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COMPARISON OF MACHINE RATE AND CASH FLOW APPROACHES FOR ESTIMATING FOREST HARVESTING EQUIPMENT COSTS

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SUMMARY:

A computer program was developed to calculate average equipment costs on a cash flow and machine rate basis. The program is designed for easy use in order to provide comparisons of machine rate and cash flow costs on a before- and after-tax basis. Comparisons of both methods using 1988 estimated equipment purchase and operating costs are reviewed.

KEYWORDS:

FOREST, HARVESTING, EQUIPMENT COSTS

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INTRODUCTION

Forest harvesting specialists and practitioners estimate the productivity and costs of harvesting equipment continually. Researchers analyze costs to determine the benefits of equipment use or adoption. Logging managers estimate equipment costs as one component of overall logging costs in order to help determine if they should buy new equipment or make other changes in their operations. Procurement foresters use equipment costs to help determine contract rates for independent loggers and for estimating overall company wood costs.

In estimating these equipment costs, most researchers and practitioners prefer to use as simple a method as possible. The dominant method that has been adopted over the last few decades is referred to as a machine rate calculation (Matthews 1942, Miyata 1980). This calculation is essentially a method of averaging all the fixed and operating costs for a piece of equipment over its entire life span so that they may be converted to a cost per operating or scheduled hour. The method includes fixed costs for depreciation, interest, insurance, and taxes and operating costs for fuel and lubricating oil, tires or track, and maintenance and repair. In theory, historical data are to be used for all of these components and then converted to average costs per hour. In practice, depreciation is often the only factor that is empirically based, and rules-of-thumb are often used to estimate the remaining cost components. As an alternative, surveys of logging equipment dealers and loggers have been made and published periodically in machine rate form (i.e, Plummer 1967-1982; Cubbage 1982; Werblow and Cubbage 1986; Dorris and Cubbage 1987; Burgess and Cubbage 1989; Brinker et al. 1989), which are often used by logging analysts.

While these machine rate calculations are widely accepted due to their simplicity and ease of use, they do have shortcomings. Average machine rate costs estimated for the life of a piece of equipment may not accurately reflect costs at any given point in time. Fixed costs for equipment are likely to be greater when the machine is new than when it is old and mostly depreciated. Conversely, repair and maintenance costs will tend to be less for new equipment than for old equipment. These may or may not balance each other out at any given point in the life span of a piece of equipment. This presents a particular problem to loggers who may be paid for contract harvesting at average rates. The possibility that "on the average" they may be making a profit is of little comfort if, at the moment, their high equipment costs are forcing them out of business. Forest products firms, too, are reluctant to pay average contract logging rates based on new equipment costs if loggers use mostly old equipment.

Another serious shortcoming of the machine rate approach is that the allocations for interest, insurance, and taxes are fairly arbitrary and simplistic. Interest costs are estimated as a percentage of an "average

annual investment" (AAI), which was derived by Matthews (1942). Machine rates almost always exclude any explicit consideration of the income tax treatment of equipment investments, and only include a value for property taxes and license fees. Thus, the machine rate formula is only a before-tax computation.

Butler and Dykstra (1981) and Tufts and Mills (1982) discussed these shortcomings of the machine rate formula and developed explicit models that could be used to calculate accurate costs on a cash flow basis. In theory, these methods are certainly superior to the standard machine rate. However, they have not been widely adopted by researchers in their published literature, nor one would expect, by practitioners. Perhaps this lack of adoption partially could be explained by the complexity of the method, the amount of detailed information required to perform the calculations, and the constantly changing federal income tax laws regarding equipment depreciation. Traditional adherence to machine rate approaches is easier. However, a more theoretically appropriate approach for estimating machine costs would still be worthwhile. The advent of microcomputers and their software should allow a fairly substantial increase in complexity, yet still provide considerable ease of use lacking in earlier models.

OBJECTIVES

The principal objective of this project was to develop a simple means for estimating harvesting equipment costs on a yearly cash flow before- and after-tax basis. Calculations were developed using a spreadsheet program in order to provide machine rate/cash flow comparisons that could easily contrast before- and after-tax advantages with traditional machine rate calculations.

This study was intended to build upon prior research of cash flow analyses, and automate equipment cost calculations for use on a microcomputer. It also was intended to provide a means of comparing cash flow costs to machine rate costs in general for many classes of equipment. This could provide some indication of the magnitude of differences between cash flow and machine rate equipment cost estimation methods.

COST CALCULATION METHODS

We developed a Lotus spreadsheet template program to estimate the cash flow and machine rate costs for equipment. This program requires some similar input data for calculation of both the machine rate and cash flow costs. We have termed the spreadsheet program the Fixed and Operating Cost Analysis System (FOCAS). The FOCAS cash flow method estimates machine rates and machine costs as they affect the actual cash flow and income of the owner. This requires standard machine rate inputs and the measurement of equipment costs as functions of actual cash flows and tax liabilities. The program calculates the average cash flow position, year to year, as well as the average position throughout the ownership period.

Two versions of FOCAS were developed. One model (FOCAS-1) includes only machine rate and before-tax cash flow cost calculations. This model should remain useful even if tax laws change. The second version (FOCAS-2) includes the machine rates, before-tax calculations, and an after-tax calculation. This version is correct as of 1989, but could become obsolete if federal tax laws change significantly.

The FOCAS programs use similar inputs for the machine rate algorithms and for the cash flow calculations. Fixed costs are analyzed on a yearly basis to determine the actual associated cash outflows for each year of ownership. Operating costs also are computed on a yearly basis using data entered in the FOCAS template. When possible, the program allows the user to enter actual yearly costs. Historical or estimated yearly costs are more useful than hourly averages for the life of the machine.

The FOCAS program calculates the yearly totals for fixed and operating costs and sums the data to provide yearly before-tax cash flows. These yearly cost figures are then divided by the productive machine hours to compute an hourly cash flow rate that may be compared with the previously calculated machine rate.

After-tax cash flows are calculated using the before-tax data and take into account those costs that are tax deductible and the year in which they may be deducted. These data also are totaled on a yearly basis and then divided by the productive machine hours to yield an after-tax cost rate.

The input data required are the same as used in the machine rate calculations. However, the cash flow algorithm treats those costs as they occur yearly and on both a before- and after-tax basis and, therefore, in a manner different from standard machine rate formula. This includes the treatment of fixed costs and some operating costs.

Fixed Costs

Fixed equipment costs include depreciation, interest, insurance, and taxes. These are calculated differently for machine rate and cash flow calculations, but both require some similar information. Data needs for both methods are listed below.

A. Delivered Price

The delivered price includes the purchase price of the machine, and all applicable sales, excise and property taxes included in the price of the equipment as delivered to the owner.

B. Down Payment

The down payment includes any pre-payments made to either the seller or the lender that effectively lowers the borrowed amount stated on the note, and against which interest will not be charged. This can significantly affect

periodic machine cost estimates made over the life of the machine. The down payment is assumed to reduce the amount of the machine cost financed.

