Xionglin Zhang,
Jingjun Pan,
Caiyun Zhang

School of Economics and Management, China Three Gorges University, Yichang, Hubei, China

THIRD PARTY LOGISTICS PROVIDER SERVICE PERFORMANCE EVALUATION BASED ON TRIANGULAR FUZZY TOPSIS

Ксіонглін Жанг,
Джингджун Пен,
Кайуюн Жанг

Школа економіки та управління, Китайський університет „Three gorges", Йічанг, Хубей, Китай

ОЦІНКА ЕФЕКТИВНОСТІ НАДАННЯ ЛОГІСТИЧНИХ ПОСЛУГ, ЗАСНОВАНА НА ТРИКУТНІЙ НЕЧІТКІЙ ТЕХНІЦІ TOPSIS

Purpose. Appeared together with a large number of the companies providing outsourcing and logistic services, the competition between complex logistic providers becomes more and more rigid every day. Facing complexity of coordinating of a line-up of deliveries, it is important to estimate effectiveness of rendering of services by third-party logistic providers.

Methodology. The method of estimation of services effectiveness by the logistic companies moves ahead under the auspices of the triangular fuzzy analysis of TOPSIS and the fuzzy set theory. Third party logistics providers is promoted under the guidance of triangular fuzzy technology for order preference by similarity to an ideal solution (TOPSIS) analysis and fuzzy set theory. Eight evaluation indexes are selected through a review of the researches on Third Party Logistics Provider Service Performance Evaluation.

Findings. The scientific analysis method for the third party logistics providers service performance evaluation has been furnished. It provides a theoretical basis for the management of the decision.

Originality. This study is one of the first studies to propose a triangular fuzzy TOPSIS method to evaluate the third party logistics providers service performance.

Practical value. We establish the analysis method to help third party logistics providers to improve their operating conditions, and find that we should focus on the economic interests and the potential profits, brought by service, to create greater cost for the company and the society.

Keywords: *service performance, triangular fuzzy TOPSIS analysis, fuzzy set theory, third party logistics provider, performance evaluation, index system*

Introduction. With the continuous development of the circulation industry, the demand for logistics services has become increasingly intense. Since enterprises focus on improving the core competitiveness, the third party logistics becomes important for suppliers and demanders. With the development of the market, the differences among logistics companies are reducing, which makes their business functions alike. Hence the business functions can no longer serve as the only factor for customers to choose third party logistics companies. The choice of the logistics providers with strong comprehensive capabilities is becoming particularly important [1].

Soonhu uses triangular fuzzy analytic hierarchy process to evaluate the third party logistics enterprises, and the sensitivity analysis is carried out [2]. Akman defines an approach that integrates fuzzy TOPSIS algorithm with fuzzy AHP to support LSP evaluation and selection decisions [3]. Wallenburg believes that logistics service providers should actively improve the cost and performance to strengthen service innovation management, to provide substantial value to customers and to improve customer's loyalty [4].

However, the customer evaluation alone cannot achieve the satisfied service performance according to the current status of domestic logistics enterprises development. The service system of third party logistics companies has not been effectively established and can't meet all the customers' needs, for example, some logistics enterprises have overlooked the quality and service management improvement and lacked effective service management system to regulate their service management behaviours and service process. Therefore scientific assessment methods should be used to select the appropriate third party logistics company when evaluate their service performance.

Establishment of evaluation index system. In order to evaluate the performance of the third party logistics enterprises effectively, the choice of indicators is particularly important. According to the previous domestic and foreign literature, the research has been focused on quantitative indicators of internal service performance of enterprises. Akman indicated that the evaluation criteria for logistics service provider includes 8 indicators: time delivery, price, product availability, reliability, firm's background, firm's reputation, knowledge sharing, flexibility [3]. Sun indicated that, the supply chain partnership and coordination and management have significant impact on the logistics service performance, but the supply chain information does not, and the supply chain integration also has significant impact on logistics service [5]. The former indexes proposed are not sufficient since the absent of logistics cost and efficiency related indicators.

Considering the complexity of the third party logistics, evaluation indexes must be comprehensively evaluated from multiple perspectives. The comprehensive index proposed by Franceschini and Rafele is adopted in the evaluation of service performance for third party logistics enterprises due to its effective combination of qualitative and quantitative factors illustrated as follows in Table 1.

