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INFLATION AND MACHINERY COST BUDGETING

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Machinery costs are affected by inflation which, if not correctly considered, will bias cost estimates. Accurate estimates of machinery costs are essential in budgeting costs of crop production in farm policy programs, crop hedging decisions, and general cost of production research. Machinery decisions relating to replacement, size, and custom or leasing alternatives are also improved by realistic budgeting techniques.

The objective of this article is to examine appropriate adjustments for inflation in developing machinery costs through budgeting techniques. The authors attempt to demonstrate the adjustments necessary in both capital and traditional budgeting models to place cost estimates on a real basis. Capital budgeting is first compared with traditional budgeting. Next, by the use of a simple machinery example, the necessary adjustments to account for inflation are shown for a capital budgeting model that does not include income tax considerations. Similarly, the inflation adjustments are demonstrated for a traditional budgeting model that does not include income tax considerations. Finally, a capital budgeting model including income tax aspects is examined in reference to real and nominal after-tax cost estimates.

Nominal dollar cost expressions employed in this article refer to costs estimated without regard to the changing value of the expression of costs. For example, annual opportunity cost for a machine is generally estimated on the basis of machine midvalue. If the used selling price (or alternatively an arbitrary salvage value) is estimated in nominal terms, the resulting midvalue has a nominal dollar basis and does not consider inflation occurring over the time period.

Until the 1960's inflation could be and usually was ignored because of its low level. However, the levels of inflation in recent years require that a clear distinction be made between nominal and real cost estimates. This distinction, though applied here only to machinery, should be considered in all time-related economic budgeting models. In general, a real or inflation-free expression of costs of intermediate and long-run resources is preferred to a nominal basis, especially in estimating optimum replacement strategies under certain limiting assumptions. Alternatives need to be placed in equivalent units for comparisons. Nominal flows are not in equivalent units because the value of the units changes with time.

In this article traditional budgeting refers to the commonly used method of estimating annual costs for a depreciable asset. It is usually done through the use of straight-line depreciation, opportunity cost based on asset midvalue, and other costs that may be estimated independently or based on purchase price or midvalue. Income tax aspects are rarely considered in such models. Capital budgeting is the procedure of discounting all economic flows over an ownership period to a net present cost. That net present cost can be placed on an annual basis by amortizing the net present cost over the ownership period. Income tax provisions can be ignored in such a model for a before-tax analysis. Alternatively, income tax provisions can be included in a capital budgeting model for an after-tax cost analysis.

Capital budgeting may be preferred to traditional budgeting as applied to machinery costs for several reasons. Income tax and timing of flows can be included more readily in capital than traditional budgets. Kay [5] and Walrath [8] point out difficulties with opportunity cost estimates for traditional budgeting models based on midvalues. The inclusion of income tax aspects in machinery cost models is demonstrated by Chisholm [4] and Kay and Rister [6] for machinery replacement decisions. Bates et al. [3] illustrate the effects of inflation on tractor replacement using capital budgeting based on after-tax costs. However, traditional budgeting continues to be widely used because of its simplicity and expediency.

For comparison, the example analysis for both capital budgeting and traditional budgeting is developed on a before-tax basis so that inflation adjustments to capital and traditional budgeting can be discussed and compared on the same tax base. The importance of income

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tax provisions and their timing is shown by Watts and Helmers [9]. They indicate traditional budgeting estimates for an example farm machine are 30 percent greater than comparable capital budgeting estimates which included income tax aspects. In that analysis the capital budgeting model included income tax features but was readjusted to a before-tax basis for comparison with a before-tax traditional model. However, both estimates were made on a nominal monetary basis.

EXAMPLE

A two-wheel drive tractor with 600 hours of annual use was selected for illustration. The purchase price of the new machine is assumed to be $20,000 and the used price after 10 years is $16,000 in nominal terms[1] at which time the tractor will be sold. Housing, insurance, and taxes, repair and maintenance, and fuel costs, hereafter referred to as adjunct costs, are estimated to be $3,000 per year (real basis).[2] A nominal discount/opportunity cost rate of 10 percent and an inflation rate of 6 percent are assumed.