C. Salvage Value

The salvage value is the residual value of an operating machine at the end of the ownership period--what one could expect to receive in sale or trade Salvage value affects depreciation during the life of the machine in machine rate calculations. In the cash flow calculations, the salvage value is treated as a cash inflow in the year of the sale or trade, which was assumed to be the year after the end of the ownership period (e.g. year 6 for 5-year equipment). Funds from salvage are taxable as income, assuming the machine is fully depreciated. If the machine is not fully depreciated, the Section 179 deduction and depreciation expense is recaptured at the appropriate rate and taxes on income (and salvage) are adjusted accordingly.

D. Ownership Period

The ownership period begins at the time liability is assumed (usually the time of the signing of the note) and ends with the disposal of the machine (i.e., sale or trade). This time period is assumed to be in terms of whole years and not to be less than the term of the note.

E. Depreciation

Depreciation is calculated considerably different in the machine rate and cash flow methods. The machine rate uses a basic straight-line method of calculating depreciation:

$$\text{Depreciation Hourly Expense} = \frac{\text{(delivered price - salvage value)}}{\text{(ownership period * usage hours)}}$$

Depreciation is not relevant in the before-tax cash flow version of FOCAS-1, since only actual fixed cost inflows or outflows (down payments, interest, principal, and salvage) constitute cash expenses or receipts. Depreciation for the after-tax approach (FOCAS-2) is calculated using the double declining rate described in the Internal Revenue Service Guidelines to Depreciation and the 1988 Modified Accelerated Recovery System (MACRS) for five year forestry equipment (Internal Revenue Service 1988). The FOCAS algorithm also uses the mid-quarter convention which bases the double declining balance calculation in the quarter in which the purchase is made. This method allows for earlier recovery of depreciation expense than the standard straight-line method used in many machine rate calculations and will produce greater tax benefits in the earlier years of the ownership period.

F. Length of Loan and Annual Interest Rate

The annual nominal interest rate (APR) is used as the charge for borrowed money. This is used in the machine rate and cash flow calculations. The machine rate uses an Average Annual Investment (AAI) computation and the interest rate to determine average interest costs over the life of a machine. The AAI formula is calculated as (Matthews 1942, Miyata 1980):

$$\text{Average Annual Investment or AAI} = \frac{(\text{delivered price} - \text{salvage value}) * (\text{ownership period} + 1)}{(2 * \text{ownership period})} + \text{Salvage value}$$

The interest is then calculated as:

$$\text{Interest Expense} = \frac{(\text{Interest rate} * \text{AAI})}{(\text{Usage hours})}$$

This formula calculates average annual interest as a function of the average yearly investment in the piece of equipment.

In the cash flow calculations, the annual interest rate is used to calculate total interest costs that vary by year. The yearly value is calculated using a Lotus macro that determines declining periodic interest payments and conversely, increasing contributions to the reduction of principal. Interest payments are tax deductible expenses and, as noted, decrease over the term of the note. The note is assumed to have no add on interest and is not discounted nor does it contain an interest buy down. The formula used in the loan payment calculation of interest and principal follows:

$$\text{Annual Payment} = \frac{i\,(1 + i)^n}{(1 + i)^n - 1}$$

where:

i = annual interest rate

n = number of years of loan

G. Productive Hours Per Year

A machine's productive hours are used to calculate average costs. This value may be calculated as an estimated percentage of scheduled hours, as a "rule of thumb" value, or actual historical hours may be used. The entry for productive hours will only include those hours in actual production and does not include major or minor maintenance or repair hours. Actual clock hours or odometer miles would be most useful in this circumstance. Charges per hour will, therefore, more accurately represent actual charges against production. Class utilization rates (i.e., Miyata 1980) may be used to convert from scheduled hours to productive hours.

H. License, Tags, and Taxes Per Year

The costs of vehicle license and tags, as levied by state and local governments, will depend upon the class of machine. Taxes include property taxes, which will generally decrease as the value of the machine decreases. License and tag charges will remain relatively stable over the life of the machine and apply to "over-the-road" equipment. The entry for these costs is assumed to be the average yearly costs over the ownership period. The machine rate formula for license, tags, and taxes is:

$$\text{License, Tags, and Taxes} = \frac{\text{(total annual license, tags, and tax expense}}{\text{(usage hours)}}$$

This same formula is used on a yearly basis for the cash flow calculations. For the cash flow approach, sales tax is treated as a tax deductible expense in the tax year the machine was purchased. Property taxes and tags also are tax deductible expenses in the year they occur.

I. Insurance Fees

Insurance costs are based on the type of machine and can vary considerably depending upon the safety record of the owner, number of machines insured, location, and other considerations. The costs also can vary over time, but for this analysis are assumed to be stable over the ownership period. These costs include insurance against fire, theft, vandalism, and liability for highway equipment. The entry for insurance in this case should be the average total cost for one machine for one year. Insurance costs also are tax-deductible. The machine rate and cash flow methods compute the average insurance cost as:

$$\text{Insurance Hourly Cost} = \frac{\text{(total annual insurance cost)}}{\text{(usage hours)}}$$

The total annual insurance cost usually is calculated based on a price per $100 in value of the machine. It is assumed that yearly costs are calculated on this basis, or historical data can be used.

J. Section 179 Deduction

The Section 179 income tax deduction is allowed in the first tax year (Internal Revenue Service 1988). The value of this deduction is not to exceed $10,000 or the current year's income, and is reduced by one dollar for every dollar in excess of $200,000 spent on equipment. The FOCAS calculations account for these trade-offs of income and deductions for an individual machine and allocate the appropriate sum to the reduction of the first year's tax liability. Should the equipment be slavaged before being fully depreciated, an appropriate portion of the 179 deduction is recaptured in the program calculations.

K. Federal Tax Rate

The default value for the tax rate is assumed to be the corporate tax rate of 34% for the current tax year analyzed (1988). The personal tax rate of 28%, or any other applicable value, may be entered in lieu of the corporate rate. These tax rates are used to determine the after-tax cash flow. State tax effects may be approximated by adding their percentage rate to the relevant federal rate. For example, for a federal personal tax rate of 28% and a state tax rate of 4%, one would use a 32% personal total income tax rate.

L. Discount Rate

The nominal discount rate is used to calculate time adjusted before- and after-tax cash flows. Cash flows are discounted from the quarter taxes are due (for ease of calculation this is assumed to be ½ year after the close of the tax year). A default value of 8% is used if no current value is entered.

Operating Costs

Operating cost may be based on historical data or on traditional rules-of-thumb. If one uses only rules-of-thumb, the operating costs for the machine rate and cash flow approaches will be almost the same. If historical data are used, the cash flow method averages will differ each year; the machine rate will, by definition, have the same averages for all years of ownership. Descriptions of the data needed follow.

