A MODEL DEVELOPED TO DETERMINE THE OPTIMUM TIME TO REPLACE TRACTORS

By P. G. BRAITHWAITE

C.G. Smith Sugar Ltd, Sezela, Natal

Abstract

A technique has been developed on a large sugar estate in South Africa to determine the optimum time to replace tractors. The method considers all accounting factors and shows the importance of obsolescence and downtime on total costs. The technique may also be used for other equipment and to evaluate future price considerations and cash flow situations.

Introduction

Traditionally tractors have been replaced on the basis of life in terms of years or according to the number of hours run or kilometres travelled. In these circumstances the working life is established by personal judgement. Deviations from the policy are determined by the ability of the workshop personnel to convince management that certain pieces of equipment are too expensive to maintain, regardless of other implications such as improved design and accounting factors.

In the current poor economic climate in the sugar industry and with rapidly rising prices of new tractors such decision-making is unsuitable to determine the optimum working life of tractors. A practical technique has therefore been developed to aid in the decision making process and is discussed with relevant examples.

Method

The theoretical optimum time to replace a tractor can be determined by considering the cost of owning and operating a new machine versus owning and operating the old machine. This point is reached by considering the following factors:

Maintenance and repair costs; depreciation; interest; income tax concessions.

However, in order to reach a practical solution it is also necessary to consider productivity factors such as downtime, availability and obsolescence. Monetary values are applied to all the above factors in order to make a decision from three options:

Buy new, continue with the old tractor, recondition the old tractor.

The technique may also be used to indicate differences between different makes of tractors.

Operating Costs

Actual maintenance and repair costs have been abstracted from the records of a fleet of 85 tractors with ages ranging from one year to nine years. Figure 1 shows the maintenance and repair costs at present value for two makes of tractors.

An analysis of these figures is shown in Appendix 1. The cost of tyres and fuel remain constant and is calculated assuming 1400 ha^{-1} independent of the age of the machine. The cost of the driver has been excluded. Peaks in the graphs are due to failures, mainly in the engines and less frequently in the gearboxes. Tractor A requires more engine maintenance than tractor B and has frequent failure at a younger age. Where the above information is not available from past records the techniques described by Murray[4] or Booysen and de Beer[2] may be used.

Depreciation

Various methods of calculating depreciation may be used, such as straight line, double declining balance or sum-of-the-years-digits. For this exercise the straight line method is used and provides the same amount of depreciation during each year of the life of the asset. It is calculated as follows:

$$\text{Depreciation} = \frac{OC - SV}{n}$$

where OC = Original cost
SV = Salvage value
n = Number of years

At the time of sale it is necessary to correct for the difference between book value and trade-in value and relate this to the cost over the working life of the vehicle. The trade-in value is taken from Mead and McGrouthers.[3]

Investment Cost

Capital investment should carry costs to cover interest, insurance and financing expenses. The cost of capital will vary and should be set according to the prevailing circumstances. If there is unlimited capital available the interest rate may be lowered. An interest rate of 14 % pa is used in the examples given here.

Taxation

Taxation is one of the most important considerations when deciding on the replacement of a tractor but unfortunately it is also the most neglected factor. A farmer who is registered as a company in South Africa is at present entitled to claim a 50 % tax rebate on assets purchased, interest costs and maintenance and repair costs. The farming development tax allowance permits 100 % tax rebate in the year of purchase on capital spent on purchasing a tractor. The correct tax rebates need to be adjusted according to the ruling entitlements at the time of calculation.

Net Present Value

The calculation incorporating maintenance and repair, depreciation, investment cost and tax benefits during the life of the machine should be adjusted back to Net Present Value. This is done by using discounted cash flow (DFC).

For example a sum of money worth R5 000 in two years time assuming 12 % interest rate is only worth R3 986 today.

