Research on Power Customer Value Evaluation Based on AHP

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Abstract

To promote the differentiation of customer evaluation results so as to accommodate large sample sizes, this paper proposed a revised evaluation model which chooses the differentiation of indicators based on actual electricity business data, determines the weight - using Analytic Hierarchy Process (AHP) method, and optimizes the dimensionless method by establishing relations between characteristic values and evaluation scores. The empirical results verified the effectiveness of the evaluation model which provides a method for power supplies to understand their customer's needs properly.

Keywords: Power Customer; Value Evaluation; Index System; Differentiation Degree of Indicators; AHP method

1. Introduction

In the competition conditions of power market, the relationship between power supply enterprise and their power customer has changed from managing and being managed to service and serviced [1]. Customer Relationship Manager (CRM) plays an import role on the marketing department in power supply enterprise. Customer value evaluation is the basis job to implement CRM [2]. According to results of customer value evaluation, power supply can select appropriate operating strategy for CRM, and provide differentiated service.

Recent researches mainly focus on the customer value index system, especially on the methods of setting weight combine objectives and subjective factors reasonably [1-3]. However, our opinion is that besides setting reasonable weight, it is still necessary to choose evaluation index with enough differentiation and proper dimensionless method which are the key factors to achieve the success of the evaluation with large numbers of customers.

The remainder of this paper is organized as follows. In Section 2, we construct and modify the power customer evaluation index system by Coefficient of Variance (CV) method. In Section3, the weight of index system is determined using AHP method, and the characteristic values and corresponding scores for index dimensionless are confirmed. Based on the above work, the redesigned model for customer value evaluate is proposed. In Section 4, computational experiments are conducted to illustrate the effectiveness of our model. A conclusion remark is presented in Section5.

2. Construction of Power Customer Value Evaluation Index System

2.1. Initial Evaluation Index System.

According to the results of literature analysis and practical investigation, the dimensionality of power customer evaluation can be summarized in three categories: ① Electricity Situation [1-3], which contains Power consumption,

Voltage class, Load rate, Power factor, Average price of electricity, Total capacity in contract, Rate of electricity in trough, Operating capacity, Electricity line loss rate, Power quality qualified rate; ② Credit Status[4-5], which contains Rate of receiving electrical fee, Current defaulting, Punctuality of receiving electrical fee, Contract execution rate, Purchasing power growth; ③Potential of Electricity[3], which contains Growth rate of electricity quantity, Contribution rate of electricity growth, Electric charge recovery rate, Growth rate of electrical fee, Contribution rate of rising electrical fee.

2.2. Evaluation Index System Modification

Coefficient of Variance method is commonly used to compare the characteristic values of variability among different sample, and the computational formula is shown in Eq. 1,

$$CV = \frac{s}{\bar{x}} = \frac{\sqrt{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2 / n-1}}{\sum_{i=1}^{n} x_i / n} \qquad (1)$$

where C·V is the corresponding coefficient of variation; s is the corresponding standard deviation of this index; $\bar{x}$ is the average value of all observation; and xi is the observation value of i index.

Original electricity data of 2627 corporate customers are extracted from marketing information system of State grid Power Company in Shaanxi province to get the validation of differentiates for every index. In the light of the advice of experts, this study uses forced proportion to dispose differentiation, taking top 75% as high differentiation index and behind 25% as low differentiation index. The calculate results are given in table1.

Based on the following selection process of the index, the power customer evaluation index system is modified as shown in table2.

