The establishment of a comprehensive evaluation model of productivity construction projects in the Sichuan Basin

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Abstract. In the process of natural gas productivity construction in the Sichuan basin, in order to carry out the technical and economic feasibility demonstrations based on the productivity of the construction project, it is necessary to establish an integrated productivity and economic risk evaluation model based on the productivity prediction of natural gas and considering the impacts of economic benefits and various risks. Based on the economic evaluation of productivity construction projects, this paper analysed the risk evaluation standards of productivity construction projects in the Sichuan basin and quantified risk indicators at all levels, then used 0-1 regularization method and Monte-Carlo technique to establish the risk evaluation model, and finally achieved projects scheme scheduling and multi-scenario, multi-scheme target optimal combination by synthesizing the economic evaluation model, risk evaluation model, and comprehensive evaluation model established by AHP method of productivity construction projects.

1. Introduction

On the basis of economic evaluation, the comprehensive evaluation of the project is carried out by combining the technical scale, benefits and other indicators, through quantitative calculation, the comprehensive evaluation of the project and the comprehensive ranking and classification of several projects can be got. It provides the basis of the comparison and selection of oil and gas development projects. Aizhen Yin [1] et al. proposed an oilfield production optimization model which was aimed at maximizing profit with multiple constraints. Ying Sun and Li Ding conducted factors selection, production forecasting and risk evaluation in oilfield development, and established a comprehensive evaluation model. Wei Zhao [2] proposed to adopt the benefit ranking method for the arrangement and deployment of many new projects, which requires comprehensive consideration of multiple technical and economic constraints. Junhang Li [3] proposed to use comprehensive risk management theory and systematic analysis of project-related risks in the process of investigating the feasibility of production capacity construction. Feng Li, Yuwen Chang, Shimin Yang et al. [4] established a target optimization
model of return and risk under multi-constraint conditions by taking return and risk as the optimization objectives.

On the basis of the optimization of projects, this paper established an economic evaluation model for productivity construction projects and the risk assessment standards for natural gas productivity construction in the Sichuan basin, and conducted a quantitative analysis of risk rating, finally completed the optimization study of the natural gas productivity construction index system in Sichuan basin by coupling the economic evaluation model, analytical quantitative evaluation model and project prioritization model.

2. Economic evaluation model of productivity construction projects
The economic evaluation methods and parameters of productivity construction projects follow the specifications of "Economic Evaluation Methods and Parameters of Petroleum Construction Projects" and "Economic Evaluation Parameters of China National Petroleum Corporation Construction Projects", and the cash flow method is used for evaluating projects.

Figure 1. Economic evaluation model of productivity construction projects.

3. Risk analysis of productivity construction projects
The construction of productivity is one of the main contents of the production and operation activities of oil-gas field enterprises, with the help of the feasibility study of oil and gas productivity construction investment projects, it’s not difficult to systematically analyze project-related risks by using comprehensive risk management theory. In accordance with the principles of system engineering, the project risk model could be established. Monte-Carlo simulation technique is used to evaluate the uncertainty of sensitive factors, simulate the probability distribution of project economic evaluation indicators and quantify project risk exposure, then provide the scientific basis for decisions. The research on risk analysis of productivity projects is based on the risk evaluation model (International Organization for Standardization ISO31000:2009 "Risk Management-Principles and Guidelines"), and on the basis of qualitative analysis, the risk evaluation standards and major risk assessment confirmations could be established, of which risk identification are the technology risks, economic risks and policy risks, and finally, quantitative risk assessment research is completed in terms of risk modeling, uncertainty assessment of sensitive factors, and quantification of project risk exposure.

Using empirical investigation method, expert investigation method, Delphi method and other methods to evaluate risks of the project, and to determine the main risks of the project.
Figure 2. Technical (left) and economic (right) risk assessment and analysis of productivity construction projects

The model represents a combination of projects which generate the greatest profits with the same level of risk and the same level of return with the lowest risk. At the same time, the combination of these projects satisfies the four constraints of predetermined income level, total investment limit, requirements of production and expected profits.

