

EVALUATION ON SITE SELECTION OF MOBILIZATION LOGISTICS CENTER BASED ON PRINCIPAL COMPONENT ANALYSIS

Yun Feng, Chengrui Xu, Yisheng Wang*

ABSTRACT: Local logistics center determined in advance can be made into a mobilization logistics center for saving or transferring materials temporarily through reconstruction and construction in order to cope with wars or emergency accidents better and treat military materials or emergency materials used for wars efficiently. In this paper, the point among all alternative ones is selected as the optimal one and the site prioritized for the location of mobilization logistics center by analyzing the principle and influence factors for site selection of mobilization logistics center, in virtue of Principal Component Analysis (PCA) and on the basis of not reducing the information reflected by the original influence factors while reducing their quantity. The effectiveness of the method can be gained by the results of calculated example in virtue of SPSS software.

KEY WORDS: principal component analysis (PCA), mobilization logistics center, site selection, SPSS.

1 INTRODUCTION

Mobilization logistics center is an organization that is able to satisfy mobilization demands and provide logistics capacity, and a special logistics business distribution center integrating different kinds of logistics facilities, and different logistics ways and forms, and able to process packaging, supply, circulation and processing of materials as well as conversion of different means of transportation and information dispatching. Local logistics center can be used for distributing support materials when war breaks out or under crisis, allocating, saving, supplying and distributing critical materials and finishing the material support task delivered by the national, provincial and municipal economic mobilization office (Tang and Li, 2011; Yang et al., 2012).

A local logistics center determined in advance can be made into a mobilization logistics center through reconstruction and construction so as to deal with military materials or emergency materials efficiency when war breaks out or under emergency circumstances in order to save or transfer materials temporarily. This requires the local logistics center must be a comprehensive and regional place that can save a great number of materials, a center integrated with business flow, logistics and information flow and able to realize the functions of providing service in usual times, coping with wars in time and facilitating wars (Olofin and Liu, 2016; Tang, 2014; Bataineh and Taamneh, 2017). In order

to satisfy the requirements of the above for mobilization logistics center, site selection becomes particularly important and there are many factors that affect site selection and are also related to each other, to a certain extent. Therefore, the influence factors which are multiple in quantity and large in relevance are replaced by those with small quantity and fewer relevance (Luo and Ren, 2016; Mocerneac and Lobonțiu, 2015). At the same time, the influence factors with small quantity and fewer relevance are made to reserve the information reflected by the former ones as much as possible. PCA is just a very effective method to resolve such kinds of problems.

2 EVALUATION METHOD AND IDEA

2.1 Principal Component Analysis (PCA)

PCA refers to a diversified statistics analysis method of converting different actually measured data variables into fewer irrelevant comprehensive indexes. According to the main principle, the original multiple relevant variables are replaced by several variables that are not highly relevant by reducing dimensions in order to reduce the complexity of data variable; the dimension is reduced on the basis of minimizing the loss of information reflected by the original multiple data variables (Sanyal et al., 2017). In light that the method is established on the basis of data analysis, the fewer variables acquired by converting multiple indexes into fewer principal component indexes are highly objectives, making all factors independent and reducing information overlapping ratio (Liang et al., 2016; Liu and Liu, 2015; Li and Chen, 2016; Gan, 2015; Shi et al., 2016). Therefore, PCA is

Department of Military Logistics, Army Logistics University, Chongqing 401331, China

* Corresponding author E-mail: xcr234@live.com

mostly used in many comprehensive evaluation issues; PCA is also used in literature to study site selection.

