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ECONOMIC ANALYSIS OF INVESTMENT PROJECTS IN MINING INDUSTRY

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ABSTRACT

In principal, the investment project in mining industry doesn't significantly differ from any other capital investment project. There are, however, some specific characteristics that must be considered, because they may affect the final conclusion. The present article stresses on: depletion allowance – an amount that is deducted from the net revenue and decreases income before taxes. The depletion allowance has an important role for development of mineral and energy resources, because it is additional source of financial funds for investments in exploration and development of new deposits; a brief comment of pros and cons of different appraisal methods of investment projects; decision tree of investment in mining industry; the most used method for measurement the uncertainty and risk – the expert assigning of probability distribution.

Summing up the discussion two main conclusions may be made: 1.) There is not a common acceptable rate of return of investment projects in mining industry; 2.) There is not a precise method of evaluation of these projects.

OBJECTIVES OF THE ECONOMIC ANALYSIS OF INVESTMENT PROJECTS

The economic analysis is necessary for making various decisions, concerning extraction and processing of mineral and energy resources: the engineering design of the development of a deposit; the acquisition or sale of a deposit; a change in the mining and processing methods; a change in the extraction rate and/or extraction level; an assessment of value of assets for taxes purposes; re-evaluation of the investment programme; the evaluation for the purposes of leasing.

With the limited firm's finance any manager must select the best investment opportunity from among those available. The economic analysis, therefore, must give answer of two important questions: does the investment project satisfy the objectives of the firm?; and how does this project compare with other investment opportunities?

Maximization of the profit or minimization of the short-run losses is a prior goal for many firms. The goal may be, however, expansion of production capacity, an increase in firm's market share, diversification, vertical and horizontal integration, or extending the life span of the firm as much as possible. Each of these goals has an important role in the processes of planning and consequently in the economic evaluation of the investment projects. Rank ordering of investment projects according to priorities of the firm ensures that a specific project is justified to the goals of the firm. It also provides good guidelines for the distribution of limited financial resources. Even there was only one investment opportunity, it must be compared with other generating profit economic activities. The concept of the opportunity cost has to be integral part of each economic analysis.

SPECIFIC CHARACTERISTICS OF THE DEVELOPMENT OF EXTRACTIBLE NATURAL RESOURCES

In principle, the investment in the extractible natural resources development projects don't differ from any other capital investments. There are, however, some specific characteristics that must be considered in the analysis, because they may affect the final conclusions. Four specific factors will be mentioned: the long period from the geological discovery to the use of the mineral – usually 8 to 12 years; the political and social environment of the extracting regions; the nonrenewable nature of the mineral and energy resources; taxation burden and allowance resulting from the extraction. In the analysis these factors are reflected in terms of long pre-production period, restricted life time of the extraction, and specific taxes (royalties) and tax allowances (depletion).

There are other factors that should also be considered. The heterogeneous nature of deposits and the restricted quantity of commercial product for example in any mineral and energy deposit may raise the problem of geological and technical uncertainty. Unstable political, economic, and social conditions pose the risk of takeover, expropriation, or the shutdown of extraction.

Accounting of depletion allowance and determining of net cash flows are the key elements in the analysis of projects in mining industry.

DEPLETION ALLOWANCE

Depletion is the exhaustion or diminution of the mineral and energy resources as a result of their extraction. In the accounting books depletion allowance represents an amount that is deducted from the net revenue and decreases income before taxes. The depletion is given to the owner of extractible

natural resources and standing timber. Only the royalty owners (the operating owners) may claim to depletion deduction.

The sixteenth Amendment to the U.S Constitution, that concerned the income taxes, allowed for the first time in the world's practice a provision for depletion – it established an allowance so that revenue resulting from a decline in natural resource value should not be taxed as income. The conception of depletion allowance was accepted by the most of the economic developed countries.