The factors in the list are not the absolute descriptor about service performance evaluation, but necessary to evaluate the service performance. In certain circumstances the influence factors can be added or reduced. This article uses these factors along with triangular fuzzy TOPSIS analysis to evaluate service performance of third-party logistic companies.

Third party logistics performance evaluation method. Triangular fuzzy TOPSIS is been used to evaluate the performance of the third party logistics. The fuzzy set theory uses accurate ways to solve practical problems with fuzziness. When confronted with complex research problems, the complexity would reduce the accuracy of its description and study. So that the accuracy and conciseness became two mutually exclusive features which need to be balanced. The advantage of fuzzy theory is that concise methods can be used to solve complex problems. Simple terms instead of figures have been used to show the performance of suppliers. For example, simple words like very good, good, bad and very bad have been used. The decision makers provide linguistic rating criteria for service performance and the alternative suppliers and then generate the overall performance score for each candidate using fuzzy TOPSIS analysis. The supplier with the highest score would be recommended for procurement.

A lingual description can transfer into triangular fuzzy number. In this paper the scale 0–1 has been used as the rating criteria. The linguistic variables of the fuzzy ratings for the alternatives have been presented in Table 2 and Table 3 shows the linguistic variables of the fuzzy ratings for the criteria.

Table 1

Logistics Service Performance Evaluation Indexes

C1 delivery date	Time between the customer places an order and signs the order
C2 regularity	Discrete average about delivery time
C3 reliability	Reliability about deliver the goods on time
C4 integrity	Ability about deliver the complete order
C5 flexibility	Ability about delivery date and amount modification
C6 accuracy	To avoid inaccurate delivery
C7 loss rate	To avoid losses
C8 productivity	Production quantity in a certain period

The TOPSIS approaches choose alternatives that were closest to the positive ideal solution and farthest from the negative ideal solution. The positive ideal solutions are composed on the best performance values for each criterion where as the negative ideal solution consists of the worst performance values. The steps of fuzzy TOPSIS analysis are presented as follows.

Step 1: Formulate criteria and ratings.

Assuming there are J possible candidates indicated by $A = \{A_1, A_2, A_3, \dots, A_j\}$, and the evaluated criteria been $C = \{C_1, C_2, C_3, \dots, C_j\}$. The criteria weights are denoted by $w_i = (i = 1, 2, 3, \dots, m)$.

Step 2: Computer aggregates fuzzy ratings for the criteria and the alternatives.

If the fuzzy ratings of all decision makers are described as the triangular fuzzy number $R_k = (a_k, b_k, c_k)$, the aggregate fuzzy ratings are $\widetilde{R} = (A, B, C)$, among which $a = \min\{a_k\}$, $b = \frac{1}{k}\sum_{i=1}^{k} b_k,$, $c = \max\{c_k\}$. If the fuzzy rating of the decision maker are $\widehat{x}_{ijk} = (a_{ijk}, b_{ijk}, c_{ijk})$, the weight of the decision maker is $\widetilde{w}_{ijk} = (w_{jk1}, w_{jk2}, w_{jk3})$, then the aggregated fuzzy ratings of alternatives with respect to each criteria are given by $\widehat{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ and

$$a_{ij} = \min\{a_{ijk}\}; \quad b_{ij} = \frac{1}{k}\sum_{k=1}^{i} b_{ijk}; \quad c_{ij} = \max\{c_{ijk}\}. \quad (1)$$

The aggregated fuzzy weights of each criterion are calculated as

$$w_j = (w_{j1}, w_{j2}, w_{j3}); \quad w_{j1} = \min\{w_{jk1}\}; \quad w_{j2} = \frac{1}{k}\sum_{i=1}^{k} w_{jk2};$$
$$w_{j3} = \max\{c_{jk3}\}. \quad (2)$$

Table 2

Linguistic terms for alternative ratings

Linguistic term	Membership function
Very High (VH)	(0.7;1;1)
High (H)	(0.5;0.7;1)
Low (L)	(0;0.3;0.5)
Very low (VL)	(0;0;0.3)

Table 3

Linguistic terms for criteria ratings

Linguistic term	Membership function
Strong (S)	(0.7;1;1)
Middle (M)	(0.3;0.5;0.7)
Weak (W)	(0;0;0.3)

Step 3: Normalize the fuzzy decision matrix.

