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BREAKEVEN DISCOUNTED CASH FLOW APPLIED TO EQUIPMENT STANDARD COSTS

by

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ABSTRACT

This thesis presents a new approach to the evaluation of equipment standard costs or rental rates by utilizing breakeven discounted cash flow concepts. Specifically, the development of rental rates and their sensitivity to variations in production schedules and forms of financing are presented for both escalated and constant dollars to illustrate the proper handling of any kind of cost incurred over the asset life. In addition, the proper handling of cost distributions resulting in the calculation of dual breakeven rates of return and the meaning of the results are also presented. Utilization of these calculations in replacement analyses where production per period varies over the estimated life is illustrated and discussed.

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CHAPTER 1

INTRODUCTION

The heavy construction industry is undergoing a transition. In the past the job market for heavy equipment has been dominated by public-financed projects such as interstate highways and water storage facilities. Restrictions in federal and state budgets, combined with the near completion of the federal interstate highway system, have forced the industry to evaluate the market for private projects such as site development for new mining ventures and contract mining. Because private projects are often bid and funded differently from public projects, the economic and financial strategy of construction firms must reflect the economic philosophies of these new sources so as to maintain a competitive bidding posture. For this reason, and for sound equipment management policy, the construction and mining industries could benefit from further use of discounted cash flow concepts as they apply to equipment costing and replacement analysis.

The objective of this study is to illustrate, by example, a method for determining the breakeven, before-tax revenue required to provide the equipment owner with a specified return on investment, and to utilize these calculations in replacement analysis. This method recognizes the time value of money and all tax considerations related to the acquisition of equipment. While these calculations are not new in terms of investment evaluation criteria, their proper application to equipment standard costing has not been published. In addition, these same calculations may be utilized in replacement analysis and can provide managers with a useful tool in accounting for the problem of variation in the productive capacities of equipment.

Equipment management policies require an accurate estimate of the costs associated with owning and operating equipment. Policies such as determination of rental rates and replacement decisions represent the long-term position of a firm and are only as accurate as the data utilized in making the decision. A variety of methods have been advocated to determine equipment standard costs. Standardization of these methods has been a controversial subject because of differences over the determination of allowable costs used to calculate a rental rate. Many times analyses are presented in a form utilizing average costs to satisfy a wide variety of owner objectives including methods of accounting, financing, job billing, and job costing requirements. While such methods may represent reasonable approximations to standard costs, they may not accurately reflect the tax, financial, contractual, and operations posture unique to the individual firm. As a result, the competitive cost position of the firm may be over- or understated.

Because variations do exist from firm to firm and across industries, no single method to determine equipment standard costs will present all of the appropriate cost parameters necessary to satisfy all equipment owners. The breakeven approach to determining standard costs as presented in this thesis is flexible enough to apply to any configuration of cost parameters. As an example of format variations, some firms prefer to handle costs in constant dollars rather than in escalated dollars. It is important to recognize that the results will always remain the same if the calculations are handled properly. Variations in tax law from state to state may have a considerable impact on the decision to purchase or lease an asset. The ability to utilize equipment over time will also impact the standard costs of acquisitions. Sound management policy necessitates a method of calculating breakeven revenues adaptable to a variety of costs and assumptions deemed appropriate by management.

As stated above, the objective of this study is to develop a method of calculating the standard costs associated with owning and operating equipment utilizing breakeven discounted cash flow concepts. This objective implies considerable understanding of the methods presently advocated by various authors and the meaning of terms such as "breakeven discounted cash flow concepts." The literature review in Chapter 2 points to the need for a clearer definition of the calculations to be made in determining standard costs and of the role these costs play as a tool in a comprehensive equipment policy. Chapter 3 presents the development of breakeven discounted cash flow calculations. The meaning and sensitivity of various input parameters is discussed to ensure a clear understanding of the calculations being made and the meaning of the results. Further, the significance of these calculations in replacement analysis is presented. Chapter 4 presents the application of this process by example to illustrate how this concept may be applied to various cost parameters in the development of standard costs and replacement analysis. Chapter 5 summarizes findings and provides suggestions for further research.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews literature related to equipment policy and the methods utilized to handle expected future equipment revenue, expenditures, and production schedules in the determination of equipment rental rates and replacement analysis. The three sections review equipment policies, equipment rental rates and replacement analysis. Equipment policy is discussed to provide an understanding of how determination of equipment rental rates and replacement analysis fit into the overall equipment management process.

2.1 Equipment Policies

Equipment policy is largely a function of the size of the equipment fleet, the projects to be served, and the ability of the firm to accumulate and assimilate pertinent information. A comprehensive equipment policy should cover all elements related to the ownership and operation of equipment. Listed below are seventeen items which should be considered in any equipment policy (Douglas, 1975).

1. Economic life of various machines
2. Timing of machine replacement

3. Standardization of equipment
4. Degree of maintenance
5. Renting or leasing versus owning
6. Contract maintenance
7. Selection of equipment
8. Organization for administering equipment
9. Equipment analysis for cost and production
10. Cost and operating records
11. Inventory management
12. Storage and security
13. Safety
14. Spare-parts support and stock levels
15. Air pollution, noise abatement and creation of attractive nuisances
16. Public relations and sales psychology
17. Tax effects

Although all seventeen items are important, the discussion here will be directed towards items 2, timing of machine replacement; 9, equipment analysis for cost and production; and 17, tax effects. The objective of this study as stated in Chapter 1 is to utilize time value of money concepts to account for financial, tax, and technological considerations in deriving rental rates, and then apply the rental rates to make appropriate replacement analysis decisions.

2.2 Equipment Rental Rates

Throughout this thesis the terms "rental rates," "use rates," "standard costs," and "life cycle costing," as applied to equipment will be considered synonymous. The rental rates to be developed using discounted cash flow concepts are applicable for equipment dealers, owners, or any individual or agency responsible for establishing or publishing equipment rental rates, and may or may not include a margin for profit or return on investment. The composition and meaning of rental rates presently utilized, along with the method to be proposed in this study, will comprise the discussion for the balance of this chapter and Chapter 3.

Contractors, equipment companies, government agencies and contractor management committees all have an idea of what rental rates for equipment should include, and with the exception of contractors, most have published their findings. Factors in rental rate variations include the geographical region equipment will operate in, regulations concerning allowable cost items, shipping costs, and differences in interest rates. Rates are developed and prescribed for use in force account work (incremental work added to an existing contract), estimating, or standard equipment costing. It is important for the equipment owner to understand the application for which the rental rate is designed. In this study the proposed rental rate may be constructed for use in any application in accordance with contract provisions and the law. For most government-funded projects, standard rates are provided for force account work but they may be negotiable. It is important for the equipment owner to calculate his costs as accurately as possible to assure that a reasonable rate is procured. As an example of the variations that do exist, a contractor may consider indirect expenditures for insurance, licenses, ownership taxes, permits, and storage as costs related to owning a specific piece of equipment, and to include such expenditures in the ownership portion of the total rate. The Army Corps of Engineers (1981), consider such expenditures as indirect and not allowable in the rental rate, and therefore, must be reimbursed by other accounting methods. In addition, rates developed by Dataquest (1982), in cooperation with the Associated General Contractors of America (AGC), include indirects such as those mentioned above, along with other items such as costs of mechanic supervision and the cost of facilities capital. Cost of facilities capital (CFC) is an allowable cost item under the Army Corp of Engineers as a form of interest expense. CFC is defined in Department of the Army Regulations 15-205.50 and CAS 414.

Variability in rental rate structure has made it difficult to standardize a procedure to calculate rates that are acceptable to all concerned. Because of variations in utilization, financing, taxation, etc., standardized methods will not provide a precise estimate for an asset over its useful life. However, management must have an approximation to make estimates and equipment policy decisions. Six presently applied methods will be reviewed with a brief discussion of how rental rates are utilized. Depending on the application of the rental rates, it is generally implied that equipment rental rates are estimates subject to conditions of the individual firm. This list is not inclusive, but is representative of the variations that exist.

U.S. Army Corps of Engineers. The ownership portion of the rate consists of allowances for depreciation and cost of facilities capital. Depreciation is based on the list price and includes sales tax and freight less 1) the estimated salvage, 2) a 7.5 percent discount off the list price for most equipment, and 3) the cost of tires, if applicable. Depreciation as used here, and in most published rental rates, is compensation for the decline in asset value due to age, obscolescence, and use, and has no relation to its use in taxation. The cost of facilities capital is also included in the ownership portion and is determined by multiplying the cost of money rate as determined by the Secretary of the Treasury pursuant to P.L. 92-41 (85 Stat. 97) by the average value of the equipment. Operating costs include allowances for fuel, filters, oil and grease, servicing the equipment, repair, maintenance, and tire wear and repair if applicable. The total rate is then adjusted to account for average, difficult, or severe terrain. This method does not utilize time value of money which implies a discount rate of zero percent. Rates are published by the Corps for "use in preparation of estimates and in pricing negotiated procurements requiring independent Government estimates" (U.S. Army Corps of Engineers, 1981).

Caterpillar Tractor Co. The ownership portion of the rate consists of allowances for the delivered price plus shipping, less tires, and any residual value at replacement. Interest, insurance, and property taxes are also included in the rate. Caterpillar suggests that

> when used equipment auction prices are used to estimate residual value, the effect of inflation during the ownership period should be removed to show in constant value what part of the asset must be recovered through work.

In general, it is undesirable to mix escalated and constant dollars in any kind of evaluation. Discussion of the proper handling of escalated and constant dollars will be taken up in Chapter 3 and illustrated in Chapter 4. Operating costs include all parts and direct labor (except for operators wages), that may be charged to the machine. Fuel, oil, filters, grease, tires, special wear items or ground engaging tools, and undercarriage, if applicable, are included. This method does not utilize time value of money which implies a discount rate of zero percent. These rates are for the general equipment costing needs of the equipment owner (Caterpillar Tractor Co., 1981).

Dataquest, (AGC). The ownership portion of the rate consists of allowances for depreciation based on list prices, plus freight, less discounts, salvage, and tires, if applicable. Indirect costs included in the ownership portion are the cost of facilities capital, storage and security costs, normal risk insurance, state and local sales and use taxes, license fees, inspection fees, and mechanics supervison costs. Operating costs include labor, parts, tire replacement and repair, undercarriage, fuel, and lubricants. These rates neglect time value of money considerations and are provided to assist contractors in establishing equipment use rates (Dataquest, 1982).

Associated General Contractors of America, (AGC). Total annual ownership expenses include depreciation, replacement cost escalation, interest on investment and taxes, insurance, and storage, expressed as a percentage of the acquisition cost. The average hourly repair and maintenance expense is generally composed of four other factors:

1. Repair and Maintenance Expenses: Includes charges for field repairs, shop repairs, overhauls, replacement tires and tracks, other major component parts, and this same work performed by agencies outside the contractor's organization

2. Operating Expenses: Includes the charges for fuel, oil, grease, other expendable parts and supplies, and service labor and equipment

3. Operating Labor Expenses: Includes the charges for the labor necessary to operate the equipment

4. Mobilization and Demobilization Expenses: Included as they relate to specific project assignments

The AGC chose to include only item number 1 in this publication. As with most methods, time value of money has been neglected, implying a discount rate equal to zero. These rates were developed for use by contractors as a compilation of data to be utilized as a guide in establishing contractors costs (Associated General Contractors of America, 1974).

WABCO. The ownership portion of the rate is composed of an allowance for depreciation based on the delivered price less the cost of tires. This figure is divided by the expected cumulative life in hours. Interest, insurance, and property taxes are taken together and expressed as a percentage of the annual average investment where average annual investment is determined by the following equation,

$$[(N+1)/(2*N)] * (\text{Delivered Price})$$

where "N" is the years of depreciation schedule. This value is divided by the annual hourly depreciation schedule (Cumulative Hours/N). Fuel, lubrication costs, maintenance and repair costs, and tires are included and are based on estimated hourly consumption or wear rates. Maintenance and repair are expressed as a constant times the hourly rate of fuel consumption. Again, time value of money has not been considered. These methods are provided for estimating only and should be adjusted for local conditions (WABCO, Construction & Mining Equipment Division).