2.2 Steps for Site Selection of Mobilization Logistics Center Based on PCA

Suppose there are m decision schemes for selecting alternative sites of the mobilization logistics center (the local logistics center selected in advance) and each decision scheme has n evaluation indexes, the following observation sample matrix X is therefore established as below:

$$X = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix}$$

The different dimensions of all evaluation indexes lead to certain difficulty in making evaluation and therefore, the original data indexes should be standardized as the data indexes with the same dimensions so as to facilitate problem evaluation. Standardization formula is:

$$a_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j}$$

(1)

Where, x_{ij} is the value of the i th index in the i th scheme, $i=1,2,\dots,m, j=1,2,\dots,n, \bar{x}_j$ is the average value of the j th index of the 1st index $\bar{x}_j = \frac{1}{m} \sum_{i=1}^m x_{ij}$ and s_j is the standard difference from the 1st to the i th index $s_j = \left(\frac{1}{m-1} \sum_{i=1}^m (x_{ij} - \bar{x}_j)^2 \right)^{\frac{1}{2}}$. The standardized indexes obtained are $A=(a_{11}, a_{12}, \dots, a_{ij})=(A_1, A_2, \dots, A_n)$.

Construct the relevant coefficient matrix R

$$R = \frac{1}{m-1} A^T A$$

(2)

Solve the eigenvalue of correlation coefficient matrix R and then solve n characteristic roots λ_i which are greater than 0 of matrix R characteristic equation $|R-\lambda I|$; arrange the characteristic roots λ_i in sequence from big to small ones; their value means the influence of all evaluation indexes on the site selection in evaluation. The eigenvector corresponding to the characteristic root is $P_t=(P_{t1}, P_{t2}, \dots, P_{tm})$, (where, $t=1, 2, \dots, n$).

The index formed according to eigenvector is:

$$y_i = P_{i1}A_1 + P_{i2}A_2 + \dots + P_{im}A_m$$

(3)

Where, A_1, A_2, \dots, A_n refer to the index after data indexes are standardized; y_n refers to the n th principal component, which is increased along with Value n ; amount of information reflected by y_n becomes fewer and fewer.

Variance contribution rate of the y_i th principal component is:

$$w_i = \frac{\lambda_i}{\sum_i^m \lambda_i}$$

(4)

Where, w_i refers to the percentage of variance of the principal component in the total variances and the proportion of the original information contained in the i th principal component, also called variance contribution rate; the accumulating contribution rate is acquired by summing the variance contribution rates in sequence.

The value of accumulating contribution rate acquired through calculation is used for selecting the quantity of evaluation indexes. In order to simplify the data structure when evaluation is made, if the sequence of the $t+1$ th principal component and the accumulating contribution rate of the t th sample remains unchanged, it means that t principal components could maintain the stability of the evaluation system. According to experience, the accumulating contribution rate is generally 85%.

Select the first t principal components whose accumulating contribution rate is greater than 85% to replace the indexes of the original data. Then carry out linear weighting calculation for the variance contribution rate of the first t principal components and the first t principal component indexes to obtain comprehensive evaluation value F :

$$F = w_1y_1 + w_2y_2 + \dots + w_t y_t$$

(5)

Finally, arrange the alternative site selection schemes of the mobilization logistics center in sequence to obtain system evaluation comprehensive value for comprehensive evaluation and then obtain evaluation conclusion, i.e., the optimal site.

3 BASIC PRINCIPLE AND INFLUENCE FACTORS FOR SITE SELECTION OF MOBILIZATION LOGISTICS CENTER

3.1 Basic principle for site selection of mobilization logistics center

The mobilization logistics center is within some region where there are several supply points and demand points; one center that can be used for collecting, saving and delivering goods is selected between supply point and demand point so that it can be used as a mobilization logistics center when war breaks out or if any emergency; one or several alternative local logistics centers can be selected and used as a temporary mobilization logistics center, when war breaks out or if any emergency. To establish mobilization logistics center is aimed at accelerating the mutual development of national economy and national defense construction, deepening the national strategy military and civilian integration and enhancing the capacity to cope with war or emergency. Therefore, the following principles should be abided by when selecting the site of mobilization logistics center:

1) Timeliness

In light of the special emergency of wars, timeliness requires the mobilization logistics center is able to supply materials for the corresponding demand points very quickly. It therefore must be closed to the entrance of main urban roads, connect the outside transport conveniently and facilitate the transportation to demand points (Banciu, 2015).

