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An "economic life" for property evaluation

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ON A STRICTLY ECONOMIC BASIS, management will not consider expanding production facilities and shortening project life until the incremental financial return from the last expansion increment equals the company's cost of capital. Incremental analysis problems of this type often involve negative cash flows and the Discounted Cash Flow (DCF) rate of return may then have several mathematical solutions that satisfy the capital and cash flow parameters. To avoid this problem, the Net Present Value (NPV) of the cash flows (discounted at the cost of capital) may be used and the expansion case selected where the NPV is maximized. The economic life (and production rate) with the highest NPV is the "optimum" life, because at this point the incremental DCF rate of return obtainable from the last expansion increment just equals the company's cost of capital. (The cost of capital as used herein means the weighted cost of internally and externally generated funds, including both the minimum acceptable return on equity and expected interest on debt, as applicable).

To obtain a relationship between economic life and profitability, four projects with varying cash flows ranging from low to high were considered. Their net present value at various lives were determined on the basis that capital varies directly with production rate to the 0.7 power and that unit operating costs remained constant. On this basis, it is shown that the "optimum life" is directly related to the profitability of the project. Projects with a DCF rate of return in the range of 13% (when evaluated at a 20-year life) should be justified at a 20-year life. Projects in the 16% DCF range (at 20 years) should be evaluated at a 20-year life and checked for a future expansion to a 15-year life. Projects in the 20% DCF range (at 20 years) should be evaluated at a 15-year life and checked for future expansions. Projects in the 25% range (at 20 years) should be evaluated with lives as short as 10 years.

The evaluation of a mineral property is more difficult than most economic evaluations because of the necessity of choosing an economic life for the evaluation. In most other evaluations the economic life is set by outside conditions, but in mineral property evaluations the economic life is one of the evaluation parameters. The choice of an economic life for a property is complex and involves several areas of corporate policy that often override the optimum life based on financial considerations alone. These policy considerations are beyond the scope of this article, and only the optimization of project life based on financial considerations will be discussed in the following analysis.

In determining the "optimum" economic life (and production rate) for a mineral property, the same business standards that are used for any capital investment can be used. When metal production and marketing considerations can be neglected, management will consider expanding a planned facility until the incremental financial returns from the last expansion increment just equals the company's cost of capital.[1,3] It is the cost of capital that must be used as a yardstick to measure the attractiveness of a project, because any investment that indicates a lower rate of return than the cost of capital will tend to lower the growth rate of earnings or dividend yield of stock.[2]

The purpose of this article is to provide project evaluators with an approximate guide to the "optimum" economic life in mineral property evaluations. It is assumed for simplification that the plant size and orebody tonnage based on a 20-year economic life have already been determined, and that the plant and mine production rate vary inversely with the life of the project. As the plant is checked for expansion to a shorter project life, the incremental rate of return for the expansion capital must be computed to determine if this increment of additional capital is giving a return of at least the corporation's cost of capital.

The first portion of this article will point out why it is more convenient to work with Net Present Value (NPV) values than the Discounted Cash Flow (DCF) rate of return when calculating the financial effect of reducing the life of a project. The remainder of the article will work out guidelines that should be of use when determining the "optimum" economic life of a mineral property.

Net present value: guide to economic life

When computing incremental cash flows generated by increasing plant capacity and reducing the project life, the higher earlier cash flows will be offset by negative cash flows at the end of the project's life making the sum of the incremental cash flows very close to zero. In cases such as this with large negative cash flows, the computed Discounted Cash Flow (DCF) rate of return becomes difficult to evaluate because in most cases several DCF rate of return figures will satisfy the capital and cash flow parameters.[4]

This article will not go more deeply into the "paradox" of the multiple DCF rate of return figures except to point out that the Net Present Value (NPV) of the *total* cash flows will give a clearer picture of the attractiveness of the investment than the incremental DCF rate of return. Table 1 illustrates that at the production rate where the NPV figure is maximized (discounting the cash flows at the cost of capital) the corporation is receiving at least their cost of capital for every increment of capital invested. As shown by the table, when the NPV drops off from its maximum point, the corporation is receiving less than their cost of capital on the final expansion increment.

