The limitations of gold-mine evaluation

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SYNOPSIS

Inherent uncertainty in the choice of parameter values places theoretical and practical limitations on the interpretation of a gold-mine valuation that are not necessarily removed by comparison of two valuations on the same assumptions. These limitations arise mainly in the estimates made of cost inflation and gold-price escalation, and lead to inconsistencies in the 'league table' method of investment analysis. The choice of discount rate is also critical in many cases. An approach to the overall problem that takes these limitations into account is suggested.

SAMEVATTING

Inherente onsekerheid wat betref die keuse van parameterwaardes plaas teoretiese en praktiese beperkings op die vertolking van 'n goudmynevaluering wat nie noodwendig uit die weg geruim word deur 'n vergelyking van twee evaluerings wat met dieselfde aannames gemaak is nie. Hierdie beperkings kom hoofsaaklik voor in die ramings van koste-inflasie en goudpryseskalasie en lei tot strydighede in die rangordemetode van beleggingsontleding. Die keuse van die diskontokoers is in baie gevalle ook van kritieke belang. Daar word 'n benadering van die probleem, as geheel aan die hand gedoen wat met hierdie beperkings rekening hou.

INTRODUCTION

The process of discounting future cash flows generated by a gold-mining company remains the only logical approach to valuation. However, it is characterized by essentially subjective assumptions, guesses, and sheer uncertainty — never more so than in the present climate of alternately soaring and plunging gold revenue and unprecedented cost inflation. The problems thus created are further compounded by uncertainty in the choice of discount rate in the light of fluctuating patterns of interest rates and yields on equity investment.

Even in less heady days, the uncertainty associated with valuations was clearly recognized. Discussing the definitive work by Luttrell-West[1] in 1947, Unger pointed out that refinements introduced by the taking of two rates of interest are of so little importance compared with the effects of the costs, grade, and price of gold that they are of practically no significance. MacWilliam noted the large number of variables that require estimation, and the very great degree of error that can be made by even the most experienced valuators. He felt that the main usefulness of a valuation to the investor is to give a comparison between the intrinsic merits of two or more different properties. Such an indication should be possible because all the properties are calculated on the same basis.

*Gold Fields of South Africa Limited, Johannesburg.

The perspective of the problem is therefore as follows. Valuations broadly serve three purposes. The first is aimed at testing the financial effect of a change of policy on an existing mine, which may involve mill expansion, dump reclamation, opening up of new areas, and similar decisions. The second seeks to define investment opportunities by way of share-market or other operations, and the third is an analysis of the feasibility of undertaking new projects. Now it is fair to assume that an investor interested in gold mining will have considered other avenues of investment. His preference for the gold-mining sector will be based on criteria quite independent of the specific valuation under consideration. This broad decision having been made, his problem becomes the *relative* one of which gold-mining policy to follow, which gold-mining investment to enter, or whether to place the money in a completely new venture rather than an established one. Paraphrasing MacWilliam, the question is which of two or more alternatives in gold mining is likely to offer the greatest investment gain under conditions of equivalent uncertainty.

This dismissal of the *absolute* features of the problem in no way diminishes the difficulties that must be faced by valuators and investment decision-makers alike. Some of these difficulties are detailed below, making use of a set of reasonably approximate mathematical expressions. Given the inherent uncertainty, these will be sufficient to quantify the limitations that need to be placed on the present value approach to mine valuation.

LIMITATIONS ON EXPENDITURE AND REVENUE ESTIMATES

Ignoring the effects of sundry revenues from byproducts or non-mining sources, which are generally small, we shall define the distributable profit of a tax-paying South African gold-mining company by the expression

$$D=(R-C-E)\ (1-t),$$

in which R denotes revenue, C operating cost, E capital expenditure, and t the effective combined tax and lease rate expressed as a decimal. For convenience, capital allowances, which are also fairly small, are neglected.

