



The evaluation of petroleum enterprise innovation ability for shale gas development

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ABSTRACT

In view of the unconventional shale gas has just started, faced with serious technology gap problems, through our technological innovation capability evaluation of petroleum, can clearly get the level of China's oil companies of technological innovation in terms of shale gas development, based on this, on the basis of conventional energy enterprise technological innovation ability evaluation index, on the basis of conventional energy enterprise technological innovation ability evaluation index, based on the construction of unconventional shale gas technological innovation ability evaluation index and gray fuzzy evaluation model; by Sinopec Jiang Han Oilfield Company technological innovation capability assessment, validation the scientific and feasibility of the model and the analysis and propose ways of enterprise technology innovation capability of petroleum development, provide the technical support for promote the development of unconventional shale industry .

Keywords: unconventional shale; petroleum enterprises; technology innovation; evaluation; fuzzy evaluation.

INTRODUCTION

As a big unconventional shale gas storage country, China pay more attention for the exploration and exploitation of unconventional shale gas. Technological innovation capability assessment is an important foundation for unconventional shale gas business operation development, and assessment models and calculation methods have become the bottleneck of technological innovation capability assessment, but also directly restricts the implementation of unconventional shale gas business development and technology innovation strategy^[1,2].

1980s, Michel tries to develop unconventional shale gas from the shale, by constant technological innovation and his engineers try to use hydraulic fracturing technology, they realized the unconventional shale gas exploration historic leap. Over the years, the United States became the world's largest natural gas resources and producing countries, not only natural gas self-sufficiency is expected to achieve but also may become gas exporter, this transition will make a huge impact on the world's natural gas supply and demand patterns. In recent years, the theoretical study of domestic technology innovation has made considerable progress, but compared with other countries except for a few areas of technology innovation policy, technological innovation diffusion, both at the level of theory, or in the areas of research, there is a big gap in there. Even compared with some of the more advanced developing countries, there are still significant gaps. Research and development of technological innovation theory is not very mature, is still in the position of a fringe theory^[3-5].

This paper constructed the unconventional shale gas enterprise technological innovation ability evaluation system can solve unconventional shale gas enterprises preliminary development in our country no more perfect evaluation

system, scientific and rational unconventional shale gas technological innovation ability evaluation system is undoubtedly the important basis of various business units for project decision-making and project evaluation, which is important to our unconventional shale gas development^[6-8].

Evaluation System Section

Unconventional shale gas technology innovation capability evaluation index system affects the evaluation parties' understand and perspectives on the ability of technology innovation of unconventional shale gas enterprises, for different technical innovation ability view corresponding to the formation of different technological innovation capability evaluation index system. Currently there are the following types of technological innovation capability concept and its technological innovation ability evaluation system, the first category is the process concept, the concepts of unconventional shale gas technological innovation capability evaluation process refers to the view from unconventional shale gas analysis technology innovation perspective evaluation of technological innovation capability. The second category is the system concept, the concept of unconventional shale gas technological innovation ability evaluation system combines the view of elements concept and process concept, and at the same time introduced of the concept of the system, the environmental factors into account, forming a more comprehensive evaluation system.

This paper according to system theory to construct the evaluation index system, divide the evaluation index system of technological innovation ability of China's unconventional shale gas enterprises into five aspects, the index system is shown in table 1

Table 1 unconventional shale gas technological innovation ability evaluation index system

Primary standard	Secondary standard	Level 3 standard
Unconventional shale gas industry technology innovation ability	The technical innovation input ability U_1	R&D Investment intensity U_{11}
		R&D The quality of personnel U_{12}
		Non-research development investment intensity U_{13}
	The technical innovation management ability U_2	Technology innovation strategy U_{21}
		Technological innovation system U_{22}
		Technical innovation process U_{23}
	R&D ability U_3	Basic Research U_{31}
		Applied Research U_{32}
		Research and development U_{33}
	Technology innovation production capacity U_4	The level of production equipment U_{41}
		Technical level of production personnel U_{42}
		Modern technology adoption rates U_{43}
	Technological innovation output capacity U_5	Efficiency of the new output U_{51}
		Innovation and overall economic efficiency U_{52}

Evaluation Model Section

This paper uses four level evaluation method, that is $m=4$, $V = (v_1, v_2, v_3, v_4) = (\text{excellent, good, medium, poor})$.