Table 1. Computational results of index identify

Name of index	CV^*	$\overline{X}^*$	S^*	Accept
Power consumption	710.3%	235884.79	16754 38.45	√
Voltage class	***10.2%***	0.781	0.079	√
Load rate	41.5%	0.866	0.359	√
Power factor	182.1%	0.232	0.423	√
Average price of electricity	118.5%	0.541	0.641	√
Total capacity in contract	639.5%	925.975	5921.542	√
Rate of electricity in trough	211.5%	0.078	0.165	√
Operating capacity	654.8%	871.855	5709.246	√
Electricity line loss rate	***8.2%***	0.073	0.006	×
Power quality qualified rate	***0.8%***	0.996	0.008	×
Rate of receiving electrical fee	847.3%	0.116	0.986	√
Current defaulting	24.1%	16.553	3.987	√
Punctuality of receiving electrical fee	857.1%	0.014	0.12	√
Contract execution rate	***3.7%***	0.975	0.036	×
Purchasing power growth	540.0%	178328.89	33023.87	×
Growth rate of electricity quantity	61.5%	0.148	0.091	√
Contribution rate of electricity growth	137.2%	0.00132	0.00181	√
Electric charge recovery rate	***6.3%***	0.983	0.0619	×
Growth rate of electrical fee	61.5%	0.091	0.148	√
Contribution rate of rising electrical fee	114.3%	0.0016	0.641	√

3. Evaluation Model of the Power Customer Value

3.1. The Weight of Index

The AHP method is an analysis and evaluation method which is proposed by T.L.Saaty in the 1970s. According to

basic algorithm of AHP [6], this study determins the weight of index as following step A and step B.

(1) Step A. The weight of rule layer to object Layer

According to literature analyze and expert survey, the judgment matrix of importance degree for rule layer (X_1, X_2, and X_3) is show in table 3. The weight of rule layer to object Layer is acquired based on 3-5 columns in table 3.

(2) Step B. The weight of indexes under rule layer

The judgment matrixes of importance degree for each index in rule layers are shown in table 4. The weight of each index to rule layer is got as eleventh column in table 4.

3.2. Index Dimensionless

As evaluation score of index dimensionless for lager sample is too low, we choose several characteristic value for every index, and set an experiential score for each characteristic value to make sure the reasonable distribution of evaluation result. The characteristic values and experiential scores are shown in the fourth and fifth columns of table 2. The specific calculation formulas are given in Eq. 2 and Eq. 3.

For performance indexes (which are indentified as symbol "↑" in table2), let

$$x_{ij}^{*}=\begin{cases}0, & x_{ij}<\alpha_1\\ f(\alpha_{k-1})+\left(\dfrac{x_{ij}-\alpha_{k-1}}{\alpha_k-\alpha_{k-1}}\right)\times\left(f(\alpha_k)-f(\alpha_{k-1})\right), & \alpha_{k-1}\le x_{ij}<\alpha_k,\ k=2,...,n\\ 1, & x_{ij}\ge \max\{\alpha_k\}\end{cases} \tag{2}$$

For negative index (which is indentified as symbol "↓" in table2), let

$$x_{ij}^{*}=\begin{cases}1, & x_{ij}<\alpha_1\\ f(\alpha_k)+\left(\dfrac{x_{ij}-\alpha_k}{\alpha_k-\alpha_{k-1}}\right)\times\left(f(\alpha_k)-f(\alpha_{k-1})\right), & \alpha_{k-1}\le x_{ij}<\alpha_k, k=2,...,n\\ 0, & x_{ij}\ge \max\{\alpha_k\}\end{cases} \tag{3}$$

Take the dimensionless process of X_{11} (Power consumption) as an example to illustrate the use of this dimensionless method. The character values and scores could be obtained as shown in table 2 as:

f(0)=0, f(2000)=0.4, f(5000)=0.6, f(10000)=0.7, f(40000)=0.8, f(100000)=0.9， f(37371840)=1.

