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APPLICATION OF FINANCIAL RISK ANALYSIS FOR PROJECT EVALUATION AT A LARGE COAL MINE

Mohammad Zare[1], Farhang Sereshki[1] and Naj Aziz[2]

ABSTRACT: Today risk analysis is largely employed in studying the uncertainty of financial decisions in new mining ventures. The methodology for examination and quantification of financial risks is investigated in this paper. A coal mining project is generally a long term process. Also, any increase in the project time, raises the probability of variation in effective financial parameters. Therefore, the forecasting and risk analysis for this kind of projects will be more important. For this reason, this work has been prepared for the purpose of presenting the methodology and uses of techniques applied in the evaluation of the long term projects to analyse and assess risk. The flexibility of spreadsheets and their statistical capabilities make them a common framework for simulation modelling. In this paper, the discussion is illustrated with an example of stochastic discounted cash flow for a real large coal mine. Then, Excel spreadsheet tools for the simulation, and also a powerful risk analysis software have been used. Finally, the paper examines output data from analysis of mentioned project.

INTRODUCTION

When uncertainty and risk are relatively absent, project evaluation is a reasonably easy exercise. However, mineral projects often involve commodities for which prices or operating procedures are difficult to forecast, and analysts must make decisions concerning how best to evaluate such projects. The introduction of risk greatly complicates the evaluation process. The key to successful evaluation is the proper inclusion and quantification of risk and the consequences (Glickman and Gough, 1990).

A complete understanding of the risks, their consequences, and their probabilities of occurrence is an absolute necessity for any project evaluation. A pro forma cash flow can provide the basis for risk assessment in an investment analysis, as well as a means to determine the optimal assignment of risk in a *financial analysis. The goal of risk assessment is not to reduce risk--that cannot* be done by analysis--but rather to increase the understanding of risk so that appropriate action can be taken. In this paper, a large coal mining project is investigated for its financial risk analysis.

Importance of Risk Analysis in Mineral Projects

Mineral investments can have a number of characteristics that make them somewhat different from other types of investment opportunities, including the depletable and often unique nature of the ore reserves, the unique location and characteristics of the deposit, the existence of geologic uncertainties, the length of time required to place a mineral property into production, the usually long-lived nature of the operation itself, and the pronounced cyclical nature of mineral prices. In addition, mineral deposits can be mined only where the minerals are found. Therefore, options for locating a mineral operating site are likely to be more limited than with other types of industrial developments. Among the mineral projects, coal mines, especially, are more remarkable and significant. This decrease in flexibility increases the risk of mining ventures compared to other types of investment opportunities (Torries, 1998).

Each mineral deposit is unique in terms of location and ore grade and characteristics. It theoretically cannot be replaced when depleted, although similar deposits can often be found or purchased. This aspect makes it difficult to compare the value of one mineral operation with another. Risk is increased since there is no guarantee that a search will yield a new mineral deposit to replace a depleted deposit.

The effects of time greatly influence the value of a mineral project, as they do any other long-lived investment. Usually prices and costs must be predicted, which introduces an element of risk common to most other types of investment opportunities. However, many mineral prices are cyclical in nature, and the difficulty in forecasting prices and costs poses particular problems in evaluating and planning mineral projects (Labys, 1992).

Time also affects mineral projects in several ways that are not always present in other investment opportunities. First, significant mineral reserves are usually required for a long-lived mineral project. Since, by definition, reserves are quantities of ore to be mined in the future, the present value of a ton of reserves is less than the present value of a ton of ore that can be mined immediately. Many other investment decisions involve deciding whether to sell an item today or to wait until the future; thus, public officials who wish to tax mineral reserves to raise funds for public projects often misunderstand the fact that not all reserves have the same present value.

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Second, the mineral evaluation process must consider that operating decisions made early during the life of a mineral deposit will affect the long-run value of the operation. For example, early mining of higher-grade ore increases early profits but lowers the average grade of the remaining ore and reduces the life of the mine. In addition, economic and operating conditions can unexpectedly change during the life of a mine, making flexibility of operation desirable.

