Analysis and Evaluation of Independent Electricity Retailer Competitiveness: A Matter-Element Extension Model Study

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Abstract

Under the situation of new electricity reform, a large number of social capital to set up an independent electricity retailer exacerbates the competition in electricity market. How to reasonably and effectively evaluate the core competitiveness of the independent electricity retailers in the electricity market has become an urgent problem to be solved. This paper constructed evaluation index system on the basis of snowflake model, evaluated the competitiveness of independent electricity company based on Matter-Element Extension model and verified this model by taking power selling company A as an example. Finally, this paper provided some solutions to improve the competitiveness of company A. This research has some reference value for the independent retailer to improve competition and provides guidance for its future development.

Keywords

Independent electricity retailer, competitiveness, snowflake model, Matter-Element Extension Model.

1. Introduction

"Orderly opening power selling business to social finance and encouraging power selling subject establishment of social investment" of Some Opinions about Deepening Power System Reform issued on March 15, 2015 announced that Chinese power selling market had been opened. Besides, further deepening of Chinese power market reform intensifies the market competition. Competition subjects of power selling market includes Grid companies, power selling subjects composed by power generation companies, distributed generation, power saving service companies, high-tech industrial parks and power selling companies1. In terms of power selling companies, based on relative data, more than 2000 companies have been established in China with a rising trend. Therefore, independent electricity retailers should identify their own competitive advantages and determine their market positions, which need scientific competitiveness evaluation.

According to research at home and abroad, foreign mature power market development generates further research on competitiveness evaluation of power selling companies. Tsutsui M et al. evaluated multistage energy efficiency of American Electric Power Co. Inc. with the SBM measurement model2. Mungyu Bae et al. analyzed the business model and pricing system of competitive power market, put forward the power distribution automatic standard and the intelligent measurement interface, and provided information security solutions3. Wioletta Sokołowsk et al. adopted tendentious analysis method to explore the ways power selling companies adjust to competitive market and attract potential customers4. Chinese power system reform now remains at the primary stage, so most of domestic relative research about competitiveness of selling companies uses qualitative methods. Huang Kangren

firstly described the situation and the development trend of Chinese power system reform, and secondly used PEST analysis, Porter's Five Forces, Cannikin Law and SWOT method to analyze the competitive circumstance5. Liu Wenya showed the construction process of a selling company, classified selling subjects into 6 classifications and evaluated them with Fuzzy Comprehensive Evaluation6. Zhang Qiuyi discussed the methods of improving competitiveness from aspects of brand, service, management and talents7. Liu Juan started with key points of the evaluation chain, constructed corresponding evaluation index system and evaluated with Entropy Weight8.

From above all, there is less research on competitiveness evaluation of independent electricity retailers at home and abroad. Meanwhile, the general way to improve the competitiveness of a company is to provide service and create value for the customers. Therefore, this paper will focus on the point of improving competitiveness of independent electricity retailers, combined with the situation of Chinese power system reform, construct the snowflake model of competitiveness influencing factors and evaluate the competitiveness with Matter-Element Extension model to provide theoretical foundation for independent electricity retailers.

2. Competitiveness Influencing Factors Identification of Independent Electricity Retailer

Under the circumstance of Chinese power system reform, the major influencing factors are power supply security and quality, power sales and added value service.

Power supply security and quality: high power supply quality helps to maintain system operation and attract potential power customers.

Power sales: the main way to obtain profit and realize value addition because power product cannot be stored.

Added value service: value, quality and service advantage of product are the key factors of competition. However, power product homogeneity cannot be avoided, which makes top quality and differentiation of service more important.

As to the assist processes in the value chain, such as infrastructure, human resource, technology development and purchasing, can be reflected in above 3 processes. Based on these processes, opinions of experts and relative research, this paper constructs the snowflake model of competitiveness evaluation influencing factors of independent electricity retailer and shows the model in following Figure 1.

