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Research Article

Research on Performance Evaluation System of Shale Gas PPP Project Based on Matter Element Analysis

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The PPP model is a Public-Private Partnership and a pattern which provides product or service to the public; applying the PPP model to the shale gas development project helps to solve the difficult problem that exists in the shale gas project. Through extensive literature analysis and in-depth study of shale gas PPP projects, for performance evaluation of shale gas PPP project, based on the five dimensions of macroenvironmental characteristics, economic benefits, the project internal processes, innovation and environmental protection and sustainable development, and stakeholder satisfaction, an indicator system consisting of 22 secondary indicators was set up, and the weight of each index was determined by AHP, using the matter element analysis method to build the comprehensive evaluation of the shale gas PPP project performance evaluation model and set indicator evaluation standard of excellent, good, medium, general, and poor in five grades. We evaluate the performance of a shale gas PPP project and conclude that the evaluation grades of the project are good, which is in line with the reality, indicating that the evaluation system and the method are effective and credible.

1. Introduction

Shale gas is an unconventional natural gas contained in shale formation. Shale gas extraction projects are characterized by large extraction risks, large investment in exploitation, involving many related enterprises, and long investment recovery period [1]. As the world's largest shale gas reserve, China's shale gas has become the strategic focus of national energy development. The shale gas mining is bound to show an accelerated development.

Although the country has more and more policy support in shale gas extraction, but the characteristics of the large investment in shale gas project lead the three major difficulties in shale gas project financing, they are [2] mainly financing body single, lack of financing channels, and lack of flexibility of capital exit mechanism effectively. The Public-Private Partnership (PPP) model is a model of providing products or services to the public based on the cooperation between the government public sector and the private sector [3]. By attracting social capital into the infrastructure construction, the PPP model can realize the optimal allocation of resources under the premise of fully mobilizing the resources of all parties. The PPP model can realize the diversification of investor and realize the limited recourse and flexible credit structure, which can solve the three difficult problems in the process of shale gas exploitation.

Based on the support of the country and the advantages of the PPP model, the PPP model is widely used in the construction of various infrastructures. Sun Jie [4] had proposed that the effective evaluation of PPP is the key to the success of the PPP project. Klijin [5] and Garvin [6] believe that PPP shares costs, risks, and contributions to profits across the parties around a win-win mindset and long-term partnership. And performance evaluation refers to the use of certain evaluation methods, quantitative indicators, and evaluation standards, to achieve the project participants to achieve their expected performance goals. The study of PPP project performance evaluation system can provide accurate information for the government and the private sector and help them make scientific and reasonable decision but also can be used for the project life cycle of all stages and all aspects of the benefit evaluation. Article 43 of the "Administrative

Measures on Infrastructure and Public Utilities Franchise" [7] implemented by the State Council from June 1, 2015, provides that the implementing agency shall regularly monitor and analyze the construction and operation of the franchise project according to the franchise agreement and conduct performance evaluation with the relevant departments and establish a mechanism to adjust the price or financial subsidies according to the performance evaluation results and in accordance with the franchise agreement to ensure the quality and efficiency of the public goods or public services provided. It can be seen that the government attaches great importance to the performance evaluation of PPP projects, but China's PPP model is in the early stage of development. There is no specific charter or document for performance evaluation, and no independent normative evaluation system has been formed. Therefore, in the performance evaluation of PPP projects, how to choose evaluation indicators, how to construct an evaluation system, and how to conduct performance evaluation among the various participants are a hot issue worth studying.

Due to the imperfect performance evaluation system, many foreign PPP projects did not achieve optimal performance after experiencing a long cycle and cost overruns [8]. As early as 2015, foreign scholars believe that the evaluation based on the whole life cycle (process-based) is a promising, comprehensive, and effective performance evaluation method for PPP projects. Whether it is in the organization or the project level, the performance evaluation is crucial to the success of the project [9–11].

Only by accurately evaluating the performance of the project, understanding the current problems of the project and improving it in time can ensure that the final operational results of the project can be recognized by the public [12]. From the perspective of the government, it is necessary to determine whether the use of financial funds can meet the economic premise, whether the operation process complies with laws and regulations, whether the products of the project meet the requirements of the public, and whether the environmental pollution level is up to standard. From the perspective of social capital, it is mainly whether the reasonable rate of return of the project is achieved under the basic premise [13].

In terms of research methods, at home and abroad, many scholars have studied the performance evaluation system of PPP projects in a variety of ways. Through a plethora of literature analysis, the author found that the methods of performance evaluation of PPP projects mainly are the Balanced Scorecard and Key Performance Indicator (KPI) and other methods, combined with fuzzy comprehensive evaluation method, AHP, and matter element analysis method to determine the weights and the quantization of the indicator.

The performance evaluation has a great positive role in improving project performance and maximizing project performance target. Scholars or institutions at home and abroad have made relatively mature achievements in performance evaluation of PPP projects, through reading a large number of literature; it is found that each type of project will have some performance evaluation indicators combined with the characteristics of the project itself. The more targeted the evaluation system, the more accurate the evaluation result. For example, in the sewage treatment plant PPP project performance evaluation there has been more mature and systematic index system at home and abroad. But in the existing performance evaluation system, the evaluation system of shale gas PPP project is still scanty. At the same time, shale gas development in PPP mode involves a large number of participants, including government, private enterprises, project companies, loan banks or other financial institutions, insurance companies, guarantee trustee, storage and transportation infrastructure operators, professional equipment suppliers, product users, etc. [14]. In the previous evaluation of the performance evaluation of PPP projects, the participants tended to focus on the performance grade of their own parties and had little consideration for the performance indicators of other participants, resulting in the lack of connection between the performance evaluation indexes of PPP project and even the lack of systematic evaluation index system [15]. Shale gas PPP project is a project with multiparticipation and long development cycle. When evaluating its performance, under the premise of such multiobjective evaluation, single index is hard to evaluate the project comprehensively, so we need to establish a comprehensive performance evaluation system [16]. In a word, to evaluate the performance of shale gas PPP project accurately, it is urgent to establish a performance evaluation system for shale gas PPP project in order to achieve the effect of performance evaluation and provide practical methods for the current and future performance evaluation of shale gas PPP projects.

