Research Article

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A new algorithm for real economy benefit evaluation based on big data analysis

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Abstract: Based on the Sino-foreign petroleum cooperation project, the benefit evaluation algorithm of real economy based on big data analysis is proposed. The investment payback period, net present value, internal rate of return, discounted profit after investment and option value are selected as the benefit evaluation indicators of the real economy. The benchmark yield, discount rate and oil option parameters are defined as the benefits evaluation parameters of the real economy. Through the Delphi method and the analytic hierarchy process, the weight of each factor is specified. The method of expert independent scoring is used to construct the judgment matrix, and the consistency check is performed on the sort. The feature quantity matrix of the evaluation indicator is established to perform dimensionless processing on the original data. The project's economic benefit indicators are divided into positive indicators of "ideal economic benefits" and negative indicators of "negative economic benefits", the grey correlations are calculated, and real economic benefits are assessed. The results of project example analysis show that the algorithm not only realizes the whole life cycle management of overseas oil and gas cooperation projects, but also conducts tracking and evaluation of project implementation and economic benefits during the implementation process, and conducts sensitivity analysis on key indicators, that provides effective decision support for managers.

Keywords: Big data analysis; real economy; benefit; evaluation

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1 Introduction

The real economy refers to the economy created by people on the earth through the use of tools. It includes economic activities such as the production and circulation of material and spiritual products. It includes the production and service sectors of agriculture, industry, transportation and communications, business services, construction and cultural industries, as well as the departments of spiritual products such as education, culture, knowledge, information, art and sports [1]. Economic efficiency refers to the value or product that the enterprise occupies as much resources and labor as possible in its production activities. There are two indicators here, namely input and output indicators, where resources are input-type indicators and products are output-type indicators [2]. When the output is greater than the input, the economic activity can be considered to be economically beneficial. At the same time, companies have social responsibilities and cannot pursue economic benefits unilaterally [3].

In summary, companies must consider three aspects in terms of economic benefits:

- first, the output is greater than the input, that is, the output is greater than the consumption;
- second, the output is greater than the input to match, taking into account the long-term interests of the enterprise;
- the third is to pursue economic benefits in the context of undertaking certain social responsibilities.

Only when the above conditions are met, the economic benefits of the enterprise can be characterized as good, which is the precondition for the evaluation of economic benefits. The comprehensive analysis of the selected indicators is the economic benefit evaluation. The evaluation results will guide the company's next cost control, capital investment and development strategy, and can also serve as the basis for corporate performance evaluation [4]. After determining the indicator system and selecting the scientific method of evaluation, the steps of evaluating the economic benefit indicators will be considered.

The benefit evaluation algorithm of the real economy based on multi-level extension evaluation method is proposed by some scholars [5]. Some have proposed the entity economic benefit evaluation algorithm based on the comprehensive index method [6]. Some scholars propose the entity economic benefit evaluation algorithm based on the analytic hierarchy process and the coefficient of variation method [7]. In addition, some scholars propose the entity economic benefit evaluation algorithm based on the entropy weight method [8].

The above algorithms cannot realize the whole life cycle management of the real economy, and in the process of project implementation, the economic benefits of the project cannot be evaluated, and the sensitivity analysis of key indicators cannot be performed. It also does not provide effective support for managing business and investment decisions.

In response to these problems, the benefit evaluation algorithm of real economy based on big data analysis is researched and proposed, and its specific research framework is described as follows:

- selection of the benefit evaluation indicators of the real economy;
- determination of evaluation parameters;
- construction of the evaluation model;
- project case analysis, test of the effectiveness of the algorithm;
- summary and outlook.

2 Methods

2.1 Selection of indicators for benefit evaluation of real economy

2.1.1 Payback period

The payback period is the period required to recover all the investment from the start of the project. The payback period includes the duration of the exploration and development project and the term of the commercial development recovery fund [9]. The formula for expressing the payback period is:

$$\sum_{t=1}^{P_t} (CI - CO)_t = 0 \tag{1}$$

where P_t is the payback period; CI and COrepresent cash inflows and cash outflows, respectively.

The biggest advantage of the investment payback period indicator is that it is intuitive and simple, can measure the investment risk, and reflects the advantages and disadvantages of the investment benefit to a certain extent, so it has been widely used.

However, there are certain shortcomings and limitations in the investment recovery period. (1) The investment recovery period cannot reflect the benefits of the project after the investment is recovered. (2) The investment recovery period is greatly affected by the cash inflow, which will not be conducive to the comparison between the schemes (3) The calculation of the payback period is generally carried out in the static manner without considering the time value of the funds.

