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Power Consumer Credit Combination Evaluation Model Based on Deviation Entropy

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Abstract: Power consumer credit evaluation modeling can help power enterprises effectively predict and avoid risks in electric charge, establish a payment service standardization system for consumers, and promote service transition to refined management. This paper targets at traditional credit combination evaluation. Although various methods are combined, considering poor compatibility between methods, evaluation is made with credit combination method based on bias entropy. This allows a high degree of consistency between the combination evaluation results and the results of each single evaluation method, reflecting characteristics of most methods. Moreover, it allows high quality of the compatible method sets as much as possible, ensures objective and credible combination evaluation. Experiment proves that the method is effective, practical and reliable.

Keywords:deviation entropy; power consumer; combination credit evaluation; compatibility.

1. INTRODUCTION

System evaluation is to review the degree of various system design programs in meeting the demand and the various resources consumed and occupied based on scheduled purpose from technical and economic aspects, and then select technologically advanced, economically reasonable optimal or satisfactory program on the basis of systematic investigation and feasibility study. Objective and comprehensive evaluation demands multi-attribute comprehensive evaluation, as well as global and holistic evaluation on the object system described by multi-attribute architecture [1, 2].

Power consumer credit evaluation modeling and risk assessment has always been a research focus and hotspot in power enterprises and research units. The most important purpose of credit evaluation is to prevent risks in electric charge, achieve differentiated marketing and electric charge risk management for customers at different credit ratings [3, 4]. Most power consumer credit evaluation adopts single evaluation method to evaluate various indicators and user behaviors. Wang Lian and Sun Heping proposed a new model for quantitative evaluation of credit value based on power consumer payment enthusiasm, and measured consumer payment enthusiasm based on weighted regularized payment period value. The model can uniformly measure the power customer enthusiasm index value and quantitatively weigh corresponding credit value [4]. Niu Xiaomei and Zhang Yinling applied analytic hierarchy process to power consumer credit risk assessment. Combining the reality of power customer credit risk, a set of power consumer credit risk grading evaluation model was established based on analytic hierarchy process to obtain more accurate evaluation [5].

2019, Volume 3, Issue 1, 13-20, DOI: 10.6723/TERP.201908_3(1).0002

The various evaluation methods have respective advantages and disadvantages. Given the complexity of power consumer credit evaluation, it is impossible to give play to advantages of a single evaluation method at all stages or aspects of consumer evaluation, nor is it possible to hide the shortcomings. Therefore, it is necessary to combine various methods in consumer credit evaluation by judging advantages and disadvantages of various methods. Hu Yahong and Fang Haoda analyzed power consumer characteristics, calculated consumer credit using analytic hierarchy process, and checked, corrected the analytic hierarchy process results based on k-means algorithm to compensate for strong subjectivity of analytic hierarchy process. In this way, the final power consumer credit rating was obtained and the evaluation algorithm is effective and feasible [6].

Credit evaluation methods are generally subject to great subjectivity. Therefore, different evaluation methods can be combined to reduce random errors and system deviations in the evaluation process, improve credibility of evaluation results, and achieve as much objectiveness as possible. Given the different mechanisms of various evaluation methods, non-unanimous evaluation conclusions are often the case when different evaluation methods are used in the same evaluation. Targeting at the shortcomings of power consumer combination evaluation program, this paper adopts deviation entropy-based combination evaluation method. On the one hand, the deviation between combination evaluation result and single method conclusion is reduced as much as possible, and on the other hand, the selected methods are compatible as much as possible for the sake of objective and consistent evaluation conclusion.

