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Research on Logistics Mode Selection of High-tech Enterprise Based on Cloud Theory

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Abstract: In order to solve the question about logistics mode selection of high-tech enterprises, according to the cloud theory, a cloud model for logistics mode selection is constructed by integrated using of cloud barycenter evaluation and analytic hierarchy process method. The logistics mode selection is realized by calculating the weighted deviation degree and utilizing the qualitative evaluating cloud generator. The instance of logistics mode selection of Sipping City Steering Gear Co. Ltd., is given to prove that the method is simple and easy to operate and it can offer reference for similar evaluation with the purpose of providing solutions for the high-tech enterprises logistics running smoothly.

Key words: Cloud theory, cloud barycenter evaluation method, analytic hierarchy process, logistics mode selection

INTRODUCTION

High-tech enterprise is the main force of the knowledge economy development and is more important force promoting the rapid development of economic globalization. When all the focuses are on capital financing and technology innovation of high-tech enterprise, logistics has increasingly become the bottleneck of restricting its further development. In order to accelerate the commercialization and the industrialization of high-tech products, high-tech enterprises must choose effective logistics mode, fully grasp the specific operational condition of the enterprise logistics, improve logistics efficiency, reduce logistics cost, improve management, promote the transformation of high and new technology into productivity. However, due to the selection and evaluation of logistics mode have such characters as diversity, multi-objective, hierarchy, fuzziness and complexity, which have become a key problem urgently to be solved in high-tech enterprises.

At present, the studies of the logistics mode are mainly concentrated in the perspective of supply chain and industrial cluster synergy (Tian and Yang, 2009). Barnes *et al.* (2000) elaborated systematically the application of Supply Hub distribution center mode to reduce logistics costs and improve service responsiveness. Chuah and Yingling (2005) put forward an integration logistics mode and established the corresponding mathematical model to optimize enterprise best inventory. Chen and Ma (2006) illustrated the effectiveness of the logistics integration by case analysis which is about how FENDER international company and UPS global logistics company implement integrated logistics. Ma and Wang (2012) proposed a fourth order synchronous logistics mode with supplier, supply-hub, manufacturer and retailer on the basis of Supply Hub and emphasized that enterprise could achieve win-win purpose through mutual consultation and cooperation. Fan (2012) put forward the main consideration factors of selecting the enterprise logistics mode on the basis of analyzing the advantages and disadvantages of third party logistics. According to the view that an alliance structure exists between market and enterprise trading pattern which was put forward by Williamson who is a Nobel prize-winning economist. Yao and Dai (2012) designed an integrated new logistics mode which is composed of three kinds of industrial cluster that includes market trading platform organization, enterprise organization and league organization and expounded the selection method based on the transaction features in details. Logistics mode of industrial clusters was introduced systematically and AHP method was used to solve the problem of selecting logistics mode (Dong *et al.*, 2011). Wang (2012) put forward a method which synthesizes grey evaluation and AHP to select logistics mode. Hu and Wang (2011) put forward a method synthesizes activity-based costing and ABC classification to solve the problem of selecting logistics mode of small and medium-sized enterprises. Ho *et al.* (2010) concluded the influence factors of affecting the logistics mode selection and summarizes the DEA, AHP, ANP, LP methods and integration of these methods.

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Zhao and Luo (2013) put forward a logistics mode selection method that based on fuzzy multi-objective programming by reason of the logistics mode selection target is diverse and fuzzy. Besides, successful cases include Apple, Dell and IBM, these enterprises set IT Supply Hub logistics mode through making cooperation with the third party logistics. There are also some enterprises like Haier, Anhui tobacco and Dong Feng-Citroen automobile, they optimized and integrated the supply chain logistics network by using proprietary mode (Yu and Chen, 2011). As a key link in supply chain or industrial cluster, the high-tech enterprises should flexibly select a feasible logistics mode based on their own product batch size, species number (Li, 2013) and the specific requirements of the logistics, etc.