Although the payback period does not fully measure the economic profit of the project, it has the effect of measuring the investment risk. In overseas exploration investment projects with high political and economic risk, the recovery of investment must be guaranteed before it can rise to the evaluation of the project's income. Therefore, the payback period should be used as the important indicator to measure overseas exploration investment projects.

2.1.2 Net present value

The net present value is the cumulative value of the discounted face value of the net cash flow, and its calculation formula is:

$$NPV = \sum_{t=0}^{T} (CI_t - CO_t) \times (1 + R)^{-t} \tag{2}$$

where CI_t and CO_t represent the cash inflow and the cash outflow of the t_{-th} year, respectively; R is the discount rate; T means the life cycle of the item.

The net present value not only considers the cash flow that occurs during the whole process of the project, but also considers the time value of the funds, which can dynamically reflect the profitability of the project during the economic life. It is the common indicator for evaluating the economic effects of projects and one of the mandatory indicators for international oil companies in evaluating exploration investment projects [10].

2.1.3 Internal rate of return

The internal rate of return refers to the discount rate when the project's current value of net cash flow is equal to zero over the life of the project. This indicator is used to evaluate the project's profitability and is an indicator of the efficiency of capital utilization. The calculation of the internal rate of return implies a basic assumption that all the economic benefits obtained during the life of the project can be used for reinvestment, and the reinvested rate of return is equal to the internal rate of return. Its calculation formula is as follows:

$$\sum_{t=1}^{T} \frac{(CI_t - CO_t)}{(1+i)^t} = 0 \tag{3}$$

where i represents the internal rate of return of the real economy.

Among all economic evaluation indicators, internal rate of return is another important indicator, which is an important evaluation basis for the financial profitability of investment projects [11].

2.1.4 Discounted after-tax investment profit rate

The profit margin is still not perfect by measuring the payback period, net present value and internal rate of return. The profitability of unit investment needs to be considered. Offshore oil exploration projects are risky and long-term, and the time value of funds must be considered. Therefore, the discounted after-tax investment profit rate is selected. The specific calculation formula is:

$$DPR = \frac{\sum_{t=1}^{T} P_t}{\sum_{t=1}^{T} I_t} \tag{4}$$

where DPR represents the project's discounted after-tax investment profit rate; I_t is the investment amount in the t-th year.

At present, many international oil companies regard the discounted after-tax investment profit rate as an important indicator of investment decisions.

2.1.5 Option value

In actual work, the investment depends not only on the value added by the project, but also on the strategic value of it. Therefore, projects with the net present value less than zero are not eager to be abandoned. Sometimes the temporarily lossy project may bring greater benefits to the future of the enterprise. In the benefits evaluation of the real economy, the option value of the project must be considered. Through the Black-Scholes model, the option value of the real economy is calculated and its formula is as follows:

$$C = AN(d_1) - Xe^{-r\tau}N(d_2) \tag{5}$$

$$d_1 = \frac{\ln(A/X) + \tau(r - \delta + \sigma^2/2)}{\sigma\sqrt{\tau}} \tag{6}$$

$$d_2 = d_1 - \sigma\sqrt{\tau} \tag{7}$$

where $\tau$is the expiration date of the selected oil option; Arepresents the present value of the income after the τ time; Xmeans the expected investment in the next stage; r represents the risk-free rate, generally taking the interest rate of the national debt; δ is the annual loss rate of cash flow, which is generally considered to be equal to r; σ represents the volatility of the value of developed petroleum resources; $N(x)$ is the cumulative probability distribution function of the standard normal distribution (*i.e.*, the probability that the random variable is less than x).

2.2 Determination of evaluation parameters

2.2.1 Benchmark rate of return

Benchmark rate of return should be determined based on the project's risk level, inflation factors, interest rates, tax policies, reinvestment opportunities and expected goals. International oil companies generally set specific standards for the company, and the benchmark yields are generally used as trade secrets and are not leaked [12].

2.2.2 Discount rate

There are currently three different methods for calculating the international discount rate:

1. the end-year method:
   Calculate the present value by the face value of the net cash flow at the end of the year. The calculation formula of the discount rate is $(1+j)^{-n}$;
2. the mid-year method:
   Converting the present value by the face value of the net cash flow in the middle of the year, the calculation formula of the discount rate is $(1+j)^{0.5-n}$;
3. Continuous compounding method:
   The internationally used continuous compounding method based on the calculation formula of the continuous equal annual cash flow discount rate is $\frac{e^j - 1}{je^{nj}}$ where, j is the nominal annual discount rate; n is the number of years of equal annual cash flow; e is the bottom of the natural logarithm.