Discount tables have been prepared to facilitate quick computation of present and future values for various interest rates and period times and have been taken from Barry, Hopkin and Baker.[1]

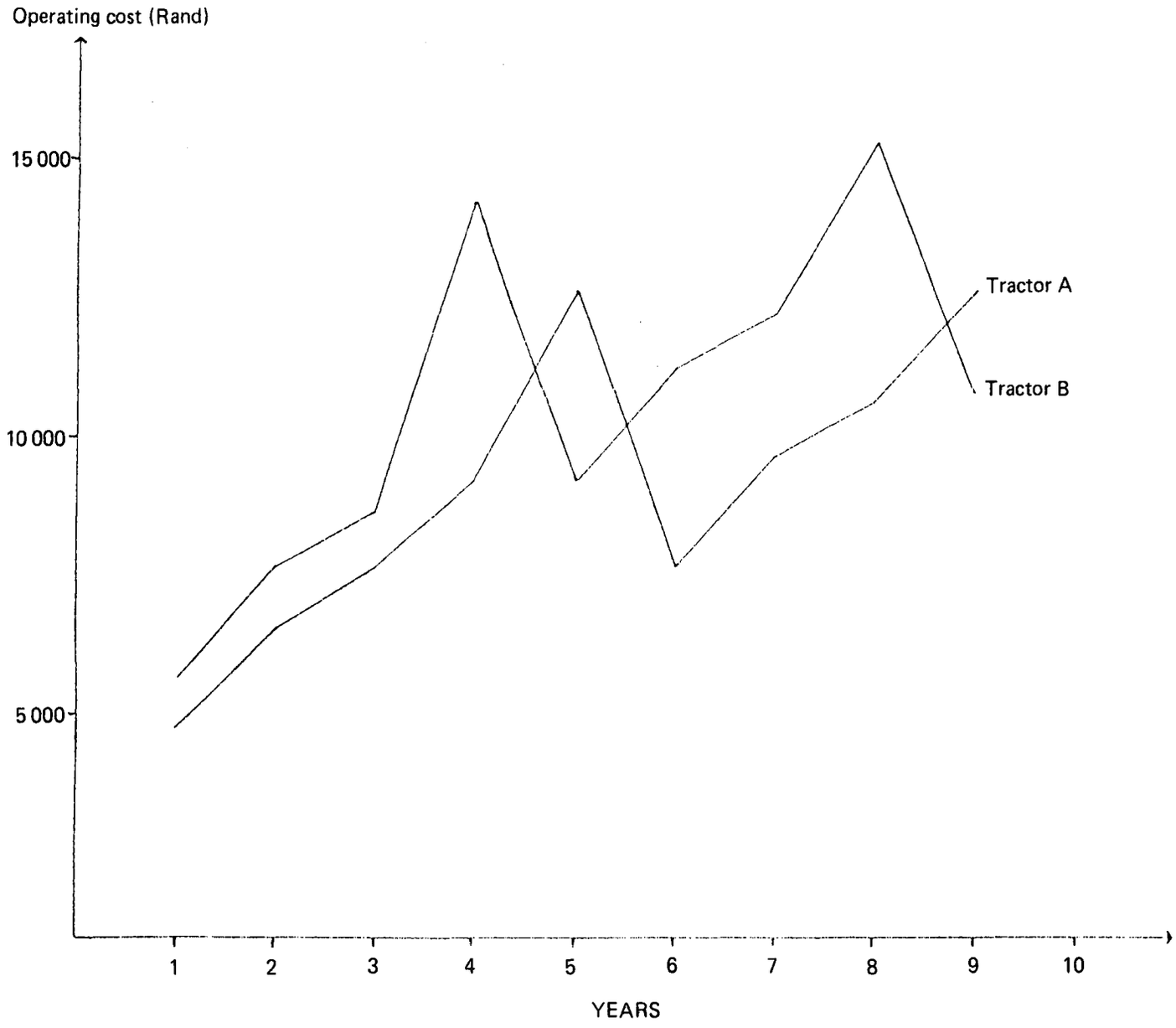

FIGURE 1 Operating costs for two makes of tractors in relation to the age of tractor

These are calculated according to the following formula:

$$Vo = R1\ (1 + i) - n$$

where Vo = present value of a future payment(s)
i = interest rate per conversion period
n = a conversion period

$$Vn = R1\ (1 + i)^n$$

where Vn = future value of a present payment
i = interest rate per conversion period
n = a conversion period.