Last, it is impossible to know the exact amount or grade of material to be mined until the deposit is depleted, for two reasons. The first has to do with geologic certainty. The geologic quantity and quality of the deposit must be determined by sampling, which by definition gives statistical estimates. The second reason involves economic certainty. The quantity and quality to be mined at any given time depend upon mining and processing costs and the prices of the resulting commodities. Since future prices cannot be forecast accurately, it is usually difficult to determine reserves even though there may be a high degree of confidence in the geologic-based estimates (Torries, 1998).

SIMULATION

Simulation is a powerful and flexible analytic tool that can be used to study a wide variety of management models. It is generally used in cases where a good analytic model either dose not exist or is too complicated to solve. Simulation can also demonstrate the effects of variability and initial conditions, as well as the length of time needed to reach steady state. This description encompasses a large segment of real world models and, as a result, surveys of the use of management science techniques typically put simulation at or near the top. However, there are a number of important factors for management to consider before making a commitment to a simulation study. The ability of simulation models to deal with complexity, capture the variability of performance measures, and reproduce short-run behaviour make simulation a powerful tool.

Monte Carlo Simulation Technique

Monte Carlo simulation method tries to investigate stochastic permutations of uncertainties, which occur in a project. The process speed and power of a computer is implemented in order to search different modes of these uncertainties. Firstly, the most proper distribution function is determined for each uncertainty found in the second phase of risk analysis process. These distribution functions are determined considering the experts' opinion and available records obtained in the previous projects. For example, total cost may have a normal distribution function with the parameters m and s^2. Then the number of runs, that the simulation should be performed, is determined regarding the project size and the importance of risks. The number of runs can be set as 1000, 2000, 5000, and so on. It could be said that while the number of runs increases, much more stochastic modes are searched in the solution space (Pindred, 1995).

In each run, a stochastic value is allocated to each uncertainty in the range of its lower bound and upper bound. The frequency of each value is followed by determined distribution function. Therefore, a set of variables are allocated to all uncertainties in each run and the underlying utility amount is determined based on the value of these variables (Stermole, 1993).

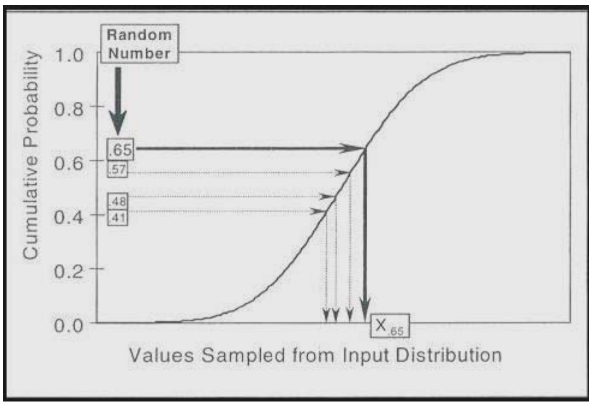

Figure 1 - Monte Carlo Sampling Method

Application in Cash Flow Probabilistic Analysis

Probabilistic analysis can be thought of as the ultimate form of scenario analysis in that all possible cases are considered simultaneously. The input for the analysis consists of a distribution of values for each variable in a cash flow analysis. In other words, for each variable used in a cash flow, a range of values and their probabilities of occurrence are used as inputs instead of a single value as in scenario analysis. Since inputs are probabilistic, most of the risk inherent in the project is reflected in the range of input variables. Therefore, the discount rate used in probabilistic evaluation methods must reflect the risk captured in the cash flow itself. The risk component in a risk-adjusted discount rate decreases in proportion to the amount of risk expressed in the probabilistic range of input values. If all risks are totally expressed in the probabilistic determination of the range in values of the inputs, a riskless discount rate must be used. This is in contrast to a risk-adjusted discount rate that may be used for nonprobabilistic evaluation methods, such as scenario analysis. A computer program using a method called Monte Carlo simulation can then be used to generate hundreds of variations of cash flows (i.e., hundreds of scenarios) and NPVs for an individual project. The statistical distribution of the NPVs is then analysed to determine the worth of the investment opportunity. The mean of the NPVs obtained by Monte Carlo simulation represents the statistically defined expected value of the project (Torries, 1998).