The value of the discount rate in each oil company has its own measurement standards, but in general, time, risk, inflation and other factors are generally necessary to be considered, usually taking the expected rate of return or weighted capital cost of similar or similar projects. In the current economic evaluation method in China, the first method is used for calculation.

2.2.3 Oil option parameters

The calculation of the value of the oil option involves six parameters, which are as following:

- The present value of the petroleum resources to be developed A refers to the present value of the income of the petroleum resources to be developed after τtime, which can be obtained by the net present value method based on the predicted cash flow;
- Expenses X for the development of petroleum resources, including block acquisition costs, exploration investment;
- Risk-free interest rate r, r takes the interest rate of US short-term government bonds;
- 4 Annual cash flow loss rate δ, generally similar to r;
- The volatility $\delta$of the value of petroleum resources, in view of the value of petroleum resources mainly affected by fluctuations in oil prices, so the value of it is similar to the volatility of oil prices;
- The term of the oil option is τ, where the exploration period of the contract is used as the value of τ.

2.3 Benefit evaluation of the real economy

2.3.1 Determination of the weight of the benefit evaluation index of the real economy

The status of each indicator is different in the system. The differences are mainly reflected in the following two aspects: First, the evaluator is in the different environment; second, the indicator plays a different role in the evaluation process. In the evaluation model, the indicators are recognized by the importance and degree of influence. On the other hand, the relative size of the indicator weight directly affects the outcome of the benefit evaluation. Reasonable determination of the weight coefficient, objectively reflecting its importance, will directly improve the accuracy of the final evaluation.

The Delphi method is combined with the analytic hierarchy process to weight the distribution factors. The experts' opinions are collected as the basis for determining the weight [13]. The working steps are as follows:

Consultation questionnaire

The specific weight values are not required to be directly determined, and the relative importance between the indicators needs to be given. The relative importance is represented by the natural numbers 1, 2, 3... 9 and their reciprocals 1/2, 1/3... 1/9; the meanings are shown in Table 1.

Table 1: Calibration method for judging the importance of two indicators

Scale value	meaning
1	they are of equal importance;
3	the C1 is slightly more important than the C2;
5	the C1 is more important than the C2;
7	the C1 is obviously more important than the C2;
9	the C1 is extremely more important than the C2;
2, 4, 6, 8	Between the two adjacent levels;
1/2, 1/3,..., 1/9	The result is the opposite of the above result

2.3.2 Calculation of weight vector and consistency test

After the establishment of the indicator system, the affiliation between the upper and lower levels will be fixed. For the same level of indicators, the two-two comparison method can be used to determine the relative weight relationship. The specific operations are as follows:

Construct the pairwise comparison matrix

Constructing the judgment matrix is the key to analytic analysis, which is directly related to the accuracy of the benefit assessment. The method of independent scoring by experts in this paper is used to construct the judgment matrix and perform consistency check on the sort. The same level indicators are compared in pairs, and the results are represented by the T.L. ratio scale, as shown in Table 1.

Assume that element B of the primary indicator is related to the element $B_1B_2, \cdots, B_m$ in the next level indicator (m is the number of indicators). By constructing the judgment matrix B as shown in Table 2, the importance of each element in the secondary index with respect to B is analyzed.

Table 2: Judgment matrix structure

B	B	B	…	B
B_1	b_{11}	b_{12}	…	b_{1m}
B_2	b_{21}	b_{22}	…	b_{2m}
…	…	…	…	…
B_m	b_{m1}	b_{m2}	…	b_{mm}

The judgment matrix has the following properties:

$$b_{i'j'} > 0 \tag{8}$$

$$b_{i'j'} = \frac{1}{b_{j'i'}} \tag{9}$$

$$b_{i'j'} = 1 \tag{10}$$

Calculation of index weights

The geometric mean method is used to calculate the weight of the indicators.

