Applicability Evaluation and Optimization Recommendations of Natural Gas Sales Standard System Under the New Development Context

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Abstract. Under the macro background of the steady realization of China's "double carbon" goal and the acceleration of digital intelligence construction in the natural gas industry, the current natural gas sales field has not yet formed a systematic quantitative evaluation method for the applicability of the standard system, which is difficult to support the industry's standardized governance and high-quality development needs. In this study, 37 core literatures in the field were selected, and the evaluation indexes were screened through keyword clustering and frequency analysis.The DEMATEL method, group decision entropy weight method and gray clustering model with central triangular whitening weight function are integrated to construct the applicability evaluation system of the standard system, and a complete evaluation framework including 5 first-class and 34 second-class indicators is formed, filling a methodological gap in this field. A comparative verification with the fuzzy comprehensive evaluation (FCE) method is further conducted to verify the effectiveness and superior performance of the proposed hybrid grey clustering model. After empirical application, this method can accurately identify the core weaknesses of the current standard system, such as local gaps in professional standards, lack of data transparency, and lag in update, which verifies the effectiveness of the method. Based on this, three optimization paths are proposed: system structure optimization, special standard preparation, and dynamic update mechanism construction. The research results can provide quantitative method support for the evaluation and optimization of the standard system in the field of natural gas sales and energy.

Keywords: Natural Gas Sales Standard System; Applicability Evaluation; DEMATEL Method; Group Decision-Making Entropy Weight Method; Grey Clustering Model; Standardization Governance

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1 Introduction

With the in-depth promotion of China's energy revolution strategy and the institutionalization of the "double carbon" goal, the natural gas sales industry has ushered in a deep digital transformation[1].From the perspective of public management and smart society governance, the standardization system of natural gas sales serves as a critical infrastructure for ensuring market order, energy security, and service equity. However, the current standard system is difficult to adapt to the core needs of industry transformation, and there are significant shortcomings in technology adaptation and management guidance. It is urgent to build a scientific applicability quantitative evaluation system to provide support for the dynamic optimization of the standard system– a challenge that lies at the intersection of public administration, smart society innovation, and energy policy[16].

At present, the academic community has carried out rich methodological exploration around the evaluation of the standard system[3-6]. Relevant research has integrated Delphi method, analytic hierarchy process, entropy method, fuzzy comprehensive evaluation and other methods to build the evaluation model of the standard system in many fields[7-8], which provides multiple ideas and theoretical support for relevant research. However, the existing applicability evaluation studies mostly focus on the energy fields such as industrial manufacturing, public services, engineering construction and coal[9-11], and there are still significant gaps in the special research in the field of natural gas sales.

In order to accurately evaluate the applicability of the natural gas sales standard system, this study completed the systematic literature retrieval based on the CNKI database. After topic filtering, weight removal and quality verification, 37 core literatures were selected to build the research sample library. Then, the research results in the field were sorted out through bibliometric Technology[12], and the evaluation index pool was initially constructed by combining the frequency analysis method.

On this basis, the DEMATEL method is introduced to analyze the causal relationships and influence intensity among candidate indicators, so as to eliminate redundant indicators and merge similar ones. Finally, a multi-dimensional indicator system covering internal synergy and external adaptability is constructed, which effectively solves the problems of vague indicator logic and insufficient system integrity in traditional evaluation. To ensure the scientificity and objectivity of weight distribution, the group decision entropy weight method is adopted to calculate the indicator weights. Finally, a center-point triangular whitening weight function is constructed based on grey clustering theory, the applicability grey class thresholds are determined, and the applicability grade is identified through the quantification of qualitative indicators, thus forming a full-link evaluation framework of "indicator screening - weight optimization - dynamic clustering".

Through the combination of quantitative and qualitative methods,and for the first time in the natural gas sales sector, this study systematically evaluates the applicability of the current natural gas sales standard system and accurately identifies its deficiencies in implementation effectiveness, cross-scenario applicability and dynamic adjustment capability. A comparative test with the fuzzy comprehensive evaluation (FCE) method is carried out for the primary indicators to verify the effectiveness and superior performance of the proposed hybrid method. This research not only provides scientific methodological support for standard system evaluation practices in this field, but also defines the direction for the subsequent optimization and improvement of the system.