A. Fuel and Lubrication

The rate of fuel consumption in gallons per hour is often calculated as a function of horsepower, but will depend upon the age of the equipment, the conditions under which the machine must operate, and machine requirements. Fuel consumption rates may be obtained from dealer specifications, loggers' records, or may be calculated using one of the methods outlined in Miyata (1980), Plummer and Stokes (1983a, 1983b), or Brinker et al. (1989). Actual historical records are the best source of consumption data as estimated or projected data is likely to be less accurate. Fuel costs are then calculated as follows:

Hourly Fuel Cost = (fuel consumption in gallons per hour * price/gallon).

If total fuel expense for a past year of operation of a like machine is available, hourly cost may be calculated as:

Hourly Fuel Cost = (total fuel expense/usage hours).

The number of gallons of lubrication and oil consumption is needed for engine oil, transmission fluid, rear drive oil, hydraulic fluid, grease, and coolant (according to regular maintenance schedules), to calculate lube and oil expense as follows:

Lube and Oil Costs = (lube & oil consumption in gallons per hour * price/gallon).

If a dealer specified or actual rates of consumption are unknown, but total expenditures and quantities for lubrication are available, average estimates may be calculated as total expenses or gallons for all fluids divided by usage hours. Miyata's (1980) rules-of-thumb may also be used.

B. Maintenance and Repair

Maintenance and repair costs usually increase as machines get older. The FOCAS programs allow yearly costs to be entered as an average machine rate

when actual data or reliable yearly estimates are not available. The average maintenance and repair costs for the life of a machine are then converted into different yearly rates per hour, based on the trends in repair costs over time reported by Caulfield and Tufts (1989). The hourly rates will be multiplied by the usage hours per year to obtain average yearly costs. Specific data may be entered on a year by year basis if available. This would reflect actual cash flows if accurate historical records are available. These costs are then treated as any expense and are deducted in the applicable tax year. The costs per hour are calculated as:

$$\text{Maintenance and Repair} = \frac{\text{(yearly maintenance costs)}}{\text{(usage hours)}}$$

This includes all expected repair and overhaul expenditures per year. If actual hourly costs are unknown, but total averaged yearly expenditures are available, estimates may be calculated as total expense ÷ usage hours. Maintenance and repair costs may be estimated as a function of straight line depreciation, as in Miyata (1980) and the Forestry Handbook (Wenger 1984). Note that estimation of equipment maintenance and repair costs on an average basis probably will lead to an overstatement of costs in early years and an understatement in later years.

C. Tire Costs and Tire Life

For the initial set of tires, costs are assumed to be fixed. They are included in the delivered price, as some portion of the amount financed (accounting for down payments), and are depreciated over the ownership period. This approach differs from Miyata's machine rate approach in which the costs are subtracted from purchase price, but is necessary to make the after-tax calculations. As initial tire life expires, subsequent tire costs are calculated by a Lotus macro. This macro charges a tire account each time usage hours exceed tire life hours. Costs for a set of tires are entered by the user and are assumed to be unchanged throughout the ownership period. Track costs are handled in the same manner as tire costs. However, replacement prices should include an average periodic cost of replacing undercarriages as well as the more frequent replacement of treads, pins, and sprockets. Thus, track average period costs represent a longer replacement interval. It should be noted that this expense does not include any charges for general maintenance. Costs may be calculated as:

$$\text{Tire or Track} = \frac{\text{(yearly tire or track expenditures)}}{\text{(usage hours)}}$$

Estimates of tire or track cost will vary according to quality of replacement equipment, terrain, amount of abuse, and number and type of parts replaced. It is important to make estimates based upon data relating to "like quality" replacement equipment where actual historical cost data are not available. If actual costs are unknown, the formulation found in Miyata may be used as an alternative method of calculation of hourly data.

The summing of the hourly fixed cost and the hourly operating costs will provide an estimate of total hourly machine rate costs--an average estimate of equipment costs over the entire ownership period.

After-Tax Computations

The after-tax computations employ that data which has already been compiled in the Lotus spreadsheet for before-tax cash flows. Since the costs incurred in the first tax year will not affect tax liability until returns are filed sometime after the close of that year, realized benefits (owner receipt of tax returns) are assumed to be offset by a half year. For example, costs incurred from January 1, 1988 to December 31, 1988 will not have any effect upon the tax liability (cash position) of the owner until tax returns are filed sometime in 1989 (assuming taxes are not paid on a quarterly basis). Therefore, all tax computations take into account this estimated half-year lag and expenses will yield tax benefits in the year after they are incurred.

All applicable expenses are multiplied by the user-entered corporate or personal tax rate to realize the acutal reduction in income tax liability. The yearly values for the fixed and operating cost are then summed providing and actual total cash flow accounting of yearly expenses. These values can then be divided by the productive machine hours, resulting in an after-tax value that can be compared with both the standard machine rate and the before-tax hourly cash flows.

SPREADSHEET TEMPLATES

The FOCAS cost analysis programs were developed as a Lotus spreadsheet template. The templates use instructional menus, Lotus macros, and cost algorithms to guide users through performance of the cost calculations. The FOCAS programs facilitate data entry, interpretation of output, and comparison of alternative scenarios. Full screen menus direct the user to initiate Lotus macros that print an introduction and operating instructions, call for data entry, calculate costs, or print machine rate/cash flow comparison output. The templates also allow the user to move through the entry cells in order to make corrections or alter scenarios as desired. Two data entry templates provide the same base data (except where previously noted) to both the machine rate and cash flow algorithms. The input and use of data into each of the data entry screens is described below.

Loan Data Entry

The loan data screen allows the user to enter specific equipment information concerning the fixed cost associated with the equipment purchase, i.e. loan payments, taxes, etc.

Machine Type.--This is the equipment description which will appear on the printed output to be used for future reference.

Price of Machine.--This value represents the "delivered" price of a particular piece of equipment and includes purchase price, transportation costs and all relevant sales taxes. This value is used as a basis for all fixed cost calculations.

Down Payment.--The down payment includes all pre-payments applied to the sales price of the equipment that effectively reduces the total amount financed.

Salvage Value.--The residual value of the equipment at the end of the stated life (projected or actual years of use by the owner) of the equipment is the salvage value. "Rules-of-thumb" indicate this value generally to be between 20% to 25% of the delivered price depending upon condition and age. Early or sale would normally command a higher salvage value. We used 25% for our analyses.

Local Sales Tax Rate.--State and local tax rates are applied to the purchase price of the machine. These are used to calculate after tax cash flows. A default value of 3% is provided if actual value is unknown.

Length of Loan in Years.--This is the term of the note, expressed in years, from the date of purchase to satisfaction of commitment to the lender. The length of note is used to calculate loan payment (interest charges and principal) and tax liabilities.

Interest Rate of Note.--The interest rate is assumed to be the stated, nominal, fixed annual percent interest rate of the note used to calculate payments. A default of 11% is provided.

Month Purchased.--The month purchased must be entered as a value from 1 to 12. It is used to calculate a portion or portions of a year or years to which costs are to be applied. If no data are entered, January 1 is assumed to be the purchase month.

