DEPRECIATION AND INFLATION: SOME PRACTICAL OBSERVATIONS

by
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Introduction

It is still commonly argued that accelerated income tax depreciation provisions are required to counteract the effects of inflation on capital investment decisions. The argument is that inflation affects before-tax investment decisions by reducing the value of historical cost income tax depreciation allowances and thus increasing the effective tax rate faced by investors. Allowing write-off on a historical cost basis under inflationary conditions is also often said to bias before-tax decisions away from longer-lived assets to shorter-lived assets and, in particular, away from capital replacement to annual maintenance expenditure which is deductible in the year it is made.

These misconceived notions continue to abound despite theoretical analyses to the contrary, such as those by King (1977) and Swan (1978), which show that investment neutrality is possible when either nominal or real interest is included in the tax base. These analyses lead, for example, directly to the conclusion that, with inflation and with nominal interest in the tax base, even straight line or reducing balance income tax depreciation allowances based on historical cost are in fact too generous to leave before-tax investment decisions unaffected.

Perhaps the misconceptions remain because of the somewhat complex mathematical formulations, usually involving the cost of capital, used to show the income tax depreciation allowances required for the neutrality of capital investment decisions. The misconceptions have also not been helped by a series of related papers emanating from the United States, such as those by Auerbach (1979), Hulten and Wykoff (1980), and Auerbach and Jorgenson (1980), which, while certainly not advocating accelerated depreciation schemes because of their variable effects on assets with different lives, continue to talk of inflation reducing the value of historical cost depreciation allowances and increasing effective tax rates.

This paper aims at dispelling the misconceptions by getting behind the mathematics and demonstrating, using simple discounting concepts, the requirements for investment neutrality regardless of the level of inflation:

- immediate write-off of capital expenditure with the exclusion of interest from the tax base, which forms the conceptual basis of cash flow taxes generally and, in particular, the resource rent tax scheme applying to petroleum projects in "green fields" offshore areas in Australia; and
- the allowance of economic value depreciation (or actual change in value of an asset) with the inclusion of nominal interest in the tax base, which forms the conceptual basis of Australia's business income tax system.

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The achievement of income tax neutrality in practice is often all too readily considered impossible because economic value depreciation is thought to be unattainable. The analysis shows, however, that with constantly deteriorating assets economic value depreciation can, regardless of the level of inflation, be determined in practice using as a basis the reducing balance method of determining depreciation allowances. The analysis concentrates on investment decisions relating to individual assets, but the results are, nevertheless, applicable to investment projects generally.

The paper goes on, again using the same discounting methodology, to show that the taxation allowances required for neutrality when real interest is incorporated in the tax base comprise economic value depreciation plus additional year-by-year deductions. This combination of allowances is often presented inappropriately as "replacement cost" or "current value" depreciation. The analysis shows that it is in this real interest case, and not the nominal interest case, that accelerated depreciation has some relevance.

Finally, some aspects of risks are discussed to show the relevance of the general results under uncertainty.

Analysis

In order to highlight the tax-related issues, take the situation where there is a known current and future 8% rate of inflation for prices generally and a healthy capital market enabling people to borrow or lend as much as they like at the going inflation-affected nominal 15% interest rate. The future net revenue stream from any capital investment is also known with certainty and there is always sufficient income to write off tax deductions in full in the year they become available. Personal and company taxation are fully integrated.

Exactly how, or to what extent, the nominal interest rate has adjusted to inflation is not important. The analysis focuses on the neutrality of investment decisions after tax and with inflation, compared to the situation before tax under the same inflationary conditions (with the going interest rate unaffected by the tax).

Before tax, marginal capital investments are those with returns just equal to the going 15% interest rate, or with a net present value (NPV) of zero with discounting at that interest rate. The return from those investments just compensates entrepreneurs for the opportunity cost of tying their money up in them. One such marginal before-tax investment can be represented, with discounting at the 15% rate, by:

$$NPV_b = R - C = 0 \quad (1)$$

where NPV_b = net present value of the investment before tax;
R = value of discounted end-of-year receipts including any asset sale value, less operating expenses; and
C = price of asset at the start of the first year.

Any loan funding used to purchase the asset need not be included explicitly as the equity contribution plus the present value (PV) of the repayments of any loan is simply the price of the asset.

After tax, we want these same investments to remain marginal. In other words, we want the capital allowances for tax purposes such that these investments provide the entrepreneur with the same after-tax return that could be obtained from putting the money in the financial market. That is, with discounting at each entrepreneur's after-tax opportunity cost of money, the NPV of these investments should remain zero.

Tax With Interest Excluded

A tax with interest excluded does not affect entrepreneurs' before-tax discount rate. They are still able to receive their 15% from the financial market after the tax.

In these circumstances, allowing immediate write-off of capital expenditure (and including any sale value in assessable income) results in the initial investment outlay, as well as the net receipts in each year, being reduced by a proportion equal to the tax rate applicable to the entrepreneur. Thus, the tax-reduced net receipts and sale value represented in equation (1), discounted at the same 15%, equal the price of the asset reduced by the effect of writing off this capital cost immediately against other income. The investment remains marginal after tax.