2 Construction of Indicator System

2.1 Preliminary Screening Indicators

The frequency analysis method is a core index screening method. High frequency indicators are screened through the use frequency of indicators in the literature related to the subject of statistical research. The important values of indicators are composed of relative density, relative frequency and relative dominance. The core calculation formula is as follows:

$$I = \frac{d + f + s}{3} \tag{1}$$

Where: I is the important value of the index; d is the relative density; f is the relative frequency; s is a comparative advantage.

In order to clarify the applicability evaluation index of the natural gas sales standard system, the frequency analysis method is adopted in this research. Literature retrieval is carried out in the China National Knowledge Infrastructure (CNKI) database with a time span of 2006-2024, with the subject retrieval formula: (quality of standard system OR level of standard system OR implementation of standard system) AND (evaluation OR assessment). 37 valid Chinese core literatures are obtained after excluding irrelevant documents. On this basis, the adoption status of first-level indicators is analyzed, the importance evaluation of second-level indicators is conducted, and the final evaluation indicator framework is established.

Bibliometric analysis of the 37 relevant literatures indicates that more than 60% of the literatures take "Rationality of Standard System Structure", "Relevance of Standard System Content", "Standard System Benefit", "Standard System Cycle" and "Demand Degree of Standard System" as first-level evaluation indicators, reflecting a prominent academic consensus on this indicator set. In order to improve the systematicness and adaptability of the evaluation framework, the research combined with expert consultation method to optimize the index classification from internal and external dimensions: the internal dimension focused on the static core attributes of the standard system, including two indicators of "Rationality of Standard System Structure" and "Relevance of Standard System Content"; The external dimension centers on the characteristics of the full cycle of dynamic implementation of the standard, covering three indicators: "Standard System Benefit", "Standard System Cycle" and "Demand Degree of Standard System". It realizes the full coverage of static structure and dynamic implementation, and finally determines the above five dimensions as the core first level indicators.

On this basis, the evaluation indicators extracted from the literatures are systematically collated, with overlapping indicators removed and indicators with similar connotations merged, and 49 second-level indicators are preliminarily selected. By calculating and ranking the important values of each index, 43 core secondary evaluation indexes were finally selected, which laid the foundation for the construction of subsequent evaluation system.

2.2 Indicator System

In order to ensure the scientificity and practical adaptability of causal correlation analysis between indicators, clarify the internal causal correlation between indicators, and eliminate redundant indicators, this study carried out indicator screening according to DEMATEL standard process[13].The DEMATEL method is a well-established complex system causal analysis approach, whose analytical reliability depends primarily on the domain expertise matching of participating experts, rather than large sample sizes[14]. Mainstream applications in the energy sector and systematic reviews of DEMATEL methodological specifications have verified that 5–15 rigorously selected domain experts are sufficient to generate stable and reliable causal analysis results[15-16].

Based on this, this study invited 5 authoritative industry experts with over 10 years of hands-on experience in natural gas sales management, standardization research and energy economic analysis. All experts have participated in the formulation and revision of national/industrial natural gas standards, and are affiliated with industry regulators, large gas operators and national energy standardization committees, fully complying with the method's professional requirements. To control subjective scoring bias, this study provided a unified scoring protocol with complete indicator definitions and rules in advance, and constructed the direct influence matrix using the mode of expert scores to eliminate extreme value interference.

The specific implementation process is as follows: the invited experts conducted pairwise comparison and scoring on the influence relationship between indicators using a 0-4 point scale, based on the two dimensions of "the influence degree of one indicator on other indicators" and "the degree to which the indicator is influenced by others", and the direct impact matrix was constructed with the highest frequency score. After standardized treatment, the comprehensive impact matrix was calculated, and finally the impact degree, affected degree, centrality, and cause degree of each indicator were obtained;Combined with the core requirements of the evaluation system, the top ten key indicators (Table 1) were selected in descending order of centrality, and then further integrated and optimized based on the DEMATEL analysis results of the whole system indicators. Finally, the applicability evaluation index framework of the natural gas sales Standard System with 5 primary indicators and 34 secondary indicators is constructed(Table 2).