This study takes advantage of the cloud theory in uncertain conversion, uses the AHP method to determine index weight and puts cloud barycenter deviation in cloud generator which can make quantitative data into the qualitative concept easy to understand. That not only considers both the impact of human factors and other factors but also makes the conversion between qualitative concept and quantitative expression. At the same time, the assessment results are the language evaluation values. So, it is concise and comprehensive, easy to understand. It can provide a new solution to select logistics mode for high-tech enterprises.

CLOUD THEORY

Li (2000) proposed the cloud theory based on probability statistics and traditional fuzzy theory. This theory can make fuzziness and randomness of qualitative concept in the national language organically integrated together, thus it can implement the conversion between qualitative language values and quantitative numerical values. The cloud is an uncertainty transformation model with language value which indicates between a qualitative concept and quantitative expression. Digital characteristics of cloud can be expressed by expectation E_x, entropy E_n and hyper entropy H_e on the basis of normal distribution function and Gaussian membership function. Normal cloud model of $E_x = 0$, $E_n = 1$, $H_e = 0.02$ is shown in Fig. 1.

These features reflect the quantitative characteristics of qualitative knowledge. Among them, E_x is the barycenter position of the cloud, it means an expectation of a fuzzy conception. Entropy E_n is a measure of the conceptual ambiguity, which stands for the measurable granularity of a qualitative concept. That is to say, entropy E_n reflects the uncertainty of a qualitative concept and represents the value range size of domain space which is accepted by the qualitative concept. Hyper entropy H_e is the measurement of the thickness of cloud, the maximum of the thickness of cloud. It not only reflects the discrete degree of cloud but also measures the uncertainty of entropy E_n. Hyper entropy H_e reflects randomness of samples which represent qualitative concept and reveals the association between the fuzziness and the randomness (Yang *et al*., 2011).

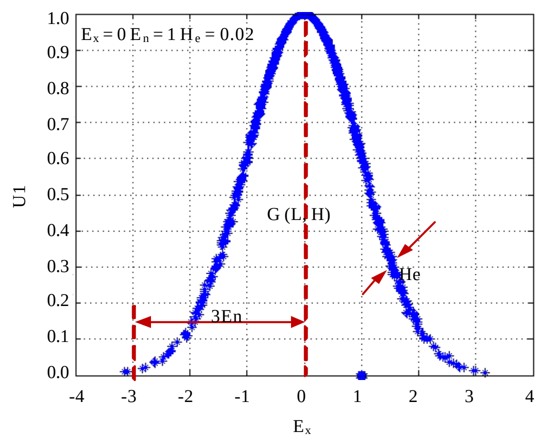

Fig. 1: Normal cloud model diagram

CONSTRUCTION OF CLOUD MODEL FOR LOGISTICS MODE SELECTION

It can overcome the incompleteness of the traditional fuzzy theory to use the cloud theory to select the logistics mode. Because of using multidimensional comprehensive cloud model, the cloud theory can evaluate the multiple factors of objects in a period time. The results are more reasonable as well as representative.

According to the cloud barycenter model that developed from the cloud theory, the cloud model for logistics mode selection of high-tech enterprise can be expressed as:

$$G = L \times H$$

Among them, the cloud barycenter position can be expressed as:

$$L = \{E_{x1}, E_{x2}, \ldots, E_{xn}\}$$

which is an n-dimensional vector and represents the expectations of each evaluation indexes of logistics mode. The height of cloud barycenter can be expressed as:

$$H = \{w_1, w_2, \ldots, w_n\}$$

which reflects the corresponding index weights of each evaluation indexes of logistics mode. The cloud barycenter G represents the comprehensive expectations of selecting different logistics mode. It will lead the cloud barycenter to have a change on account of differentiation of expert evaluation and variation of each index weight, so a better evaluation results can be gotten by comparing them with ideal comprehensive expectations of cloud model (Wang *et al*., 2012). The specific process of construction the cloud model of logistics mode selection is as follows.

