiding the bias that may be brought by subjective human assignment. Combining the

entropy weight method with TOPSIS can improve the scientificity and accuracy of the importance ranking of urban express sites.

The research in this paper is based on multi-objective decision-making theory, through the combination of entropy weight method and TOPSIS model, established a set of comprehensive evaluation model for the importance of urban express site. Firstly, for the problem of outliers in the data, data preprocessing was carried out using multiple interpolation method to ensure the completeness and accuracy of the data. Next, based on the preprocessed data, four key indicators, namely, shipment volume, receipt volume, relevance and growth trend of the number of expresses, were selected, which not only measure the existing logistics demand of the urban sites, but also reflect their hub role in the network as well as their potential for future development. Then, objective weights are assigned to these four indicators through the entropy weighting method, and the characteristics of information entropy are used to determine the weights of each indicator to ensure the objectivity of the assessment. Finally, using the TOPSIS model, the distance of each city site from the ideal solution and the negative ideal solution is calculated to obtain the results of the importance ranking of each site.

The main contribution of this study is to provide an optimised multi-objective decision-making method that can effectively assess the importance of urban express sites. By introducing the entropy weight method, the subjectivity of indicator assignment is solved, and the complexity and computational difficulties in the comprehensive evaluation of multiple indicators are overcome by combining the TOPSIS model. The evaluation method proposed in this paper not only provides theoretical support for logistics enterprises to optimize the urban express network, but also provides a data basis for the layout planning and capacity deployment of future express sites. In today's increasingly complex express

network, this method has a wide range of application prospects, and can be extended to other logistics areas and transport hubs in the planning research.

2. Related Work

In the research field of ranking the importance of urban express sites, multi-objective decision-making methods have been the main research direction. In recent years, with the rapid expansion of express delivery network, how to comprehensively consider the position and role of different cities in the logistics network has become a key issue faced by logistics enterprises and urban planners. In this process, various evaluation methods, such as hierarchical analysis method (AHP), fuzzy comprehensive evaluation method, grey system theory and RSR method (rank and ratio method), have been widely used in multi-objective decision-making in different scenarios [3]. Each of these methods has its own advantages, but in the case of high complexity of processing data and uneven distribution of indicators, they often suffer from the problems of high difficulty of subjective assignment, high computational complexity, and high influence of results by human factors. Therefore, scholars have gradually begun to explore how to introduce more objective and automated assignment methods to improve the accuracy and scientificity of model evaluation [4].

Hierarchical analysis, as a classical multi-objective decision-making method, is able to obtain the relative weight of each indicator by constructing a hierarchical structure and making two-by-two comparisons. However, because AHP relies on the subjective judgement of the decision maker, the stability and consistency of its results in different contexts are difficult to guarantee, especially when there are more indicators, the computational complexity increases, and the error caused by subjectivity is more significant. To cope with this limitation, the fuzzy comprehensive evaluation method has been applied in scenarios dealing with uncertainty and ambiguity. The method is able to express the relationship between indicators through fuzzy matrices to effectively deal with uncertainty in complex environments, but its dependence on expert knowledge is high and it is difficult to avoid the interference of human factors. In addition, the grey system theory and RSR method perform well in dealing with some missing data and strong data correlation, and are able to give reasonable evaluation results by processing and analysing a small amount of data, however, their computational efficiency and applicability are somewhat limited when facing large-scale and multi-dimensional data.

In order to make up for the shortcomings of these methods, the introduction of information entropy provides a new solution idea for the problem of weight allocation in multi-objective decision-making. The information entropy theory is based on the intrinsic attributes of data for weight allocation, which can effectively avoid the interference of subjective factors and ensure the objectivity of weight allocation. In recent years, the combination of entropy weight method and various evaluation models has become a research hotspot in the field of multi-objective decision-making [5]. The entropy weight method determines the weights by analysing the degree of dispersion of the indicator data, and the greater the degree of dispersion of the data, the greater the contribution of the indicator to the decision-making, thus giving higher weights. The introduction of entropy weight method greatly improves the scientific and rationality of the model, especially suitable for dealing with complex scenarios with

many indicators and large differences in data distribution.