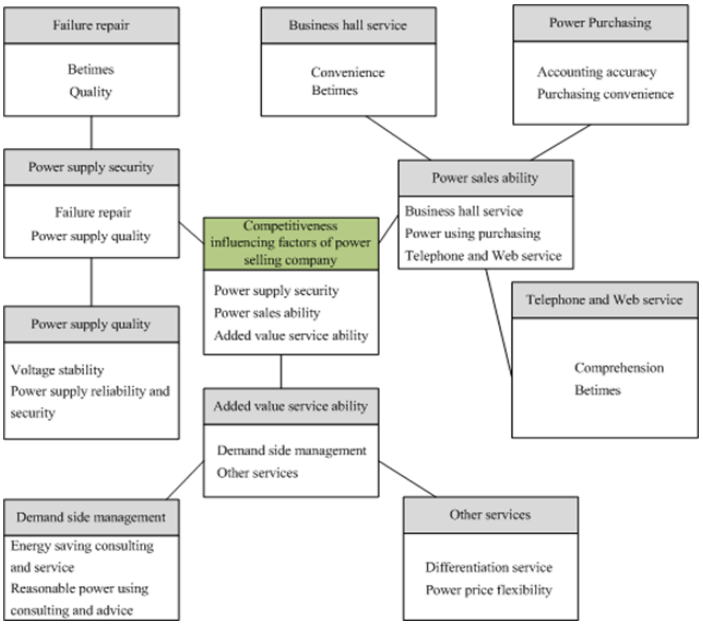

Figure 1. Snowflake model of competitiveness influencing factors of independent electricity retailer

3. Matter-Element Extension Model

Matter-element extension model was created by Chinese researcher Cai Wen in 1983, and it's widely used in comprehensive evaluation of various fields9-10. This paper adopts this model and uses correlation function to describe the competitiveness level of the independent electricity retailer.

3.1 Classical Field And Segment Field Determination

Matter-element extension model describes matter, its characters and character measurement value with ordered set, namely R (matter, character, character measurement value).

$$R_0 = \begin{bmatrix} N_{0j} & c_1 & X_{0j1} \\ & c_2 & X_{0j2} \\ & \cdots & \cdots \\ & c_n & X_{0jn} \end{bmatrix} = \begin{bmatrix} N_{0j} & c_1 & \langle a_{0j1}, b_{0j1} \rangle \\ & c_2 & \langle a_{0j2}, b_{0j2} \rangle \\ & \cdots & \cdots \\ & c_n & \langle a_{0jn}, b_{0jn} \rangle \end{bmatrix} \tag{1}$$

Among which, R_0 is the matter-element of the j-th level of competitiveness, N_{0j} shows the competitiveness level is of the j-th (j=1,2,…,n) level, c_i (i=1,2,…,n) is the character of competitiveness level, and X_{0ji} (i=1,2,…,n) is the measurement value range of character c_i of competitiveness level N_{0j}, which is also called the classical field.

The allowed value ranges of all competitiveness evaluation indexes compose the matter-element model named the segment field, represented by R_p.

$$R_P = \begin{bmatrix} P & c_1 & X_{P1} \\ & c_2 & X_{P2} \\ & \cdots & \cdots \\ & c_n & X_{Pn} \end{bmatrix} = \begin{bmatrix} P & c_1 & \langle a_{P1}, b_{P1} \rangle \\ & c_2 & \langle a_{P2}, b_{P2} \rangle \\ & \cdots & \cdots \\ & c_n & \langle a_{Pn}, b_{Pn} \rangle \end{bmatrix} \tag{2}$$

In Equation (2), R_P is the segment field, P is the comprehensive evaluation level, X_{Pi} (i=1,2,…n) is the value range of c_i (i=1,2,…n) of level P, obviously, $X_{0i} \in X_{Pi}$ (i=1,2,…n).

3.2 Correlation Function Calculation

In competitiveness evaluation of independent electricity retailer, p presents the target company, c_i is the evaluation index, and v_i is the value of corresponding index. Therefore, its matter-element can be determined by following Equation (3).

$$R = (P, C, V) = \begin{bmatrix} P & c_1 & V_1 \\ & c_2 & V_2 \\ & \cdots\cdots & \\ & c_n & V_n \end{bmatrix} \tag{3}$$

In the matter-element extension comprehensive evaluation model, if the value of matter-element is taken at some point of the real axis, the correlation function represents the level of matter-element11. The evaluating matter-elements, namely the correlation functions of competitiveness indexes and various levels, can be calculated with Equation (4).

$$K_j(v_i) = \begin{cases} \dfrac{-\rho(v_i, V_{ji})}{|V_{ji}|} & vi \in V_{ji} \\ \dfrac{\rho(v_i, V_{ji})}{\rho(v_i, V_{pi}) - \rho(v_i, V_{ji})} & vi \notin V_{ji} \end{cases} \tag{4}$$

In Equation (4), $K_j(v_i)$ means the correlation function of i-th index about j-th level, $|V_{ji}|$ is the distance of classical field of i-th index about j-th level, (v_i, V_{pi}) is the distance between evaluating matter-element value of i-th index and its classical field, and $\rho(v_i, V_{pi})$ represents the distance between evaluating matter-element value of i-th index and its segment field.