There are two permissible methods of computing depletion allowance: 1) "cost of depletion" and 2) "rate of depletion". Large oil companies avoid the using of the method "cost of depletion", whereas owners of the standing timber have never used the method "rate of depletion". Under the first method depletion allowance per year is computed as follows: the sum from the cost of acquiring the deposit property and exploration expenditures incurred in discovering this deposit, is divided by the estimated remaining reserves, and the result is multiplied by the quantity sold during the year. For example, if the cost of acquiring the property is 500 000 levs, exploration expenditures 200 000 levs, the estimated remaining reserves are 350 000 tons, annual sales are 30 000 tons, depletion allowance for the first year amounts to:

$$\frac{500{,}000 + 200{,}000}{350{,}000 - 30{,}000} = \frac{700{,}000}{320{,}000} = 2{,}19 \text{ levs per ton}$$

and 2.19 levs/ton. 30 000 tons = 65 700 annual depletion.

Assuming no changes in the reserves or annual production depletion for the second year amounts to:

$$\frac{700{,}000 - 65{,}700}{290{,}000} = 2{,}19 \text{ levs per ton}$$

and 2.19 levs/ton. 30 000 tons = 65 700 annual depletion

The method "rate of depletion" permits deduction for depletion as percentage of the net revenue. The depletion must not, however, exceed 50 percent of net income before taxes, computed without the deduction for depletion.

The example in table 1 clarifies the process of computing the allowance of depletion, assuming a percentage depletion of 10 percent (O. Rudawsky, p.61).

The income statement of mine A demonstrates that 10 percent of the net revenue is smaller than 50 percent of income before taxes and depletion, and therefore this percentage may be applied. In the case of mine B this requirement is not valid and the allowance of depletion is computed as a 50 percent of the net revenue.

The depletion allowance under method "rate of depletion" is always more than it would be under the method "cost of depletion". Unlike the method "cost of depletion and unlike depreciation under the method "rate of depletion" the owner may deduct depletion, even he has recovered the full cost of the property. The depletion allowances have an important role for development of mineral and energy resources, because they are additional sources of financial funds for further investment in exploration and development of new deposits. During the last years the concept of depletion were under attack. As a result of the debates the rate of depletion was reduced and the large companies phased out the method "rate of depletion".

NET CASH FLOW

After obtaining or estimating the data needed for an economic appraisal of mining or energy projects the next step is determining of accounting profits for the life of the projects. The sequence in this determining is a good illustration of the different stages of the economic analysis. Accounting profit further is covered in to net cash flow – the best indicator of return on investments. A hypothetical example of project for development of coal strip mine is considered in table 2 (O. Rudawsky, pp. 68-69). The annual production is 3.1 million tons, and all of these are sold to a public utility at a price of 12 levs. The gross revenue is 3.1 millions.12= 37 200 000 levs. One fifth of this amount is paid as a royalty or 37 200 000 0.2=7 440 000 levs. The net revenue is, therefore, 29 700 000 levs. Part of investments can be legally deducted as current expenditures – expensed investments. In mining industry such investments are intangible assets and costs of unsuccessful explorations.

Cash flow measures the actual flow into or out of the project per given period of time. Net cash flow is the difference between revenue inflows and outlays for operating costs and capital expenditures. Ordinary investment projects generate negative cash flows, changing into positive flows after production starts. Net cash flow differs from the accounting profit in three items: depreciation allowance; depletion allowance; capitalized investments. The first two items have to be added to the accounting profit, because they are "inside flows" for the firm. These are permissible deductions from profit for tax purposes, and therefore affect the cash flow indirectly. Capitalized investments are investments with an expected life time exceeding one year. Nonproductive exploration activity may also be capitalized. Capitalized investments are not permissible deductions for the period in which they occurred, but being actual expenditures they must be deducted in computing net cash flow. Computing of net cash flow in the example of coal strip mine is presented in table 3.

