

The Risk Assessment Study for Electric Power Marketing Competitiveness Based on Cloud Model and TOPSIS

Cunbin Li^{1, a)}, Yi Wang^{1, b)} and Shuaishuai Lin^{1, c)}

¹Institute School of Economics and Management, North China Electric Power University, Beijing 102206, China

E-mail: ^{a)} lcb999@263.com, ^{b)} wyi@ncepu.edu.cn

Abstract. With the rapid development of the energy internet and the deepening of the electric power reform, the traditional marketing mode of electric power does not apply to most of electric power enterprises, so must seek a breakthrough, however, in the face of increasingly complex marketing information, how to make a quick, reasonable transformation, makes the electric power marketing competitiveness assessment more accurate and objective becomes a big problem. In this paper, cloud model and TOPSIS method is proposed. Firstly, build the electric power marketing competitiveness evaluation index system. Then utilize the cloud model to transform the qualitative evaluation of the marketing data into quantitative values and use the entropy weight method to weaken the subjective factors of evaluation index weight. Finally, by TOPSIS method the closeness degrees of alternatives are obtained. This method provides a novel solution for the electric power marketing competitiveness evaluation. Through the case analysis, the effectiveness and feasibility of this model are verified.

1. Introduction

In recent years, with the deepening of the electric power reform, the electric power marketing [1] becomes more and more important for the basic work of electric power enterprises. The effective risk assessment of electric power marketing will not only affect the stability of enterprise and customer satisfaction, but also has an important significance for long-term development of enterprise. So, how to set up the electric power marketing risk assessment index and make an effective risk assessment is the first problem of electric power enterprise, and has an important theoretical and practical significance.

At present, more and more researches have been done on power marketing. In the literature [1], the interval of the assessment level is studied by the concept of cloud measure, and the early warning model of power marketing risk assessment based on cloud measure is constructed. The fuzzy AHP and fuzzy synthesis are used in literature [2] and [3]. In order to evaluate the effectiveness of the service strategy of the power supply enterprise, the literature [4] adopts the method of analytic hierarchy process and linear weighting method to study the quality of the power supply service and the power supply enterprise's marketing work. Combining the order relation method and AHP method, Literature [5] evaluates the marketing execution ability of the power supply enterprise and selects the Yantai power supply company as an example. The literature [6] analyzes the power marketing safety through expert investigation and brainstorming risk identification, taking into account the BP neural network, factor analysis and other methods of risk analysis and evaluation.

Based on the above literatures, we can see that: 1) At present, most of the current risk research for power marketing has taken into account the combination of qualitative and quantitative, but how to



convert the two is still a problem to be solved urgently. 2) There are many literatures on the evaluation of electric power marketing, but the research subjects rarely choose the risk assessment of power marketing competitiveness. Aiming at the above two points, this paper will establish a risk assessment model of power marketing competitiveness based on cloud model [7] and TOPSIS.

How to describe information is a major problem in the process of data mining and knowledge acquisition. The best way is to be expressed in natural language, because natural language can be better understood [8-10], while natural language is also the basis of thinking and intelligence, but many of the concepts in natural language are unknown factors, such as ambiguity, randomness, imprecision and incompleteness. In these unknown factors, randomness and fuzziness have aroused people's attention [12]. Although these uncertainties are difficult to define precisely, but its existence does not affect the exchange between people [11]. However, in order to make the computer have similar to human understanding and judgment, for the study of ambiguity and randomness is necessary [13].

Rough set and probability theory are the two most effective methods to deal with the uncertainty. However, considering the randomness of membership degree and probability, Professor Deyi Li put forward the cloud model theory on the basis of rough set and probability theory in 1995. This model is an indeterminate conversion model that deals with qualitative and quantitative descriptions. Because experts can't express their subjective professional judgments in numerical form, they are often replaced by fuzzy numbers or interval numbers, but both of the two ways have some limitations, and can't be like the natural language expression that fit the experts. On this basis, put forward the cloud model to implement the natural language evaluation transformation into quantitative values, provides a good foundation for quantitative decision.