CAPITAL BUDGETING

The capital budgeting approach involves discounting all flows over the ownership life to a net present cost and, if costs are desired on an annual basis, amortizing the net present cost over the expected ownership period. As indicated before, the capital budgeting example does not include income tax aspects. To correctly allow for inflation, real flows should be discounted by a real discount rate and nominal flows should be discounted by a nominal discount rate to determine the net present cost.[3]

In the example, adjunct costs are discounted by the real discount rate and the used price is discounted by the nominal discount rate. Stermole [7, pp. 169-170] has shown the relationship of the real discount (r'), the inflation rate (f), and the nominal discount rate (r) to be

(1) $$r' = \frac{1+r}{1+f} - 1.$$ [4]

Thus, for a nominal discount rate of 10 percent and an inflation rate of 6 percent, the real discount rate is 3.774 percent. Therefore the present value of total adjunct cost is $24,608.77 and the present value of the used price is $6,168.69. These values together with the initial $20,000 outlay result in a net present cost of $38,440.08.

Equivalent annual costs are found by amortizing the net present cost over the ownership period. If annual costs are amortized with a nominal discount rate, the resulting equivalent annual costs are constant over the period in nominal dollars. Nominal annuities, if inflation occurs, are changing in value over time. Being aware of the cost basis is especially important in estimating optimum replacement strategies. An optimum replacement strategy for purposes of this article is defined as selecting an ownership period or replacement age that minimizes amortized costs over an infinite planning horizon. Table 1 shows costs for a hypothetical

TABLE 1. ILLUSTRATION OF REAL VERSUS NOMINAL AMORTIZED COSTS FOR A HYPOTHETICAL MACHINE

Ownership Period	Present Value of Total Cost	Real Amortized Cost	Nominal Amortized Cost
(years)	($)	($)	($)
1	1000	1037.70	1100.00
2	1900	1004.10	1094.80
3	2750	986.60	1105.80
4	3590	983.70	1132.50
5	4470	997.60	1179.20

example. A 10 percent real discount rate and an inflation rate of 6 percent are assumed. If real costs are constant over time, the optimum ownership period is four years as indicated by the minimal real amortized cost. However, the minimal nominal amortized cost coincides with an ownership period of only two years. Therefore, it appears more appropriate to amortize the net present cost by using a real discount rate so that the resulting annuity has a constant value even though the actual nominal amount would change as a function of the inflation rate. The annuity equivalent in real terms to the present value of $38,440.08 is $4,686.16 in the tractor example. The annuity equivalent in nominal terms to the present value of $38,440.08 is $6,255.95. The difference between the equivalent real and nominal annuities is relatively large and therefore deserves

[1]Estimating the used price in real terms may be preferable, for a reason made obvious hereafter. However, to delineate the differences between nominal and real costs, it is convenient to start with a nominal estimate of the used selling price.

[2]Generally repair and maintenance costs are expected to increase with age and so realistically adjunct costs should do likewise. However, such an assumption complicates the example in terms of explaining the effects of inflation on accurate estimates of machinery costs.

[3]Inflating real flows to nominal terms and discounting by a nominal discount rate is equivalent to discounting real flows by a real discount rate. Conversely, deflating nominal flows to real terms and discounting by a real discount rate is equivalent to discounting nominal flows by a nominal discount rate. Regardless of which method is used, the net present cost will be the same.

[4]This is for annual compounding. For continuous compounding the real discount rate r' is found as r-f.

consideration in the estimation of annual machinery costs.

TRADITIONAL BUDGETING

Traditional machinery cost budgeting is defined (for purposes of this article) as estimating costs on an annual basis by (1) basing opportunity cost on a percentage of midvalue of the machine, (2) using straight-line depreciation, and (3) the inclusion of adjunct costs. In practice adjunct costs are usually broken down into various categories and estimated (1) on the basis of a midvalue of the machine, (2) on the basis of purchase price, or (3) independently of machine value. In this article adjunct costs are assumed to be estimated independently of the machine value.

If annual machinery costs are estimated naïvely, ignoring inflation, depreciation is \$400, opportunity cost is \$1,800 (10 percent opportunity cost rate and \$18,000 midvalue),[5] and adjunct costs are \$3,000. Total annual costs are estimated to be \$5,200, a figure very different from the capital budgeting estimate. Initially the \$5,200 cost estimate might appear to be in real terms because adjunct costs are in real terms; however, closer investigation indicates that depreciation and opportunity cost are estimated in nominal terms because the used price to compute midvalue and the opportunity cost are in nominal terms. Therefore, quantities on a different monetary basis have been added, an obviously incorrect procedure. All flows must be analyzed on the same basis for the analysis to be consistent.

If the cost estimate is to be on a nominal basis (that is, if the cost estimate is to be made such that the dollar amount is an approximate average dollar amount versus an average value over time), real flows must be adjusted to nominal flows. In the example, adjunct costs are estimated on a real basis. This real annuity can be adjusted to a nominal annuity in the following manner.