Colorado State Department of Highways. The State of Colorado publishes a rental schedule, the application and intent of which is to compensate for equipment used for extra work on a force account basis as provided for in subsection 109.04 of the Standard Specifications. The primary data source for establishing rates is The Contractors Equipment Manual, Seventh Edition (1974), as published by the Associated General Contractors of America. A factor for replacement cost escalation is deleted, and the interest revised annually to reflect market conditions. Adjustments are made to account for current prices for fuel oil and grease based on a price for fuel F.O.B. Pueblo. Historically, this has been considered as representative of the state average (State Department of Highways, Colorado, 1982).

These methods indicate considerable confusion in the industry concerning what costs should be accounted for in equipment rental rate analysis and how costs should be handled. With the exception of some brief discussion of the need to account for opportunity costs this study will address the proper handling of expected costs and revenues over an asset's life.

2.3 Replacement Considerations

The objective of most replacement analyses is to select a method for providing a necessary service at the minimum cost or maximum profit. For service producing alternatives, the evaluation to maximize profit is usually made on an incremental basis to determine if the incremental investment generates sufficient savings to provide a return on the invested capital. Many authors have addressed the issue of equipment economics utilizing time value of money concepts (Caterpillar, 1981; Douglas, 1975; Stewart, 1982; Terborgh, 1967). The objective of this study is not to define replacement analysis, but to show how proper development of rental rates can be applied to replacement analysis to address the problem of comparing equipment with variations in service provided per period. With this in mind, a brief review of some publications on the issue are addressed.

The MAPI method of investment and replacement analysis was developed and published by George Terborgh, research director of the Machinery and Allied Products Institute. DeGarmo, Canada, and Sullivan (1979) give a brief introduction to the objectives of this method.

> The MAPI method provides a series of charts and forms to facilitate investment analysis computation. One of its main features is the inclusion of provision for consideration of obsolescence and deterioration, assumed to affect operating results as a linear function of time. The MAPI charts provide for ease in determining the percentage retention value and are computed for various service lives, salvage values, and tax write-off methods.

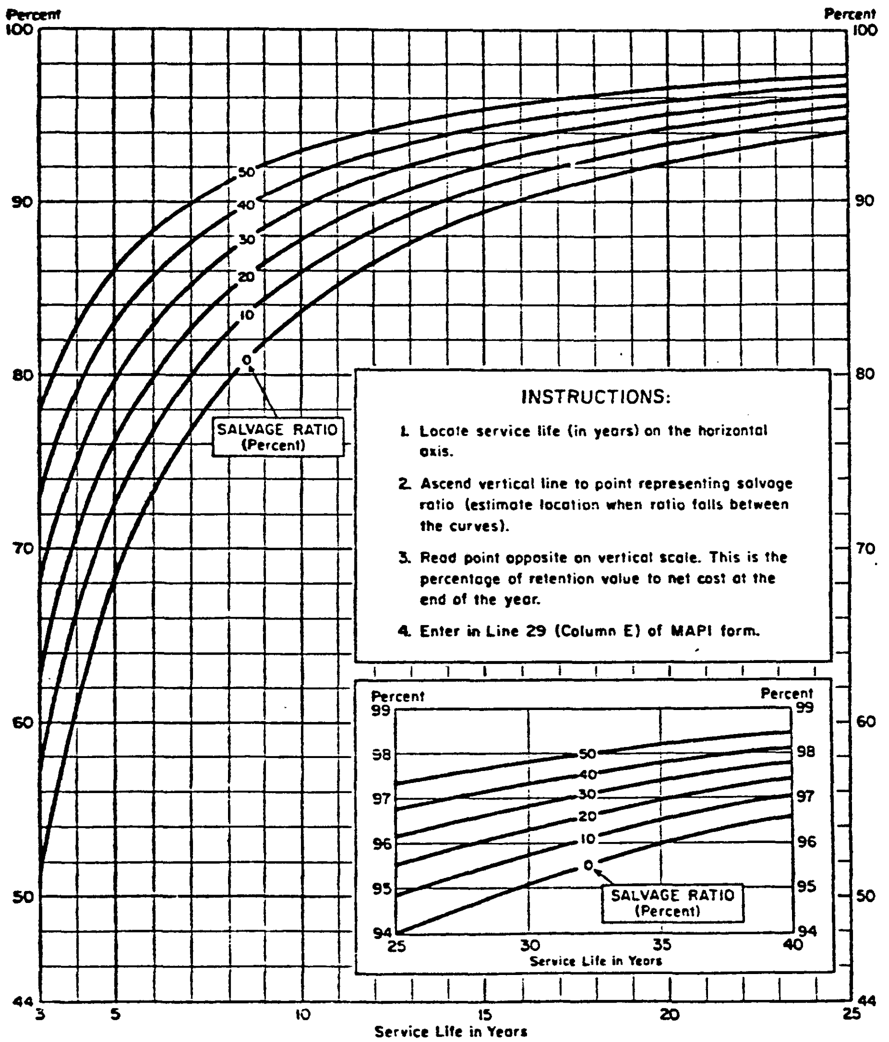
Four publications, <u>Dynamic Equipment Policy</u> (1949), <u>The MAPI Replacement Manual</u> (1950), <u>Business Investment Policy</u> (1958), and <u>Business Investment Management</u> (1967), comprise the development of this method. A detailed review is beyond the scope of this study, but it is worth noting that the later two editions introduced evaluations on an after-tax basis. This implies that the after-tax value of depreciation was incorporated into the curves utilized to determine the percentage retention value illustrated in Figure 2.1. This, in effect, forced the evaluator to accept an evaluation life for the challenger (new alternative) equal to the tax life, and may represent a significant drawback depending on the equipment being reviewed. Examples of the MAPI worksheets appear in Figures 2.2 and 2.3.

In general, the MAPI approach is considered a "cookbook" approach to making replacement analyses. It is standardized to reduce the chances of overlooking relevant cost considerations. The real question in any replacement analysis is, Should replacement occur now, or at a point in the future when the asset will no longer be capable of providing a service at any cost? Evaluations involving comparisons of equipment lives established by tax lives may render a solution with no meaning because the actual or

INVESTMENT AND RETURN CALCULATIONS

MAPI CHART No. 1A

(ONE-YEAR COMPARISON PERIOD AND SUM-OF-DIGITS TAX DEPRECIATION)



Copyright 1967, Machinery and Allied Products Institute

Source: Terborgh, George, <u>Business Investment Management</u>, 1967, Machinery and Allied Products Institute and Council for Technological Advancement, Washington D.C., p. 149.

Figure 2.1 MAPI Curve to Establish Equipment Percentage Retention Values

PROJECT NO.___________

MAPI SUMMARY FORM
(AVERAGING SHORTCUT)

PROJECT Box Machine and Stitcher

ALTERNATIVE Continuing as is

COMPARISON PERIOD (YEARS) (P) 1

ASSUMED OPERATING RATE OF PROJECT (HOURS PER YEAR) 1,200

I. OPERATING ADVANTAGE
(NEXT-YEAR FOR A 1-YEAR COMPARISON PERIOD,* ANNUAL AVERAGES FOR LONGER PERIODS)

A. EFFECT OF PROJECT ON REVENUE

		INCREASE	DECREASE	
1	FROM CHANGE IN QUALITY OF PRODUCTS	$	$	1
2	FROM CHANGE IN VOLUME OF OUTPUT			2
3	TOTAL	$ X	$ Y	3

B. EFFECT ON OPERATING COSTS

		INCREASE	DECREASE	
4	DIRECT LABOR	$ 900	$	4
5	INDIRECT LABOR	150		5
6	FRINGE BENEFITS	190		6
7	MAINTENANCE	200		7
8	TOOLING	80		8
9	MATERIALS AND SUPPLIES		16,800	9
10	INSPECTION			10
11	ASSEMBLY			11
12	SCRAP AND REWORK			12
13	DOWN TIME			13
14	POWER	40		14
15	FLOOR SPACE		1,000	15
16	PROPERTY TAXES AND INSURANCE	320		16
17	SUBCONTRACTING			17
18	INVENTORY		1,100	18
19	SAFETY			19
20	FLEXIBILITY			20
21	OTHER			21
22	TOTAL	$ 1,880 Y	$ 18,900 X	22

C. COMBINED EFFECT

23	NET INCREASE IN REVENUE (3X−3Y)	$	23
24	NET DECREASE IN OPERATING COSTS (22X−22Y)	$ 17,020	24
25	ANNUAL OPERATING ADVANTAGE (23+24)	$ 17,020	25

* Next year means the first year of project operation. For projects with a significant break-in period, use performance after break-in.

Source: Terborgh, George, Business Investment Management, 1967, Machinery and Allied Products Institute and Council for Technological Advancement, Washington, D.C., p. 157.

Figure 2.2 MAPI Operating Advantage Worksheet, Page 1

II. INVESTMENT AND RETURN

A. INITIAL INVESTMENT

26	INSTALLED COST OF PROJECT	$ 29,800			
	MINUS INITIAL TAX BENEFIT OF	$ 2,100	(Net Cost)	$ 27,700	26
27	INVESTMENT IN ALTERNATIVE				
	CAPITAL ADDITIONS MINUS INITIAL TAX BENEFIT		$		
	PLUS: DISPOSAL VALUE OF ASSETS RETIRED BY PROJECT*		$ 4,000	$ 4,000	27
28	INITIAL NET INVESTMENT (26–27)			$ 23,700	28

B. TERMINAL INVESTMENT

29 RETENTION VALUE OF PROJECT AT END OF COMPARISON PERIOD
(ESTIMATE FOR ASSETS, IF ANY, THAT CANNOT BE DEPRECIATED OR EXPENSED. FOR OTHERS, ESTIMATE OR USE MAPI CHARTS.)

Item or Group	Installed Cost, Minus Initial Tax Benefit (Net Cost) A	Service Life (Years) B	Disposal Value, End of Life (Percent of Net Cost) C	MAPI Chart Number D	Chart Percentage E	Retention Value $\left(\frac{A \times E}{100}\right)$ F
Box Machine and Stitcher	$ 27,700	13	10	1A	89.4	$ 24,760

	ESTIMATED FROM CHARTS (TOTAL OF COL. F)	$		
	PLUS: OTHERWISE ESTIMATED	$	$ 24,760	29
30	DISPOSAL VALUE OF ALTERNATIVE AT END OF PERIOD*		$ 4,000	30
31	TERMINAL NET INVESTMENT (29–30)		$ 20,760	31

C. RETURN

32	AVERAGE NET CAPITAL CONSUMPTION $\left(\frac{28-31}{P}\right)$	$ 2,940	32
33	AVERAGE NET INVESTMENT $\left(\frac{28+31}{2}\right)$	$ 22,230	33
34	BEFORE-TAX RETURN $\left(\frac{25-32}{33} \times 100\right)$	% 63.3	34
35	INCREASE IN DEPRECIATION AND INTEREST DEDUCTIONS	$ 4,190	35
36	TAXABLE OPERATING ADVANTAGE (25–35)	$ 12,830	36
37	INCREASE IN INCOME TAX (36×TAX RATE)	$ 6,415	37
38	AFTER-TAX OPERATING ADVANTAGE (25–37)	$ 10,605	38
39	AVAILABLE FOR RETURN ON INVESTMENT (38–32)	$ 7,665	39
40	AFTER-TAX RETURN $\left(\frac{39}{33} \times 100\right)$	% 34.5	40

* After terminal tax adjustments.