2. Competitiveness Risk ASSESSMENT Index System

Electric power marketing competitiveness assessment refers to the electric power enterprise marketing aspects of the existence of the unique, advantages, in the face of adversity can survive and develop the ability to assess. Evaluation of the competitiveness of an enterprise should pay attention to the following four points:1) The operation of the current electric power marketing strategy; 2) What are the opportunities and threats, strengths and weaknesses that companies face in marketing;3) Whether the price and cost of the enterprise are competitive; 4) Relative to other enterprises, marketing competitive position.

Considering the above four points, and in order to make the evaluation valuable, we must use the following principles in the establishment of the index system: systematic, dynamic, typical, comparable and quantifiable. This article established an evaluation index system, including three first-level indicators and 20 secondary indicators, as shown in Figure 1.

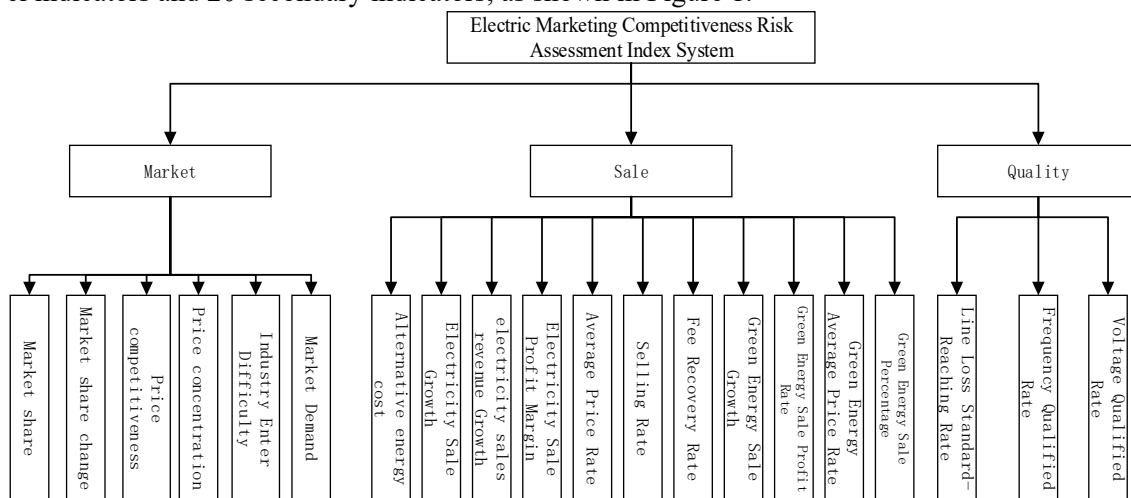


FIGURE 1. Electric marketing competitiveness risk assessment index system.

3. Cloud model introduction

3.1 Definition of cloud model

The cloud model is a method to convert the qualitative concept and the quantitative numerical phase. The model combines the knowledge of fuzzy mathematics and statistics to reflect the uncertainty of things and the ambiguity and randomness of human subjective thinking.

Definition1 U is a field with exact values, C is a qualitative concept in U , if there is a quantitative variable $x \in C$, and x is a random implementation in the qualitative concept C , the certainty $u(x) \in [0,1]$ for C is a random number with a stable tendency, such as equation 0, then the distribution in U of x is called cloud, each x is a cloud droplet.

$$u:U \rightarrow [0,1] \quad \forall x \in Ux \rightarrow u(x) \quad (0)$$

The cloud model has three digital features, namely, expectation value Ex , entropy En and super entropy He . In the process of the assessment, these three numerical features can be used to realize the transformation between qualitative concept and electric quantity data. Among them, the expectation value Ex is the most representative of the concept of qualitative point, and is the central information value of fuzzy concept. It is not only the center gravity of the cloud position, but also the most typical sample points of quantification for the qualitative concept. This paper selects the expected value Ex as the quantitative value for the conversion of qualitative concept. Entropy En reflects the uncertainty of qualitative concepts, including the randomness and ambiguity of qualitative concepts. In terms of randomness, entropy En mainly reflects the degree of discretization of cloud droplets, it also represents the randomness of cloud droplets. In terms of fuzziness, entropy En reflects the possibility of the qualitative concept, and it represents the value range of the droplet. In general, the greater En represents the greater uncertainty. The super entropy He is the entropy of the En , which is the uncertainty of the entropy En . It is determined by the randomness and fuzziness of the En . The super entropy He can indirectly reflect the cloud thickness of the cloud droplets in certain domain. The thickness of the cloud is not the same, close to the concept center and away from the concept of the center of the cloud thickness is small, between the cloud thickness is large, with the largest fuzzy value of the cloud thickness of the largest, as shown in Figure 2.