According to the economic evaluation theory of projects, between the economic evaluation index (E) and sensitive factors of projects, the risk model can be established by the following mathematical formulas:

\[ E(FNPV, FIRR...) = \mathcal{f}(P, Q, C, I...) \]  
\[ \sum_{t=1}^{n} (CI - CO)_t (1 + FIRR)^{-t} = 0 \]  
\[ FNPV = \sum_{t=1}^{n} (CI - CO)_t (1 + i_c)^{-t} = 0 \]

in formulas:

- \(FNPV\)——financial net present value;
- \(FIRR\)——financial internal rate of return;
- \(P\)——oil-gas price;
- \(Q\)——production;
- \(C\)——operating cost;
- \(I\)——construction investment (which is a sensitive factor of projects);
- \(CI\)——cash inflow;
- \(CO\)——cash outflow;
- \(t\)——project evaluation period;
- \((CI-CO)\)——net cash flow in year t;
- \(i\)——basic discount rate.
Based on the above risk model, the relationship between sensitive factors of project and various risks can be analyzed and determined: crude oil price (economic risk), crude oil production (technical risk), operating costs (economic risk, technical risk), construction investment (economic risk, technical risk).

Combining production prediction model, economic evaluation model and risk assessment model, then using Monte-Carlo simulation technique to sample calculations to quantify the uncertainty of projects’ sensitive factors and evaluate risk exposure of projects. The above model is a nonlinear 0-1 programming model with multiple variables, multiple constraints and multiple objectives. It has the characteristics of large scale, uncertain solution space shape and discrete variables, and can be solved by hybrid genetic algorithm. The evaluation results are as follows:

![Figure 3. Technical (left) and economic (right) risk analysis and evaluation results.](image)

4. Project optimization sequencing model

Project optimization sequencing is divided into single index ranking and multi-index ranking. Single index sorting is to sort projects according to internal rate of return, input-output ratio, etc. Multi-index comprehensive sorting is to use multiple technical and economic indicators (such as production investment of per billion cubic meters, internal rate of return, single well daily production, capacity scale) to perform a composite sorting through weight setting.

The criteria for project ranking and parametric optimization are divided into three aspects: development effects of well, investment costs, and profit costs. The evaluation of the effects consists of initial production, water cut, stable production period, cumulative gas production and contribution rate. The investment costs is composed of investment of drilling and surface, the total operation cost of a single well, and the operation cost of per thousand cubic meters gas. The profit costs is composed of internal rate of return, investment payback period and the ratio of output to input. Thus, a data matrix of index systems at all levels is formed.

The AHP method (Analytic Hierarchy Process) is a comprehensive evaluation method for system analysis and decision-making. It is a flexible and practical multi-criteria decision-making method that can rationally quantify qualitative problems. First, establish a hierarchical structure based on the primary and secondary index system of effects of well development, investment costs, and profit costs, and then transform subjective judgments into comparisons of importance among factors. The goal is to classify all the selected indicators and solutions according to the nature of the problems which are studied, and then divide them into several levels, so that problems will be transformed into a ranking problem of the relative advantages and disadvantages of each index and solution, and finally build a judgment matrix to calculate the single sorting structure and the total sorting result of indicators of a certain level.

Screening by single index requires single indicator such as internal rate of return and the ratio of input-output. Multi-objective screening according to given constraints requires multiple constraint conditions such as the total scale of construction and production, the total scale of investment, and the rate of return, etc.
5. Conclusion
First, this paper established a risk assessment model for productivity construction projects through risk quantification, 0-1 regularization and Monte-Carlo methods, which is conducive to improving the scientificity and accuracy of risk assessment of projects, and fully displaying the impacts of various risks on projects’ economic indicators, and improving the risk tolerances of enterprises.

Secondly, the comprehensive evaluation model established by combining the economic evaluation model, risk assessment model and AHP method of productivity construction projects can effectively realize the combination of projects’ sorting and multiple scenarios and multiple objectives, which is more conducive to achieving composite evaluation goals of complex structures and various demand systems.

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