Operating Cost Data Entry

The operating costs section records data required to calculate those costs which are normally associated with daily operation of the equipment, and the fixed costs of taxes and insurance as well. Operating costs generally vary with use. These costs include fluid use, maintenance and repair, and tire or track costs. They do not include allowances for abnormal damage incurred or major repair beyond that expected through normal use.

Average Horsepower.--Equipment horsepower is entered on the spreadsheet for information purposes only, and not used in the template calculations.

Productive Machine Hours.--This is the actual hours of production and does not include hours spent undergoing maintenance or repair downtime.

Discount Rate.--The nominal discount rate is used to calculate time adjusted cash flows. If no current rate is available, a default value of 8% is provided.

Years of Use.--This represents the period, in years, over which the machine is productive in which variable costs are incurred. This period must be 6 years or greater in length to avoid recapture of Section 179 deduction assuming that equipment is depreciated as 5 year forestry equipment. This value is used to provide average machine rate costs over the ownership period and to determine the number of years in which cash flows are calculated.

Fuel Consumption and Cost.--Historical, dealer, literature, or calculated fuel use and costs may be used. This rate is used to determine the total and hourly expense for machine rate and cash flow calculations. Horsepower data may be used to calculate fuel usage data by hand. Template instructions may be printed that state how to make these calculations. These costs will be slightly less for new equipment than for old equipment. The FOCAS programs will calculate these yearly differences from the average for all years based on historical data. Users may also enter their own percentage differences for each year.

Oil and Lube Consumption and Cost.--These costs include engine, transmission, and final drive oil, filters, grease, coolant, and hydraulic fluid. The costs are treated the same for the machine rate as for the before-tax cash flows. These costs also may be estimated using rules-of-thumb if accurate historical data are unavailable.

Cost of Tires or Track and Life.--One must enter the replacement cost for complete set of tires (as originally equipped) or track (treads, pins, or sprockets) and tire or track life (in hours). The machine rate for these values is a simple hourly average, whereas the cash flow program uses a LOTUS macro to allocate charges on an annual basis based on equipment use per year.

Federal Tax Rate.--The current corporate tax rate (34%), personal tax rate (28%) or any other relevant rate may be used to determine effect of operating costs reduction of taxable income. A default rate of 34% is incorporated into the program.

Section 179 Deduction.--The current 1988 tax law allows initial reduction of equipment value affecting depreciation (MACRS) and taxable income. This entry affects only the cash flow portion of the program and a default of the $10,000 maximum is provided.

Insurance & License, Tags, and Taxes.--These costs include average yearly insurance charges and local and state costs of permits to operate and local property taxes. These costs are calculated on the same basis for machine rate and cash flow methods.

Maintenance and Repair.--Estimates of maintenance and repair include planned simple maintenance and periodic overhaul of major components. Users may enter an approximate average hourly value or yearly costs as desired. Machine rate formulas will calculate an average hourly value. Cash flow formulas will calculate a yearly charge when specific yearly values have been entered. Otherwise, hourly values will be multiplied times the total yearly average productive hours.

Average hourly cost for the life of a machine may also be converted into different costs per hour for each year, as described before. Users may also enter an average cost per hour for all years, and their own percentage differences in each year. Users should only enter an average cost per hour or total costs per year, not both.

ANALYSES

The FOCAS program was used to make before- and after-tax cash flow and machine rate calculations for a variety of timber harvesting equipment. The equipment classes analyzed included feller bunchers, skidders, loaders, road work equipment, and trucks of various sizes. The equipment classes used by Burgess and Cubbage (1989) for 1988 machine rate calculations were also used in the FOCAS program. The mid-point of each equipment horsepower size class was used in calculating costs (i.e., 110 horsepower for a 100 to 120 horsepower class). A specific horsepower value was needed to calculate the fuel and oil consumption rates.

For each of the equipment types and size classes, the average machine rate cost per hour and the average yearly cash flow cost per hour were calculated. The results provided the basis for making comparisons between the two cost calculation approaches. Table 1 summarizes the machine classes analyzed, the purchase price and usage, the assumptions, and the average hourly costs for the machine rate; and before- and after-tax cost average hourly costs for all years. Machines that had a delivered price that was so high or low as to greatly distort the class averages were removed from the analysis in Table 1. They include the tracked feller buncher and the lowboy trailer for their higher than class average and the bigstick cable loader and half-ton pickup truck for their lower than class average. Table 2 summarizes the hourly machine rate and cash flow cost for each year.

The results summarized in Table 1 include before- and after-tax cash flow averages. The before-tax average consists of all average costs per year (for the number of years owned plus the benefit of salvage in the next year) divided by the number of years owned. This represents a weighted average cash cost per hour for all costs or receipts for a piece of equipment. The after-tax cost calculation represents the cash flow costs minus the tax benefits. It is reported for both the number of years in the ownership period (to compare with the before-tax data) and for the entire time that cash flows occur (the ownership period plus two years--one for salvage and one for tax on the salvage).

RESULTS

The FOCAS cost calculations of overall class averages indicated that before-tax cash flow costs were generally higher than might be predicted by average machine rates over the life of a 3 year note (i.e., feller bunchers 23%, cable skidders 35%, grapple skidders 31%, and loaders 43%). After-tax

Table 1. Estimated FOCAS Program Equipment Machine Rate and Cash Flow Costs, 1988

Equipment	Delivered Price ($)	Salvage Value ($)	Years Owned	Hr(Mi) /Yr	Average Machine Rate	Average Cash Flow Costs By Years Owned B. T.	A. T.	By Tax Yrs. A.T.
						($/Hr or Mi)		
Feller bunchers								
3 wheel 56hp	67000	16750	3	1300	25.37	23.65	21.33	11.28
Small 75hp	77200	19300	3	1300	31.13	28.72	25.81	13.60
Medium 90hp	79000	19750	4	1300	28.85	26.30	21.95	12.60
Large 120hp	115043	28760	4	1300	39.18	35.83	30.11	17.29
Machine type Avg.	84560	21140	3.5	1300	31.13	28.62	24.80	13.69
% of Mach. rate						92%	80%	44%
Cable skidders								
75 hp	46700	11675	4	1300	18.73	17.08	14.09	8.10
90 hp	55275	13818	4	1300	21.38	19.50	16.14	9.28
110 hp	66092	16523	5	1200	23.63	21.24	16.85	10.26
130 hp	71703	17925	5	1200	27.40	24.75	19.57	11.94
165 hp	83755	20938	5	1200	32.44	29.38	23.23	14.17
Machine type Avg.	64705	16176	4.6	1240	24.72	22.39	17.98	10.75
% of Mach. rate						91%	73%	43%
Grapple skidders								
80 hp	66222	16555	4	1300	27.63	25.00	20.70	11.86
100 hp	75532	18883	4	1200	31.74	28.94	24.06	13.80
120 hp	86781	21695	4	1200	35.06	32.04	21.46	15.33
165 hp	95021	23755	5	1200	36.76	33.30	26.37	16.06
Machine type Avg.	80889	20222	4.3	1225	32.80	29.82	23.15	14.26
% of Mach. rate						91%	71%	43%
Forwarders								
90 hp	63800	15950	4	1300	28.97	26.13	21.53	12.32
125 hp	82265	20566	4	1300	34.89	31.62	26.17	14.99
Machine type Avg.	73032	18258	4.0	1300	31.93	28.87	23.85	13.66
% of Mach. rate						90%	75%	43%
Knuckleboom Loaders*								
Sm 9-15K1b 90hp	30000	7500	5	1000	13.64	12.44	9.84	6.00
Md 15-23K1b 125hp	53837	13459	5	1000	23.00	20.90	16.66	10.09
Lg 23-33K1b 160hp	79478	19869	5	1000	32.52	29.46	23.60	14.25
Machine type Avg.	54438	13609	5.0	1000	23.05	20.93	16.70	10.11
% of Mach. rate						91%	72%	44%
WT chippers								
Med. to 350 hp	247700	61925	5	1500	63.99	57.76	44.59	26.66
Lg. 500 hp	259700	64925	5	1500	74.75	68.02	51.92	31.20
Machine type Avg.	253700	63425	5.0	1500	69.37	62.89	48.26	28.93
% of Mach. rate						91%	70%	42%