The s bit of the j index evaluation samples recorded as l_{sj} , the R bit data evaluation on technical innovation ability of an enterprise evaluation are written as sample matrix, according to the function of each evaluation criteria determined by the grey statistical method, (whitening function of grey number), find out l_{sj} , belong to the first class i evaluation grades of rights $f_i(l_{sj})$, through it to find out the grey statistical evaluation matrix number n_{ij} and the total number of Grey Statistics n_j , the comprehensive views of the r experts, the grey weight of the j evaluation

factors advised the article i evaluation level $r_{ij} = \frac{n_{ij}}{n_i}$, have r_{ij} composed of matrix R.

In this paper, gray correlation theory to determine the weight of each index. Use the following formula to calculate U_j pair of U_0 in the first correlation coefficient s reviewer ($j=1, 2, \dots, n$; $s=1, 2, \dots, r$).

$$\zeta_j(s) = \frac{\min_j \min_s |U_0(s) - U_j(s)| + \rho \cdot \max_j \max_s |U_0(s) - U_j(s)|}{|U_0(s) - U_i(s)| + \rho \cdot \max_j \max_s |U_0(s) - U_j(s)|} \quad (1)$$

In the above formula, ρ is distinguish coefficient, $\rho \in [0,1]$, it is introduced in order to reduce the influence of extreme value of calculation. Using the formula $r_j = \frac{1}{r} \sum_{s=1}^r \zeta_j(s)$ then correlation degree can be calculated.

Correlation degree directly reflects the relationship between the advantages and disadvantages of various comparison sequences for reference sequence. You can find the weight of each factor.

By doing the above normalized correlation seek treatment, then can find the weight of each factor. That

$w_j = r_j / \sum_{j=1}^n r_j$ ($j=1,2,\dots,n$) Relative membership degree are calculated by the following formula:

$$B = W \bullet R \quad (2)$$

Delphi method is used for the evaluation grade score, denoted $D = (d_1, d_2, \dots, d_m)$, that is v_i grade scores for d_i . As used in this paper is the four level evaluation method, so the assumption that $D = (d_1, d_2, d_3, d_4) = (10, 7, 5, 2)$. $Z = B \bullet D^T$ can be used to calculate the corresponding value of the enterprise technology innovation ability, using this score can judge the technical innovation ability of the enterprise in which the evaluation grade, and can be compared to other enterprise technology innovation ability.

CALCULATION AND RESULTS

In this paper, China oil in Jiang Han Oilfield Company is analyzed as an example, technological innovation capability of enterprises belonging to the statistics of the number of classes for each gray:

$$n_{11} = f_1(9) + f_1(10) + f_1(9) + f_1(8) + f_1(8) + f_1(7) + f_1(9) + f_1(10) + f_1(9) = 2 + 59/9 = 8.5556$$

$$n_{12} = f_2(9) + f_2(10) + f_2(9) + f_2(8) + f_2(8) + f_2(7) + f_2(9) + f_2(10) + f_2(9) = 18 - 79/7 = 6.7143$$

$$n_{13} = f_2(9) + f_2(10) + f_2(9) + f_2(8) + f_2(8) + f_2(7) + f_2(9) + f_2(10) + f_2(9) = 18 - 79/5 = 2.2$$

$$n_{14} = f_3(9) + f_3(10) + f_3(9) + f_3(8) + f_3(8) + f_3(7) + f_3(9) + f_3(10) + f_3(9) = 0$$