Determine the cloud model of evaluation index system: It is important to determine the evaluation index system and status value of each index. After that, the expert should score each index according to the actual situation. A sample decision matrix of n sets is extracted, n quantitative numeric indexes can be represented with a cloud model. Expectations and entropy of the model, respectively are:

$$E_x = (E_{x1}+E_{x2}+...+E_{xn})/n \tag{1}$$

$$E_n = \frac{\max(E_{x1}+E_{x2}+\cdots+E_{xn})-\min(E_{x1}+E_{x2}+\cdots+E_{xn})}{6} \tag{2}$$

When there is a language value indicators appeared, a cloud model can also be used. An index which indicated by n language value can be represented with one-dimensional comprehensive cloud. Expectations and entropy of the model, respectively are:

$$E_x = \frac{E_{x1}E_{n1}+E_{x2}E_{n2}+...+E_{xn}E_{nn}}{E_{n1}+E_{n2}+...+E_{nn}} \tag{3}$$

$$E_n = E_{n1}+E_{n2}+...+E_{nn} \tag{4}$$

Then the decision matrix is established by extracting the corresponding evaluation index sample according to the actual situation, the index which exist bilateral constraint $[D_{min}, D_{max}]$ can be expressed by a cloud model (Li *et al*., 2012). There into:

$$E_{xi} = (D_{min}+D_{max})/2 \tag{5}$$

$$E_{ni} = (D_{max}-D_{min})/6 \tag{6}$$

Determination of evaluation index weight: There are many ways to determine the evaluation index weight such as interval estimation method, expert scoring method, Delphi method and AHP method, etc. The characteristics are different from each other. AHP method can break down the index factors of the problem according to the nature of the problem and the goal and then form a hierarchy model according to the relationship between each index factor, finally obtain the important index weights, so AHP method is used to determine each evaluation index weight.

Calculate the weighted deviation: In the ideal state, let the expectations of evaluation indexes:

$$L^0 = (E^0_{x1}, E^0_{x2}, ..., E^0_{xn})$$

the height of cloud barycenter:

$$H^0 = (w_1, w_2, ..., w_n)$$

then the comprehensive cloud barycenter vector is:

$$G^0 = L^0 \times H^0 = (E^0_{xi} \times w_i)$$

Similarly, an n-dimensional vector of comprehensive cloud barycenter can be gotten in a state which is $G = L \times H = (E_{xi} \times w_i)$. $G' = \{G'_1, G'_2, ..., G', ... G'_n\}$ can be obtained by the normalization. There into:

$$G'_i = \begin{cases} (G^0_i - G_i)/G^0_i & G_i < G^0_i \\ (G_i - G^0_i)/G_i & G_i \geq G^0_i \end{cases} \quad i = 1, 2, ..., n \tag{7}$$

Thus, the weighted deviation θ can be used to measure the difference of cloud barycenter between ideal state and actual state. The value of θ can be gotten by adding the normalized index vector value that multiplied by their weights. That is:

$$\theta = \sum_{i=1}^{n} (G'_i \times w_i) \tag{8}$$

Analysis of evaluation results: Use an evaluation set which include eleven evaluation: $V = (v_1, v_2, ..., v_n)$ = (none, worst, much worse, worse, bad, general, good, better, much better, best, excellent). If the ideal state of the logistics mode is regarded as excellent, the smaller the value of the weighted deviation θ is, the closer distance between the current situation and the ideal situation can be, otherwise the difference between the current situation and the ideal situation is more obvious. A cloud generator for qualitative evaluation is constituted by using the cloud model to implement each evaluation value of evaluation set on continuous language value scale that given before. As shown in Fig. 2, the horizontal axis stands for the evaluation quantitative range of weighted deviation θ after

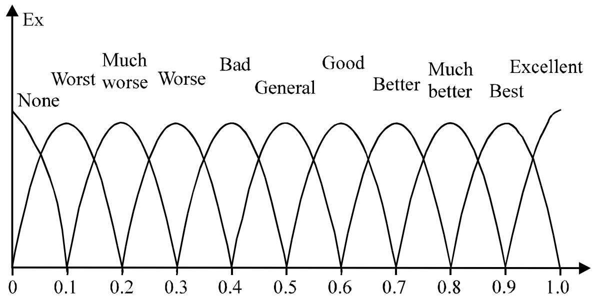

Fig. 2: Qualitative evaluating cloud generators

dimension, the vertical axis is cloud barycenter position, the wave stands for the highest degree of evaluation membership, then decreasing to zero gradually (Feng *et al*., 2011; Lu *et al*., 2013).