Equipment	Delivered Price ($)	Salvage Value ($)	Years Owned	Hr(Mi) /Yr	Average Machine Rate	Average Cash Flow Costs By Years Owned B. T.	By Years Owned A. T.	By Tax Yrs. A.T.
						($/Hr or Mi)		
Road work equip.								
Sm. dozer 80 hp	51300	12825	5	1200	21.34	18.93	14.87	9.12
Md. dozer 140 hp	103242	25810	5	1200	33.56	30.16	23.85	14.42
Grader 140 hp	113422	28355	5	1250	34.22	30.87	24.90	14.97
Machine type Avg.	89321	22330	5.0	1217	29.71	26.65	21.21	12.84
% of Mach. rate						90%	71%	43%
Trucks								
Dead tndm bob.	25600	6400	3	24K	1.11	1.36	0.81	0.44
Live tndm bob.	31800	7950	4	24K	1.25	1.51	0.93	0.54
Diesel trctr.	59000	14750	5	60K	0.85	0.81	0.62	0.38
1-ton service	27850	6962	3	25K	0.82	0.77	0.65	0.34
Machine type Avg.	36062	9015	3.8	33.3	1.11	1.11	0.75	0.43
% of Mach. rate						110%	75%	42%
Trailers								
Shortwood	10500	2625	8	50K	0.13	0.13	0.06	0.06
Dble-deck log	10667	2666	8	50K	0.14	0.13	0.06	0.06
Pole	9966	2491	8	50K	0.13	0.13	0.06	0.06
Chip van	19966	4991	8	37.5K	0.20	0.19	0.10	0.09
Machine type Avg.	12774	3193	8.0	46.9	0.15	0.14	0.07	0.07
% of Mach. rate						95%	46%	46%

Note: B. T. = Before-tax cash flow analysis, average costs for all years.
A. T. = After-tax cash flow analysis; average costs just for ownership years (by years owned) or for all years (by tax years).

cash flows are equal to or marginally less for equipment class averages over the same period of time (0 to 6%). As the time period was extended to include the ownership period and then beyond to the last tax benefit period, cash flow costs fell below the machine rate average (Table 2).

For example, at the time of the expiration of the 3 year note the average class machine rate for feller-bunchers was $31.13 while the before-tax and after-tax cash flows were $38.30 and $29.21 respectively (4 year ownership period). As would be expected, when the analysis was extended to include those years between the end of the note and the end of the ownership period cash flow costs fell further. When the ownership period extended one year beyond the end of the note or 4 years (assuming 3 year note), the average machine rate for feller-bunchers remained at $31.13, while the after-tax cash flow costs fell to $20.84. When the after-tax cash flows were calculated to the last period in which a tax impact is realized (the sixth year), the average rate fell to $14.33. This additional benefit is caused by the cash inflows from the sale of the used machine, and by the tax benefits realized beyond the tax year in which the expenses were incurred.

The table below characterizes the average hourly cost for some selected classes of equipment studied.

		Ownership period (4-5 years)		Tax period (5-7 years)
Class	Machine Rate	Before-Tax	After-Tax	After-Tax
	average cost ($/hour)			
Loaders	23.06	20.93	16.70	10.11
Cable Skidder	24.72	22.39	17.98	10.75
Grapple Skidders	32.80	29.82	23.15	14.26
Roadwork Equip.	29.71	26.65	21.21	12.84

Class average data may be somewhat misleading when applying comparisons to different machine sizes within a particular class. These averages, when calculated to the end of the ownership period, may be distorted when machines have different ownership periods or length of loans.

Within class cash flow costs seem to reinforce the pattern indicated in the class averages as costs drop below the machine rate average upon termination of the note (Figures 1 and 2). Larger equipment requires a larger investment, which provides greater early tax deductions for interest expense. The Section 179 deduction also provides a fairly large tax benefit early in the ownership period, as demonstrated by reduced cash flow costs in the second year of ownership (assuming equipment is to be fully depreciated). During the third year, note payments are primarily composed of principal, and non-deductible costs increase. As the note is satisfied and capital expenses cease, deductible operating costs become the main expense charged against income and cash flow costs begin to fall again.

Equipment purchased with loans that exceed 3 years will have lower yearly before- and after-tax cash flows than machines with three year notes

Table 2. Estimated FOCAS Program Equipment Machine Rate and Cash Flow Costs, 1988