More generally, the relationship between the NPV of an investment before and after this immediate expensing—or Brown (1948)—tax, as shown by Mayo (1979) using this simple discounting approach, is given by:

$$NPV_a = (R - C)(1 - t) = NPV_b(1 - t) \quad (2)$$

where t = the entrepreneur's marginal tax rate.

This neutrality condition holds regardless of the rate of inflation or the particular marginal tax rate of the entrepreneur (although progressive tax rates could affect the required balance).

Because the before-tax discount rate is not directly affected by the immediate expensing tax, the tax is ideal in terms of efficiency as an additional tax or royalty on a particular sector of an economy. A resource rent tax (RRT) is, of course, a variation of this immediate expensing tax with losses being carried forward at a specified "threshold" rate when, in practice, sufficient other income is not available to offset fully available deductions. Under our assumption of certainty, this "threshold" rate would equal the going nominal interest rate if the RRT is imposed before income tax. When the losses carried forward at this rate are

eventually recouped, their value as a tax deduction in discounted terms will be equal to that value had full loss offset been available.

Tax With Nominal Interest Included

In contrast to the immediate expensing tax, an income tax with nominal interest included in the tax base does affect entrepreneurs' before-tax discount rate. If an entrepreneur faces a 46% income tax rate, the 15% before-tax return from the financial market will be reduced in proportion to this tax rate to 8.1%.

Nevertheless, with economic value depreciation allowed and with discounting at 8.1%, the investment represented by equation (1) will still have a NPV of zero. The entrepreneur will, after tax, still be indifferent between receiving 8.1% from the financial market and from that capital investment. This comes about because both C and R in equation (1) remain the same as they were before tax with discounting at 15%.

Appendix 1 uses a general discounting principle to show that the cost of the asset, C, is unaffected regardless of the level of debt used to acquire it. This is because the before-tax discount rate (the going interest rate) and the interest component of any loan repayments are reduced by the tax in proportion to the entrepreneur's tax rate. In these circumstances, the after-tax PV of any loan repayments is again the initial value of the loan. Thus, after the income tax, the equity contributions and the PV of the stream of any net loan repayments still sum to the price of the asset.

Similarly, for the net receipts stream represented in equation (1) to discount after tax to R, only the "interest component" of the before-tax net receipts in each year must be reduced by a proportion equal to the entrepreneur's tax rate. That is, the "principal component" of the net receipts in each year must be an allowable deduction for income tax purposes, so that only the "interest component" is taxed. With net receipts obtaining at the end of each year, the "principal component" of the net receipts in any year is the difference in the PV of the net receipts stream at the start and end of that year, or the difference in the value, including the inflationary component, of the asset over that year. That difference is economic value depreciation.

This neutrality, shown by Samuelson (1964), of a nominal income tax system allowing economic value depreciation, applies regardless of the rate of inflation and of the marginal tax rate of the particular entrepreneur who is deciding the viability of the investment (although again progressivity could affect this). In contrast to the immediate expensing tax, the neutrality of the income tax depends on its direct effect on entrepreneurs' after-tax discount rates, an effect which can only be achieved if the tax is applied economy-wide and not to just one particular sector.

Economic Value Depreciation in Practice

It is often assumed that economic value depreciation cannot readily be determined in practice and allowed for income tax purposes. The income tax law of most Western countries including Australia, however, provides for a balancing adjustment on the disposal of a depreciable asset to ensure that, over its years of use, only the difference in its original cost and its final sale value is allowed for tax purposes (except to the extent that any nominal capital gain realised is not taxed). Thus, generally, economic depreciation is already allowed over the whole period of use of an asset. The depreciation provisions for tax purposes really specify the structure of write-off of this overall change in economic value year by year over the asset's period of use.

Further, for a marginal asset which is physically deteriorating at a constant rate (as would be reflected with no inflation in a constant proportional reduction in its net receipts), economic value depreciation is changing year by year by the same proportion as the net receipts are changing (see Appendix 2). With deterioration at the rate s and inflation at the rate i, the asset's net receipts, say P, in one year change to $(1 - s)(1 + i)P$ the next, so its net receipts and economic value change each year by the proportion $(1 - s)(1 + i) - 1$.

Therefore, if K is the depreciated value of the asset at the start of a year, economic depreciation, D, for that year, which is positive if the proportional change in economic value is negative, is given by:

$$\begin{aligned} D &= (1 - (1 - s)(1 + i))K \\ &= (s(1 + i) - i)K \\ &= sK - i(1 - s)K \qquad (3) \end{aligned}$$

This result, illustrated in Table 1, is equivalent to that obtained by King (1977, p. 242) for his debt financing case and corresponds to Proposition 1A of Swan (1978, p. 3).