The total number of gray statistical indicators u_{11} : $n_1 = n_{11} + n_{12} + n_{13} + n_{14} = 17.4699$. So for indicators u_{11} , technological innovation capability of enterprises belonging to the statistics of the number of classes for each gray:

$$r_{11} = n_{11} / n_1 = 0.4897, r_{12} = n_{12} / n_1 = 0.3844, r_{13} = n_{13} / n_1 = 0.1259, r_{14} = n_{14} / n_1 = 0 \quad \text{Similarly}$$

rectifiable gray statistics other indicators n_{ij} and total gray statistics n_j , then get a gray fuzzy evaluation matrix:

$$R = \begin{bmatrix} 0.4897 & 0.4362 & 0.447 & 0.3841 & 0.3688 & 0.4712 & 0.4476 & 0.4036 & 0.5525 & 0.4593 \\ 0.3844 & 0.3941 & 0.3913 & 0.3922 & 0.4034 & 0.3856 & 0.3913 & 0.4020 & 0.3729 & 0.3885 \\ 0.1259 & 0.1698 & 0.1611 & 0.2237 & 0.2279 & 0.1432 & 0.1611 & 0.1944 & 0.0746 & 0.1523 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

0.4593	0.4545	0.3786	0.2674
0.3885	0.3818	0.4009	0.4438
0.1523	0.1636	0.2205	0.2888
0	0	0	0

Using the formula $r_j = \frac{1}{r} \sum_{s=1}^r \zeta_j(s)$ Correlation can be calculated:

$r = (0.8236, 0.7136, 0.7454, 0.6164, 0.5684, 0.7948, 0.7454, 0.6325, 0.9683, 0.7566, 0.7566, 0.7595, 0.6100, 0.4611)$
Will be normalized correlation processing, the weights are to set as follows:

$W = (0.0828, 0.0717, 0.0749, 0.0619, 0.0571, 0.0799, 0.0749, 0.0636, 0.0973, 0.0760, 0.0760, 0.0763, 0.0613, 0.0463)$

According to the previous calculation results can be obtained the fuzzy evaluation matrix. If according to maximum membership degree principle, the enterprise technological innovation ability evaluation level is optimal, but can be seen from the fuzzy evaluation matrix, there is a small difference between excellent membership and good membership, and can not be compared with other equivalent technological innovation capability. So here you can use the method of each evaluation grade rating for Integrated operational that comprehensive evaluation of the results should be $Z = B \bullet D^T = 7.9963$. Through the results can be seen that the technology innovation ability of the enterprise is good.

From correlation calculation results in unconventional shale gas enterprise technological innovation ability evaluation, R & D investment intensity, technological innovation management process research and development plays an important role. These three aspects have provided strong support for enterprise technology innovation ability help; In addition, we can also find the third indicators in enterprise technology innovation capability of the two indicators of technological innovation management ability in technological innovation strategies and mechanisms is not perfect, while technical innovation output capability is weak, the new output efficiency and innovation overall economic efficiency is low.

CONCLUSION

This paper established a technology innovation ability evaluation index system of unconventional shale gas companies. Index system has three levels of indicators. Second level index includes investment in technological innovation, technological innovation management capabilities, R & D capabilities, technological innovation capacity and technological innovation output capacity of these five indicators, the third level index including fourteen indicators.

Gray fuzzy evaluation model can be applied to unconventional shale gas evaluation of technological innovation capability, and then through the example shows that this model is scientific and feasible.

China petroleum technology innovation ability of Jiang Han Oilfield Company comprehensive evaluation result is good, in the R&D and technical innovation on process management and the development of research, the performance of the company is excellent, but it is weak in technology innovation management capability and technological output ability.

Acknowledgements

Project supported jointly by the National Natural Science Foundation of China No. 51374074 and the oil fund of the China No. 2013D-5006-0210.

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