Why Teach Depreciation and Income Taxes?

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Abstract

Often the best mutually exclusive alternative in a before-tax economy study is an inferior course of action in an after-tax study. Hence, we teach our students to include the effects of income taxes to avoid mis-allocating scarce capital. Despite this, our students who work in industry frequently perform only before-tax profitability studies and, as appropriate, leave the income tax intricacies to finance/accounting people. The purpose of this paper is to reinforce the necessity of after-tax economy studies in practice. An example is presented that illustrates four methods for taking income taxes into account. Two of the methods produce the correct rank ordering of projects while the remaining two do not. We recommend that an income tax specialist be consulted in practice when the projects under consideration are complicated with respect to their tax ramifications.

1. Introduction

When deciding among mutually exclusive alternatives, managers as fiducial agents for a company's owners are principally concerned with the after-tax profitability (present worth, annual worth, internal rate of return) of a capital investment. Income taxes are viewed as a normal expense incurred in generating income, and income is not as important as how much money is left after all expenses, including income taxes, are paid [4]. Because of this reality, we teach our students to present the after-tax consequences of competing projects in order to give managers a fair and complete picture of the after-tax profit potential of the feasible projects.

Engineering students need to consider income taxes in their economy studies to ensure that they understand income tax trade-offs. For instance, students learn about capitalizing versus expensing a cost element, and this is important to understand when capital-intensive projects are compared with, for example, labor-intensive projects and leasing arrangements. If the effective income tax rate is 40%, students understand that an expensed investment (e.g., a machine overhaul) costs 60 cents on the dollar after taxes whereas a capitalized (depreciated) investment produces an after-tax benefit of 8 cents on the dollar with straight line depreciation over five years. Its after-tax cost is therefore 92 cents on the dollar, so students know to expense an item when it's legal and appropriate.

Despite our best efforts to teach the necessity for after-tax profitability studies, a large number of practicing engineers perform only before-tax studies and leave the income tax and financial details to other professionals (or are they ignored?). The aim of this paper is to reinforce the need for after-tax economic studies and to illustrate four popular methods for accomplishing this

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end. Even though engineers tend to deal with operational/tactical problems concerning cost reduction, equipment replacement or make versus buy scenarios, after-tax profitability assessments should be mandatory. It should also be made clear to our students that strategic investments involving new business and/or products must be evaluated on an after-tax basis. Engineering economy analyses must be communicated in the "language of the listener," and increasingly this requires an after-tax measure of profitability.

2. A Typical Investment Situation

This example illustrates a situation in which the before-tax (BT) rank ordering of mutually exclusive cost-only alternatives is different from after-tax (AT) rank ordering. It is commonplace to see identical rank orderings of BT and AT results in many real-life situations. A company must install a new sheet metal stamping press, and four different presses are being considered [1]. The essential cash flow elements of the presses are summarized below (these are cost-only alternatives):

	Press			
	A	B	C	D
Capital Investment	\$6,000	\$7,600	\$12,400	\$13,000
Total Annual Expenses	7,800	7,282	6,298	5,220

The useful life of each press is expected to be five years, and market (salvage) values are assumed to be negligible at the end of useful life. The after-tax minimum attractive rate of return (MARR) is 15% per year. Which press should be recommended in an after-tax economy study? The firm's effective income tax rate is 40%, and straight line depreciation will be used to recover the capital investment required by each press.

Four popular methods for conducting the after-tax analysis are now presented and compared in terms of their rank orderings of the annual equivalent worth of each press.

2.1 Tabular/Equation-Based Analysis

The tabular (first) approach to after-tax comparisons of mutually exclusive alternatives is presented in most engineering economy textbooks [3, 6, 7]. It is applied to Press A. Equations are shown for Press B, C and D to streamline the analysis.

Press A:

EOY	Before-Tax Cash Flow	Deprec.	Taxable Income	40% Income Tax	After-Tax Cash Flow
0	-\$6,000	- -	- -	- -	-\$6,000
1-5	- 7,800	\$1,200	-\$9,000	\$3,600	- 4,200

$AW_A(15\%) = -\$6{,}000(A/P,15\%,5) - \$4{,}200 = -\$5{,}990$

Press B:

$$AW_B(15\%) = -\$7,600(A/P,15\%,5) - \$7,282(0.60) + \$1,520(0.4)$$
$$= -\$6,028$$

Press C:

$$AW_C(15\%) = -\$12,400(A/P,15\%,5) - \$6,298(0.60) + \$2,480(0.4)$$
$$= -\$6,486$$

Press D:

$$AW_D(15\%) = -\$13,000(A/P,15\%,5) - \$5,220(0.60) + \$2,600(0.4)$$
$$= -\$5,970$$

Rank ordering: D > A > B > C (Alternative D is best).