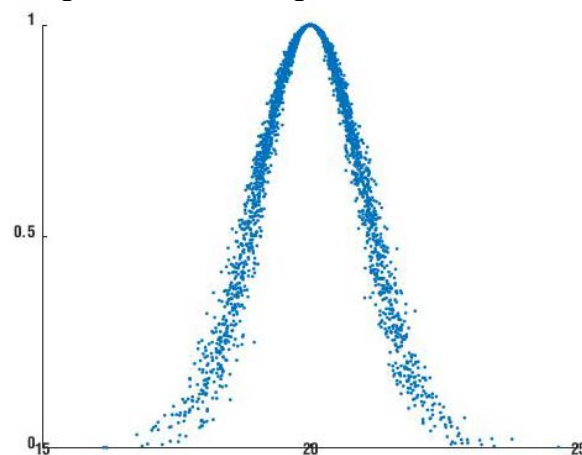


FIGURE 2. 20km membership cloud chart

Figure 2 shows the membership cloud of the concept of 20 km or so, in which $Ex = 20$, $En=1$, $He=0.1$, N (cloud droplet number) =3000. In the distance of 20 km and 20 km away, because the concept is uncertain small, cloud thickness is small; not far from 20 km near the cloud thickness increases, because the concept of uncertainty, and the subjective feelings of people is consistent.

3.2 The language evaluation value into the cloud method

Set the language of the experts to assess the scale as n (according to the actual situation arbitrarily

selected), experts specify the effective domain as $[X_{\min}, X_{\max}]$, you can generate n clouds to express the language value. In this paper, the language used in the evaluation scale is 5, using golden segmentation to generate five clouds. Set the middle cloud as $C_0(Ex_0, En_0, He_0)$, the left and right as $C_{-1}(Ex_{-1}, En_{-1}, He_{-1})$, $C_{+1}(Ex_{+1}, En_{+1}, He_{+1})$, $C_{-2}(Ex_{-2}, En_{-2}, He_{-2})$, $C_{+2}(Ex_{+2}, En_{+2}, He_{+2})$. The characteristics of these five clouds are shown in Table 1.

Table 1 Golden segmentation method to generate five cloud features digital calculation method

Cloud	Ex	En	He
$C_{+2}(Ex_{+2}, En_{+2}, He_{+2})$	X_{\max}	$En_{+1} / 0.618$	$He_{+1} / 0.618$
$C_{+1}(Ex_{+1}, En_{+1}, He_{+1})$	$Ex_0 + 0.382(X_{\max} + X_{\min}) / 2$	$0.382(X_{\max} - X_{\min}) / 6$	$He_0 / 0.618$
$C_0(Ex_0, En_0, He_0)$	$(X_{\min} + X_{\max}) / 2$	$0.618En_{+1}$	
$C_{-1}(Ex_{-1}, En_{-1}, He_{-1})$	$Ex_0 - 0.382(X_{\max} + X_{\min}) / 2$	$0.382(X_{\max} - X_{\min}) / 6$	$He_0 / 0.618$
$C_{-2}(Ex_{-2}, En_{-2}, He_{-2})$	X_{\min}	$En_{+1} / 0.618$	$He_{-1} / 0.618$

4. Research on risk assessment model of power marketing competitiveness based on cloud model and grey TOPSIS

Given m schemes and n evaluation indexes of electric power marketing competitiveness, for schema i , the evaluation value of risk factor C_j is $x_{ij} (0 < i \leq m, 0 < j \leq n)$, and the language evaluation matrix is $(x_{ij})_{m \times n}$. Based on the cloud model and gray correlation TOPSIS method, evaluation calculation steps are as follows:

4.1 Convert language evaluation value

According to the expert's language evaluation value, the method shown in Table 1 is transformed into the normal cloud model, and the language evaluation matrix given by the expert is transformed into the corresponding cloud model matrix.