Table 1. DEMATEL calculation results (top ten by centrality)

Indicator Name	Influence Degree	Affected Degree	Center Degree	Cause Degree
Market Demand Degree	2.0720	2.6804	4.7524	-0.6084
Standard Update Speed	2.0039	2.5056	4.5095	-0.5017

Number of Newly Compiled Standards	1.8506	2.5653	4.4159	-0.7147
Application Frequency and Scope of Standards	0.9635	3.1465	4.1100	-2.1830
Compatibility of Sub-standard System	2.6495	1.4154	4.0649	1.2341
Standard Stock	1.8462	2.1856	4.0318	-0.3394
Completeness of Professional Standards	2.5421	1.3353	3.8374	1.2068
Completeness of Technical Standards	2.5072	1.3613	3.8685	1.1459
Completeness of Standard Application Stages	2.5117	1.1724	3.6841	1.3393
Completeness of Standard Management	2.3281	1.1753	3.5034	1.1528

Table 2. Evaluation Index of Applicability of Natural Gas Sales Standard System

Target level	Criteria level	Tertiary indicators
Applicability Evaluation of Natural Gas Sales Standard System	Rationality of Standard System Structure	Supporting Compatibility of Sub-Standard Systems Coordination of Sub-Standard Systems Universality of Standards Rationality of Standard System Classification Rationality of Standard Level Completeness of Standard Application Stages Completeness of Various Professional Standards Completeness of Technical Standards Completeness of Standard Management
	Content Relevance of Standard System	Correlation with Supply Stability Correlation with Production Safety Correlation with Market Compliance Correlation with Intelligent Dispatching Correlation with Terminal Services Correlation with Emergency Response Capability Correlation with Infrastructure Compatibility Correlation with Price Fluctuation Management Correlation with Data Transparency Correlation with Local Policies
	Benefit of Standard System	Impact on Economic Development Impact on Energy Conservation and Emission Reduction Impact on Related Industries Impact on Environmental Development
	Cycle of Standard System	Standard Stock Standard Update Speed Number of Newly Compiled Standards Standard Half-Life Standard Obsoletion Rate Standard Age Distribution

	Demand Degree of Standard System	Technical Level of Standards Application Frequency and Scope of Standards Standard Issuing Authority Market Demand Degree Internationalization Level of Standards

3 Construction of Applicability Evaluation Model

The applicability evaluation model of natural gas sales standard system is constructed, which includes weight calculation and grade evaluation. In order to weaken the interference of the subjective deviation of expert scoring on the evaluation results and ensure the objectivity and scientificity of weight distribution, this study uses the entropy weight model of group decision-making to determine the expert weight and index weight[17-18]. This method is a mature and general method in the multi-agent group decision-making scenario, which can quantify the contribution of expert decision-making through the discreteness of expert scoring data and realize the scientific integration of multi-source evaluation information.

In view of the characteristics of limited sample size and incomplete effective information in the evaluation scenario of natural gas sales standard system, this study uses the grey clustering method to complete the applicability evaluation. The grey system theory can effectively mine the effective laws in the uncertain system with poor information and small samples, which is highly suitable for the evaluation needs of this study. The specific steps of the clustering method are as follows.

3.1 Determination of the Applicability Evaluation Matrix

Grey clustering is a method that discriminates the category of research objects and determines their evaluation grades based on known information. According to the differences in weights and whitening weight functions, grey clustering can be divided into grey fixed-weight clustering and grey variable-weight clustering, as well as grey clustering with endpoint-based triangular whitening weight function and grey clustering with center-point-based triangular whitening weight function.[19-21]

There are n primary indicators and m secondary indicators, The secondary indicators under each primary indicator are recorded as j ,where each primary indicator is recorded as $X_i(i=1,2,\cdots,n)$,the secondary indicator is $X_{ij}(i=1,2,\cdots,n)$,and the sample observation value of the indicator is recorded as x_i . In order to evaluate the applicability of the natural gas sales standard system, it is necessary to quantify the qualitative indicators obtained above. In this paper, the expert scoring method is used to obtain the observed value x_{ij} of each indicator, which is composed of

$$X_z=(\mathrm{x}_{11},\mathrm{x}_{12},\cdots,\mathrm{x}_{ij})^T \tag{2}$$

3.2 Determination of Grey Class Thresholds and Whitening Weight Function

For grey clustering evaluation, 5-level equidistant grading is a classic specification that ensures the consistency of membership calculation, balances result discrimination and clustering stability, which is the core principle of the method [18-20]. Based on this, this study determined the 5 evaluation grey classes and their threshold ranges via expert scoring and meeting consultation combined with industry actual conditions, which is unanimously recognized by the invited industry expert group and conforms to industry general practice.