The normalized fuzzy decision matrix R is given by

$$\tilde{R} = [\tilde{r}_{ij}]_{m\times n}, \quad i = 1,2,\ldots,m; \quad j = 1,2,\ldots,n; \qquad (3)$$

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right), \quad c_j^* = \max c_{ij}; \qquad (4)$$

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right), \quad a_j^- = \min a_{ij}. \qquad (5)$$

Step 4: Compute the weighted normalized matrix $\tilde{v}$.

$$\tilde{V} = [\tilde{v}_{ij}]_{m\times n}, \quad i = 1,2,\ldots,m; \quad j = 1,2,\ldots,n; \qquad (6)$$

$$\tilde{v}_{ij} = \tilde{r}_{ij} \times \tilde{w}_j. \qquad (7)$$

Step 5: Compute the fuzzy positive ideal solution (FPIS) and fuzzy negative ideal solution (FNIS).

The FPIS and FNIS of the alternatives are computed as follows

$$A^* = (\tilde{V}_1^*, \tilde{V}_2^*, \ldots, \tilde{V}_n^*); \quad \tilde{V}_j^* = \max\{v_{ij3}\}, \qquad (8)$$

which $i = 1, 2, \ldots, m$; $j = 1, 2, \ldots, n$.

$$A^- = (\tilde{V}_1^-, \tilde{V}_2^-, \ldots, \tilde{V}_n^-); \quad \tilde{V}_j^- = \min\{v_{ij1}\}, \qquad (9)$$

which $i = 1, 2, \ldots, m$; $j = 1, 2, \ldots, n$.

Step 6: Compute the distance of each alternative d_v.

$$d_i^* = \sum_{j=1}^{n} d_v(\tilde{v}_{ij,} \tilde{v}_j^*), \quad i = 1,2,\ldots,m; \qquad (10)$$

$$d_i^- = \sum_{j=1}^{n} d_v(\tilde{v}_{ij,} \tilde{v}_j^-), \quad i = 1,2,\ldots,m. \qquad (11)$$

Step 7: Compute and rank the closeness coefficient (CC_i) of each alternative.

$$cc_i = \frac{d_i^-}{d_i^- + d_i^*}, \quad i = 1,2,\ldots,m. \qquad (12)$$

Case study. The fuzzy TOPSIS analysis method is been used to evaluate service performance of third party logistics companies. Firstly, assuming there are three alternatives (suppliers A1, A2, and A3). These alternatives would be evaluated using the environmental performance criteria by a committee of three decision makers (D1, D2, and D3). D1 is more inclined to the delivery time and integrity. D2 is more inclined to integrity. D3 is more inclined to the reliability of the third party's logistics providers. The decision makers used linguistic ratings for alternatives and these criteria are presented in Table 2 and Table 3. The criterion for decision makers is given in Table 4.

1. Then the aggregated fuzzy weights of each criterion are calculated using Eq. (1).

For example, for criteria C1, the aggregated fuzzy weight is given by

$$w_{j1} = \min\{0,0,0\}; \quad w_{j2} = \frac{1}{3}\sum_{i=1}^{3}(1 + 0.3 + 0.3);$$

$$w_{j3} = \max\{1, 0.5, 0.5\}.$$

Hence $w_j = (0,0.53,1)$.

Others can be calculated using the same method. All aggregated fuzzy weights are listed in Table 5.

2. The aggregate fuzzy weights of the alternatives are computed using Eq. (2). For example, the aggregate rating weight for supplier A1 for criteria C1 is computed as follows

$$a_{ij} = \min\{0.7,0.3,0.7\};$$

$$b_{ij} = \frac{1}{3}\sum_{k=1}^{3}(1 + 0.5 + 1);$$

$$c_{ij} = \max\{1,0.7,1\}.$$

Hence $\tilde{x}_{ij} = (0.3,0.83,1)$.

Likewise, the aggregate ratings for all the three alternatives (A1, A2 and A3) with respect to the eight criteria can be computed. The aggregate fuzzy decision matrix for the alternatives is presented in Table 6 and Table 7.