The financial statements of the mining firm are strongly affected from the methods of accounting of exploration activities. Two methods are applied in the world practice – full cost (FC) and successful efforts (SE). Under FC, all the costs of exploration are capitalized, regardless of whether those costs lead to a specific discovery of reserves. Under SE, only the exploration costs that result in a producing deposit are capitalized and those that result in "dry holes" are accounted as current expenditures.

Table 1. Computing the allowance of depletion, assuming a percentage depletion of 10 percent.

	Mine A, levs	Mine B, levs
Net revenue	450,000	450,000
less Operating cost	300,000	330,000
Balance 1	150,000	120,000
less Depreciation	50,000	50,000
Balance 2	100,000	70,000
less Depletion	45,000	35,000
Income before taxes	55,000	35,000

Table 2. Accounting profit of coal strip mine (thousands of levs)

		(1) Gross revenue	37,200
less (1)·0,2	=	(2) Royalty payments	7,440
(1) – (2)	=	(3) Net revenue	29,760
		(4) Expensed investment	0
		(5) Operating costs	16,770
(4) + (5)	=	(6) Total costs	16,770
(3) – (6)	=	(7) Gross profit	12,990
less		(8) Depreciation	3,358
(7) – (8)	=	(9) Balance 1	9,632
(3) · 0,1	=	(10) Depletion	2,976
(9) – (10)	=	(11) Profit before taxes	6,656
(11) .· 0,5	=	(12) Taxes	3,328
		(13) Tax credit	24
(12) – (13)	=	(14) Adjusted taxes liability	3,304
(11) – (14)	=	(15) Net profit after taxes	3,352

REVIEW OF THE METHODS OF INVESTMENT APPRAISAL

The more common method of investment appraisal in mining industry are: the accounting rate of return (ARR); the pay back period (PB); the net present value (NPV); the relative present value (RPV); the Hoskold method; and the internal rate of return (IRR). A brief comment of pros and cons of different methods is presented in this section.

The accounting rate of return (ARR) was for many years the most popular for mining' managers method. It is still applied, because of its simplicity and the definite final result. The shortcomings of the ARR method may be generalized as follows: it doesn't use the conceptions of time value of money and cash flow; the residual value of asset is ignored; there is no basis of real comparison between profits or rates of return, obtained in different time periods; the influence of the preproduction period over profit is not considered.

The payback period (PB) is the simplest evaluation technique, thus it is very popular. This method is especially useful for investment projects in industries with rapid technological development - if the physical life of a new machine is longer than its obsolescence, it must ensure profits over a very short period. Under such conditions the payback period is very appropriate criterion for the profitability of investment projects. It is also applicable, to some degree, for measuring risk. Long time projects are risky, at least because it is not easy to forecast future cash flows. Investments in relatively short time projects protect the firm against risk. In this respect payback period reflects the liquidity of investment projects. Nevertheless, firm may obtain high rate of return when it undertakes risky investments. The weaknesses of the method are: time value of money is not considered; cash flows beyond the payback are neglected. Therefore, the method doesn't give a satisfactory assessment of profitability – shorter time period projects are not always more profitable. PB method may be used, as an indicator for rank ordering, only in the cases where the projects have identical lifetime and the same cash flows – the shorter is payback period and the more profitable is project. Because the method ignores the time value of money, it seldom gives positive assessment to projects whose return is reached over a period of 12 – 15 years.

Net present value method (NPV) uses both conceptions – for the time value of money and for cash flows. Furthermore, the method considers the full life of projects. Rank ordering of alternative investments is meaningful only if the initial investment and the lifetime of the projects are identical. Very serious problem in using this technique is determining the cost of capital. The cost of capital is not always constant over the life of project. Possible changes should be incorporated into the analysis. Another problem is that, stressing the profit maximization NPV disregards liquidity of the firm.

Some of the disadvantages of NPV are corrected by the relative present value (RPV) method, although the problem with the cost of capital still remains. RPV allows precise comparison among projects with different initial investments. The RPV method simply modifies NPV measuring the present value per lev of investment.

