Research on Comprehensive Evaluation of Power Grid Enterprise Information Management

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Abstract: With the rapid development of China's economy and information technology, power grid enterprise informatization also conforms to the trend of The Times. How to objectively and scientifically evaluate the benefits of the information construction of power grid enterprises has become a major problem. Therefore, it is of great significance to establish a set of scientific and systematic evaluation index system for the development of power grid enterprise informatization. On the basis of studying the theories and methods of enterprise informatization evaluation at home and abroad, and combining the previous research results and expert opinions, this paper establishes a set of informatization evaluation index system with characteristics of power grid enterprises. Then using analytic hierarchy process (AHP) to give weight to the index, to do information evaluation for a power grid enterprise. Data were collected through field survey and expert questionnaire, and fuzzy comprehensive evaluation method (FCE) was used to evaluate the enterprise.

1. Introduction

With the rapid development of computer technology and communication technology, informatization has gradually penetrated into various fields of the economy and society, and has a far-reaching impact on the development of electric power economy. However, power grid enterprises are also faced with great difficulties in the construction of informatization, such as inaccurate direction of informatization construction, lack of investment and shortage of human resources. Therefore, power grid enterprises must have a clear understanding of their own information construction degree, which requires a set of scientific evaluation index system to measure.

After decades of development, the theories and models of the information evaluation system have become mature, among which the representative methods are the information index method, borat method, mark lupp method, Nolan model and the information society index method [1-4]. Li Yang et al. studied the index system and evaluation method of power information monitoring platform under the current provincial and regional integration framework. The information entropy and time degree are introduced to form the time sequence vector and the dynamic scale evaluation model is established [5]. Mo yifu et al. studied the complexity characteristics of smart grid information management system and proposed a complexity evaluation method based on structural entropy [6]. Chen qi et al. put forward the design and implementation scheme of the power informatization supervision system aiming at the current situation that the information collection and management is seriously restricted in the power supervision work of the southern power supervision bureau [7-10].

Based on previous studies, this paper establishes a set of reasonable and accurate evaluation index system. The purpose is to guide the grid enterprise informatization on the basis of effective measures, so that enterprises have a correct understanding of informatization work. At the same time, it can put forward scientific Suggestions for enterprises in the evaluation process of power grid enterprise informatization. And it can also help enterprises solve the problems encountered in the information construction.

2. Power Grid Enterprise Informatization Evaluation Index System Design

Based on the characteristics of power grid enterprise informatization construction and the theory of national informatization index, this paper designs a highly operable evaluation index system suitable for power grid enterprises. It includes 2 first-level indicators, 9 second-level indicators and 28 third-level indicators. The index system is shown in table 1.

Table 1. Power grid enterprise informatization evaluation index system

First Grade Indicators: Information level I_1	
Second Grade Indicators	Third Grade Indicators
Informatization strategy and organization construction I_{11}	Power grid enterprise informatization strategy and planning I_{111}
	The organization and construction of power grid enterprise informatization I_{112}
Information infrastructure construction I_{12}	Network performance level I_{121}
	Total information investment I_{122}
	Computer ownership per ten people I_{123}
Information security guarantee I_{13}	Application degree of information security measures I_{131}
	Information security cost ratio I_{132}
Information-based human resources I_{14}	Personnel training system I_{141}
	The popularity of information technology I_{142}
	Human resource index I_{143}
	Information quality of power grid management I_{144}
Information application status I_{15}	Core business process informatization level I_{151}
	Coverage of information means I_{152}
	Degree of office automation system application I_{153}
First Grade Indicators: Information efficiency I2	
Second Grade Indicators	Third Grade Indicators
Application effect of informatization I_{21}	Planned improvement I_{211}
	Business improvement I_{212}
	Decision improvement I_{213}
	Product and service improvements I_{214}
Information technology sustainable development ability I_{22}	Organizational learning and innovationI_{221}
	Potential application capability of information system I_{222}
Economic benefits of informatization I_{23}	Sales revenue growth I_{231}
	Total cost reduction I_{232}
	Market share growth I_{233}
	Debt reduction I_{234}
	Increase of assets I_{235}
Information society benefits I_{24}	Environmental benefits I_{241}
	Corporate culture and corporate image improvement I_{242}
	The popularization value of information mode I_{243}

3. Power Grid Enterprise Information Evaluation Model

The determination of evaluation index weight is very important in the establishment of index system. The determination of weight will play a decisive role in the evaluation results. In the evaluation of power grid enterprise informatization, AHP is used to determine the index weight, and FCE is used to divide the overall risk of the project. By combining the two methods, a fuzzy comprehensive evaluation model with hierarchical analysis is established. The steps are as follows.