According to the Eq. 2, the calculation expression of normalization for X11 is established as Eq. 4. Evaluation score for each original power consumption can be calculated according to Eq. 4.

$$x_{ij}^{*}=\begin{cases}\dfrac{x_{ij}}{2000}\times 0.4, & 0\le x_{ij}<2000\\ 0.4+\dfrac{x_{ij}-2000}{5000-2000}\times 0.2, & 2000\le x_{ij}<5000\\ 0.6+\dfrac{x_{ij}-5000}{10000-5000}\times 0.1, & 5000\le x_{ij}<10000\\ 0.7+\dfrac{x_{ij}-10000}{40000-10000}\times 0.1, & 10000\le x_{ij}<40000\\ 0.8+\dfrac{x_{ij}-40000}{100000-40000}\times 0.1, & 40000\le x_{ij}<100000\\ 0.9+\dfrac{x_{ij}-100000}{37371840-100000}\times 0.1, & 100000\le x_{ij}<37371840\\ 1, & x_{ij}\ge 37371840\end{cases},\quad i=1,...,n;\quad j=1,... \tag{5}$$

The processes of normalization for other indicators are the same as X_{11}, so the calculation steps are left out.

3.3. Comprehensive Evaluation of Power Custom Value

The evaluation result could be got after the recursion of each score multiply by accordingly weight. The calculation formula is shown as Eq. 5,

$$A=\sum_{i=1}^{n}A_i\times w_i=\sum_{i=1}^{n}\sum_{j=1}^{n}\left(x_{ij}^{*}\times w_{ij}\right)\times w_i \tag{6}$$

where A_i (i3 the score of each item in rule layer), w_j is corresponding weight of A_i; x_{ij}^{*} is normalization score of each item in index layer, w_{ij} is corresponding weight of each index. The score of A_i in rule layer could be obtained by its branch normalization(score x_{ij}^{*} multiply by w_{ij}.

4)

4. Case Analyze of Power Customer Value Evaluation

Because of the large quantity of power customers, 4 topical customers' evaluation results are given in table 5 to prove the effectiveness of evaluate model.

Table 2. The index system of modified power customer value evaluation

Object Layer	Rule layer X_i	Index layer X_{ij}		Characteristics number $\{\alpha_n\}$	Evaluation score $\{f(\alpha_n)\}$
Power customer value	X_1 Electricity Situation	X_{11}	*Power consumption* (↑)	{0,2000,5000,10000,40000, 100000}	{0,0.4,0.6,0.7,0.8,0.9}
		X_{12}	*Voltage class* (↑)	{220,380, 10000,110000}	{0.3,0.5, 0.8,1}
		X_{13}	*Load rate* (↑)	{0.1,0.5,0.8,0.9}	{0.3,0.5,0.7,0.9}
		X_{14}	*Power factor* (↑)	{0.1,0.5,0.8,0.9}	{0.3,0.5,0.7,0.9}
		X_{15}	*Average price of electricity* (↑)	{0.27,0.40,0.5,0.6,0.8,1}	{0.4,0.5,0.7,0.8,0.9,0. 95}
		X_{16}	*Total capacity in contract*(↑)	{500,1000,4000,10000,100000}	{0.4,0.6,0.7,0.8,0.90}
		X_{17}	*Rate of electricity in trough* (↑)	{0.1,0.3,0.5,0.7,0.8,0.9}	{0.6,0.7,0.8,0.85,0.9,0 .95}
		X_{18}	*Operating capacity* (↑)	{500,1000,4000,10000,100000}	{0.4,0.6,0.7,0.8,0.90}
	X_2 Credit Status	X_{21}	*Rate of receiving electrical fee* (↑)	{0.3,0.5,0.8,0.9,1}	{0.1,0.3,0.5,0.6,1}
		X_{22}	*Current defaulting* (↓)	{-10000,-1000, 0,100,1000}	{0.9,0.8, 0.7,0.3,0.1}
		X_{23}	*Punctuality of receiving electrical fee* (↑)	{0.5,0.9, 1}	{0.1,0.6,1}
	X_3 Potential of Electricity	X_{31}	*Growth rate of electricity quantity* (↑)	{0.05,0.08,0.1,0.2}	{0.4,0.6,0.8,0.9}
		X_{32}	*Contribution rate of electricity growth* (↑)	{0.1%,0.2%,1%,5%}	{0.4,0.6,0.8,0.9}
		X_{33}	*Growth rate of electrical fee* (↑)	{0.05,0.08,0.1,0.2}	{0.4,0.6,0.8,0.9}
		X_{34}	*Contribution rate of rising electrical fee* (↑)	{0.1%,0.2%,1%,5%}	{0.4,0.6,0.8,0.9}