The Hoskold method uses two interest rates – a speculative one of investment in mining activity and a safe rate of investment in sinking funds. Presumption in the method is that the profits obtained will be invested in sinking funds. Nevertheless, sinking funds are not attractive in modern financial management. Using of sinking funds reduces the amounts invested in mining activity and thus reduces the overall profitability. Speculative rate can't increase to compensate the negative effect of the safe rate over the profit. According to the managerial theory the statement that the higher rate compensate the higher risky operations is not correct. Risk probability is measured by other techniques, not by different interest rates.

The internal rate of return (IRR) method has three main advantages: it shows the real rate of return of capital investment; it gives a meaningful measure of the profitability of projects; it depends to a lower degree on the cost of capital.

Table 3. Accounting profit and net cash flow of coal strip mine (thousands of levs)

	(15)) Net profit after taxes	3,352
Add	(8) Depreciation	3,358
Add	(10) Depletion	2,976
(15) + (8) + (10)	= (16) Balance 2	9,686
Less	(17) Capitalized investment	744
Add	(18) Other cash adjustments	3
(16) - (17) + (18)	= (16) Net cash flow	8,945

The main disadvantage of the method is the implicit assumption that all the cash flows are reinvested in opportunities that yield the same rate of return. This assumption is valid only under certain conditions. Ordinary, the rate of return of investment is highly variable. Therefore, NPV gives almost always more precise assessment of rank-ordering then IRR. Another problem is that for noncon-ventional projects the method gives more then one decision.

Although, more of the financial experts recommend the NPV and the RPV methods, the statistics data shows that the managers prefer the IRR method (D. Salvatore, p.606). About 54 percents of the firms used the IRR method as a primary method for assessment of investment projects. The managers of 23 percent of the firms have preferences to the method ARR, and only 9.8 percent to the NPV method. The methods that ignore the concepts of the time value of money and cash flow – the accounting rate of return method and the payback period method, are applied mainly as secondary methods.

DECISION TREE OF INVESTMENT IN MINING INDUSTRY

A positive assessment of the profitability of investment project is not always enough for its acceptance. Starting of the projects in mining industry as well as the risk projects in other industries lead to sequence of situations in which must be chosen among several alternative decisions. The manager must also consider these situations to make the final investment decision.

There is an economic model describing this kind of subsequent managerial decisions. Since the sequence of decisions and events are represented graphically as the branches of a tree, this model has been named "decision tree".

Figure 1 shows a decision tree for development of oil field (T. Wonnacott, R. Wonnacott, p.763). The point from which the branches emanate is called a node. Boxes are used to show decision nodes – the points at which the manager subjectively chooses the next branch, while the circles show chance nodes – the points where the outcome is determined through probability distribution. While the construction of the tree starts at the left and moves to the right, the analysis begins at the right and works backward to the left. The first problem for the company is whether or not to buy field. If the decision is to buy, the next dilemma is – drilling immediately on the basis of available geological information or additional seismic surveys. If the decision is drilling, there are three possible outcomes – gusher, wet field and dry hole. The assessments of the first two outcomes are the net present values of investment projects. The assessment of the outcome "dry hole" is a negative – the drilling costs. Dry hole drilling has two alternative decisions –stopping of activity and second drilling. Seismic surveys must prove availability of reserves. The alternative decisions here are again stopping of activity and second drilling. In this case of "stopping of activity the assessment of outcome are costs for seismic surveys. When the economic conditions are changed the decision tree must be adjusted.

UNCERTAINTY AND RISK

In section 5 were discussed some appraisal methods of economic feasibility of investment projects, assuming full certainty of economic environment. Under such conditions the manager determine the most likely values of the variables, necessary for IRR method or some other techniques for evaluation, to obtain the solution of economic analysis. In many situations, however, the manager makes assessments with some uncertainty.