Source: Terborgh, George, Business Investment Management, 1967, Machinery and Allied Products Institute and Council for Technological Advancement, Washington, D.C., p. 158.

Figure 2.3 MAPI Incremental Rate of Return Worksheet, Page 2 required life may differ.

Douglas (1975) developed a series of exponential curves for determining future equipment revenues and expenses. These values are then discounted to the present and costs are subtracted from revenues to obtain the present value of profits after taxes. A drawback to this method is the mixing of constant and escalated dollars as stated by Douglas (1975).

> Costs and revenues are reckoned in present dollars except those for depreciation, interest charges, and gain on sale. They will be recognized from those curves and equations which contain the inflation factor.

As discussed in the Caterpillar method presented in Section 2.2, the mixing of escalated and constant dollars is not correct. The proper handling of these dollars will be presented in the following chapters. The objective of the Douglas approach is to maximize the value obtained from subtracting present worth costs from present worth revenues.

Life-cycle costing represents a method of determining the total cost associated with owning and operating an asset over its useful life. This approach utilizes time value of money concepts and tax benefits derived from the acquisition of such assets to make present-worth cost analyses for determination of the least-cost alternative (Stewart, 1982).

The applications presented for determination of rental rates are reasonable approximations, but they have not addressed the issue of developing hourly rental rates to be applied to any firm for broader utilization in equipment policy. The concern of this study is not with the components that make up rental rates but with the proper handling of the appropriate costs over the asset life. Chapter 3 develops a method to handle any number of cost elements while properly accounting for the time value of money on an after-tax basis using either escalated or constant dollars. The application of the breakeven results in replacement analysis will also be presented.

CHAPTER 3

BREAKEVEN CONCEPTS

This chapter will describe the process of breakeven discounted cash flow concepts applied to the evaluation of equipment rental rates. The input parameters are discussed to provide the evaluator with an understanding of breakeven discounted cash flow components utilized in determining breakeven results and the application of these results to replacement analysis.

Equipment costs vary dramatically over time depending on considerations such as job site conditions, interest rates, and the economy in general. This requires a method of accounting for costs capable of measuring the effects of occurences such as variations in expected interest rates or production schedules. The concepts of breakeven discounted cash flow cost analysis are applicable to any type of equipment from rental cars to 200-ton trucks and are capable of handling variations such as those discussed above.

The determination of the breakeven discounted cash flow standard cost per hour is the summation of present-worth, after-tax costs and miscellaneous revenues (such as salvage) referred to as the cash flow associated with owning and operating a machine, divided by the present-worth, after-tax hours expected to occur over the asset life.

Breakeven discounted cash flow standard cost per hour, denoted by X, is given by

$$X = \sum_{n=0}^{n=N} (CF_n)\left[1/(1+i)^n\right] \Big/ \sum_{n=0}^{n=N} (H_n)(1-t_n)\left[1/(1+i)^n\right]$$

where "CF_n" is the after-tax value per period from non-cash deductions and appropriate cost items, "H_n" is the hours of operation per annum, "i" is the effective discount rate per compounding period, "N" is the number of compounding periods, and "t_n" equals the effective tax rate.

The objective of the breakeven discounted cash flow concept is to determine the average before-tax cost per hour necessary to provide the equipment owner a specified after-tax return on invested capital to satisfy the opportunity cost of not investing in other alternatives. This concept utilizes cash flow, which implies that tax benefits resulting solely from the acquisition of equipment are included in the calculations. Depreciation is a tax benefit that represents a noncash deduction from taxable income, effectively lowering the tax liability to the owner. Depreciation and any similar non-cash deductions are added back to net profit to obtain cash flow. The investment tax credit is a one time, dollar-for-dollar reduction in the owner's tax liability. Both of these items reflect savings in cash as a result of reduced tax expenditures and must be incorporated to make a proper determination of the total cost per hour of equipment operation.

Analyses are not limited to hours; any other unit of time may be used, but hours have been selected for the examples in this study. The determination of expected production per period over the asset life can have an impact on the ability of the equipment owner to determine accurately the cost of operations. Levels of equipment production can vary over time with market conditions, equipment fatigue, technological improvements, etc. Production variations require a method for determining rental rates that accounts for differences in the comparison of equipment. For example, the determination of benefits resulting from higher production in early years provides greater present-worth production and revenue accrual.

Although the acquisition basis or price to be used in the evaluation is subject to managerial policy, it should reflect as accurately as possible the depreciable basis of the asset for proper depreciation and investment tax credit calculations. In general, the current market value, including expenditures for freight, sales tax, and assembly, if applicable, represents the desired basis. Price discounts, and tire costs are generally excluded. The precise handling of these and other cost components is a function of the accounting policies of each firm.

Salvage value should reflect the best estimate of potential future sale value that management can make using historical records and any other available methods. Salvage values will vary with individual firm maintenance and replacement policies. Some firms will sell immediately prior to the need for a major repair; others will make replacement decisions based on project requirements, regardless of machine condition. The significance of the salvage will be dependent on the expected life of the asset. For either escalated or constant dollar analyses, the actual escalated dollar value expected to be realized should be used in the calculations. For constant dollar analysis, the salvage and all other escalated dollar cash flows are adjusted for inflation occuring to the time such expenditures or revenues are realized.

The discount rate "i" utilized to present-worth future cash flows will influence the computed rental rate. In general, the term "discount rate" refers to the after-tax return on the unamortized investment and may be expressed in either escalated or constant dollars. Breakeven rental rates are determined using a discount rate that reflects the after-tax return that could be realized from other investment opportunities. If a discount rate of zero is used in determining rental rates, the firm is really incurring an opportunity cost amounting to the after-tax rate of return from alternative investments. As illustrated in Chapter 2, if a contractor is providing work subject to published force-account rates, it is important that he realize that an opportunity cost of capital exists. In such instances, if the published force-account rate does not cover the opportunity cost of capital, it is the role of the contractor to assure that reimbursement is achieved by another method of accounting.

With the breakeven discounted cash flow approach, the rates being developed do not imply a return to the project for which they provide a service. The computed rates cover only the costs of owning and operating equipment, inclusive of all opportunity costs incurred. Discount rates in general investment analyses are often associated with a return per annum, but it is important to recognize that the rates being developed should reflect as accurately as possible the compounding period over which costs actually will be incurred. If costs are distributed so that it is more appropriate to utilize semi-annual, quarterly, monthly, daily, or continuous compounding periods, the equipment owner should adjust the method of calculation accordingly. Again, the discount rate and the appropriate compounding period selected is a function of the individual firm's accounting methods and management preferences.

Consideration of various forms of financing can be accounted for by incorporating the appropriate expenses into the cash flows. If the acquisition is leveraged, cash flows will include expenses for interest, which is tax deductible, and for principal, which is not. If leasing is utilized, the analysis may be made by incorporating the lease payments, which are deductible, into the cash-flow stream. So long as the after-tax discount rate discussed above exceeds the after-tax cost of capital, leverage or leasing should always work for the equipment owner providing a more competitive cost per hour. This occurs because the capital costs associated with the acquisition are deferred into the future, where time value of money considerations reduce the level of significance.

As previously mentioned, analyses can be made either in escalated or constant dollars; if handled properly, the breakeven rate will be the same. The essential condition is that all costs, revenues, and discount rates be expressed on the same basis. Mixing escalated and constant dollars as advocated by Caterpillar and Douglas will result in meaningless solutions. Constant dollar analysis requires that the rate of inflation be backed out of all escalated dollar values. This can be achieved using the single-payment, present-worth factor, $(P/F_{f\%,n})$ where f% is the rate of inflation and n is the number of compounding periods in the future. If the rate of inflation is different for each compounding period, then n, single-payment, present-worth factors will be required for each rate of inflation.

By comparing the relative cost per hour of the existing machine, and the proposed alternative, it is possible to evaluate quickly the advantages occurring as a result of higher production in early years. When production varies over the expected life of the asset the computed breakeven rate reflects a weighted average accounting for the time value of money. This is significant in terms of recognizing that in general, over the evaluation life, new equipment is capable of levels of production above existing machines. The concept of breakeven discounted cash flow applied to rental rates is best understood when applied to examples. In Chapter 4, two examples are presented to illustrate how this concept can provide management information related to rental rates, replacement analysis and the sensitivity of solutions to variations in input parameters.

CHAPTER 4

APPLICATION OF BREAKEVEN CONCEPTS

This chapter will illustrate, by example, how breakeven considerations may be applied to any kind of asset. Discounted cash flow methods provide meaningful information only if used properly. Because the methods for determining breakeven costs are not rigid in application, several different solutions are presented in the examples. The intention is not to confuse, but to show that alternative approaches, properly applied, will provide identical results. Furthermore, the sensitivity of breakeven calculations to occurrences such as cost-income-cost and income-cost-income are identified and the solutions discussed.

The following examples can help management by providing methods to generate information that will assist in allocating equipment to provide a service at minimum cost. This can be achieved by utilizing the breakeven rental rates in developing accurate budgeting and job costing information, allowing management to monitor the economic progress of existing work, and to estimate with greater accuracy the cost of future work. Example 4.1 evaluates a single piece of equipment to be acquired. Example 4.2

evaluates an existing machine challenged by a new machine capable of a greater number of production hours per year.

4.1 Example of Breakeven Calculations

A firm is considering the acquisition of a Caterpillar D9L tractor complete with dozer, ripper and cab. The list price is $454,328, and sales tax is 7.1 percent. Based on historical information, the firm can expect to realize 30 percent of the list price in salvage in five years. Salvage will be taxed as ordinary income. Expected machine life is 15,000 hours: 4,000 hours each in years one and two, 3,000 hours in year three, and 2,000 hours each in years four and five. The machine will be depreciated using the Accelerated Cost Recovery System (ACRS) schedule for a five year life, taking the full 10 percent investment tax credit (ITC) at time zero. State ownership taxes and permits are estimated to be 2.3 percent of the list price of the machine in year one, 1.5 percent in year two, 1.25 percent in year three, 1.0 percent in year four and .75 percent in year five. (In practice, the state tax is based on 75 percent of cost, but to cover miscellaneous fees and permits in various counties, 100 percent of list price is used.) Insurance is $.55 per $100 invested in year one, escalating 6 percent per annum.

Major repairs of \$100,000 at the end of year two, \$75,000 at the end of year three, and \$125,000 at the end of year four will be necessary. Minor repairs will be \$15,000 in year one escalating by 6 percent per annum. In addition, \$20,000 will be spent at the end of year five to prepare the unit for auction. For tax purposes, major and minor repairs should be expensed as operating costs in the year incurred since these expenditures are not expected to add to the life of the machine or cause significant modifications to the unit.

The objective of this example is to determine the escalated dollar, before-tax standard cost per hour, necessary for a 15 percent after-tax minimum rate of return. The effective state and federal income tax rate is 48.7 percent. It will be assumed that other income exists against which to use all deductions in the year incurred.

The solutions to Example 4.1 are broken down according to the relative ownership and maintenance expenses. In the heavy construction industry, a distinction is made to provide management with more information for considerations such as double or triple shifting where variable rates may exist, and for use in revenue accruals for maintenance budgets and cost reports of any nature.

4.1.1 100 Percent Equity Solution

Table 4.1 illustrates the calculations to determine the cost of sales tax (which has been included in the depreciable basis) and the cash or book benefits including salvage, depreciation, and investment tax credit. Table 4.2, Part A, utilizes these figures in development of the ownership cash flows to be realized over the equipment expected life. Cash expenditures and book deductions specifically related to the acquisition of this unit are accounted for on an after-tax basis. Depreciation is added back to net profit to reflect that it is not an out-of-pocket expenditure but, rather, a reduction in taxable income which will reduce the tax expenditure each year. Investment tax credit is a dollar-for-dollar reduction in tax liability against other income, and it is assumed this benefit will be realized immediately. Table 4.3 shows the cash flows to be generated from the maintenance of the asset. In Table 4.2, Parts A and B, X is the unknown breakeven before-tax standard cost per hour for ownership, and in Table 4.3, Y is the unknown breakeven before-tax standard cost per hour for maintenance.