Availability

As the tractors get older it is reasonable to expect an increase in downtime and therefore a loss in the time during which that particular machine is available. Acceptable standards need to be set which allow a certain downtime that does not affect productivity, or require the purchase of additional tractors. Current standards allow for cane at Sezela to be handled with a fleet of 36 tractors with a 5% downtime. If this downtime should rise to 10% two extra tractors would be required and this is unacceptable. Downtime can be contained by either buying new machinery or spending additional money on maintenance.

Obsolescence

Obsolescence is important when making the decision to buy new or maintain old tractors. Improvements to tractors are being made all the time resulting in increased productivity. This is measured by the ratio of output/input (ie tons/hour or tons/litre).

Therefore once the owning and operation costs of the various options have been calculated it is necessary to relate them to the productivity of the tractors for each option.

Results

Calculation of Owning and Operating costs for a tractor over 5 years

Table 1 is an example showing the calculation of owning and operating costs assuming the tractor is kept for 5 years taking into account maintenance and repair, depreciation,

investment, escalation and tax allowance. In this example the following assumptions are made:

1.1 1400 hours worked per annum.

1.2 trade-in value according to Mead and McGrouthers.[3]

1.3 total operating costs are those for tractor A in Appendix 1.

1.4 present values and future values are calculated using 14% inflation.

1.5 interest on capital is taken at 14%.

1.6 all tax concessions are taken at 50%.

Sensitivity analysis can now be done for each variable.

Table 1

Owning and operation costs for a tractor over 5 years (excluding the driver)

Tractor A

YEARS	0	1	2	3	4	5
1. Cumulative hours		1 400	2 800	4 200	5 600	7 000
2. Trade in value	28 000	17 400	14 500	12 000	9 900	8 000
3. Book value		24 500	21 000	17 500	14 000	10 500
4. Total operation costs		(5 520)	(7 630)	(8 680)	(14 280)	(9 080)
5. Esc Op costs A Tax (50%)		(2 760)	4 349	(5 642)	(10 581)	(7 668)
6. Int Costs A Tax (50%)		(1 960)	(1 715)	(1 470)	(1 225)	(980)
7. Depreciation		(3 500)	(3 500)	(3 500)	(3 500)	(3 500)
8. Esc Trade in value (14%)						15 400
9. Tax on sale (50%)						(7 700)
10. Profit/loss on book value (8-3)						+4 900
11. Tax Benefits (50% of purchase price)		+14 000				
12. Sum of 5+6+7+9 +10+11		+5 780	(9 564)	10 612	15 306	14 948
13. P.V. (14%)		+5 069	(7 355)	(7 163)	(9 061)	(7 758)
14. NPV (of years)						(26 268)
15. NPV per hour Rand h^{-1}						3,75

The significant point to note is the sensitivity to tax allowance. A different picture is presented if these are not considered. In this example the hourly cost if tax is not taken into account increases from R3,75 to R8,88.

Comparing owning and operating costs between buying new, continuing the old tractor, or reconditioning the old tractor

In this example comparison is made between owning and operating tractors for four years. Each tractor is assumed to work 1400 ha^{-1} and the maintenance and repair costs are according to Appendix 1. The new tractor is bought and paid for in the first year and sold in the 4th year. The old tractors are costed when they are 5 to 8 years old and sold in the 8th year. The reconditioned tractor is reconditioned in year 5 at a cost of R4 000 and sold in year 8.

Table 2

Owning and operating costs comparing new and old and reconditioning

	Year 1	Year 2	Year 3	Year 4	NPV sum of year	NPV Rand h^{-1}
New	2 315	(9 389)	(8 703)	(3 459)	(19 236)	3,44
Old	(3 945)	(5 617)	(6 099)	(3 950)	(19 611)	3,50
Recon	(5 950)	(5 837)	(6 293)	(6 547)	(24 627)	4,40

Referring to Table 2 it can be seen that the cheapest option is the new tractor. This need not always be the case and the outcome will vary according to the inputs. Tax is the major factor in the example making the new tractor the best choice.

The effect of obsolescence and downtime on costs

In this worked example (see Table 3), three different conditions are considered. The decision is whether to purchase new tractors, recondition the old ones, or to run old tractors in a run-down state. From tests and long term data the following outputs are expected from these tractors:

- new tractors, due to innovation are capable of hauling 15 t h^{-1}.
- reconditioned tractors will continue to produce 12,5 t h^{-1} which is the same as they were capable of when new.
- old run down tractors due to high downtime are capable of hauling only 10 t h^{-1}.