It is seen from the table that Expansion No. 3 is the "optimum" expansion when using maximum NPV as the criterion. Expansion No. 4 gives an incremental rate of return less than the assumed cost of capital (15%), dropping the NPV from $1,478 to $1,383. Although perhaps oversimplified, Table 1 points out that the NPV of total cash flows can be used instead of the DCF incremental

Table 1: Net present value maximized where rate of return from last increment of capital equals the cost of capital

Cost of Capital = 15%
Economic Life = 15 Years

Plant Size	Total Capital	Annual Cash Flow	Total DCF	Incremental Analysis: Incremental Capital	Incremental Analysis: Incremental Annual Cash Flow	Incremental Analysis: Inc. DCF	Net Present Value @ 15%
Initial	2,000	$ 518.23	25.0	—	—	—	$1030
Expansion 1	3,000	732.11	23.5	1,000	213.88	20%	1281
Expansion 2	4,000	928.51	22.3	1,000	196.40	18%	1429
Expansion 3	5,000	1107.87	21.0	1,000	179.36	16%	1478
Expansion 4	6,000	1262.61	19.6	1,000	154.74	13%	1383

rate of return. This greatly simplifies the evaluation of projects with large negative cash flows and multiple DCF rate of return figures.

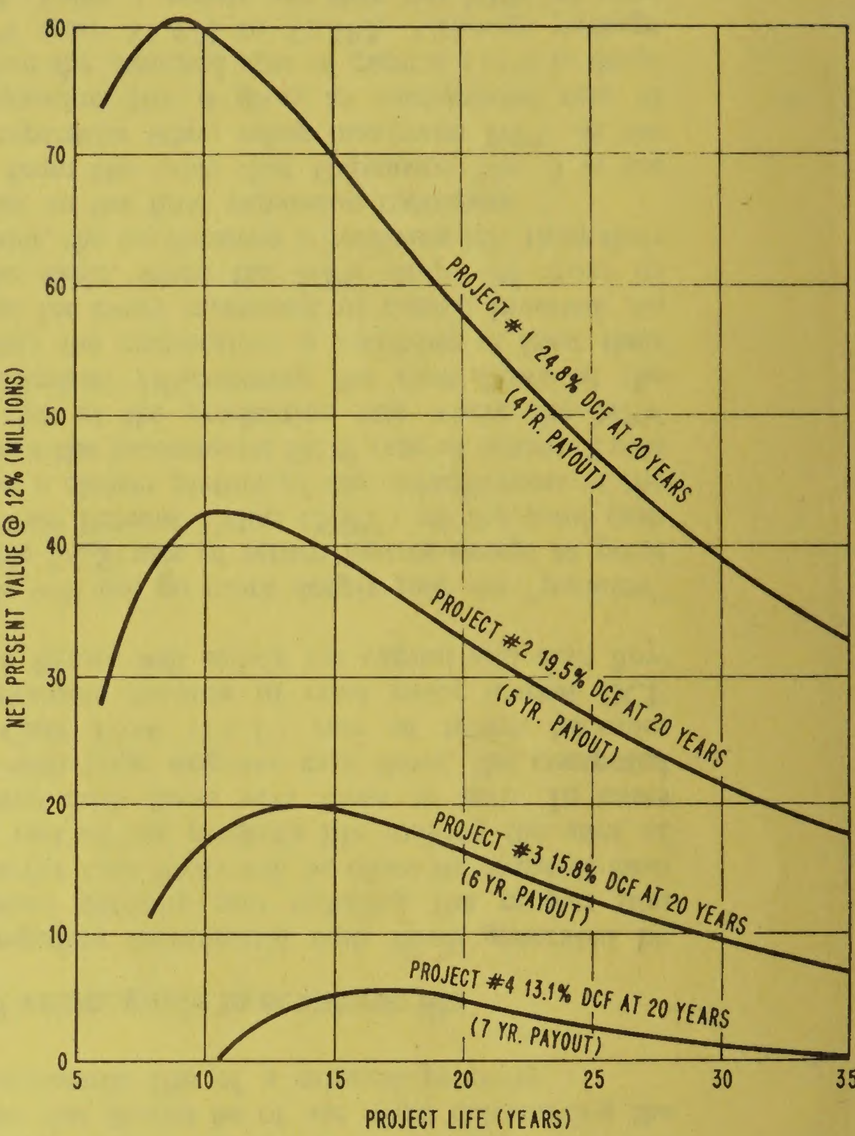
Selecting an "optimum" economic life

Based on the above discussion, an "optimum" economic life may be defined as the point where the NPV of the property is maximized. Using, say, 12% as a typical cost of capital, Table 2 was prepared to get a "feel" for the optimum economic life for four projects with increasing rates of return. Capital cost of the project[5] was assumed to vary directly with the production rate raised to the 0.7 power: Capital = k $(TPD)^{0.7}$. The constant (k) was evaluated from a base capital estimate of $25,000,000 for a 5,000-tpd facility. Cash flows at the 20-year "base" life were obtained by dividing the $66,010,000 capital by the payout years indicated for a specific project, and cash flows for other lives vary directly with the tpd plant capacity.