The product of each row element in the judgment matrix is calculated as follows.

$$M_{i'} = \prod_{i'=1}^{m} b_{i'j'} (i' = 1, 2, \cdots, m) \tag{11}$$

By calculating the N root of $M_{i'}$, $\overline{W_{i'}}$ can be written as

$$\overline{W_{i'}} = N\sqrt{M_{i'}} \tag{12}$$

where $\overline{W_{i'}}$ is normalized to obtain the weight vector $W_{i'}$ of the evaluation indicator:

$$W_{i'} = \frac{\overline{W_{i'}}}{\sum_{i'=1}^{m} \overline{W_{i'}}} \tag{13}$$

Consistency test

The maximum eigenvalue of the judgment matrix is calculated

$$\lambda_{\max} = \frac{1}{m} \times \sum_{i'=1}^{m} \frac{(B_{i'} \times W_{i'})}{W_{i'}} \tag{14}$$

The consistency index CI of judgment matrix is calculated,

$$CI = (\lambda_{\max} - m)/(m - 1) \tag{15}$$

The formula for calculating the random consistency ratio CR is as follows:

$$CR = CI/RI \tag{16}$$

where RI represents the average random consistency index of the judgment matrix of the real economic benefit evaluation index.

According to the above formula (16), the consistency check is performed on the constructed judgment matrix. It is generally considered that the judgment matrix has acceptable consistency, and $CR < 0.1$. Otherwise, the judgment matrix needs to be corrected. The values of the random consistency coefficient are shown in Table 3.

2.3.3 Establishment of indicator feature quantity matrix

Assume that there are n' mines to be evaluated, and each mine has m' evaluation indicators. By arranging the indicators in order, the index feature matrix of n' order can be obtained [14]:

$$X' = \begin{bmatrix} x'_{11} & x'_{12} & \wedge & x'_{1n'} \\ x'_{21} & x'_{22} & \wedge & x'_{2n'} \\ M & M & M & M \\ x'_{m'1} & x'_{m'2} & \wedge & x'_{m'n'} \end{bmatrix} \tag{17}$$

where $x'_{i'j'}$ is the feature quantity of the $i'(i' = 1, 2, \cdots, m')$ evaluation indicator of the $j'(j' = 1, 2, \cdots, n')$ mine.

Usually, it has two types of benefits: the bigger of the benefit the better and the smaller of the cost the better.

The so-called mean value, that is, the average value of the same index of the evaluated mine is used to remove each item, and the formula is

$$x''_{i'j'} = \frac{x'_{i'j'}}{\sum_{i'=1}^{m} x'_{i'j'}} \tag{18}$$

Table 3: Value of random consistency coefficient

Order of the matrix	1	2	3	4	5	6	7	8	9	10
RI value	0.0	0.0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.63

2.3.4 "Positive economic benefits" and "Negative economic benefits"

Let I^+ is the set of profitable economic indicators; I^- is the cost-based economic indicators.

The two types of indicators can be regarded as one collection, and the "positive economic benefits" can be combined into one collection:

$$x'^+ = \left\{ \left(\max_{j'} x'_{i'j'} \left| i' \in I^+ \right. \right), \left(\max_{j'} x'_{i'j'} \left| i' \in I^+ \right. \right) \left| j' = 1, 2, \wedge, n' \right. \right\} = \left\{ x'^+_1, x'^+_2, x'^+_3, \wedge, x'^+_{m'} \right\} \quad (19)$$

$$x'^- = \left\{ \left(\max_{j'} x'_{i'j'} \left| i' \in I^- \right. \right), \left(\max_{j'} x'_{i'j'} \left| i' \in I^- \right. \right) \left| j' = 1, 2, \wedge, n' \right. \right\} = \left\{ x'^-_1, x'^-_2, x'^-_3, \wedge, x'^-_{m'} \right\} \quad (20)$$

The approximate degree of the i'_{th} indicator of the positive ideal economic benefit and j'_{-th} mine is represented by the grey correlation coefficient $\xi(x'_{i'j'}, x'^+)$:

$$\xi(x'_{i'j'}, x'^+) = \frac{\min_{j'} \min_{i'} \left| x'_{i'j'} - x'^+ \right| + \rho \max_{j'} \max_{i'} \left| x'_{i'j'} - x'^+ \right|}{\left| x'_{i'j'} - x'^+ \right| + \rho \max_{j'} \max_{i'} \left| x'_{i'j'} - x'^+ \right|} \quad (21)$$

where $\min_{j'} \min_{i'} \left| x'_{i'j'} - x'^+ \right|$ and $\max_{j'} \max_{i'} \left| x'_{i'j'} - x'^+ \right|$ are the minimum and maximum differences of the two levels, respectively. ρ is the resolution coefficient, which ranges from $0 < \rho < 1$.

