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Enterprise E-marketing Performance Evaluation Based on Interval-valued Intuitionistic Fuzzy Sets OWA Operator

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This paper establishes the network marketing performance evaluation index system followed the principles of "scientific, objective, systematic, feasibility and stability". Then use interval-valued intuitionistic fuzzy sets OWA (Ordered Weighted Averaging) operator to calculate the evaluation value. The reason of this paper use interval-valued intuitionistic fuzzy sets is some index value is not necessarily a certain number in real life, the interval-valued intuitionistic fuzzy sets can describe some parameter values in greater detail; Next OWA operator is used to calculate the e-marketing performance evaluation value of various enterprises, then compare the evaluation value and put forward the corresponding strategy. Finally enumerated instances to validate the method adopted by this paper used in the enterprise e-marketing performance evaluation is feasible and effective.

1. Introduction

Since the birth of the e-marketing, some domestic and overseas scholars have discussed e-marketing performance indicators and assessment by using the relevant theories and models. Foreign scholars put more focus on using the mature theory to evaluate enterprise e-marketing performance. Famous strategic management Porter (2001) used " Five Forces Model " and the theory of value chain, he thought e-marketing can increase the service value , improve operational efficiency, expand the scope of the market for the enterprises, thus create value for the enterprise, improve the performance of enterprises, and obtain competitive advantage in every link of the value chain. On the basis of the theory of enterprise resources (RBV theory), Zhu (2004) pointed out that the combination of e-marketing ability and information technology ability of the enterprise can create value, and can improve the functioning of enterprises. Malone and Laubacher (1988) demonstrated e-marketing can reduce the information asymmetry and transaction cost based on the theory of transaction cost economics. Companies carrying out the e-marketing can obtain these values to improve enterprise performance. Lee and Clark (1996) pointed out the part that the e-marketing can affect significantly from the perspective of transaction cost economics, such as search, price discovery and the settlement of trade. Relatively, in regard to the research of e-marketing performance, the domestic scholars put more focus on the study of performance index system, and carry out empirical research by using a comprehensive evaluation method on this basis. Indexes that Fu Xiaohua and Li Zhicheng (2003) selected included the effect index, cost index, efficiency index. Indexes that Su Hang (2008) selected include website design index, website promotion index, website traffic index, the e-marketing effectiveness index. According to the principle of establishing network performance evaluation index system, Dai Wenfeng (2009) combined with the characteristics of enterprise e-marketing activities, analyze and synthesizing the factors that affect the e-marketing performance evaluation, and establish a set of evaluation index system including the website design index, website promotion index, website traffic index. Wang Yan, et al (2006) thought that characteristics of the site are the comprehensive reflection of e-marketing strategy and a variety of e-marketing strategy, evaluating site can capture the root of the e-marketing. Mainly centre on the site evaluation, establish the e-marketing evaluation index system, the index system includes website design index, website promotion index, website traffic index and the e-marketing effectiveness index.
Throughout the previous studies, foreign scholars mainly use mature theories and models to evaluate e-marketing performance, and domestic scholars put focus on building e-marketing performance evaluation

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index system, focus that domestic and foreign scholars put on is different, when doing e-marketing performance evaluation research, if synthesize the research methods of scholars both at home and abroad, the effect of 0 research would be better. This paper combines the research methods at home and abroad, first of all, builds e-marketing performance evaluation index system following the principles of "scientific, objective, systematic, feasibility and stability", and then evaluates enterprise e-marketing performance by using interval-valued intuitionistic fuzzy sets OWA operator.

2. Establish enterprise e-marketing performance evaluation index system

When evaluate enterprise e-marketing performance, firstly, build enterprise e-marketing performance evaluation index system, the choice of evaluation index affects the effect of e-marketing performance evaluation directly. The choice of evaluation index must follow the principle of "scientific, purposeful, systematic, feasibility, stability". This paper makes ample consideration of the enterprise performance, customer relations performance and website performance.