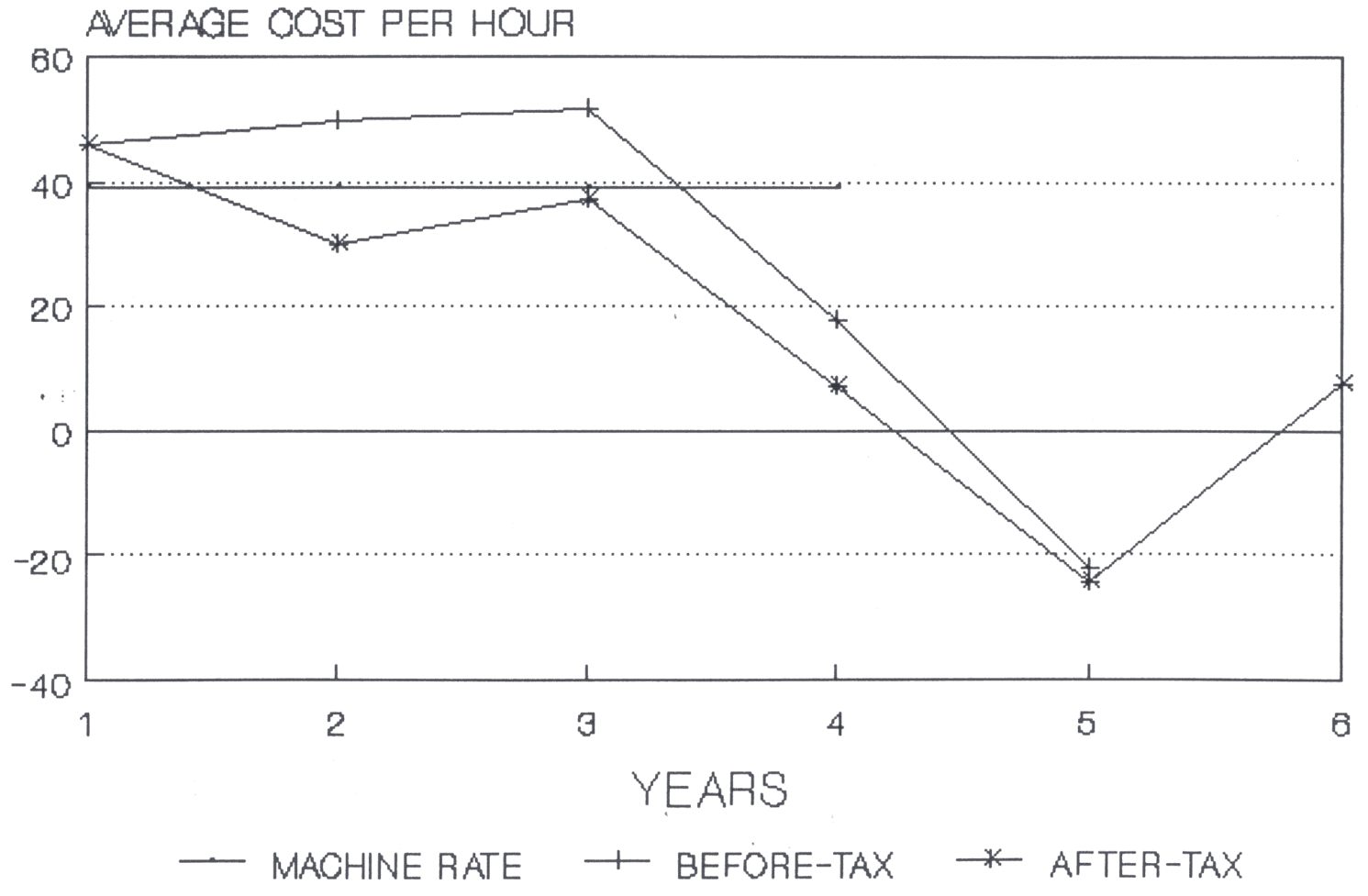
Equipment	Machine rate average	ESTIMATED CASH FLOW COSTS BY YEAR: Yearly cash flows before taxes 1	2	3	4	5	6	7	Average for All Years of Ownership	Yearly cash flows after taxes 1	2	3	4	5	6	7	Average for All Tax Years
	Total cost per hour (mile)																
Feller bunchers																	
3 wheeled 56 hp	25.37	26.16	28.36	29.30	-12.88	0.00	0.00	0.00	23.65	26.16	16.44	21.38	-11.96	4.38	0.00	0.00	11.28
Sm. rubber-tired 65-82 hp	31.13	31.11	34.25	35.65	-14.85	0.00	0.00	0.00	28.72	31.11	20.44	25.88	-14.48	5.05	0.00	0.00	13.60
Md. rubber-tired 83-100 hp	28.85	32.45	35.81	37.42	14.70	-15.19	0.00	0.00	26.30	32.45	21.51	27.15	6.68	-17.34	5.17	0.00	12.60
Lg. rubber-tired 110-130 hp	39.18	46.12	49.74	51.65	17.94	-22.12	0.00	0.00	35.83	46.12	30.08	37.20	7.05	-24.21	7.52	0.00	17.29
Average	31.13	33.96	37.04	38.51	1.23	-18.66	0.00	0.00	28.62	33.96	22.12	27.90	-3.18	-8.03	4.23	0.00	13.69
Cable skidders																	
70-80 hp	18.73	20.03	22.75	23.87	10.63	-8.98	0.00	0.00	17.08	20.03	13.31	17.54	5.46	-10.79	3.05	0.00	8.10
80-100 hp	21.38	23.44	26.21	27.42	11.56	-10.63	0.00	0.00	19.50	23.44	15.44	20.04	5.65	-12.48	3.61	0.00	9.28
100-120 hp	23.63	29.62	32.48	33.75	12.79	11.35	-13.77	0.00	21.24	29.62	19.14	24.56	5.65	5.26	-17.06	4.68	10.26
120-140 hp	27.40	33.10	36.54	38.29	16.06	14.70	-14.94	0.00	24.75	33.10	21.90	27.81	7.72	7.32	-19.34	5.08	11.94
140 hp	32.44	39.15	42.95	45.09	19.23	17.95	-17.45	0.00	29.38	39.15	25.99	32.63	9.29	9.11	-22.91	5.93	14.17
Average	24.72	29.07	32.19	33.68	14.05	4.88	-15.39	0.00	22.39	29.07	19.16	24.52	6.75	-0.32	-10.53	5.23	10.75
Grapple skidders																	
70-90 hp	27.63	28.64	32.70	34.72	16.68	-12.74	0.00	0.00	25.00	28.64	19.95	25.31	8.99	-15.97	4.33	0.00	11.86
90-110 hp	31.74	34.50	38.61	40.67	17.70	-15.74	0.00	0.00	28.94	34.50	23.41	29.54	8.77	-18.79	5.35	0.00	13.80
110-130 hp	35.06	39.20	43.23	45.23	18.50	-18.08	0.00	0.00	32.04	39.20	26.19	32.81	8.66	-21.01	6.15	0.00	15.33
130 + hp	36.76	44.13	48.51	51.04	21.93	20.70	-19.80	0.00	33.30	44.13	29.63	36.88	10.63	10.59	-26.15	6.73	16.06
Average	32.80	36.62	40.76	42.94	18.70	-6.47	-19.80	0.00	29.82	36.62	24.80	31.14	9.24	-11.30	-2.58	6.73	14.26
Forwarders																	
80-100 hp	28.97	28.78	33.33	35.72	18.97	-12.27	0.00	0.00	26.13	28.78	20.58	26.05	10.71	-16.36	4.17	0.00	12.32
120-130 hp	34.89	36.35	41.01	43.63	21.29	-15.82	0.00	0.00	31.62	36.35	25.32	31.64	11.35	-20.11	5.38	0.00	14.99
Average	31.93	32.57	37.17	39.68	20.13	-14.05	0.00	0.00	28.87	32.57	22.95	28.85	11.03	-18.24	4.78	0.00	13.66