Given the language evaluation level $V = \{(\text{high/hard/strong}), (\text{higher/harder/stronger}), (\text{general}), (\text{lower/easier/weaker}), (\text{low/easy/weak})\}$. The valid domain of the cloud model is $[0,1]$. Let $He_0 = 0.005$, according to the method of Table 1, five clouds $\{C_{+2}, C_{+1}, C_0, C_{-1}, C_{-2}\}$ corresponding to the language evaluation level are generated, and the numerical characteristics of the five clouds are shown in Table 2.

Table2 the characteristic number of 5 cloud

Evaluation Level	Cloud Model	Ex	En	He
high/hard/strong	$C_{+2}(Ex_{+2}, En_{+2}, He_{+2})$	1	0.104	0.013
higher/harder/stronger	$C_{+1}(Ex_{+1}, En_{+1}, He_{+1})$	0.691	0.064	0.008
general	$C_0(Ex_0, En_0, He_0)$	0.5	0.040	0.005
lower/easier/weaker	$C_{-1}(Ex_{-1}, En_{-1}, He_{-1})$	0.309	0.064	0.008
low/easier/weak	$C_{-2}(Ex_{-2}, En_{-2}, He_{-2})$	0	0.104	0.013

4.2 Normalize the decision matrix

Because of the existence of cost-type indicators and efficiency indicators in the listed index system, the initial decision matrix $(x_{ij})_{m \times n}$ is transformed into a standardized decision matrix $D = (d_{ij})_{m \times n}$ by normalizing the indexes using vector normalization.

$$d_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m d_{ij}^2}}, i = 1, 2, \dots, m; j = 1, 2, \dots, n \quad (1)$$

4.3 Obtain the index weight.

As the subjective weighting method has some limitations, here we take the entropy method to find the weight of the index, $W = (w_1, w_2, \dots, w_n)$.

- 1) Calculate the proportion p_{ij} of the i schema plan under the j index.

$$p_{ij} = \frac{d_{ij}}{\sum_{i=1}^m d_{ij}} \quad (2)$$

- 2) Calculate the entropy e_j of the j index.

$$e_j = -k \sum_{i=1}^m p_{ij} \cdot \ln p_{ij}, \quad k = 1 / \ln m \quad (3)$$

- 3) Calculate the entropy weight w_j of the j index.

$$w_j = (1 - e_j) / \sum_{j=1}^n (1 - e_j) \quad (4)$$

4.4 Find the weighted normalization matrix

the formula is as follows.

$$Y = WD = \begin{bmatrix} y_1(1) & y_1(2) & \dots & y_1(n) \\ y_2(1) & y_2(2) & \dots & y_2(n) \\ \vdots & \vdots & \vdots & \vdots \\ y_m(1) & y_m(2) & \dots & y_m(n) \end{bmatrix} \quad (5)$$

4.5 Determine the positive and negative ideal scheme

The positive and negative ideal solution of TOPSIS method is the optimal solution and the worst solution of the index under all schemes.

$$\begin{aligned} U_0^+ &= \{(\max_{1 \leq i \leq m} y_i(j), j \in J^+), (\min_{1 \leq i \leq m} y_i(j), j \in J^-)\} = (u_0^+(j)) \\ U_0^- &= \{(\min_{1 \leq i \leq m} y_i(j), j \in J^+), (\max_{1 \leq i \leq m} y_i(j), j \in J^-)\} = (u_0^-(j)) \end{aligned} \quad (6)$$

J^+ for efficiency indicator, J^- for cost-type indicator.