(1) Determine the index factors and establish the hierarchical structure.

The factor set is $U = \{ U_1 + U_2 + \ldots + U_n \}$. n is the number of evaluation factors, which is determined by the specific indicator system. Classify factors according to attributes and establish hierarchical relationship from top to bottom. Arrange according to the order of target layer, criterion layer and scheme layer.

(2) Determine factor weight vector and conduct consistency test.

The relative importance of each index factor is given according to the scale from 1 to 9. The judgment matrix of target layer to criterion layer and criterion layer to sub-criterion layer is obtained. The judgment matrix meets the consistency requirement. If meet:

$CR < 0.1$, then the weight is calculated. Get weight vector $A = (a_1, a_2, \ldots, a_n)$, and satisfy $\sum_{i=1}^{n} a_i = 1$ and $a_i \geq 0$.

(3) Determine the set of risk factor reviews.

Given the comment set $V = \{ V_1 + V_2 + \ldots + V_m \}$, where m is the number of evaluation results. This paper adopts the five-level comment collection, which is {very low risk, low risk, medium risk, high risk, very high risk}.

(4) Single factor fuzzy evaluation was performed.

The subjection degree of the evaluated factors to each comment in the comment set is given. Get the fuzzy set $r_i = \{ r_{i1}, r_{i2}, \ldots, r_{im} \}$. Where r_{ij} represents the membership degree of evaluation factor U_i to hierarchical fuzzy subset V_j. The fuzzy sets corresponding to each factor are merged to form the evaluation matrix (1).

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix} \tag{1}$$

In order to eliminate the effect of dimension, normalization is carried out. Make the $\sum r_{ij} = 1$.

(5) Multi-index comprehensive evaluation was conducted. Make a fuzzy transformation:

$$B = (b_1, b_2, \ldots, b_m) = A \circ R = (a_1, a_2, \ldots, a_n) \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1m} \\ r_{21} & r_{22} & \cdots & r_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nm} \end{bmatrix} \tag{2}$$

In the type: b_j is the membership degree of the evaluation object belonging to the j comment V_j when all factors are considered comprehensively. B is a fuzzy set that belongs to the judgment set V.O stands for some kind of composition operator. In this paper, M $(\cdot, \oplus)$ operator is selected.

(6) The comprehensive evaluation conclusion is given.

According to the maximum membership principle, the maximum possible membership comments of the final target are determined, and the conclusion is given.

4. The Example Analysis

A power grid enterprise is selected as an example to evaluate its informatization level. Firstly, the index weight was determined and the consistency was tested. Take the second-level evaluation index of informatization as an example. According to the expert opinions, the judgment matrix can be formed as shown in table 2. The maximum eigenvalue of the matrix λmax=5.08. Consistency ratio CI=0.0177, which passed the consistency test.

Table 2. Information level two evaluation index judgment matrix

	I_{11}	I_{12}	I_{13}	I_{14}	I_{15}	W_i
I_{11}	1	1/4	1/2	1/3	1/4	0.0679
I_{12}	4	1	3	2	1	0.3123
I_{13}	2	1/3	1	1/2	1/3	0.1087
I_{14}	3	1/2	2	1	1/3	0.1695
I_{15}	4	1	3	3	1	0.3415

Similarly, the weights of other secondary and tertiary evaluation indexes can be determined and tested for consistency, and the weights of all indexes can be finally summarized. The results are shown in table 3.

Determine the evaluation set V= {v1, v2, v3, v4} = {Excellent, good, medium, poor}, respectively representing the different grades of the evaluation. In order to make a comprehensive evaluation of the informatization of the power grid enterprise, professional technicians and enterprise managers of the power grid enterprise are selected. Collect opinions in the form of interviews and questionnaires, sort out and count the questionnaires. The results are shown in table 4.

According to the above table, we can get:

$$R_{11}=\begin{bmatrix}0.4 & 0.4 & 0.1 & 0.1\\ 0.3 & 0.4 & 0.2 & 0.1\end{bmatrix}, R_{12}=\begin{bmatrix}0.1 & 0.5 & 0.2 & 0.2\\ 0 & 0.1 & 0.7 & 0.2\\ 0 & 0 & 0.9 & 0.1\end{bmatrix}, R_{13}=\begin{bmatrix}0.3 & 0.4 & 0.2 & 0.2\\ 0.1 & 0.4 & 0.4 & 0.1\end{bmatrix},$$