Equipment	Machine rate average	Yearly cash flows before taxes							Average for All Years of Ownership	Yearly cash flows after taxes							Average for All Tax Years
		1	2	3	4	5	6	7		1	2	3	4	5	6	7	
	Total cost per hour (mile)																
Knuckleboom Loaders																	
Sm. hyd. (9000-15000 lb max.)	13.64	16.91	17.87	18.91	7.92	8.11	-7.50	0.00	12.44	16.91	9.14	14.32	4.14	4.67	-9.74	2.55	6.00
Md. hyd. (15000-23000 lb max.)	23.00	29.11	30.82	32.50	12.61	12.90	-13.46	0.00	20.90	29.11	17.32	23.99	5.90	6.98	-17.22	4.58	10.09
Lg. hyd. (23000-33000 lb max.)	32.52	41.97	44.32	46.58	16.95	17.35	-19.87	0.00	29.46	41.97	25.79	33.99	7.27	8.98	-25.02	6.76	14.25
Average	23.05	29.33	31.00	32.66	12.49	12.79	-13.61	0.00	20.93	29.33	17.42	24.10	5.77	6.88	-17.33	4.63	10.11
Whole-tree chippers																	
Md. W-T chipper (18"-20", 300-400 hp)	63.99	86.52	89.47	92.98	30.90	30.22	-41.28	0.00	57.76	86.52	50.54	63.66	9.64	12.60	-50.39	14.04	26.66
Lg. W-T chipper (20"-23", 500 + hp)	74.75	96.08	100.13	105.02	41.28	40.87	-43.28	0.00	68.02	96.08	56.79	71.53	16.07	19.11	-55.93	14.72	31.20
Average	69.37	91.30	94.80	99.00	36.09	35.55	-42.28	0.00	62.89	91.30	53.67	67.60	12.86	15.86	-53.16	14.38	28.93
Road work equipment																	
Sm. dozer-80 hp	21.34	23.37	25.24	26.83	18.15	11.75	-10.69	0.00	18.93	23.37	14.35	19.85	12.50	4.29	-14.17	3.63	9.12
Md. dozer-140 hp	33.56	45.52	45.18	46.91	20.52	14.16	-21.51	0.00	30.16	43.52	26.33	34.01	11.10	4.28	-25.61	7.31	14.42
Road grader-135 hp	34.22	45.59	48.92	50.69	15.77	16.08	-22.68	0.00	30.87	45.59	29.31	36.59	5.38	7.63	-27.43	7.71	14.97
Average	29.71	38.16	39.78	41.48	18.15	14.00	-18.29	0.00	26.65	37.49	23.33	30.15	9.66	5.40	-22.40	6.22	12.84
Trucks																	
Dead tandem bobtail	1.11	0.97	1.10	1.14	0.86	0.83	-0.27	0.00	1.36	0.97	0.65	0.82	0.57	0.51	-0.53	0.09	0.44
Live tandem bobtail	1.25	1.23	1.36	1.41	1.03	1.00	-0.33	0.00	1.51	1.23	0.82	1.01	0.67	0.61	-0.65	0.11	0.54
Diesel tractor	0.85	0.89	0.95	1.02	0.70	0.72	-0.25	0.00	0.81	0.39	0.59	0.73	0.43	0.45	-0.48	0.08	0.38
1-ton service	0.83	0.82	0.88	0.90	-0.28	0.00	0.00	0.00	0.77	0.82	0.48	0.66	-0.33	0.09	0.00	0.00	0.34
Average	1.01	0.98	1.07	1.12	0.58	0.64	-0.21	0.00	1.11	0.98	0.64	0.81	0.34	0.42	-0.55	0.09	0.43
Trailers																	
Shortwood	0.13	0.15	0.16	0.17	0.10	0.10	-0.05	0.00	0.13	0.15	0.06	0.14	0.07	0.07	-0.08	0.02	0.06
Double-deck log	0.14	0.15	0.16	0.17	0.10	0.10	-0.05	0.00	0.13	0.15	0.06	0.14	0.07	0.07	-0.08	0.02	0.06
Pole	0.13	0.15	0.16	0.17	0.10	0.10	-0.05	0.00	0.13	0.15	0.06	0.13	0.07	0.07	-0.08	0.02	0.06
Chip van	0.22	0.25	0.32	0.33	0.07	0.12	-0.13	0.00	0.19	0.25	0.16	0.25	0.01	0.09	-0.16	0.05	0.09
Average	0.16	0.18	0.20	0.21	0.09	0.11	-0.07	0.00	0.14	0.18	0.09	0.17	0.06	0.08	-0.10	0.03	0.07

Note: Equipment data taken from Table 1. Negative costs indicate positive cash flows (revenues), due to tax benefits or used equipment sales.

