Study on optimization model of overseas oil and gas resources structure

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Abstract. Due to the unreasonable structure of overseas oil and gas resources and the lack of resource optimization strategy will seriously affect the stable development of oil companies in the global field, it is an urgent problem for oil companies to provide scientific and rapid optimization solutions to meet the resource allocation objectives for managers. In view of the lack of multi-stage dynamic planning model for overseas oil and gas resource structure optimization allocation, based on the operational research theory, according to the resource characteristics of overseas oil and gas projects, a dynamic programming mathematical model is established in this paper, which aims at the allocation of resource structure. It is solved by genetic algorithm, and realized by programming with MATLAB language. This study provides a new way and method for optimizing the allocation of overseas oil and gas resources.

1. Introduction

With the rapid development of China's economy and the rapid increase of oil consumption, Sinopec, PetroChina and other oil companies implement the strategy of "going global" and invest in overseas oil and gas projects [1, 2]. The exploration and development risk of overseas projects is high, and the amount of capital investment is large. Unreasonable oil and gas resource structure and lack of resource allocation strategy will seriously affect the stable development of oil enterprises [3, 4]. International oil companies attach great importance to the optimization of investment structure. In order to maintain the long-term healthy development of the company, enterprises adjust the asset layout and optimize the investment structure by means of increasing the investment in core assets and selling assets that do not conform to the development direction [5, 6].

How to make a scientific and reasonable optimization strategy of resource structure according to the characteristics of its own resource structure, oil price and environmental requirements, so as to promote the growth of investment benefits of overseas oil and gas projects, reduce and avoid decision-making errors has important practical significance. The optimization and adjustment of the asset structure of overseas oil and gas projects is a dynamic planning process, which should not only focus on the profitability and risk level of the enterprise, but also consider the new purchase of some typical projects that may exist in a certain region due to the strategic needs. Therefore, it is a dynamic planning problem that needs to meet the goal of resource allocation.

The purpose of this paper is to solve the multi-stage dynamic decision-making problem of realizing the strategic goal of overseas oil and gas resources allocation. According to the characteristics of
overseas oil and gas resources, a mathematical model aiming at structural allocation is constructed. The multi-stage planning method is introduced to solve the optimization problem of resource structure, and the genetic algorithm is used to solve the optimization model, which is realized in the computer. In order to realize the development of overseas oil and gas resources, reduce the manual planning and huge workload in the process of making strategic planning, assist enterprise managers to make scientific and reasonable strategic planning, and explore a new way and thinking for solving the problem of optimizing the configuration of overseas oil and gas resources.

2. Problem description and resource allocation objectives

2.1. Problem description
When petroleum enterprises develop overseas oil and gas business, they should evaluate and classify their existing oil and gas exploration and development resources, and understand the problems existing in the structure of oil and gas resources. Through the analysis of the long-term resource development strategy and the international situation of the enterprise, the enterprise managers make the resource allocation goals for the next five or ten years.

For oil companies, the adjustment of oil and gas resource structure is carried out by year. For example, the implementation process of five-year planning period of resource structure optimization is shown in Figure 1. In order to meet the goal of resource allocation at the end of strategic planning period, there may be different paths for resource structure adjustment. The decision-maker should select some resource structure adjustment schemes that meet specific constraints from all possible paths. It can be seen that the optimal allocation of overseas oil and gas resources is a typical dynamic planning problem.

![Figure 1. Schematic diagram of realization path of optimized allocation of overseas oil and gas resources structure.](image)

2.2. Goal of resource structure optimization
In order to optimize the allocation of overseas oil and gas resources, it is necessary to build a mathematical planning model according to different resource allocation objectives. The target of resource allocation can be: Exploration and development ratio (investment amount, number of blocks), oil-gas ratio, proportion of a certain resource, resource concentration of a certain region, etc.

3. Introduction to mathematical model

3.1. Objective function model
Taking the ratio of investment under the dimension parameter of exploration and development ratio as the objective of optimizing the allocation of overseas oil and gas assets structure, by the nth year, the ratio of exploration and development investment reaches a, and the mathematical expression of the objective function is as follows:
\[ S_n = \frac{X_n}{Y_n} = a \]  

In the first year, the ratio of exploration and development investment is \( b \), and the mathematical expression is as follows:

\[ S_k = \frac{X_k}{Y_k} = b \]  

The exploration and development ratio in year \( K \) is

\[ S_k = \frac{X_k}{Y_k} = X_{k+1} - S_k = \frac{X_{k+1}}{Y_k + B_{k+1}} \]

\[ A_k = \sum_{i=1}^{n} a_{i}(k) \]

\[ B_k = \sum_{j=1}^{m} b_{j}(k) \]

Where, \( X_n \) as of the amount of exploration investment in year \( n \); \( Y_n \) as of the amount of development investment in year \( n \); \( a_{i}(k) \) as the investment amount of the \( i \)-th exploration project in the \( k \)-th year; \( b_{j}(k) \) as the investment amount of the \( j \)-th development project in the \( k \)-th year.

### 3.2. Decision variables

During the investment planning period of overseas oil and gas projects, the investment activities of an oil and gas project in different time periods (years) are determined according to the long-term development strategy of the enterprise and the objective of optimal allocation of resource structure: whether to invest or not, whether to delay the investment, the proportion of project withdrawal or sale, and the selection of alternative projects. These investment activities constitute decision variables. According to the optimization model, different decision variables are determined, and the optimal allocation scheme of resource structure is obtained.