EXAMPLE; A LARGE COAL MINE

In this part, a large coal mine project is examined as a financial mining project. The life of project is 29 years. Basic data and the DCF are demonstrated in Table 1. For reach to final goal (risk analysis of project), this table must set up in a spreadsheet as Excel and the main parameters must be connected together. In this table, interest rate parameter is set up separately for the future aims.

INTRODUCING A POWERFUL SOFTWARE FOR RISK ANALYSIS

@Risk is a powerful software in risk analysis of projects that adds in Excel Spreadsheet and is capable of incorporation with Excel's modelling abilities with best efficiency. This software is applied for the analysis of projects with probabilistic parameters. Probability distribution of each parameter must be inserted into for its cell. Then @Risk runs the model by the Monte Carlo and Latin Hypercube methods and random numbers generation for many times. Then, project's parameters are analysed and finally, outputs and their probability distributions are presented. Examining the output data and with respect to expectations, the counted risk of project will be gained. Also, @Risk is capable of presenting output data graphically that cause of better realisation from the results. In this paper, we have used the newest edition of software (4.5 Industrial Version) that has more capabilities than older versions.

PROCESS

Definition of input and output parameters

Two parameters of interest rate and coal price are selected for input parameters for their oscillation and variation in two past decades based on historical data. These historical data are collected and their probability distributions are defined by curve fitting. The results of these definitions for interest rate and coal price are shown in figures 2 and 3 respectively. The results show that the interest rate follows Logistic distribution and also coal price follows the Exponential distribution.

Afterwards, the output cells must be defined in the spreadsheet. In this study, final Net Present Value of the project (NPV) and present values of each year defined as the output parameters.

Simulation

After definition of inputs and outputs, we can run the model and perform simulation. But, before this, settings of simulation must be set up. The model should be run with logic (sufficient) iterations in the way that convergence is yielded. Table 2 shows the output data resulted from simulation.

Also, Figures 4 and 5 shows the final probability distribution and histogram for the NPV output parameter. Analysing of these graphs, we can measure the counted risk of the project respect to expectations.

Table 1 - Basic data and DCF for the coal mine project

Description	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Capital Investment	1E+08														
Depreciation		3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06
Operating Costs		1E+09	1E+09	1E+09	1E+09	3E+09	3E+09	3E+09	3E+09	3E+09	3E+09	3E+09	3E+09	3E+09	3E+09
Government Rights		80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000
Sale Volume		3E+06	3E+06	3E+06	3E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06
Price Per Tonne		3600	3600	3600	3600	3600	3600	3600	3600	3599.7	3599.7	3599.7	3600	3600	3600
Revenue		1E+10	1E+10	1E+10	1E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10
Taxable Revenue		1E+10	1E+10	1E+10	1E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2.2E+10
Tax		2E+09	2E+09	2E+09	2E+09	5E+09	5E+09	4E+09	5E+09	5E+09	5E+09	5E+09	5E+09	5E+09	5E+09
Net Revenue		9E+09	9E+09	9E+09	9E+09	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10
Depreciation		3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06
Cash Flow		9E+09	9E+09	9E+09	9E+09	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10
Net Present Value	-1E+08	7E+09	6E+09	5E+09	4E+09	7E+09	6E+09	5E+09	4E+09	3E+09	3E+09	2E+09	2E+09	2E+09	2E+09
Interest Rate	**0.2029**														
NPV	**6E+10**														

Table 1 - Basic data and DCF for the coal mine project (continued)

Description	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Capital Investment															
Depreciation	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06
Operating Costs	3E+09	3E+09	3E+09	3E+09	3E+09	3E+09	3E+09	3E+09	3E+09	3E+09	3E+09	3E+09	3E+09	3E+09	3E+09
Government Rights	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000	80000
Sale Volume	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06	7E+06
Price Per Tonne	3599.7	3600	3600	3600	3600	3600	3600	3600	3600	3599.7	3599.7	3599.7	3600	3600	3599.7
Revenue	3E+10	3E+10	3E+10	3E+10	3E+10	2E+10	2E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10	3E+10
Taxable Revenue	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10
Tax	4E+09	5E+09	5E+09	4E+09	5E+09	4E+09	4E+09	5E+09	5E+09	5E+09	5E+09	5E+09	5E+09	5E+09	4E+09
Net Revenue	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10
Depreciation	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06	3E+06
Cash Flow	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10	2E+10
Net Present Value	1E+09	9E+08	8E+08	6E+08	5E+08	4E+08	4E+08	3E+08	3E+08	2E+08	2E+08	1E+08	1E+08	1E+08	8E+07