This expression is, of course, complicated by the dependence of t on the ratio P/R, where

$$\frac{P}{R}=\frac{R-C-E}{R}.$$

However, it is a simple matter to derive the incremental effects of changes in revenue and total expenditure on distributable profit, and this is illustrated for a particular mine in Fig. 1.

Since a high P/R ratio implies a low cost per unit of gold produced and *vice versa*, this graph indicates how the order of unit cost will affect the uncertainty of the valuation. For example, a low-cost (high P/R) mine is relatively insensitive to incremental changes in expenditure, and its value is therefore less dependent on the accuracy of cost estimation. On the other hand, high-cost

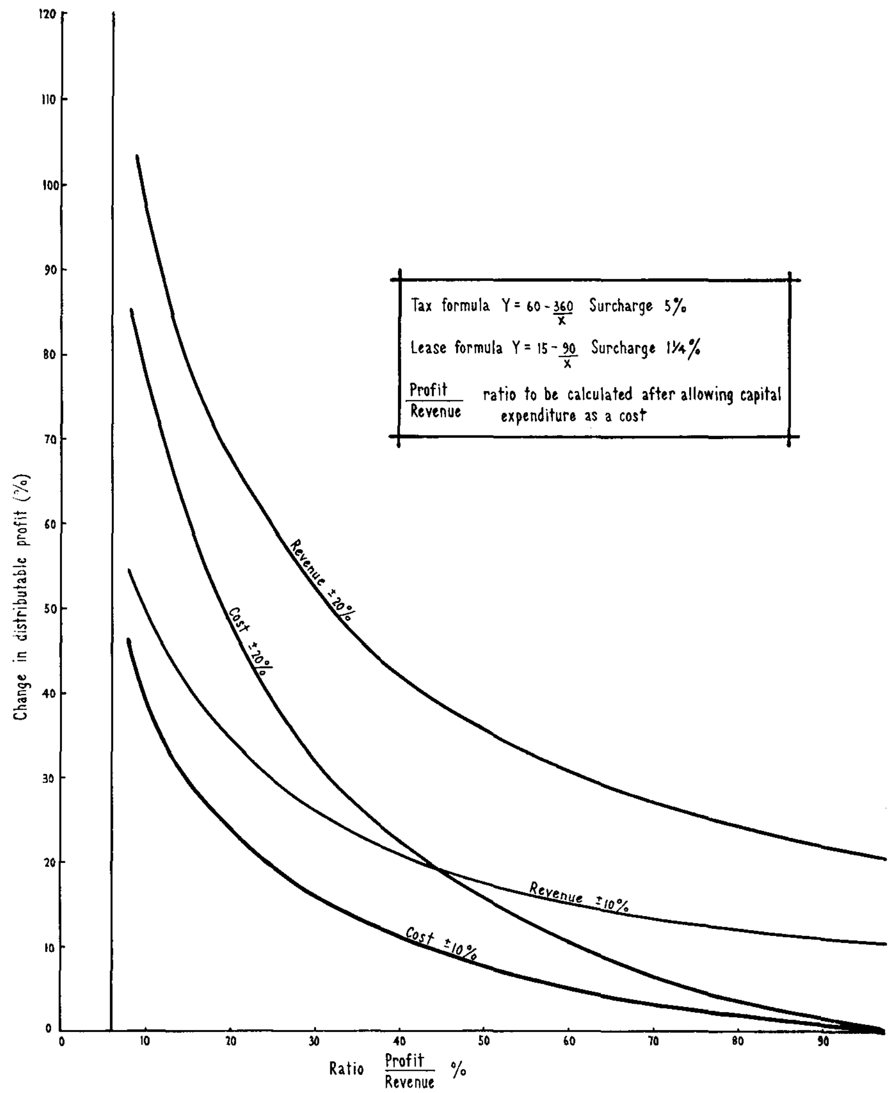

Fig. 1—Incremental changes in distributable profit for charges of 10 and 20 per cent in revenue and costs

mines react in a fairly spectacular way to changes in both revenue and cost. This feature becomes vital in cases where investment decisions are to be made between mines far removed on the P/R spectrum.

