Evaluation Model of Compliance Management of Power Grid Enterprises Based on the Experience of Typical Enterprises

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Abstract—The compliance issue of electric power companies is the focus of supervision of various countries' regulatory agencies. This article first puts forward a compliance evaluation index system for power companies based on the compliance practices of typical companies. Secondly, based on the Bayesian best-worst and matter-element extension method, the power enterprise compliance evaluation model is constructed. Finally, an empirical analysis is carried out by taking a certain provincial power grid company as an example. The empirical results show that the company's compliance management is at a medium level, and it is particularly necessary to improve the implementation of the compliance plans.

Keywords- enterprise management; performance evaluation; evaluation model; Bayesian best-worst method; matter-element expansion method

1 INTRODUCTION

In recent years, more and more countries have begun to attach importance to corporate compliance issues. In 2018, China's regulatory authorities required central enterprises to accelerate the development of compliance management capabilities. Chinese power companies need to establish a compliance management system that is in line with the world to ensure their sustainable development.

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This article first summarizes the compliance management experience of typical power companies, and then builds a power company compliance management evaluation index system based on this, and then proposes a risk measurement based on the Bayesian best-worst and matter-element expansion model. Finally, take a certain provincial power grid company as an example for empirical analysis. The empirical results prove the validity and scientificity of the proposed model.

2 EVALUATION INDEX SYSTEM OF ELECTRIC COMPANY COMPLIANCE BASED ON WESTERN EXPERIENCE

2.1 Compliance practice experience of Southern Power Corporation

Southern Power Company (SPC) is the fourth largest power company in the United States, serving more than 9 million users. SPC has been subject to many integrations and splits by the US government in its history, and is still subject to strict supervision. The company has established a Governance and Corporate Social Responsibility Committee (GCSRC) to review and supervise compliance policies, and to supervise the board of directors. The GCSRC also formulates the "Southern Company Compliance Principles", which covers all compliance requirements related to corporate governance.

2.2 Compliance Practice Experience of Scottish Power Group

In order to comply with the relevant provisions of the UK's anti-corruption laws and EU competition laws, under the guidance of relevant documents of the International Basel Committee on Banking Supervision[1], the Scottish Power Group has established a dedicated compliance department and chief compliance officer (CCO). Since the Scottish Power Group has its own transmission network-SPENHL, in order to comply with Ofgem's "separation of transmission and distribution" requirements [2-3], its compliance department has formulated a "business separation policy", that is, SPENHL must operate independently.

2.3 Compliance Practice Experience of Scottish Power Group

EDF is a French state-owned company with power generation, transmission and distribution businesses. The EDF Executive Committee (Excom) is responsible for determining the direction and priority of its ethics and compliance program; the EDF Ethics and Compliance Department is responsible for the specific implementation of the above plans; in addition, EDF has also established a corporate responsibility committee to oversee and review corporate ethics, Implementation of compliance and corporate responsibility policies. The "EDF Group Ethics Charter" promulgated by the EDF Board of Directors is the core document of its ethics and compliance activities.

2.4 Evaluation Index System of Electric Company Compliance management

Based on the foregoing analysis of the compliance management experience of typical power companies, this article believes that the power company's compliance management evaluation index system should include the following points [4]:

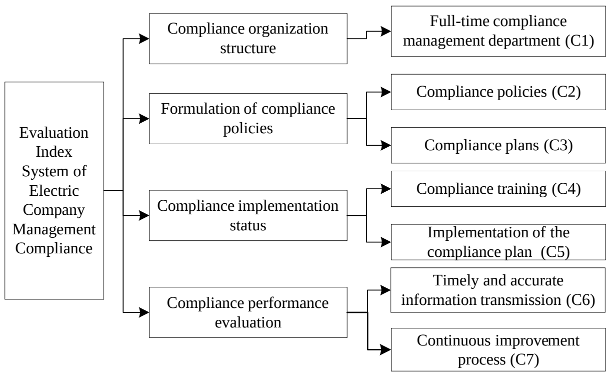

Figure 1. Evaluation Index System of Electric Company Compliance management

3 MEASUREMENT MODEL OF REGULATORY RISK FOR REGULATORY BUSINESS IN POWER GRID ENTERPRISES

3.1 Bayesian best-worst method

In 2015, J Rezaei proposed the best-worst method (BWM) [5]. Compared with the traditional analytic hierarchy process, BWM method reduces the number of weight determination and improves the efficacy. On the basis of BWM, Bayesian best-worst method (BBWM) considers the probability interpretation of input and output and regards the weight as the possibility of each event. When the input and output are determined, the polynomial probability distribution is added [6]. Taking the worst index c_W as an example, the polynomial probability distribution function can be expressed as:

$$P\left(A_W \mid w\right)=\frac{\left(\sum_{j=1}^{n} a_{jW}\right)!}{\Pi_{j=1}^{n} a_{jW}\,!}\prod_{j=1}^{n} w_j^{a_{jw}} \tag{1}$$

where w represents the probability distribution.

The probability of event j is positively correlated with the total number of events:

$$w_j \propto \frac{a_{jW}}{\sum_{j=1}^{n} a_{jW}} \tag{2}$$

Therefore, the probability of occurrence for the worst indicator c_W can be expressed as:

$$w_W \propto \frac{a_{WW}}{\sum_{j=1}^{n} a_{jW}} = \frac{1}{\sum_{j=1}^{n} a_{jW}} \tag{3}$$

According to the formula (2) and (3):

$$\frac{w_j}{w_W} \propto a_{jW} \tag{4}$$

So far, the weight determination process has been transformed into probability distribution estimation problem, the hierarchical Bayesian model is used to solve this problem:

Assuming that there are K decision makers, the best and worst comparison vectors of the $k(k=1,2\ldots K)$ decision maker can be expressed as A_B^k and A_W^k respectively. The weight of each index determined by the decision maker can be expressed as w^k. Therefore, the comprehensive weight w^{agg} determined by all decision makers can be calculated by the weight w^k of each decision maker, and the joint probability distribution can be expressed as:

$$P\left(w^{agg}, w^{1:K} \mid A_B^{1:K}, A_W^{1:K}\right) \tag{5}$$

The probability of each random variable can be calculated by formula (6):

$$P(x) = \sum_{y} P(x, y) \tag{6}$$

where x and y represent arbitrary random variables.

3.2 Matter element extension method

The matter-element extension method takes the matter-element theory and the extended set theory as the theoretical framework, establishes the classical domain, nodal domain and evaluation grade. It calculates the correlation between the matter-element to be evaluated and each evaluation grade through the measured data, which can further evaluate the grade of the evaluation object.

P have several characteristics C, the corresponding value is called V, so P,C,V is called the basic element of matter element R, also known as three elements.

Suppose P has n features, then it can be described by $\{c_1, c_2, \ldots\ldots, c_n\}$ and $\{v_1, v_2, \ldots\ldots, v_n\}$, R is also called n dimensional matter element.

$$R = (P, C, V) = [R_1, R_2, \ldots R_n]^T = \begin{bmatrix} P & c_1 & v_1 \\ & c_2 & v_2 \\ & \vdots & \vdots \\ & c_n & v_n \end{bmatrix} \tag{7}$$

The specific steps of matter-element extension model are as follows:

Step 1: Set classical domain, node domain and matter element to be evaluated.

$$R_j = (P_j, C_i, V_{ij}) = \begin{bmatrix} P_j & c_1 & v_{1j} \\ & c_2 & v_{2j} \\ & \vdots & \vdots \\ & c_n & v_{nj} \end{bmatrix} = \begin{bmatrix} P_j & c_1 & < a_{1j}, b_{1j} > \\ & c_2 & < a_{2j}, b_{2j} > \\ & \vdots & \vdots \\ & c_n & < a_{nj}, b_{nj} > \end{bmatrix} \tag{8}$$

where $\{c_1, c_2, \ldots\ldots, c_n\}$ represents the characteristics of P_j, $\{v_1, v_2, \ldots\ldots, v_n\}$ represents the value of P_j, and P_j represents the j evaluation level. $< a_{ij}, b_{ij} >$ represents the upper and lower bounds of v_{ij}.

