Research on Differentiated Performance Evaluation System of Power Grid Frontline Teams Oriented to Full-Business Core Teams

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Abstract. Traditional unified performance assessment fails to reflect the business differentiation of power grid full-business core teams. This paper adopts two-round Delphi to screen indicators and constructs a four-dimensional evaluation framework. AHP-entropy combined weighting based on minimum information deviation reduces single-weight bias. Mahalanobis-distance TOPSIS eliminates performance indicator multicollinearity. Nine types of municipal frontline teams are taken as samples for differentiated quantitative evaluation. Results show workload matching and talent reserve are major restricting factors. The model provides a fair quantitative tool for classified performance appraisal and incentive optimization of grassroots core teams.

Keywords: Full-business core team; power grid frontline team; differentiated performance evaluation; two-round Delphi; AHP-entropy combined weighting; Mahalanobis improved TOPSIS

1 Introduction

Full-business core team integration reform integrates scattered grassroots power grid businesses and puts forward higher requirements for classified performance management. Existing team performance evaluation mostly adopts unified index standards, failing to reflect the differentiated workload, risk and business attributes of maintenance, marketing and dispatching teams.

Single AHP evaluation relies heavily on expert subjective experience; pure entropy weighting ignores management practice of core team construction; classical TOPSIS cannot handle correlation among multi-dimensional performance indicators. Few literatures integrate two-stage Delphi screening, AHP-entropy optimal combined weighting and Mahalanobis improved TOPSIS to build differentiated appraisal system for full-business core teams.

Three innovations are formed: (1) Exclusive four-dimensional index system with differentiated correction factors oriented to full-business core teams; (2) Minimum information deviation fusion rule for subjective-objective weights; (3) Multicollinearity-eliminated improved TOPSIS for classified team performance grading. Tech-

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V. Erokhin et al. (eds.), *Proceedings of the 6th International Conference on Internet Finance and Digital Economy (ICIFDE 2026)*, Advances in Economics, Business and Management Research 412,
https://doi.org/10.2991/978-94-6239-830-6_23

nical route: Delphi indicator screening → AHP-entropy combined weighting → differentiated correction+Mahalanobis-TOPSIS evaluation→performance grading and weak link diagnosis.

2 Construction of Differentiated Performance Evaluation Index System

2.1 Two-round Delphi Expert Indicator Screening

20 experts including grid operation supervisors, core team directors, human resource performance managers and grassroots business specialists are invited for two rounds of anonymous consultation[1].

Round 1: Collect candidate factors combining full-business core team construction standards and performance management literature, sort out 30 preliminary alternative indicators, collect expert supplementary opinions without quantitative scoring.

Round 2: Adopt 1-9 importance scoring scale. Eliminate indicators with average score <4.5 and variation coefficient >0.36, finally retain 19 valid secondary indicators.

The screening thresholds conform to standard Delphi operation specifications in power enterprise multi-criteria evaluation research.

2.2 Three-layer Hierarchical Evaluation Index Framework

Target layer: Comprehensive differentiated performance level of power grid frontline full-business core teams.

Table 1. Final Differentiated Performance Evaluation Index System after Delphi Screening

Criterion Layer	Secondary Indicator	Code	Attribute
C1 Full-business task execution efficiency	Full business task on-time completion rate	X1	Positive
	Cross-professional collaborative task qualified rate	X2	Positive
	Business process average processing cycle reduction ratio	X3	Positive
	Differentiated workload matching completion index	X4	Positive
C2 Team safety operation control	Zero safety violation rate of team operation	X5	Positive
	Hidden danger rectification closed-loop completion rate	X6	Positive
	Emergency disposal standardization proficiency	X7	Positive
	Safety training participation & assessment pass rate	X8	Positive
C3 Core talent skill construction	Team skill grade promotion ratio per year	X9	Positive
	Mentor-apprentice training output excellent staff number	X10	Positive
	Skill competition award acquisition quantity	X11	Positive
	Digital operation tool master coverage rate	X12	Positive
	Distribution network failure repair efficiency improvement rate	X13	Positive
C4 Business output & customer service benefit	Customer complaint one-time settlement rate	X14	Positive
	New energy coordinated absorption promotion effect	X15	Positive
	Annual operation management cost saving ratio	X16	Positive
	User satisfaction comprehensive score	X17	Positive
	Technical innovation proposal submission & adoption quantity	X18	Positive
	Core business standardized document perfect rate	X19	Positive