Costs are calculated assuming the tractors have a working life of four years from the time of consideration.

Table 3

Comparison of costs between operation new, reconditioned and old tractors over 4 years

	New (1)	New (2)	Recon	Old
c h^{-1}	344	510	440	35
t h^{-1}	15,0	15,0	12,5	10,0
c t^{-1}	23	34	35	

In terms of cost/hour and cents/ton the new tractor is the cheapest option. The option of reconditioning an old tractor is expensive and in this situation should not be recommended. The cost per hour of the new tractor could in fact rise to as high as R5,1 h^{-1} and still be competitive (see New (2) in Table 3).

Comparing owning and operating costs between two different makes of tractors

Figure 2 shows the results for calculations worked out for two different makes of tractors. The cost against each year represents that cost/hour it would take to operate the tractor for the years in question.

ie against year five tractor A would average R3,63 h^{-1} to operate over the five year period.

The information presented in this form highlights firstly the most economical tractor to operate and secondly the optimum replacement time in terms of owning and operating costs. Ideally assuming no difference in output, the choice would be tractor B replacing after every 4 years.

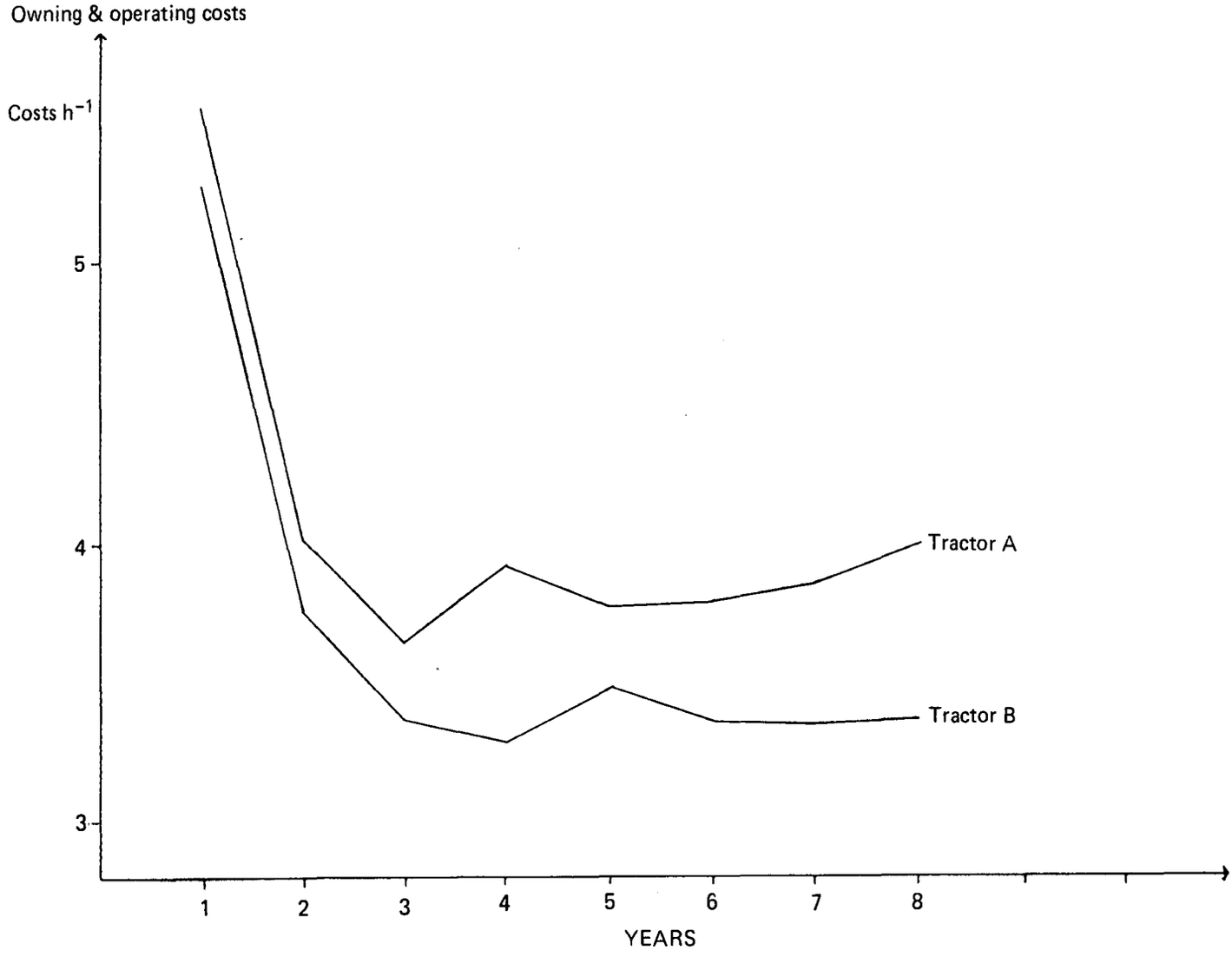

FIGURE 2 Owning and operating costs for two makes of tractors against the age of tractor.

Conclusion

The method of calculating owning and operating costs shown here is simple, detailed cost areas are given and an overall picture is obtained. In addition the effects of obsolescence and productivity have been shown to be significant factors when considering the replacement of tractors. From the examples it has been shown that a decision can be made regarding which make of tractor to purchase and how long that tractor should be run. Secondly, the examples show that under the conditions considered it is not advantageous to recondition an old tractor. Similarly as a tractor gets older, due to higher downtime, its cost/ton to move cane becomes more expensive than it would be for a new tractor. This tractor could at this stage be "withdrawn" from critical work such as haulage and put onto lighter work which does not call for high availability.