Solving for both X and Y, the ownership and maintenance cash flows yield $49.76 and $24.70 per hour respectively,

Table 4.1 - Calculations for Example 4.1 to Determine the Sales Tax, Depreciation, Investment Tax Credit and Salvage Dollar Amounts

List Price	$ 454,328.00
Sales Tax @ 7.1 Percent	$ 32,257.00
Total Cost	$ 486,585.00

Depreciation Basis* ($486,585.00)(.95)	$ 462,256.00

Depreciation Schedule

Yr		
1	(462,256)(.15)	$ 69,338.00
2	(462,256)(.22)	$ 101,696.00
3	(462,256)(.21)	$ 97,074.00
4	(462,256)(.21)	$ 97,074.00
5	(462,256)(.21)	$ 97,074.00

Investment Tax Credit (ITC)

(486,585)(.10)	$ 48,658.00

Salvage

(454,328)(.30)	$ 136,298.00

* Based on 1982 TEFRA Act, if full 10% ITC is taken, then the depreciation basis must be reduced by one-half of the ITC.

Table 4.2, Part A, - Ownership Cash Flows for 100 Percent Equity Case

Year	0	1	2	3	4	5
Breakeven Revenue	-	4000X	4000X	3000X	2000X	2000X
+Salvage	-	-	-	-	-	136298
-Insurance	-	-2498	-2649	-2808	-2976	-3155
-State Taxes	-	-10450	-6815	-5679	-4543	-3407
-Depreciation	-	-69338	-101696	-97074	-97074	-97074
Taxable Income	-	4000X- 82286	4000X-111160	3000X-105561	2000X-104593	2000X+ 32662
-Tax @ 48.7%	-	-1948X+ 40073	-1948X+ 54135	-1461X+ 51408	- 974X+ 50937	- 974X- 15906
+Invest. Tax Cr.	48658	-	-	-	-	-
Net Income	48658	2052X- 42213	2052X- 57025	1539X- 54153	1026X- 53656	1026X+ 16756
+Depreciation	-	69338	101696	97074	97074	97074
-Principal	-486585	-	-	-	-	-
Cash Flow	-437927	2052X+ 27125	2052X+ 44671	1539X+ 42921	1026X+ 43418	1026X+113830

Table 4.2, Part B, - Adjustments to Convert the Part A Equity Cash Flows to 100 Percent Leveraged Cash Flows

Year	0	1	2	3	4	5
-Interest	-	-58390	-43793	-34061	-17030	-
Taxable	-	-58390	-43793	-34061	-17030	-
-Tax @ 48.7%	-	+28436	+21327	+16588	+ 8294	-
Net Income	-	-29954	-22466	-17473	- 8736	-
+Borrowed Funds	486585	-	-	-	-	-
-Principal	-	-121646	-121646	-121646	-121646	-
Cash Flow	486585	-151600	-144112	-139119	-130382	-
Net Leveraged Cash Flow (A&B)	48658	2052X-124475	2052X- 99441	1539X- 96198	1026X- 86964	1026X+113830

"X" is the before-tax, breakeven standard cost per hour for ownership

Table 4.3 - Maintenance Cash Flows

Year	0	1	2	3	4	5
Breakeven Revenue	-	4000Y	4000Y	3000Y	2000Y	2000Y
-Major Repairs	-	-	-100000	-75000	-125000	-
-Minor Repairs	-	-15000	-15900	-16854	-17865	-38937
Taxable	-	4000Y- 15000	4000Y-115900	3000Y- 91854	2000Y-142865	2000Y- 38937
-Tax @ 48.7%	-	-1948Y+ 7305	-1948Y+ 56443	-1461Y+ 44773	- 974Y+ 69575	- 974Y+ 18962
Net Income	-	2052Y- 7695	2052Y- 59457	1539Y- 47121	1026Y- 73290	1026Y- 19975
Cash Flow	-	2052Y- 7695	2052Y- 59457	1539Y- 47121	1026Y- 73290	1026Y- 19975

"Y" is the before-tax, breakeven standard cost per hour for maintenance for a total standard cost per hour of \$74.46. The ownership calculations are made as follows:

$$(2052X + 27125)(P/F_{15\%,1}) + (2052X + 44671)(P/F_{15\%,2})$$
$$+ (1539X + 42921)(P/F_{15\%,3}) + (1026X + 43418)(P/F_{15\%,4})$$
$$+ (1026X + 113830)(P/F_{15\%,5}) = 437,927$$

which simplifies to

$$5445X + 167007 = 437927.$$

Therefore, the standard cost of ownership X is \$49.76 per hour. Similar calculations required for the maintenance rate are shown below.

$$(2052Y - 7695)(P/F_{15\%,1}) + (2052Y - 59457)(P/F_{15\%,2})$$
$$+ (1539Y - 47121)(P/F_{15\%,3}) + (1026Y - 73290)(P/F_{15\%,4})$$
$$+ (1026Y - 19975)(P/F_{15\%,5}) = 0$$

which simplifies to

$$5445Y - 134467 = 0.$$

Therefore, the standard cost of maintenance Y is \$24.70 per hour.

This figure of \$74.46 (\$49.76 + \$24.70) is not a total operating cost. An estimate of wages and the associated burden for operators, the cost of fuel, oil, grease, and filter consumption, and relevant wear items such as dozer or bucket teeth, wear plates in end dump beds, and tires should be included in the hourly rate. The exact blending of cost components will be dependent on the approach used by each individual firm and equipment manager. These costs are unique to the firm and the project and, therefore, have not been addressed in this study. However, the approach for determining the cost of these items would be equivalent to the approaches shown in the examples. Because of the variation in cost components among different jobs and equipment types, it is important to understand what the calculations presented here really mean. Proper understanding of this process will allow any equipment manager or owner to design and program a system for specific cost items and requirements.

4.1.2 Ownership Unit Cost Analysis

Table 4.4 illustrates the same cost analysis presented above, but on a cost per "cost item" basis. Here a "cost item" may be defined as the cost or benefit of individual items such as principal, interest, insurance or depreciation. This analysis determines the discounted after-tax value for each component used in developing the

Table 4.4 - Alternative Solution for 100 Percent Equity Case

Breakeven Revenue	$[4000X(P/F_{15,1}) + 4000X(P/F_{15,2}) + 3000X(P/F_{15,3})$
	$+ 2000X(P/A_{15,2})(P/F_{15,3})(1 - .487) = \underline{5445X}$
Salvage	$[136298(P/F_{15,5})(1 - .487) = \underline{34765}$
Insurance	$[2498(P/F_{15,1}) + 2649(P/F_{15,2}) + 2808(P/F_{15,3}) + 2976(P/F_{15,4})$
	$+ 3155(P/F_{15,5})](1 - .487) = \underline{4767}$
State Taxes	$[10450(P/F_{15,1}) + 6815(P/F_{15,2}) + 5679(P/F_{15,3})$
	$+ 4543(P/F_{15,4}) + 3407(P/F_{15,5})](1 - .487) = \underline{11422}$
Depreciation	$[69338(P/F_{15,1}) + 101696(P/F_{15,2}) + 97074(P/A_{15,3})(P/F_{15,2})]$
	$(.487) = \underline{148431}$
Principal	$486585(1) = \underline{486585}$
Investment Tax Cr.	$48658(1) = \underline{48658}$

Summation of After-Tax Present Values		Totals
Breakeven Revenue (In Hours)		5445X
Salvage	34765	
Insurance	- 4767	
State Taxes	- 11422	
Depreciation	148431	
Principal	-486585	
Investment Tax Cr.	48658	
Summation of Cost and Benefit Items		-270920

"X" is the before-tax, breakeven standard cost per hour for ownership total rate per hour. Breakeven revenue is expressed as price times the hours of operation per annum. Present-worth, after-tax revenue is represented by the sum of the discounted hours times the standard cost X over the asset life, that quantity times one minus the tax rate. For tax purposes, deductions are allowed for the costs associated with operating an asset, and all book deductions generated from the acquisition of the asset such as depreciation and investment tax credit. The present worth, after-tax net sum of these items will yield a total cost equation from which the standard cost per hour for ownership, X, may be determined. The present-worth, after-tax costs of insurance, state taxes and permits are the relative discounted sums times one minus the tax rate. Depreciation is a non-cash book deduction which reduces taxable income and saves the net amount of the discounted deductions times the tax rate. Investment tax credit is a dollar-for-dollar reduction in tax liability so that 100 percent of the value is realized. Principal payments are not deductible, but interest accrued on debt is treated as an operating expense. This "unit cost" approach may be necessary if contracts stipulate hourly rates subject to recourse by audit verification.

These calculations are summarized at the bottom of

Table 4.4. Setting the total after-tax discounted breakeven revenue equal to the summation of discounted after-tax costs and tax benefits, the ownership standard cost per hour is determined by solving the following equation

$$5445X = 270,920.$$

This breakeven value for X is \$49.76 per hour, which is the same value for ownership standard costs per hour arrived at in the preceding section.

4.1.3 100 Percent Leveraged Solution

Assume a four-year note will be signed for the acquisition of the D9L, and that the compound interest rate will be 12 percent in years one and two, and 14 percent in years three and four. The principal payments will be made in four equal annual payments. This results in the interest payment schedule presented in Table 4.5.

Table 4.5 - Interest Calculation Schedule

Yr	Principal		Basis	Unamortized Balance		Rate		Interest
1	486,585	-	0	486,585	*	(.12)	=	58,390
2	486,585	-	121,646	364,939	*	(.12)	=	43,793
3	364,939	-	121,646	243,293	*	(.14)	=	34,061
4	243,293	-	121,646	121,646	*	(.14)	=	17,030

By adjusting the cumulative discounted cash flow values as calculated in Table 4.2, Parts A & B, the Net Leveraged Cash Flows are obtained. The total discounted cost is the only variable changing within the equation. The after-tax discounted hours of operation have remained constant. This equation is then solved for X.

$$(2052X - 124475)(P/F_{15\%,1}) + (2052X - 99441)(P/F_{15\%,2})$$
$$+ (1539X - 96198)(P/F_{15\%,3}) + (1026X - 86964)(P/F_{15\%,4})$$
$$+ (1026X + 113830)(P/F_{15\%,5}) = -48658$$

which simplifies to

$$5445X - 239811 = -48658.$$

Therefore, the leveraged solution for the standard cost of ownership X is \$35.11 per hour.

Using the method discussed in Section 4.1.2 it is easy to present an alternative solution to determine the breakeven standard cost required for the 100 percent leveraged case. This is done by discounting the principal and interest payments and accounting for the deductibility of interest expense.

Present Worth After-Tax Cost of Interest

$$\Big[58390(P/F_{15\%,1}) + 43793(P/F_{15\%,2}) + 34061(P/F_{15\%,3})$$

$$+ 17030(P/F_{15\%,4})\Big](1 - .487) = 59519$$

Present Worth After-Tax Cost of Principal

$$121646(P/A_{15\%,4}) = 347297$$

Substituting these costs into the cumulative cost shown in the lower portion of Table 4.4 the leveraged ownership cost per hour is as follows:

$$5445X = (270920 - 486585 + 347297 + 59519),$$

or

$$X = \$35.11 \text{ per hour.}$$

The incremental decrease in the hourly cost of $14.65 ($49.76-$35.11) occurs because costs are deferred into the future, and diminish in terms of present value. So long as the after-tax cost of borrowed funds is less than the after-tax discount rate, leveraged acquisitions will always give the equipment owner an advantage in cost per hour.