Table 3. Gray scale

Applicability Level	Very Low	Low	Moderate	High	Very High
Value Range	(0,2]	(2,4]	(4,6]	(6,8]	(8,10]

By scoring the above applicability evaluation indexes, and calculating the model according to the scoring results, the applicability grade of ash is obtained. According to the evaluation results, corresponding improvement measures are taken to improve the natural gas sales standard system, and the whitening weight function is determined to expand the ash in two directions, i.e.0 ash and

$$f_{ij}^{k}(x)=\begin{cases}0 & x\notin\left[\lambda_{k-1},\lambda_{k+1}\right]\\ \dfrac{x-\lambda_{k-1}}{\lambda_{k}-\lambda_{k-1}} & x\notin\left[\lambda_{k-1},\lambda_{k+1}\right]\\ \dfrac{\lambda_{k+1}-x}{\lambda_{k+1}-\lambda_{k}} & x\in\left(\lambda_{k},\lambda_{k+1}\right)\end{cases} \tag{3}$$

3.3 Grey Clustering Calculation

According to the membership degree $f_{ij}^{k}(x)$ of the above calculated index j with respect to the grey class k , all the indexes of each grey class are weighted and summed to obtain the comprehensive clustering coefficient $\sigma_i^k(x)$ of each grey class. The calculation formula is as follows:

$$\sigma_i^k=\sum_{i=1}^{n}f_i^k(x)\eta_i \tag{4}$$

Where f_i^k is the whitening weight function of index i with respect to grey class k , and η_i is the weight of index i .

The comprehensive clustering coefficient $\sigma_i^{k^*}=\max\left\{\sigma_i^1,\sigma_i^2,\cdots,\sigma_i^k\right\}$ of each grey class is obtained through formula (4), and the grey class k^* of the evaluation object is judged.

4 Empirical Analysis

4.1 Model Application and Data Sources

This study takes the natural gas sales standard system as the evaluation object, uses DEMATEL method to screen out 5 first-class indicators and 34 second-class indicators, uses the group decision entropy weight method to calculate the index weight, and combined with the gray clustering model of the center point triangle whitening weight function to determine the index applicability level.

The evaluation data comes from industry research, policy text analysis and expert scoring. Three principles should be followed in the selection of experts: First, the work units should cover four types of subjects: universities and scientific research institutions, provincial gas authorities, grass-roots natural gas operating units, and natural gas related enterprises, so as to ensure the comprehensiveness of the evaluation perspective; Second, the employees in relevant fields have been engaged for at least 5 years and are familiar with the research topics of natural gas sales standard system, so as to ensure the suitability of the evaluation professional ability; The third is to voluntarily participate in the evaluation work to ensure the degree of cooperation in the research process.

In this study, a 10 person expert review team was established: 7 experts in the field of natural gas, covering the technology and management of the whole sales chain; Three experts in the field of standard preparation.

An example of the standard system framework for applicability evaluation is shown in Figure 1:

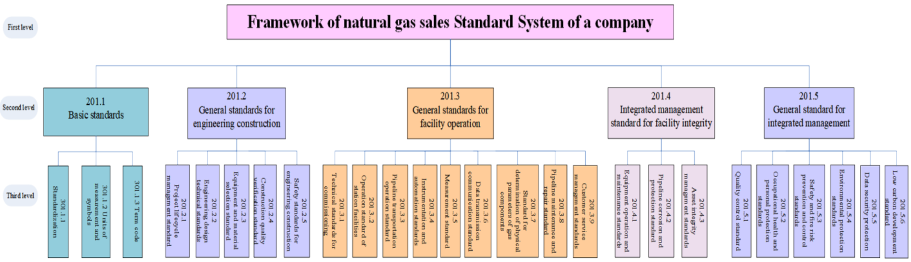

Fig. 1. Framework of Natural Gas Sales Standard System

4.2 Evaluation Result Analysis

Based on the applicability evaluation model constructed in the previous sections, a visual analysis is conducted on the applicability clustering results of the first-level and second-level indicators of the natural gas sales standard system, to accurately identify the applicability deficiencies of the system and provide a solid basis for its subsequent optimization. Meanwhile, a comparative verification with the fuzzy comprehensive evaluation (FCE) method is performed for the primary indicators, so as to verify the effectiveness and superior performance of the proposed hybrid grey clustering model.It should be noted that the clustering coefficients of "Low Applicability" and "High Applicability" in the clustering results of secondary indicators are zero, so the following chart presentation and analysis of secondary indicators only focus on the results of "Relatively Low Applicability", "Moderate Applicability" and "Relatively High Applicability"; all five levels of primary indicators are reserved.Sensitivity analysis by varying grey clustering thresholds confirmed the stability of the applicability rankings, indicating that the evaluation results are robust.