We proceed now to a more detailed consideration of uncertainties in the expenditure and revenue elements of the distributable-profit flows that contribute to the present value of a mining company.

Estimates of Capital and Operating Expenditure

The tax status of capital expenditure allows it to be treated as if it were merely a non-recurring operating expenditure. The process of scrutiny of capital estimates at various levels right up to board approval makes them fairly reliable in *present money* terms. Similarly, on the basis of the extensive statistical analyses of operating costs that are generally readily available, it is usually possible to arrive at adequate *present money* estimates of future operating expenditure.

The problems in the estimation of both cost and capital expenditure are therefore mainly related to the effects of using incorrect inflation parameters. If the valuator assumes a compound inflation rate h, the uninflated cost estimate C_n in year n is increased to

$$C_n' = C_n\,(1+h)^n.$$

The actual cost in year n is

$$C_n'' = C_n\,(1+i)^n,$$

where i is the actual compound cost-inflation rate. The fractional error is therefore

$$\frac{C_n' - C_n''}{C_n''} = \left(\frac{1+h}{1+i}\right)^n - 1.$$

The size of this error is illustrated in Table I as a percentage for the case in which h is assumed to be 10 per cent. Here, potential errors in the inflation assumption begin to dominate the expenditure estimate after some three years. The differing effects that this error will have on distributable cash flows for mines with different P/R ratios therefore places serious limitations on the 'league table' approach to investment analysis. In addition, if the consequence of a policy decision is a temporary change in the taxable proportion of a mine's profit, the error will not be eliminated in the comparison between the 'go' and 'no-go' valuations.

TABLE I

PERCENTAGE EFFECT ON COSTS OF AN INCORRECT INFLATION ASSUMPTION OF 10 PER CENT WHEN ACTUAL INFLATION IS i PER CENT

n Years	i (per cent)		
	8	13	15
2	3,7	5,2	8,5
3	5,7	7,8	12,5
4	7,6	10,2	16,3
5	9,6	12,6	19,9

Revenue and Profit

For a given tonnage of mill throughput, the accuracy of calculated revenue depends equally on that of the grade and gold-price estimates. Here the complications are daunting because grade itself depends *inter alia* on both the gold price and the operating costs that define the pay limit. In addition, in recent years there has been a widening gap between the pay limit based on an official view of the gold price and the cut-off grade to which companies are prepared to mine.

This last problem is ameliorated to some extent in the short term by the comparative lack of flexibility of operations on South African gold mines, and in the longer term by the nature of longwall mining, which limits selectivity of faces. We shall therefore assume that it is possible for a skilled valuator, given a pay limit, to arrive at a reasonably good estimate of grade, and shall consider the overall theoretical effects of price and cost estimates on the pay limit itself and on profits in future years.

The conventional approach to price and costs is to 'take a view' for the base year and then to escalate both at compound rates, which may or may not vary in the valuation during the course of the mine's life.

We assume for simplicity that there is no such variation and ignore the effects of incorrect inflation assumptions discussed above. The following symbols are used:

- p Base-year gold price per gram
- c Base-year operating costs per tonne milled
- h Assumed cost-inflation rate
- $h+d$ Assumed gold-price escalation rate
- i Actual cost-inflation rate
- y_j Recovery grade in year j
- P_j Operating profit per tonne milled in year j.

The mill pay limit in the base year is

$$L_o=\frac{c}{p},$$

and in year j is

$$L_j=\frac{c(1+h)^j}{p(1+h+d)^j}$$

$$=L_o\left(1-\frac{d}{1+h+d}\right)^j.$$

The profit in the base year is

$P_o=py_o-c$

and in year 1

$P_1=p(1+h+d)y_1-c\ (1+h)$.