3.3 Weight Determination and Membership Calculation

If $K_j(p_0) = \max\{K_j(p_0)\}(j = 1,2,\ldots,m)$, the evaluating matter-element belongs to j-th level. Among which:

$$j^* = \frac{\sum_{j=1}^{m} j\overline{K_j}(p_0)}{\sum_{j=1}^{m} j\overline{K_j}} \tag{5}$$

$$\overline{K_j}(p_0) = \frac{K_j(p_0) - \min K(p_0)}{\max K(p_0) - \min K(p_0)} \tag{6}$$

In Equation (5) and (6), j^* is the variable value of risk level of p_0, and the value of j^* can evaluate the adjacent levels of evaluating matter-element and the distances between them12.

4. Analysis of Examples

With the development of power market, more and more independent electricity retailers have been established. Due to different market positioning, management modes, benefit modes and scales, we need to evaluate company's competitiveness level to improve its competitiveness, enlarge the market and improve customer loyalty of independent electricity retailer. This paper takes power selling company A in Zhejiang province as example and uses matter-element extension model to evaluate its competitiveness level. Company A actively responses to national policies and was established in the initial stage of Chinese power system reform with 30 million of registered fund. Its businesses include power sales, electric engineering design, contract energy management, computer integration and new energy development. This paper uses the matter-element extension model to evaluate its competitiveness level in following steps.

(1) First of all, we need to construct the evaluating index system of company A. The index system is constructed as Figure 1. Among which, this index system has 3 first grade indexes, 7 second grade indexes and 14 third grade indexes. The first grade indexes include power supply quality, power sales ability and added value service and the second grade indexes include failure repair, power supply quality, business hall service, power using purchasing, telephone and Web service, demand side management and other services.

(2) Second, based on opinions of relative experts, dividing the competitiveness level into 5 degrees: Excellent, Good, Medium, General, and Fail .

(3) The classical fields of quantitative indexes of the third grade indexes in Figure 2 are given by expert experience and divided into 0-20%, 20%-40%, 40%-60%, 60%-80%, and 80%-100%. Meanwhile, the value calculations of qualitative indexes are obtained with Expert Grade Method, and their classical fields are 0-2, 2-4, 4-6, 6-8, and 8-10. Therefore, we can obtain the values of classical fields R_1', R_2', R_3', R_4', R_5' and evaluating matter-element R_0' as follows:

$$R_1' = \begin{bmatrix} N_1 & C_1 & (0,0.2) \\ & C_2 & (0,0.2) \\ & C_3 & (0,0.2) \\ & C_4 & (0,0.2) \\ & C_5 & (0,0.2) \\ & C_6 & (0,0.2) \\ & C_7 & (0,0.2) \\ & C_8 & (0,0.2) \\ & C_9 & (0,0.2) \\ & C_{10} & (0,0.2) \\ & C_{11} & (0,0.2) \\ & C_{12} & (0,0.2) \\ & C_{13} & (0,0.2) \\ & C_{14} & (0,0.2) \end{bmatrix} \quad R_2' = \begin{bmatrix} N_2 & C_1 & (0.2,0.4) \\ & C_2 & (0.2,0.4) \\ & C_3 & (0.2,0.4) \\ & C_4 & (0.2,0.4) \\ & C_5 & (0.2,0.4) \\ & C_6 & (0.2,0.4) \\ & C_7 & (0.2,0.4) \\ & C_8 & (0.2,0.4) \\ & C_9 & (0.2,0.4) \\ & C_{10} & (0.2,0.4) \\ & C_{11} & (0.2,0.4) \\ & C_{12} & (0.2,0.4) \\ & C_{13} & (0.2,0.4) \\ & C_{14} & (0.2,0.4) \end{bmatrix}$$