As a common multi-objective decision-making method, TOPSIS (Approximate Ideal Solution Sorting Method) model has been widely used in logistics, transport and other fields in recent years due to its easy calculation and clear results. The core idea of TOPSIS model is to judge the superiority of the evaluation object by its distance from the positive ideal solution and the negative ideal solution, and the closer the distance is, the better the evaluation result is [6]. Compared with other methods, TOPSIS is able to deal with multiple positive and negative indicators at the same time, which is especially suitable for the application in the comprehensive evaluation of multiple indicators such as logistics sites and transport hubs. Its advantage lies in its ability to better reflect the relative merits of each evaluation object, rather than a simple absolute ranking.

In the existing related research, scholars have begun to combine the entropy weight method with the TOPSIS model and apply it to complex scenarios of multi-objective decision-making. For example, the application of entropy weight method-TOPSIS model has already achieved certain results in the fields of ranking the importance of transport hubs, optimising the layout of logistics sites, and urban development planning. Studies have shown that this combination method can effectively reduce the errors caused by subjective assignment and improve the stability and accuracy of the model evaluation results. In addition, the combination of entropy weight method and TOPSIS also provides an effective path for the processing of multi-dimensional complex data, especially in the logistics network, the role of each city site is often affected by a number of factors together, the use of entropy weight method and TOPSIS model can comprehensively take into account the shipment volume, the receipt volume, the relevance of the city and other multiple indicators, to give a more reasonable sorting results [7].

However, although the entropy weighting method-TOPSIS model shows a strong application potential in multi-objective decision-making, there are still relatively few studies on the method in the optimisation of express delivery network, the importance of city site ranking and other specific problems. Current research focuses on the optimisation of the overall layout of the logistics system or transport routes, while a systematic research system has not yet been formed for the individual importance ranking of urban sites. Therefore, this paper explores the importance ranking problem of urban courier sites based on entropy weight method and TOPSIS model in combination with actual data, which provides a new research idea for the optimisation of urban courier network and lays a theoretical foundation for future research in related fields.

3. Model building and solving

3.1. Data pre-processing

In the data processing, we find that there are some abnormal values, which need to be processed by us. By observing the data, we can find that there are obvious outliers in some indicators such as shipping volume and receiving volume, for example, some shipping data has a shipping volume or receiving volume of 0, which may be due to errors or omissions in the process of data collection, rather than the actual express shipping data we need [8]. Therefore, for these outliers, we regard them as missing values and process them

using multiple interpolation. After processing, the data are shown in Table 1 below:

Table 1 Data after processing

City Name	Shipment volume	Receiving volume	Relevance	Trend of growth in number of express shipments
A	31276	51708	5	-0.11
B	12458	15624	2	0.09
C	18361	13228	4	-0.07
D	31135	52401	7	0.08
E	14643	20055	2	-0.09
G	287248	273737	10	0.24
H	45866	47155	3	0.06
I	45100	50855	3	-0.12
J	99173	98557	4	0.15
K	74841	71003	3	0.09
L	296846	311289	12	0.26
M	52041	47609	7	0.12
N	62359	44445	5	0.06
O	64986	87091	6	0.14
P	15419	13357	2	-0.16
Q	60654	81076	7	0.11
R	109685	91333	5	0.17
S	56714	37140	5	0.09
T	32819	51709	2	-0.07
U	40548	24339	6	0.05
V	164403	192823	7	0.21
W	69505	77336	3	0.07
X	89437	84303	5	0.12
Y	52758	41811	3	0.09

The correlation of one city with another city is recorded as 1, the correlation of one city with two cities is recorded as 2, and so on.

Courier Volume Growth Trend calculates the growth rate of courier shipments and receipts by using the number of courier shipments and receipts per month.

$$\text{Trend of growth in the number of express deliveries} = \frac{\text{Monthly courier shipments} - \text{Number of shipments received}}{\text{Number of days in the month}} \quad (1)$$

The receipt and delivery volume can measure the importance of the station city for express delivery; the growth/decrease trend of the number of express delivery can measure the future development trend of the station city; the correlation can measure the degree of connection between the station city and other station cities.

