Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 13 (24): 5729-5733, 2013
ISSN 1812-5654 / DOI: 10.3923/jas.2013.5729.5733

Study on Logistics Capability of Manufacturing Enterprise via AHP and Fuzzy Evaluation

[1]Xianming Liu, [2]Shujie Yun, [1]Xiaorong Huang, [1]Jingyuan Xing and [1]Yazhou Xiong
[1]School of Economics and Management, Hubei Polytechnic University, Huangshi, 435003, China
[2]Department of Basic, Henan Mechanical and Electrical Engineering College, Xinxiang, 453000, China

Abstract: Logistics is called as a source of the third profit and it is also one of the most important and difficult factors in the successful implementation of the supply chain. The logistics capability is summarized as a comprehensive logistics ability, including the logistics cost controlling, logistics service, logistics elements and logistics organization and management. After analyzing the fundamental connotation of logistics capability, this study establishes an evaluation system of logistics capability from the above four aspects. The model of AHP and fuzzy evaluation are comprehensively used to assess the logistics capability of manufacturing enterprise. And a case of manufacturing enterprise in 2011 is analyzed to prove that the method is valid.

Key words: Logistics capability, analytic hierarchy process (AHP), fuzzy evaluation

INTRODUCTION

Regarded as the third profit source, logistics is playing an extremely important role in the process of the modern industrial production. At present it becomes more and more difficult that the enterprises only rely on the ability to create ways to obtain the sustainable competitive advantage. Therefore, the enterprises begin to turn their attention to the logistics field, which is called "the third profit source" of the enterprises.

In the past decades, a lot of research on the logistics capability had been made by many experts and scholars at home and abroad. Shang *et al*. (2009) summarized the logistics capability from four aspects and evaluated the logistics capability of a case based on the fuzzy evaluation method. Logistics capability should include processing ability and the value-added capacity and the relationship between them was analyzed (Kumar, 2008). Morash *et al*. (1996) made a study on strategic logistics capabilities for competitive advantage and firm success. Huang (2008) put forward some problem-solving measures to improve the logistics capability. Daugherty and Pittman (1995) studied the logistics capability from the speed of product distribution, information exchange and flexibility. Daugherty *et al*. (1998) thought that logistics capability should been studied from five performance measures, including the response speed of the customer, the level of customer service, delivery on time, stability of the quality and advance notice of delay or shortage.

Generally speaking, a lot of experts and scholars performed some empirical studies on logistics capabilities via some evaluation methods, including the Analytic Hierarchy Process (AHP), fuzzy evaluation, Principal Component Analysis (PCA) and entropy theory and so on (Shi *et al*., 2009; Yu *et al*., 2010). At the same time, every evaluation method has its advantages and disadvantages. Using the model of AHP and fuzzy evaluation, the study establishes logistics capability evaluation system from four aspects and tests it via a case study in the manufacturing enterprise.

TO CONSTRUCT THE EVALUATION SYSTEM OF LOGISTICS CAPABILITY

Different industries have different priorities about the evaluation indicator of logistics capability. Based on the results of previous research, according to the comparison and summary, this study intends to establish a more scientific indicator system from the following five aspects and every aspect can be divided into different components.

Ability to control the logistics cost:

- **Supply logistics cost:** It mainly refers to forecast cost of logistics, projected cost of logistics and preparation cost of logistics
- **Production logistics cost:** It mainly refers to a variety of productive logistics cost, including loading and unloading, transportation, processing, storage and transportation, etc
- **Sales logistics cost:** It mainly refers to the sales service cost of the logistics, including the storage, packaging, service fees, etc

Corresponding Author: Yazhou Xiong, School of Economics and management, Hubei Polytechnic University, Huangshi, 435003, China

- **Return logistics cost:** It mainly refers to the logistics cost for the return and exchange
- **Abandoned logistics cost:** It mainly refers to the logistics cost produced by waste, substandard products

