RISK ANALYSIS METHOD FOR OPENCAST MINING PROJECTS

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ABSTRACT. The most commonly used methods for project assessment in the mining industry are based on analysis of the expected value as a criterion for project implementation. However, the designing, the exploration and the mining of mineral resources are carried out within conditions of high uncertainty both with regard to the present moment and the future plans. This is due not only to the geological uncertainty but also to a number of economic factors, such as prices, expenses, inflation, possible tax changes, etc. The mining activity as a whole and the open mining in particular is related to specific risks which are inherent to all participants in the international mining industry. Therefore, under these circumstances, it is appropriate to apply the method of risk analysis using Monte Carlo simulations. This probability approach takes into account the uncertainty related to evaluation of the economic indicators used to assess the profitability of the project.

ПРИЛАГАНЕ МЕТОДА НА АНАЛИЗ НА РИСКА ПРИ ОЦЕНКА НА ПРОЕКТИ НА ОТКРИТИ РУДНИЦИ

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РЕЗЮМЕ. Най-често използваните методи за оценка на проекти в минната практика се основават на анализ на очакваната стойност, като критерий за реализиране на проекта. Но проектирането, проучването и добива на полезни изкопаеми се извършват в условия на висока неопределеност, както в настоящ, така и в бъдещ план. Това се дължи не само на геоложката неопределеност, но и на редица икономически фактори, като цени, разходи, инфлация, евентуални данъчни промени и др. Ето защо добива изобщо и в частност открития добив е свързан със специфични рискове, които до известна степен са присъщи на всички участници на международната метална индустрия. При тези обстоятелства е подходящо прилагането на метода на анализ на риска с помощта на Монте Карло симулациите. Този вероятностен подход отчита по-пълно неопределеността, свързана с оценка на икономическите показатели, използвани за оценка на рентабилността на проекта.

The most commonly used methods of project evaluation in mining exploration rely on expected value analysis as criteria for undertaking the project. Expected value methods summarize the attributes of a project by calculating the average outcome on which decisions are based.

Risk analysis is a very powerful tool for certain mining processes where decision under uncertainty is involved. A range of methods is available to support project decision making under uncertainty, such as sensitivity analysis, scenario analysis and risk analysis using simulation.

Open cast mine is subject to certain inherent risks, which to some degree apply to all participants of the international metals industry. These include:

- Commodity Price Fluctuations: These may be influenced by demand for metals in industry, actual or expected sales by central banks, sales by metal producers in forward transactions and production cost levels in major producing countries.
- Inflation Rate Fluctuations: Specifically related to the macro-economic policies of the individual countries.
- Country Risk: Specifically country risk including: political, economic, legal, tax, operational and security risks;
- Exchange Rate Fluctuations.
- Legislative Risk: Specifically changes to future legislation (tenure, mining activity, labour, occupational health, safety and environmental) within the Russian Federation;
- Exploration Risk: Resulting from the elapsed time between discovery of deposits, development of economic feasibility studies to bankable standards and associated uncertainty of outcome;
- Development Project Risk: Specifically technical risks associated with green field projects for which technical studies are limited to pre-feasibility studies or less and development and production has not commenced.

This risk is the opportunity to re-assess that portion of the Mineral Resource which is amenable to open-pit mining by extending the optimizations process to include Inferred Mineral Resources. Coupled with further drilling to target upgrading of the currently identified Mineral Resource this may well increase the base for modification to produce Ore Reserves on completion of the appropriate technical studies.

With the improvements in computers and the availability of simulation software, risk analysis using Monte Carlo simulation especially has seen a increase in popularity. Software consists of economic and financial analysis for the evaluation of new mine development proposals.

The probabilistic approach used here takes into account the uncertainty associated with the estimation of the economic variables used to assess the profitability of proposals.

In this approach, the variables are defined by probability distributions rather than by point estimates. The analysis technique used in the model, originally referred to as the Monte Carlo simulation technique, consists of an iterative approach which randomly simulates values of the uncertain variables.

In Monte Carlo simulation, a specific operation is mathematically performed thousands of times.

Input data involve estimates of the range of probabilities for the variables. By means of a random number generator, specific values for each variable are chosen at frequencies described by input data. Values for each variable are generated and the resultant answer to the mathematical operations contains the complete range of probable solutions. The answer takes the form of a cumulative probability distribution curve.