$$R_3' = \begin{bmatrix} N_3 & C_1 & (0.4,0.6) \\ & C_2 & (0.4,0.6) \\ & C_3 & (0.4,0.6) \\ & C_4 & (0.4,0.6) \\ & C_5 & (0.4,0.6) \\ & C_6 & (0.4,0.6) \\ & C_7 & (0.4,0.6) \\ & C_8 & (0.4,0.6) \\ & C_9 & (0.4,0.6) \\ & C_{10} & (0.4,0.6) \\ & C_{11} & (0.4,0.6) \\ & C_{12} & (0.4,0.6) \\ & C_{13} & (0.4,0.6) \\ & C_{14} & (0.4,0.6) \end{bmatrix} \quad R_4' = \begin{bmatrix} N_4 & C_1 & (0.6,0.8) \\ & C_2 & (0.6,0.8) \\ & C_3 & (0.6,0.8) \\ & C_4 & (0.6,0.8) \\ & C_5 & (0.6,0.8) \\ & C_6 & (0.6,0.8) \\ & C_7 & (0.6,0.8) \\ & C_8 & (0.6,0.8) \\ & C_9 & (0.6,0.8) \\ & C_{10} & (0.6,0.8) \\ & C_{11} & (0.6,0.8) \\ & C_{12} & (0.6,0.8) \\ & C_{13} & (0.6,0.8) \\ & C_{14} & (0.6,0.8) \end{bmatrix}$$

$$R_5' = \begin{bmatrix} N_5 & C_1 & (0.8,1) \\ & C_2 & (0.8,1) \\ & C_3 & (0.8,1) \\ & C_4 & (0.8,1) \\ & C_5 & (0.8,1) \\ & C_6 & (0.8,1) \\ & C_7 & (0.8,1) \\ & C_8 & (0.8,1) \\ & C_9 & (0.8,1) \\ & C_{10} & (0.8,1) \\ & C_{11} & (0.8,1) \\ & C_{12} & (0.8,1) \\ & C_{13} & (0.8,1) \\ & C_{14} & (0.8,1) \end{bmatrix} \quad R_0' = \begin{bmatrix} N_5 & C_1 & 0.58 \\ & C_2 & 0.43 \\ & C_3 & 0.38 \\ & C_4 & 0.69 \\ & C_5 & 0.73 \\ & C_6 & 0.82 \\ & C_7 & 0.72 \\ & C_8 & 0.34 \\ & C_9 & 0.45 \\ & C_{10} & 0.12 \\ & C_{11} & 0.34 \\ & C_{12} & 0.38 \\ & C_{13} & 0.46 \\ & C_{14} & 0.89 \end{bmatrix}$$

Where, R_1', R_2', R_3', R_4', R_5' are the classical fields, the competitiveness evaluation level of N_1, N_2, N_3, N_4 and N_5 means Fail, General, Medium, Good and Excellent, and R_0' is the evaluating matter-element.

(4) This paper adopts fuzzy analytic hierarchy process to determine index weights. The first step is to get the hierarchical relation of different layers of indexes, the second step is to determine index weights by pairwise comparison, and the last step is to obtain the index weight of every index to the general goal. In this way, the index weights are obtained:

ω=（0.0732,0.0498,0.0812,0.1218,0.0533,0.0767,0.1140,0.0760,0.1002,0.0688,0.0501,0.0595,0.0301,0.0453）

(5) Calculate the classical field distances of evaluating matter-element, results of which are showed in following Table 1.

Table 1. Distances between data and new classical fields of evaluating matter-element

Index	Fail D1(vi)	General D2(vi)	Medium D3(vi)	Good D4(vi)	Excellent D5(vi)
C1	0.38	0.18	-0.02	0.02	0.22
C2	0.23	0.03	-0.03	0.17	0.37
C3	0.18	-0.02	0.02	0.22	0.42
C4	0.49	0.29	0.09	-0.09	0.11
C5	0.53	0.33	0.13	-0.07	0.07
C6	0.62	0.42	0.22	0.02	-0.02
C7	0.52	0.32	0.12	-0.08	0.08
C8	0.14	-0.06	0.06	0.26	0.46
C9	0.25	0.05	-0.05	0.15	0.35
C10	-0.08	0.08	0.28	0.48	0.68
C11	0.14	-0.06	0.06	0.26	0.46
C12	0.18	-0.02	0.02	0.22	0.42
C13	0.26	0.06	-0.06	0.14	0.34
C14	0.69	0.49	0.29	0.09	-0.09