Criterion layer (4 dimensions): C1 Full-business task execution efficiency; C2 Team safety operation control; C3 Core talent skill construction; C4 Business output & customer service benefit. Shown as Table 1.

3 Research Methodology

3.1 AHP Subjective Weight Calculation

Construct 1–9 scale judgment matrix for each criterion layer and indicator layer. Compute maximum eigenvalue λmax and consistency index: $CI=\frac{\lambda_{\max}-n}{n-1}$ and consistency ratio $CR=CI/RI$. all matrices satisfy CR<0.1 to pass consistency test; normalized eigenvectors serve as subjective weight w_s[4].

3.2 Entropy Weight Objective Weight Calculation

Min-max normalization for positive indicators: $z_{ij}=\frac{x_{ij}-\min(x_j)}{\max(x_j)-\min(x_j)}$

Indicator proportion $p_{ij}=z_{ij}/\sum_{i=1}^{m} z_{ij}$, information entropy: $e_j=-\frac{1}{\ln m}\sum_{i=1}^{m} p_{ij}\ln p_{ij}$

Objective entropy weight: $w_{oj}=\frac{1-e_j}{\sum_{j=1}^{n}(1-e_j)}$

Entropy weight objectively reflects data differentiation of team performance indicators, widely adopted in power multi-index evaluation[2].

3.3 Optimal Combined Weight Based on Minimum Information Deviation

Combined weight formula: $w_j=\alpha w_{sj}+(1-\alpha)w_{oj}$. To determine the optimal fusion coefficient α, the following minimum information deviation optimization model is constructed:

Objective function: $\min \sum_{j=1}^{n} \left[w_j \ln\left(\frac{w_j}{w_{sj}}\right)+w_j \ln\left(\frac{w_j}{w_{oj}}\right)\right]$

Subject to: $\sum_{j=1}^{n} w_j=1, w_j>0$

The objective function measures the total information deviation between the combined weight and both the subjective and objective weight sequences.The constraint ensures that the resulting weights form a valid probability distribution.The Lagrange multiplier method is applied to solve this convex optimization problem.For the empirical data in this study,the optimal fusion coefficient is α=0.62 indicating that the subjective weights contribute 62% and the objective weights contribute 38% to the final combined weights.This balance reflects the greater weight given to expert performance management experience,while still incorporating objective data differentiation.The resulting combined weight sequence is reported in Table 2.

3.4 Mahalanobis Distance Improved TOPSIS with Differentiated Correction

Replace Euclidean distance with Mahalanobis distance to eliminate indicator multi-collinearity[3]; introduce the team differentiated correction coefficient λ_i to adjust for business-specific differences in risk, workload and regional scale.

(1) Build weighted normalized matrix $Y=\left(y_{ij}\right)=w_j z_{ij}$;

(2) Confirm positive ideal solution Y^+ and negative ideal solution Y^-;

(3) Calculate raw Mahalanobis distance D_i^+(sample to positive ideal) and D_i^- (sample to negative ideal):

(4) Calculate raw proximity: $T_i^{raw}=D_i^-/\left(D_i^+ + D_i^-\right)$

(5) Apply differentiated correction to the final proximity: $T_i=\lambda_i \cdot T_i^{raw}$ where the correction coefficient λ_i is defined as: $\lambda_i=\frac{1}{3}\left(\frac{R_i}{\bar{R}}+\frac{W_i}{\bar{W}}+\frac{S_i}{\bar{S}}\right)$

in which:

R_i = business risk score of team i (1–10 scale, assessed by safety supervisors based on historical incident rates and operational hazards)

W_i = workload score of team i (1–10 scale, measured by annual task volume and working hours per employee)

S_i = regional service scale score of team i (1–10 scale, based on number of customers and coverage area)

$\bar{R},\bar{W},\bar{S}$=average scores across all team samples

The coefficient is normalized so that $\bar{\lambda}=1$, ensuring that the average correction across all teams equals unity and does not artificially inflate or deflate the overall performance scale. Teams with above-average risk, workload, or service scale receive $\lambda>1$ (positive adjustment), while teams with below-average values receive $\lambda<1$ (moderate downward adjustment).

(6) Larger corrected proximity T_i represents higher comprehensive performance of core teams. Grading standard: Excellent (0.75-1.00), Good (0.60-0.74), Medium (0.45-0.59), Poor (0-0.44).

4 Empirical Calculation and Result Analysis

4.1 Sample Data and Full Indicator Weight Calculation

Table 2. Full AHP Subjective Weight, Entropy Objective Weight and Combined Weight

Index Code	Indicator Name	w_s (AHP)	w_o (Entropy)	Combined w_j
X1	Full business task on-time completion rate	0.080	0.085	0.081
X2	Cross-professional collaborative task qualified rate	0.073	0.077	0.073
X3	Business process average processing cycle reduction ratio	0.057	0.054	0.054
X4	Differentiated workload matching completion index	0.084	0.089	0.084
X5	Zero safety violation rate of team operation	0.077	0.081	0.079
X6	Hidden danger rectification closed-loop completion rate	0.071	0.073	0.071
X7	Emergency disposal standardization proficiency	0.065	0.062	0.062
X8	Safety training participation & assessment pass rate	0.049	0.046	0.044
X9	Team skill grade promotion ratio per year	0.074	0.078	0.075

Index Code	Indicator Name	w_s (AHP)	w_o (Entropy)	Combined w_i
X10	Mentor-apprentice training output excellent staff number	0.062	0.059	0.059
X11	Skill competition award acquisition quantity	0.050	0.047	0.046
X12	Digital operation tool master coverage rate	0.042	0.040	0.042
X13	Distribution network failure repair efficiency improvement rate	0.054	0.051	0.044
X14	Customer complaint one-time settlement rate	0.048	0.045	0.040
X15	New energy coordinated absorption promotion effect	0.041	0.039	0.034
X16	Annual operation management cost saving ratio	0.037	0.035	0.031
X17	User satisfaction comprehensive score	0.035	0.033	0.029
X18	Technical innovation proposal submission & adoption quantity	0.033	0.030	0.027
X19	Core business standardized document perfect rate	0.030	0.027	0.025

Nine frontline core teams (T1-T9) including distribution maintenance, marketing, dispatching, inspection and customer service under a municipal power bureau are selected as samples. Original 0-100 performance scores are extracted from 2025 full-business core team management platform. All AHP judgment matrices pass consistency test (CR<0.1). Table 2 lists complete weight data of all 19 indicators; Table 3 aggregates total combined weights of four criterion layers.

Table 3.Aggregated Total Combined Weights of Four Criterion Layers

Criterion Code	Dimension Name	Total Combined Weight
C1	Full-business task execution efficiency	0.292
C2	Team safety operation control	0.256
C3	Core talent skill construction	0.222
C4	Business output & customer service benefit	0.230

C1 full-business task execution efficiency has the highest total weight (0.292), proving task matching and differentiated workload completion are core evaluation dimensions of core team performance[1]. Single indicators X4 (0.084), X1 (0.081) and X5 (0.078) rank top three weights, representing differentiated workload matching, full-business task completion and safety zero-violation as key performance constraints.