Table 1: Enterprise e-marketing performance evaluation indicator system

First class indicator	Second class indicator	Third class indicator	
Enterprise performance	Enterprise economic performance	Sales revenue growth	x_1
		Sales profit growth	x_2
	Enterprise market competitiveness performance	Growth of the market share	x_3
		Consumers permeability	x_4
Customer relations performance	Customer loyalty	Online fixed rate increasing	x_5
	Customer satisfaction	Ratio of customer complaint	x_6
Website performance	Performance evaluation	Comprehensiveness of function	x_7
		Online transaction security	x_8
	Operation effect	Growth rate of user retention time	x_9
		Website hits	x_{10}

The relationship between language variables and interval-valued intuitionistic fuzzy sets is shown in the table below:

Table 2: The relationship between language variables and interval-valued intuitionistic fuzzy sets

Language variables	Interval-valued intuitionistic fuzzy sets
Excellent,	$<[0.6,0.7],[0.1,0.2]>$
Good	$<[0.4,0.5],[0.2,0.3]>$
Bad	$<[0.1,0.2],[0.4,0.5]>$

3. Model based on interval-valued intuitionistic fuzzy sets OWA operator

Assume $A_j =<[\mu_j^L, \mu_j^U],[\nu_j^L, \nu_j^U]> (j=1,2,\ldots,n)$ is interval-valued intuitionistic fuzzy sets. If map $g: F_1^n \to F_1$ satisfied:

$$g(A_1, A_2, \ldots, A_n) = \sum_{k=1}^{n} w_k B_k \tag{1}$$

g is called interval-valued intuitionistic fuzzy sets OWA operator.

The characteristic of interval-valued intuitionistic fuzzy sets OWA operator is: determine the non-increasing arrangement of interval-valued intuitionistic fuzzy sets A_j ($j=1,2,\ldots,n$) by using some kind of sorting method of interval-valued intuitionistic fuzzy set, and then weight and aggregate it. There is no relationship between the weighting vector and interval-valued intuitionistic fuzzy sets aggregated, only has something with the position in the process of aggregation.

Assume $A_j =<[\mu_j^L, \mu_j^U],[\nu_j^L, \nu_j^U]> (j=1,2,\ldots,n)$ is interval-valued intuitionistic fuzzy sets. $B_k =<[\mu'^L_k, \mu'^U_k],[\nu'^L_k, \nu'^U_k]>$ ($k=1,2,\ldots,n$) is the k largest element of n interval-valued intuitionistic fuzzy sets A_j ($j=1,2,\ldots,n$) according to certain ordering method, the result computed by interval-valued intuitionistic fuzzy sets OWA operator, namely formula (1) is still interval-valued intuitionistic fuzzy sets, and

$$g(A_1, A_2, \ldots, A_n) =<[1-\prod_{k=1}^{n}(1-\mu'^L_k)^{w_k}, 1-\prod_{k=1}^{n}(1-\mu'^U_k)^{w_k}],[\prod_{k=1}^{n}\nu'^{Lw_k}_k, \prod_{k=1}^{n}\nu'^{Uw_k}_k]> \tag{2}$$

When make evaluation by using interval-valued intuitionistic fuzzy sets OWA operator, the steps as follow:

(1) Construct interval-valued intuitionistic fuzzy sets matrix.

Scheme set is denoted by $A=\{A_1, A_2, \ldots, A_m\}$, attribute set is denoted by $X=\{x_1, x_2, \ldots, x_n\}$, the evaluation of scheme $A_i \in A$ about quantitative attribute $x_j \in X$ is interval-valued intuitionistic fuzzy sets. Construct interval-valued intuitionistic fuzzy sets matrix as follows:

$$A=\begin{bmatrix} A_{11} & A_{12} & \cdots & A_{1m} \\ A_{21} & A_{22} & \cdots & A_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ A_{n1} & A_{n2} & \cdots & A_{nm} \end{bmatrix}$$

Of which $A_{ij} =<[\mu_{ij}^L, \mu_{ij}^U],[\nu_{ij}^L, \nu_{ij}^U]>$, i expresses scheme, j expresses an attribute.

(2) Order each index interval-valued intuitionistic fuzzy sets.

Assume $A_j =<[\mu_j^L, \mu_j^U],[\nu_j^L, \nu_j^U]> (j=1,2,\ldots,n)$ is interval-valued intuitionistic fuzzy sets, calculate the score value and the accurate value of each interval-valued intuitionistic fuzzy set by using formula(1), and order each interval-valued intuitionistic fuzzy set according to order method below formula(1).

(3) Calculate evaluation value of all schemes.