Now, denote by e the rate of gold-price escalation required to balance *actual* cost inflation so that the *money value* of the profit remains unchanged. Then,

$P_1=p(1+e)y_1-c(1+i)$.

From the two expressions for P_1, the value of e can be obtained as

$$e=h+d+\frac{c}{py_1}\ (i-h).$$

We shall refer to e as the 'implied escalation rate'.

With the near-certainty that cost inflation will occur, i.e., that i will be non-zero and positive, the expressions for pay limit and implied escalation rate derived above enable an examination to be made of the way in which four different assumptions of price escalation/cost inflation influence the resulting valuations.

A. Escalation and inflation both zero

Heath *et al.*[2] termed this the constant money approach and considered it in some detail. Both h and d are zero. The pay limit remains constant, which is convenient for the valuator, and

$$e=\frac{c}{py_1}i=\frac{L_o}{y_1}i.$$

Since $L_o<y_1$ (otherwise the mine would be operating at a loss), the implied escalation rate is less than the cost-inflation rate that the mine will actually suffer.

Also, since c/y_1 is the cost per gram of gold recovered, the implied escalation rate will vary according to the position of the mine on the P/R spectrum. This means that relative valuations of different mines are in fact incompatible; it would therefore be invalid to use this method to compare an investment in, say ERPM, with one in West Driefontein, and a league table derived on this basis is misleading.

B. Positive cost inflation, zero price escalation

Since h is positive and $d=-h$, the pay limit increases at the rate of cost inflation. The implied escalation rate is

$$e=\frac{c}{py_1}(i-h)$$

and again depends, but to a lesser extent, on the P/R value. A 'realistically' chosen cost-inflation rate will improve the compatibility of different mines and reduce e to near zero for most companies. The problem for the decision-maker then becomes one of whether the assumptions and their implications make economic sense in the last quarter of the twentieth century.

C. Positive price escalation, zero cost inflation

The pay limit now decreases at a rate equivalent to $d/(1+d)$, i.e., slightly less than the assumed price-escalation rate. The implied escalation rate is

$$e=d+\frac{c}{py_1}i.$$

The effect of incompatibility between different mines is diminished if the assumed price-escalation rate d is chosen large enough.

D. Escalation and inflation both positive

This assumption has a similar effect to that of C above, except that the pay limit decreases at a slower rate, becoming constant if the assumed escalation and inflation rates are equal.

Summary

If a set of valuation assumptions leads to a variable pay limit, the derivation of recovery grades over an extended life becomes a particularly difficult and prolonged exercise. Given the inherent uncertainties of the whole procedure, there is no reason for imposing this task on a valuator. It is suggested, therefore, that no more than four sets of assumptions or 'cases' need be examined and that they should have the following characteristics:

- two different base-year gold prices
- two different non-zero cost-inflation rates
- gold-price-escalation rate equal to cost-inflation rate
- no termination of either price escalation or cost inflation at any stage in the valuation.

This procedure will result in four different 'current money' valuations. Heath[2] has noted that a present value calculated direct from the current, or inflated, cash flows will be a mixture of money values and therefore quite meaningless. He therefore recommended appropriate deflation of the cash flows before discounting them. This lends further emphasis to the need for avoiding the trap, inherent in constant-money valuation, of implying different price-escalation rates on different mines. No deflation is necessary here, but a comparison of present values for different mines is just as meaningless.

DISCOUNTING

Deflation and discounting are essentially the same mathematical process, and they can therefore be done simultaneously using a composite discount rate equivalent to the sum of the deflation rate and the required internal rate of return (plus a small correction, which, for our purposes, is immaterial).

Fig. 2, which is compiled for convenience on semi-log paper, is a plot of present value against discount rate for a number of gold-mining companies on the same gold-price and cost assumptions. A broadly similar set of curves would be obtained for one mine but using different price/cost combinations.