$$R_p = (P, C_i, V_{ij}) = \begin{bmatrix} P & c_1 & V_{1p} \\ & c_2 & V_{2p} \\ & \vdots & \vdots \\ & c_n & V_{np} \end{bmatrix} = \begin{bmatrix} P & c_1 & < a_{1p}, b_{1p} > \\ & c_2 & < a_{2p}, b_{2p} > \\ & \vdots & \vdots \\ & c_n & < a_{np}, b_{np} > \end{bmatrix} \tag{9}$$

where $\{v_{1p}, v_{2p}, \ldots\ldots, v_{np}\}$ is the range of P corresponding to $\{c_1, c_2, \ldots\ldots, c_n\}$ that is the segment, P represents the evaluation level.

$$R_0 = (P_0, C_i, V_i) = \begin{bmatrix} P_0 & c_1 & v_1 \\ & c_2 & v_2 \\ & \vdots & \vdots \\ & c_n & v_n \end{bmatrix} \tag{10}$$

where R_0 is the matter element to be evaluated, $\{v_1, v_2, \ldots\ldots, v_n\}$ represents the measured data of P_0 corresponding to $\{c_1, c_2, \ldots\ldots, c_n\}$.

Step 2: Determine the index weight.

Based on the above BBWM method, the weight values of each evaluation index are determined.

Step 3: Establish closeness function and calculate closeness function value.

The distance between the matter element to be evaluated and the normalized domain can be expressed by formula (11):

$$D(v') = \left| v' - \frac{a'_{ij} + b'_{ij}}{2} \right| - \frac{b'_{ij} - a'_{ij}}{2} \tag{11}$$

where a and b represents the left and right endpoint values of the normalized nodal domain.

Asymmetric closeness formula can be expressed by (12):

$$N = 1 - \frac{1}{n(n+1)} \sum_{i=1}^{n} D w_i \tag{12}$$

where N represents the closeness, D represents distance and w_i represents the weight.

Combining formula (11) and (12), the closeness can be obtained as follows.

$$N_j(p_0) = 1 - \frac{1}{n(n+1)} \sum_{i=1}^{n} D_j\left(v_i\right) w_i(X) \tag{13}$$

where $N_j(p_0)$ represents the closeness between the matter element to be evaluated and each level, $D_j(v_i)$ represents the distance between the object element to be evaluated and the normalized domain, $w_i(X)$ represents the weight of each indicator, and n represents the number of evaluation indicators.

Step 4: Evaluation level determination.

$N_{j'}(p_0) = max\left\{N_j(p_0)\right\}, (j = 1, 2, 3, ..., m)$ means that R_0 is closer to level j'.

4 CASE STUDY

This paper uses a provincial power grid company in eastern China as an example to verify the model. This model aims to evaluate the compliance management system of electric power enterprises. The evaluation level is set to five: 1-very bad, 2-bad, 3-medium, 4-good, 5-very good.

4.1 Establishment and normalization of classical domain, segment domain and matter-element to be evaluated

The qualitative indicators are based on field research and consultation with relevant experts, and a ten-point scoring rule is adopted.

4.1.1 Set the classical domain.

$$R_1 = \begin{bmatrix} P_1 & C1 & \langle 0,2\rangle \\ & C2 & \langle 0,2\rangle \\ & C3 & \langle 0,2\rangle \\ & C4 & \langle 0,2\rangle \\ & C5 & \langle 0,2\rangle \\ & C6 & \langle 0,2\rangle \\ & C7 & \langle 0,2\rangle \\ & C8 & \langle 0,2\rangle \end{bmatrix} \quad R_2 = \begin{bmatrix} P_2 & C1 & \langle 2,4\rangle \\ & C2 & \langle 2,4\rangle \\ & C3 & \langle 2,4\rangle \\ & C4 & \langle 2,4\rangle \\ & C5 & \langle 2,4\rangle \\ & C6 & \langle 2,4\rangle \\ & C7 & \langle 2,4\rangle \\ & C8 & \langle 2,4\rangle \end{bmatrix} \quad R_3 = \begin{bmatrix} P_3 & C1 & \langle 4,6\rangle \\ & C2 & \langle 4,6\rangle \\ & C3 & \langle 4,6\rangle \\ & C4 & \langle 4,6\rangle \\ & C5 & \langle 4,6\rangle \\ & C6 & \langle 4,6\rangle \\ & C7 & \langle 4,6\rangle \\ & C8 & \langle 4,6\rangle \end{bmatrix}$$