3. The fuzzy decision matrix is calculated using Eq. (3) to Eq. (6). For example, the normalized rating for alternative A1 for criteria C1 is given by

$$c_j^* = \max(1,1,1) = 1; \quad a_j^- = \min(0.3,0.3,0) = 0.$$

Table 4

Linguistic assessments for the 6 criteria

Criteria	Decision makers		
	D1	D2	D3
C1	VH	L	L
C2	H	H	H
C3	H	H	VH
C4	VH	VH	H
C5	VL	L	L
C6	L	L	L
C7	L	VL	VL
C8	L	L	L

Table 5

Aggregate fuzzy weight for the decision makers

Criteria	Decision makers			Aggregate fuzzy weight
	D1	D2	D3	
C1	VH	L	L	(0,0.53,1)
C2	H	H	H	(0.5,0.7,1)
C3	H	H	VH	(0.5,0.8,1)
C4	VH	VH	H	(0.5,0.9,1)
C5	VL	L	L	(0,0.2,0.5)
C6	L	L	L	(0,0.3,0.5)
C7	L	VL	VL	(0,0.1,0.5)
C8	L	L	L	(0,0.1,0.5)

Table 6

Linguistic assessments for the three alternatives

Criteria	Alternatives								
	A1			A2			A3		
	D1	D2	D3	D1	D2	D3	D1	D2	D3
C1	S	M	S	M	M	S	V	M	S
C2	M	V	S	V	S	M	M	S	M
C3	V	V	M	S	V	V	M	M	V
C4	V	S	V	S	V	M	S	V	S
C5	V	S	M	M	S	S	V	S	V
C6	M	B	M	V	M	S	M	S	V
C7	S	M	V	V	M	V	S	M	M
C8	S	V	M	V	V	M	V	V	M

Table 7

Aggregate fuzzy decision matrix for alternatives

Criteria	Alternatives		
	A1	A2	A3
C1	(0.3,0.83,1)	(0.3,0.67,0.1)	(0,0.5,1)
C2	(0,0.5,1)	(0,0.5,1)	(0.3,0.67,0.1)
C3	(0,0.17,0.7)	(0,0.33,0.1)	(0,0.33,0.7)
C4	(0,0.33,0.1)	(0,0.5,0.1)	(0,0.67,1)
C5	(0,0.5,1)	(0.3,0.83,1)	(0,0.33,0.1)
C6	(0,0.33,0.7)	(0,0.5,1)	(0,0.5,1)
C7	(0,0.5,1)	(0,0.17,0.7)	(0.3,0.67,0.1)
C8	(0,0.5,1)	(0,0.17,0.7)	(0,0.17,0.7)

Considering the maximum of benefits, the positive ideal value would be chosen. The positive ideal value is 1 and the negative ideal is 0.

Hence $\tilde{r}_{ij} = \left(\frac{0.3}{1}, \frac{0.83}{1}, \frac{1}{1}\right) = (0.3, 0.83, 1).$

Likewise, the normalized values of all the alternatives for the criteria have been computed in Table 8.

4. The fuzzy weighted decision matrix for the four alternatives is constructed using Eq. (7). The $\tilde{r}_{ij}$ values from Table 8 and w_j values from Table 5 are used to compute the fuzzy weighted decision matrix for the alternatives. Then, the fuzzy positive ideal solutions and the fuzzy negative ideal solutions are computed using Eq. (8) and Eq. (9) for the four alternatives. For example, for criteria C1

$$\tilde{v}_{ij} = (0.3, 0.83, 1) \times (0, 0.53, 1) = (0, 0.4399, 1);$$

$$A^* = (1,\ 1,\ 1,),\quad A^- = (0,\ 0,\ 0).$$

The others are listed in Table 9.

5. Compute the distance d_v of each alternative from the fuzzy positive ideal matrix (A^*) and fuzzy negative ideal matrix (A^-) using Eq. (10) and Eq. (11). For example, for alternative A1 and criteria C1,the distances are calculated as follows

$$d_V(A_1, A^*) = \sqrt{\frac{1}{3}[(0-1)^2 + (0.4399-1)^2 + (1-1)^2]} = 0.6617;$$