On a broader scale the technique can also be used to determine the future company cash flow situation, net cost after tax comparisons and future price of vehicle considerations.

Acknowledgements

The assistance of Mr M. Montagner who helped with abstracting maintenance and repair costs and Mr D. Rawlinson for advising on the accounting procedure is greatfully acknowledged. The Management of C.G. Smith Sugar is acknowledged for their encouragement and support in permitting this paper to be submitted.

REFERENCES

1. Barry, PJ; Hopkin, JA and Baker, CB (1979). *Financial Management in Agriculture* (2 *ed*). The Interstate Printers and Publishers Inc p 529.
2. Booysen, SS; de Beer, AC (1971). Machinery selection by costing analysis. *Proc S Afr Sug Technol Ass* 51: 12–15.
3. Mead and McGrouthers (1985). *Agricultural Machinery Dealers Digest* Randburg p 128.
4. Murray, TJ (1982). A technique to determine the optimum replacement cycle for Capital Equipment. *Proc S Afr Sug Technol Assoc* 56: 157–160.

APPENDIX I

Operation tractor cost over 9 years — Tractor A

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Spares	R 420	R1 100	R1 700	R 6 000	R1 500	R 3 000	R 3 500	R 6 000	R 2 000
Labour	R 200–	R 750	R1 200	R 2 500	R 1 800	R 2 500	R 3 000	R 3 000	R 3 000
Tyres	R 100	R 980–	R 980	R 980	R 980	R 980	R 980	R 980	R 980
Oil	R 500	R 500	R 500	R 500	R 500	R 500	R 500	R 500	R 500
Diesel	R4 300	R4 300	R4 300	R 4 300	R4 300	R 4 300	R 4 300	R 4 300	R 4 300
Total	R5 520	R7 630	R8 680	R14 280	R9 080	R11 280	R12 280	R15 280	R10 780

Operating tractor cost over 9 years — Tractor B

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9
Spares	R 420	R1 000	R1 500	R2 500	R 5 000	R1 000	R2 000	R 2 500	R 3 500
Labour	R 200	R 500	R1 000	R1 500	R 2 500	R1 500	R2 500	R 3 000	R 4 000
Tyres	R 100	R 980	R 980	R 980	R 980	R 980	R 980	R 980	R 980
Oil	R 480	R 480	R 480	R 480	R 480	R 480	R 480	R 480	R 480
Diesel	R3 600	R3 600	R3 600	R3 600	R 3 600	R3 600	R3 600	R 3 600	R 3 600
Total	R4 800	R6 560	R7 560	R9 060	R12 560	R7 560	R9 560	R10 560	R12 560