The approximate degree of the i'_{-th} indicator of the negative ideal economic benefit and j'_{-th} mine is represented by the grey correlation coefficient $\xi(x'_{i'j'}, x'^-)$.

$$\xi(x'_{i'j'}, x'^-) = \frac{\min_{j'} \min_{i'} \left| x'_{i'j'} - x'^- \right| + \rho \max_{j'} \max_{i'} \left| x'_{i'j'} - x'^- \right|}{\left| x'_{i'j'} - x'^- \right| + \rho \max_{j'} \max_{i'} \left| x'_{i'j'} - x'^- \right|} \quad (22)$$

where $\min_{j'} \min_{i'} \left| x'_{i'j'} - x'^- \right|$ and $\max_{j'} \max_{i'} \left| x'_{i'j'} - x'^- \right|$ are the minimum and maximum differences of the two levels, respectively.

Assume that the indicator weight is $\omega_{i'}(i' = 1, 2, \cdots, m')$, The grey correlations of the "ideal economic benefits" and "negative economic benefits" of the j'_{-th} mines are

$$\gamma(x'_{j'}, x'^+) = \sum_{i'=1}^{m} \omega_{i'} \xi(x'_{i'j'}, x'^+) \quad (23)$$

$$\gamma(x'_{j'}, x'^-) = \sum_{i'=1}^{m} \omega_{i'} \xi(x'_{i'j'}, x'^-) \quad (24)$$

2.3.5 Construction of the benefit evaluation model of the real economy

The sum of the squares of the weights of all schemes is the largest objective function [15–21]

$$\max \left\{ F(u_{j'}) \right\} = \sum_{j'=1}^{n'} \left\{ \left[(1 - u_{j'}) \gamma(x'_{j'}, x'^+) \right]^2 + \left[u_{j'} \gamma(x'_{j'}, x'^-) \right]^2 \right\} \quad (25)$$

Let the first derivative of the above formula (25) be zero, that is $\frac{dF(u_{j'})}{du_{j'}} = 0$, the benefit evaluation model of the real economy is

$$u_{j'} = \frac{\left[\gamma(x'_{j'}, x'^+) \right]^2}{\left[\gamma(x'_{j'}, x'^+) \right]^2 + \left[\gamma(x'_{j'}, x'^-) \right]^2} = \frac{1}{1 + \left[\frac{\gamma(x'_{j'}, x'^-)}{\gamma(x'_{j'}, x'^+)} \right]^2} \quad (26)$$

The large $u_{j'}$ value means that the project's economic benefits are very good. Through this model, the economic benefits of post-assessment and pre-assessment of the same mine can be compared, and the economic benefits between mines of different years or different scales can also be compared.

3 Results

3.1 Basic information of the project

The project began with the signing of the contract between the Chinese and foreign contractors in 2007, the transfer of

Table 4: Summary of project output and output value

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
output / billion square	0.28	2.98	3.39	3.22	2.68	3.61	4.22	4.67	13.83	30.42	32.21
Production value / million US dollars	179	198	226	215	187	2.2	311	419	129	312	346

Table 5: Project investment and cost

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Exploration investment / 10, 000 US dollars	19961	2085	2340	259	112	1103	789	-	-	-	
Development investment / 10, 000 US dollars	4680	-	-	-	49	-	8134	10105	13716	15482	12961
Operating cost / million dollars	132	867	787	662	551	716	729	689	4695	3651	5894
Gas price / (Yuan / thousand square)	556.5	556.5	556.5	556.5	582.8	582.8	613.4	716.3	716.3	716.3	736.3

production rights to the project in January 2017, and commercial production began in March 2017. The project operation benefit is the analysis of the historical data from 2007 to 2017.

3.2 Project operation benefit evaluation

3.2.1 Production, investment and cost

Before the contract is signed in 2007, China has built a production capacity of 300 million cubic meters of natural gas in the block. From 2007 to 2015, the Chinese self-operated gas production is 2.5 billion square meters. In January 2015, the project's production operation rights are transferred to foreign contractors. In December 2015, the annual processing capacity of 3 billion cubic meters of natural gas processing plant is officially completed. From 2015 to 2017, the company has cumulatively produced 7.6 billion cubic meters of natural gas. The benefit evaluation algorithm of real economic based on big data analysis is used to evaluate the operational efficiency of the project. The comprehensive production and output value of the block from 2007 to 2017 can be obtained as shown in Table 4 and Figure 1.