### 3.3. Constraint condition

Overseas oil and gas projects have the attributes of resource area, country, resource type, geographical location, proportion of working rights and interests, operation type, reserves and resource type. See Table 1 for specific parameters.

#### Table 1. Attribute parameters of overseas oil and gas projects.

| Numble | Resource area     | Country         | Resource type          | geographical position | Working equity | Job type       | Reserves and resource type |
|--------|-------------------|-----------------|------------------------|-----------------------|----------------|----------------|---------------------------|
| 1      | America           | Canada          | routine                | Land                  | 30%            | Operator       | 2P                        |
| 2      | Asia-Pacific     | U.S.A           | Tight oil and gas     | Shoal and shoal       | 70%            | Joint operation| 2C                        |
| 3      | Europe            | Russia          | LNG                    | Meso deep sea         | etc.           | Share participation| New exploration         |
| 4      | Africa and Russia | Nigeria         | oil sand               | etc.                  |                |                |                           |
| 5      | Central Asia      | etc.            | Heavy oil              |                       |                |                |                           |
| 6      | Middle East       |                 |                        |                       |                |                |                           |

For the seven attributes in Table 1, each attribute corresponds to a specific indicator. In the construction of the mathematical model of the optimal allocation of resources, the corresponding constraints can be established for the specific indicators under each attribute parameter in Table 2. For
example, the resource area can select up to 5 areas and at least 3 areas. Constraints of other attribute parameter indicators can be selected by users.

3.4. Risk analysis

Three main risks are considered: reserves risk, political situation risk and oil price risk [7, 8]. Define a risk possibility for each project and measure the comprehensive risk coefficient. The comprehensive risk coefficient of each project can be expressed by weighted average calculation of three kinds of risks.

1. Reserves risk
   Based on the risk degree corresponding to the reserve grade, we give different weights to 2P reserves, 2C resources and new exploration resources. According to the three types of reserves corresponding to the project, the reserves grade of the project can be calculated by weighting.

2. Political situation risk
   According to the international situation at that time, the measurement of regional political risk was set within a certain range, taking into account the armed conflict, terrorist attacks and kidnappings, community and tribal interference and religious and ethnic conflicts, and grading different regions by sections to get the political risk coefficient.

3. Oil price risk
   Considering the sensitivity of each project under different oil prices, the NPV value calculated under different oil prices is calculated, and the oil price risk is calculated by weighted average.

4. Mathematical model solution and analysis

4.1. Calculation process

Based on the existing oil and gas project database and the typical new project database, the resource structure allocation optimization model is completed through the objective function, decision variables and constraints, and the intelligent algorithm is used to solve. When the results of the model meet the goal of resource structure allocation or deviate from the elastic range given by the goal, a series of resource allocation schemes are obtained. After the risk analysis of the optimal allocation scheme of resources, it is provided to the decision-maker.

With the help of MATLAB programming language, the program can be solved. The model is solved by multi-objective genetic algorithm (NSGA-II). NSGA-II algorithm constructs the non-dominated set by two steps, which shortens the operation time of model solution [9]. Meanwhile, it defines the partial order set by calculating the crowding distance and selects individuals to construct a new group in the partial order set, which can also greatly improve the operation efficiency of the algorithm.

4.2. Model application

The overseas oil and gas resources project of an oil field enterprise has the problems of unreasonable resource structure allocation and unsatisfactory overall investment benefit. According to the business data, the company currently has 20 exploration and development projects, 5 exploration projects and 15 development projects. It is known that the oil and gas production, development well number planning data, operation data (investment, cost, cash flow, etc.) and typical newly purchased project database of each project by the end of the contract period. Due to the reasons of confidentiality, the specific parameters are not detailed.

The ratio of exploration and development investment in 2020 is 1:5. According to the overall strategic goal of the enterprise, the index of exploration and development investment after five years is set as 5:1. The newly increased exploration projects need to be concentrated in Asia Pacific and Central Asia of Russia, and 70% of the projects after five years are mainly land-based projects, 80% of the resources are oil resources. How can the oil company achieve the resource allocation goal by the ratio of exploration and development investment within the five-year planning time?

According to the theory of operational research, this is a multi-stage dynamic planning problem to meet the goal of resource allocation. According to the corresponding model and solution method
established in the previous theory, the scheme meeting the resource allocation target can be obtained through MATLAB programming calculation. During the planned five years, 10 new exploration projects and 2 development projects were sold. In Figure 2, the size of the circle represents the production index of exploration and development of the scheme. The larger the circle is, the greater the production of the scheme is. The color of the circle represents the investment index of the scheme. The closer the color is to dark blue, the larger the investment scale is. It can be seen from the figure that the configuration objectives of the recommended scheme are highly consistent, with low risk coefficient and moderate investment scale.

![Resource structure](image)

**Figure 2.** Resource structure allocation scheme set and risk factors.

5. **Conclusion**

Based on the theory of multi-stage dynamic planning in operational research, according to the characteristics of overseas oil and gas project resources, this paper constructs a mathematical model aiming at resource structure allocation, solves the optimization results by using genetic algorithm, and realizes it by programming with MATLAB language, thus providing a new method for the optimization of overseas oil and gas resource structure allocation.

This model can provide a scientific and rapid optimization scheme for managers of petroleum enterprises to meet resource allocation objectives, reduce a large number of manual work in the process of strategic planning, and its application prospects will be very broad. However, the model mainly considers the macro strategic planning and does not consider many economic factors in the construction. Subsequently, according to the strategic decision-making of managers, we can further screen out the schemes with poor economic effect and continue to carry out progressive optimization, so that the optimization results of resource allocation are more scientific and reasonable.

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