With no inflation, equation (3) shows that the annual economic value depreciation of a marginal asset corresponds to the income tax allowance obtained from the standard declining balance method applied to historical cost at the rate of physical deterioration. Under the Australian pre-July 1982 depreciation arrangements, which are still available to taxpayers as an option, the Commissioner of Taxation determines the "effective life" of categories of depreciable assets. The effective lives translate into reducing balance depreciation rates 1.5 times the alternative straight line rate. Consequently, under non-inflationary conditions, if the declining balance rate determined under this system corresponds to the constant rate of physical deterioration of that type of asset, the reducing balance allowances based on historical cost would equate with economic value depreciation.

Under inflationary conditions, however, equation (3) shows that standard historical cost allowances for capital assets (and stocks) would be too generous. In practice, from the allowance in a particular year, determined by applying the declining balance rate to the depreciated value at the start of the year, would be subtracted an amount equal to the proportion $i(1 - s)$ of that same depreciated value. The economic depreciation so

obtained would determine the asset's depreciated value at the start of the next year, and so on until the asset was scrapped or sold.

With inflation, the depreciated value under reducing balance write-off would, in the early years, fall year by year further and further below the true economic value of the asset. Eventually, in later years the depreciated value would become so low that the annual depreciation allowances from the reducing balance method would become less than the actual economic depreciation in those years. Once the asset was sold, however, the balancing adjustment on disposal would generally ensure that the sum of the income tax allowances equalled the economic depreciation of the asset over its period of use. This is illustrated in Table 1.

Nevertheless, because the historical cost reducing balance allowances must be greater than economic depreciation in the early years, the PV of the historical cost allowances will be greater than the PV of economic value depreciation allowances. During periods of inflation, depreciation allowances based on historical cost are "accelerated" compared to the neutral case as shown in Table 1. As Swan (1978, p. 7) points out, the "tax liability of the firm is reduced in the relevant present value sense by the impact of inflation which drives a wedge between economic and historical based depreciation schemes". Thus, contrary to common belief, statutory accelerated depreciation provisions, such as write-off over either three or five years as with the post-July 1982 Australian depreciation scheme, in no way counteract the effects of inflation on historical cost depreciation allowances. They actually exacerbate the generosity of the historical cost allowances.

The "acceleration" of the historical cost allowances could be removed in practice by determining the appropriate "effective" lives or rates of deterioration of constantly deteriorating asset types and applying equation (3) as described above. Of course, all assets would not be expected to have a neat constant rate of deterioration. Nevertheless, studies by Hulten and Wykoff (1981) have suggested that the physical deterioration profile of many types of assets does indeed approximate that of a constantly deteriorating asset. To the extent that an asset tended towards either linear depreciation or the "one-horse-shay" type, with net receipts maintained at the same level until there is total collapse, equation (3) would still generally provide year-by-year allowances which were too generous. With a marginal "one-horse-shay" asset, for example, economic value depreciation actually increases during the life of the asset and corresponds to the principal components of a loan at the going interest rate over the life of the asset with repayments equal to the constant annual net receipts.[1]

1. Incidentally, this means that with a marginal asset leased for equal annual rentals, even straight line depreciation will result in an increase in the return to the lessor above the going interest rate which, if passed on via lower lease payments to lessees with tax rates lower than the lessor's, will make leasing more attractive than loan finance.

TABLE 1

EFFECT OF INFLATION ON ASSETS WITH DIFFERENT RATES OF PHYSICAL DETERIORATION UNDER AN INCOME TAX INCORPORATING NOMINAL INTEREST(a)

Year	Investment	Net Receipts	Economic Depreciation (b)	DB (Hist. Cost) Depreciation (c)	Tax Payments Ec. Val.	Tax Payments DB	Cash Flow Ec. Val. (d)	Cash Flow DB
Long-lived Asset (s = 0.15)								
0	1000.0	0.0	0.0	0.0	0.0	0.0	- 1000.0	- 1000.0
1		232.0	82.0	150.0	69.0	37.7	163.0	194.3
2		213.0	75.3	127.5	63.3	39.3	149.6	173.7
3		195.5	69.1	108.4	58.1	40.1	137.4	155.4
4		179.5	63.4	92.1	53.4	40.2	126.1	139.3
5	- 651.9	164.8	58.2(e)	- 129.9(f)	49.0	135.6	767.7	681.1
PV	0.0 (at 15%)				236.3	221.5	0.0	14.8
Effective Tax Rate (g)							46.0%	43.1%
Short-lived Asset (s = 0.375)								
0	1000.0	0.0	0.0		0.0	0.0	- 1000.0	- 1000.0
1		475.0	325.0	375.0	69.0	46.0	406.0	429.0
2		320.6	219.4	234.4	46.6	39.7	274.1	281.0
3		216.4	148.1	146.5	31.4	32.2	185.0	184.2
4		146.1	100.0	91.6	21.2	25.1	124.9	121.0
5	- 140.0	98.6	67.5(e)	12.5(f)	14.3	39.6	224.4	199.1
PV	0.0 (at 15%)				153.8	147.2	0.0	6.6
Effective tax rate (g)							46.0%	44.0%

(a) Inflation, i, is at 8%, the nominal interest rate at 15%, and tax at 46%. The NPV before tax of both investments is zero. With no inflation, the long-lived asset's net return in period 1 would be \$214.8 reducing by 15% per year, and the short-lived asset's net return would be \$439.8 reducing by 37.5% per year.