Figure 1

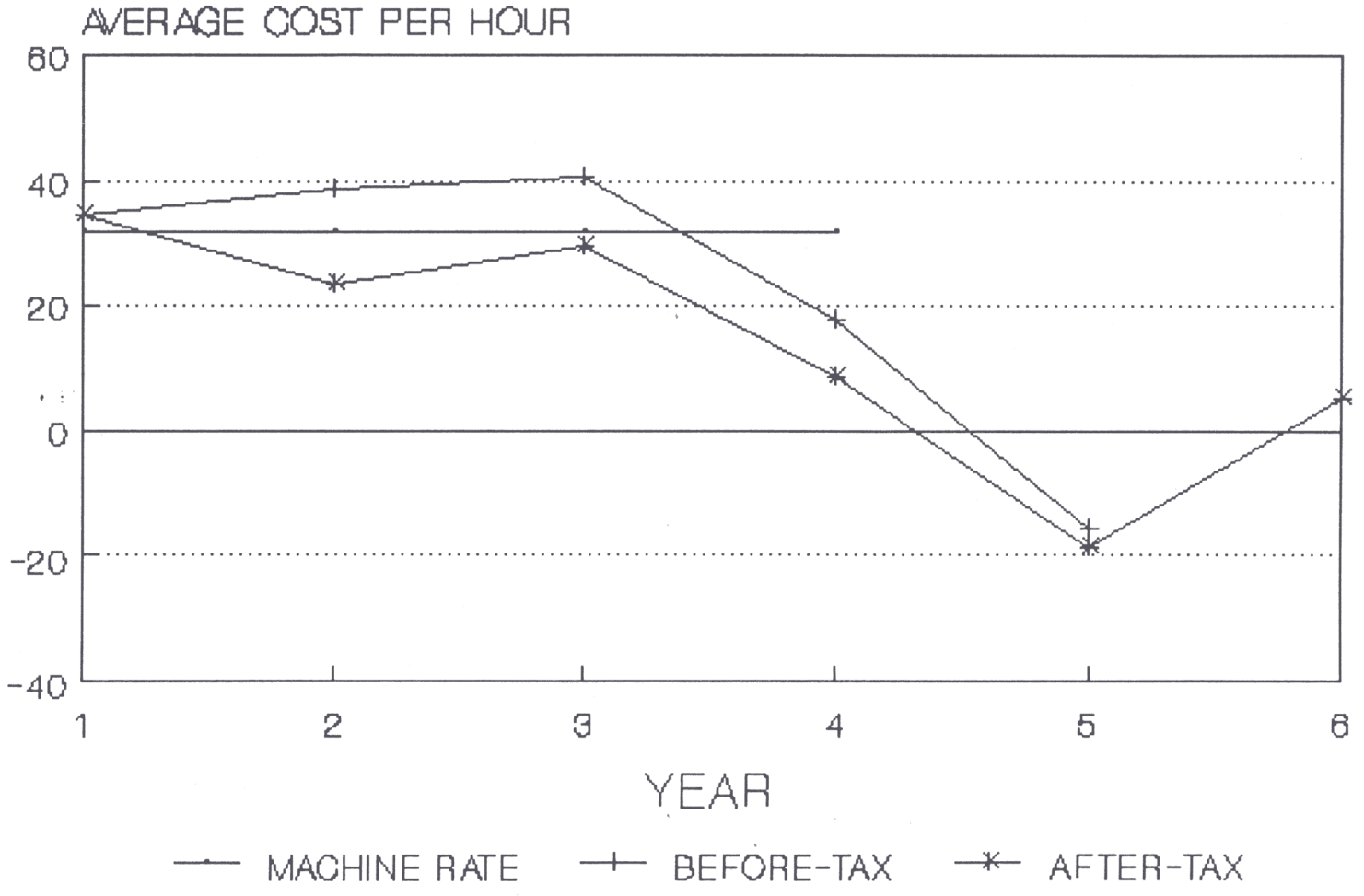
CASH FLOW AND MACHINE RATE COSTS
LARGE FELLER BUNCHER



1988 DOLLARS, 3 YEAR LOAN

Figure 2

CASH FLOW AND MACHINE RATE COSTS
MEDIUM GRAPPLE SKIDDER



1988 DOLLARS, 3 YEAR LOAN

for the first three years. After that time, costs for the longer note generally exceed those of the shorter one. The following table compares 3 versus 5 year loans for one machine:

Grapple Skidder 120 Hp. Note Length		Year 1	2	3	4	5	6	7
		average cost ($/hour)						
3 years	Before-tax	49.85	51.52	51.52	19.12	17.45	-19.8	---
5 years		38.88	40.54	40.54	40.54	38.88	-19.8	---
3 years	After-tax	49.85	30.69	36.33	7.65	8.30	-25.05	6.73
5 years		38.88	19.34	24.54	27.88	28.12	-25.85	6.73

For individual pieces of equipment, cash flow costs appear to increase at a rate similar to the rate of increase in delivered price as we move to larger machines (around 5% to 12% difference). In general, there is no obvious benefit to owning a larger versus a smaller machine in term of leaps in cash flow benefits; rather overall cost benefits appear to be somewhat linear. However, smaller machines generally had a lower average cash flow cost/hour/unit horsepower than larger machines. This would also indicate that overall class averages were slightly weighted towards the larger machines with higher horsepowers.

Between class differences are difficult to compare because of the different types of machines, costs, horsepowers, and applications. Generally, the average before-tax cash flow costs were about 90% of estimated machine rate costs over the ownership period and between 42% and 46% of the machine rate cost over the tax benefit period. Cable skidders and knuckleboom loaders exhibited the lowest class average after-tax cash flow costs ($10.75 and $10.11), whole-tree chippers the highest ($28.93), and feller bunchers and grapple skidders about equal ($13.69 and $14.26, respectively).

CONCLUSIONS

Cost Calculation Methods

Cash flow analysis of new equipment purchases is obviously important. This analysis indicated that cash flows vary widely over the period of equipment ownership and receipt of tax benefits. This fluctuation will certainly impact yearly income and should influence logger budgeting decisions and timing of equipment purchases.

Is the cash flow approach better than the machine rate in predicting average costs throughout the entire ownership period? The answer to this question depends upon a number of considerations, the principal ones being the accuracy of the input data, the length of the note, and whether the logger can continue to operate in the long run while possibly incurring short run yearly losses.

The length of the note is important because, according to this analysis, only during the last year of the three year note (generally speaking) does the machine rate approximate the averaged after-tax cash flow rate. After that time, the machine rate overestimates expected cash yearly costs. The FOCAS analysis conducted with specifically selected equipment demonstrates that for five year notes the machine rate will overstate cash flow costs after the first year. This indicates the machine rate is less accurate for estimating costs for longer term notes.

The ability of the logger to operate in the "red" for periods of a year or longer will determine the long-term success of the operation. While it is true that after-tax cash flow costs are often lower than the machine rate in the second and subsequent years, the logger in the short term must bear large before-tax cash costs. After-tax benefits are only realized after the tax year has expired and often income tax returns are not received for six months after that. In any case, it is clear that logging equipment purchse decisions should be performed on a cash flow basis, preferably both before- and after-tax.

Analysts usually have calculated harvesting equipment or system costs using machine rate calculations. This study indicates that cash flow estimation may lead to substantially different yearly costs, both before and after taxes. This presents somewhat of a quandry for all analysts. To be theoretically correct and practically accurate, cash flow estimation should be preferred to machine rates. But even with the use of the FOCAS program, calculating many different harvest system costs will be more cumbersome. One must also convert the value of future years costs to a present value. Despite the difficulty, we would recommend that analysts consider cash-flow costs when making harvesting cost calculations. It may be too difficult to use in all cases, but it can be more accurate, assuming accurate input data are available. Use of the FOCAS before- and after-tax programs or other approaches also may facilitate such calculations.

FOCAS Program Uses

As with any computer program, the FOCAS template approach has advantages and disadvantages. These can be discussed and considered in any future program development.

The FOCAS cash flow template provides advantages compared to basic machine rate calculations. The design allows ease of data entry and the use of actual or averaged information in the algorithms. The presentation of all machine estimates is designed for easy comparison and the program can be altered somewhat to accept changing federal tax regulations concerning depreciation. It is relatively easy to use, and provides accurate yearly cash flow estimates of equipment costs. Cost calculations also can be saved after each computer run.

The cash flow algorithm will portray a more accurate analysis of the actual variability of costs over the term of ownership of the machine than the standard machine rate. This should allow the logger to better asses his cash

and profit/loss position and to better time the purchase of machinery to coincide with his most appropriate cash flow position.

One principal disadvantage of the program is that radical changes in federal tax law will require further revisions of the after-tax version of the program (FOCAS-2). Minor changes in depreciation rates and some allowable deductions can now be accomplished with a minimum of effort. But even if tax laws change considerably, the before-tax cash flow and machine rate calculations can still be estimated with the before-tax version of the program (FOCAS-1). While it does estimate after-tax costs, the FOCAS-2 program should not be relied on in place of qualified tax accounting or legal counsel. It is meant for comparative analyses among machines or financing approaches; not to fulfill IRS requirements. Last, we must again stress that the quality of the results from both models will depend on the quality of the input data used to calculate average costs.

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