LOGISTICS MODE SELECTION EVALUATION INSTANCE ANALYSIS

According to the cloud model for the selection of logistics mode, an instance of a high-tech enterprise of Sipping City Steering Gear Co. Ltd. (SCSG) is analyzed. SCSG established in February 1998 is a automobile professional factory and provide automobile parts for more than 30 domestic car manufacturers such as the First Automobile Group, Dandong yellow bus factory, Nanjing automobile factory, Qingdao automobile factory, Shenyang automobile factory and etc. According to the specific condition of SCSG enterprise logistics operation, the application example of using the cloud theory and cloud barycenter evaluation method to select the logistics mode for SCSG enterprise is given. The specific steps are as follows.

Determination of evaluation index system: The most important three factors mainly considered in logistics mode of SCSG enterprise are cost, service and the ability. It is vital to apply all kinds of ways and measures on the basis of meeting the demand of logistics in cost factor, mainly includes the transportation and distribution cost, storage cost and management cost. Service factor refers to the response time of enterprise completing the basic logistics activities such as transportation, warehousing, distribution, circulation processing, loading and unloading handling. It is also stands for the accuracy and service attitude. Capacity factor concludes the logistics elements ability, the logistics capability and the logistics controlling ability which can be influenced by some important factors of enterprises such as enterprise logistics specific circumstances, the number and advanced degree of enterprise logistics facilities, enterprise capital, capital turnover rate and etc. Indicators included in SCSG enterprise logistics operation process are shown in Fig. 3.

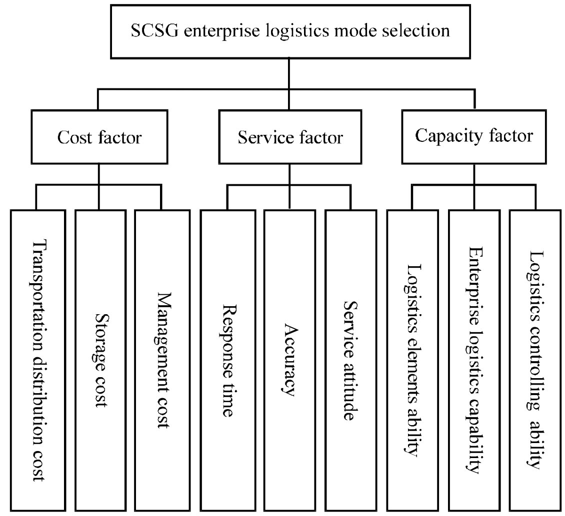

Fig. 3: Evaluation index system

Table 1: Evaluation index status of SCSG enterprise logistics mode selection factors

Status	Language value	Quantitative range
1	Much worse	0, 0.2
2	Bad	0.2, 0.4
3	General	0.4, 0.6
4	Good	0.6, 0.8
5	Much better	0.8, 1.0
Perfect state	Excellent	1.0

Extraction of status value of every index: Index status values can be extracted from expert evaluation, at the same time, it should have sample size in order to guarantee the accuracy of the evaluation results.

Therefore, SCSG enterprises choose five experts to evaluate the factors of logistics mode selection, draw various states and then extract five typical states which are shown in Table 1 from these different index status values.

Determination of expectation and entropy of each index cloud model: Transforming the qualitative index into the quantitative index according to the standard of evaluation index status table of SCSG enterprise logistics mode selection factors. At the same time, expectation and entropy of each index cloud model can be obtained according to the index cloud Eq. 1-6. The specific index values of three logistics mode are shown in Table 2.