From 2007 to 2017, the project has invested a total of 938.23 million US dollars, including exploration investment of 285.88 million US dollars and development investment of 65.135 million US dollars. The total investment of the Chinese side is 231.32 million US dollars, and the total investment of contractors is 709.91 million US dollars. The specifics of investment costs from 2007 to 2017 are shown in Table 5 and Figure 2.

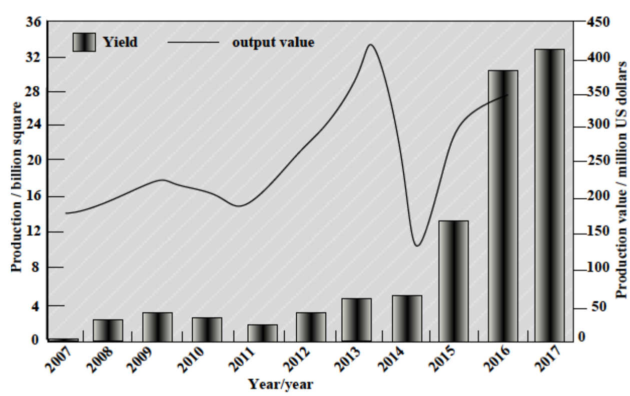

Figure 1: Project output and output value

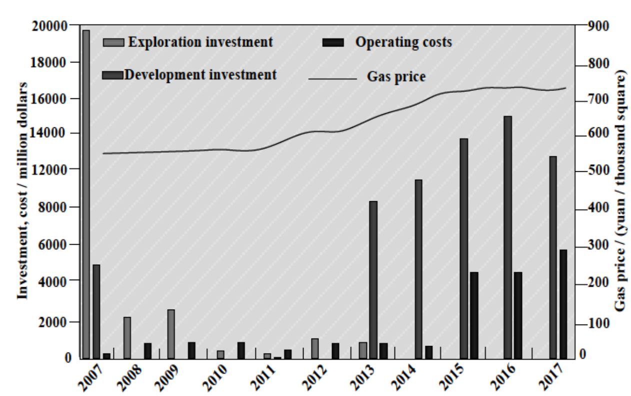

Figure 2: Project investment and cos

Table 6: Status of various evaluation indicators for the project from 2007 to 2017

evaluation indicators	2007 year – 2017 year					
Gas price / (Yuan / thousand square)	628.38					
Production / billion square	102.41					
Total investment / 10, 000 US dollars	93824.15					
Total cost / million dollars	19362.89					
Total unit cost / 10, 000 USD	191.92					
	project		CN		Foreign	
	Pre-tax	Post-tax	Pre-tax	Post-tax	Pre-tax	Post-tax
Internal Rate of Return%	−12.1	-	36.2	-	34.4	-
Net present value / 10, 000 USD	−25.48	−29.19	8.62	7.24	−17.67	−19.97
Cumulative cash contribution / 10, 000 USD	−24.17	−35.75	26.71	22.48	−32.48	−39.85
Payback period / month	12	12	5	5	12	13
Cash return on investment%	−26.3	−38.2	-	-	-	-
Return on investment capital%	16.1	4.2	-	-	-	-

3.2.2 Evaluation indicators of the project

The evaluation indicators of economic benefit include internal rate of return, net present value, accumulated cash contribution, investment recovery period, cash investment return rate and return on investment capital. The evaluation indicators of the project from 2007 to 2017 are shown in Table 6.

4 Discussion

After the contract is signed in 2007, after the evaluation period and development period, 2017 officially enters the commercial production period, and the commercial period is 20 years, to 2037. In the economic benefit evaluation analysis of the whole life cycle of the project, the data historical data from 2007 to 2017 and the data from 2017 to 2037 are adjusted based on the overall development plan data. The following analysis results are based on the natural gas price of 900 Yuan / thousand in the future.

4.1 Evaluation indicators of the project in the whole life cycle

From 2017 to 2037, the project produced a total of 65.66 billion square meters of natural gas. Among them, the stable production period from 2017 to 2027 is expected to be stable for 10 years, and the annual production of stable production will be 3.6 billion cubic meters of natural gas. The period from 2027 to 2037 is the period of reduced production, and the rate of decline in production during the period of production reduction is 6% per year, as shown in Table 7.

From 2007 to 2037, with an estimated natural gas price of 900 Yuan / thousand square meters, the project is expected to accumulate a total investment of 149.953 million US dollars, including exploration investment of 286.88 million US dollars (Chinese 184 million US dollars), development investment 12 (2.65 million US dollars, The Chinese side is $47.32 million).