4.1.4 Dual Breakeven Rates

The segmented or component approach to breakeven analyses is satisfactory if the evaluator can be certain of the avoidance of income-cost-income or cost-income-cost occurrences in the cash-flow streams. The leveraged portion of the ownership analysis does have an income-cost-income cash flow stream resulting from the investment tax credit in year zero and the salvage at the end of year five. This is demonstrated in Table 4.6 by inserting the breakeven value of $35.11 calculated for X into the yearly cash flows from Table 4.2, Part B. Looking at the ownership portion of the cash flows presented in Table 4.6, and using net present value, there are two "i" values at approximately 15 and 55 percent which satisfy the net present value (NPV) equation equal to zero. The data points in Table 4.7 are determined

Table 4.6 - Leveraged Ownership Cash Flows

Year	Cash Flow	Total Amount @ X = $35.11
0	48,658	48,658
1	2052X - 124,475	-52,429
2	2052X - 99,441	-27,395
3	1539X - 96,198	-42,164
4	1026X - 86,964	-50,941
5	1026X + 113,830	149,853

by using the same NPV equation for a range of discount rates from 0 to 75 percent and solving using the breakeven cost per hour of $35.11. In other words, the figures shown under "Total Amount" in Table 4.6 are discounted over a range of discount rates. These net present values and corresponding discount rates as shown in Table 4.7 are graphed in Figure 4.1.

In rate of return analysis the existance of dual "i" values leaves a solution with no economic meaning and forces the evaluator to utilize other techniques such as growth rate of return or net present value. However, for breakeven calculations, if the "i" value selected truly reflects the after-tax value of other opportunities for the use of capital, then $35.11 is the cost per hour for ownership which should be utilized. The discussion on the following pages of this section are presented to illustrate the importance of selecting the appropriate discount rate, to properly account for the opportunity cost of capital. These calculations are presented as an academic exercise and do not need to be repeated by the equipment owner if the appropriate discount rate is used, as discussed in this study. In Figure 4.2, the breakeven rates per hour for ownership are plotted for discount rates ranging from zero to 75 percent. The calculations for these points are presented in Table 4.8 where the discounted after-tax hours are set equal to the discounted after-tax sum of cost and benefit items specified. The relevant costs and hours necessary for these calculations are presented in Table 4.6

Table 4.7 - NPV Calculations for Table 4.6 Cash Flow Amounts Over a Range of Discount Rates, "i"

$$NPV = 48658 + 149853(P/F_{i\%,5}) - 52429(P/F_{i\%,1}) - 27395(P/F_{i\%,2}) - 42164(P/F_{i\%,3}) - 50941(P/F_{i\%,4})$$

@ i = 0	NPV = 25582
i = 5	NPV = 12959
i = 10	NPV = 4930
i = 15	NPV = 7 *
i = 20	NPV = - 2801
i = 25	NPV = - 4168
i = 30	NPV = - 4550
i = 35	NPV = - 4265
i = 40	NPV = - 3532
i = 45	NPV = - 2505
i = 50	NPV = - 1292
i = 55	NPV = 32 *
i = 60	NPV = 1413
i = 70	NPV = 4211
i = 75	NPV = 5585

* The approximate discount rate where NPV equals zero, "i" is the discount rate reflecting the other opportunities that exist for the use of capital.

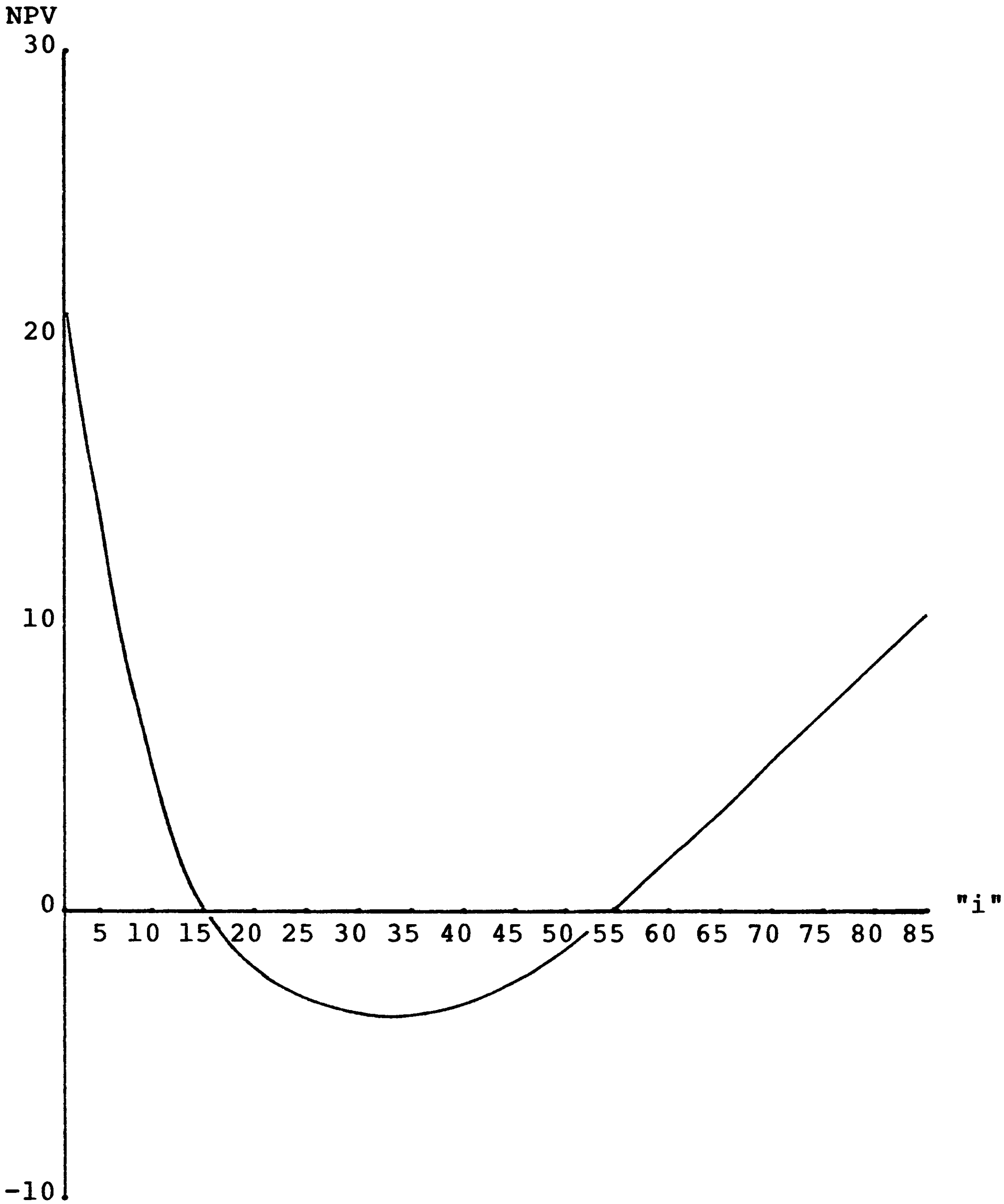


Figure 4.1 - Plot of NPV for Various Discount Rates, "i"

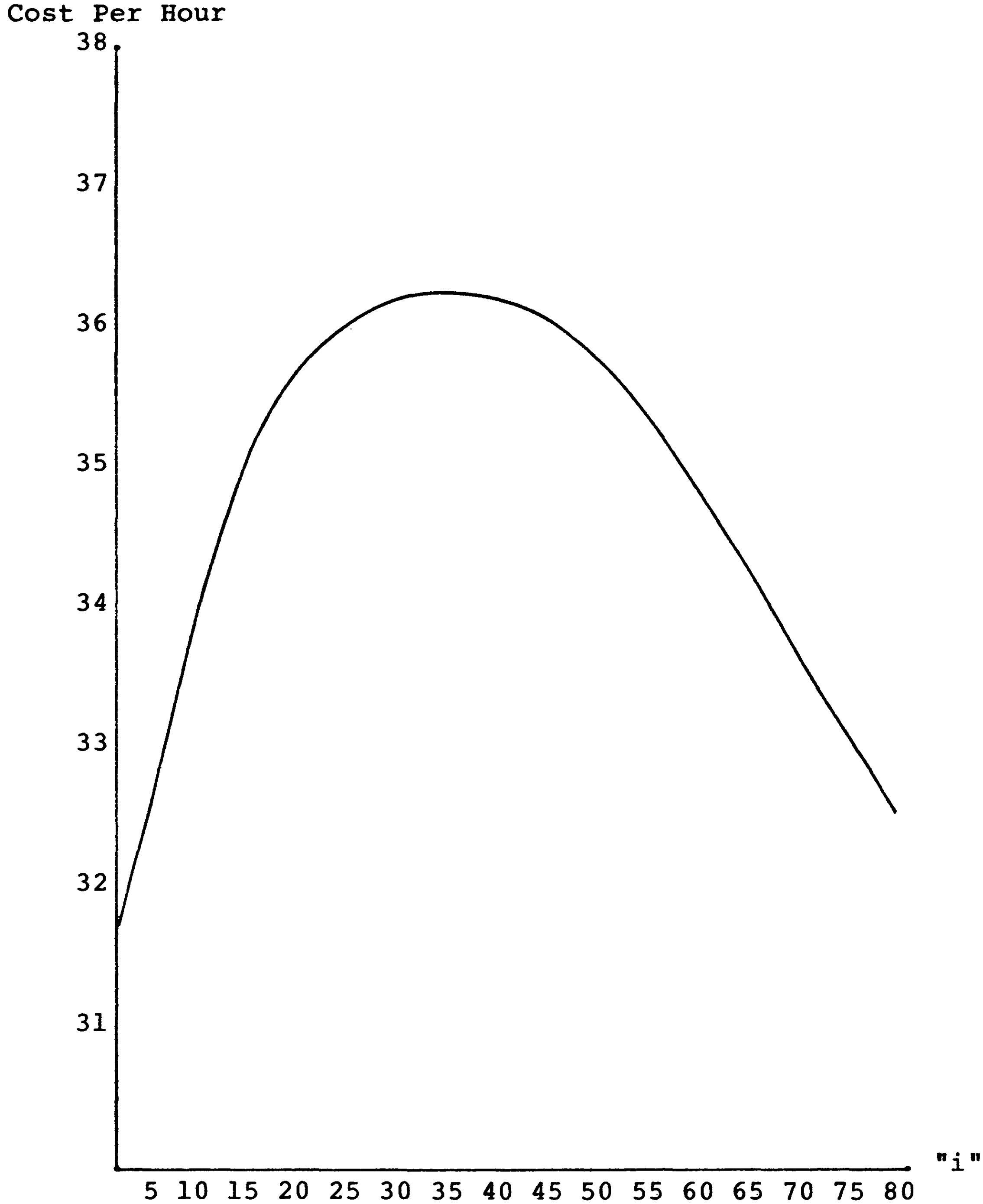


Figure 4.2 - Breakeven Cost per Hour Versus the Discount Rate, "i"

Table 4.8 - Leveraged Case, Breakeven Ownership Costs Per Hour for Variations in the Discount Rate, "i"

i = 0	7695X = 244590	X = $31.79 per hour
i = 5	6793X = 225542	X = 33.20
i = 10	6055X = 207677	X = 34.30
i = 15	5445X = 191153	X = 35.11 *
i = 20	4933X = 175990	X = 35.68
i = 25	4499X = 162138	X = 36.04
i = 30	4129X = 149510	X = 36.21
i = 35	3809X = 138004	X = 36.23
i = 40	3531X = 127518	X = 36.11
i = 45	3288X = 117952	X = 35.87
i = 50	3074X = 109213	X = 35.53
i = 55	2884X = 101215	X = 35.10 *
i = 60	2714X = 93883	X = 34.59
i = 65	2562X = 87147	X = 34.02
i = 70	2425X = 80947	X = 33.38
i = 75	2302X = 75228	X = 32.68

* The approximate discount rate where breakeven values are equal, "i" is the discount rate reflecting the other opportunities that exist for the use of capital.

under the column headed Cash Flow. The calculated breakeven rate for a discount rate equal to zero is often assumed to be the pure cost figure. This assumes that money has no time value, that is, that no other opportunities exist for the use of capital. In general, this is not a realistic assumption. At the breakeven rate of $31.79 per hour, the equipment owner realizes an opportunity cost amounting to the interest or rate of return revenue forgone by not having the same dollars invested in other investment opportunities projected to yield a given after-tax rate of return. Because some contracts may prohibit the use of any discount rate other than zero, it is important for project estimators to realize that if this opportunity cost is not accounted for in the equipment hourly rate it must be recognized elsewhere as overhead.