The clustering coefficients of the secondary indicators of Rationality of Standard System Structure (Figure 2) are mostly concentrated in the "Moderate Applicability" range, and all indicators are slightly inclined to "Relatively High Applicability" and "Relatively Low Applicability"。

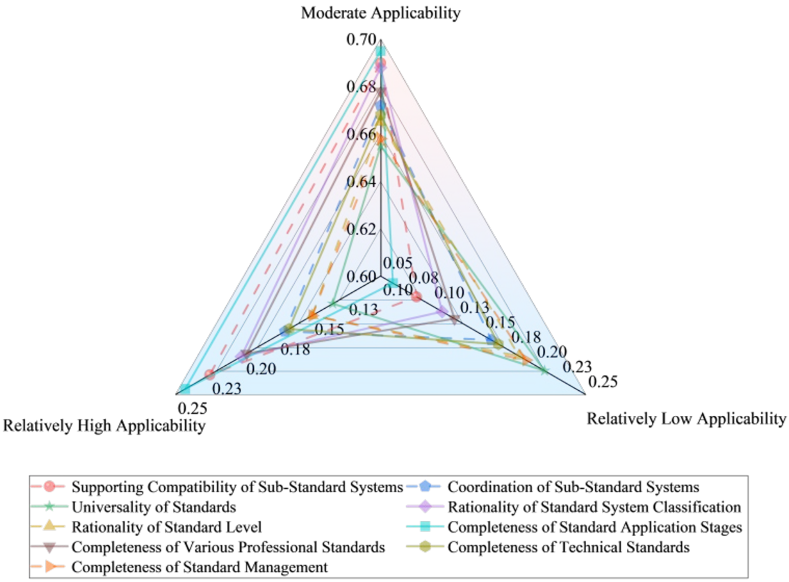

Fig. 2. The calculation results of the secondary indicators under the reasonably structured standard system

The secondary indicators of Content Relevance of Standard System (Figure 3) are mainly "Moderate Applicability", and all indicators are slightly biased towards the "Relatively High Applicability" range, showing little inclination to the "Relatively Low Applicability" range.

From the analysis results, the Rationality of Standard System Structure dimension presents partial gaps in professional standards and insufficient overall supporting capacity, as its core indicators are at "Moderate Applicability" level and show a bidirectional distribution trend towards "Relatively High Applicability" and "Relatively Low Applicability". While the Content Relevance of Standard System dimension has an overall favorable applicability trend, its insufficient matching with data transparency makes it hard to meet the needs of digital transformation and data-driven decision-making.

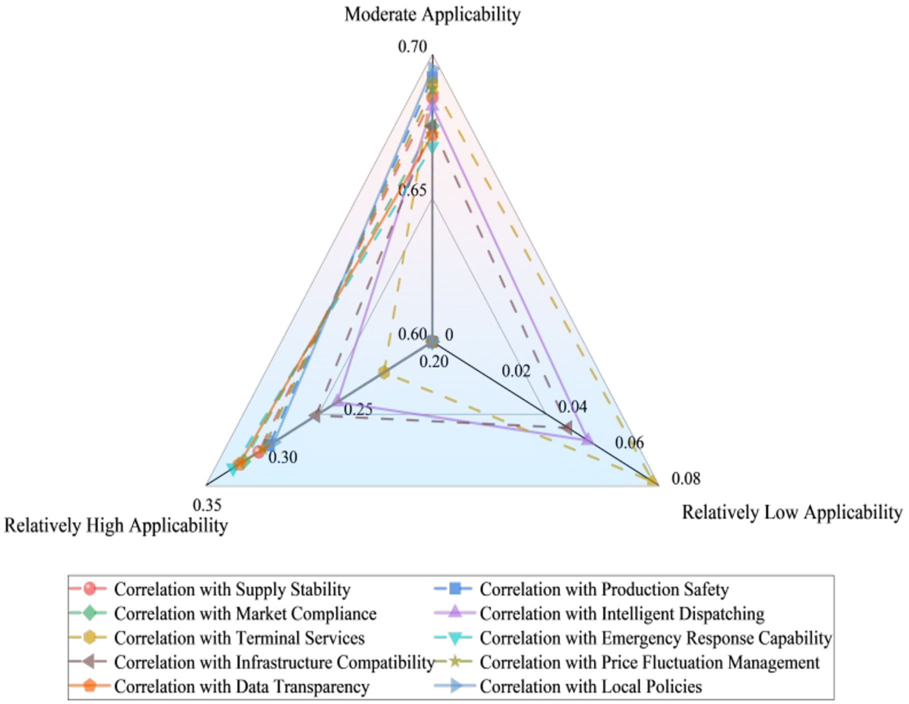

Fig. 3. The calculation results of the second-level indicators under the content relevance of the standard system