2. Material and Theory Support

2.1. Theory Support. In the implementation process of PPP projects, the public sector's pursuit of public satisfaction and social benefits of public goods or services may, to a certain extent, ignore the interests of the private sector. The private sector focuses on the profitability of the project, paying attention to the cost and benefits of the project, and may ignore the social benefits of the project. If the two sides conduct performance evaluation separately, it will not reflect the characteristics of the PPP project and its comprehensive benefits. The balanced scorecard method breaks the traditional performance evaluation model focusing only on financial indicators and advocates that the performance evaluation of enterprises is carried out in four aspects: customer, finance, internal process, learning, and growth. Among them, the customer's focus is on how the company creates value for the customer; the financial focus is on the company's ability to control the cost; the internal process is based on the customer's needs and on the premise of effectively controlling the cost and the company's achievement of the field beyond the evaluation. The focus of learning and growth is on the improvement of the company and the sustainability of value creation (Greatbanks et al., 2007; Harvey et al., 2018). Therefore, the balanced scorecard method is more suitable for performance evaluation of PPP projects. Based on the balanced scorecard theory, the performance evaluation

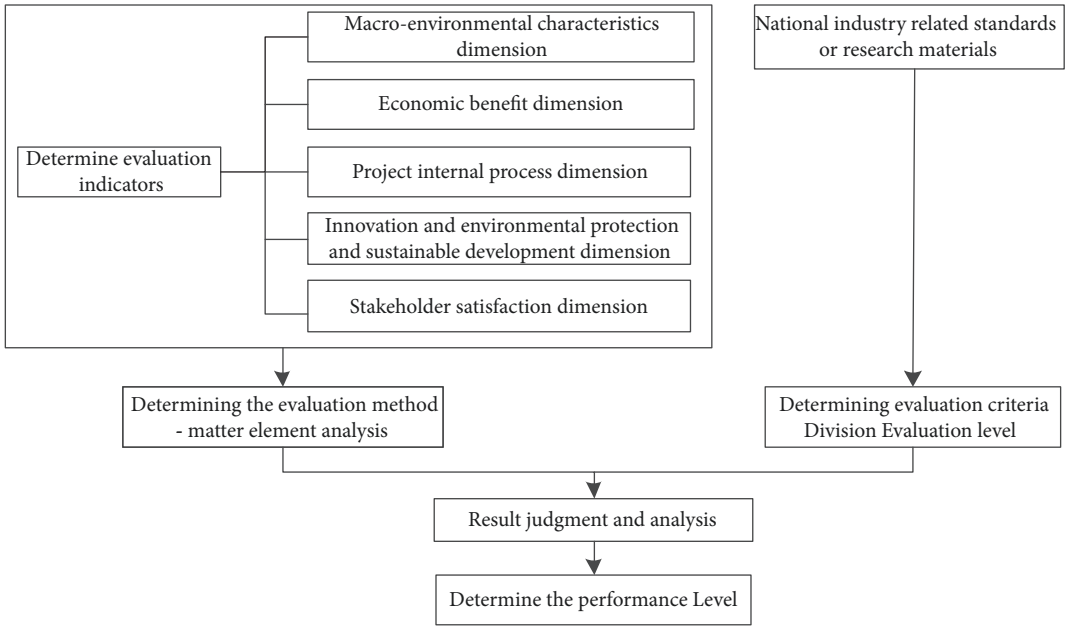

Figure 1: Proposed framework of the performance evaluation of shale gas PPP project.

of shale gas PPP project can select indicators from the macroenvironment dimension, economic benefit dimension, and project internal process dimension.

As a public good, PPP projects should pursue the realization of the common interests of the public sector and the private sector. The public sector represents the interests of the government and the general public. The private sector represents the interests of social capital. Therefore, PPP projects need to achieve a balanced state among the interests of the government, the public, and social capital. The *Administrative Measures on Infrastructure and Utilities Franchising* mentioned that the implementing agency should take public opinions as an important part of monitoring analysis and performance evaluation. This shows the government's emphasis on public opinion and public interest. If investors want to realize the public interest of shale gas PPP projects, they need to consider the sustainable development of the project. The theory of sustainable development refers to the development theory that meets the needs of the present and does not constitute a harm to the ability of future generations to meet their needs. The development theories of fairness, continuity, and commonality are the three basic principles [29]. The ultimate goal is to achieve common, coordinated, fair, efficient, and multidimensional development. The sustainable development system includes social sustainable development system, economic sustainable development, and resource and environment sustainable development system. Based on the theory of sustainable development, the performance evaluation of shale gas PPP projects needs to select evaluation indicators from the dimensions of innovation, environmental protection, and sustainable development. Freeman [30] proposed that stakeholders are individuals or groups that affect the realization of organizational goals. While achieving economic goals, enterprises must also achieve the interests of stakeholders [30, 31]. Based on the stakeholder satisfaction theory, the performance evaluation of shale gas PPP project needs to select the evaluation index from the dimension of stakeholder satisfaction.

The shale gas PPP project is different from the general infrastructure construction project. It not only is extremely sensitive to macroeconomic policies, but also has high technical requirements and has a great impact on the environment during the mining process. In general, its resource conditions, technological advancement, economic efficiency, and environmental impact are closely related to the performance evaluation of the project. This study is based on four aspects of the balanced scorecard theory, combined with the requirements of the sustainable development theory for shale gas projects, and the number of stakeholders considering PPP projects, applying the stakeholder satisfaction theory to the performance evaluation of shale gas PPP projects, mainly from the macroenvironment, economic benefits, project internal processes, stakeholder satisfaction and innovation, environmental protection, and sustainable development to evaluate the performance of shale gas PPP projects (Figure 1).

2.2. Macroenvironmental Characteristics. For the shale gas PPP project, apart from the difficulties of extensive participants, long project duration, and large project investment, there are also some unique and difficult problems in shale gas development projects currently under the conditions of China's market economy: China's shale gas mining rights access standards, mining sequence, exit system, circulation conditions, and supervision and other problems, restricting the development of shale gas industrialization and large-scale development [32, 33]; according to the latest circular on "Notice on the Financial Subsidy Policy for the Exploitation

and Utilization" of Shale Gas issued by the Ministry of Finance of China and the National Energy Administration, the central government continued to grant subsidies to shale gas mining enterprises from 2016 to 2020: the subsidy standard for 2016 to 2018 is 0.3 CNY/m^3 and from 2019 to 2020 is 0.2 CNY/m^3. It is shown that the fiscal support is not strong enough, the fiscal support is not long enough, the preferential tax treatment is not large enough, and the unreasonableness of the relevant fiscal incentives is limited to the development of the shale gas industry to a large extent [34] (Lin 2013). Comparing with developed countries in Europe and America, China's pipeline network infrastructure construction is not perfect. "China Natural Gas Development Report 2017" shows that, as of the end of 2016, China's per thousand square kilometers of land area corresponding to pipeline mileage is about 70 km, equivalent to only 12% of the United States, the formation of underground gas storage capacity of 6.4 billion cubic meters, accounting for only 3.1% of consumption, far below the world average of 10%. In addition, the market construction is the key to the development of shale gas industry, the "Shale Gas Revolution" in North America benefits from the open and fair market environment obtained after breaking the monopoly and effective incentive mechanism, and the monopoly in our shale gas market has seriously hindered the development of the shale gas industry in China [35].