Many economists use the term risk to define uncertain situation that can be described with probability distribution. Uncertainty then is a situation for which probability distribution can't be constructed. In recent years this concept was changed. Risk is accepted as a consequence of possible uncertain outcomes. For example, the outcome of investment decision is not certain, so there is a risk of losses. The magnitude of uncertainty in mining projects is larger than in most other industries. On the basis of restricted geology information several important decisions must be made – about the method for development of deposit, the production

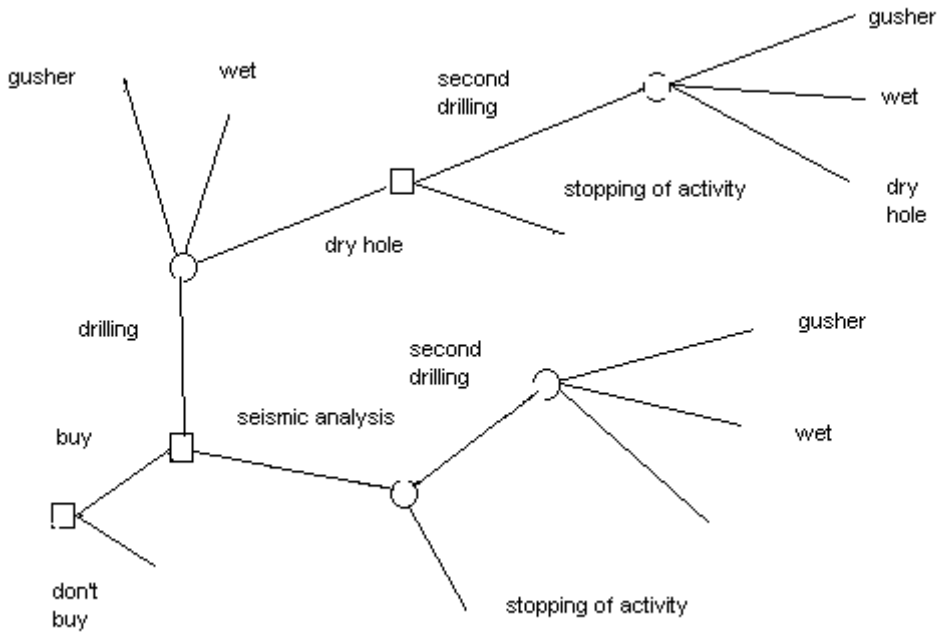

fig.1 Decision tree

capacity and the processing plant. Uncertainty can arise in the estimation of reserves, in the assessment of demand and prices or as a result of government policy. The combined effect of all these sources of uncertainty has a significant impact over the cash flows and the rate of return. The cumulative effect may be large even when the different types of uncertainty have a low probability of occurrence. The measurement of the uncertainty and risk, therefore, is very important for making real assessment of the profitability of investment.

The most used method for measurement the uncertainty and risk is the expert (or subjective) assigning the probability distribution to the variations in the value of the variables. The managers of ore mine may decide that the uncertain variables are only two – operating costs and the price of ore (O. Rudawsky, p.81). The probability distribution of both variables must be assigned by the experts, who have the best information – in our case the chief engineer for operating costs and the director of marketing for the variations in the ore price. Standard deviation, computed on the basis of probability distribution, is an absolute measure of risk. An example for the probability distributions of the price and operating costs of extraction is presented in table 4. The best aspect of this method – the expert assessment - may lead, however, to incorrect results. The people are inclined to compromises in their own favor. The mining engineer will overestimate production efficiency, while the marketing director will favor higher prices. As a result operating costs will be lower and the price and profit will be larger. To solve this problem mining companies often engage outside consultants. Many managers prefer also the methods for simulating probability distributions.