Ability of logistics service:

- **Time efficiency elements:** It mainly refers to order processing speed, delivery accuracy and flexibility
- **Information elements:** It mainly refers to informatization level, complete information and visibility
- **Customer element:** It mainly refers to the goods availability, complaint handling, personalized response

Ability of logistics elements:

- **Logistics equipment:** It mainly refers to the machinery and equipment needed for various logistics activities and logistics operations
- **Logistics facilities area:** It mainly refers to the facilities area needed for various logistics activities and logistics operations
- **Logistics capital:** It mainly refers to the capital needed for various logistics activities and logistics operations

Ability of logistics organization and management:

- **Management ability:** It mainly refers to the management ability of logistics administrators
- **Operation ability:** It mainly refers to the operation ability of logistics activity operators
- **Technical level:** It mainly refers to the technical level of logistics technical personnel

Considering the principles of purpose, scientific, adaptability, comparability and overall system about indicators, an evaluation indicator system of logistics capabilities that contains 4 first-level indicators, 14 second-level indicators is established (Table 1).

TO DETERMINE THE MODEL INDICATORS VIA AHP

The Analytic Hierarchy Process (AHP) is a functional decision process proposed and gradually improved by the American mathematician Saaty T. L. in the 1970's (Saaty, 1990). It is appropriate to use the AHP method to determine weights among the second-level indicators and weighted calculation. Finally, this study uses the AHP method to establish a model, whose main steps are as follows (Duan *et al*., 2011).

To construct the judgment matrices of each level: After the model of AHP is established, the judgment matrices of each level will be easily constructed. According to the questionnaires survey and expert opinion, the relative important each other will be easily expressed. Then the data matrixes that represent respectively the judgment matrices of the second-level indicators will be constructed (Chen and Li, 2011).

To perform hierarchical single sorting and consistency check: As some program can be written simply and run in the Matlab software, the hierarchical single sorting and the consistency check can be easily solved. And the equation of the consistency check is as follows:

$$CI = \frac{(\lambda_{max} - n)}{(n-1)} \quad (1)$$

$$CR = \frac{CI}{RI} \quad (2)$$

Where:
λ_{max} = The maximum eigenvalue
n = The rank of judgment matrix

Table 1: Evaluation indicator system of logistics capabilities

First-level indicators	No.	Second-level indicators	No.	Relative weights
Ability to control the logistics cost	U_1	Supply logistics cost	u_{11}	w_{11}
		Production logistics cost	u_{12}	w_{12}
		Sales logistics cost	u_{13}	w_{13}
		Return logistics cost	u_{14}	w_{14}
		Abandoned logistics cost	u_{15}	w_{15}
Ability of logistics service	U_2	Time efficiency elements	u_{21}	w_{21}
		Information elements	u_{22}	w_{22}
		Customer element	u_{23}	w_{23}
Ability of logistics elements	U_3	Logistics equipment	u_{31}	w_{31}
		Logistics facilities area	u_{32}	w_{32}
		Logistics capital	u_{33}	w_{33}
Ability of logistics organization and management	U_4	Management ability	u_{41}	w_{41}
		Operation ability	u_{42}	w_{42}
		Technical level	u_{43}	w_{43}

CI = Consistency of judgment matrix deviation
CR = Random consistence rate
RI = The average random consistency of different rank judgment matrix

To adjust the judgment matrix and hierarchical ranking model: After the calculation of the judgment matrix via the Matlab software, CI and CR will be easily obtained. If necessary, the judgment matrix and hierarchical ranking model may be corrected and adjusted. If CR is less than 0.1, the results of hierarchical sorting will satisfy the requirement for consistency, otherwise the judgment matrix will need to be adjusted.

TO ESTABLLISH EVALUATION SYSTEM OF LOGISTICS ABILITY VIA FUZZY EVALUATION

To determine the evaluation set: In the model of the fuzzy evaluation, the evaluation set of the logistics capability is C_i (i = 1, 2, 3, 4, 5) that express, respectively five grades, including the higher, high, general, low and lower. And the above five grades are given the assignment V = {95, 85, 75, 65, 30}.