4.6 Determine the solution to the positive and negative ideal solution of the distance.

By calculating the distance of each scheme to the positive and negative ideal solution, we can see the distance between each scheme and the positive and negative ideal solution.

$$\begin{aligned} D_i^+ &= \sqrt{\sum_{j=1}^n [g_i(j) - u_0^+(j)]^2}, i = 1, 2, \dots, m \\ D_i^- &= \sqrt{\sum_{j=1}^n [g_i(j) - u_0^-(j)]^2}, i = 1, 2, \dots, m \end{aligned} \quad (7)$$

4.7 Determine the relative degree of the program.

According to the size of the close degree of the optimal sort, the greater the degree of close and

negative ideal solution that the greater the distance, that is, the better the program.

$$C_i^* = \frac{D_i^-}{D_i^+ + D_i^-} \tag{8}$$

5. Case study

Table 3 shows the marketing competitiveness data of an electric power enterprise from July to December, which quantitative data are the actual data of the enterprise, qualitative evaluations are based on the expert evaluation. The problem is a multi-attribute decision-making problem with six decision-making schemes and 20 evaluation indexes, and to determine the order of competitiveness in the final 6 months.

Table 3 Power marketing competitiveness original data

	7	8	9	10	11	12
C ₁	82.38	78.46	66.15	68.62	76.91	80.53
C ₂	5.16	4.96	3.87	4.02	4.01	5.22
C ₃	0.78	0.86	1.14	1.15	0.99	1.02
C ₄	general	general	higher	higher	High	high
C ₅	harder	hard	hard	general	hard	hard
C ₆	strong	strong	stronger	general	strong	strong
C ₇	higher	higher	general	lower	general	general
C ₈	9.79	12.89	2.28	5.54	8.17	6.98
C ₉	2.27	5.65	1.05	2.02	7.64	9.98
C ₁₀	high	higher	general	lower	lower	general
C ₁₁	110.56	102.43	84.62	99.04	104.56	108.11
C ₁₂	4.39	6.78	5.66	8.01	5.16	6.99
C ₁₃	71.22	89.45	87.66	90.21	94.35	95.12
C ₁₄	6.01	6.78	3.23	2.12	2.25	3.01
C ₁₅	2.57	2.43	0.69	0.22	2.79	2.98
C ₁₆	796.98	799.16	800.17	801.16	815.21	811.17
C ₁₇	4.95	4.92	3.28	2.98	1.31	1.09
C ₁₈	109.8	112.5	100.3	99.2	96.5	95.4
C ₁₉	93.21	92.11	97.06	99.67	99.82	98.16
C ₂₀	96.12	96.71	97.43	98.98	99.17	99.16

1) According to Table 1 and Table 2, the qualitative language in Table 3 is transformed into a cloud model. Since the expected value is the most representative point of qualitative concept, the expected value *Ex* is used as the index value after conversion.

Table 4 Qualitative language into quantitative values

	7	8	9	10	11	12
C ₄	0.5	0.5	0.691	0.691	1	1
C ₅	0.691	1	1	0.5	1	1
C ₆	1	1	0.691	0.5	1	1
C ₇	0.691	0.691	0.5	0.309	0.5	0.5
C ₁₀	1	0.691	0.5	0.309	0.309	0.5

2) Normalize the quantitative data in Table 3 and Table 4 according to the formula (1) to obtain the normalized matrix $D = (d_{ij})_{m \times n}$ and use the entropy method of the formula (2-4) for the matrix to obtain 20 evaluation indexes weighing, based on the known weight, we can use the formula (5) to calculate the weighted evaluation matrix. Here, due to the limited space, only the final weight value and weighted evaluation matrix are listed.

$$W = \{0.026, 0.045, 0.023, 0.009, 0.005, 0.013, 0.011, 0.092, 0.085, 0.113, 0.068, 0.033, 0.053, 0.031, 0.024, 0.022, 0.026, 0.046, 0.137, 0.147\}$$