(b) To the depreciated value (asset cost less allowed economic value depreciation) at the end of the previous year, the rate of physical decline, s, is applied less the inflationary adjustment i(1 - s).

(c) Declining balance depreciation at the rate of physical decline, s, of the asset (including balancing adjustment on disposal in period 5).

(d) With discounting at the after-tax rate of 8.1%, the NPV is again zero (and the effective tax rate 46%).

(e) Balancing adjustment on disposal is \$0.0.

(f) Balancing adjustment on disposal is \$208.2 and \$44.8 for the long- and short-lived asset respectively.

(g) With economic depreciation or reducing balance depreciation applied at the asset's rate of physical deterioration, the effective tax rate may alternatively be determined by dividing the PV of the actual tax payments by the PV of the taxable income were economic depreciation allowed. (This PV method could, incidentally, be a more generally appropriate way of defining effective tax rates.)

The result that, with inflation, historical cost allowances are too generous may seem counter-intuitive. But the result takes into account considerations often ignored: the effect of inflation on the year-by-year nominal value of the asset; and the fact that the full nominal value, and not just the real value, of interest payments is included in the tax base. With nominal interest in the tax base, allowing the nominal change in

value of the asset as depreciation means that income for tax purposes from the \$1000 assets in Table 1 or the alternative interest income from \$1000 is the same as the corresponding before-tax nominal income. Thus, taking into account the effect on the entrepreneur's discount rate, the tax system maintains the before-tax nominal wealth of \$1000 regardless of the investment undertaken. The entrepreneur's real wealth (command over future real consumption) may be affected—and accountants may well wish to measure the increase or decrease in this real wealth—but it will be affected in the same way for both the capital investment and the alternative financial investment to maintain the balance between these two alternatives. This balance would, however, be upset by providing the capital investment accelerated depreciation: with nominal interest income being taxed in full, nominal income from capital investments should also be taxed in full.

Effective Tax Rates

The neutrality condition of zero NPV before and after income tax is the same as requiring the effective tax rate to be equal to the nominal tax rate, with the effective tax rate defined as the difference in the before- and after-tax nominal rates of return expressed as a percentage of the before-tax nominal rate of return. This equivalence results directly from the fact that the entrepreneur's before-tax discount rate is reduced by the tax by a proportion equal to the relevant marginal tax rate. Thus, the effective tax rates in Table 1 equal the nominal rate when economic depreciation is allowed, and are less than the nominal rate with historical cost depreciation allowed.

In general terms, effective tax rates compare actual tax payments, according to the system under study, with the taxable income that would be applicable under the neutral tax system which incorporates interest in the same way—either nominal, real, or excluded completely—as the system under study. In terms of investment neutrality, it would be meaningless to compare, say, the actual income tax paid under a system such as ours, which has nominal interest included, with taxable income under a neutral tax system which incorporated real interest.

The series of related papers from the United States, however, effectively makes just that comparison and not surprisingly comes up with exactly the opposite conclusion to that of the above analysis: that, with inflation, standard historical cost allowances are less generous than economic depreciation, thus increasing the effective tax rate above the nominal rate. These papers, for example Auerbach (1979) and Hulten and Wykoff (1980), have nominal interest in the tax base and use the reduction in the nominal before-tax rate of return by the tax rate proportion in their cost of capital formulation. The definition of effective tax rate in those papers, however, is in terms of real rates of return which entails the inconsistent requirement that the real before-tax return is also reduced by a proportion equal to the tax rate. That inconsistency in turn requires the taxation allowances for neutrality to be specified not in terms of equation (3) above, but in terms of equation (4) obtained later for the real interest case.

Applying equation (3) in this present paper to the analytical framework in Hulten and Wykoff (1980), for example, would result in the rate of inflation being subtracted from the numerator of equation (5) in the Hulten and Wykoff paper. That would then be consistent with defining the effective tax rate in equation (10) of that paper in terms of nominal (not real) rates of return, as well as with the proportional relationship between before- and after-tax nominal discount rates.

The Choice of Asset Lives and Repairs versus Replacement

As shown from equation (3), the closer the rate of physical decay is to unity (or the shorter the life of the asset), the closer will be the PV of the historical cost declining balance allowances plus disposal adjustment to the PV of year-by-year economic value depreciation. Consequently, the shorter the life of an asset marginal before tax, the closer will the (positive) after-tax NPV of the asset be to zero.

Thus, in times of inflation, with an income tax system incorporating nominal interest and historical cost depreciation allowances, investment decisions will be biased towards assets with longer lives. This bias is illustrated in Table 1 where the NPVs of the shorter- and longer-lived assets in Table 1 are $6.6 and $14.8 respectively, which correspond to effective tax rates of 44.0% and 43.1%.