Table 2: Expectation and entropy of three logistics mode's index cloud model

	Self-run logistics mode		Joint logistics mode		Third party logistics mode	
Factors	E_x	E_n	E_x	E_n	E_x	E_n
Cost factor						
Transportation distribution cost	0.54	0.033	0.5	0.067	0.46	0.067
Storage cost	0.58	0.033	0.54	0.033	0.38	0.033
Management cost	0.38	0.1	0.58	0.1	0.7	0.067
Service factor						
Response time	0.38	0.067	0.5	0.067	0.7	0.067
Accuracy	0.58	0.033	0.62	0.033	0.74	0.033
Service attitude	0.54	0.033	0.58	0.033	0.7	0.067
Capacity factor						
Logistics elements ability	0.42	0.033	0.62	0.033	0.7	0.067
Enterprise logistics capability	0.38	0.033	0.58	0.033	0.7	0.067
Logistics controlling ability	0.42	0.067	0.66	0.067	0.78	0.033

Table 3: Evaluation results of three types logistics modes

Parameters	Self-run logistics mode	Joint logistics mode	Third party logistics mode
Assessed value	0.514	0.548	0.609
Level	Between general and good, tend to be good.	Between general and good, more tend to be good	Between good and better, tend to be better

Determination of evaluation index weight: AHP method is used to determine the index weight. Through the establishment of judgment matrix of each index, with yaahp software root method for solving eigenvalue, the index weight vector verified by randomness and consistency can be obtained:

$$W_i = 0.464, 0.210, 0.057, 0.015, 0.059, 0.007, 0.019, 0.043, 0.127$$

Calculate the weighted deviation: According to the cloud barycenter G = L×H, because of ideal cloud height is 1, the comprehensive cloud barycenter vector of evaluation index of SCSG enterprise logistics mode under ideal situation is as follows:

$$G^0 = L^0 \times H^0 = 0.464, 0.210, 0.057, 0.015, 0.059, 0.007, 0.019, 0.043, 0.127$$

The comprehensive cloud barycenter vector of self-run logistics mode under real condition is as follows:

$$G^1 = 0.251, 0.122, 0.022, 0.006, 0.034, 0.004, 0.008, 0.016, 0.053$$

Similarly, the comprehensive cloud barycenter vector of joint logistics mode under real condition is as follows:

$$G^2 = 0.232, 0.113, 0.033, 0.008, 0.037, 0.004, 0.012, 0.025, 0.084$$

The comprehensive cloud barycenter vector of the third party logistics mode under real condition is as follows:

$$G^3 = 0.213, 0.080, 0.040, 0.011, 0.044, 0.005, 0.013, 0.030, 0.099$$

Three comprehensive cloud barycenter vectors are normalized according to the Eq. 7-8. Thus, the weighted deviation θ can be used to measure the differences of comprehensive cloud barycenter between ideal state and real state. The weighted deviation of self-run logistics mode is θ_1 = 0.486. The weighted deviation of joint logistics mode is θ_1 = 0.452. The weighted deviation of the third party logistics mode is θ_3 = 0.391.

Analysis of evaluation results: It is known that final evaluation results were 0.514, 0.548 and 0.609 according to the state position $1-\theta_1$, $1-\theta_2$, $1-\theta_3$ after calculating the weighted deviation θ_1, θ_2, θ_3. According to the evaluation of qualitative evaluation cloud generator, the results of three types of logistics models are shown in Table 3.

Therefore, SCSG enterprise should select the third party logistics mode on the existing situation. And the result is consistent with the actual situation.

CONCLUSION

It is a complex process that selecting the logistics mode for the high-tech enterprise, because it should make subjective information and objective information integrated. Logistics mode selection evaluation method based on cloud theory combines the subjective and objective factors in a better way.

The method, which makes the AHP method combine with cloud barycenter evaluation method, can highly integrate the fuzzy language comments value with accurate data, constitute a mutual mapping between qualitative and q uantity. And the evaluation results are language evaluation value that has very well intuition and clarity. Practice indicates that it is feasible to apply the cloud model in enterprise logistics mode selection.

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