To establish evaluation membership matrix μi:

$$u_i = \begin{pmatrix} u_{11} & u_{12} & \cdots & u_{1n} \\ u_{21} & u_{22} & \cdots & u_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ u_{m1} & u_{m2} & \cdots & u_{mn} \end{pmatrix} \quad (3)$$

Where:
i = No. of the first-level indicators
u_{mm} = The membership degree of No. m responding to No. n
n = No. of evaluation grades in the evaluation set
m = No. of the evaluated factors

To make the fuzzy comprehensive evaluation:

- To make the second-level fuzzy comprehensive evaluation:

$$T_i = w_i \times u_i = \left(w_{i1}, w_{i2}, \ldots, w_{ij}\right) \times \begin{pmatrix} u_{11} & u_{12} & \cdots & u_{1n} \\ u_{21} & u_{22} & \cdots & u_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ u_{m1} & u_{m2} & \cdots & u_{mn} \end{pmatrix} \quad (4)$$

Where:
i = Number of the first-level indicators
wi = Internal weight of the first-level evaluation index U_i (i = 1, 2, 3)
μ_i = Evaluation matrix of level i

- To make the first-level fuzzy comprehensive evaluation:

$$A = w \times T \quad (5)$$

Where:
w = Relative weights among the first-level indicators
T = Membership vector of the factor U corresponding to the evaluation set V
A = Comprehensive evaluation vector

- To determine the grade of comprehensive evaluation:

$$F = A \times d \quad (6)$$

Where:
F = Final evaluation score
d = Rating scores matrix
A = Comprehensive evaluation vector

Case study: In this study, the logistics capability of a manufacturing enterprise in 2011 is evaluated by the models of AHP and fuzzy evaluation.

To determine weights among the second-level indicators via AHP: According to the expert scoring and results of the questionnaires, the hierarchical analysis matrix will be built so as to determine the internal weights of evaluation index level. The maximum eigenvalue of all judgment matrices is as follows and all the results of hierarchical sorting can satisfy the requirement for consistency check:

- **The calculation of the judgment matrix U_1 (Table 2)**

Remarks: λ_{max} = 5.2826, CI = 0.0706, CR = 0.0631<0.10

w_1 = Relative weights of the first-level indicators U_1.

- **The calculation of the judgment matrix U_2 (Table 3)**

Remarks: λ_{max} = 3.0385, CI = 0.0193, CR = 0.0332<0.10

w_2 = Relative weights of the first-level indicators U_2.

- **The calculation of the judgment matrix U_3 (Table 4)**

Remarks: λ_{max} = 3.0383, CI = 0.0091, CR = 0.0158<0.10

w_3 = Relative weights of the first-level indicators U_3.

- **The calculation of the judgment matrix U_4 (Table 5)**

Remarks: λ_{max} = 3.0765, CI = 0.0368, CR = 0.0634<0.10

w_4 = Relative weights of the first-level indicators U_4.

Table 2: Judgment matrix U_1

Ability to control the logistics cost (U_1)	u_{11}	u_{12}	u_{13}	u_{14}	u_{15}	w_1
Supply logistics cost (u_{11})	1	1/3	1/5	3	2	0.1140
Production logistics cost (u_{12})	3	1	1/3	5	7	0.2711
Sales logistics cost (u_{13})	5	3	1	6	8	0.5016
Return logistics cost (u_{14})	1/3	1/5	1/6	1	3	0.0708
Abandoned logistics cost (u_{15})	1/2	1/7	1/8	1/3	1	0.0425

Table 3: Judgment matrix U_2

Ability of logistics service (U_2)	u_{21}	u_{22}	u_{23}	w_2
Time efficiency elements (u_{21})	1	3	5	0.6370
Information elements (u_{22})	1/3	1	3	0.2583
Customer element (u_{23})	1/5	1/3	1	0.1047

