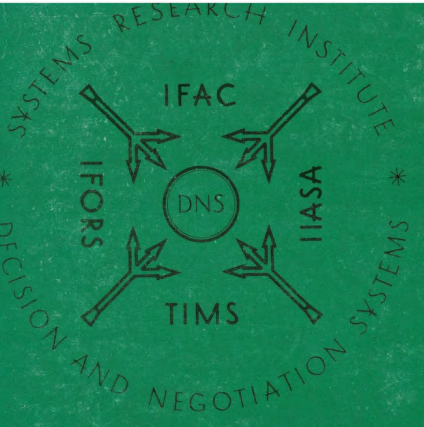

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SUPPORT SYSTEMS FOR DECISION AND NEGOTIATION PROCESSES

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DECISION-MAKING TOOLS IN PETROLEUM EXPLORATION

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Abstract: To put the new management methods into practice of oil and gas exploration, the mathematical decision-making methods must be used. We proposed such methods to the industry, and our implementation effort and results obtained are described in the paper. Three types of models are discussed: prognostic models, risk analysis models, and competitive bidding model. The CALIF software package is presented that contains PROGNOSIS, MONEY, KODEM, TREE, ALI, SHEIK, and BIDDER computer programs to support the decision making process in petroleum exploration.

Keywords: petroleum exploration, decision-making, prognostic model, risk model, bidding model, decision support system

1. Introduction

The changes in Polish economy cover also the petroleum exploration industry. By now, the exploration activity is not financed by the national budget and new geological law is in force. Also the restructurization process of the industry takes place aiming at more efficient investing of capital.

In effect, there is a demand for objective methods of decision-making, suitable for market economy. We offered several decision models to the exploration industry, and our implementation effort and results obtained are described in the paper. Three types of models are discussed: prognostic models, risk analysis models, and competitive bidding model.

2. Prognostic Models

Many statistical prognostic models exist for forecasting the future results of petroleum exploration activity. Among them, three models of exploration process prevail in the literature: exploration function, model of exploration effectiveness, and field size distribution model. The paper by Łucki and Szkutnik (1989) contains a résumé of the literature of the prognostic models, while the paper by Łucki (1990) gives the results of their application to the Polish petroleum geology.

Three computer programs have been made to use the prognostic

models in industrial practice. The PROGNOSIS program is based on the "discovery process model" or "exploration function", known as the model of Arps and Roberts or the model of Drew. The input data are: annual drilling effort and annual oil and gas discoveries. The results include estimates of ultimate exploratory effect and of partial exploratory effects due to determined exploratory effort.

The MONEY program combines the prognostic function with the economic analysis of exploration process. The input data consist of historical data mentioned above and of costs of drilling and exploitation activity. The results are: volume of commercial oil/gas reserves in a function of hydrocarbon price and discount rate.

The KODEM program is based on Kontorovich/Demin (Pareto) distribution of hydrocarbon fields size. Having the size data on the field already discovered and estimate of ultimate reserves, one can estimate the distribution of parent population of fields and of fields remained to be discovered.

On the basis of historical data, the following forecasts have been estimated for Poland and its main geological provinces: ultimate reserves of oil and gas, effectiveness of exploration in the nearest future, total number of hydrocarbon fields, and number of fields in individual size classes. It should be emphasized that the estimates obtained are interval estimates rather than points ones. As forecasts obtained from the statistical models were used successfully by the industrial geologists to check up the geological estimates, we are now to compute the similar forecast for smaller geological units, i.e. for individual geological basins in the country.

3.Risk Analysis Models

The theoretical basis of risk analysis in the petroleum exploration has been developed by Newendorp (1975,1984). Łucki et al.(1990,1991) have adapted the analysis to the needs of Polish users. Three computer programs are available to analyze risk and uncertainty for petroleum exploration ventures:

* TREE program to draw and analyze the decision tree in simple

decision situations, like: to drill or not to drill, to run casing or not to run, etc.

* ALI program to assess the economic value of geological structure or oil/gas field,
* SHEIK program to estimate the economic value of geological basin.

The computations used in the analysis include: Monte Carlo simulation of reserves, drilling expenditures, and profits; discounting procedures to calculate the present values; and calculation of expected values of reserves and profit. The input data include: geological information on the structure; assumed development and exploitation program of the discovered field; economic data like drilling costs, price of oil or gas, and discount rate; and probability values of various events.

Above 300 geological structures have been assessed with use of the following criteria: expected reserves, average capital expenditure on drilling, average net present value of the venture, expected monetary value, unit cost of discovery, unit profit, and profit ratio. Results of the appraisal aid the decision makers to choose to drill the structure, to carry out the additional seismic and geological survey, or to reject the structure as non-commercial.

Thus, the risk analysis models have been accepted by the industrial geologists and decision makers. They use them to prepare plans of exploration activity while such the plans had no economic background beforehand.

4.Competitive Bidding Model

Capen et al. (1971) have published the report on competitive bidding for land for petroleum exploration. In a competitive lease sale bidders tend to buy land that is worth much less than they thought prior to the sale. For protection, one must bid less than his value estimate, but how much less is sometimes hard to determine. Capen et al. presented a probabilistic model that can provide guidelines on bidding strategy. They use a concept of the expected value of the winning bid and give the relation of mean high estimate to true value of tract under various conditions of

uncertainty and for various number of competitors. They also made the analysis of historical data on bidding and proposed a simulation model of bidding. There are also many other papers on bidding published in the petroleum literature, e.g. by Dougherty and Lohrenz (1976).

For decades, we neglected such the papers as they were not useful for Polish petroleum industry. Now, when the new geological law is in force, we have adapted the bidding model (the BIDDER program) to the needs of domestic bidders. We hope that our effort will be welcomed by the industry as in the cases of the prognostic and risk models.

5. Software Package

To use the above described models in practice, we offered the software package CALIF which contains seven above presented programs written for personal computers: PROGNOSIS, MONEY, KODEM, TREE, ALI, SHEIK, and BIDDER. Most of these programs were modified several times to meet better the needs of industrial users, and now the forth version is available. The package has been sold to the Polish State Oil and Gas Company and to some of its divisions and is used in practice to prepare petroleum exploration business plans and feasibility studies.

The newest version of CALIF package is a fully integrated system for supporting exploration decision making. Exploitation of the system is very clear and simple due to fully windowed user's interface (using WIMP convention) based on Borland's Turbo Vision application framework. System requires PC XT, AT, 386 Computer, hard disk, 640 kB RAM, any of popular graphics adapters, and any of 9-pin printers.

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