Table 2 - Output Data Resulted From the Simulation

Name	Workbook	Worksheet	Cell	Sim#	Minimum	Mean	Maximum	x1	p1	x2	p2
PV1	Book1.xls	Sheet1	C14	1	1.77E+09	7.89E+09	3.91E+10	2.26E+09	5%	1.98E+10	95%
PV2	Book1.xls	Sheet1	D14	1	1.22E+09	6.26E+09	3.32E+10	1.80E+09	5%	1.61E+10	95%
PV3	Book1.xls	Sheet1	E14	1	8.01E+08	5.31E+09	2.85E+10	1.44E+09	5%	1.28E+10	95%
PV4	Book1.xls	Sheet1	F14	1	6.80E+08	4.56E+09	3.08E+10	1.21E+09	5%	1.20E+10	95%
PV5	Book1.xls	Sheet1	G14	1	5.69E+08	7.83E+09	5.63E+10	1.79E+09	5%	2.10E+10	95%
PV6	Book1.xls	Sheet1	H14	1	4.19E+08	6.73E+09	9.73E+10	1.47E+09	5%	1.86E+10	95%
PV7	Book1.xls	Sheet1	I14	1	2.66E+08	5.78E+09	1.05E+11	1.09E+09	5%	1.60E+10	95%
PV8	Book1.xls	Sheet1	J14	1	1.28E+08	4.82E+09	9.79E+10	8.17E+08	5%	1.40E+10	95%
PV9	Book1.xls	Sheet1	K14	1	1.70E+08	4.26E+09	8.50E+10	6.48E+08	5%	1.21E+10	95%
PV10	Book1.xls	Sheet1	L14	1	1.69E+08	4.06E+09	1.54E+11	4.98E+08	5%	1.19E+10	95%
PV11	Book1.xls	Sheet1	M14	1	3.36E+07	3.39E+09	8.56E+10	3.89E+08	5%	9.83E+09	95%
PV12	Book1.xls	Sheet1	N14	1	3.42E+07	2.98E+09	7.57E+10	2.80E+08	5%	8.69E+09	95%
PV13	Book1.xls	Sheet1	O14	1	1.76E+07	2.77E+09	8.05E+10	2.19E+08	5%	9.29E+09	95%
PV14	Book1.xls	Sheet1	P14	1	8484516	2.49E+09	5.27E+10	1.72E+08	5%	8.81E+09	95%
PV15	Book1.xls	Sheet1	Q14	1	8259557	2.41E+09	1.32E+11	1.31E+08	5%	7.73E+09	95%
PV16	Book1.xls	Sheet1	R14	1	6202285	2.06E+09	8.81E+10	9.83E+07	5%	6.74E+09	95%
PV17	Book1.xls	Sheet1	S14	1	2937620	1.90E+09	9.38E+10	7.41E+07	5%	6.00E+09	95%
PV18	Book1.xls	Sheet1	T14	1	1358177	1.95E+09	2.49E+11	5.26E+07	5%	6.21E+09	95%
PV19	Book1.xls	Sheet1	U14	1	589958.8	1.72E+09	1.11E+11	3.97E+07	5%	5.06E+09	95%
PV20	Book1.xls	Sheet1	V14	1	427951.8	1.78E+09	3.22E+11	3.05E+07	5%	4.73E+09	95%
PV21	Book1.xls	Sheet1	W14	1	268119.6	1.63E+09	1.81E+11	2.25E+07	5%	4.36E+09	95%
PV22	Book1.xls	Sheet1	X14	1	179776.7	1.77E+09	3.18E+11	1.64E+07	5%	3.72E+09	95%
PV23	Book1.xls	Sheet1	Y14	1	77801.02	1.70E+09	3.25E+11	1.33E+07	5%	3.93E+09	95%
PV24	Book1.xls	Sheet1	Z14	1	145434.1	1.80E+09	3.05E+11	1.11E+07	5%	3.64E+09	95%
PV25	Book1.xls	Sheet1	AA14	1	21706.77	1.58E+09	2.88E+11	6731015	5%	2.84E+09	95%
PV26	Book1.xls	Sheet1	AB14	1	9819.742	2.37E+09	9.75E+11	5241728	5%	3.28E+09	95%
PV27	Book1.xls	Sheet1	AC14	1	13402.15	1.74E+09	2.55E+11	4085175	5%	2.47E+09	95%
PV28	Book1.xls	Sheet1	AD14	1	4679.25	2.14E+09	7.40E+11	3183672	5%	2.52E+09	95%
PV29	Book1.xls	Sheet1	AE14	1	2291.726	1.92E+09	5.15E+11	2466758	5%	2.46E+09	95%
NPV	Book1.xls	Sheet1	B16	1	1.49E+10	9.76E+10	5.09E+12	3.01E+10	5%	1.92E+11	95%