As the discount rate exceeds approximately 34 percent at a rate of $36.24 per hour, the up-front revenues being generated by the investment tax credit allow the equipment owner to lower the rate charged per hour. Therefore, if other opportunities really exist for returns of 55 percent after taxes, the same rate of $35.11 may be charged. The cost per hour continues to decline for larger "i" values as the up front revenues generate larger and larger earnings to offset future expenditures. This implies the meaning of the "i" value is both rate of return and a return on reinvested capital.

One potential problem could occur with auditors familiar with engineering economy techniques. They may argue that the true return on investment realized by this unit is 55 percent, which may exceed contract provisions for a reasonable or normal profit. This position may be countered by factoring the investment tax credit forward one year at the minimum rate of return of 15 percent and crediting it against the negative year one cash flow, or the positive revenue in year five may be discounted back and applied against negative cash flows until it is depleted. Clearly these methods will eliminate the income-cost-income cash flow characteristics providing an identical breakeven cost per hour for the minimum rate of return of 15 percent. Referring to the Net Leveraged Cash Flows presented in Table 4.2, Part B, the calculations to eliminate the presence of income-cost-income are presented.

$$
\begin{array}{lr}
(1{,}026X + 113{,}830)(P/F_{15\%,1}) = & 892X + 98{,}987 \\
\text{Add: Yr. 4 Cash Flow} & 1{,}026X - 86{,}964 \\
\hline
 & 1{,}918X + 12{,}023
\end{array}
$$

$$
\begin{array}{lr}
(1{,}918X + 12{,}023)(P/F_{15\%,1}) = & 1{,}668X + 10{,}455 \\
\text{Add: Yr. 3 Cash Flow} & 1{,}539X - 96{,}198 \\
\hline
 & 3{,}207X - 85{,}743
\end{array}
$$

At the breakeven rate of \$35.11, the year-three, net cash flow is still positive, so the year three cash flow must be discounted to year two.

$(3{,}207X - 85{,}743)(P/F_{15\%,1})$	=	$2{,}789X - 74{,}562$
Add: Yr. 2 Cash Flow		$2{,}052X - 99{,}441$
		$4{,}841X - 174{,}003$

$$(2{,}052X - 124{,}475)(P/F_{15\%,1}) + (4{,}841X - 174{,}003)(P/F_{15\%,2}) + 48{,}658 = 0$$

which simplifies to

$$5{,}445X = 191{,}149.$$

Therefore, the leveraged ownership standard cost X is \$35.11 per hour. This occurs because the breakeven rate is determined at the minimum rate of return which is the discount rate used to remove the positive cash flow in year five. Similarly, future-worthing the time zero investment tax credit to year one at the minimum rate of return would be exactly offset by discounting one period, at the same discount rate, to determine the breakeven cost.

4.1.5 - Variation to Production Schedules Solution

Another easy solution is to measure the impact of a variation to the production schedule. Assume the machine will operate 3,000 hours per year for five years with all other costs remaining constant. What is the breakeven cost per hour for the 100 percent equity case?

Referring to the cash flows presented in Table 4.2, Part A, and Table 4.3, the only variables to change are the breakeven revenues. Substituting the after-tax discounted value of the new expected production schedule of 3,000 hours per year, facilitates the determination of the incremental cost to be realized for both of the breakeven ownership and maintenance values. These calculations are presented below.

Ownership

$437,927 = [3,000X(P/A_{15\%\ 5})](1-.487) + 167,007$

$437,927 = 5,158.7X + 167,007$

$X = \$52.52$ per hour.

Maintenance

$134,467 = 5,158.7Y$

$Y = \$26.07$ per hour.

Deferring 1,000 hours of production, or revenue equivalent, per year in years one and two, has added an incremental \$2.76 per hour to the standard cost of owning the machine, and an incremental \$1.37 to the standard cost of maintenance, for a total increase of \$4.13 per hour. The earlier equipment hours, or production, occur over an assets expected life, the more cost competitive equipment becomes. This occurs as the time-value of money considerations work to amortize costs more rapidly. The breakeven discounted cash flow method clearly illustrates the advantage.

4.1.6 - Constant Dollar Analysis

For advocates of constant dollar analysis, the recommended approach is to utilize total cash flows accounting for cumulative ownership and maintenance expenditures, and minimize the number of calculations. The procedure is as follows:

Assume an inflation rate, "f" of 5 percent in years one and two, and 7 percent in years three, four, and five. Determine the constant dollar breakeven cost per hour for the leveraged base case.

To make a proper constant dollar analysis the effects of inflation must be backed out from the stated escalated dollar revenues and costs. Then the escalated dollar calculations must be repeated using the constant dollar equivalent rate of return for the given rate of inflation. Because the rates of inflation are not constant over the expected life it will be necessary to calculate two constant dollar minimum rates of return that are equivalent to the 15 percent escalated dollar minimum rate of return for the periods of 5 and 7 percent inflation respectively. These constant dollar equivalent discount rate calculations are presented using the 15 percent escalated dollar minimum rate of return used throughout the problem. Stermole's text, Economic Evaluation and Investment Decision Methods (1982), is an appropriate reference on the derivation of the conversion formulas below.

Constant Dollar Discount Rates

$f = 5\%$ $(1 + .15)/(1 + .05) - 1 = .095$ or 9.5 percent

$f = 7\%$ $(1 + .15)/(1 + .05) - 1 = .075$ or 7.5 percent

By discounting the constant dollar cash flows presented in Table 4.9, the equation may be solved for X to determine the constant dollar equivalent rate per hour. Note that X as used here is the total cumulative cost per hour, where in previous solutions, it reflected only the ownership portion of the rate.

$$\begin{aligned} 48{,}658 = {} & (1{,}954X - 125{,}879)(P/F_{9.5\%,1}) \\ & + (1{,}861X - 144{,}120)(P/F_{9.5\%,2}) \\ & + (1{,}305X - 121{,}489)(P/F_{9.5\%,2})(P/F_{7.5\%,1}) \\ & + (813X - 126{,}949)(P/F_{9.5\%,2})(P/F_{7.5\%,2}) \end{aligned}$$

Table 4.9 - Constant Dollar Cash Flow Calculations

Year	0	1	2	3	4	5
Breakeven Revenue	-	4000X	4000X	3000X	2000X	2000X
Salvage	-	-	-	-	-	136298
-Insurance	-	-2498	-2649	-2808	-2976	-3155
-State Taxes	-	-10450	-6815	-5679	-4543	-3407
-Depreciation	-	-69338	-101696	-97074	-97074	-97074
-Major Repairs	-	-	-100000	-75000	-125000	-
-Minor Repairs	-	-15000	-15900	-16854	-17865	-38937
-Interest	-	-58390	-43793	-34061	-17030	-
Taxable Income	-	4000X-155676	4000X-270853	3000X-231476	2000X-264488	2000X- 6275
Tax @ 48.7%	-	-1948X+ 75814	-1948X+131905	-1461X+112729	- 974X+128806	- 974X+ 3056
Invest. Tax Cr.	48658	-	-	-	-	-
Net Income	48658	2052X- 79862	2052X-138948	1539X-118747	1026X-135682	1026X- 3219
+Depreciation	-	69338	101696	97074	97074	97074
-Principal	-	-121646	-121646	-121646	-121646	-
Esc. $ Cash Flow	48658	2052X-132170	2052X-158898	1539X-143319	1026X-160254	1026X+93855
*$(P/F_{5\%,1,2})$		.9524	.9070	.9070	.9070	.9070
*$(P/F_{7\%,1,2,3})$		-	-	.9346	.8734	.8163
Const. $ Cash Flow	48658	1954X-125879	1861X-144120	1305X-121489	813X-126949	760X+69489

* Multiply the escalated dollar cash flows by these factors to obtain the constant dollar cash flows.

"X" is the before-tax, breakeven standard cost per hour for ownership and maintenance

$$+ (760X + 69{,}489)(P/F_{9.5\%,2})(P/F_{7.5\%,3})$$

$$48{,}658 = 5{,}446X - 325{,}701$$

The constant dollar standard cost for X is equal to \$59.81 per hour, which is equivalent to the solution obtained in sections 4.1.1 and 4.1.3 by adding the respective escalated dollar costs per hour for maintenance and leveraged ownership. The constant dollar analysis will always yield a breakeven solution equivalent to the escalated dollar result if the values are handled properly.

4.1.7 Summary of Example 4.1

As stated in Section 4.1.1, it is important to recognize that the standard costs calculated, and summarized in Table 4.10, do not represent the total cost per hour associated with equipment operation. The standard costs summarized in this example are relatively fixed, and should not vary significantly over the assets life. If rental rates are being developed for contracts extending beyond approximately one year, clauses should be included in the contract to reconcile escalation in variable cost items such as operators wages and burden; the cost of fuel, oil, grease, filters; applicable wear items; and any other cost

Table 4.10 - Summary of Solutions to Example 4.1

		Breakeven Standard Costs		
		Ownership	Maint.	Total
4.1.1	100% Equity Solution in Escalated Dollars for Declining Hours Prod.	$49.76	$24.70	$74.46
4.1.2	Ownership Unit Cost Anal.	$49.76	--	--
4.1.3	100% Leveraged Solution	$35.11	$24.70	$59.81
4.1.4	Handling Dual Breakeven Rates: Provided the breakeven rate is calculated at the minimum rate of return that truly reflects the other opportunities that exist for the use of capital, the dual breakeven rate at another "i" value can effectively be ignored.			
4.1.5	Variation in Production to 3000 Hours Per Year	$52.52	$26.07	$78.59
4.1.6	Constant Dollar Analysis: The approach advocated in this thesis is to begin with escalated dollars and convert the after-tax cash flows to constant dollars by backing out inflation. The constant dollars are then discounted at the constant dollar minimum rate of return and the equation solved for the breakeven price which if handled properly will be equivalent to the escalated dollar solution.			

components appropriate to the project contract.

This example has also shown that leverage can work for the equipment owner in effectively lowering the standard cost per hour, if the after-tax cost of capital is less than the after-tax minimum rate of return. Further, if the after-tax minimum rate of return properly reflects the other opportunities thought to exist for the use of capital, then results yielding dual breakeven rates can be ignored. Also, results for either escalated or constant dollars will be equivalent if cash flows and discount rates are properly handled.