$$R_{14}=\begin{bmatrix}0.1 & 0.5 & 0.3 & 0.1\\ 0.2 & 0.4 & 0.3 & 0.1\\ 0.8 & 0.1 & 0.1 & 0\\ 0.3 & 0.3 & 0.3 & 0.1\end{bmatrix}, R_{15}=\begin{bmatrix}0.2 & 0.5 & 0.2 & 0.1\\ 0.2 & 0.1 & 0.5 & 0.2\\ 0.6 & 0.2 & 0.1 & 0.1\end{bmatrix}; R_{21}=\begin{bmatrix}0.1 & 0.3 & 0.4 & 0.2\\ 0 & 0.4 & 0.3 & 0.3\\ 0.2 & 0.3 & 0.4 & 0.1\\ 0.2 & 0.5 & 0.2 & 0.1\end{bmatrix},$$

$$R_{22}=\begin{bmatrix}0.4 & 0.3 & 0.2 & 0.1\\ 0.2 & 0.5 & 0.3 & 0\end{bmatrix}, R_{23}=\begin{bmatrix}0.1 & 0.5 & 0.3 & 0.1\\ 0 & 0.3 & 0.6 & 0.1\\ 0.1 & 0.3 & 0.5 & 0.1\\ 0.1 & 0.1 & 0.7 & 0.1\\ 0.1 & 0.2 & 0.6 & 0.2\end{bmatrix}, R_{24}=\begin{bmatrix}0.4 & 0.4 & 0.2 & 0\\ 0.3 & 0.5 & 0.2 & 0\\ 0.2 & 0.2 & 0.5 & 0.1\end{bmatrix}$$

According to formula $B = AoR$, the comprehensive evaluation results can be calculated.

$$B_{11}=A_{11}\bullet R_{11}=(0.75 \quad 0.25)\bullet\begin{bmatrix}0.4 & 0.4 & 0.1 & 0.1\\ 0.3 & 0.4 & 0.2 & 0.1\end{bmatrix}$$

$$=(0.375 \quad 0.4 \quad 0.125\ 0.1)$$

Table 3. Index weight summary table

First Grade Indicators: Information level I_1 (Weight: 0.5)			
Second Grade Indicators	Weight	Third Grade Indicators	Weight
Informatization strategy and organization construction I_{11}	0.0679	Power grid enterprise informatization strategy and planning I_{111}	0.75
		The organization and construction of power grid enterprise informatization I_{112}	0.25
Information infrastructure construction I_{12}	0.3123	Network performance level I_{121}	0.1222
		Total information investment I_{122}	0.6479
		Computer ownership per ten people I_{123}	0.2299
Information security guarantee I_{13}	0.1087	Application degree of information security measures I_{131}	0.3333
		Information security cost ratio I_{132}	0.6667
Information-based human resources I_{14}	0.1695	Personnel training system I_{141}	0.2718
		The popularity of information technology I_{142}	0.0883
		Human resource index I_{143}	0.4824
		Information quality of power grid management I_{144}	0.1575
Information application status I_{15}	0.3415	Core business process informatization level I_{151}	0.1222
		Coverage of information means I_{152}	0.6479
		Degree of office automation system application I_{153}	0.2299
First Grade Indicators: Information efficiency I_2 (Weight: 0.5)			
Second Grade Indicators (weight)	Weight	Third Grade Indicators (weight)	Weight
Application effect of informatization I_{21}	0.4445	Planned improvement I_{211}	0.5254
		Business improvement I_{212}	0.0634
		Decision improvement I_{213}	0.1104
		Product and service improvements I_{214}	0.3009
Information technology sustainable development ability I_{22}	0.1651	Organizational learning and innovationI_{221}	0.6667
		Potential application capability of information system I_{222}	0.3333
Economic benefits of informatization I_{23}	0.2832	Sales revenue growth I_{231}	0.2476
		Total cost reduction I_{232}	0.4979
		Market share growth I_{233}	0.1484
		Debt reduction I_{234}	0.0425
		Increase of assets I_{235}	0.0636
Information society benefits I_{24}	0.1072	Environmental benefits I_{241}	0.3092
		Corporate culture and corporate image improvement I_{242}	0.5813
		The popularization value of information mode I_{243}	0.1096