2.3. Economic Benefits. The economic evaluation of shale gas PPP projects is mainly conducted from two aspects: the economic benefit evaluation of shale gas project and the economic benefit evaluation of PPP project. Evaluation of the economic benefits of the shale gas project should be evaluated in terms of macroeconomic benefits and industrial development benefits, that is, the promotion of the regional economy and possible added value of various links in the industrial chain [17], and they are ultimately reflected in the improvement of the residents' income level. As the PPP project, using or intending to use the PPP mode in our country of the project shall be in accordance with the "The Guidelines of Evaluation of PPP Value for Money (Try Out)"; the relevant provisions of value evaluation and the quantitative evaluation are evaluated through two quantitative results of the value for money and the value for money index. The character of huge investment and long development cycle of shale gas development projects requires that shale gas development enterprises have a continuous good capital structure, mainly reflected in the enterprise total asset-liability ratio and shareholder equity ratio [17].

2.4. The Project Internal Processes. The success of a PPP project and the large-scale production of shale gas require that shale gas company has good financial ability and its management ability is also an important factor for the success of performance. In 2003, a natural gas blowout accident occurred in Kaixian, Chongqing. After investigation, the reason of the accident was that a technical manager of CNPC issued instructions to the subordinate technician to replace the damaged equipment, knowing that the removal of the back-pressure valve may cause blowout accident, but the technician did not raise any objection to this obvious violation, which eventually led to the occurrence of the accident (Yu 2014). From this case, we can see the importance of a well-established Health Safety and Environment System (HSE) for shale gas development projects [36]. In the previous domestic PPP projects, such as Beijing Jingtong Road, Hangzhou Bay Sea-Crossing Bridge, Shenyang No. 9 Water Plant, Beijing No. 10 Water Plant, and other relatively unsuccessful cases, are mostly due to the problem of the allocation of rights and responsibilities in the management of the project contract by the government or the partnership [37], showing the importance of contract management on a PPP project. At the same time, for shale gas development projects which have multistakeholder, reasonable project company organization structure and the good operation of the project company are inseparable.

2.5. Innovation and Environmental Protection and Sustainable Development. In the Shale Gas Revolution that began in the United States since 1982, with the strong support of the government, the United States launched the Eastern Shale Gas Project (EGSP) for shale gas research and development, aiming at enhancing the research of shale gas geochemistry, geological conditions, and development technology [38]. First, the Michel Energy Company took the lead in making breakthroughs in hydraulic fracturing technology; then the Devon Energy Company achieved a major breakthrough in the horizontal drilling technology; thus the innovation and progress of shale gas exploration and mining technology prompted the US Shale Gas Revolution success [34, 39, 40].

The main environmental problems in shale gas mining process include [41–47] large consumption of water resources, groundwater and soil pollution, methane leakage, and geological risk. The greatest impact is on the water environment and atmospheric environment [44]. Horizontal wells have high production but large consumption of water resources, with up to 7560 ~18900m^3 of water consumption per well, which is 60~100 times larger than that of conventional hydraulic fracturing wells. For every million cubic meters of shale gas produced, there will be produced 30~130m^3 effluent [48, 49]. The atmospheric pollutants in the mining process are mainly methane and nitrogen oxides [44], wherein the greenhouse effect of methane is 25 times as CO_2 is an important greenhouse gas; Wigley teams' [46] research shows that only methane leakage is less than 2%; the use of natural gas compared to traditional coal has the advantage of reducing the greenhouse effect. According to the British Geological Survey's (BGS) report, high pressure water injected into deep strata and causing rock fracture both can induce seismicity [50]. Since the "Environmental Protection Law of the People's Republic of China "came into effect on January 1, 2015, China has attached great importance to the land reclamation and the quality standards for land reclamation have been promulgated for soil pollution such as the "Land Reclamation Regulations" and "Land Reclamation Quality Control Standards" (TD/T1036-2013) [51, 52].

At present, the shale gas PPP project is in the initial stage and lacks the experience of the industry. Therefore, every project is required to have the sustainability of learning and promoting. The sustainability of learning and promotion of the project is demonstrated through human resources (building and cultivating professional teams and professionals) and through the promotion of shale gas PPP projects (reproducibility of shale gas PPP projects) [53].

2.6. Stakeholder Satisfaction. In 1963, researchers from the Stanford University first proposed the concept of stakeholder; Freeman [30] proposed that stakeholders are individuals or groups that influence the realization of organizational goals. While realizing economic goals, stakeholders also need to achieve stakeholder interests. Participants involved in the PPP project include government, social capital, the public, banks and other financial institutions, consulting firms, and other participating companies. Among them, the social public is the social supervisory body for the shale gas PPP project and the "Environmental Protection Law of the People's Republic of China" clearly stipulates the qualification of public interest litigation. The study divides stakeholders into three categories: government agencies, private sector, and the general public.

2.7. Establishment of Performance Evaluation System for Shale Gas PPP Project. In view of the impact of the above indicators on the performance of shale gas PPP projects, the relevant departments of various countries have taken a series of measures [54–56], for example, from the government point of view, improve the relevant legal system; from the perspective of the project company, do a good job in the initial shale gas resources exploration and environmental impact assessment, promote technological innovation and technological progress, establish and improve the environmental risk supervision mechanism and emergency mechanism of shale gas mining, etc., so as to reduce the negative impact on the environment. In terms of technology, the mining of high-efficiency and low-pollution in China is in urgent need of innovation and the corresponding shortage of professional and technical personnel; in terms of environmental protection, there is a lack of corresponding mandatory policy and lack of environmental awareness among enterprises.

To sum up, according to the collation and demonstration of a large number of literatures and the actual situation, based on the principle of scientific rationality, high-efficiency evaluation, independence of relevant subjects, and the combination of qualitative and quantitative indicators, the author sets 22 secondary indicators from the five dimensions of macroenvironmental characteristics, economic benefits, the project internal processes, innovation and environmental protection and sustainable development, and stakeholder satisfaction. The evaluation of indicators is divided into excellent, good, medium, general, and poor five grades. The study makes a comprehensive evaluation of the project management, production technology, environment, economy, society, and other factors in the shale gas development process and builds a performance evaluation system of shale gas PPP project (Table 2).

The macroenvironmental characteristics include the degree of the perfection of national shale gas mining rights management legal system, the degree of the reasonableness of financial incentives, supporting infrastructure of storage and transportation, and construction of shale gas market, all of which are qualitative description indicators; according to the above description of indicators, the classification is determined by expert scoring.