$$R_4 = \begin{bmatrix} P_4 & C1 & \langle 6,8\rangle \\ & C2 & \langle 6,8\rangle \\ & C3 & \langle 6,8\rangle \\ & C4 & \langle 6,8\rangle \\ & C5 & \langle 6,8\rangle \\ & C6 & \langle 6,8\rangle \\ & C7 & \langle 6,8\rangle \\ & C8 & \langle 6,8\rangle \end{bmatrix} \quad R_5 = \begin{bmatrix} P_5 & C1 & \langle 8,10\rangle \\ & C2 & \langle 8,10\rangle \\ & C3 & \langle 8,10\rangle \\ & C4 & \langle 8,10\rangle \\ & C5 & \langle 8,10\rangle \\ & C6 & \langle 8,10\rangle \\ & C7 & \langle 8,10\rangle \\ & C8 & \langle 8,10\rangle \end{bmatrix}$$

4.1.2 Set the classical domain.

$$R_p = \begin{bmatrix} P & C1 & \langle 0,10\rangle \\ & C2 & \langle 0,10\rangle \\ & C3 & \langle 0,10\rangle \\ & C4 & \langle 0,10\rangle \\ & C5 & \langle 0,10\rangle \\ & C6 & \langle 0,10\rangle \\ & C7 & \langle 0,10\rangle \end{bmatrix} \quad R_0 = \begin{bmatrix} P_0 & 6.5 \\ & 8.3 \\ & 6.5 \\ & 7.3 \\ & 5.3 \\ & 5.6 \\ & 4.2 \end{bmatrix}$$

4.2 Indicator weight determination

According to the opinions of three experts, the best and worst comparison vector are as follows:

$$A_B = \begin{pmatrix} 2 & 7 & 3 & 5 & 1 & 4 & 6 \\ 2 & 7 & 4 & 5 & 1 & 6 & 3 \\ 3 & 5 & 2 & 6 & 1 & 3 & 4 \end{pmatrix} \quad A_W = \begin{pmatrix} 6 & 1 & 5 & 4 & 7 & 4 & 2 \\ 6 & 1 & 4 & 3 & 7 & 2 & 5 \\ 5 & 2 & 6 & 1 & 7 & 4 & 3 \end{pmatrix}$$

The comprehensive weight can be calculated by MATLAB software. The calculation results are as follows:

Table 1 Weights of eight indicators

Indicator	C1	C2	C3	C4	C5	C6	C7
Weight(%)	17.03	5.03	17.36	7.14	30.75	11.59	11.10

4.3 Evaluation level determination

According to the formula mentioned in section 3.2, the proximity of the evaluation level of the provincial grid company's compliance management system is calculated as follows:

$$N_1(p_0) = 1 - \frac{1}{8*(8+1)} \sum_{i=1}^{8} D_j\left(v_i\right) w_i = 0.930021$$

$$N_2(p_0) = 1 - \frac{1}{8*(8+1)} \sum_{i=1}^{8} D_j\left(v_i\right) w_i = 0.965735$$

$$N_3(p_0) = 1 - \frac{1}{8*(8+1)} \sum_{i=1}^{8} D_j\left(v_i\right) w_i = 0.998277$$

$$N_4(p_0) = 1 - \frac{1}{8*(8+1)} \sum_{i=1}^{8} D_j\left(v_i\right) w_i = 0.995453$$

$$N_5(p_0) = 1 - \frac{1}{8*(8+1)} \sum_{i=1}^{8} D_j\left(v_i\right) w_i = 0.962837$$

It is obvious that the evaluation level of the provincial grid company's compliance management system belongs to Medium level.

5 CONCLUSION

This paper constructs an evaluation model for the compliance management system of Chinese power companies based on the experience of typical power companies. According to a case study of a provincial power grid company, the following conclusions can be drawn:

- The implementation of the compliance plans is considered to be the most important evaluation indicator, which is essential for evaluating the compliance management system.
- According to the results of qualitative analysis, the current compliance management system of grid companies is at an intermediate level.
- The evaluation model of compliance management system proposed in this paper performs well in evaluating the compliance management system of grid enterprises. It can be further applied to other fields.

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