Table 4. Fuzzy comprehensive evaluation single factor membership summary table

Third Grade Indicators	Membership			
	optimal	good	medium	poor
Power grid enterprise informatization strategy and planning I_{111}	0.4	0.4	0.1	0.1
The organization and construction of power grid enterprise informatization I_{112}	0.3	0.4	0.2	0.1
Network performance level I_{121}	0.1	0.5	0.2	0.2
Total information investment I_{122}	0	0.1	0.7	0.2
Computer ownership per ten people I_{123}	0	0	0.9	0.1
Application degree of information security measures I_{131}	0.3	0.4	0.2	0.2
Information security cost ratio I_{132}	0.1	0.4	0.4	0.1
Personnel training system I_{141}	0.1	0.5	0.3	0.1
The popularity of information technology I_{142}	0.2	0.4	0.3	0.1
Human resource index I_{143}	0.8	0.1	0.1	0
Information quality of power grid management I_{144}	0.3	0.3	0.3	0.1
Core business process informatization level I_{151}	0.2	0.5	0.2	0.1
Coverage of information means I_{152}	0.2	0.1	0.5	0.2
Degree of office automation system application I_{153}	0.6	0.2	0.1	0.1
Planned improvement I_{211}	0.1	0.3	0.4	0.2
Business improvement I_{212}	0	0.4	0.3	0.3
Decision improvement I_{213}	0.2	0.3	0.4	0.1
Product and service improvements I_{214}	0.2	0.5	0.2	0.1
Organizational learning and innovationI_{221}	0.4	0.3	0.2	0.1
Potential application capability of information system I_{222}	0.2	0.5	0.3	0
Sales revenue growth I_{231}	0.1	0.5	0.3	0.1
Total cost reduction I_{232}	0	0.3	0.6	0.1
Market share growth I_{233}	0.1	0.3	0.5	0.1
Debt reduction I_{234}	0.1	0.1	0.7	0.1
Increase of assets I_{235}	0.1	0.2	0.6	0.2
Environmental benefits I_{241}	0.4	0.4	0.2	0
Corporate culture and corporate image improvement I_{242}	0.3	0.5	0.2	0
The popularization value of information mode I_{243}	0.2	0.2	0.5	0.1

And by the same logic,

$B_{12}=A_{12} \bullet R_{12}=$ (0.0122 0.1259 0.6849 0.1770),$B_{13}=A_{13} \bullet R_{13}=$(0.1667 0.4 0.3333 0.1333),

$B_{14}=A_{14} \bullet R_{14}=$ (0.4780 0.2667 0.2035 0.0518),$B_{15}=A_{15} \bullet R_{15}=$(0.2920 0.1719 0.3714 0.1648);

$B_{21}=A_{21} \bullet R_{21}=$ (0.1348 0.3666 0.3335 0.1652),$B_{22}=A_{22} \bullet R_{22}=$(0.3333 0.3667 0.2333 0.0667),

$B_{23}=A_{23} \bullet R_{23}=$ (0.0502 0.3347 0.5151 0.1064),$B_{24}=A_{24} \bullet R_{24}$=(0.3199 0.4363 0.2329 0.0110),

$B_1=A_1 \bullet R_1$== (0.2281 0.2139 0.4199 0.1416), $B_2=A_2 \bullet R_2$ = (0.1635 0.3650 0.3576 0.1157),

$B=A \bullet R= A \bullet \begin{bmatrix} B1 \\ B2 \end{bmatrix}$ = (0.1958 0.2894 0.3888 0.1287)

The three-level comprehensive evaluation result is B= (0.1958 0.2894 0.3888 0.1287). According to the principle of maximum membership, the comprehensive evaluation grade of the power grid enterprise informatization is medium. The information construction of the enterprise has a certain scale and benefits, but there is still a lot of room for development. Specifically, the comprehensive evaluation level of the power grid enterprise informatization is medium. Among them, the evaluation level of informatization strategy and organizational construction is good. The evaluation level of informatization infrastructure is medium. The evaluation level of informatization security guarantee is good. The evaluation level of informatization human resources is excellent, and the evaluation level of informatization application is medium.

The comprehensive evaluation grade of enterprise informatization benefit is good. Enterprise investment in informatization can improve the work efficiency of enterprises, improve the progress efficiency of various processes, and bring certain economic benefits to enterprises. Among them, the evaluation grade of informatization application effect is good. The evaluation grade of informatization sustainable development ability is good. The evaluation grade of informatization economic benefit is medium. And the evaluation grade of informatization social benefit is good.

5. Conclusion

This paper comprehensively analyzes the power grid enterprise informatization theory related knowledge. The evaluation index system and research methods of power grid enterprise informatization are studied comprehensively. According to the characteristics of China's power grid enterprises, and based on the level of information evaluation and benefit evaluation, a set of information evaluation index system with the characteristics of power grid enterprises is designed. According to the expert opinions, AHP method is adopted to finally obtain all the index weights of the evaluation index system, making the evaluation results more accurate and objective. The evaluation index system is applied to power grid enterprises, and the informatization level is evaluated by fuzzy comprehensive evaluation method. Conclusion the informatization evaluation grade of the enterprise is medium.

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