During periods of inflation, therefore, even the depreciation provisions of the pre-July 1982 Australian tax law would tend to bias investment in capital assets towards longer-lived assets. In the same way, decisions would be biased away from year-by-year repairs to existing plant with the associated year-by-year deductions and towards "longer-lived" expenditure on replacement, or capital modification, of existing plant with the associated deductions for depreciation over the effective life of the capital investment. Further, because the balancing adjustment on disposal brings back to assessment at the time of sale reducing balance deductions allowed over the period of asset use in excess of economic depreciation, historical cost allowances under inflation would tend to distort decisions towards longer asset holding.

Income tax systems with statutory write-off periods, such as write-off in the year of expenditure or our 5/3 depreciation scheme, bias decisions towards longer-lived assets even when there is no inflation, and the generosity of these arrangements is magnified during periods of inflation. With write-off in the year of expenditure, for example, the effective tax rates faced by the two investments in Table 1 would be 26.7% and 19.6% for the shorter- and longer-lived asset respectively.

If depreciation allowances which were less distortive were desired in Australia, a move back to write-off over the "effective" lives of assets would be a move in the right direction. To go further and introduce full

adjustments for inflation in line with equation (3) would require the acceptance of the possibility of negative depreciation , or additions to taxable income, particularly in respect of longer-lived assets in periods of inflation. For example, with 8% inflation, assets which were deteriorating at a rate less than 7.4% per year would be providing increasing net receipts year by year.

The reductions in effective rates in the above illustrations do not imply that, despite the distortions imposed, everyone would gain from the introduction of generally available first-year write-off of capital expenditure. With everyone receiving the same generous treatment, there would be consequential offsetting general adjustments in terms of, for example, prices, interest rates, and exchange rates, and all that would remain after these had worked their way through the economy would be the distortions around the new "margin" (and, of course, the transitional revenue losses associated with the introduction of accelerated depreciation). To the extent that any, perhaps relatively capital intensive, firm or industry benefited it would be at the expense of others; everyone would, in effect, be worse off. Any potential macroeconomic stimulation aimed at could be better achieved by less distortive measures.

Related Issues

Tax With Real Interest Included

After imposing an economy-wide income tax incorporating symmetrical treatment of real interest payments and receipts, only the real part of the entrepreneur's 15% return from the financial market would be taxed at the 46% rate. With 8% inflation, only the real 7% would be taxed, reducing the 15% return by 3.22% to 11.78%.

Looked at another way, the nominal 15% return would be taxed in full, leaving the 8.1% return as in the nominal interest case, and a refund of tax provided for the excess 3.68% tax paid on the 8% inflationary component. Thus, the entrepreneur's discount rate would be increased, compared with that in the nominal interest case, by a factor equal to the tax rate times the inflation rate. Symmetrically, the entrepreneur would be allowed deductibility of real interest payments, which is the same as being allowed a deduction in full of nominal interest payments (as in the nominal interest case) and in addition being taxed on the fall in the real value of net monetary liabilities in each year.

As shown in Appendix 1, these effects on the stream of loan repayments and on the discount rate mean that, again, C in equation (1) is unaffected by this tax regardless of the gearing ratio used to acquire the asset. Similarly, for the revenue stream of the asset to discount (at each entrepreneur's after-tax discount rate) after tax to R in equation (1), thus keeping the investment marginal after tax, taxation allowances are required in addition to economic depreciation allowances. Appendix 1 shows that this additional allowance in each year is the inflation rate times the PV of the asset's revenue stream at the start of the corresponding year (i.e. the value of the asset at that time or, in practical terms, the depreciated value of the asset when economic depreciation is allowed). That is, for constantly deteriorating assets, the taxation allowances needed to achieve neutrality are given by:

$$A = (s(1+i)-i)K + iK \qquad (4)$$

The additional capital allowance, iK, is the asset's annual nominal capital gain. This result, illustrated in Table 2, is that derived by King (1977, p. 242) again for his debt financing case, and is equivalent to Proposition 2A of Swan (1978, p. 4).

These arrangements not only maintain the entrepreneur's $1000 nominal wealth in the examples of Table 2 but, as Swan (1982) points out, they also maintain the before-tax real wealth, thus avoiding any inequities resulting from real wealth effects of the nominal interest system. This real interest system may also better hold up against the assumption of an unchanged nominal interest rate with the imposition of tax. Nevertheless, any future move in Australia to a true real income tax base should not involve accelerated depreciation provisions.

With the constant rate of 8% inflation assumed here for both capital goods and prices generally, the taxation allowances in equation (4) reduce to $s(1+i)K$. This formulation can be quite misleading as it may be read to imply that some form of "current value" or "replacement cost" depreciation allowances are required for neutrality. The taxation allowances required for neutrality comprise, however, two quite distinct components: economic value depreciation allowances, which could be determined in practice according to equation (3) on the assumption of constantly deteriorating assets; and an additional capital allowance, which would depend on the general rate of price increases used to determine the real component of interest payments and receipts for income tax purposes. The important point here is that the additional capital allowance would not be part of the depreciation allowances for income tax purposes: it would not be used in determining the depreciated value of the asset at any time, and it would not come into the determination of the balancing adjustment for taxation purposes when the asset is sold. The effect of the additional capital allowance is to maintain the indifference of the entrepreneur between investing in an asset which is marginal before tax and investing in the financial market when only the real component of interest from his financial investment is taxable.