The final result process is a probability distribution of possible investment which can be used to assess the attractiveness of the investment proposal. The Net Present Value and DCF Rate of Return criteria are used here for this purpose.

The final result of the model realization are:

- distribution of Net Present Value (NPV);
- risk of the mining project realization (probability of loss, population mean NPV<0);
- distribution of Internal Rate of Return (IRR).

For realization given purposes at Mining Department of Saint Petersburg State Mining Institute (Technical University) was designed model and software.

The results of model realization for project open cast mining Korpanga iron ore deposit are shown in fig. 1, 2 and table 1 - 4.

Table 1. *The results of model realization for project open cast mining Korpanga iron ore deposit (for different ore output of open cast mine)*

№	PROJECT	COST 992	COST 991	COST 99	COST 993	COST 994
1	Mean of Net Present Value (NPV), Mln.rub.	360,67	263,9	204,0	127,6	56,98
2	Standard deviation NPV, Mln.rub.	456,84	471,98	486,0	460,7	462,59
3	Probability of loss (Risk), %	24,67	31,5	35,17	39,5	46,67
4	Mean of loss, Mln.rub.	-205,4	-257,44	-309,0	-317,91	-336,05
5	Mean of Internal Rate of Return (IRR) , %	17,25	15,6	14,77	13,76	12,83
6	Standard deviation IRR, %	6,78	6,48	6,38	5,81	5,53
7	Ore output , (A_p) Thousand ton/year	4000	5000	6000	7000	8000

Table 2. *The results of model realization for project open cast mining Korpanga iron ore deposit (for different investments)*

№	PROJECT	CORP 0	CORP 2	CORP 1	COST 999	CORP 3	CORP 4
1	Mean of Net Present Value (NPV), Mln.rub.	-378,52	-277,24	-88,24	204,0	323,85	443,05
2	Standard deviation NPV, Mln.rub.	376,57	339,85	394,66	486,0	481,69	526,49
3	Probability of loss (Risk), %	83,17	79,17	62,0	35,17	26,17	21,17
4	Mean of loss, Mln.rub.	-496,03	-404,62	-333,02	-309,0	-278,28	-255,79
5	Mean of Internal Rate of Return (IRR), %	7,55	8,26	10,96	14,77	15,88	17,04
6	Standard deviation IRR, %	7,55	4,76	5,36	6,38	5,92	6,10
7	Investment, (I) Mln.dol.	52	56	60	64	68	72

Table 3. *The results of model realization for project open cast mining Korpanga iron ore deposit (for different price of iron concentrate)*

№	PROJECT	CORP 11	COST 99	CORP 12	CORP 13	CORP 14
1	Mean of Net Present Value (NPV), Mln.rub.	-10,20	204,0	395,46	594,3	788,48
2	Standard deviation NPV, Mln.rub.	419,45	486,0	506,61	535,26	559,4
3	Probability of loss (Risk), %	52,67	35,17	22,0	15,0	7,83
4	Mean of loss, Mln.rub.	-329,97	-309,0	-277,52	-205,38	-201,28
5	Mean of Internal Rate of Return (IRR), %	11,90	14,77	17,32	20,24	22,87
6	Standard deviation IRR, %	5,25	6,38	6,96	7,93	8,22
7	Price of iron concentrate, Rub./ton	450	500	550	600	650

Table 4. *The results of model realization for project open cast mining Korpanga iron ore deposit*

№	PROJECT	COST 99	COST 99n	CORP FS	CORP FSn
1	Mean of Net Present Value (NPV), Mln.rub.	204,0	-114,48	826,53	333,69
2	Standard deviation NPV, Mln.rub.	486,0	300,16	659,94	427,73
3	Probability of loss (Risk), %	35,17	63,17	11,17	23,67
4	Mean of loss, Mln.rub.	-309,0	-298,42	-259,54	-215,45
5	Mean of Internal Rate of Return (IRR), %	14,77	10,32	25,85	18,91
6	Standard deviation IRR, %	6,38	4,72	12,68	9,30
7	Output Ore, Thousand ton/year Overburden, Thousand m^3/year	 6000 2700	 6000 2700	 6000 2700	 6000 2700
8	Investment, (I) Mln.dol.	64	64	60	60