A characteristic of these curves is the variability of their slopes, and this has the effect that investment decisions become highly dependent on the discount rate chosen to calculate the present value of a proposition. The factors that determine slope are, firstly, the order of magnitude of the cash flows; secondly, the rate of their growth or decay; and, thirdly, the life of the mine, as is demonstrated in the Appendix. If a policy decision or a change in price/cost assumptions alters any of these factors, the result will be a tilt in the present-value curve and, potentially, an incorrect investment decision.

Cost of capital and the employment of risk premiums are considerations that must obviously be taken into account in the choice of discount rate. Merret and Sykes[3], among others, have studied this approach. A further guide is given by the stock market in the following way:

Using a given set of price and cost assumptions, life cash flows are prepared for a cross-section of quoted gold-mining companies, and present-value curves similar to those of Fig. 2 are plotted. The market price of each of the quoted shares then determines the

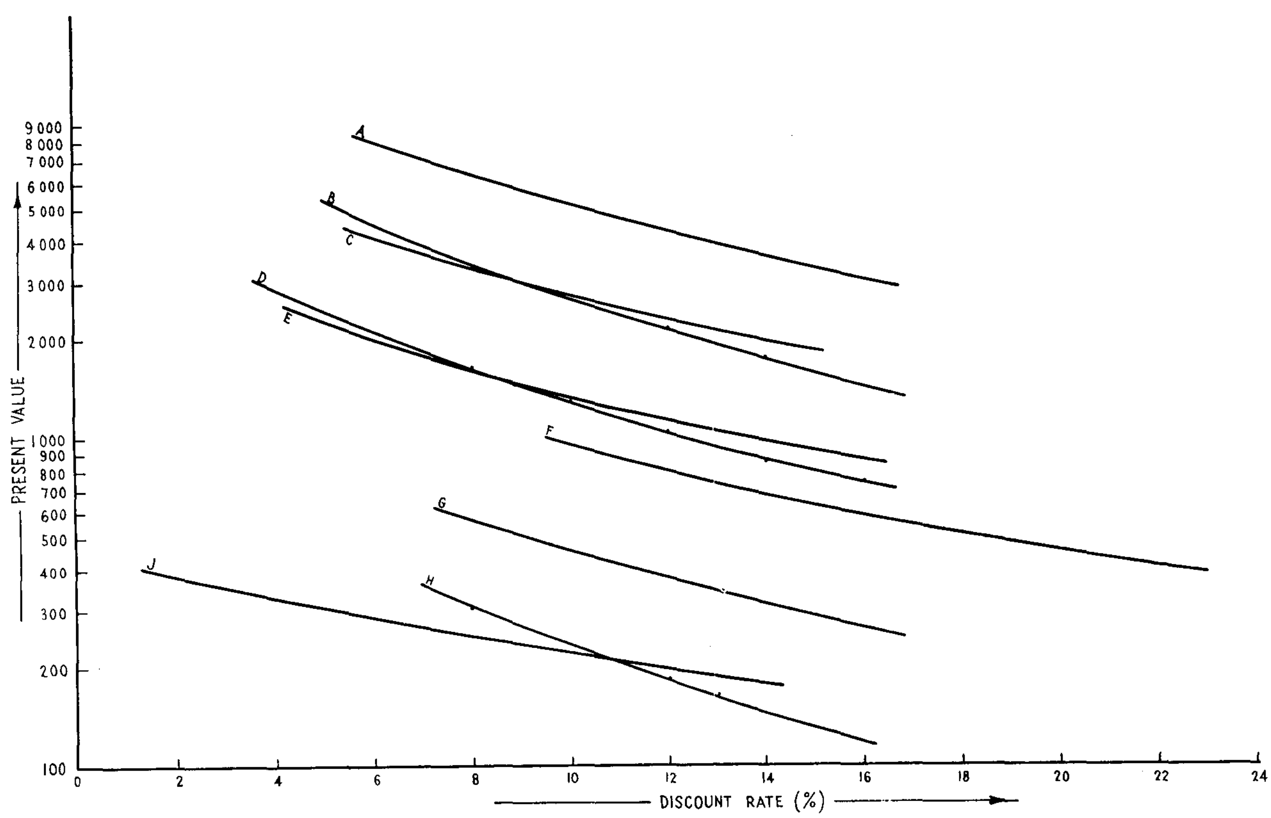

Fig. 2—Present-value curves for different mines on the same cost/price assumption