Table 8

Normalized fuzzy decision matrix for alternatives

Criteria	Alternatives		
	A1	A2	A3
C1	(0.3,0.83,1)	(0.3,0.67,1)	(0,0.5,1)
C2	(0,0.5,1)	(0,0.5,1)	(0.3,0.67,1)
C3	(0,0.17,0.7)	(0,0.33,1)	(0,0.33,0.7)
C4	(0,0.33,1)	(0,0.5,1)	(0,0.67,1)
C5	(0,0.5,1)	(0.3,0.83,1)	(0,0.33,1)
C6	(0,0.33,0.7)	(0,0.5,1)	(0,0.5,1)
C7	(0,0.5,1)	(0,0.17,0.7)	(0.3,0.67,1)
C8	(0,0.5,1)	(0,0.17,0.7)	(0,0.17,0.7)

Table 9

Weighted normalized alternatives, FPIS and FNIS

Criteria	Alternatives			FNIS (A^-)	FPS (A^*)
	A1	A2	A3		
C1	(0,0.4399,1)	(0,0.3551,1)	(0,0.265,1)	0	1
C2	(0,0.35,1)	(0,0.35,1)	(0.15,0.469,1)	0	1
C3	(0,0.136,0.7)	(0,0.264,1)	(0,0.264,0.7)	0	1
C4	(0,0.297,1)	(0,0.45,1)	(0,0.603,1)	0	1
C5	(0,0.1,0.5)	(0,0.166,0.5)	(0,0.066,0.5)	0	0.5
C6	(0,0.099,0.35)	(0,0.15,0.5)	(0,0.15,0.5)	0	0.5
C7	(0,0.05,0.5)	(0,0.017,0.35)	(0,0.067,0.5)	0	0.5
C8	(0,0.15,0.5)	(0,0.051,0.35)	(0,0.051,0.35)	0	0.5

Table 10

Distance for alternatives

Criteria	$d_v(A_1, A^-)$			$d_v(A_1, A^*)$		
	A1	A2	A3	A1	A2	A3
C1	0.6307	0.6127	0.5973	0.6617	0.6870	0.7165
C2	0.6117	0.6117	0.6435	0.6886	0.6886	0.5786
C3	0.4117	0.5971	0.4319	0.7824	0.7169	0.7375
C4	0.6023	0.6331	0.6742	0.7057	0.6589	0.6212
C5	0.2943	0.3042	0.2912	0.3697	0.3472	0.3423
C6	0.2100	0.3014	0.3014	0.3800	0.3524	0.3524
C7	0.2901	0.2023	0.2913	0.3884	0.4106	0.4771
C8	0.3014	0.2042	0.2042	0.3524	0.3957	0.3957
$\sum$	2.7215	3.4667	3.435	4.3298	4.2573	4.2213

$$d_v(A_1, A^-) = \sqrt{\frac{1}{3}[(0-0)^2 + (0.4399-0)^2 + (1-0)^2} = 0.6307.$$

The others are listed in Table 10.

6. Compute the distances d_i^* and d_i^- using Eq. (12), and the closeness coefficient (CC_i). For example, for alternative A1 and criteria C1, the distances d_i^* and d_i^- are given by

$$cc_i = \frac{d_i^-}{d_i^- + d_i^*} = \frac{2.7215}{4.3298 + 2.7215} = 0.3860.$$

Likewise, CC_i for the other three alternatives are computed. The final results are shown in Table 11.

By comparing the CC_i values of the three alternatives, we find, that A2 > A3 > A1. Therefore, the supplier A1 has been considered having the best service performance according to the opinion of the decision making committee.

Conclusion. In this article, we use triangular fuzzy TOPSIS method to evaluate service performance of providers under fuzzy environment. Triangular fuzzy TOPSIS method can transform exact value to fuzzy analysis, which can reduce subjective errors, has been more accurate for the selection of the third party logistics providers in B2B business. Another important part is to determine the weighing values of criteria. In this paper the method of combination weight has been used to determine the criteria weights. After determine the criteria weights, fuzzy TOPSIS method has been adopted to choose the best solution. The advantage of this method is that it can evaluate the service performance in the absence of quantitative information of the third party logistics suppliers.

Table 11

Closeness coefficient (CC_i) for the three alternatives

	Alternatives		
	A1	A2	A3
d_i^*	4.3298	4.2573	4.2213
d_i^-	2.7215	3.4667	3.435
CC_i	0.3860	0.4488	0.4487

The future development of the third party logistics providers in B2B business will focus on the economic interests and the potential profits brought by service. Logistics performance assessment should be used to help enterprises to select the most appropriate logistics provider to reduce the cost and improve the economic benefit.