Weighted evaluation matrix:

$$Y = WD = \begin{bmatrix} 0.012 & 0.011 & 0.009 & 0.010 & 0.011 & 0.011 \\ 0.021 & 0.020 & 0.016 & 0.016 & 0.016 & 0.021 \\ 0.007 & 0.008 & 0.011 & 0.011 & 0.009 & 0.010 \\ 0.002 & 0.002 & 0.003 & 0.003 & 0.005 & 0.005 \\ 0.002 & 0.002 & 0.002 & 0.001 & 0.002 & 0.002 \\ 0.006 & 0.006 & 0.004 & 0.003 & 0.006 & 0.006 \\ 0.006 & 0.006 & 0.004 & 0.003 & 0.004 & 0.004 \\ 0.044 & 0.058 & 0.010 & 0.025 & 0.037 & 0.031 \\ 0.014 & 0.034 & 0.006 & 0.012 & 0.046 & 0.060 \\ 0.077 & 0.053 & 0.038 & 0.024 & 0.024 & 0.038 \\ 0.030 & 0.028 & 0.023 & 0.027 & 0.029 & 0.030 \\ 0.009 & 0.014 & 0.012 & 0.017 & 0.011 & 0.015 \\ 0.018 & 0.022 & 0.022 & 0.022 & 0.023 & 0.023 \\ 0.017 & 0.020 & 0.009 & 0.006 & 0.007 & 0.009 \\ 0.011 & 0.011 & 0.003 & 0.001 & 0.012 & 0.013 \\ 0.009 & 0.009 & 0.009 & 0.009 & 0.009 & 0.009 \\ 0.016 & 0.015 & 0.010 & 0.009 & 0.004 & 0.003 \\ 0.020 & 0.020 & 0.018 & 0.018 & 0.018 & 0.017 \\ 0.054 & 0.053 & 0.056 & 0.058 & 0.058 & 0.057 \\ 0.055 & 0.055 & 0.056 & 0.057 & 0.057 & 0.057 \end{bmatrix}$$

3) The distance from the scheme to the positive and negative ideal scheme is calculated by the formula (6-7) as shown below and plotted as shown in figure 3.

$$D_i^+ = \{0.049, 0.036, 0.084, 0.082, 0.062, 0.050\}$$

$$D_i^- = \{0.068, 0.067, 0.019, 0.019, 0.051, 0.062\}$$

In the figure 3, the abscissa represents 1-6 of the six schemas, the ordinate is the distance between the schema and the positive and negative ideal solution, line1 represents the distance between the schema and the positive ideal solution, and line2 represents the distance between the schema and the negative ideal solution. From the two curves in the figure can be roughly analyzed the 6 months of the enterprise's power marketing competitiveness of the situation.

4) Finally, according to the calculated positive and negative ideal solution of the distance from the formula (8) to get the proximity of each schema.

$$C_i^* = \{0.577, 0.647, 0.181, 0.188, 0.451, 0.555\}$$

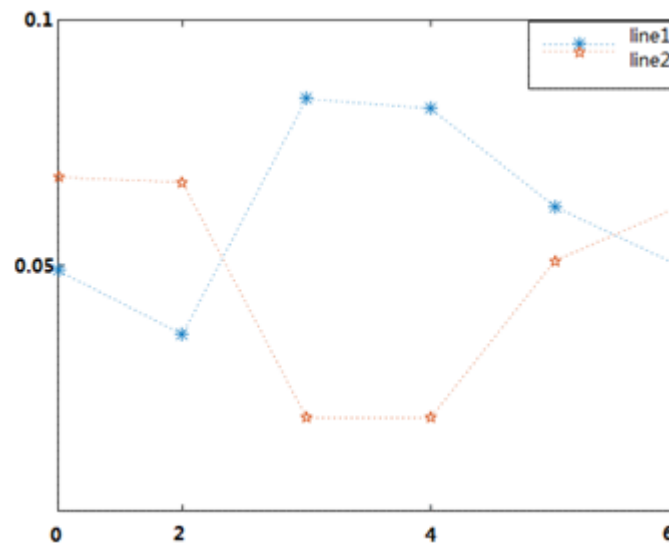


FIGURE 3. The distance between the schemes and the positive and negative ideal solutions

5) Sorting. The 6-month electricity marketing competitiveness is sorted according to the degree of proximity in step 4): August> July> December> November> October> September.