The clustering coefficients of the indicators related to the impact on economic development and related industries under the Benefit of the Standard System (Figure 4) are all at "Moderate Applicability", while the indicators related to the impact on energy conservation and emission reduction and environmental development show a transition trend towards "Relatively High Applicability". Among the indicators under the Cycle of the Standard System (Figure 5), the indicators represented by standard half-life and standard obsolete rate are mainly at "Moderate Applicability", and all indicators show a slight skewness towards "Relatively High Applicability" and "Relatively Low Applicability".

These results indicate that although Standard System Benefit dimension has achieved initial results in the green and low-carbon field, its driving effect on economic growth and support for industrial synergy still need to be strengthened. The Cycle of the Standard System dimension, with its indicators showing the characteristics of "Moderate Applicability" and bidirectional skewness, exposes the system's lag in response to market dynamics, and part of its content is disconnected from the development of new business formats and technologies.

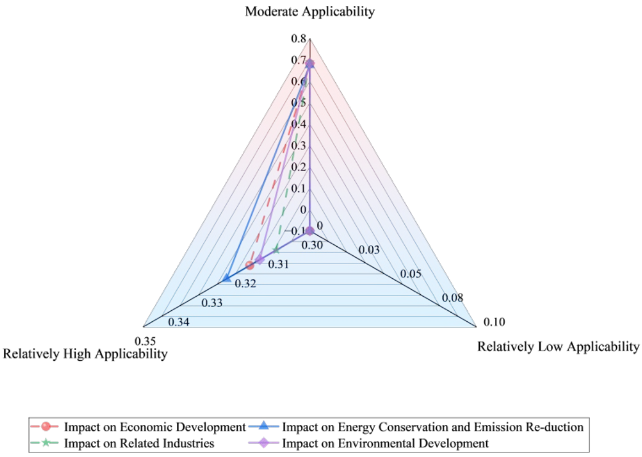

Fig. 4. Calculation Results of Secondary Indicators Subordinate to the Benefits of Standard System

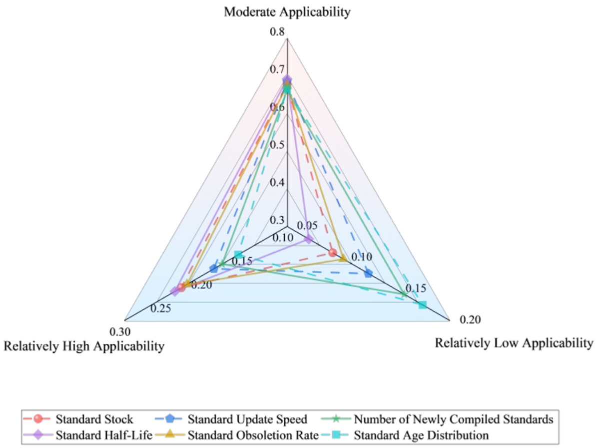

Fig. 5. Calculation results of secondary indicators under the cycle of standard system

Among the indicators under the Demand Degree of the Standard System (Figure 6), the clustering coefficients of most indicators such as market demand degree and application frequency and scope of standards are at "Moderate Applicability", with a slight skewness towards "Relatively Low Applicability", and only the indicator of standard issuing authority falls into "Relatively Low Applicability". These results show that there is insufficient connection between standard formulation and market demand, with a low overall application level. Meanwhile, the insufficient adaptation of the issuing authority further reduces the overall application efficiency of the standard system.