2. Low-voltage power consumer credit combination evaluation model based on deviation entropy

2.1 Deviation entropy

Consumer credit is evaluated using different methods.Assume the combination evaluation result as $y=\left(y_{1,}y_{2},...,y_{n}\right)^{T}$ .The *j*-th evaluation method is set as I_j , and the deviation between combination evaluation result y_i and evaluation result x_{ij} (for object O_i evaluated by I_j) can be indicated as:

$$d_{ij}=\left|y_i-x_{ij}\right|=\sqrt{(w_j x_{ij}-x_{ij})^2} \quad (1)$$

Deviation exists between the evaluation results by single evaluation method and combination method, which is set as:

$$d_j=\sum_{i=1}^{n}\left|y_i-x_{ij}\right|=\sum_{i=1}^{n}\sqrt{(w_j x_{ij}-x_{ij})^2} \quad (2)$$

Compatibility quality of various single evaluation methods can be described using deviation entropy. Entropy derives from thermodynamics, which can measure the degree of system disarrangement. Shannon, an important figure in information theory, first introduced information entropy to measure the amount of effective information in the data. For larger entropy, the

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2019, Volume 3, Issue 1, 13-20, DOI: 10.6723/TERP.201908_3(1).0002

information is more uncertain and on the contrary, more certain. Combination method evaluation combinesdifferent methods to a method set, and compatibility of the methods in the set needs description.Here,the ratio of the evaluation result deviation d_j of the evaluation method I_j to the entire deviation $\sum_{i=1}^{n} d_j$ is set as δ_j .The uncertainty in deviation of single evaluation results, that is, compatibility quality is known as deviation entropy.Relative to single evaluation method I_j , deviation entropy can be defined as $-\delta_j \ln \delta_j$. Here, $\delta_j = d_j / \sum_{j=1}^{m} d_j$ .It shows that for a larger deviation entropy value, compatible method set has smaller difference and higher compatibility quality; conversely, a smaller deviation entropy value means larger set difference and poorer compatible quality.

$$\max H = -\sum_{j=1}^{n} \delta_j \ln \delta_j = -\sum_{j=1}^{n} \left(d_j / \sum_{j=1}^{m} d_j \right) \ln \left(d_j / \sum_{j=1}^{m} d_j \right)$$

$$= -\sum_{j=1}^{n} \left[\sum_{i=1}^{n} \sqrt{(w_j x_{ij} - x_{ij})^2} / \sum_{j=1}^{m} \sum_{i=1}^{n} \sqrt{(w_j x_{ij} - x_{ij})^2} \right]$$

$$\times \ln \left[\sum_{i=1}^{n} \sqrt{\left(w_j x_{ij} - x_{ij}\right)^2} / \sum_{j=1}^{m} \sum_{i=1}^{n} \sqrt{\left(w_j x_{ij} - x_{ij}\right)^2} \right] \quad (3)$$

$$1 \geq w_j \geq 0 \qquad s.t. \sum_{i=1}^{m} w_j = 1$$

Equation (3) above needs to solve the constrained maximum deviation entropy. If Lagrange multiplier method is used to solve the above formula, the weight vector w can be obtained. Where, w is the weight vector when quality of compatible method set is maximal. The model maximizes the "compatibility quality" of the compatible method set. Traditional combination evaluation methods consider deviation factors more, but this paper assumes that two factors should be considered when combining single methods: on the one hand, the deviation between combination evaluation result and each single evaluation method should be minimum to reflect characteristics of most methods; on the other hand, the quality of the compatible method set should be as high as possible to ensure objective and credible combination evaluation results. Giving consideration to the above two aspects, the evaluation model of combination methods can be expressed as:

$$\min T = \alpha \left[-\sum_{j=1}^{m} \left[\frac{\sum_{i=1}^{n} \sqrt{(w_j x_{ij} - x_{ij})^2}}{\sum_{j=1}^{m} \sum_{i=1}^{n} \sqrt{(w_j x_{ij} - x_{ij})^2}} \right] \right] \times$$

2019, Volume 3, Issue 1, 13-20, DOI: 10.6723/TERP.201908_3(1).0002

$$ln\frac{\sum_{i=1}^{n}\sqrt{(w_j x_{ij}-x_{ij})^2}}{\sum_{j=1}^{m}\sum_{i=1}^{n}\sqrt{(w_j x_{ij}-x_{ij})^2}}-\beta\sum_{i=1}^{n}\sqrt{(w_j x_{ij}-x_{ij})^2} \quad (4)$$

In formula (4), α and β can be used to indicate the evaluator's weight estimate for deviation and compatibility quality requirements or the evaluator's preference for both. The shortcoming lies in absence of obvious preference, then α = β =0.5.