The reduced form of equation (4) shows, however, that with uniform inflation, standard historical cost reducing balance allowances would be less generous than the combination of economic depreciation and the deductibility of the nominal capital gain, and would result in effective tax rates greater than the nominal tax rate. Accelerated depreciation allowances may, for particular types of assets, be more appropriate than the historical cost allowances. Write-off allowed in the year of expenditure, for example, reduces the effective tax rates of the short-lived and long-lived assets illustrated in Table 2 below the rates applicable with

historical cost depreciation, to 57.2% and 41.8% respectively. An asset with a life somewhat shorter than the long-lived asset would, with first-year write-off, just attract an effective tax rate of 46%, the same rate that would apply were economic depreciation allowed plus appropriate additional capital allowances.

TABLE 2

EFFECT OF INFLATION ON ASSETS WITH DIFFERENT RATES OF PHYSICAL DETERIORATION UNDER AN INCOME TAX INCORPORATING REAL INTEREST(a)

Year	Investment	Net Receipts	Economic Depreciation (b)	Additional Allowance (c)	Tax Payments		Cash Flow	
					Ec. Val.	1 year (d)	Ec. Val. (e)	1 year (d)
Long-lived Asset (s = 0.15)								
0	1000.0	0.0	0.0	0.0	0.0	0.0	– 1000.0	– 1000.0
1		232.0	82.0	80.0	32.2	– 353.3	199.8	585.3
2		213.0	75.3	73.4	29.6	98.0	183.4	115.0
3		195.5	69.1	67.4	27.1	89.9	168.4	105.6
4		179.5	63.4	61.9	24.9	82.6	154.6	96.9
5	– 651.9	164.8	58.2(f)	56.8	22.9	375.7(g)	793.8	441.0
PV					101.0	94.9	0.0	6.0
Effective Tax Rate (h)							46.0%	41.8%
Short-lived Asset (s = 0.375)								
0	1000.0	0.0	0.0	0.0	0.0	0.0	– 1000.0	– 1000.0
1		475.0	325.0	80.0	32.2	– 241.5	442.8	716.5
2		320.6	219.4	54.0	21.7	147.5	298.9	173.1
3		216.4	148.1	36.5	14.7	99.6	201.8	116.9
4		146.1	100.0	24.6	9.9	67.2	136.2	78.9
5	– 140.0	98.6	67.5(f)	16.6	6.7	109.8(g)	232.1	128.9
PV					66.9	79.2	0.0	– 12.4
Effective tax rate (h)							46.0%	57.2%

(a) The NPV before tax of both investments is zero as in Table 1.
(b) As in Table 1.
(c) Depreciated value at the end of the previous period times the rate of inflation, 8%.
(d) Tax payments with write-off in the year of expenditure allowed.
(e) With discounting at the after-tax rate of 11.78%, the NPV is again zero (and the effective tax rate 46%).
(f) Balancing adjustment on disposal is $0.0.
(g) Includes balancing adjustment on disposal of $651.9 and $140.0 for the long- and short-lived assets respectively.
(h) Effective tax rates in the real interest case are determined by expressing the difference between the real before- and after-tax rates of return as a percentage of the real before-tax return. Regardless of the levels of inflation and the nominal interest rate, the real before-tax interest rate, reduced by the tax rate proportion, equals the real after-tax rate. Thus, with the neutral taxation allowances, the effective tax rate equals the nominal tax rate.

Thus, it is with real (and not nominal) interest incorporated in the system that particular, politically determined, accelerated depreciation allowances may adjust for the effect of inflation, but only at a specific level of inflation and for assets with a specific rate of physical deterioration. Relative biases between assets with different lives would be unavoidable. While the additional capital allowance required for neutrality in the real interest case is the same in the first period for assets with different rates of deterioration but with equal prices, for longer-lived assets the capital allowance in later periods reduces at a slower rate. Thus, at higher levels of inflation, accelerated depreciation substituting for the lack of the capital allowances would be expected to impose a weaker bias towards long-lived assets compared with the nominal interest case, and perhaps the bias might even be reversed in certain circumstances.

As mentioned earlier, the series of related United States papers inappropriately uses equation (4) as the basis for neutral tax allowances, and uses real rates of return to determine effective tax rates (see footnote (h) to Table 2), even though nominal, and not real, interest is assumed to be incorporated in the tax base in those papers. Thus, the results in those papers for effective tax rate movements follow the above conclusions in relation to historical cost and accelerated depreciation in a real interest system.