The economic benefit indicators include the degree of the improvement of residents' income level, total asset-liability ratio, shareholder equity ratio, and value for money index. According to the requirements of *"the 13th Five-Year Plan for Economic and Social Development of the People's Republic of China (2016-2020)"*, the performance of the evaluation project is excellent when the residents' income level is increased by more than 5%. The total asset-liability ratio, shareholder equity ratio, and value for money index are quantitative indicators. According to their actual calculation values and related literatures rating level [17, 57], see Table 2.

The project internal processes indicators include the construction of HSE management system, validity of contract management, and the organization structure of SPV. The score of the index is based on the score, which is graded by the relevant experts.

Innovation and environmental protection and sustainable development indicators include technical innovation and progress of shale gas exploration and development, reclamation of shale gas platform, the national set up shale gas innovation award, and other eight indicators. The 13th Five-Year Plan proposed the growth rate of the proportion that the nonfossil energy accounts for primary energy consumption from 12% in 2015 to 2020 to achieve the goal of 15% (a total of 3 percentage points), so for the evaluation project to bring nonfossil energy in primary energy consumption growth of 2.5 and above, the index of performance is excellent. The score of the index is based on the score, which is graded by the relevant experts.

Stakeholder satisfaction indicators include government agencies satisfaction, private sector satisfaction, and the general public satisfaction. Through the form of questionnaire to score the satisfaction of all parties, each questionnaire is divided into 100 points, divided into five grades.

3. Method

3.1. Superiority of Method. The matter element model was established by professor Cai Wen [58] in the 1980s; it is mainly used to solve complex and incompatible problems and is suitable for multi-index evaluation. The performance evaluation of matter element analysis applied to PPP projects has the following advantages [20]: The comprehensive impact of various factors on performance can be fully considered; using the correlation function to establish a mathematical relationship between the evaluation target and the evaluation criteria can fully reflect the degree of relevance between the evaluation target and the evaluation criteria; not only can the

shale gas PPP project performance level be defined by which rating level, but also the difference in the same level indicator can be expressed by accurate values; the evaluation system is flexible; by using the correlation function and the correlation function belongs to (-∞, +∞), the research scope of the method is expanded. The matter element analysis method can conduct comprehensive performance evaluation research on the project, making the performance evaluation result more objective.

3.2. Operation Steps. The performance evaluation of the shale gas PPP project can be regarded as an incompatible problem, and the number of indicators involved is large. The performance evaluation matter model of the shale gas PPP project is constructed according to the matter element analysis method. The steps are as follows [59–61].

Step 1 (determine the weight of each indicator). Use the Analytic Hierarchy Process (AHP) to determine the weight of each indicator.

Step 2 (determining the shale gas PPP project performance evaluation matter element). The shale gas PPP project performance evaluation N, the performance evaluation feature c, and the feature magnitude V together constitute the shale gas PPP project performance evaluation matter element, which is expressed as

$$R = \begin{vmatrix} N & c_1 & v_1 \\ & c_2 & v_2 \\ & \vdots & \vdots \\ & c_n & v_n \end{vmatrix} = \begin{vmatrix} R_1 \\ R_2 \\ \vdots \\ R_n \end{vmatrix} \tag{1}$$

In this matrix, R is n-dimension shale gas PPP project performance evaluation matter element, recorded as R= (N, C, V)

Step 3 (determining the classical domain matrix). The classical domain matter matrix of shale gas PPP project performance evaluation can be expressed as

$$R_{oj} = \left(N_{oj}, c_i, v_0\right) = \begin{vmatrix} N_{oj} & c_1 & \left(a_{oj1}, b_{oj1}\right) \\ & c_2 & \left(a_{oj2}, b_{oj2}\right) \\ & \vdots & \vdots \\ & c_n & \left(a_{ojn}, b_{ojn}\right) \end{vmatrix} \tag{2}$$

In this matrix, R_{oj} is classical domain matter element; N_{oj} is the jth grade of shale gas PPP project performance evaluation (j = 1, 2, . . . , m); c_i is the ith character of the jth grade, the classical domain describing the corresponding characteristics of each grade (a_{oij}, b_{oij}).

Step 4 (determining the joint domain matter element matrix). The joint domain matter element matrix of the shale gas PPP project performance evaluation is expressed as

$$R_p = \left(N_p, C_n, V_p\right) = \begin{vmatrix} N_p & c_1 & \left(a_{p1}, b_{p1}\right) \\ & c_2 & \left(a_{p2}, b_{p2}\right) \\ & \vdots & \vdots \\ & c_n & \left(a_{pn}, b_{pn}\right) \end{vmatrix} \tag{3}$$

In this matrix, R_p is joint domain matter element; N_p is all grades of shale gas PPP project performance evaluation; V_p is the quantity value of R_p with respect to c_i, joint domain (a_{pi}, b_{pi}).

Step 5 (determining the object to be evaluated). Representing the object element of the object to be evaluated N_x as R_x:

$$R_x = \begin{vmatrix} N_x & c_1 & v_1 \\ & c_2 & v_2 \\ & \vdots & \vdots \\ & c_n & v_n \end{vmatrix} \tag{4}$$

Step 6 (determining the correlation function and the degree of association). The shale gas PPP project performance evaluation index correlation function K(x) is defined as

$$K\left(x_i\right) = \begin{cases} \dfrac{-\rho\left(X, X_o\right)}{\left|X_o\right|}, & X \in X_o \\ \dfrac{\rho\left(X, X_o\right)}{\rho\left(X, X_p\right) - \rho\left(X, X_o\right)}, & X \notin X_o \end{cases} \tag{5}$$

In this equation,

$$\rho\left(X, X_o\right) = \left|X - \frac{1}{2}\left(a_o + b_o\right)\right| - \frac{1}{2}\left(b_o - a_o\right) \tag{6}$$

$$\rho\left(X, X_p\right) = \left|X - \frac{1}{2}\left(a_p + b_p\right)\right| - \frac{1}{2}\left(b_p - a_p\right) \tag{7}$$

In these equations, $\rho(X, X_0)$ is the distance of point X and finite interval $X_p=[a_p, b_p]$; $|X_0| = |b_0 - a_0|$, X, X_o, X_p are the value of the to be evaluated shale gas PPP project performance evaluation matter element, the magnitude of classical domain matter element, and the magnitude of joint domain matter element.

Step 7 (calculate the comprehensive relevance and determine the rating). The synthetically correlation degree $K_j(N_x)$ can be expressed as

$$K_j\left(N_x\right) = \sum_{i=1}^{n} \omega_i K_j\left(X_i\right) \tag{8}$$

In this equation, $K_j(N_x)$ is the synthetically relational degree, $K_j(X_j)$ is the single correlation degree (j = 1, 2, . . . , m), and ω_i is the weight of each indicators. If

$$K_{ij} = \max\left[K_j\left(X_i\right)\right], \quad j = 1, 2, \ldots, n \tag{9}$$

then to be evaluated i indicator belongs to the jth grade of shale gas PPP project performance evaluation.

$$K_{jx} = \max\left[K_j\left(N_x\right)\right], \quad j = 1, 2, \ldots, n \tag{10}$$

Then to be evaluated N_x indicator belongs to the jth grade of shale gas PPP project performance evaluation.