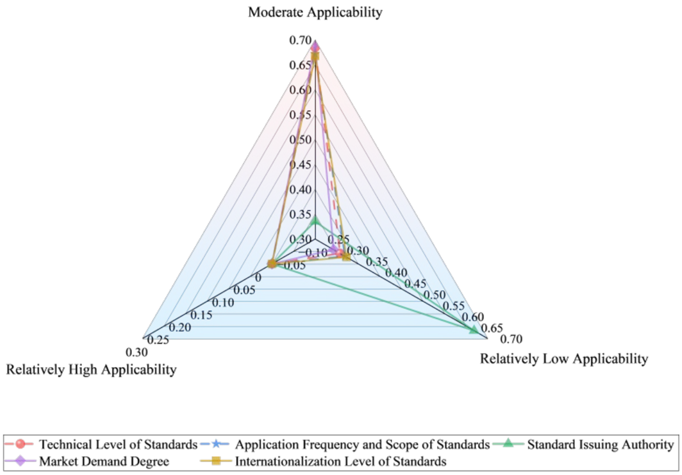

Fig. 6. The calculation result of the second-level index under the demande of the standard system

The clustering coefficients of the four primary indicators, namely Structural Rationality, Content Relevance, Benefit and Cycle (Figure 7), are all at "Moderate Applicability". Only the clustering coefficient of the Demand Degree of the Standard System shifts towards "Relatively High Applicability", and none of the primary indicators fall into "High Applicability" ,"Low Applicability" and "Relatively Low Applicability".

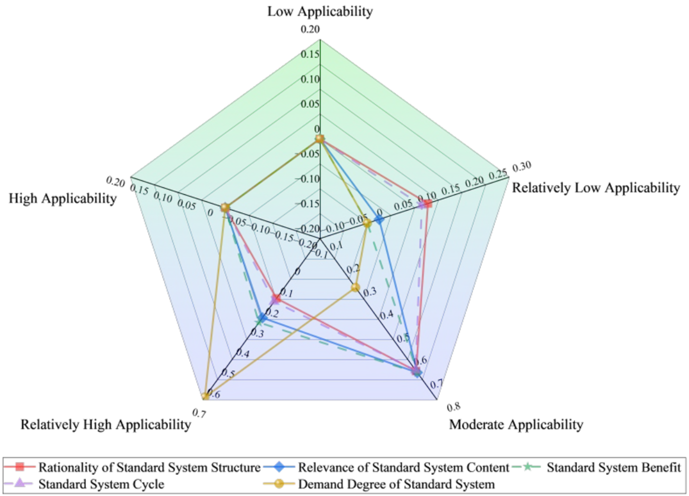

Fig. 7. Calculation Results of the First Level Index of Applicability Evaluation of Standard System

To further verify the superiority and discriminative capability of the hybrid grey clustering model, a comparative analysis is conducted with the conventional Fuzzy Comprehensive Evaluation (FCE) method [20]. To ensure a fair comparison, the FCE model adopts the exact same indicator weights from the group decision entropy weight method and the same grade thresholds defined in Table 3. We uniformly extract the values corresponding to the Moderate Applicability grade for both methods, with the comparison results for the five primary indicators shown in Fig. 8. As shown in Fig. 8, the grey clustering results show clear hierarchical differences between indicators, effectively capturing the actual applicability gaps of the standard system. In contrast, the FCE results are highly converged with a significant averaging effect that obscures indicator-specific deficiencies, which confirms the stronger discriminative power and incremental value of the proposed model.

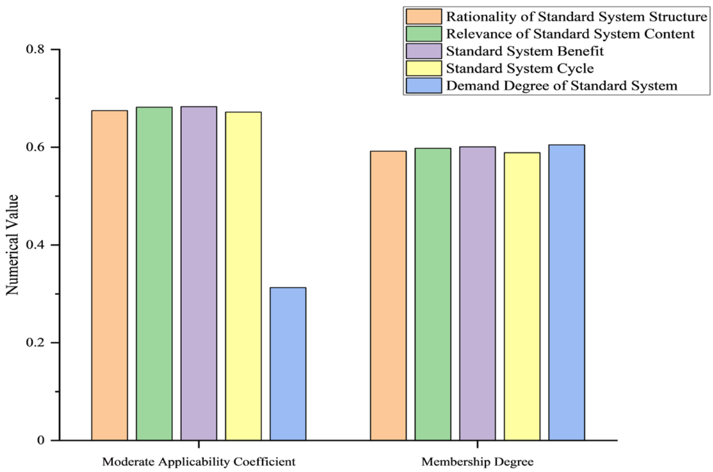

Fig. 8. Comparison of Moderate Applicability Results between Hybrid Grey Clustering Model and FCE Method

This characteristic indicates that the current natural gas sales standard system presents an overall applicability pattern of "local advantage - overall medium": the high applicability of the Demand Degree of the Standard System dimension benefits from the effective connection between the system and the basic industry demands. However, the moderate applicability performance of the Structural Rationality dimension exposes the problem of insufficient coordination among sub-standard systems; the moderate applicability performance of the Content Relevance dimension highlights the core deficiencies of the system in data transparency and adaptation to local policies; the moderate applicability performance of the Benefit and Cycle dimensions reflects the deep-seated problems of insufficient driving effect on economic development and lagging iterative update of standards. Overall, the current system has not yet formed a full-dimensional collaborative closed loop of "demand - structure - content - benefit - cycle".