Because the electric power marketing competitive ability and profit directly related, so the profit of the six months of the comparative analysis found that the size of the profit and power marketing competitiveness of the same order, which also shows that the model built in this article has a scientific and rationality, and can provide a basis for the decision-making of electric power marketing competitiveness.

6. Conclusion

1) Based on the comprehensive consideration of market share, sales situation and product quality, this paper has established 20 comprehensive evaluation indexes system which includes qualitative and quantitative, cost-effective and cost-type. Through the study of evaluation indexes systems, it can be a deeper understanding about the status quo of the electric power marketing competitiveness.

2) In order to obtain more objective evaluation results, this paper introduces the cloud model, realizes the qualitative evaluation of the scientific and rational transformation of the qualitative evaluation language to the quantitative value, effectively solves the fuzziness and randomness of the natural language evaluation. At the same time, the cloud model and TOPSIS method are combined to propose a more scientific evaluation method. In addition, in the calculation of index weight, the use of entropy, effectively weaken the subjective factors of expert evaluation, making the evaluation results more practical and objective.

3) An example is given to analyze the marketing data of an electric power enterprise for six months. The evaluation model proposed in this paper is analyzed and verified, which provides a new method and new idea for the evaluation of power marketing competitiveness. At the same time, the model can also be used for electric power target market state analysis, electric power marketing evaluation early warning and other fields.

Acknowledgments

This article is sponsored by the National Natural Science Foundation of China, No 71271084.

References

- [1] Yang Wu and Junyong Li. Research on assessment and forewarning model of power marketing condition based on cloud measure theory[J] (The Power System Protection and Control, 2013, 1) pp. 61–69.
- [2] He Wang, Ming Zeng, Shan Chen, Jian Zhou and Zhixiang Zhang. *Comprehensive Evaluation*

- Model for Power Supply Service Quality Based on Fuzzy Analytic Hierarchy Process*[J] (The Power System Technology, 2006, 17) pp. 92–96.
- [3] Wei Sun and Jingru Li. *Establishment and Evaluation Method of Performance Indicator System for Comprehensive Power Marketing of Power Utilities*[J] (Electric Power Technologic Economics, 2006, 03) pp. 54–58.
- [4] Ming Zeng, Zhou Liang, Yong Ju and Guo Tian. *Evaluation of Service Strategy of Power Supply Enterprise Based on AHP* [J] (Technoeconomics & Management Research, 2010, 02) pp. 8–11.
- [5] Tingjing Ruan. *Research on the Evaluation of Marketing Executive Power in Power Supply Companies* [D], North China Electric Power University, 2014.
- [6] Xiaoqian Du. *Research on marketing security risk evaluation and management system of electricity power enterprise*[D], North China Electric Power University, 2012.
- [7] Zongze Li and Chengjun Shi. *Simulation research on PID excitation system of synchronous generator based on two-dimensional cloud model*[J] (Power System Protection and Control, 2016, 07) pp 19-24.
- [8] K. Alexandridis, Y. Maru, Collapse and reorganization patterns of social knowledge representation in evolving semantic networks, Inform. Sci. 200(2012) 1–21.
- [9] J. Dassow, F. Manea, R. Mercas, Regular languages of partial words, Inform. Sci. 268 (2014) 290–304.
- [10] J.Q. Wang, P. Lu, H.Y. Zhang, X.H. Chen, Method of multi-criteria group decision-making based on cloud aggregation operators with linguistic information, Inform. Sci. 274 (2014) 177–91.
- [11] Akbarzadeh-T, A qualified description of extended fuzzy logic, Inform. Sci. 244 (2013) 60–74.
- [12] G.Y. Wang, C.L. Xu., Q.H. Zhang, X.R. Wang, A multi-step backward cloud generator algorithm, in: Proceeding of 8th International Conference on Rough Sets and Current Trends in Computing, LNAI, vol. 7413, 2012, pp. 313–322.
- [13] K. Alexandridis, Y. Maru, Collapse and reorganization patterns of social knowledge representation in evolving semantic networks, Inform. Sci. 200(2012) 1–21.

Reproduced with permission of copyright owner. Further reproduction prohibited without permission.