Step 8 (analysis of the result performance evaluation level). When $0 < K_j(N_x) < 1$, it indicates that the unit to be evaluated meets the requirements of the standard object; when $-1 < K_j(N_x) < 0$, it indicates that the unit to be evaluated does not meet the requirements of a certain evaluation standard, but the unit to be evaluated has the conditions of conversion to a standard object, and the smaller the value is, the easier it is to convert; when $K_j(N_x) < -1$, it indicates that the unit to be evaluated does not meet the requirements of a certain level of evaluation criteria and does not have the conditions for conversion into an evaluation standard.

4. Case Analysis

4.1. Case Overview. A certain Southwest Shale Gas PPP Project Platform Drilling Project is located in the central and southern Sichuan Basin, Neijiang Weiyuan County territory. The nature of the project is a new project, with a total investment of 120 million yuan, of which 3.35 million yuan is environmental protection investment, accounting for about 2.8% of the total investment. The project includes predrilling, drilling, and completion engineering. The platform will drill 3 horizontal wells with a designed well depth of 4800 meters (straight well section of 3000 meters + horizontal section of 1800 meters), and the target layer is the Silurian LongMaxi Formation.

4.2. Evaluation Procedures

4.2.1. Determine the Weight. Based on the concept of performance evaluation of shale gas PPP project defined in this paper, the index system of Table 2 is established, and the weight of each index is determined through the method of expert consultation and Analytic Hierarchy Process (AHP). Limited to the space, the specific calculation process is not describing; the results are shown in Table 3.

4.2.2. Determine the Classical Domain and Joint Domain Matter Element of the Shale Gas PPP Project Performance Evaluation System. Classical domain, the specific value range of evaluation grade, is the basis of matter element evaluation. According to the extension of performance evaluation, experts are asked to score according to the index of Table 1, and their scores are divided into 5 grades, that is, $N_{01} \longrightarrow N_{05}$; qualitative description is excellent, good, medium, general, and poor. The determination of classical domain mainly refers to the relevant project index value, "the 13th Five-Year Plan for Economic and Social Development of the People's Republic of China(2016-2020)" and other existing national or industry norms and requirements then establish the classical domain matter matrices R_{01}, R_{02}, R_{03}, R_{04}, and R_{05}, and a joint domain matter element matrix R_p was shown in Table 4.

4.2.3. The Matter to Be Evaluated of Case Performance Evaluation. For this project, five relevant experts were invited to score according to the indicator description in Section 2.6 of the indicator system, in which stakeholder satisfaction scores were averaged by actual questionnaire scores. According to the expert score and Section 3.2 of matter element method, the shale gas PPP project to be evaluated element matrix R_x for

$$R_{x1} = \begin{vmatrix} N & c_1 & 78 \\ & c_2 & 86 \\ & c_3 & 75 \\ & c_4 & 79 \\ & c_5 & 84 \\ & c_6 & 92 \\ & c_7 & 93 \\ & c_8 & 91 \\ & c_9 & 92 \\ & c_{10} & 89 \\ & c_{11} & 92 \end{vmatrix} \tag{11}$$

$$R_{x2} = \begin{vmatrix} N & c_{12} & 86 \\ & c_{13} & 88 \\ & c_{14} & 75 \\ & c_{15} & 89 \\ & c_{16} & 92 \\ & c_{17} & 93 \\ & c_{18} & 89 \\ & c_{19} & 94 \\ & c_{20} & 91 \\ & c_{21} & 96 \\ & c_{22} & 93 \end{vmatrix} \tag{12}$$

4.2.4. Result of Case Performance Evaluation. The matter element to be evaluated is input into the matter element model, and the corresponding calculation result is obtained. The results are shown in Table 5.

The correlation degree of each index will correspond to the weight in Table 3 and figure out the correlation degree of the primary dimension, as shown in Table 6.

The correlation degree of each index will correspond to the weight in Table 3, and the input equation (8) is used to find the synthetically correlation degree of all the indexes, as shown in Table 7.

According to (10), it can be concluded that K_j=-0.0520($-1 < K_j < 0$), indicating that the project performance evaluation grade can be considered as good, but the standard

Table 1: Summarization of performance evaluation indicators.

Indicator System	Main Points (Applications and Limitations)	Method	References
PPP project performance evaluation system	(i) Five dimensions: project environment, stakeholder satisfaction, financial ability, internal control management, innovation and growth (ii) The relatively independent third party is the main body of evaluation, and the stakeholders and responsible parties of the indicator are collected. (iii) The newly added satisfaction of stakeholders has made the performance evaluation results more accurate.	Balanced scorecard	[17]
PPP project performance evaluation system	(i) From the six stages of PPP project establishment, bidding, concession grant, construction, operation and handover, an evaluation system will be established. (ii) The research did not specifically target a certain type of project, and the indicator system was not targeted.	Key performance indicator method	[18]
Identification of key success factors in PPP projects	(i) Questionnaires were distributed to five stakeholder groups and 26 key success factors were obtained. (ii) It is proposed that the identified critical success factors (CSFs) can improve the success rate of PPP projects to some extent.	Critical success factor method	(Solomon et al., 2016)
Road Engineering PPP Project	(i) Measurement of the success of 13 PPP road projects in Europe based on PMS (Performance Measurement System) (ii) Slightly messy in the classification of indicators.	Delphi method	[19]
Geothermal PPP project performance evaluation system	(i) Starting from the life cycle of the project, 36 performance evaluation indicators were selected for performance evaluation of geothermal projects. (ii) There are a large number of indicators and insufficient consideration for stakeholders	Matter element analysis	[15]
Geothermal PPP project performance evaluation system	(i) Based on the KPI performance evaluation idea, a performance evaluation system based on the project life cycle infrastructure project was constructed. (ii) The evaluation system is highly targeted and the evaluation results are more credible.	Matter element analysis	[20]

Table 1: Continued.

