

Relationship between discount rates to be applied to before-tax and after-tax cashflows

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Abstract

This paper illustrates how there is no constant relationship between the discount rates to be applied to before-tax and after-tax cashflows in order to derive the same value for a stand or forest.

If all forestry revenues were immediately taxable and all forestry costs (including the purchase price) were immediately deductible then the "equivalent" discount rate to be applied to before-tax cashflows would equal that applied to after-tax cashflows; i.e. the same discount rate could be applied to either before-tax or after-tax cashflows and the same value would arise.

However the purchase price is not immediately deductible and must be carried forward and deducted against harvest revenues. Consequently the "equivalent" discount rate to apply to before-tax cashflows will be different to (and greater than) the discount rate to apply to after-tax cashflows to give the same value.

Stand-level and forest-level examples illustrate that, although there are general trends with age, there is no simple rule to find the discount rate to apply to before-tax cashflows which is equivalent to a given discount rate that is applied to after-tax cashflows. The "equivalent" discount rate to apply to before-tax cashflows is sensitive to the unique circumstances of each situation and the underlying assumptions made.

Introduction

The NZIF Forest Valuation Standards (NZIF 1999) are based on the convention that "all values derived from discounted cashflow analysis should be calculated from post-tax cashflows". This stance is taken because forest transactions take place in a tax-paying environment. Although an entity may have a unique tax position "it is however reasonably obvious that a market price would not reflect a nil tax exposure". Consequently a set of conventions is detailed in the Standards, which "in determining taxation, the valuer will follow ...or state clearly the departures."

A recent survey of discount rates used for forest valuation (Manley 2001) indicates that forest valuers in New Zealand are divided on whether to discount before-tax cashflows or after-tax cashflows when using the expectation (or discounted cashflow) method to estimate the market value of a forest crop.

Eight of the 19 respondents discount before-tax cashflows using real discount rates in the range of 9 to 13%. The other 11 respondents prefer to discount after-tax cashflows generally using discount rates in the range 7.5 to 9.5%.

One issue that arises is what is the relationship between discount rates to be applied to before-tax and after-tax cashflows? What is the "equivalent" discount

rate to apply in a before-tax valuation to give the same estimate of market value as that derived from an after-tax valuation in which after-tax cashflows are discounted using the required rate of return?

If all forestry revenues were immediately taxable and all forestry costs (including the purchase price of a forest crop) were immediately deductible then the "equivalent" discount rate to be applied to before-tax cashflows would be the same as that applied to after-tax cashflows; i.e. the same discount rate could be applied to either before-tax or after-tax cashflows and the same value would arise.

However in reality not all forestry expenditures are immediately deductible. They can be divided into four categories on the basis of tax treatment (McSoriley & Herrington 1994):

- Immediately deductible expenditures. This includes planting and tending expenses, annual operating expenses, harvest expenses, and post-harvesting expenses.
- Expenditures that are capitalised and deducted against future revenue. This includes the cost of purchasing a crop of trees that goes into a "cost of bush" or "cost of timber" account and is deducted against harvest revenue.
- Expenditures that are capitalised and depreciated. This includes land development expenditures such as the construction of roads.
- Non-deductible expenditures. This includes the cost of land contouring or other permanent improvements to land.

As not all expenditures are immediately deductible, the "equivalent" discount rate to apply to before-tax cashflows will generally be larger than the discount rate to apply to after-tax cashflows to give the same Present Value. (See Everts (1987) and Bilek (1999) for a detailed discussion of the impact that capitalisation of expenditure into a "cost of bush" account has on tax neutrality).

Campbell and Colletti (1990) investigated the accuracy of using the rule-of-thumb relationship between the discount rates to be applied to before-tax and after-tax cashflows:

$$r_a = r_b (1-T)$$

where r_a = real discount rate applied to after-tax cashflows

r_b = real discount rate applied to before-tax cashflows

T = marginal income tax rate

They found that for investment alternatives with depreciable, depletable, or tax-deferred assets, the rule-of-thumb estimate is not accurate. Further, they observed that the relationship between the discount rates varied with the rate of return of the investment, the marginal tax rate, the level of inflation and the investment period.