2.2 Algorithm steps

Based on the above discussion, power consumer credit evaluation method based on deviation entropy is proposed herein. The deviation entropy model is used to solve the weights of various methods in the compatible method set, so that the final decision scheme is obtained. The steps of combination evaluation method based on deviation entropy are as follows:

1. Standardize the results under single comprehensive evaluation method to obtain a matrix $X=[x_{ij}]_{n\times m}$;
2. Select preference parameters α, β, solve the model according to formula (3) or (4) to calculate the combination weight W of the combination evaluation method;
3. Substitute the weight w_j to the following formula (5) and obtain the final combination evaluation result y;

$$X_i=\sum_{j=1}^{q_i}w_{ij}\bullet X'_i \quad (5)$$

4. Perform sorting and preference of the combination evaluation results.

3.Experiment

First, we set the power consumer credit evaluation indicators as number of cash payment, number of collection payment, number of self-payments, average days of payment, number of arrears, accumulated arrears, average electricity price and electricity quantity, and then calculate the weights of each indicator respectively using entropy method, support vector SVM, RBF neural network, fuzzy comprehensive evaluation method, principal component analysis method and factor analysis weight method. The results are shown in Table 1.

Table 1 The weights of indicators in credit evaluation of electric power consumers by single method

	Entropy method	SVM	RBF	Fuzzy Combination	PCA	Factor Analysis

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2019, Volume 3, Issue 1, 13-20, DOI: 10.6723/TERP.201908_3(1).0002

Number of cash payment	0.142	0.147	0.145	0.152	0.148	0.137
Number of collection payment	0.093	0.102	0.099	0.095	0.101	0.096
Number of self-payments	0.091	0.082	0.090	0.085	0.099	0.089
Average days of payment	0.130	0.124	0.125	0.127	0.117	0.135
Number of arrears	0.147	0.152	0.151	0.149	0.155	0.158
Accumulated arrears	0.150	0.143	0.134	0.142	0.145	0.152
Average electricity price	0.122	0.130	0.135	0.127	0.120	0.126
Electricity quantity	0.125	0.120	0.121	0.123	0.115	0.107

Based on deviation entropy method, we combine the above six methods to solve the credit evaluation indicator weight by formulas (3) and (4). According to calculation, T reaches the minimum when α=0.71, β=0.29 in formula (4) (see results in Table 2).

Table 2 The weights of indicators in credit evaluation of electric power consumersbased on combination method

	Number of cash payment	Number of collection payment	Number of self-payments	Average days of arrears	Number of arrears	Accumulated arrears	Average electricity price	Electricity quantity
Formula (3) model	0.143	0.096	0.095	0.133	0.153	0.145	0.120	0.115
Formul	0.148	0.094	0.096	0.130	0.154	0.150	0.115	0.113

2019, Volume 3, Issue 1, 13-20, DOI: 10.6723/TERP.201908_3(1).0002

a model	(4)

By calculating the combination method weight based on deviation entropy, the credit evaluation scores of each consumer are obtained. There are 267,672 power consumers, the lowest score is 32.8 points and the highest is 87.2 points.The credit weighted average is 68.36 points and the standard deviation is 9.37 points according to formula (3).The credit weighted average is 66.52 points and the standard deviation is 10.13 points according to formula (4). The scores basically follow normal distribution.

According to the data and business requirements, the credit rating is divided into 6 grades from high to low, A grade (90 or more), B+ grade (83-90), B-grade (75-83), C+ grade (70- 75), C-class (60-70), D-class (60 or less), respectively. A lower grade indicates worse business performance and payment status of the evaluated customers, which means greater risk in electric charge collection. After sorting the credit scores, it was found that392 D-grade consumers had poor reputation (with score below 60 points). For consumers with poor reputation, it is recommended to change the sales strategy, such as payment before consumption.