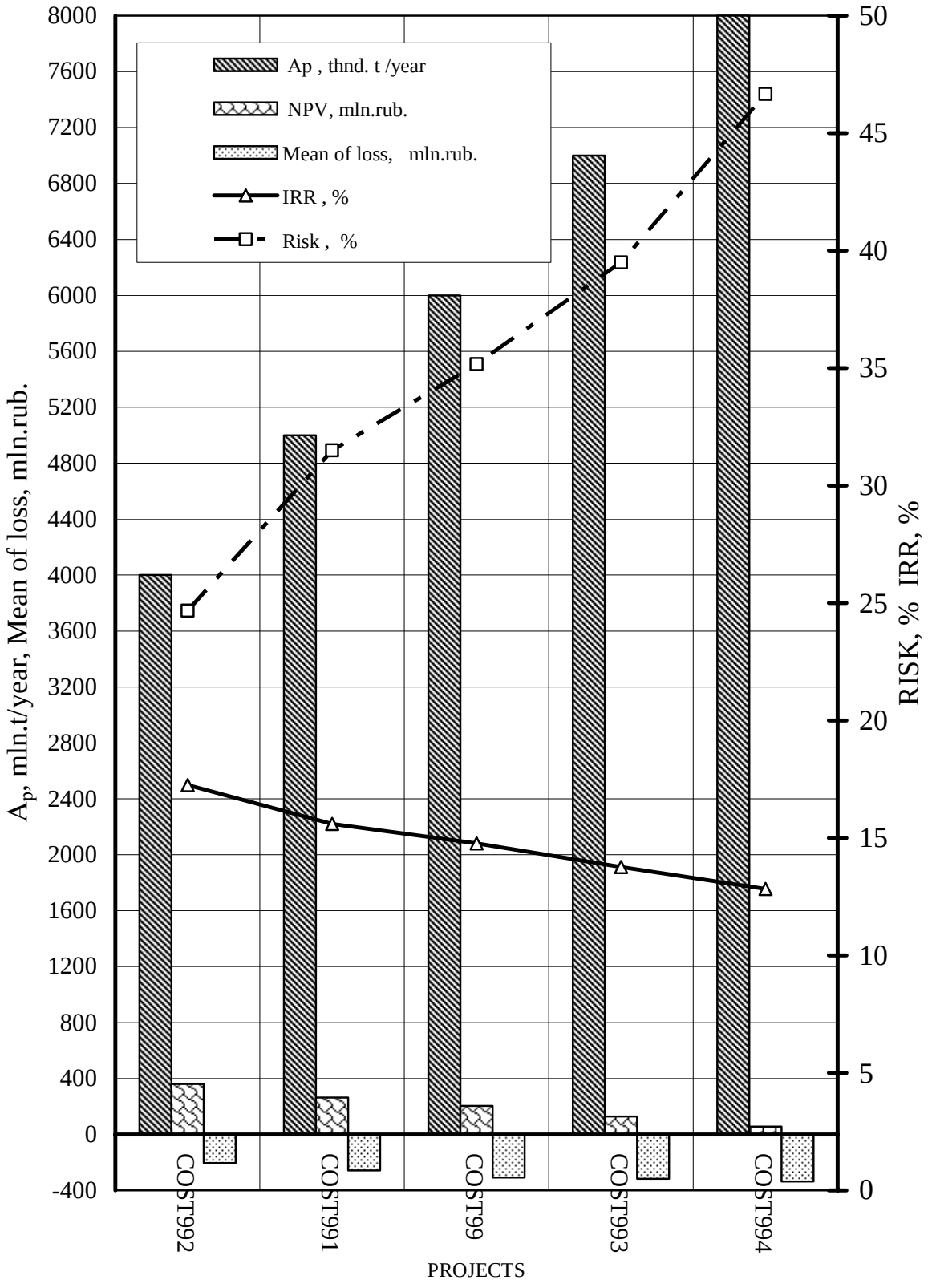

Fig. 1. Diagram of risk assessment for alternative projects of open cast mining Korpanga iron ore deposit