(6) Comprehensive competitiveness level determination of company A. The correlation degrees of different competitiveness levels are:

$K_1(p_0) = 1 - \sum_{i=1}^{14} \omega_i D_{i1} = 0.664196$ $K_2(p_0) = 1 - \sum_{i=1}^{14} \omega_i D_{i4} = 0.839748$ $K_3(p_0) = 1 - \sum_{i=1}^{14} \omega_i D_{i2} = 0.919108$

$K_4(p_0) = 1 - \sum_{i=1}^{14} \omega_i D_{i5} = 0.893224$ $K_5(p_0) = 1 - \sum_{i=1}^{14} \omega_i D_{i3} = 0.737004$

$K_3(p_0) = \max K_j(p_0)$ (j=1, 2, 3, 4, 5) means the competitiveness level of company A is the medium.

Analyzing matrix R_0', we can find that the major influencing factors are voltage stability, comprehension and betimes of Web service, energy saving consulting and service, and reasonable power using consulting and service. Among them, the evaluating level of comprehension and betimes

of Web service of company A is Fail. Relative research shows that this company has no official website and relative website consulting service.

For this reason, company A should build its official website and introduce its businesses, operation situation, organization system and other information, construct the real time conversion platform to improve its online service and gain customer loyalty, provide energy saving consulting and reasonable power using consulting and other services and corresponding energy saving programs, and negotiate with power supplier to improve power supply stability.

5. Conclusion

As a new market entity, the external environment and operation mode of the independent electricity retailer are complex and changeable. The snowflake model is built to determine the factors that affect the core competitiveness of independent electricity retailers. On this basis, the fuzzy comprehensive evaluation model is used for the relevant evaluation. Finally, an example is given to verify the effectiveness of the model, which provides a theoretical basis and practical significance for the evaluation and promotion of the core competitiveness of the independent electricity retailer.

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References

[1] Hu Chen, Du Songhuai, Su Juan, et al., Power purchasing ways and operation modes research considering Chinese power system reform, Power System Technology, vol.40, no.11, pp.3293-3299, 2016.

[2] Tsutsui M, Goto M, A multi-division efficiency evaluation of U.S. electric power companies using a weighted slacks-based measure, Socio-Economic Planning Sciences, vol.43, no.3, pp.201-208, 2009.

[3] Bae M, Kim H, Kim E, et al., Toward electricity retail competition: Survey and case study on technical infrastructure for advanced electricity market system, Applied Energy, vol.133, no.10, pp.252-273, 2014.

[4] Wioletta Sokotowska, Tymoteusz Hossa, Karol Fabisz, et al., Sentiment Analysis as a Source of Gaining Competitive Advantage on the Electricity Markets, Journal of Electronic Science and Technology, no.3, pp.229-236, 2015.

[5] Huang Kangren, Competitive strategy research on power selling subject of Chinese power system reform, North China Electric Power University (Beijing), 2016.

[6] Liu Wenya, Jiao Jie, The evaluation research of main bodies' competitiveness of the electric selling market in the future based on the fuzzy comprehensive evaluation method, Power Demand Side Management, no.05, pp.15-20, 2016.

[7] Zhang Qiuyi, Zhang Xiaoxv, Meng Fanli, et al., Thinking about improving competitiveness of power supply companies considering open power selling market, Rural Power Management, no.12, pp.43-44, 2016.

[8] Liu Juan, Yang Xinfa, Yao Jiangang, et al., Design and Application of the Index System for the Competitiveness Evaluation of Power Supplying Enterprises, Proc. of the CSU-EPSA, vol.22, no.3, pp.118-122, 2010.

[9] Li Hongze, Guo Sen, Tang Hui and Li Chunjie, Comprehensive Evaluation on Power Quality Based on Improved Matter-Element Extension Model with Variable Weight, Power System Technology, no.03, pp.653-659, 2013.

[10] Li Congdong, Chen Xiaofeng and Gao Lianyi, Evaluation of the Competitive Competence of Enterprise Using Extension Method, INDUSTRIAL ENGINEERING JOURNAL, no.04, pp.5-10, 2005.

[11] Zhang Fangfang, Risk study on investment and financing platform of local government of Hunan province based on matter-element extension model, Central South University, 2010.
[12] He Yongxiu, Electricity comprehension evaluation method and application, China Electric Power Press, Beijing, 2011.