3.2. Model selection

There are many models for evaluating the pros and cons of indicators, such as comprehensive index method, hierarchical analysis method, RSR method, fuzzy comprehensive evaluation method, gray system method, etc. These methods have their own characteristics and advantages and disadvantages. Among them, TOPSIS comprehensive evaluation method is a decision-making method in the multi-objective decision analysis of finite solutions in the system. This method has the characteristics of simple calculation, reasonable results, and flexible application. It can be used for the importance of the city and obtain satisfactory ranking results [9].

First, we take the city as the object to be evaluated, and take the receipt volume, delivery volume, growth/decrease trend of express delivery volume, and correlation as the influencing indicators of the importance of each station city. Secondly, we use the entropy weight method to objectively assign weights to these four indicators. By analyzing the dispersion of each indicator data, using information entropy to determine the weight of each indicator, and at the same time making appropriate corrections to these weights, we finally get a more

accurate indicator weight.

3.3. Model Solution

Next, we construct and solve the entropy weight model based on the data after data preprocessing:

(1) Determine our evaluation object, establish an evaluation index system, and construct the level matrix T_{ij} :

(2) Standardize our evaluation matrix to obtain the matrix T' :

When j is a positive index:

$$T'_{ij} = \frac{T_{ij} - \min(T_{ij})}{\max(T_{ij}) - \min(T_{ij})} \quad (2)$$

When j is a negative index:

$$T'_{ij} = \frac{\max(T_{ij}) - T_{ij}}{\max(T_{ij}) - \min(T_{ij})} \quad (3)$$

(3) Calculate the entropy value of each indicator

$$H_j = - \sum_{i=1}^m f_{ij} \cdot \ln f_{ij} \quad (4)$$

$$f_{ij} = \frac{r_{ij}}{\sum_{i=1}^m r_{ij}}, k = \frac{1}{\ln m} \quad (5)$$

Where f_{ij} is the weight of the index value of the i -th item under the j -th index.

(4) Calculate the entropy weight w_j of the j -th index

$$w_j = \frac{1 - H_j}{\sum_{j=1}^n (1 - H_j)} = \frac{1 - H_j}{n - \sum_{j=1}^n H_j} \quad (6)$$

Through calculation, we get the results shown in Table 2 below:

Table 2 Weights of evaluation indicators

Entropy weight method	Column 1	Column 2	Column 3
Indicator	Information entropy value e	Information utility value d	Weight (%)
Shipment volume	0.84	0.16	32.413
Received volume	0.838	0.162	32.821
Correlation	0.877	0.123	24.792
Express delivery volume growth trend	0.951	0.049	9.975

Through the entropy weight method, we get the weight of the shipment volume is 32.413%, the weight of the receipt volume is 32.821%, the weight of the correlation is 24.792%, and the weight of the express quantity growth trend is 9.975%. The maximum indicator weight is the receipt volume (32.821%), and the minimum is the express quantity growth trend (9.975%).

Next, we will use the preprocessed data to build the topsis model and solve it.

(1) Now we assume that there are n objects to be evaluated, and the matrix composed of m evaluation indicators is as follows:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \quad (7)$$

(2) Perform a positive process on the matrix, unify different types of indicators into positive (extremely large) indicators, and then standardize the matrix after the positive process [10]. The matrix after the positive process and the standardization process is denoted as the matrix Z :

$$X = \begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1m} \\ z_{21} & z_{22} & \cdots & z_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ z_{n1} & z_{n2} & \cdots & z_{nm} \end{bmatrix} \quad (8)$$

Each element in Z is calculated as:

$$z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^n x_{ij}^2}} \quad (9)$$

(3) Calculate the positive ideal solution distance (D^+) and the negative ideal distance (D^-), and find the unnormalized score:

Define the distance between the $i(i = 1, 2, \dots, n)$ evaluation object and the maximum value:

$$D_i^+ = \sqrt{\sum_{j=1}^m (Z_j^+ - z_{ij})^2} \quad (10)$$

Define the distance between the $i(i = 1, 2, \dots, n)$ evaluation object and the minimum value:

$$D_i^- = \sqrt{\sum_{j=1}^m (Z_j^- - z_{ij})^2} \quad (11)$$

Then, we can calculate the unnormalized score of the $i(i = 1, 2, \dots, n)$ evaluation object:

$$S_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (12)$$

(4) Calculate the normalized score and sort the results:

Normalized result calculation formula:

$$\tilde{S}_i = \frac{S_i}{\sum_{i=1}^n S_i} \quad (13)$$

The final calculation results are shown in Table 3 below:

Table 3 Ranking of importance of each station city

City name	Positive ideal solution distance (D^+)	Negative ideal solution distance (D^-)	Comprehensive score	Rank
L	0.00010612	0.99999398	1.00030015	1
G	0.13012048	0.89232641	0.87273626	2
V	0.45254438	0.55213353	0.54956274	3
R	0.68590509	0.31523421	0.31487547	4
Q	0.71679148	0.32747854	0.31359565	5
O	0.72690091	0.29238464	0.28685253	6
M	0.76558895	0.29994524	0.28149752	7
J	0.72483145	0.28153881	0.27975668	8
X	0.72057826	0.27986246	0.27973917	9
D	0.79379695	0.29250344	0.26926573	10
U	0.82926035	0.23201252	0.21861722	11
N	0.79972823	0.21310577	0.21040543	12
S	0.81551896	0.20235566	0.19880214	13
K	0.81582941	0.19454785	0.19254967	14
W	0.81716123	0.19420762	0.19202452	15
A	0.83849147	0.19295974	0.18707594	16
Y	0.87327689	0.12815804	0.12797441	17
I	0.87518115	0.12788583	0.12749481	18
H	0.87760941	0.12432102	0.12408149	19
C	0.92201099	0.11292752	0.10911523	20
T	0.97246822	0.04489716	0.04413087	21
E	0.97765685	0.03596139	0.03547824	22
B	0.98490811	0.02776341	0.02741601	23
P	0.98292778	0.02461668	0.02443235	24

4. Accuracy test of results

The weight obtained by entropy weight method is corrected by calculating the comprehensive weight λ_j of the indicator:

$$\lambda_j = \frac{\lambda'_j w_j}{\sum_{j=1}^n \lambda'_j w_j} \quad (14)$$

Through calculation, we get the results shown in Table 4 below:

Table 4 Corrected weight results of each station city

Indicators	Weight
Shipment volume	32.562
Received volume	32.874
Correlation	24.752
Express delivery growth trend	9.979

By comparing with our uncorrected weight results, the error between the two is less than 0.1, so we believe that the results calculated by the entropy weight method are good and relatively accurate.

5. Discussion

In the problem of ranking the importance of urban express delivery stations, the combination of the entropy weight method and the TOPSIS model provides an effective optimization method for solving multi-objective decision-making problems. The entropy weight method uses the discreteness of the data to determine the objective weight of each indicator, while the TOPSIS model ranks the evaluation object by the distance from the ideal solution and the negative ideal solution [11]. Combining the two helps to more scientifically and reasonably evaluate the importance of different urban stations in the express delivery network.

First, data preprocessing is an important link to ensure the accuracy of model results. In actual express delivery data, outliers or missing values often appear. In order to ensure the integrity and correctness of the data, this paper uses multiple interpolation to process outliers. By eliminating unreasonable values, such as zero shipment or receipt, the impact of errors in the data collection process on the model results can be reduced. At the same time, indicators such as shipment and receipt can not only reflect the current express demand of urban stations, but also indirectly measure their importance in the entire express delivery network. The correlation index reflects the closeness of the logistics connection between the city and other cities, while the growth trend of the number of express deliveries reflects the potential development capacity of the site. Taking these indicators into consideration, the importance of express delivery sites in each city can be fully reflected.

The introduction of the entropy weight method provides an objective method for weight allocation. By calculating the information entropy, the discreteness of the data distribution of each indicator can be effectively captured. The greater the degree of discreteness of the indicator, the stronger its influence on the decision-making results, and thus the higher the weight. According to the calculation results of this paper, the weights of the receipt volume and the delivery volume are both over 32%, showing the core role of these indicators in measuring the importance of express delivery sites. In contrast, the weight of the growth trend of the number of express deliveries is relatively low, only 9.975%, indicating that its influence on the overall importance ranking is relatively small, but it is still not negligible. The advantage of the entropy weight method is that it does not require

subjective weighting, and can automatically allocate weights according to the intrinsic characteristics of the data, thereby avoiding the influence of human bias.