discount rate apparently being applied by the market to each share for that particular set of assumptions. This rate will differ from mine to mine because it is only natural that the body of mining analysts and investors that makes the market will differ from an individual valuator in the assessment of yield trends and mine lives. Despite this, it should be possible to select a discount rate by giving appropriate weight to those curves with slopes similar to that of the mine under investigation, and in this way to arrive at a rate compatible with the one that might be expected by the market.

CONCLUSIONS

The broad conclusions suggested by this essentially brief study of the present-value approach to gold-mine valuation are as follows:

1. Two decisions are necessary to enter a gold-mining investment. The first is whether or not the investor should be in mining at all. The second is which of several available investments in gold mining is likely to be most favourable. It is the second problem, and not the first, that is served by the valuation.
2. No valuation can be studied in isolation; it should be compared with valuations of alternative investment opportunities based on the same cost/price assumptions.
3. The theoretical and practical

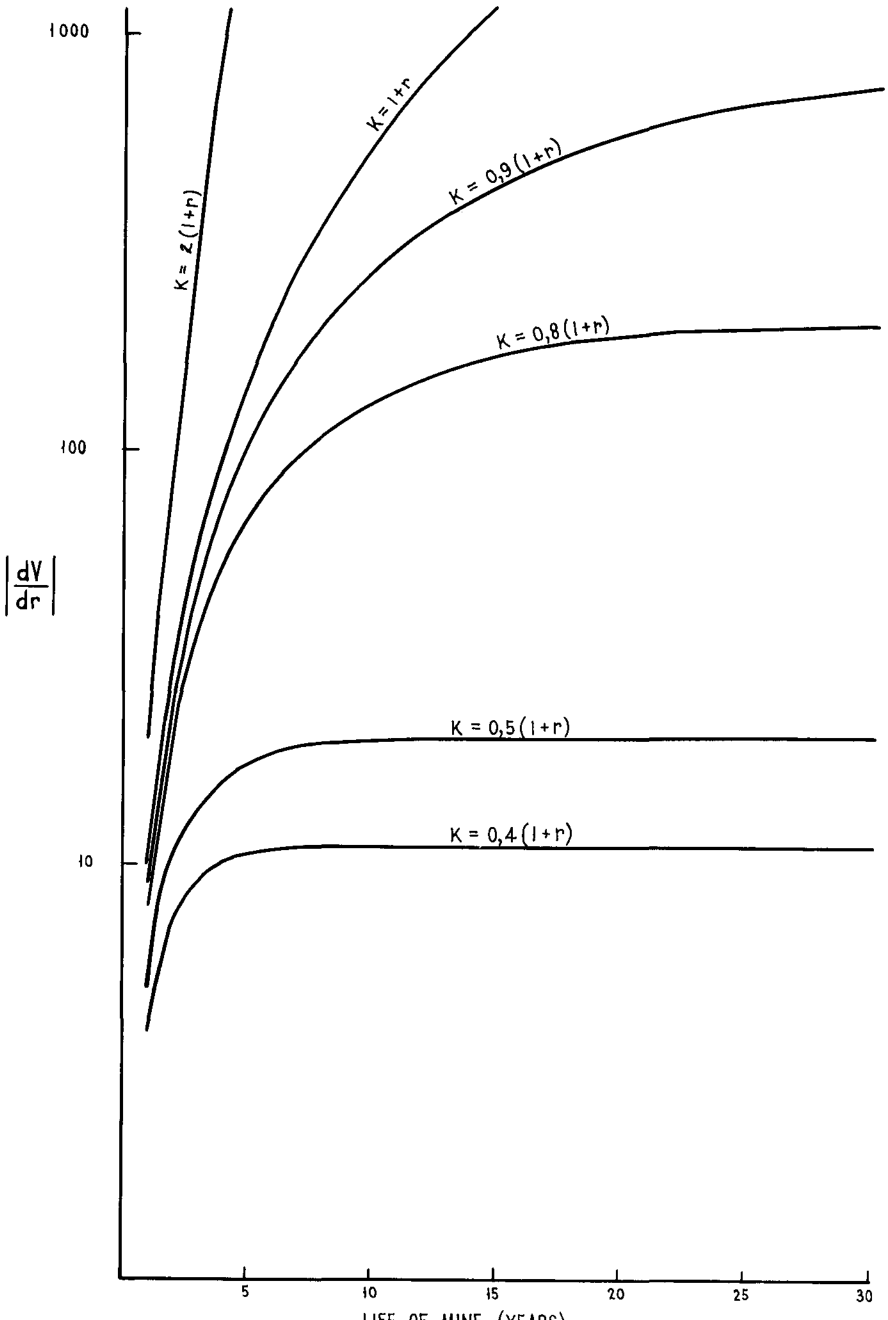

Fig. 3—Slope of the present-value curve

limitations on the evaluation of present values are not necessarily eliminated in the process of comparison. For this reason it is necessary to examine particular investment opportunities on the basis of several sets of cost/price assumptions.

4. Present-value curves should be constructed in every case in order to determine the sensitivity of the investment decision to the discount rate chosen.
5. A guide to the choice of discount rate is given by the consensus of opinion reflected in stock-market prices.
6. The investment decision is ultimately a subjective one, and no valuation can claim to be anything more than a temporary indication. Therefore, if any benefit at all is to be derived, it is incumbent upon the decision-maker to be aware of its limitations.