Indicator System	Main Points (Applications and Limitations)	Method	References
Sewage treatment plant performance evaluation system	(i) Establishing the performance evaluation system of sewage treatment plant project from four dimensions: financial dimension, stakeholder satisfaction dimension, internal process dimension and learning and growth dimension. (ii) Innovative in the theory of balanced scorecards, introducing stakeholder satisfaction indicators to make the evaluation system more complete.	Balanced scorecard	[21]
Sewage treatment plant performance evaluation system	(i) Evaluation from the life cycle of the project. (ii) There is no environmental assessment and safety management related indicators in the indicators, and there is no distinction between evaluation indicators on the satisfaction indicators.	Matter element analysis	[22]
Performance evaluation of infrastructure construction projects	(i) Establish an evaluation system from five aspects (physical characteristics of the project, financial financing and market development indicators, construction indicators of innovation and learning organizations, stakeholder satisfaction indicators, process control indicators). (ii) The key performance indicator method is used to determine the indicators, and then the performance evaluation structural equation model is established to identify the more important indicators and determine the relationship between the indicators. (iii) Although it has been optimized many times, the number of indicators is still high.	Structural equation model(SEM), Key performance indicator method	[23–26]
Performance Evaluation of Infrastructure Construction Projects in Indonesia	(i) Determining the factors that should be considered in the performance evaluation of Indonesian PPP projects. (ii) The 24 performance impact factors are divided into seven groups: institutional framework, economic, social and environmental sustainability, and management of project resources, costs and time.	Exploratory factor analysis and Two-dimensional quadrant analysis	[27]
Performance Evaluation of Highway Maintenance PPP Project	(i) Performance comparison of different PPP contract programs. (ii) For highway-related projects, the system is highly targeted.	Linear regression analysis	[28]

Table 2: Performance evaluation system for shale gas PPP project.

Primary dimension	Secondary indicators	Indicator Description
Macro-environmental characteristics(A)	The degree of the perfection of national shale gas mining rights management legal system (a1)	The state shall improve the relevant legislation and legal system of shale gas mining management in China, establish a multi-level professional shale gas mining rights management system, in order to solve the problems of shale gas industry system, mining rights mining and withdrawal system, circulation of mining rights and overlapping mining rights disposal, etc., according to the degree of improvement and establishment is divided into five grades.
	The degree of the reasonableness of financial incentives (a2)	①improving the fiscal incentive policy and improving the subsidy, such as: financial support should be tilted to exploration, technology research and pipeline construction, reduce subsidy threshold, increase subsidies, extend the subsidy years, adopt a progressive subsidies, and carry out subsidies with different levels for different price fluctuation intervals; ②increase the preferential tax intensity of shale gas industry, such as: cancel the fees of use the two rights, formulate shale gas resource tax, improve and implement the shale gas value-added tax and income tax concessions, increase the total tax subsidies of shale gas exploration and development; ③a systematic and stable fiscal and tax incentive policy; ④implement a strong government procurement; ⑤the central government should encourage local government subsidies to implement the action; ⑥ financial discount. According to the above 6 implementation conditions, the score is divided into five grades.
	Infrastructure of storage and transportation (a3)	neutral pipeline network, the pursuit of fair distribution. The introduction of social capital, expand the coverage of the pipeline network, and by independent third parties to operate the network transport business; The construction of underground gas storage; the degree of openness of the existing long-distance oil and gas pipelines, natural gas municipal pipelines, warehouses and LNG receiving stations
	Construction of shale gas market (a4)	From the government's perspective: formulate policies to encourage shale gas consumption, break the monopoly of large enterprises, encourage small and medium-sized enterprises to participate in competition, improve technology and reduce costs through competition

Table 2: Continued.

Primary dimension	Secondary indicators	Indicator Description
Economic benefits (B)	The degree of the improvement of residents' income level (b1)	Shale gas development has impact on regional economy, thus improving the income level of residents.
	Total asset-liability ratio (b2)	The ratio is excellent in the range of 40 % ~ 60 %, if there is any deviation, by experts to determine the grade.
	Shareholder equity ratio (b3)	The ratio is excellent in the range of 40 % ~ 60 %, if there is any deviation, by experts to determine the grade.
	Value for money index(b4)	Value of value for money = Public Sector Comparator (PSC)-PPP project life-cycle government net cost present value (PPP) value for money index = (PSC-PPP)/PSC ∗ 100 % value for money and value for money index is value for money when greater than zero.
the Project internal processes(C)	The construction of HSE management system (c1)	①whether there are staff health and safety education training; ②whether there are employees' monthly or weekly maximum working hours; ③whether the medical personnel and equipment are sufficient; ④whether to establish the development environment evaluation system; ⑤whether to establish the supervision mechanism of the risk of mining environment; ⑥whether there is a perfect safety management system and emergency mechanism; ⑦whether the safety meetings are held regularly (weekly or monthly); ⑧there is no safety accident. According to the above 8 implementation conditions, the score is divided into five grades.
	Validity of contract management (c2)	①the roles and responsibilities of the parties to the contract are clearly defined; ②there is a clear indicator of performance evaluation; ③there are procedures to modify, dispute and terminate the contract; ④there are the provisions of punishment for violations. According to the above 4 implementation conditions, the score is divided into five grades.
	The organization structure of Special Purpose Vehicle(SPV) (c3)	The reasonableness of the organizational structure of the SPV is reflected in the organizational structure model, organizational division of labor and workflow organization.

Table 2: Continued.

Primary dimension	Secondary indicators	Indicator Description
Innovation and environmental protection and sustainable development (D)	Technical innovation and progress of shale gas exploration and development (d1)	Using advanced mining technology, give priority to the use of clean energy, the use of high resource utilization and less pollutant emissions of the process and equipment or the use of independent research and development of new technologies: such as the use of fracturing microseismic monitoring technology, production dynamic predication system, the use of supercritical carbon dioxide fracturing (SC-CO_2), clean and green slickwater fracturing fluid, DF-HWBM high-performance water-based drilling fluid, RP120 recyclable oligomer fracturing fluid system, etc., According to the use of new equipment and new technology to determine the score grade.
	Reclamation of shale gas platform(d2)	Develop reclamation plans and reclaim land to meet the requirements of *"Land Reclamation Regulations "*and *"Land reclamation quality control standards "(TD / T1036-2013)*. The score is determined according to the systematicness of the reclamation plan, the execution of the plan and the quality of the final reclamation.
	the National set up shale gas innovation award(d3)	It includes shale gas exploration and mining technology innovation, business mode innovation, organization structure mode and regulatory mechanism innovation. According to The number of established and benefit it generated, it can be divided into 5 grades.
	Professional talent introduction and training, team building(d4)	There is professional talent introduction and skills upgrading plan, and effectively implement, effective communication and coordination within the project team and talent complement.
	Water resource protection (d5)	①the government introduce relevant policies to clarify the prevention and control of water pollution and the main body of water resources protection; ②using horizontal fracturing technique, the water consumption of single well is lower than average; ③control shale gas well wastewater overflow and leakage ratio below the average ratio. According to the above 3 implementation conditions, the score is divided into five grades.
	Atmospheric and geological protection (d6)	①the highest NO_x emission concentration (mg/m3) ≤ 192 is excellent, > 192 and ≦ 208 is good, > 208 and ≦ 224 is medium, > 224 and ≦ 240 is general, > 240 is poor; ② the highest VOC emission concentration (mg/m3) ≤ 80 is excellent, > 80 and ≤ 90 is good, > 90 and ≤ 100 is medium, > 100 and ≤ 110 is general, > 110 is poor; ③the highest sulfur dioxide emission concentration (mg/m3) ≤ 440 is preferred, > 440 and < = 475 is good, > 475 and < = 510 is medium, > 510 and < = 540 is general, > 540 is poor; ④did not cause geological disasters such as landslides or landslides. According to the above 4 implementation conditions, the score is divided into five grades.
	The growth rate of the proportion that the non-fossil energy accounts for primary energy consumption(d7)	The optimization of energy consumption structure, more rational energy consumption, low-carbon energy consumption system basically formed, there is a growth of non-fossil energy accounted for a certain proportion of primary energy consumption.
	The promotion of shale gas PPP project(d8)	①the experience accumulation of shale gas PPP project; ②the reference of shale gas PPP project.
Stakeholder satisfaction (E)	Government agencies satisfaction(e1)	Through a questionnaire survey on the main parties involved in the project to the satisfaction of the collection, each questionnaire total score of 100 points, divided into five grades: ≥95, 85~95, 75~85, 65~75, < 65.
	Private sector satisfaction (e2)	
	The general public satisfaction (e3)	