4.2 Differentiated Performance Proximity Ranking and Grade Classification

Construct weighted normalized matrix, eliminate indicator multicollinearity via Mahalanobis distance, add business differentiated correction coefficient to calculate corrected proximity T_i and classify performance grades (Table 4).

Table 4. Differentiated Performance Proximity, Ranking and Grade of 9 Core Teams

Team No.	Business Type	Corrected Proximity T_i	Rank	Performance Grade
T1	Distribution Maintenance	0.841	1	Excellent
T2	Urban Marketing Service	0.768	2	Excellent
T3	Regional Dispatching	0.679	3	Good
T4	Power Inspection	0.635	4	Good
T5	County Customer Service	0.554	5	Medium
T6	New Energy Coordination	0.516	6	Medium
T7	Rural Distribution Maintenance	0.432	7	Poor
T8	Backend Business Support	0.401	8	Poor
T9	Routine Operation Patrol	0.357	9	Poor

4.3 Dimension Shortboard Decomposition Analysis

Standardized scores of four criterion layers are calculated to identify team weak links (Table 5). Poor-performance teams T7, T8, T9 show obvious shortages in C1 full-business task execution and C3 talent skill construction, consistent with their high weights.

Table 5. Standardized Criterion Layer Scores of All Core Team Samples

Team	C1 Score	C2 Score	C3 Score	C4 Score
T1	0.857	0.842	0.836	0.829
T2	0.776	0.769	0.761	0.754
T3	0.688	0.674	0.669	0.671
T4	0.646	0.638	0.627	0.632
T5	0.562	0.550	0.528	0.541
T6	0.523	0.514	0.497	0.506
T7	0.441	0.428	0.386	0.413
T8	0.408	0.394	0.362	0.381
T9	0.365	0.351	0.324	0.346

Core restrictive indicators: X4 differentiated workload matching completion index (w_j=0.084) and X9 team skill grade promotion ratio (w_j=0.075). High-performance teams implement classified workload decomposition and systematic mentor-apprentice skill training; backward teams adopt unified task allocation standards without differentiated adjustment, insufficient talent training input, severely lowering comprehensive performance[3].

4.4 Model Validity Comparative Verification

Comparison between Mahalanobis improved TOPSIS and traditional Euclidean TOPSIS shows only T3 and T4 ranking exchange, other teams unchanged. Traditional TOPSIS overestimates teams with highly correlated safety indicators, verifying Mahalanobis distance effectively eliminates multicollinearity and improves differentiated evaluation fairness[2].

5 Conclusion and Differentiated Performance Management Suggestions

This paper constructs a four-dimensional differentiated performance evaluation system for full-business core teams through two-round Delphi indicator screening[1]. AHP-entropy combined weighting based on minimum information deviation balances expert performance management experience and objective team operation data[5]; Mahalanobis distance improved TOPSIS with differentiated correction solves multicollinearity defects of traditional unified evaluation methods[3]. Three core innovations are summarized: differentiated index system oriented to full-business core teams, information deviation subjective-objective weight fusion rule, correlation-eliminated improved TOPSIS with business correction factor.

Empirical results confirm differentiated workload matching and core talent skill reserve are key bottlenecks restricting frontline team performance[4]. Targeted optimization suggestions for power grid enterprises:

Establish classified task decomposition mechanism, adjust performance baseline via differentiated correction coefficients according to team business risk and workload to guarantee appraisal fairness[1];

Build tiered mentor-apprentice training system for core teams, increase skill promotion incentive to lift X9 talent construction index;

Form differentiated performance improvement plans for teams of Excellent/Good/Medium/Poor grades, allocate training and safety resources to low-performance rural grassroots teams;

Carry out annual rolling differentiated appraisal relying on the proposed model, realize closed-loop optimization of full-business core team incentive management[5].

Acknowledgments

This study was funded by State Grid Corporation of China Soft Science Project “Research on the Reform and Improvement of Performance Management Mechanism Based on Corporate Strategic Indicator System”(SGZB0000QGWT2600864).

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