4.2 Replacement Considerations

A common problem with the evaluation of service producing alternatives is the determination of equivalent service per machine per period of time. If it is assumed that 100 percent of the potential service from the more productive equipment can be utilized, then it is necessary to account for any performance variations that may exist. Historically this has required manipulation of the data by one of several methods to obtain equivalent cost per period of service. These methods include adding costs to the less productive equipment to provide equivalent service, or applying a percentage to the costs of service provided by the more productive machine so that service costs are equivalent to the less productive units. Either of these methods may require adjustments to both capital and operating expenses. As a third approach, the opportunity cost of forgoing the more productive machine may be charged to the less productive unit. This opportunity cost may be the net revenue forgone from not having a more productive unit in operation. Each of these methods applied properly will yield the same economic conclusions, but they cannot account for variations in production over the assets service life. By utilizing the breakeven discounted cost per hour, it is possible to make an analysis on individual units and avoid the factoring of capital and operating expenses. In addition, the use of breakeven analysis provides for an assessment of the value of variations in production over the assets use service life. Further, while historical methods do yield consistent economic conclusions as a result of the factoring, the meaning of the results is relatively useless to management in other facets of equipment management policies. The following example illustrates how costs would be assessed with historical methods as well as with the hourly cost approach.

4.2.1 Example Illustrating Replacement Considerations

An existing machine has a present trade-in value of $65,000 and a remaining book value $25,000. Replacement of the existing unit with a new machine that will provide 150 percent of the productivity provided by the existing machine is being considered. The service of either the old or new machine is needed for the next four years so a four year evaluation life will be used. The old machine is expected to run 2,000 hours per year, and the new machine will run 3,000 hours per year. If the old machine is kept, the remaining book value will be depreciated straight line over the next two years. This assumes the old machine was purchased prior to January 1, 1981, and is being depreciated by double-declining balance, switching to straight line. Salvage on the old machine will be zero four years from now. The existing machine operating costs are projected to be $30,000 in year one, $35,000 in year two, $40,000 in year three and $45,000 in year four.

The new machine which costs $120,000, will be depreciated over a five year ACRS life. Salvage is estimated to be $30,000 at the end of year four. Operating expenses for the new machine will be $25,000 in year one, $30,000 in year two, $35,000 in year three and $40,000 in year four. The effective state and federal income tax rate is 50 percent. The full 10 percent investment tax credit will be applicable, and subject to recapture at the end of year four, this will also require an adjustment to the depreciation basis, and the book writeoff in the final year of service. It is assumed that other income exists against which to use deductions in the year incurred, and that all values are in escalated dollars. For an escalated dollar, after-tax minimum rate of return of 15 percent, determine whether the old machine should be replaced by the new. Then look at the sensitivity of the breakeven hourly cost for each machine given the following accelerated production schedule. The old machine production schedule will be 3,000 hours in year one, 2,500 hours in year two, 1,500 hours in year three and 1,000 hours in year four. The new machine production schedule will be 4,000 hours in year one, 3,500 hours in year two, 2,500 hours in year three and 2,000 hours in year four.

4.2.2 Problem Solution

The historical solution to this problem would involve determination of a common denominator to factor the costs for equivalent service. For example, the cost of two new machines could be compared to the costs of three existing machines, or the new machine costs could be factored down by one third to account for the additional capability. Present worth cost, future worth cost, or annual cost would then be calculated on an after-tax basis to determine which alternative, could provide the service at the least cost. As an alternative the breakeven before tax revenue necessary to cover the costs of owning and operating equipment over its useful life is presented. Time diagrams are in thousands of dollars as follows:

Year	0	1	2	3	4
OLD	C=65-20	OC=30	OC=35	OC=40	OC=45
NEW	C=120	OC=25	OC=30	OC=35	OC=40

The -20 on the capital cost of the old machine at year zero accounts for the tax that would have been paid had the old asset been sold. The cost is determined by reducing the opportunity sale price by the book value which represents the taxable gain, (treated here as ordinary income). Reducing the sale value by the tax on the gain yields the after-tax opportunity cost 65-(65-25)(.50) = 45 of not selling.

The breakeven cost per hour for the old machine may be calculated by discounting the cash flows presented in Table

4.11, back to time zero, and solving for X.

$$45 = (X - 8.75)(P/F_{15\%,1}) + (X - 11.25)(P/F_{15\%,2}) + (X - 20)(P/F_{15\%,3}) + (X - 22.5)(P/F_{15\%,4})$$

$$87.131 = 2.855X$$

Therefore, X is \$30.52 per hour for the old machine. Similarly, the breakeven cost per hour for the new machine is determined by discounting the cash flows presented in Table 4.12 to the present, and solving for X.

$$108 = (1.5X - 4)(P/F_{15,1}) + (1.5X - 2.5)(P/F_{15,2}) + (1.5X - 5.6)(P/F_{15,4}) + (1.5X + 34.5)(P/F_{15,4})$$

$$97.32 = 4.2825X$$

Therefore, X is \$22.72, which is the breakeven cost per hour for the new machine.

If it is feasible for the owner to utilize the total production capabilities of the new machine, there is a \$7.80 per hour advantage to acquiring the new machine. However, if three old machines were presently performing the task, the acquisition of two new machines would result in savings of \$46.12 per hour (3*30.52 - 2*22.72 = \$46.12).

As shown in section 4.1.2 of example 4.1 these values

Table 4.11 - Old Machine Breakeven Cost Per Hour Cash Flows
(All Figures in 000's)

Year	0	1	2	3	4
Revenue	-	2X	2X	2X	2X
-O.C.	-	-30	-35	-40	-45
-Deprec.	-	-12.5	-12.5	-	-
Taxable	-	2X-42.5	2X-47.5	2X-40	2X-45
-Tax @ 50%	-	-1X+21.25	-1X+23.75	-1X+20	-1X+22.5
Net Inc.	-	1X-21.25	1X-23.75	1X-20	1X-22.5
+Deprec.	-	12.5	12.5	-	-
Opportunity -Cost	-45	-	-	-	-
-Cash Flow	-45	1X-8.75	1X-11.25	1X-20	1X-22.5

"X" is the before-tax, breakeven standard cost per hour

Table 4.12 - New Machine Breakeven Cost Per Hour Cash Flows (All Figures in 000's)

Year	0	1	2	3	4
Revenue	-	3X	3X	3X	3X+60
-O.C.	-	-25	-30	-35	-40
-Deprec.	-	-17.1	-25.1	-23.9	-23.9
-Book Value	-	-	-	-	-25.1
Taxable	-	3X-42.1	3X-55.1	3X-58.9	3X-29.0
-Tax @ 50%	-	-1.5X+21.0	-1.5X+27.5	-1.5X+29.4	-1.5X+14.5
+ITC	12	-	-	-	- 2.4
Net Inc.	12	1.5X-21.1	1.5X-27.6	1.5X-29.5	1.5X-14.5
+Deprec.	-	17.1	25.1	23.9	49.0
-Cap. Cost	-120	-	-	-	-
Cash Flow	-108	1.5X- 4	1.5X- 2.5	1.5X- 5.6	1.5X+34.5

"X" is the before-tax, breakeven standard cost per hour can be equivalently determined by dividing the present-worth cost of owning and operating a machine by the present worth after-tax hours discounted at the same minimum rate of return. This implies that the hours are multiplied by one minus the tax rate, or 2(1-.5) for the old machine, and 3(1-.5) for the new machine, as follows:

<u>Old Machine</u>

$$87.131 \ / \ [1.0(P/F_{15\%,1}) + 1.0(P/F_{15\%,2}) + 1.0(P/F_{15\%,3}) + 1.0(P/F_{15\%,4})]$$

$$87.131 \ / \ 2.855 = \$30.52 \text{ per hour.}$$

<u>New Machine</u>

$$97.32 \ / \ [1.5(P/F_{15\%,1}) + 1.5(P/F_{15\%,2}) + 1.5(P/F_{15\%,3}) + 1.5(P/F_{15\%,4})]$$

$$97.32 \ / \ 4.2825 = \$22.72 \text{ per hour.}$$

With this simplified method it can be shown that breakeven calculations are really present worth costs divided by the present worth after-tax hours. Present worthing any series of cash flows which are derived from hourly rental or unit sales implicitly indicates discounting after-tax hours or units. With this understanding it is much easier to evaluate the sensitivity of alternatives to variations in the hours of production per annum as requested in the example statement. These calculations are presented for the following production schedules:

Year	0	1	2	3	4
Old Hours	-	3000	2500	1500	1000
New Hours	-	4000	3500	2500	2000

Old Machine

$87.131 \;/\; 1.5(P/F_{15\%,1}) + 1.25(P/F_{15\%,2}) + .75(P/F_{15\%,3})$
$+ .5(P/F_{15\%,1})$

$87.131 / 3.0286 = \$28.77$ per hour.

New Machine

$97.32 \;/\; 2(P/F_{15\%,1}) + 1.75(P/F_{15\%,2}) + 1.25(P/F_{15\%,3})$
$+ 1(P/F_{15\%,4})$

$97.32 / 4.4561 = \$21.84$ per hour.

Initially, the old machine represents a less capital intensive alternative allowing the breakeven cost per hour to be enhanced, by a slightly larger incremental reduction in cost per hour. This occurs because the larger revenues generated in year one are not offset by substantial capital expenditures. The net cash flows (in thousands) for the accelerated production schedules are presented in Table 4.13 for both machines. The old machine cash flows, including year zero, indicate a cost-income-cost scenario requiring analysis of the existance of a dual "i" value satisfying the equation at the specified breakeven rate. Solving the net present value calculations at the breakeven hourly cost ($28.77 per hour) will permit determination of the other "i" value which satisfies this equation being equal to zero. These calculations are presented in Table 4.14. The

Table 4.13 - Calculations of Net Cash Flows at the Breakeven Rate of $28.77 Determined for a 15 Percent Minimum Rate of Return

YEAR	OLD MACHINE	NET CF	NEW MACHINE	NET CF
0		-45.00		-108.00
1	1.50(28.77)- 8.75 =	34.41	2.00(21.84)- 4.0 =	39.98
2	1.25(28.77)-11.25 =	7.19	1.75(21.84)- 2.5 =	35.72
3	.75(28.77)-20.00 =	1.58	1.25(21.84)- 5.6 =	21.70
4	.50(28.77)-22.50 =	-8.12	1.00(21.84)+33.9 =	55.74

computed cost per hour should account for a 15 percent after-tax opportunity cost of capital, which may be verified by showing the net present value is exactly equal to zero.

Table 4.14 - Calculation of Old Machine Dual "i" Values

"i" Value (%)	Net Present Value (in $)
60	-14,697
30	- 6,035
15	0
0	7,580
-15	16,704
-30	25,384
-40	25,675
-50	5,440
-60	-96,878

By interpolation, the "i" value in addition to 15 percent which makes the net present value equal to zero is -51.2 percent. This implies that for a discount rate of negative 51.2 percent, the cost per hour for operating this equipment will be equal to the $28.77 calculated at a 15 percent opportunity cost rate. Graphs in Figures 4.3 and 4.4 explain the meaning of these results. These figures show that the true meaning of the calculated breakeven cost per hour is not defined as the before-tax rate necessary to receive a 15 percent discounted cash flow rate of return on the unamortized investment. Rather, it is based on a rate of return, rate of reinvestment meaning which is not equivalent to a pure discounted cash flow rate of return (DCFROR) result. Consistant with the results of Example