4.3 Optimization Recommendations

The above evaluation results show that all primary indicators are at the Moderate level. The Rationality of Standard System Structure and its secondary indicators have poor coordination and structural gaps, which fail to adapt to industrial green and digital development and require structural improvement. Secondary indicators including data transparency, economic benefit and market demand are mediocre, and Standard Issuing Authority is Relatively Low with weak implementation support, calling for optimized standard preparation. Cycle-related secondary indicators are lagged in update, which needs a collaborative dynamic mechanism to ensure timeliness.

Based on the applicability evaluation results of the above natural gas sales standard system, combined with the energy revolution, the "double carbon" goal and the core orientation of the industry digital intelligence transformation[21-24], This paper puts forward optimization suggestions from three aspects: the improvement of system structure, the optimization of standard preparation, and the construction of collaborative update mechanism.

First, in terms of the improvement of the standard system structure, aiming at the problem of partial gaps in professional standards exposed by the Structural Rationality dimension, General Standards for Green and Low-Carbon Development and General Standards for Digital and Intelligent Transformation can be added to the secondary level of the existing standard system. The former covers carbon footprint tracing, carbon emission reduction accounting, new energy collaborative sales, etc; The latter covers intelligent device integration, cross platform data interaction, digital terminal management, etc., forming a standard framework suitable for the development of the industry.

Second, in terms of standard preparation, in combination with the problems pointed out in the above analysis, such as insufficient data transparency, weak economic pull, and low market adaptation, the content of the standard system is supplemented and improved in three categories: The first is digital intelligent adaptation standards, which unify and standardize the data acquisition, transmission and storage standards of the whole process of natural gas sales, as well as the technical requirements of intelligent metering equipment and digital terminals; Second, standards for improving economic and social benefits should be formulated to supplement special standards such as evaluation of carbon emission reduction, pricing and charging of low-carbon services, and collaborative operation and sales of natural gas and renewable energy; The third is to adapt standards to market demand, refine differentiated management terms in different regions, and improve the feedback mechanism and implementation effect evaluation process for the implementation of standards.

Third, in terms of the construction of coordination and dynamic update mechanisms, targeting the core problem of lagging standard update, on the one hand, we will strengthen the collaborative review of sub-systems to fill the gaps in collaborative adaptation; on the other hand, we will establish a hierarchical dynamic update mechanism, shorten the update cycle of green low-carbon and digital and intelligent-related standards, and promptly eliminate content disconnected from new industry formats through regular monitoring of standard age and invalidation assessment of overdue standards.

5 Conclusion

China's natural gas sales industry is in the critical development period of "double carbon" transformation and digital intelligence upgrading. Standardized governance is the core tool to support the high-quality development of the industry, but there is no systematic applicability quantitative evaluation method for the natural gas sales Standard System in the current field, and there is an obvious research gap.

Therefore, this paper constructs a set of quantitative evaluation methods for the applicability of natural gas sales standard system by comprehensively using DEMATEL method, group decision entropy weight method and gray clustering model of center point triangular whitening weight function. This method can accurately identify the short board of the standard system, provide quantitative support for system optimization, and has good portability. It can be extended to the evaluation of other standard systems in the field of energy sales, and has positive significance for improving the quantitative evaluation methodology of standardization management in the energy industry.This study fills a methodological gap in the quantitative evaluation of standard system applicability for natural gas sales, and the proposed framework is transferable to other energy sales sectors.

Although the evaluation method constructed in this study has achieved the core research objectives and completed the empirical application and effectiveness verification, it still warrants further improvement.Future research may explore the dynamic adjustment of evaluation weights and the refinement of evaluation levels, while also expanding the indicator system by incorporating international standards, foreign literature and industry grey documents. In this way, the framework can be endowed with international dimensions such as green development, digital transformation and cross-border coordination, so as to enhance its global comparability, adaptability and practical management value.

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Disclosure of Interests

The authors have no competing interests to declare that are relevant to the content of this article.

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