Risk

With certainty in relation to the net receipts stream, the investment "margin" corresponds to the going return from the financial market. When net receipts streams are not known with certainty, the investment "margin" of a particular entrepreneur can be imagined as a continuum of NPV probability distributions corresponding to marginal capital investments of different levels of risk. At one extreme in this continuum is the riskless investment, with a sure zero NPV and a before-tax return corresponding to the going rate of interest. As the spread of possible outcomes of investments in this continuum increases, the expected NPV also increases to balance the increased risk.

Each risky capital investment in this continuum would be judged marginal by the entrepreneur after establishing its NPV probability distribution by obtaining the NPV for each possible net receipts stream from that investment at his risk-free discount rate (before tax, the going interest rate). This probability distribution would contain all the information about risk. To use a risk-weighted discount rate to build up the distribution would be double counting.

In broad terms, a tax would be neutral under uncertainty if it had an impact, in a symmetrical way, on the loss-making end and the profitable end of the range of possible outcomes of each capital investment on the entrepreneur's before-tax continuum of marginal distributions, such that the investment remained on that continuum after tax. This symmetrical impact would result with the "neutral" cash flow tax from its proportional effect (equation (2)) on before-tax positive or negative NPVs.

With the income taxes, the proportional relationship of equation (2) could, however, only result with investments not having a zero before-tax NPV if the investor were somehow able to be taxed at the time of asset purchase on the basis of the difference between the asset's value, as

reflected in its future receipts stream, and its price. In practice, of course, an asset's price has to be taken as its economic value at the time of purchase. Further, even if the physical deterioration of these investments were at a constant rate, the year-by-year economic depreciation for them would not be given by equations (3) and (4) as these only relate to investments with prices reflecting their future net receipts streams. The depreciation allowances from equation (3), for example, applicable in the nominal interest case, would in practice be either too generous or not generous enough for a constantly deteriorating inframarginal or supramarginal asset respectively.

Nevertheless, the closer the NPV of one possible outcome of a particular investment were to zero, the closer would the per period allowances from equation (3) be to the economic depreciation of that outcome. Thus, with constantly deteriorating assets, the use of equations (3) or (4) would still mean that the respective "neutral" income taxes would have a symmetrical impact on the NPV probability distribution of prospective investments.

Thus, the effect of the cash flow and income taxes neutral without uncertainty would, in broad terms, be to move each NPV probability distribution in an entrepreneur's continuum of marginal distributions proportionately closer to the riskless investment earning a sure return equal to the entrepreneur's after-tax discount rate.[2] While risk-averse entrepreneurs would usually be expected to require a greater than proportional decrease in the expected NPV of an investment to balance a proportional decrease in the associated risk, the effect of the "neutral" taxes would broadly be to keep investments which were on an entrepreneur's marginal continuum before tax on his continuum after tax. The taxes would, in broad terms, be neutral under uncertainty.

The symmetrical effect of the neutral tax schemes on the NPV probability distributions depends, importantly, on there being full loss offset. With no uncertainty in relation to future net receipts, the lack of adequate income against which to write off in full deductions when they are available can be handled, as discussed earlier by reference to a RRT, by carrying any losses forward at a threshold rate equal to the going nominal interest rate. This concept is no different with uncertainty.

To the extent that appropriate provisions are made for the write-off of losses which would otherwise not be deducted, for example, losses associated with unsuccessful mineral exploration, the threshold rate for loss carry-forward would still be the rate of return of a riskless investment, or the discount rate used to determine the range of possible NPV

2. This movement is similar to that illustrated by Mayo (1979, p. 204, Figure 2(b)) for his inframarginal project except that that illustration incorrectly reduces the before-tax NPV at each level of absolute probability in proportion to the tax rate. With the reduction in the standard deviation, the peakedness of the distribution should increase commensurately to maintain the area under the distribution.

values of risky investments. In other words, to the extent that it is certain that any excess deductions in a particular year would be eventually written off in full, the threshold rate required to maintain the value of the deductions would correspond to the year-by-year cost of having to wait to recoup that certain value. Thus, even with uncertainty, were full loss offset available, with an RRT applied before income tax the appropriate threshold rate would correspond to, say, the going long term bond rate.

When write-off provisions do not completely remove the risk of undeducted losses, the NPV probability distribution of a potential project may be skewed by the neutral taxes, including an RRT. The loss-making end of the range of possible outcomes is not reduced to balance the reduction in the profitable outcomes. It is in these circumstances, for example, that loading the RRT threshold rate might be looked to as a method of offsetting, in a very rough way, the effect of the skewed probability distributions.