CONCLUSIONS

Summing up the discussion so far two main conclusions may be made: 1.) There is not a common acceptable rate of return of the investment projects in mining industry; and 2.) There is not a precise method of evaluation of these projects. Suppose the manager must choose between several alternative projects. He (or she) computed IRR and probability distribution with expected value and standard deviation for each of these projects. Are the results he has estimated acceptable for all managers and investors and under all circumstances? Does the project that is attractive for one firm is attractive for another? What is the required rate of return – 20, 15, 10 percent? Definite answers of all these questions, obviously, can't be given. In the past consulting firms tried to impose standards in the mining industry, announcing that the expected rate of return must be at least 32 percent. There are many mining and energy firms, however, which are satisfied from yielding half of that rate projects.

In principle the preferences of the company depend on the profit, productivity, objectives, as well as the capital and the skill of the human resource. Under conditions of changing economic environment the preferences may vary. It is especially the case when the profitability is connected to high level of uncertainty. It is not uncommon then that a deposit, rejected by one firm, is successfully developed by another firm.

The rate of return is not the only criterion for investment appraisal, although for more of the managers it is a main factor. Preferences of the company for example depend on the intuition and personal judgment of the manager. Practically, these factors are not considered, because they are not quantifiable.

What is the best method of investment appraisal in mining industry? There is just no such a method. Although new techniques of investment appraisal including the conceptions of cash flows and time value of money are more precise then the traditional, they are not perfect. Their efficiency depends to high degree on the objectives of the analysis. Furthermore, a full investment picture can be constructed only with additional analysis of uncertainty and risk. Good managers

Table 4 Subjective probability distributions of the price and operating costs (levs)

Price (P_i)	Probability (p_i)	Operating costs (C_i)	Probability (p_i)
9,00	0,04	6,00	0,05
10,00	0,07	7,00	0,15
11,00	0,12	8,00	0,22
12,00	0,16	9,00	0,27
13,00	0,20	10,00	0,16
14,00	0,15	11,00	0,10
15,00	0,11	12,00	0,05
16,00	0,09		
17,00	0,06		
Expected value			
$\hat{P} = 13{,}11$		$\hat{C} = 8{,}84$	
Risk			
$\sigma_P = 2{,}05$		$\sigma_C = 1{,}49$	

use always two different appraisal methods (IRR and PB for instance). If the results obtained from both methods are similar the manager's conclusions are reinforced. If the results are contradictable, manager must solve contradiction, using other appraisal methods.

REFERENCES

Hamid Beladi and Habib Zuberi, "Environmental constraints and a dynamic model for energy development", Energy economics, January 1988, pp. 18-28.

Milton Weinstein and Richard Leckhouser, "Optimal consumption of depletable nature resources", Quarterly Journal of Economics, August 1975, pp. 371-392.

Lewis Cecile Gray, "Rent under the assumption of exhaustibility", Quarterly Journal of Economics, Vol. 28, May, 1914, pp.466-489.

Harold Hotelling, "The economics of exhaustible resources", Journal of Political Economy, vol. 39, April, 1931, pp. 137-175.

Walter Nicholson, Microeconomic theory- basic principles and extensions, The Dryden Press, Orlando, 1992

Oded Rudawsky, Mineral economics - development and management of natural resources, ELSEVIER, 1986 .

Dominik Solvasore, Managerial economics, New York, Harpet Colors, 1991.

Thomas Wonnacott,, Ronald Wonnacott, Introductory statistics for business and economics. Singapore, 1990.

Ю.Радев, "Пазарна оценка на екологичните изисквания към добива и преработката ни минерални суровини", Международна конференция по опазване и възстановяване на околната среда при проучването, добива на полезни изкопаеми и металургичното производство, Научни доклади, 1999.

Ю.Радев, "Концепция за дефицитните разходи и ролята им на пазара на минерални суровини", Минно дело и геология, 1-2, 1999.

Ю.Радев, Моделиране на ефективното разпределение на минерални суровини (с пример за условията на комплекс "Марица-изток") - дисертационен труд, Архив на УНСС, 1996.