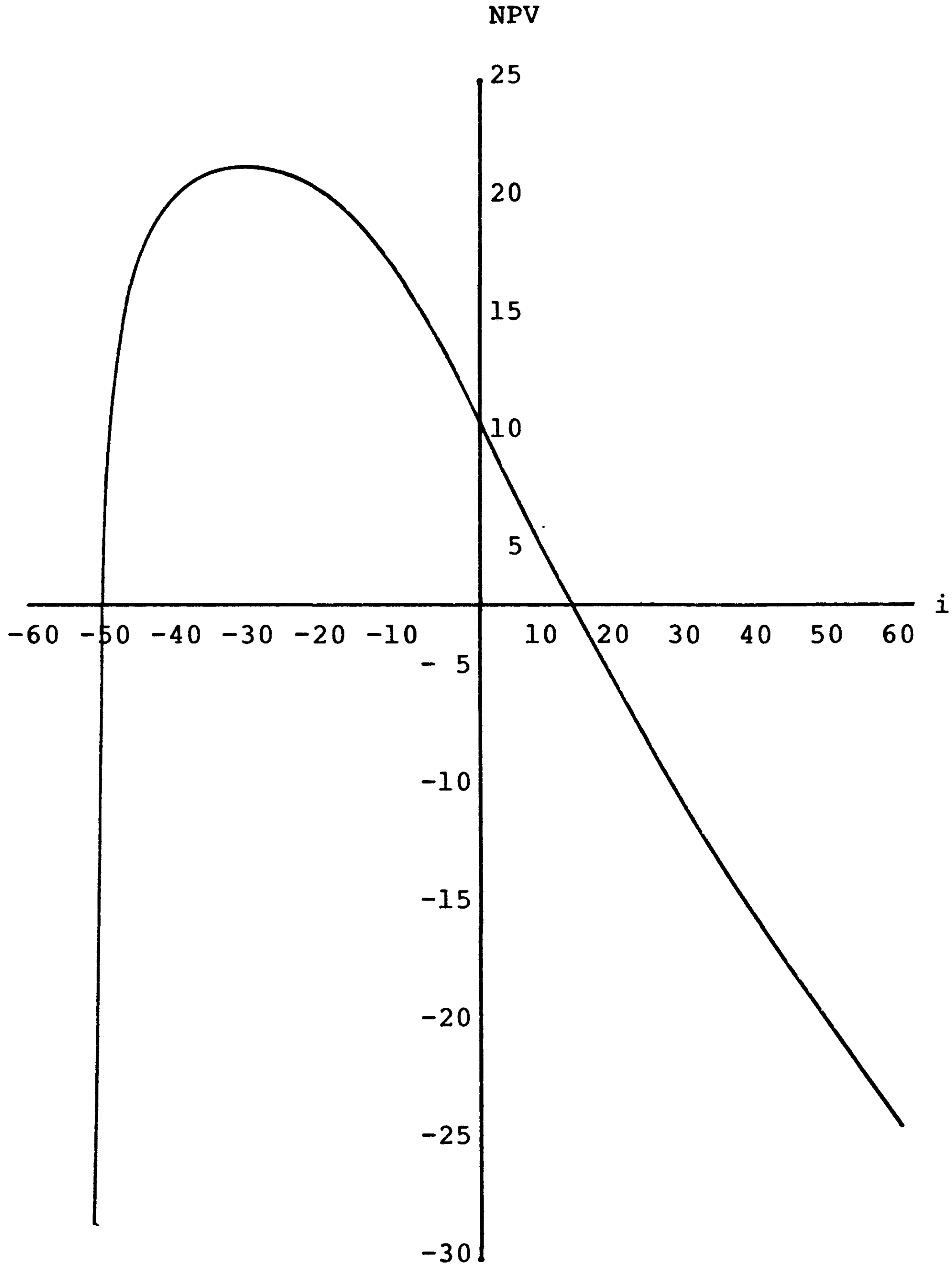


Figure 4.3 - Plot of Net Present Values Versus "i" Values. (NPV in thousands of dollars)

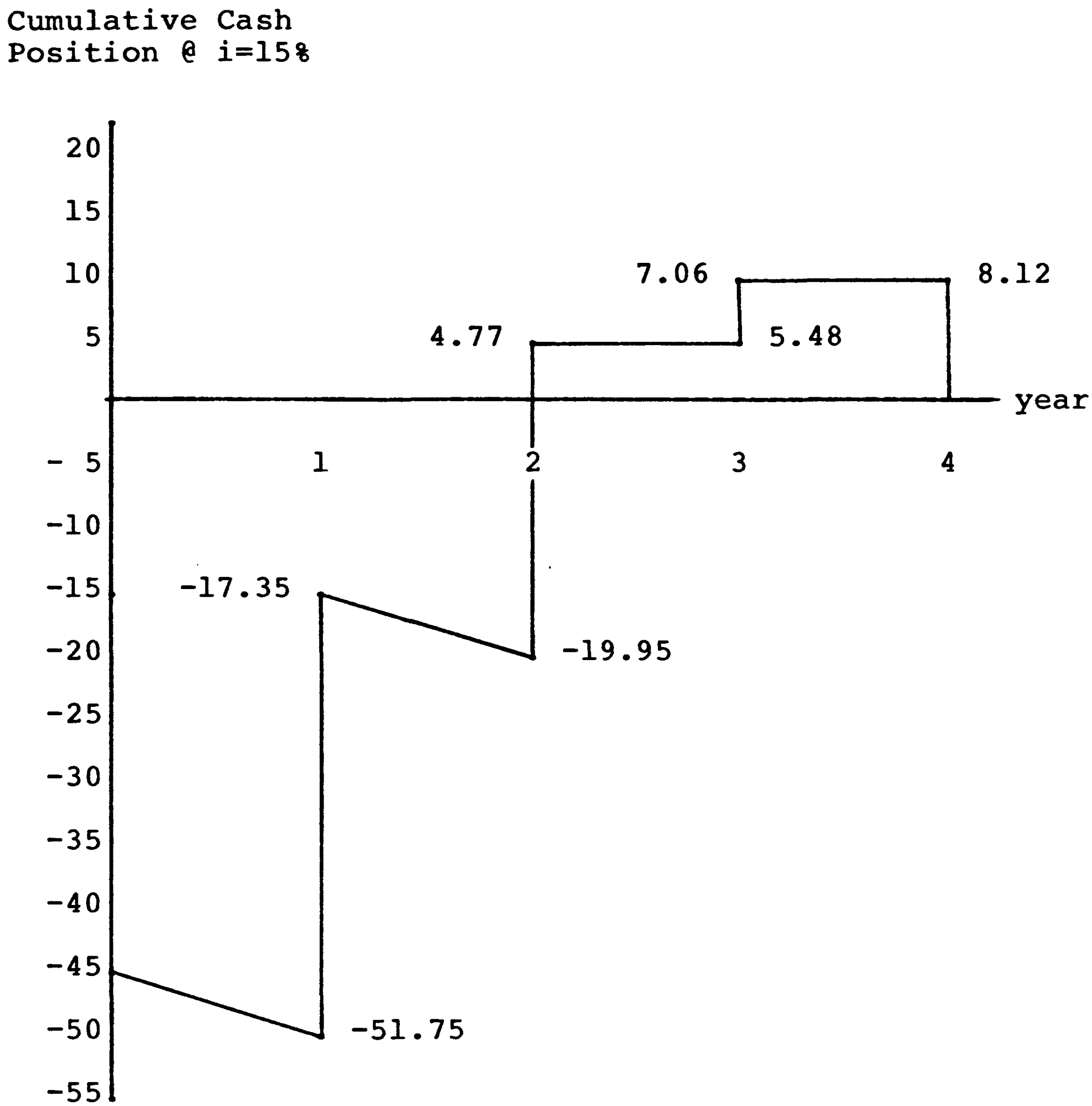


Figure 4.4 - Cumulative Cash Position Diagram @ i = 15%
(Cash Flows in thousands of dollars)

4.1, if the actual opportunities thought to exist for the use of capital are 15 percent after-taxes, then the use of this breakeven rate will satisfy the requirements for standard cost consideration. Dual "i" values have been solved, and illustrated in this example, to illustrate the necessity for using a discount rate that reflects the actual other opportunities that exist for the use of capital. It is recognized that no real-world meaning exists for rates developed using negative discount values.

As represented in Figure 4.4, the fact that cash flow is negative in the fourth year does not indicate that the owner should be selling the asset at the end of the third year. As the cumulative cash position diagram shows, after the second year the asset is generating a positive cumulative cash flow which implies that the owner is reinvesting capital to cover the cost or negative cash flow incurred in year four. Except for round-off error the revenue accrued will exactly cover the year four expense. The results of example 4.2 are summarized in Table 4.15.

These two examples have illustrated that, provided the input parameters are properly established, breakeven discounted cash flow concepts can provide equipment managers and owners with more information than a simple cost per hour. The breakeven discounted cash flow approach provides

Table 4.15 - Summary of Findings for Example 4.2

	Method of Calculation	Old Machine	New Machine
1)	Escalated $ Breakeven Costs for Constant Production Schedules Per Machine.......	$30.52	$22.72
2)	Relevant Comparison Figures Based on 100% Utilization of Productive Capacities.......	$91.56	$45.44
3)	Escalated $ Breakeven Costs for Accelerated Production Schedules Per Machine.......	$28.77	$21.84

4) The appropriate breakeven rate should always be calculated with a discount rate that reflects the other opportunities actually available for the use of capital.

a tool for monitoring the sensitivity of costs to changes in tax policy, production schedules, maintenance programs, and machine performance. In addition, potential drawbacks have been presented to allow the manager to properly evaluate and interpret results. The use of this concept in replacement decisions provides an instrument for the evaluator to account for variations in performance which is almost impossible to determine when using historical methods.

CHAPTER 5

SUMMARY AND SUGGESTIONS FOR FURTHER RESEARCH

5.1 Summary

The examples in Chapter 4 have illustrated the ease with which breakeven concepts may be applied to equipment acquisitions in determining the cost per period for operating these assets. Although the solutions were presented on an hours per annum basis, the results could have been made just as easily on an hours per month, or any equivalent unit basis. An argument often presented is that evaluations are distorted if the tax life is utilized for the equipment life. With the breakeven discounted cash flow method the actual physical life of an asset and its tax life are allowed to stand independently. Any compounding period may be used to provide the accuracy required in problems such as lease, rental, or rental purchase agreements which usually involve monthly payments. If appropriate, continuous compounding may also be applied. By accounting for variations in the level of production per period, breakeven concepts represent a straightforward approach to replacement analyses in which the benefit of present worth revenues or production for more productive types of equipment may be recognized.

Advances in equipment technology require that managers use the most advanced methods available in determining costs and in making equipment policy decisions. Equipment size and productive capabilities change as do equipment needs for efficient performance. This mandates the constant evaluation of existing assets with replacement by equipment suited to specific project characteristics. Tax policies are complex and seldom remain constant. These considerations, combined with fluctuations in the cost and methods of financing, mandate a system capable of handling the calculations while remaining flexible enough to adapt to variations over time.

The use of average cost per hour calculations on a before-tax basis, may be suitable for very small firms operating with a limited amount of equipment, but for larger firms, the use of such methods may spell financial disaster. Managers of any size firm who use the breakeven concepts in this study should possess a distinct competitive advantage as the result of better understanding of the costs associated with equipment. For larger firms, given the capital at risk to acquire new assets, failure to use these concepts in all applicable facets of the industry may result in a non-optimal level of operation.

5.2 Suggestions for Further Research

While this study has addressed the problem of evaluating individual pieces of equipment, research is still required to measure the costs incurred by a company if it chooses not to replace. Costs are not limited to the expenditures incurred for labor, parts, and overhead necessary to repair the machine. When one piece of equipment goes down for non-scheduled repairs the efficiency of other portions of a project is affected. The overall sensitivity of equipment downtime will vary with the associated equipment and the level of production. As an example, the cost of downtime for a loader or shovel will have a much greater monetary effect on a project or mining operation then that of a haul truck. If a shovel goes down, the entire truck fleet may be stopped; if one truck goes down, the operation will continue, albeit less efficiently. For mining applications, the determination of these downtime costs may be easier given a more standardized production schedule. For the contractor, variations in production over time may require an evaluation incorporating the relative probabilities of occurence and the associated cost of not operating.

While new machines may produce a much smaller increment of air pollution, the installed pollution control equipment may increase consumption of fuel and the costs of items such as filters. The cost of negative externalities such as the air pollution or excessive fuel consumption of either the new or old units should also be accounted for and incorporated into the breakeven cash flow calculations to make a proper evaluation.

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