Conclusions

The main observations in the paper can be briefly put as follows:

- With an income tax system such as Australia's, incorporating nominal interest in its base, economic value depreciation is required to keep before-tax investment decisions unaffected even with inflation.
- Under inflationary conditions, historical cost reducing balance or straight line depreciation allowances for income tax purposes are too generous. These allowances would bias investment decisions towards longer-lived assets, and away from repairs and maintenance to replacement expenditure, and would encourage longer asset holding.
- For constantly deteriorating marginal assets, annual economic depreciation could be determined, in practice, by using as a basis the reducing balance method applied at the rate of asset deterioration. The rate of deterioration of asset types can be specified indirectly by setting down "effective" lives of assets as under the pre-July 1982 Australian depreciation system.
- Less distortive treatment of depreciation for income tax purposes would be achieved in Australia by reverting from the current 5/3 depreciation system to the pre-July 1982 system.
- It is with real, and not nominal, interest incorporated in the income tax base that particular statutory accelerated depreciation allowances may adjust for inflationary effects, but only at a particular level of inflation and for assets with one particular rate of deterioration.
- These observations are largely unaffected under uncertainty concerning the future net receipt streams of capital investments.

APPENDIX 1

General Discounting Principle

The discounting principle applicable with both nominal and real income tax systems is that any stream of numbers will discount after tax to

the same value as that before tax if the effect of that tax is:

- to add to each number the PV of the stream of numbers to the start of the corresponding period times a given factor; and
- to add that same factor to the discount rate.

Any given stream of numbers (with the number in each period in the stream obtaining at the end of that period) will discount at a given discount rate, say, p, to a specific value, say, C. In this discounting process, the numbers can be regarded as having a principal and interest component, as would the per period repayments of a reducing balance loan having a value of C and interest rate p. The principal component of the number in each period is the difference between the PV of the stream of numbers at the start and end of the corresponding period. The interest component makes up the rest of the number and is equal to p times the PV of the stream of numbers to the start of the corresponding period.

Take the two numbers N_1 and N_2 obtaining at the end of two consecutive time periods. With discounting at the rate p, the PV of the two numbers at the start of the first period is $N_1/(1+p) + N_2/(1+p)^2$.

Now, if t and x are any proportions, add to N_1 an amount equal to x.t times the PV of N_1 and N_2 at the start of period 1 (with discounting at the rate p) and to N_2 an amount equal to x.t times the PV (with discounting at the rate p) of N_2 at the start of period 2. With discounting at the rate p + xt, the PV at the start of period 1 of N_1 and N_2 plus the amounts added to N_1 and N_2

$$= \frac{(1+p)N_1 + xtN_1}{(1+p)(1+p+xt)}$$

$$+ \frac{xtN_2}{(1+p)^2(1+p+xt)} + \frac{(1+p)N_2 + xtN_2}{(1+p)(1+p+xt)^2}$$

$$= N_1/(1+p) + N_2/(1+p)^2$$

which is the same as before the amounts were added to the two numbers and the change in discount rate. By increasing the number of numbers and time periods and applying the above methodology, it can be shown by induction that this result holds for any stream of numbers.

Application to Nominal Interest Case

If the proportion p is equal to the going interest rate r, and x is equal to $-r$ and t is the entrepreneur's tax rate, $p + xt$ corresponds to $r - rt$ or $r(1-t)$, the after-tax discount rate with an income tax system incorporating nominal interest in the tax base. In this case $-rt$, i.e. xt, times the PV of the stream of numbers to the start of each period corresponds to:

- if the numbers are loan repayments (receipts), the interest component of each repayment (receipts) being deductible (taxable). That is because r times the PV of the stream of numbers to the start of a period is the interest component of the number in that period; and

- if the numbers are net receipts, their "interest" component being taxable or, in other words, the "principal" component (i.e. economic depreciation) being deductible.

Application to Real Interest Case

If the proportion p is equal to $r(1-t)$—i.e. the after-tax discount rate in the nominal case—and x is equal to the known inflation rate i, $p+xt$ corresponds to $r(1-t)+i.t$, the after-tax discount rate with an income tax system incorporating real interest in the tax base. In this case i.t, i.e. xt, times the PV of the stream of numbers to the start of each period corresponds to:

- if the numbers are loan repayments (receipts), an additional amount being taxable (deductible) equal to the fall in the real value of monetary liabilities (assets). (This is equivalent to incorporating real interest in the tax base.) The fall in the real value of net monetary liabilities in a particular period is equal to the inflation rate times the PV of the stream of net monetary liabilities to the start of that period; and
- if the numbers are net receipts, an additional deduction equal to i times the value of the asset at the start of each period (i.e. the nominal capital gain in that period).

APPENDIX 2

Take a marginal asset's infinite stream of net receipts (N at the end of period 1) changing at the end of each time period by the proportion q:

$N, N(1+q), \ldots N(1+q)^{n-1}, N(1+q)^n \ldots$

With discounting at the rate r, the result for the sum of an infinite geometric series shows that

economic value depreciation of the asset in period n

= difference in PV at start and end of period n

$$= \frac{N(1+q)^{n-1}}{r-q} \cdot (-q)$$

= (value of asset at start of period n) x $(-q)$

Thus, for a marginal asset, the stream of economic value depreciation changes each period by the same proportion, q, as the net receipts stream. With an asset deteriorating constantly at the rate s and no inflation, $q = -s$. With the same asset and inflation at the rate i, $q = i - s(1+i)$.

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