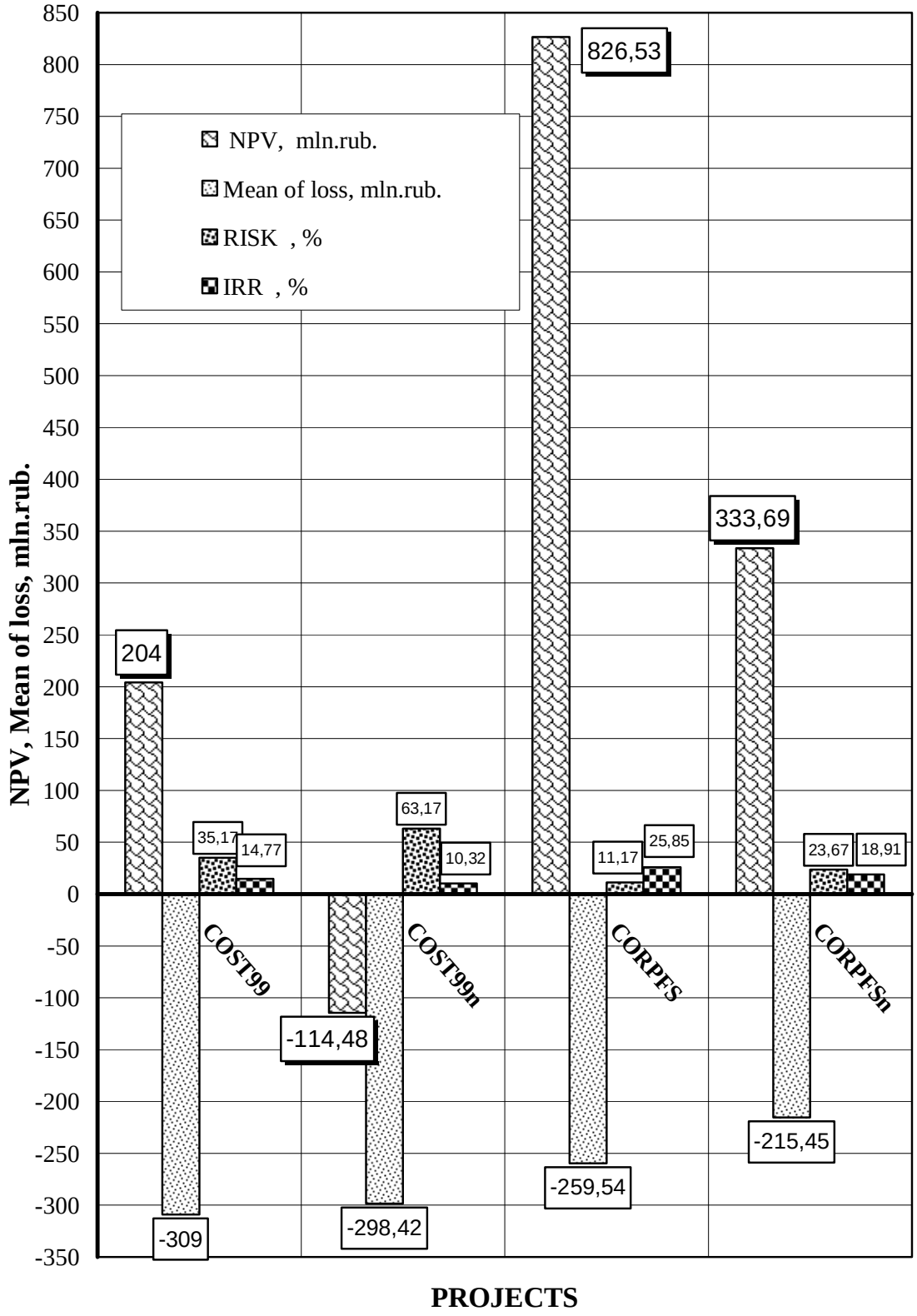

Fig. 2. Diagram of risk assessment for alternative projects of open cast mining Korpanga iron ore deposit

Mining or exploration is a process which commits company funds to unknown future. The unknowns involve not only geologic uncertainty but a number of critical economic factors such as price, cost, inflation and possible changes in tax laws.

The output of open cast mines can give distribution of results and can be used to perform sensitivity analysis of various input distribution parameters. In new mineral deposits or exploration areas, where costs are important but not specifically know, the effects of cost variance can be estimated by Monte Carlo simulation.