Here, we adopt accuracy and recall rates, two important evaluation indicators in statistics, for evaluation. Accuracy rate represents the ratio P of the number of consumers with correct grading predictions to the predicted number of consumers. Recall rate means the ratio R of the number of consumers with correct grading predictions to the number of truly correctly graded consumers. In order to verify effectiveness of the above methods, power consumer credit rating is calculated respectively by entropy weight method, RBF neural network, fuzzy combination, factor analysis and the method of formula (3). The experimental results are compared and analyzed, and the accuracy and recall rates are compared, with the results shown in Figure 1.

2019, Volume 3, Issue 1, 13-20, DOI: 10.6723/TERP.201908_3(1).0002

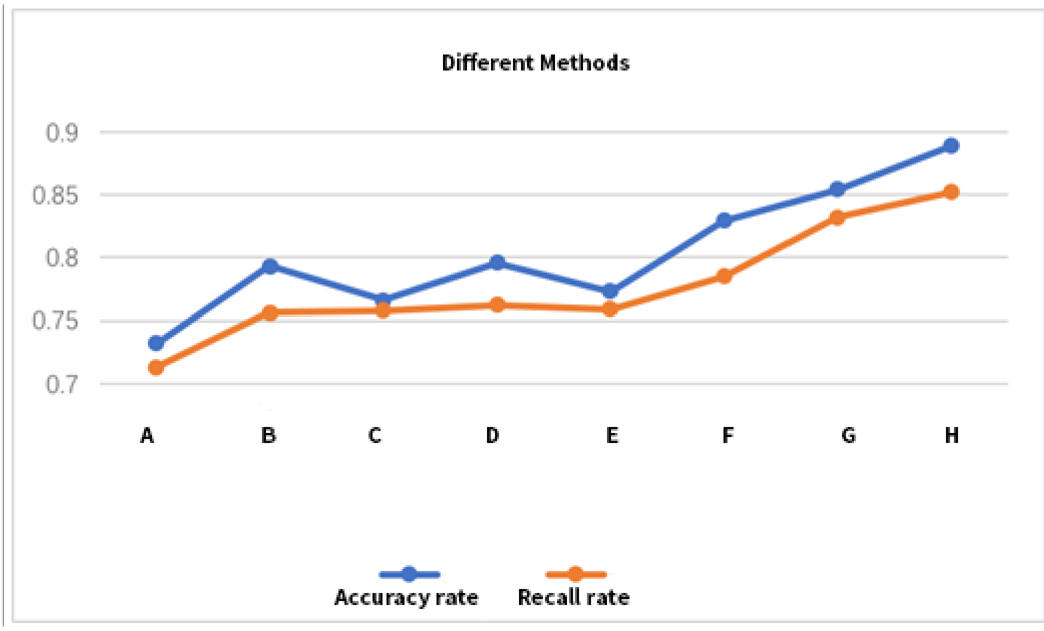

Figure 1The Comparison of experimental results of different methods. <**A** entropy weight method; **B** RBF neural network; **C** fuzzy combination; **D** factor analysis; **E** method in literature [7]; **F** method in literature [15]; **G** method of formula (3); **H** method of formula (3)>

The experimental results are shown in Figure 1. As can be seen from the experimental results of accuracy and recall rates, the method herein is superior to those in the above literature. By comparison, the method of formula (4) is superior.

4. Conlusion

In multi-attribute comprehensive evaluation, due to the uncertainty and difference of the evaluation methods, there will be different results in evaluation of an object by a variety of logically feasible evaluation methods, so combination evaluation is needed. It can reduce random error and system deviation in the evaluation process and improve credibility of the evaluation results. The low-voltage power consumer combination evaluation method proposed herein based on bias entropy improves the traditional combination evaluation model, and takes information combination into account from the perspective of quality of compatible method set. It not only enables minimal deviation between combination evaluation result and single evaluation results to reflect characteristics of most methods, but also enables maximally high quality of compatible method set to ensure objective and credible combination evaluation. Experiment verifies that the method herein is effective and feasible, and the result is reliable and practical.

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2019, Volume 3, Issue 1, 13-20, DOI: 10.6723/TERP.201908_3(1).0002

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Author Introduction

Xin He, a master of Data Science, Southwest Forestry University, research directions: data analysis.