Let

R = real annuity
r' = real discount rate
n = time period
N = equivalent nominal
r = nominal discount rate.

If a nominal and real annuity are equivalent or have the same present value,

$$(2)\quad R\left[\frac{1-(1+r')^{-n}}{r'}\right] = N\left[\frac{1-(1+r)^{-n}}{r}\right].$$

Therefore

$$(3)\quad N = R\left[\frac{1-(1+r')^{-n}}{r'}\right]\left[\frac{r}{1-(1+r)^{-n}}\right].$$

Applying this relationship, one finds that the nominal annuity equivalent to \$3,000 in real adjunct costs is \$4,004.96. Total annual nominal cost is \$6,204.96. The relatively small (\$50.99) difference between the nominal traditional and capital budgeting estimates (explained in the appendix) is due not to inflation but to inherent shortcomings of the traditional method in handling opportunity cost.

As explained previously, a real basis for cost estimates is generally preferred. If costs are to be expressed on a real basis, those nominal flows must be adjusted to equivalent real flows. Opportunity cost and depreciation are now in nominal terms because the opportunity cost rate and the used price are in nominal terms. The used price must be deflated to compute depreciation and midvalue on a real basis. Furthermore, the opportunity cost rate must be adjusted to a real rate in a manner analogous to adjusting a nominal discount rate to a real discount rate. Therefore the real annual straight-line depreciation is \$1,106.57 and opportunity cost is \$545.99. Including adjunct costs of \$3,000 yields a total annual real cost of \$4,652.56. Again, the difference between the real traditional and capital budgeting estimates is due to shortcomings in the way opportunity cost is treated in the traditional method (explained in the appendix).

CAPITAL BUDGETING WITH INCOME TAX

Inflation adjustments to capital budgeting including income taxes are similar to those ignoring taxes. Adjustments to capital budgeting to estimate costs on after-tax bases are discussed in the literature. Therefore, in this section of the article the authors are mainly concerned with inflation but must review the necessary tax adjustments in capital budgeting models. The flows of concern are tax depreciation benefits, investment credit, purchase price, after-tax selling price, and adjunct costs. The objective of machinery budgeting is to estimate annual costs; therefore benefits are considered negative flows and costs positive flows. All flows are discounted at a discount rate consistent with the basis of the flow to estimate the net present cost. The net present cost then is amortized to estimate annual costs.

This capital budgeting analysis involves an after-tax basis in its discounting and

[5]Often an arbitrary salvage value is used in computing machine midvalue and depreciation even in periods of increasing machine prices. Such a salvage value can be considerably different from an expected used price. A first step in machinery budgeting under inflation is the use of a used selling price rather than an arbitrary salvage value.

amortizing. Thus the discount rate must consider the tax basis as well as the real-nominal basis previously discussed. As discussed by Adams [1], the discount rate must correspond to its tax basis. Hence, a nominal before-tax discount rate (r) is adjusted to a nominal after-tax rate ($\bar{r}$) by multiplying by the complement of the marginal income tax rate (MTR) as in equation 4.

$$\bar{r} = r(1-MTR) \tag{4}$$

Therefore, the real after-tax discount rate ($\bar{r}'$) is

$$\bar{r}' = \frac{1+r(1-MTR)}{1+f} - 1. \tag{5}$$

The nominal after-tax discount rate ($\bar{r}$) is used to discount nominal after-tax flows and the real after-tax discount rate ($\bar{r}'$) is used to discount real after-tax flows to estimate net present cost. If average annual nominal after-tax costs are desired, the net present cost is amortized by using a nominal after-tax discount rate; if average annual real costs are desired, the net present cost is amortized by using a real after-tax discount rate.

The monetary basis of certain flows is confusing. The adjustments to an after-tax basis are not always obvious even though well documented. The basis of the selling price is nominal and adjunct cost is real by assumption. The nominal selling price is adjusted to a nominal after-tax basis by subtracting depreciation recapture. Adjunct costs are adjusted to a real after-tax basis by multiplying by the complement of the marginal tax rate. Implicitly this procedure assumes that the marginal tax rate will be constant during future inflationary periods. Depreciation and investment credit tax benefits are received in future dollars and so are on a nominal basis. Depreciation tax benefits are computed by multiplying annual depreciation calculated for tax purposes by the marginal tax rate. Of course investment credit is an after-tax flow.