Substitute sorted interval-valued intuitionistic fuzzy sets and each target position weight into formula (3), and calculate evaluation value of each scheme.

(4) Compare each scheme.

Calculate the score value and the accurate value of each scheme, and carry on the sorting.

4. Empirical analysis

Now evaluate e-marketing performance of four auto enterprise A_1, A_2, A_3, A_4 of China, the index data of companies are known, these data are in the form of interval-valued intuitionistic fuzzy sets, calculate the

weight by using subjective and objective comprehensive weighting method, and evaluate e-marketing performance of each enterprise by using interval-valued intuitionistic fuzzy sets OWA operator, make the enterprise to understand their and competitor's marketing performance situation, and make corresponding analysis, so that put forward the corresponding strategy.
We give index values of four companies as follow:

Table 3: Index values of four companies

index	A_1	A_2	A_3	A_4
x_1	$<[0.1,0.3],[0.4,0.6]>$	$<[0.2,0.3],[0.5,0.6]>$	$<[0.3,0.5],[0.4,0.5]>$	$<[0.1,0.3],[0.4,0.5]>$
x_2	$<[0.2,0.4],[0.3,0.5]>$	$<[0.1,0.2],[0.5,0.7]>$	$<[0.2,0.3],[0.4,0.5]>$	$<[0.5,0.6],[0.1,0.3]>$
x_3	$<[0.1,0.4],[0.4,0.5]>$	$<[0.1,0.3],[0.4,0.6]>$	$<[0.7,0.8],[0.1,0.2]>$	$<[0.1,0.2],[0.6,0.7]>$
x_4	$<[0.4,0.5],[0.3,0.4]>$	$<[0.1,0.3],[0.3,0.5]>$	$<[0.1,0.3],[0.4,0.6]>$	$<[0.1,0.2],[0.4,0.5]>$
x_5	$<[0.4,0.5],[0.1,0.2]>$	$<[0.3,0.4],[0.2,0.3]>$	$<[0.7,0.8],[0.1,0.2]>$	$<[0.5,0.6],[0.2,0.3]>$
x_6	$<[0.4,0.6],[0.2,0.3]>$	$<[0.2,0.3],[0.2,0.4]>$	$<[0.1,0.3],[0.4,0.6]>$	$<[0.4,0.5],[0.2,0.3]>$
x_7	$<[0.6,0.7],[0.1,0.2]>$	$<[0.1,0.2],[0.4,0.5]>$	$<[0.4,0.5],[0.2,0.3]>$	$<[0.4,0.5],[0.2,0.3]>$
x_8	$<[0.1,0.2],[0.4,0.5]>$	$<[0.4,0.5],[0.2,0.3]>$	$<[0.6,0.7],[0.1,0.2]>$	$<[0.1,0.2],[0.4,0.5]>$
x_9	$<[0.3,0.4],[0.1,0.2]>$	$<[0.2,0.3],[0.4,0.5]>$	$<[0.3,0.4],[0.4,0.5]>$	$<[0.1,0.3],[0.4,0.6]>$
x_{10}	$<[0.4,0.5],[0.1,0.2]>$	$<[0.3,0.4],[0.4,0.6]>$	$<[0.4,0.5],[0.2,0.3]>$	$<[0.1,0.2],[0.4,0.5]>$

Determine the index weight by using subjective and objective comprehensive integration weighting method, and calculated weight of index are $w=(0.05,0.1,0.25,0.08,0.14,0.02,0.06,0.1,0.05,0.15)^{\mathrm{T}}$.
According to the interval-valued intuitionistic fuzzy sets is given in Table 2 and formula (1), calculated the score values of each index are:
$M_{11}=-0.3$, $M_{12}=-0.1$, $M_{13}=-0.2$, $M_{14}=0.1$, $M_{15}=0.3$, $M_{16}=0.25$, $M_{17}=0.5$, $M_{18}=-0.3$, $M_{19}=0.2$, $M_{110}=0.3$. Obviously, $M_{17}>M_{15}=M_{110}>M_{16}>M_{19}>M_{14}>M_{12}>M_{13}>M_{11}=M_{18}$.
Calculate the evaluation value of A_i ($i=2,3,4$) as follow:

Table 4: Evaluation value, score value and accurate value of scheme

	r_i	$M(A_i)$
A_1	$<[0.2223, 0.3636], [0.2999, 0.4696]>$	–0.0918
A_2	$<[0.0000, 0.4139], [0.2929, 0.4497]>$	–0.1644
A_3	$<[0.3023, 0.4673], [0.3260, 0.4566]>$	–0.0065
A_4	$<[0.0000, 0.3875], [0.3942, 0.5335]>$	–0.2701

The above-mentioned score values generate a histogram as shown:

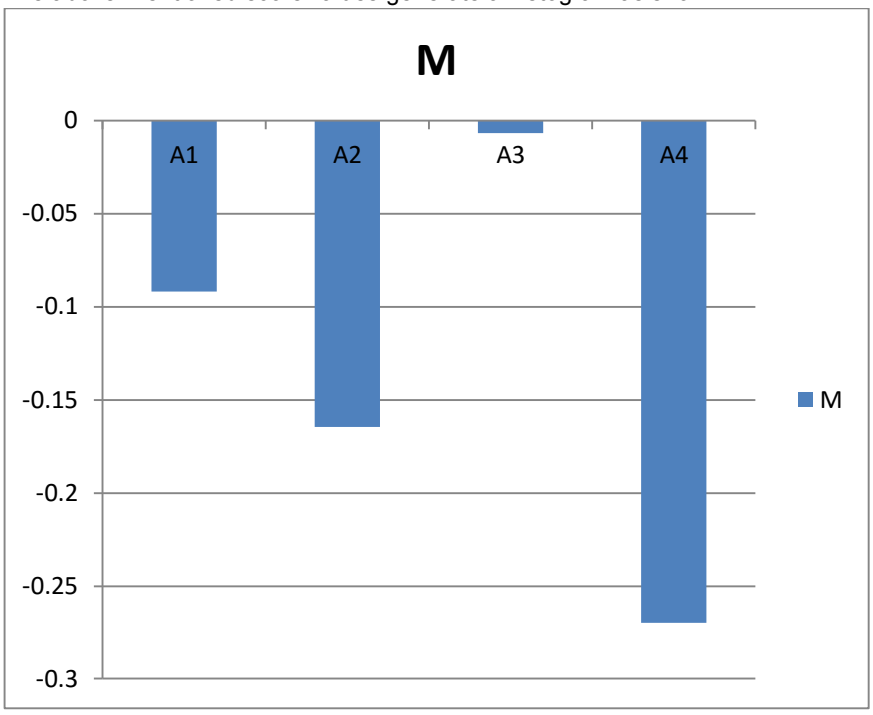

Figure 1. The histogram of evaluation results

The figure 1 shows $M(A_3) > M(A_1) > M(A_2) > M(A_4)$, so the sorting of e-marketing performance of these companies is A_3 , A_1 , A_2 , A_4 . Compare four companies, from the intuitive judgment, e-marketing performance of enterprise A_3 is the best, e-marketing performance of enterprise A_4 is the weakest. Therefore, the experimental result is consistent with the artificial judgment, and the model is used for enterprise e-marketing performance evaluation is feasible. The e-marketing effect of A_3 is best due to its growth of market share, online fixed rate increasing, comprehensiveness of function, online transaction security, website hits, and other parameter values are high. And the e-marketing performance of A_4 is weakest due to its sales revenue growth, growth of market share, consumers permeability and comprehensiveness of function are relatively low. So according to the evaluation results and combining with the parameter values , each enterprise can come up with the corresponding strategies, to improve the performance of enterprise e-marketing.

5. Conclusions

This paper has made the following results on the e-marketing performance: (1)This paper constructs the enterprise e-marketing performance evaluation system by following the principles of "scientific, objective, systematic, feasibility and stability"; (2)This paper represents index values of each scheme with interval-valued intuitionistic fuzzy sets. Because interval-valued intuitionistic fuzzy sets use interval number to represent the degree of membership, the degree of non-membership and hesitation of intuitionistic fuzzy sets, so it can be more flexible to express uncertain information. (3)Use interval-valued intuitionistic fuzzy sets OWA operator to evaluate the enterprise internal e-marketing performance objectively and effectively. (4)Finally, use of empirical analysis to verify the model and the method used by the enterprise network marketing performance is feasible and effective. Of course, there will be other methods are also suitable for this field, that still can continue to study.

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