Table 3. The judgment matrix A of importance degree for rule layer

(1) No.	(2)A	(3) X_1	(4) X_2	(5) X_3	(6) w_i	(7)CR
1	X_1	1	1/2	2	0.320	
2	X_2	2	1	4	0.480	0
3	X_3	1/2	1/4	1	0.200	

Table 4. The judgment matrixes Ai of importance degree for index layer

(1)No.	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1	A_1	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}	X_{18}	w_{1j}	CR
2	X_{11}	1	6	4	5	1	3	8	4	0.282	
3	X_{12}	1/6	1	1/2	1	1/6	1/3	2	1/2	0.046	
4	X_{13}	1/4	2	1	2	1/5	1/2	4	1	0.081	
5	X_{14}	1/5	1	1/2	1	1/7	1/4	3	1/3	0.047	0.045
6	X_{15}	1	6	5	7	1	3	8	4	0.302	
7	X_{16}	1/3	3	2	4	1/3	1	5	2	0.132	
8	X_{17}	1/8	1/2	1/4	1/3	1/8	1/5	1	1/2	0.027	
9	X_{18}	1/4	2	1	3	1/4	1/2	2	1	0.081	
10	A_2	X_{21}	X_{22}	X_{23}	—	—	—	—	—	w_{2j}	CR
11	X_{21}	1	1/3	3	—	—	—	—	—	0.258	
12	X_{22}	3	1	5	—	—	—	—	—	0.637	0.062
13	X_{23}	1/3	1/5	1	—	—	—	—	—	0.105	
14	A_3	X_{31}	X_{32}	X_{33}	X_{34}	—	—	—	—	w_{3j}	CR
15	X_{31}	1	1/2	1/3	1/4	—	—	—	—	0.100	
16	X_{32}	2	1	1/2	1/2	—	—	—	—	0.185	0.0044
17	X_{33}	3	2	1	1	—	—	—	—	0.345	
18	X_{34}	4	2	1	1	—	—	—	—	0.370	

In table 5, the cement enterprise is a superior customer because it has a highest value, not only on good electricity situation but also on the potential. Power supply enterprise should pay more attention on how to provide personalized service such as electric safety guide, dilatation analyze etc. business.

Table 5. Topical customers' evaluate results

Customer ID	Customer describe	Customer value	Electricity Situation	Credit Status	Potential of Electricity
0100000421	Cement enterprise	***0.857***	***0.858***	0.796	1
0200007159	A research institute	0.78	0.668	0.796	***0.923***
0200007192	A paper mill	0.715	0.543	***0.872***	0.612
0400004488	A government department	***0.316***	***0.447***	***0.121***	***0.572***

5. Conclusions

Selecting the appropriate index, rational allocation of weights and the optimization index dimensionless processing have key impact on the construction of evaluation model. This paper constructed and revised the evaluation index system of power customer value by means of identifying the differentiation degree of indicators with customers' practical power business data. The weights of indicators were determined by AHP method, and characteristic values and corresponding scores were confirmed for the index dimensionless. The eventual evaluation model has the advantages of reasonable index composition, scientific weight and strong operability.

6. Acknowledgments.

This study is supported by the National Natural Science Foundation of China (71172124); Doctoral Fund of Ministry of Education of China (20116102110036); Shaanxi Soft Science Project (2012KRM24) ; Science and Technology Projects of SGCC entitled "Research on the Integrated Supporting Technologies for Intelligent Marketing Business based on the International IEC-CIM/CIS Standard".

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