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2. HEATH, K. C. G., KALKOV, G. D., and INNS, G. S. Treatment of inflation in mine valuations. *Trans. Instn Min. Metall.*, Section A, Jan. 1974.
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APPENDIX

Present value is defined by

$$V=\sum_{i=0}^{n}\frac{A_i}{(1+r)^i},$$

where n is the life of the mine, r the discount rate, and A_i the annual cash flows. We shall examine cases in which the A_i reflect an increasing, constant, or decreasing trend. Ideally, these can be represented by

$A_i=Ak^i$,

in which k is a parameter defined as follows:

If $k<1$, A_i is decreasing

$k=1$, A_i is constant

$k>1$, A_i is increasing.

Present value now becomes

$$V = A\sum_{i=0}^{n}\left(\frac{k}{1+r}\right)^i.$$

The slope of the present-value curve is then

$$\frac{dV}{dr}=-A\sum_{i=1}^{n}\frac{ik^i}{(1+r)^{i+1}}$$

$$=-\frac{A}{1+r}\sum_{i=1}^{n}i\left(\frac{k}{1+r}\right)^i.$$

This power series converges if $\left|\frac{k}{1+r}\right|<1$.

In the practical situation the value of A determines the order of magnitude of the cash flows; the present-value curve of a rich mine is steeper than for a poorer mine, and this will be appreciated if Fig. 2 is redrawn to a natural scale. The critical elements determining slope are, however, k and n, and their effects are illustrated in Fig. 3, which was drawn for an arbitrary value of $\frac{A}{1+r}=10$.

Low values of k imply short-life mines, and higher values correspond to longer lives. With discounting reducing the importance of cash flows, after about ten years the vital factor becomes the length of time in the initial years of the valuation for which the increasing or decreasing trend is maintained. This can be affected to a major extent by policy decisions or by changes in cost/price assumptions.

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