2.2 Before Tax Cash Flows Discounted at 15%/(1-t)

The second method for conducting an after-tax economy study is to discount the before-tax cash flows at the BT MARR, which is approximately equal to the AT MARR divided by (1-*t*). In this example the BT MARR is about 25% per year. For Press A the AW at 25% is -\$6,000(A/P,25%,5) - \$7,800 = -\$9,516. The other three AWs are: Press B = -\$9,627, Press C = -\$10,493 and Press D = -\$9,989. The rank ordering is A > B > D > C which does not agree with the rank ordering by the first method. While it is quite common to observe identical rank orderings with these first two methods of AT economic analysis, this is not always the case as shown in this example. Because the rank orderings do not agree, it is recommended that the second method not be used to select the most profitable mutually exclusive alternative when income taxes are considered.

2.3 Fixed Charge Rate Analysis

The third method of after-tax comparisons among cost-only alternatives is heavily utilized by engineers in investor-owned utilities. It uses a fixed charge rate that is multiplied by the capital investment and added to annual operating and maintenance expenses, property taxes and other recurring annual expenses. The rate includes an allowance for income taxes and is based on systematic recovery of invested capital, debt and equity capitalization of the firm, book depreciation versus tax depreciation and other assumptions too numerous to list here [5]. For capital investments in general plant and equipment, the Duke Power Company mandates a fixed charge rate of 0.358 (five-year plant life)[*].

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[*]Duke Power Company, "Fixed Charges and Discount Rates," internal memorandum dated September 1994.

Applied to the four presses, the fixed charge rate analysis of after-tax profitability yields the following annual worths:

	Press			
	A	B	C	D
Fixed Charge Amount	$2,148	$ 2,721	$ 4,439	$4,654
O & M Expenses	7,800	7,282	6,298	5,220
Total Cost	$9,948	$10,003	$10,737	$9,874

The fixed charge rate is very simple to apply, and for this example, results in the same rank ordering as the tabular/equation-based analysis: D > A > B > C.

2.4 Adjust Cash Flows by the Income Tax Credit

The last method adjusts annual revenues/operating and maintenance cash flows by their annual income tax liability (or credit). Collier and Glagola [2] advocate such an approach to dealing with income taxes. If the marginal income tax rate is 40%, the four presses would be evaluated as follows with the annual worth criterion and an after-tax MARR of 15% per year:

	A	B	C	D
Capital Recovery Amount	$1,790	$2,267	$3,699	$3,878
Adjusted O & M Expenses (1-t)(O & M per year)	4,680	4,369	3,779	3,132
Total Cost	$6,470	$6,636	$7,478	$7,010

Rank ordering: A > B > D > C (Alternative A is best). This ordering does not correspond to the correct ordering given by the first method and should not be used in most circumstances.

3.0 Summary and Recommendations

There is little doubt that engineering economy studies should be conducted on an after-tax basis. But a large percentage of economy studies in actual industrial applications stop short with only before-tax assessments. The assumption is apparently that the rank ordering of mutually exclusive alternatives is not affected by income tax considerations. Or could it be that the subject of income taxes is too intricate to be part and parcel of the analysis performed by engineers on operational/tactical types of projects? If the capital investments being considered are large and complicated, the accounting/financial people will normally prepare the after-tax recommendations for upper management to review.

Our example revealed that even for simple projects there can be confusion concerning how to evaluate alternatives on an after-tax basis. The first and third methods ordered the projects D > A > B > C while the other two methods arrived at two different rank orderings. Our recommendation is to teach the high-level effects of income taxes to your students but leave the details to a tax specialist. Knowing the difference between a capitalized and an expensed cash flow is important for an engineer to appreciate – but spare your students the aggravating details of income taxation that a specialist will bring to the table when s/he is needed to facilitate management decision making.

References

1. Canada, J. R., W. G. Sullivan and J. A. White, Capital Investment Analysis for Engineering and Management, 2nd ed., (Upper Saddle River, NJ: Prentice Hall, Inc., 1996).

2. Collier, C. A. and C. R. Glagola, Engineering Economic and Cost Analysis, 3rd ed., (Reading, MA: Addison Wesley, 1998).

3. DeGarmo, E. P., W. G. Sullivan and J. R. Canada, Engineering Economy, 7th ed., (New York, NY: Macmillan Publishing Company, 1984).

4. Grant, E. L., W. G. Ireson and R. S. Leavenworth, Principles of Engineering Economy, 8th ed., (New York, NY: John Wiley & Sons, 1990).

5. Jeynes, P. H., Profitability and Economic Choice, (Ames, IA: Iowa State University Press, 1968).

6. Sullivan, W. G., E. M. Wicks and J. T. Luxhoj, Engineering Economy, 12th ed., (Upper Saddle River, NJ: Prentice Hall, Inc., 2003).

7. Thuesen, G. J. and W. J. Fabrycky, Engineering Economy, 9th ed., (Upper Saddle River, NJ: Prentice Hall, Inc., 2001).

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