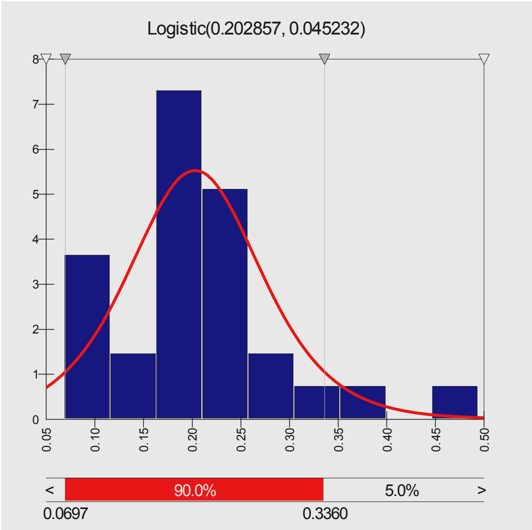

Figure 2 - probability distribution for interest rate parameter

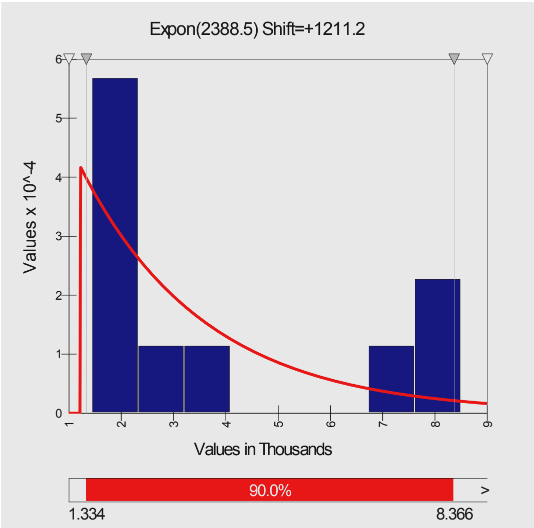

Figure 3 - probability distribution for coal price parameter

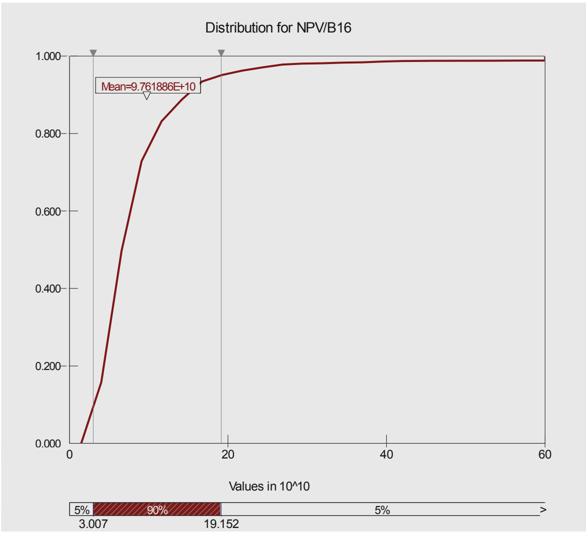

Figure 4 - Final probability distribution for NPV

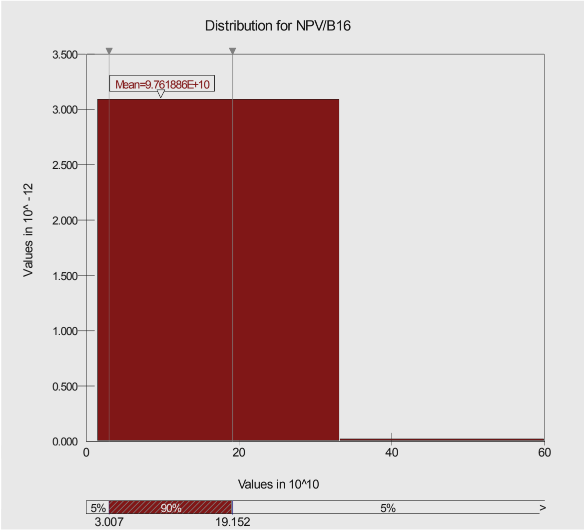

Figure 5 - Final histogram for NPV

In figure 6, we have demonstrated an applicable graph nominated Tornado for NPV parameter that be used for sensitivity analysis of parameters affected in the project. Analysing this graph, we realize that the most important input parameter that affects the NPV, is interest rate.

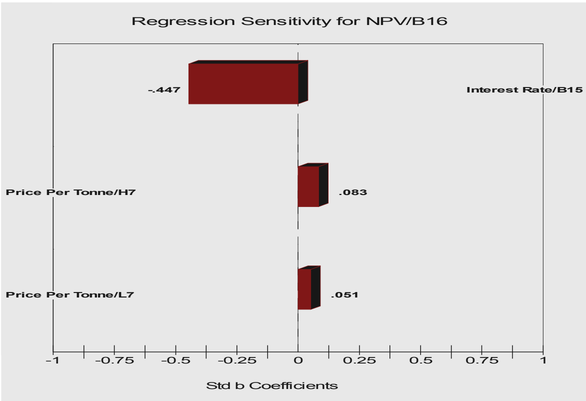

Figure 6 - Tornado graph for sensitivity analysis of NPV

CONCLUSIONS

Risk analysis has moved from the research laboratories of financial economists into the wider world. The techniques now available include a powerful array of simulation methodologies- Monte Carlo and Latin Hypercube sampling and natural language computation (Hacura et al. 2001). They allow the evaluator to provide much more objectives assessments of the risk of a mineral prospect. These methods are available in relatively inexpensive software capable of functioning in most modern personal computers. The most serious difficulty currently encountered in the stochastic risk analysis of mining projects is lack of historical information about the industry. In this study, we analysed the risk of a large coal mining project in some stages briefly. Surveying the output graphs, the manager will be able to measure counted risk of project.

Results including tables and graphs showed that this project has a low risk with taking about interest rate and price as probabilistic parameters in the analyses. However, sensitivity analysis show that the most important input parameter that affects the NPV, is interest rate and the managers must pay high attention in the project period.

REFERENCES

Glickman, T., and M. Gough, eds. 1990. Readings in risk. Washington, D.C.: Resources for the Future.

Hacura A., Jadamus-Hacura M., Kocot A., 2001. Risk analysis in investment appraisal based on the Monte Carlo simulation technique. Eur. Phys. J. B (20), pp. 551-553.

Labys, W. 1992. The changing severity and impact of commodity price fluctuations. overcoming the third world economic crisis. Essays in Honor of Alfred Maizels. Edited by M. Nissanke. Oxford, England: Oxford University Press.

Pindred, R.J. 1995. (Mis)use of Monte Carlo Simulations in NPV Analysis:Discussion. Mining Engineering, 47(12):861-862.

Stermole, F.J., and J.M. Stermole. 1993. Economic Evaluation and Investment Decision Methods, 8th ed. Golden, Colo.: Investment Evaluations Corporation.

Torries, F.T. 1998. Evaluating Mineral Projects: Applications and Misconceptions, Societ af Mining, Metallurgy and Exploration, Inc. (SME).