Reference/Список літератури

1. Yijun Huang, Kaikai Yin, 2014. Research on the Evaluation and Selection of Third-Party Logistics Providers in B2C E-Commerce Mode, *Journal of Electronic Commerce in Organizations*, Vol. 12, No. 2, pp. 74–88.

2. Soonhu S, 2010. A Decision Model for Evaluating Third-party Logistics Providers Using Fuzzy Analytic Hierarchy Process, *African Journal of Business Management*, Vol. 4, No. 3, pp. 339–349.

3. Gülşen Akman, Kasım Baynal, 2014. Logistics Service Provider Selection through an Integrated Fuzzy Multicriteria Decision Making Approach, *Journal of Industrial Engineering*, pp. 1–16.

4. Carl Marcus Wallenburg, Jan Simon Raue, 2011. Conflict and its governance in horizontal cooperation of logistics service providers, *International Journal of Physical Distribution & Logistics Management*, Vol. 41, No. 4, pp. 385–400.

5. Sun Chao, Zhang Guangming, 2012. An empirical investigation of the impact of SCM components on the logistics service performance, *Proc. Of International Symposium on Distributed Computing & Applications to Business*, pp. 251–255.

Мета. З'явившись разом з великою кількістю компаній, що надають аутсорсинг і логістичні послуги, конкуренція між комплексними логістичними провайдерами стає все більш жорсткою з кожним днем. Стикаючись зі складністю координування ланцюжка поставок, важливо оцінити ефективність надання послуг сторонніми логістичними провайдерами.

Методика. Метод оцінювання ефективності послуг логістичними компаніями просувається під егідою трикутного нечіткого аналізу TOPSIS і теорії нечітких множин. Обираються вісім оціночних показників за допомогою огляду досліджень з оцінюванню ефективності надання послуг сторонніми логістичними провайдерами.

Результати. Надано науковий аналітичний метод для оцінювання ефективності надання послуг сторонніми логістичними провайдерами. Він надає теоретичні основи для управління прийняттям рішень.

Наукова новизна. Метод трикутного нечіткого TOPSIS може перетворити точне значення в нечіткий аналіз, що дозволяє зменшити суб'єктивні помилки, і є точнішим при виборі провайдерів логістичних послуг.

Практична значимість. Запропоновано метод аналізу, що дозволяє стороннім постачальникам логістичних послуг покращувати свої робочі умови. Вважаємо, що нам потрібно зосередитися на економічних інтересах і потенційному сервісному прибутку, аби створити ще більшу цінність для компанії та суспільства.

Ключові слова: *продуктивність служби, трикутний нечіткий TOPSIS-аналіз, теорія нечітких множин, сторонній логістичний провайдер, оцінка ефективності, система показників*

Цель. Появившаяся вместе с большим количеством компаний, предоставляющих аутсорсинг и логистические услуги, конкуренция между комплексными логистическими провайдерами становится всё более жесткой с каждым днём. Сталкиваясь со сложностью координирования цепочки поставок, важно оценить эффективность предоставления услуг сторонними логистическими провайдерами.

Методика. Метод оценивания эффективности услуг логистическими компаниями продвигается под эгидой треугольного нечеткого анализа TOPSIS и теории нечётких множеств. Выбираются восемь оценочных показателей посредством обзора исследований по оцениванию эффективности предоставления услуг сторонними логистическими провайдерами.

Результаты. Предоставлен научный аналитический метод для оценивания эффективности предоставления услуг сторонними логистическими провайдерами. Он предоставляет теоретические основы для управления принятием решений.

Научная новизна. Метод треугольного нечеткого TOPSIS может преобразовать точное значение в нечёткий анализ, что позволяет уменьшить субъективные ошибки, и является более точным при выборе провайдеров логистических услуг.

Практическая значимость. Предложен метод анализа, позволяющий сторонним поставщикам логистических услуг улучшить свои рабочие условия. Считаем, что нам нужно сосредоточиться на экономических интересах и потенциальной сервисной прибыли, чтобы создать еще большую ценность для компании и общества.

Ключевые слова: *производительность службы, треугольный нечеткий TOPSIS-анализ, теория нечетких множеств, сторонний логистический провайдер, оценка эффективности, система показателей*

Рекомендовано до публікації докт. техн. наук В. В. Гнатушенком. Дата надходження рукопису 15.06.15.