When the natural gas price is expected to be 900 Yuan/1000 in the future, the evaluation indicators of the whole life cycle of the project (2007 to 2037) are shown in Table 8.

4.2 Sensitivity analysis

In the sensitivity analysis of the project, the data for the project from 2007 to 2017 is historical data, and the data for 2017 to 2037 is the adjusted development plan data. The following analysis results are based on the following variables: The natural gas price is expected to be 900 Yuan / thousand squares in the future.

4.2.1 Analysis of the impact of natural gas price changes on economic benefit evaluation

Take the sensitivity analysis of “expected natural gas prices” as an example. In the analysis, based on 1000 Yuan / thousand squares, the change values are 1400, 1200, 1000, 800 and 600 US dollars / thousand squares, if only natural gas prices fluctuate. The results of the benefit indi-

Table 7: Production estimate in life cycle

	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Production value / million US dollars	14	32	35	53	53	53	53	53	53	53	53
Production / billion square	1313.7	3130.3	3432.1	5235.9	5235.9	5235.9	5235.9	5235.9	5235.9	5235.9	5235.9
	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	
Production value / million US dollars	53	53	50	47	44	42	39	37	35	33	
Production / billion square	5235.9	5235.9	4933.7	4631.7	4329.8	4128.0	3826.3	3624.7	3423.2	3221.8	

Table 8: Financial benefit indicators for the project from 2007 to 2037

evaluation indicators	2007 year – 2037 year					
Gas price / (Yuan / thousand square)	858.77					
Production / billion square	682.63					
Total investment / 10, 000 US dollars	144084.16					
Total cost / million dollars	31534.62					
Total unit cost / 10, 000 USD	45.29					
	project		CN		Foreign	
	Pre-tax	Post-tax	Pre-tax	Pre-tax	Post-tax	Pre-tax
Internal Rate of Return%	20.6	17.9	42.7	40.03	21.2	17.9
Net present value / 10, 000 USD	57.9	34.9	50.7	37.5	23.6	13.7
Cumulative cash contribution / 10, 000 USD	687.6	507.3	430.9	318.2	274.3	207.5
Payback period / month	12	12	5	5	12	13
Cash return on investment%	477	352	-	-	-	-
Return on investment capital%	477	352	-	-	-	-

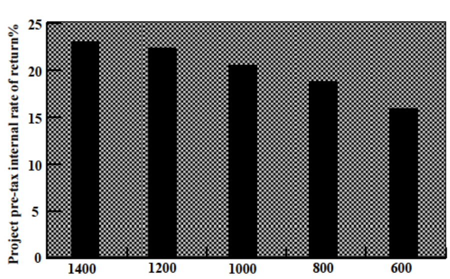

Figure 3: Internal rate of return of the project from 2007 to 2037 with changes in natural gas prices

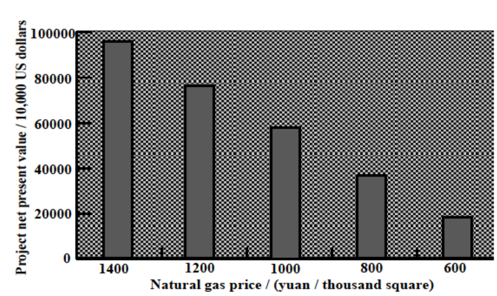

Figure 4: The net present value of the project from 2007 to 2037 with the price of natural gas

cators for the period from 2007 to 2037 are shown in Table 9 (the results are all pre-tax values).

As can be seen from Figures 3 and 4, during the period from 2007 to 2037, the natural gas price is 1400, 1200, 1000, 800 and 600 USD/1000, respectively, and the change in the pre-tax internal rate of return and the net present value of the project.

Table 9: Sensitivity analysis of natural gas prices from 2007 to 2037

	evaluation indicators	1400	1200	1000	800	600
project	Internal Rate of Return%	23.7	22.2	20.5	18.5	15.9
	Net present value / 10, 000 USD	95961	76918	57876	38833	19790
	Cumulative cash contribution / 10, 000 USD	936986	782333	627681	473029	318376
	Payback period / month	11	12	12	12	13
	Cash return on investment%	650.3	542.9	435.7	328.3	220.9
	Return on investment capital%	650.4	543.1	435.7	328.4	221.1
CN	Internal Rate of Return%	45.2	44.1	42.7	41.1	39.5
	Net present value / 10, 000 USD	74072	62719	50680	38727	27508
	Cumulative cash contribution / 10, 000 USD	632352	533496	430797	327532	224268
	Payback period / month	5	5	5	5	5
	Cash return on investment%	-	-	-	-	-
	Return on investment capital%	-	-	-	-	-
foreign	Internal Rate of Return%	23.4	21.4	19.2	16.6	12.9
	Net present value / 10, 000 USD	31409	23719	16715	9626	1802
	Cumulative cash contribution / 10, 000 USD	323033	267236	215283	163895	112507
	Payback period / month	12	12	12	13	14
	Cash return on investment%	-	-	-	-	-
	Return on investment capital%	-	-	-	-	-