Table 3: Performance evaluation system and weight of shale gas PPP project.

Target	Primary dimension	Weight	Secondary indicators	weight	
				Index weight	Dependent weight
The performance of the shale gas PPP project	Macro-environmental characteristics	0.1354	A1 The degree of the perfection of national shale gas mining rights management legal system	0.4300	0.0582
			A2 The degree of the reasonableness of financial incentives	0.2310	0.0313
			A3 Infrastructure of storage and transportation	0.1634	0.0221
			A4 Construction of shale gas market	0.1756	0.0238
	Economic benefits	0.1938	B1 The degree of the improvement of residents' income level	0.2470	0.0479
			B2 Total asset-liability ratio	0.1626	0.0315
			B3 Shareholder equity ratio	0.1626	0.0315
			B4 Value for money index	0.4279	0.0829
	the Project internal processes	0.1179	C1 The construction of HSE management system	0.1634	0.0193
			C2 Validity of contract management	0.2970	0.0350
			C3 The organization structure of SPV	0.5396	0.0636
	Innovation and environmental protection and sustainable development	0.4559	D1 Technical innovation and progress of shale gas exploration and development	0.0486	0.0221
			D2 Reclamation of shale gas platform	0.0684	0.0312
			D3 the National set up shale gas innovation award	0.0364	0.0166
			D4 Professional talent introduction and training, team building	0.0506	0.0231
			D5 Water resource protection	0.2963	0.1351
			D6 Atmospheric and geological protection	0.3014	0.1374
			D7 The growth rate of the proportion that the non-fossil energy accounts for primary energy consumption	0.1428	0.0651
			D8 The promotion of shale gas PPP project	0.0554	0.0252
	Stakeholder satisfaction	0.0969	E1 Government agencies satisfaction	0.5769	0.0559
			E2 Private sector satisfaction	0.0811	0.0079
			E3 The general public satisfaction	0.3420	0.0331

Table 4: Performance evaluation criteria for shale gas PPP project based on matter element analysis.

Evaluating indicator	Unit	Excellent(R_{01})	Good(R_{02})	Medium(R_{03})	General(R_{04})	Poor(R_{05})	R_P
C1 The degree of the perfection of national shale gas mining rights management legal system	point	90~100	80~90	70~80	60~70	0~60	0~100
C2 The degree of the reasonableness of financial incentives	point	90~100	80~90	70~80	60~70	0~60	0~100
C3 Infrastructure of storage and transportation	point	90~100	80~90	70~80	60~70	0~60	0~100
C4 Construction of shale gas market	point	90~100	80~90	70~80	60~70	0~60	0~100
C5 The degree of the improvement of residents' income leve	point	90~100	80~90	70~80	60~70	0~60	0~100
C6 Total asset-liability ratio	point	90~100	80~90	70~80	60~70	0~60	0~100
C7 Shareholder equity ratio	point	90~100	80~90	70~80	60~70	0~60	0~100
C8 Value for money index	point	90~100	80~90	70~80	60~70	0~60	0~100
C9 The construction of HSE management system	point	90~100	80~90	70~80	60~70	0~60	0~100
C10 Validity of contract management	point	90~100	80~90	70~80	60~70	0~60	0~100
C11 The organization structure of SPV	point	90~100	80~90	70~80	60~70	0~60	0~100
C12 Technical innovation and progress of shale gas exploration and development	point	90~100	80~90	70~80	60~70	0~60	0~100
C13 Reclamation of shale gas platform	point	90~100	80~90	70~80	60~70	0~60	0~100
C14 the National set up shale gas innovation award	point	90~100	80~90	70~80	60~70	0~60	0~100
C15 Professional talent introduction and training, team building	point	90~100	80~90	70~80	60~70	0~60	0~100
C16 Water resource protection	point	90~100	80~90	70~80	60~70	0~60	0~100
C17 Atmospheric and geological protection	point	90~100	80~90	70~80	60~70	0~60	0~100
C18 The growth rate of the proportion that the non-fossil energy accounts for primary energy consumption	point	90~100	80~90	70~80	60~70	0~60	0~100
C19 The promotion of shale gas PPP project	point	90~100	80~90	70~80	60~70	0~60	0~100
C20 Government agencies satisfaction	point	90~100	80~90	70~80	60~70	0~60	0~100
C21 Private sector satisfaction	point	90~100	80~90	70~80	60~70	0~60	0~100
C22 The general public satisfaction	point	90~100	80~90	70~80	60~70	0~60	0~100

Table 5: The correlation degree of the certain shale gas PPP project performance evaluation indicator.