After determining the weights of each indicator, the TOPSIS model further ranks the sites by calculating the distance between each city site and the positive and negative ideal solutions. The positive ideal solution represents the optimal value of each indicator, while the negative ideal solution represents the worst value. By calculating the distance between each city station and these two ideal solutions, its relative advantages and disadvantages can be quantified. According to the results of this paper, city L ranks first with an absolute advantage, and G and V rank second and third respectively. These cities not only perform well in terms of shipping and receiving volumes, but also maintain a high logistics correlation with other cities, so they stand out in the comprehensive score. In contrast, cities B and P are ranked at the bottom due to their mediocre performance in various indicators.

The results of the TOPSIS model in this paper have been normalized, which ensures that indicators of different dimensions can be compared on the same scale. By calculating the positive ideal solution distance and the negative ideal solution distance of each city station and further normalizing them, the final ranking results are ensured to have high reliability and interpretability. In addition, this paper also corrects the weights obtained by the entropy weight method through precision testing to verify the accuracy of the calculation results. The error between the corrected weights and the original results is extremely small, which further proves the effectiveness and stability of the entropy weight method in dealing with multi-criteria decision-making problems.

In short, the combination of the entropy weight method and the TOPSIS model provides a complete framework for the importance ranking of urban express delivery stations. The objective weighting mechanism of the entropy weight method makes the weight distribution of each indicator more scientific and reasonable, while the TOPSIS model obtains the relative importance of each city station through distance calculation, ensuring the accuracy and rationality of the ranking results. In the future, this model can be further promoted and applied to other multi-objective decision-making scenarios, such as transportation hub site selection, logistics network optimization, etc., in order to provide theoretical support and practical tools for more complex decision-making problems.

6. Conclusion

Through the study of the importance ranking of urban express delivery stations, we adopted the combination of the entropy weight method and the TOPSIS model to construct a multi-objective decision-making model, and performed multiple interpolation processing on the outliers in the data to ensure the integrity and rationality of the data. The research results show that the entropy weight method can effectively allocate the weights of each indicator, making the weight distribution more objective, while the TOPSIS model calculates the distance between the evaluation object and the positive and negative ideal solutions, and finally gives a reasonable ranking of the importance of urban express delivery stations.

In the process of model application, the weight value calculated by the entropy weight method reflects the degree of influence of each indicator on the importance of the city station. Among them, the shipment volume and the receipt volume, as key indicators that directly reflect the intensity of logistics activities at urban sites, have obtained higher weights, 32.413% and 32.821% respectively, indicating their dominant role in the model. The correlation between cities, as an indicator to measure the closeness of logistics connections between cities and other sites, has a weight of 24.792%, which also plays an important auxiliary role. In comparison, although the growth trend of express delivery volume has a smaller weight of only 9.975%, this indicator can provide a certain reference for the development potential of urban express delivery sites in the future.

The TOPSIS model calculates the distance between positive and negative ideal solutions, so that the performance of different cities in multidimensional indicators can be comprehensively measured. By calculating the distance between each city and the ideal solution for the data after positive and normalization, we obtained the comprehensive scores and rankings of different cities. According to the results, cities L, G, and V ranked in the top three. They performed particularly well in key indicators such as shipment volume and receipt volume, and had a high correlation with other cities, showing their importance in the entire express delivery network. On the contrary, cities such as cities B and P ranked low due to their relatively weak performance in various indicators and low comprehensive scores. This ranking result not only reflects the current logistics importance of each city, but also provides a decision-making basis for the future site planning of logistics companies.

This study verifies the accuracy of the entropy weight method to calculate the weights through precision testing. After the weights are corrected, the weights of indicators such as shipment volume and receipt volume have very small errors with the initial results, proving the stability and reliability of the entropy weight method. The accuracy of the model calculation results provides strong theoretical support for further optimizing the urban express network. The performance of the TOPSIS model in the calculation of the comprehensive score has also been verified. The final normalized result ensures the comparability between different

types of cities and provides a clear ranking basis for the importance of express delivery stations in different cities.

In general, the comprehensive evaluation method based on the entropy weight method and the TOPSIS model provides a simple and effective tool for solving multi-index decision-making problems. In the future, with the continuous development of the express industry, this method can be further applied to other similar logistics network planning and optimization scenarios, in order to provide scientific basis and practical tools for more complex decision-making problems.

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