2) Economy

Costs always matter a lot in selecting the site of mobilization logistics center. The costs for site selection mainly consist of two parts; the first one is the construction costs of the center and the second is the fees such as logistics distribution, transportation and inventory custody. Besides the requirements for distribution and delivery speed, the mobilization logistics center should be determined by considering costs, one of the several critical factors. The site should be determined when the total costs are well matched with timeliness (Dutta and Kumar, 2017).

3) Demand

The site of mobilization logistics center should consider both mobilization demand and the national defense military or emergency demands so that it could both satisfy dual demands, i.e., the local civil

demands in peaceful times and military demand in emergency case.

4) Strategy

In order to mobilize the long-term development of mobilization logistics center, the site should be selected from a strategic perspective. The site of mobilization logistics center should be closely related to the local productivity layout and the demand layout of all users' demand points and decided by considering the general layout and details. According to the requirements above, the mobilization logistics center should be determined strategically and a long-term development planning should be prepared (Mohamed et al., 2017).

3.2 Influence factors of site selection of mobilization logistics center

1) Safety

In light that mobilization logistics center provides service to troops so as to strongly guarantee materials supply, if war breaks out, safety becomes the top priority when determining its site. If the center is within the effective range protected by the existing defense system of Chinese troop, it can receive timely rescue within the shortest time even if it is attacked, minimizing the possibility of being attacked by enemies.

2) Timeliness

War or emergency means a battle against time; one can win the initiative if winning time in a war; winning time means saving more lives in a disaster or emergency circumstance. Therefore, the time spent from the mobilization logistics center to all demand points is of great importance and war or emergency can be better responded if logistics can be ensured. Special attention should be paid to timeliness, when determining the site of mobilization logistics center (Mohamed et al., 2017).

3) Infrastructure

The mobilization logistics center should have convenient traffic conditions, be closed to main transport roads or the roads to a majority of demand points can bear different means of transportation; for instance, the center can be established along highway transport hub, port and wharf, railway transport hub or airport terminal; distribution by several means of transportation is preferred.

The public facilities should be always under good conditions. The surroundings of the mobilization logistics center should have complete transportation facilities, communication facilities and sufficient water, electricity, gas and heat supply

capacity; sewage and solid wastes can be treated near the center. All the above should ensure the safety of logistics, demands such as fire safety and life necessities and the quality of materials saved.

4) Economy

Although not economy but timeliness and safety of distribution or warehousing is stressed for the mobilization logistics center, it does not mean site selection does not consider economy at all. When selecting address, a meticulous logistics mobilization preparation plan should be prepared by targeting at certain points and efforts should be made to improve performance ratio while reducing costs; acquire a better result, improve error-tolerant rate and finishing tasks with minimized costs.

5) Technical effect

The mobilization logistics center must be provided with complete functions, such as comprehensive transportation service facilities and specialized delivery equipment; what is more, its functions must be reliable and can provide bulk service or specialized niche service; last but not the least, it should own multimodal transport coordination capacity and good convenience and accessibility.

6) Other factors

Besides considering the main factors above, the site selection of mobilization logistics center should consider other factors: climate, environmental protection and humanistic factors (Xun et al., 2015).

3.3 Establishing index evaluation system for site selection of mobilization logistics center

Eight influence indexes are summarized by considering the aforesaid site selection principle of

Table 2. Evaluation Matrix of All Alternative Sites

Alternative address	Safety	Timeliness	Infrastructure	Economy	Technical effect	Climate	Environmental protection	Humanistic factor
A	74	85	82	70	90	60	70	68
B	78	69	70	88	80	71	66	70
C	82	70	75	80	77	70	61	69
D	70	76	80	75	79	65	68	70
E	76	70	85	77	87	67	60	66

The characteristic value, variance contribution rate and accumulating contribution rate of all influence factors as calculated by PCA using SPSS statistical analysis software are shown in Table 3. It can be concluded from Table 3 that the accumulating contribution rate of characteristic root of the 1st and 2nd influence factors is 87.033%,

mobilization logistics center and factors affecting site selection and by considering the actual site selection; the index evaluation system for site selection of mobilization logistics center is shown in Table 1.