Correlation degree	R_{01}	R_{02}	R_{03}	R_{04}	R_{05}	Grade
$K_j(x_1)$	-2.4000	-0.0833	0.2000	-0.2667	-0.4500	Medium
$K_j(x_2)$	-0.8000	0.4000	-0.3000	-0.5333	-0.6500	Good
$K_j(x_3)$	-3.0000	-0.1667	0.5000	-0.1667	-0.3750	Medium
$K_j(x_4)$	-2.2000	-0.0455	0.1000	-0.3000	-0.4750	Medium
$K_j(x_5)$	-1.2000	0.4000	-0.2000	-0.4667	-0.6000	Good
$K_j(x_6)$	0.2000	-0.2000	-0.6000	-0.7333	-0.8000	Excellent
$K_j(x_7)$	0.3000	-0.3000	-0.6500	-0.7667	-0.8250	Excellent
$K_j(x_8)$	0.1000	-0.1000	-0.5500	-0.7000	-0.7750	Excellent
$K_j(x_9)$	0.2000	-0.2000	-0.6000	-0.7333	-0.8000	Excellent
$K_j(x_{10})$	-0.2000	0.1000	-0.4500	-0.6333	-0.8000	Good
$K_j(x_{11})$	0.2000	-0.2000	-0.6000	-0.7333	-0.8000	Excellent
$K_j(x_{12})$	-0.8000	0.4000	-0.6000	-0.5333	-0.6500	Good
$K_j(x_{13})$	-0.4000	0.2000	-0.4000	-0.6000	-0.7000	Good
$K_j(x_{14})$	-3.0000	-0.1667	0.5000	-0.1667	-0.3750	Medium
$K_j(x_{15})$	-0.2000	0.1000	-0.4500	-0.6333	-0.7250	Good
$K_j(x_{16})$	0.2000	-0.2000	-0.6000	-0.7333	-0.8000	Excellent
$K_j(x_{17})$	0.3000	-0.1000	-0.5500	-0.7000	-0.7750	Excellent
$K_j(x_{18})$	-0.2000	0.3000	-0.3500	-0.5667	-0.6750	Good
$K_j(x_{19})$	0.4000	-0.4000	-0.7000	-0.8000	-0.8500	Excellent
$K_j(x_{20})$	0.1000	-0.1000	-0.5500	-0.7000	-0.7750	Excellent
$K_j(x_{21})$	0.4000	-0.6000	-0.8000	-0.8667	-0.9000	Excellent
$K_j(x_{22})$	0.3000	-0.3000	-0.6500	-0.7667	-0.8250	Excellent

Table 6: The correlation degree of the primary dimension.

Correlation degree	R_{01}	R_{02}	R_{03}	R_{04}	R_{05}	Grade
$K_j(A)$	-2.0932	0.0214	0.1159	-0.3178	-0.4883	Good
$K_j(B)$	-0.1724	-0.0253	-0.4879	-0.6586	-0.7440	Good
$K_j(C)$	0.0812	-0.1109	-0.5555	-0.7036	-0.8000	Excellent
$K_j(D)$	-0.0423	-0.0366	-0.4934	-0.6586	-0.7440	Good
$K_j(E)$	0.1927	-0.2089	-0.6045	-0.7363	-0.8022	Excellent

Table 7: The synthetically correlation degree of the matter element to be evaluated.

synthetically correlation degree	Excellent(R_{01})	Good(R_{02})	Medium(R_{03})	General(R_{04})	Poor(R_{05})	Grade
$K_j(N_0)$	-0.3080	-0.0520	-0.4279	-0.6253	-0.7216	Good

which is not fully conformed, R_{02}, has the condition of transformation, and the grade of good is unstable.

4.3. Result Analysis

(1) Macroenvironmental Characteristics. The performance level of the macroenvironment dimension is general. It shows that the current political and economic policies related to shale gas industry in China still need to be improved, mainly in the excessive concentration of upstream mining rights, the monopoly of the midstream pipeline network is still serious, and the construction of the downstream market system is not perfect. Therefore, the state should start from the current regulations and management system, focus on promoting the construction of the market system, promote the diversification of investment entities and market entities, encourage fair and effective competition, and build a stable and powerful macroenvironment for the development of shale gas industry.

(2) Economic Benefits. The performance level of the economic benefit dimension is good, although it does not fully meet the "good" standard, but it has the transformation conditions. According to the secondary indicators of this dimension, the project contributes less to the improvement of residents' income level. The company's internal financial status and value for money index are good. Therefore, the next stage of shale gas companies should take corresponding actions to raise the income level of residents.

(3) The Project Internal Processes. The internal process dimension of the project has a performance rating of excellent. It shows that the HSE management system of the project is well constructed and implemented properly, and the organizational structure and staffing of the project company are also reasonable. However, due to the large number of participants, the performance in contract management is not very good. Therefore, the next stage of shale gas companies should continue to maintain good internal operations and management, while paying more attention to contract management.

(4) Innovation and Environmental Protection and Sustainable Development. The performance level of innovation and environmental protection is good. According to the degree of relevance, it can be judged that the project has performed well in four aspects: exploration and mining technology innovation and progress, shale gas platform reclamation, professional talent introduction and team building, and nonfossil energy consumption growth. The performance in water resources, atmosphere, and geological protection is excellent, but the performance of the national shale gas innovation award is general. It shows that the encouragement of technological innovation at the national level is not enough, and the innovation capability of the industry should also be enhanced.

(5) Stakeholder Satisfaction. The stakeholder satisfaction dimension performance rating is excellent. Among them, the satisfaction performance of government departments and the public and the private sector is all excellent.

(6) Comprehensive Performance Level Result Analysis. In summary, the performance level of the project is good, indicating that, in order to improve the performance of shale gas PPP projects, in the macroenvironment, it is necessary to increase technological innovation and encouragement at the national level to improve shale gas related policies and mining rights management systems; as for enterprise, we should strive for greater breakthroughs in technological innovation and pay more attention to the training of professional personnel and the protection of the environment.

5. Conclusion

(1) The performance evaluation system of shale gas PPP project is constructed from the five dimensions of macroenvironmental characteristics, economic benefits, the project internal processes, innovation and environmental protection and sustainable development, and stakeholder satisfaction which was set up, consisting of 22 secondary indicators with five grades of indicators include excellent, good, medium, general, and poor. Using the Analytic Hierarchy Process (AHP) to determine the weight of each indicator, a matter element model for the performance evaluation of shale gas PPP project is established. The establishment of this evaluation model fills in the blank of shale gas PPP project

performance evaluation and provides a practical system for it.

(2) Evaluating the performance of a certain Southwest Shale Gas PPP Project Platform Drilling Project in Southwest China shows that its performance grade is good and in line with the actual situation. Among them, the performance grade of the three dimensions of the economic benefits and the project internal processes and stakeholder satisfaction is excellent; the performance grade of the two dimensions of macroenvironmental characteristics and innovation and environmental protection and sustainable development is good. It shows that, on the macroenvironment, China's shale gas related policies and the management system of mining rights remain to be improved. In terms of innovation and environmental protection, sustainable development state and enterprise related technology departments should increase investment in technology research and pay more attention to professional training and environmental protection.

(3) This study provides a complete and feasible evaluation system for the future performance evaluation of shale gas PPP projects. The system is evaluated from the perspective of a relatively independent third party, considers the performance evaluation of stakeholders of all participating parties, and can reflect the idea of "win-win"; it is helpful for the government and the private sector to make decisions on future projects.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflicts of interest.

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