Several tax-related assumptions are added to the previous example. Double declining balance depreciation, additional first-year depreciation, and 10 percent investment credit are assumed in the after-tax capital budgeting model along with an 8-year depreciable life and $2,000 salvage value. The $2,000 salvage value is used for tax purposes to cut off depreciation at a $2,000 book value even though the ownership period is 10 years. A marginal tax rate of 32 percent is assumed.

Table 2 is a summary of after-tax discounted net present costs for the capital budgeting model incorporating income tax. Negative entries refer to positive dollar flows arising from tax credits or sale of the used machine.

TABLE 2. DISCOUNTED NET PRESENT COSTS FOR THE EXAMPLE MACHINE USING THE AFTER-TAX CAPITAL BUDGETING MODEL FOR A 10-YEAR OWNERSHIP PERIOD

Item	$
New price	20,000.00
Adjunct costs	19,578.16
Tax depreciation benefits	-4,910.30
Investment credit	-1,872.66
Used sale[a]	-6,805.85
Total net present cost	25,989.35

[a]Includes depreciation recapture tax.

The equivalent real annuity using the real after-tax amortization rate is $2,708.03. The equivalent nominal annuity using the nominal after-tax amortization rate is $3,666.16. Obviously, the reason for these estimates being lower than the previous capital budgeting model estimates is the after-tax basis of this model.

The focus of this article is the modifications to capital and traditional budgeting models whereby inflation can be properly considered in machinery cost estimates. The adjustments are reflected in the wide differences between real and nominal cost estimates for each model. For the example the nominal estimates range from 33 to 35 percent higher than the real estimates at a 6 percent inflation rate. Real estimates of machinery costs are more applicable and useful than nominal expressions because the value of the estimate has a time point reference and is not confounded with a changing monetary basis. The difference between nominal and real estimates is large enough to deserve consideration in the construction of economic models involving time, inflation, and projections of cost. The implicaton of the inflation adjustments is applicable to a wide range of economic models involved with time.

Under certain conditions a real cost estimate can be updated with an inflation index. The inflation rate upon which costs were originally estimated must have been accurate and must be consistent with the inflation index used for updating. Furthermore, the original discount rate must still be applicable. If these conditions are not met, rebudgeting may be necessary.

SUMMARY AND CONCLUSIONS

The adjustments to capital and traditional budgeting needed to place cost estimates on a real basis are demonstrated for comparable capital and traditional budgeting models (no income tax aspects considered).

For the traditional budgeting model all flows and opportunity cost must be adjusted to be consistent with the desired basis of the cost estimate. After these adjustments, traditional and capital budgeting (ignoring taxes) cost estimate differences are relatively small and are due to the manner in which opportunity cost is computed in the traditional method.

When these adjustments are made, the difference between real and nominal cost estimates for either traditional or capital budgeting methods is approximately 33 percent at a 6 percent inflation rate. This difference should be considered in the construction and expression of machinery cost estimates. Though adjunct costs are assumed to be estimated on a real basis, similar adjustments would be required in the models had part or all of the adjunct costs been estimated on a nominal basis. For the traditional budgeting model, translation of a nominal annuity to a real annuity would be needed. Finally, the inflationary adjustments for a capital budgeting model that includes income tax are also large, changing costs by 35 percent in that particular example.

APPENDIX

As Walrath [8] has pointed out, it is appropriate to base opportunity cost on the beginning value rather than on midvalue as does traditional budgeting. In capital budgeting, amortizing the difference between the discounted salvage value and the purchase price accounts for both opportunity cost and depreciation. Therefore:

$$P - S(1+r)^{-n} = C + D \tag{6}$$

where

P = purchase price
S = salvage value
C = present value of opportunity cost
D = present value of depreciation
n = ownership period.

If straight-line depreciation is assumed, then

$$D = d\left[\frac{1-(1+r)^{-n}}{r}\right] \tag{7}$$

where

d = annual depreciation.

Therefore:

$$C = P - S(1+r)^{-n} - D \tag{8}$$

which can be proven algebraically to be equal to

$$C = \sum_{i=1}^{n} r\,[P-d(i-1)]\,[1+r]^{i-n}. \tag{9}$$

Note that the capital budgeting method correctly bases opportunity cost on the beginning of the year value, $P - d\,(i-1)$, not midyear value, $P - d\,(i-\frac{1}{2})$. Traditional budgeting opportunity cost is based on midvalue $(\frac{P+S}{2})$ which can be shown to be equal to the mean of the midyear values. Further differences are due to the decreasing amount of opportunity cost coupled with the compounding factor in the capital budgeting model versus a rate applied to an average quantity in the traditional model.

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