Fig. 1 is taken from Table 2 and plots Net Present Value @ 12% for each project vs project life. Assuming the above capital cost formula to be realistic and that unit operating costs remain constant, analysis of the curves shows that there is an advantage to reduce the life of all projects to at least a 20-year life; the advantage increasing with the DCF rate of return. Projects with a DCF rate of return in the 16% range (when evaluated at a 20-year life) should be justified at a 20-year life and checked for a future expansion after operating costs have been determined. Projects in the range of 20% DCF rate of return (at 20 years) should be evaluated at a 15-year life and checked for future expansions. Projects in the 25% DCF rate of return range (at 20 years) should be evaluated with lives as short as 10 years.

It must be emphasized that Fig. 1 has a practical value only as a general guide to the economic life giving the maximum Net Present Value to the property. The total DCF rate of return should be computed as a means of comparing any project with other projects within the company.[1] The comparison of DCF rates of return between alternative projects, together with metal marketing considerations and the community relations aspect of project life may well impose a project life that is much longer than the "optimum" life indicated by Fig. 1.

Fig. 1. Net present value @ 12% vs project life



References

1. Halls, J. L., Bellum, D. P. & Lewis, C. K.: "The Determination of Optimum Ore Reserves and Plant Size by Incremental Financial Analysis," Annual AIME Meeting (February 1969).
2. Hunt, Williams & Donaldson: "Basic Business Finance," Richard D. Irwin, Inc., Homewood, Illinois (1966).
3. Grant, Ireson: "Principles of Engineering Economy," Ronald Press Co., New York (1964).
4. Kirshenbaum: "A Resolution of the Multiple Rate of Return Paradox," Engineering Economist, Volume 10, Number 1 (Fall 1964).
5. Lang, H. J.: "Simplified Approach to Preliminary Cost Estimates," McGraw-Hill Book Company, New York (1960).

Table 2: "Optimum" economic life of four projects

("Optimum" Life is Defined at Maximum NPV)

Life	TPD Capacity	$ Capital (1)	Present Value Factor @ 12%	Project #1 (4 yr Payout at 20 yr Life) Yearly Cash Flow	Project #1 Net P. V. @ 12%	Project #2 (5 yr Payout at 20 yr Life) Yearly Cash Flow	Project #2 Net P. V. @ 12%	Project #3 (6 yr Payout at 20 yr Life) Yearly Cash Flow	Project #3 Net P. V. @ 12%	Project #4 (7 yr Payout at 20 yr Life) Yearly Cash Flow	Project #4 Net P. V. @ 12%
35 Yrs.	11,430	44,619,000	8.1755	9,431,000	32,484,000	7,545,000	17,065,000	6,287,000	6,780,000	5,389,000	—
30 Yrs.	13,330	49,690,000	8.0552	10,999,000	38,909,000	8,799,000	21,188,000	7,333,000	9,379,000	6,285,000	937,000
25 Yrs.	16,000	56,464,000	7.8431	13,202,000	47,081,000	10,562,000	26,375,000	8,801,000	12,563,000	7,544,000	2,704,000
20 Yrs.	20,000	66,010,000	7.4694	16,503,000(2)	57,258,000	13,202,000(2)	32,601,000	11,002,000(2)	16,168,000	9,430,000(2)	4,426,000
16 Yrs.	25,000	77,169,000	6.9740	20,629,000	66,698,000	16,503,000	37,923,000	13,752,000	18,737,000	11,788,000	**5,041,000**
14 Yrs.	28,570	84,727,000	6.6282	23,575,000	71,533,000	18,859,000	40,274,000	15,716,000	**19,442,000**	13,471,000	4,561,000
12 Yrs.	33,330	94,378,000	6.1944	27,502,000	75,980,000	22,001,000	41,905,000	18,334,000	19,190,000	15,715,000	2,967,000
10 Yrs.	40,000	107,233,000	5.6502	33,006,000	79,258,000	26,404,000	**41,955,000**	22,003,000	17,088,000	18,860,000	—
8 Yrs.	50,000	125,362,000	4.9676	41,258,000	**79,591,000**	33,005,000	38,594,000	27,504,000	11,267,000	23,575,000	—
6 Yrs.	66,670	153,334,000	4.1114	55,013,000	72,846,000	44,009,000	27,605,000	36,674,000	—	31,435,000	—

Note 1: Capital is assumed to vary directly with production rate raised to the 0.7 power. $ Capital = k $(TPD)^{0.7}$. The constant k was evaluated from a base capital estimate of $25,000,000 for a 5,000 TPD facility.

Note 2: Cash flows at the 20 year "base" life were obtained by dividing the $66,010,000 capital by the payout years indicated for the project.