Table 1. Index Evaluation System for Site Selection of Mobilization Logistics Center

Evaluation Indexes	Influence Indexes
Site selection for mobilization logistics center	Safety
	Timeliness
	Infrastructure
	Economy
	Technical effect
	Climate
	Environmental protection
	Humanistic factor

4 ANALYSIS OF EXAMPLES

By taking Chongqing Municipality as an example, five different local logistics centers are selected: A, B, C, D and E. There are many restrictions that must be taken into consideration for site selection of mobilization logistics center. Eight factors, i.e., safety, timeliness, infrastructure, economy, technical effect, climate, environmental protection and humanistic environment, are selected by considering the principle for site selection of mobilization logistics center analyzed above and all influence factors and based on the actual demands, as the evaluation indexes for site selection. The evaluation matrix of five alternative local logistics center is shown in the Table 2 below by considering the realities and expert scoring:

exceeding 85%; it means that the two influence factors can basically express the information reflected by other influence factors when selecting the site of mobilization logistics center; therefore, the safety and efficient, the two influence factors, can be made as the 1st and 2nd principal component considered for site selection. These two factors will

be taken as the index for site selection evaluation again, before all schemes are evaluated.

The eigenvectors corresponding to the characteristic values of the two influence factors are:

$$e_1 = \begin{pmatrix} -0.144, .0185, 0.165, -0.192, \\ 0.165, 0.205, 0.113, -0.085 \end{pmatrix}^T$$

$$e_2 = \begin{pmatrix} -0.175, 0.163, -0.240, 0.039, \\ -0.168, -0.061, 0.375, 0.418 \end{pmatrix}^T$$

Therefore,

$$F_1 = -0.144X_1 + 0.185X_2 + 0.165X_3 - 0.192X_4 + 0.165X_5 - 0.205X_6 + 0.113X_7 - 0.085X_8$$

$$F_2 = -0.175X_1 + 0.163X_2 - 0.240X_3 + 0.039X_4 - 0.168X_5 - 0.061X_6 + 0.375X_7 + 0.418X_8$$

The variance contribution rates of the two principal components are the weight of F_1 and F_2 previously so the calculation formula for the site selection of mobilization logistics center is:

$$F = 0.60021F_1 + 0.27012F_2$$

See Table 4 for the PCA result:

It can be concluded from the ordering result of the table above that the mobilization logistics center in Scheme A is the best, followed by Scheme D, B, C and E.

Table 3. Characteristic Value, Variance Contribution Rate and Accumulating Contribution Rate of All Influence Factors

Principal components	Characteristic value	Variance contribution rate (%)	Accumulating contribution rate (%)
1	4.802	60.021	60.021
2	2.161	27.012	87.033
3	0.630	7.869	94.902
4	0.408	5.098	100.000
5	4.092E-16	5.114E-15	100.000
6	3.195E-16	3.993E-15	100.000
7	1.782E-17	2.228E-16	100.000
8	-1.675E-16	-2.094E-15	100.000

Table 4.

Comprehensive Evaluation Value of All Alternative Schemes

Scheme	F1	F2	F	Ordering result
A	9.728	19.925	11.226	1
B	3.726	4.490	8.214	3
C	2.480	5.080	3.084	5
D	2.480	5.797	8.277	2
E	1.766	3.291	5.056	4

5 CONCLUSION

The site selection of mobilization logistics center is of great importance and therefore needs analysis and demonstration with a scientific method. Principal component analysis (PCA) can shorten the quantity of influence factors, workload and the complexity for site selection evaluation, eliminate the influence among influence factors, and provide reliable basis for removing such kinds of problems. In course of site selection evaluation, calculation can be made by taking advantage of SPSS software to reduce the original complex calculation process and calculated amount.

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