Table 4: Judgment matrix U_3

Ability of logistics elements (U_3)	u_{31}	u_{32}	u_{33}	w_3
Logistics equipment (u_{31})	1	2	4	0.5584
Logistics facilities area (u_{32})	1/2	1	3	0.3196
Logistics capital (u_{33})	1/4	1/3	1	0.1220

Table 5: Judgment matrix U_4

Ability of logistics organization and management (U_4)	u_{41}	u_{42}	u_{43}	w_4
Management ability (u_{41})	1	1/3	1/4	0.1172
Operation ability (u_{42})	3	1	1/3	0.2684
Technical level (u_{43})	4	3	1	0.6144

Table 6: Judgment matrix U

Comprehensive logistics ability	U_1	U_2	U_3	U_4	w
Ability to control the logistics cost (U_1)	1	3	4	5	0.5292
Ability of logistics service (U_2)	1/3	1	3	4	0.2682
Ability of logistics elements (U_3)	1/4	1/3	1	3	0.1342
Ability of logistics organization and management (U_4)	1/5	1/4	1/3	1	0.0684

- **The calculation of the judgment matrix U (Table 6)**

Remarks: $\lambda_{max} = 4.1807$, CI = 0.0602, CR = 0.0669<0.10

w = Relative weights among the first-level indicators.

To make the fuzzy comprehensive evaluation of logistics capability: According to questionnaires survey and Eq. 3, the membership of indicators μi (i = 1, 2, 3, 4) will be obtainedwhich is as follows:

$$u_1 = \begin{bmatrix} 0.20 & 0.30 & 0.30 & 0.12 & 0.08 \\ 0.15 & 0.35 & 0.20 & 0.16 & 0.14 \\ 0.30 & 0.20 & 0.36 & 0.08 & 0.06 \\ 0.20 & 0.30 & 0.30 & 0.15 & 0.05 \\ 0.20 & 0.20 & 0.40 & 0.12 & 0.08 \end{bmatrix} \quad u_2 = \begin{bmatrix} 0.30 & 0.20 & 0.30 & 0.10 & 0.10 \\ 0.40 & 0.25 & 0.28 & 0.05 & 0.02 \\ 0.20 & 0.40 & 0.28 & 0.10 & 0.02 \end{bmatrix}$$

$$u_3 = \begin{bmatrix} 0.40 & 0.30 & 0.20 & 0.05 & 0.05 \\ 0.40 & 0.20 & 0.20 & 0.10 & 0.10 \\ 0.20 & 0.30 & 0.30 & 0.10 & 0.10 \end{bmatrix} \quad u_4 = \begin{bmatrix} 0.40 & 0.30 & 0.12 & 0.10 & 0.08 \\ 0.30 & 0.36 & 0.20 & 0.10 & 0.04 \\ 0.30 & 0.30 & 0.26 & 0.07 & 0.07 \end{bmatrix}$$

According to the Eq. 4, fuzzy comprehensive evaluation of subspace dimension can be obtained:

$$T_1 = w_1 \times \mu_1 = (0.2366, 0.2591, 0.3072, 0.1129, 0.0841)$$

Where:

$$w_1 = (0.1140, 0.2711, 0.5016, 0.0708, 0.0425)$$

Similarly:

$$T_2 = w_2 \times \mu_2 = (0.3154, 0.2339, 0.2927, 0.0871, 0.0710)$$

$$T_3 = (0.3756, 0.2680, 0.2122, 0.0721, 0.0721)$$

$$T_4 = (0.3117, 0.3161, 0.2275, 0.0816, 0.0631)$$

According to the Eq. 5, the evaluation values of the first-indicator can be obtained:

$$T = \begin{pmatrix} T_1 \\ T_2 \\ T_3 \\ T_4 \end{pmatrix} = \begin{bmatrix} 0.2366 & 0.2591 & 0.3072 & 0.1129 & 0.0841 \\ 0.3154 & 0.2339 & 0.2927 & 0.0871 & 0.0710 \\ 0.3756 & 0.2680 & 0.2122 & 0.0721 & 0.0721 \\ 0.3117 & 0.3161 & 0.2275 & 0.0816 & 0.0631 \end{bmatrix}$$

$$A = w \times T = (0.5292\ 0.2682\ 0.1342\ 0.0684) \times T = (0.2815\ 0.2574\ 0.2851\ 0.0984\ 0.0775)$$

According to the Eq. 6, value of logistics capabilities of every level can be obtained:

The score of the first-level indicator: $F_1 = T_1 \times (95\ 85\ 75\ 65\ 30)^T = 77.402$ Similarly:

$F_2 = 79.588$
$F_3 = 81.226$
$F_4 = 80.739$

The score of comprehensive evaluation of logistic capability in manufacturing enterprise:

$$F = A \times d = A \times (95\ 85\ 75\ 65\ 30)^T = 78.73$$

The evaluation of calculation results: By the above calculation, all of the final evaluation score is between 85 and 75. So the conclusion can be drawn that the comprehensive evaluation of logistic capability in manufacturing enterprise is at the secondary level and all of the capability of four aspects is in general, which is consistent with the actual situation.

CONCLUSION

In this study, an evaluation system of logistics capabilities is established from four aspects. A model of AHP and fuzzy evaluation is used to analyze the logistics capabilities of manufacturing enterprise. And the result of an empirical analysis proved to be valid.

ACKNOWLEDGMENTS

The study is supported by the outstanding Youth Science and Technology Innovation Team funded projects of Hubei Polytechnic University under Grant No. 13xtr03 and the Laboratory Open Foundation of Hubei Polytechnic University Grant No. 201343.

REFERENCES

Chen, J.L. and X.J. Li, 2011. A study on assessment for bank performance via PCA and AHP. J. Syst. Sci., 19: 74-76.

Daugherty, P.J. and P.H. Pittman, 1995. Utilization of time-based strategies: Creating distribution flexibility/responsiveness. Int. J. Oper. Prod. Manage., 15: 54-60.

Daugherty, P.J., T.P. Stank and A.E. Ellinger, 1998. Leveraging logistics/distribution capabilities: The effect of logistics service on market share. J. Bus. Logist., 19: 35-51.

Duan, C.Q., A.P. Cui, N. Li and J. Liu, 2011. Application of analytic hierarchy process in circular economy evaluation in Tangshan. J. Hebei Univ. Technol., 40: 114-118.

Huang, Y., 2008. Building and promotion of logistics capability of enterprise. J. Guangxi Univ. (Philos. Social Sci.), 30: 35-38.

Kumar, S., 2008. A study of the supermarket industry and its growing logistics capabilities. Int. J. Retail Distrib. Manage., 36: 192-211.

Morash, E.A., C.L.M. Droge and S.K. Vickery, 1996. Strategic logistics capabilities for competitive advantage and firm success. Bus. Logist., 17: 1-22.

Saaty, T.L., 1990. How to make a decision: The analytic hierarchy process. Eur. J. Oper. Res., 48: 9-26.

Shang, L., L.H. Sun, M.Y. Li and X. Li, 2009. The logistics capability evaluation system of manufacturing enterprise. Sci. Technol. Eng., 9: 5933-5936.

Shi, T.T., S. Guo, X.Y. Zhang and X.P. Cui, 2009. Pure water quality evaluation model of language is based on the fuzzy math and entropy weight. Sci. Technol. West China, 8: 38-39.

Yu, J.W., H.P. Qian, W.C. Shi and Y. Zhang, 2010. Optimal selection of plans for expressway asphalt pavement structures based on fuzzy membership function. Technol. Highway Transp., 6: 33-36.