TECHNICAL NOTE — A NOTE ON THE COST OF OWNERSHIP, CAPITAL RECOVERY AND DEPRECIATION

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ABSTRACT

This paper develops an after-tax version of the classical capital recovery equation and demonstrates its value as a screening device and as an expository tool to convey conceptual understanding of the cost of ownership, capital recovery and depreciation.

INTRODUCTION

Traditional approaches to the exposition of concepts in the field of engineering economics remain strongly entrenched in textbooks as well as the literature. For example the recent text by Bowman [1] continues the tradition of treating income tax effects late in the course. Taxes are not considered until Chapter 11 even though depreciation is covered in Chapter 4. A quick scan of other undergraduate texts [2], 3], [4], [5] confirms that deferral of tax effects is typical. Graduate texts [6], [7], and [8] introduce taxes more quickly. However, after-tax cash flows should be utilized in any analysis. A concern here is that students might consider taxes as a refinement best left to accountants thereby unnecessarily confining their role in a capital project appraisal. Equally important this deferral of reality may affect their ability to make sound comparisons when doing a quick "back of the envelope" screen of potential projects. To demonstrate this point, this article uses the cost of asset ownership. This is a fundamental and important concept in engineering economics that is developed in a pre-tax context in the texts noted above.

ANALYSIS

Quite often, the annual cost of ownership of an asset is expressed by the notion of capital recovery. It is defined by the equation:

$$CR = P\,[A/P,\ i,n]\ - L\,[A/F,i,\ n] \tag{1}$$

where:

- P is the purchase price of the asset at time 0
- L is the salvage value n years hence
- CR is the annual equivalent cost of ownership or the capital recovery cost
- i is the annual interest rate based upon the minimum attractive rate of return
- n is the useful life of the asset

The "capital recovery equation" familiar to readers of *The Engineering Economist* results from a simple rearrangement of this expression:

$$CR = (P - L)[A/P,i,n] + Li \tag{2}$$

obtained by substituting $[A/P,\ i,\ n] - i$ for $[A/F,\ i,\ n]$ into the first expression.

This second form of the capital recovery equation is useful not so much for its economy of computation but rather for its revealing economic interpretation, as suggested by Bussey [6]. That is, the first term in Eq. (2) is shown to be equivalent to "annual depreciation plus interest on the unrecovered depreciable balance" [6, p.67], and the second term is "the return on the salvage value of the investment". Bussey uses the term depreciation in the economic sense of capital consumption rather than the accounting concept of decrementing the book value of an asset. This interpretation sheds much light on the cost of owning capital equipment whether an automobile for personal use or a machine for productive use. Sullivan, Bontadelli and Wicks [5] share appreciation for this interpretation by demonstrating the equivalence of unrecovered depreciation computations on a year-by-year basis [5, p.155]. In addition to this helpful interpretation, the capital recovery concept provides a meaningful way to think about the cost of ownership in "on the spot" judgments regarding potential economic merits of a proposal. Were it not for this conceptual value, there would be little point to introducing the second form of the capital recovery Eq. (2) as the computational savings is trivial in this era of spreadsheets and financial calculators.

Both Eqs. (1) and (2) presume a pre-tax analysis and consider outflows like P to be positive and inflows like L to be negative. However, as shown below, the real expository value of the capital recovery concept is more dramatically and more accurately portrayed in a post-tax analysis. Consider the development of the cash flow after tax from typical income statement information:

$$ATCF = [R-O-D](1-t) + D \quad (3)$$

where:

ATCF is the cash flow after tax
R is the revenue stream associated with an entity
O is the operating costs associated with the revenue stream
D is the depreciation associated with the asset producing the revenue stream
t is the tax rate

It is useful to rearrange this expression to

$$ATCF = [R-O](1-t) + tD \quad (4)$$

with the helpful interpretation that $[R - O](1 - t)$ is equal to the gross profit after tax and tD is commonly called the depreciation tax shield.

Note that in Eq. (4), both these components of *ATCF* are inflows and additive. In scenarios where revenues are unknown or not traceable to decision alternatives, the cash flow Eq. (4) becomes

$$ATCF' = -O(1-t) + tD \quad (5)$$

In order to include *ATCF* in the capital recovery equation, the sign convention must be reversed so that, as in then capital recovery Eq. (2), outflows are positive. Further the purchase price, P, and the salvage value, L, must be after tax values, say P^A and L^A. Then the annual costs of owning and operating an asset (*ACOO*) are

$$ACOO = CR - ATCF' = (P^A - L^A)[A/P, i, n] + L^A i + O(1-t) - tD \quad (6)$$

Here we assume level operating expenses (O), and level depreciation shields, (tD) or their annual equivalents. Additionally, outflows (P^A, O) are positive and inflows (L^A, tD) are negative as in the initial capital recovery Eq. (2). P^A usually equals P unless there is an investment tax credit to be subtracted. L^A simply equals $L - [L - BV]\, t$ in the event that it is foreseen that the asset would be disposed at a price differing from its book value (BV) at year n. There, a positive difference between L and BV is taxed at the ordinary marginal rate, t, and a negative difference creates a tax credit. This follows the usual operating assumptions associated with incremental investments: no impact on tax brackets, no carry over of unused depreciation and availability of other income to absorb tax credits. If the Eq. (6) above is rearranged into operating and ownership components, then the annual after tax operating cost is $O\,(1-t)$ and the annual ownership cost is the after-tax capital recovery, *CRAT*, is

$$CRAT = (P^A - L^A)[A/P, i, n] + L^A i - tD \tag{7}$$

There are some very specific uses and insights available in this formulation:

- Capital recovery is more accurately seen to include three components: interest-weighted decline in value, imputed interest on the foregone salvage value, and an offsetting depreciation tax shield, *tD*.
- The cash flow resulting from depreciation is firmly established as a tax artifact related to capital recovery.
- The distinction between capital recovery and depreciation is made clear.

ILLUSTRATIONS

To illustrate the impact of the after-tax modification in a decision situation, consider the following example taken directly from [5, p. 155]:

> Consider a machine or other asset that will cost $10,000, last five years, and have a salvage (market) value of $2000. Thus the loss in value of this asset over five years is $8000. Additionally the minimum attractive rate of return (*MARR*) is 10% per year.
>
> Using Eq. (2), the capital recovery, *CR*, is computed as:

$$CR = (10000 - 2000)\,[A/P,\,10\%,\,5] + 2000\,(.10) = 2110 + 200 = 2310$$

Now, suppose that the same machine can be leased for $2500 per year, the indicated choice would be to buy rather than lease as 2310 < 2500. Suppose instead, Eq. (7) is used to compute the cost of ownership reduced by the depreciation tax shield, *tD*. If the tax rate is 40% and the depreciation is computed as a straight line to the salvage value, then D is $1600 and the capital recovery after tax is:

$$CRAT = 2310 - tD = 2310 - .4(1600) = 1670$$

Since lease payments are also tax deductible, the after tax lease cost is $2500(1 – *t*) = 1500, and the analysis favors the leasing alternative by $170 per year. If it were decided that this small difference warrants further investigation, such as the impact of using accelerated depreciation, a more detailed analysis is required. For example, assume that the machine is depreciated to zero using a three-year MACRS life depreciation schedule with the half-year convention. Then the proceeds from salvage value are taxable. TABLE 1 below shows a spreadsheet analysis which re-computes the Net Present Value at –5926 for an annual equivalent cost of $1563 per year, using + 5926 [*A*/*P*, 10%, 5]

TABLE 1: Discounted Cash Flow of Annual Ownership Costs Using MACRS Depreciation

	0	1	2	3	4	5
MACRS Factor		.3333	.4445	.1481	.0741	0
Investment	–10000					
Depreciation Amount		3333	4445	1481	741	0
Depreciation Tax Shelter		1333	1378	592	296	
Present Value of Tax Shelter	3329					
After tax salvage value						1200
Present value of salvage	745					
Net Present Value	– 5926					

This result is slightly above the $1500 per year for the leasing alternative. Of course now that the details have been computed with the spreadsheet, the *CRAT* can be computed using the annual equivalent of the tax shelter in Eq. (7) as follows:

$$CRAT = (10000 - 2000)\,[A/P, 10\%, 5] + 1200\,(.10) - 3329\,[A/P, 10\%, 5]$$
$$= 2321 + 120 - 878 = 1563$$

Of course this is superfluous, since we already reached this conclusion with the spreadsheet.

There is yet one more issue, the specification of the interest rate. If the 10% *MARR* is a pre-tax desired return, then the appropriate interest rate for the after-tax capital recovery is 10%(1 – *t*) or 6%. Re-computing *CRAT* under this assumption and returning to straight-line depreciation we find:

$$CRAT = (10000 - 2000)\,[A/P, 6\%, 5] + 2000\,(.06) - .4(1600)$$
$$= 1899 + 120 - 640 = 1379$$

This swings the pendulum back to the buy option albeit by a narrower margin. In the practicing world, observed returns on investment are typically post-tax. So if the 10% were indeed an after-tax rate, then the choice should be to lease rather than buy. The point is simply that the capital recovery equation has value as a concept that serves as a mental guide for comparing options. If it is to serve that end, then it should be developed and taught under the most realistic set of circumstances. If tax complexities arise beyond the normal operating assumptions outlined above, then a detailed analysis of specific cash flows will be needed to achieve an accurate comparison.

CONCLUSION

This paper reframes a key concept, capital recovery, so that students exit with a useful and powerful notion of the cost of ownership of an asset. As argued above scholars in the field value the concept of capital recovery for its economic interpretation. That interpretation is incomplete when restricted to a pre-tax treatment. The paper reformulates the capital recovery equation that shows both the mitigating impact of the depreciation tax shield and the distinction between the economic concept of capital recovery and the accounting concept of depreciation. There is no need to develop the pre-tax equation. After all, cash flows associated with taxes are real and are part and parcel of any decision analysis, particularly those involving capital recovery and equipment replacement studies. The tradition of developing the body of knowledge in on a pre-tax basis should be limited to the earliest introduction of time value of money basics.

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BIOGRAPHICAL SKETCH

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