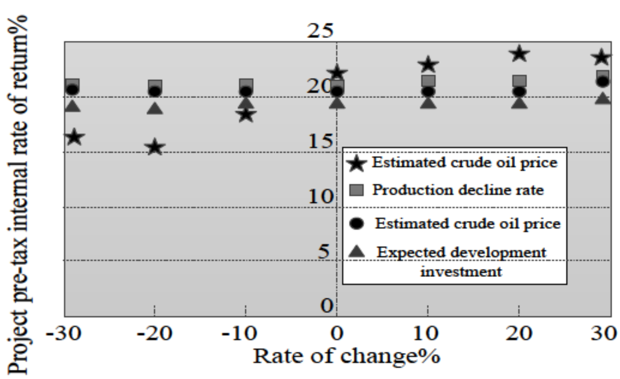

Figure 5: Sensitivity analysis of pre-tax internal rate of return from 2007 to 2037

4.2.2 Comparison of the impact of multi-factor changes on benefit evaluation

The impact of changes in multiple factors (oil price, declining production, declining investment, and declining cost) on the same indicator (project internal rate of return or project net present value) is concentrated in the same scatter plot to facilitate comparison of factor sensitivity.

Through the sensitivity analysis of various factors, the analysis results are obtained. As shown in Figure 5, the “expected crude oil price” has the greatest impact on the internal rate of return of the evaluation indicators from 2007 to 2037.

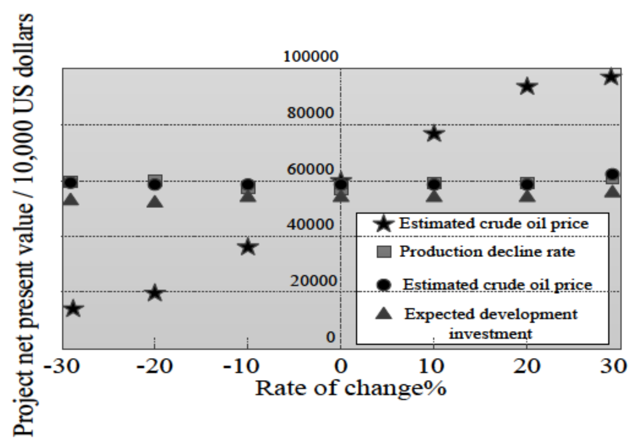

Figure 6: Sensitivity analysis of project net present value from 2007 to 2037

As can be seen from Figure 6, during the period from 2007 to 2037, expected crude oil price, expected development investment and production decline rate have greater impact on the net present value of the project.

5 Conclusions

Based on the Sino-foreign petroleum cooperation projects, the evaluation and analysis theory of project economic benefits have been deeply studied. Through the discussion of the economic evaluation indicators of overseas petroleum projects, the evaluation model of economic benefits is established. According to the model, the benefit evaluation information system is developed and utilized. The system not only realizes the whole life cycle management of overseas oil and gas cooperation projects, but also conducts tracking and evaluation of project implementation and economic benefits during the implementation process, and conducts sensitivity analysis on key indicators. It provides effective decision support for managers.

The evaluation and analysis of the economic benefits of overseas oil and gas cooperation projects need to be further studied and discussed in depth and breadth:

- the characteristics of production management of overseas oil and gas cooperation projects need to be further studied to improve the methods and theories of economic benefit evaluation and risk analysis;
- in the evaluation of the economic benefits of the whole life cycle of overseas oil and gas projects, changes in inflation and exchange rates should be considered. Regression models and BP neural network models are used to predict the eligible indicators, such as oil price, investment and operating costs. This will make the assessment and analysis of the economic benefits of the project whole life cycle more accurate and scientific.
- The economic benefit evaluation information system still has room for improvement. Establishing a project-centered evaluation and analysis system not only makes the construction of the evaluation model more flexible, but also makes project management more convenient.

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