Klemperer (1996), in discussing use of the rule-of-

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thumb formula, notes that it only applies to annual yield investments, not to delayed yield assets. When cashflows are irregular, no simple rule-of-thumb exists.

The purpose of this paper is to show that, under New Zealand tax legislation, there is no constant relationship between r_a and r_b . A simple stand-level example is used to illustrate how the discount rate to be used for before-tax valuation, that is equivalent to a given discount rate to be applied to post-tax valuation, varies with stand age as well as other assumptions. The relationship between the discount rates used for the valuation of forests (rather than individual stands) on a before-tax and after-tax basis is then considered.

Cost-of-bush effect

The major cause of the difference between r_b and r_a is that, under New Zealand tax law, the purchase price of a crop must be capitalised into a cost-of-bush account and deducted against future revenues. The New Zealand tax system is asymmetric in this regard. Whereas the seller is required to pay tax on the proceeds from the sale of a tree crop at the time of the sale, the purchaser cannot deduct the cost until the crop is harvested. Although the purchaser can make deductions against revenues from production thinning, the bulk of the deduction will not be made until the time of clearfelling (deductions from a cost-of-bush account at the time of production thinning are subsequently ignored in this paper).

When calculating crop value by discounting future after-tax cashflows, an additional revenue at the time of harvest must be added to equal the value of the tax deduction associated with the crop purchase price. This is computed as (purchase price * tax rate). As there is no "inflation-proofing" of this future tax deduction, it must be converted from nominal to real dollars by dividing by $(1+i)^{u-n}$ where i is the annual inflation rate, u is the rotation age and n is the stand age at the time of purchase. Then it is discounted using r_a . The present value of the tax deduction associated with the purchase price is calculated as:

$$PV(\text{purchase price tax deduction}) = \frac{T \cdot C}{((1+r_a) \cdot (1+i))^{u-n}} \quad (1)$$

Where

C = purchase price

T = tax rate

r_a = real discount rate applied to after-tax cashflows

i = inflation rate

u = rotation age (time of tax deduction)

n = stand age at the time of purchase

(T , r_a and i are all expressed as proportions in equation 1. e.g. $T = 0.33$ for a tax rate of 33%, $r_a = 0.09$ for a discount rate of 9% and $i = 0.03$ for an inflation rate of 3%).

Table 1 - Forest investment example

Age/Time	Silvicultural costs (\$/ha)	Overhead costs (\$/ha/year)	Clearfell revenue (\$/ha)
0	1000		
1	40		
5	450		
6	450		
8	450		
10	400		
1-28		100	
28			70,000

Stand-level example

Consider the forest investment example shown in Table 1. Assume that r_a equals 9% and the tax rate is 33%. LEV (Land Expectation Value) can be calculated for the investment by discounting after-tax cashflows. This equals \$2402/ha.

Now consider the value of the crop at age 5 (immediately after the age 5 costs have been incurred) from the perspective of a potential purchaser, calculated by discounting cashflows. A real discount rate of 9%, tax rate of 33% and inflation rate of 3% are used. A notional annual land rental is calculated by multiplying the LEV by the discount rate.

Table 2 presents the net cashflows for four different cases:

Table 2: Calculation of Crop Expectation Value (CEV) under four different cases. (Discount rate of 9% used).

Time	Age	Cost	Revenue	Land rent	Net cashflow			
					Case 1	Case 2	Case 3	Case 4
0	5							
1	6	550		216	-766	-585	-513	-513
2	7	100		216	-316	-283	-212	-212
3	8	550		216	-766	-585	-513	-513
4	9	100		216	-316	-283	-212	-212
5	10	500		216	-716	-551	-480	-480
6	11	100		216	-316	-283	-212	-212
7	12	100		216	-316	-283	-212	-212
8	13	100		216	-316	-283	-212	-212
9	14	100		216	-316	-283	-212	-212
10	15	100		216	-316	-283	-212	-212
11	16	100		216	-316	-283	-212	-212
12	17	100		216	-316	-283	-212	-212
13	18	100		216	-316	-283	-212	-212
14	19	100		216	-316	-283	-212	-212
15	20	100		216	-316	-283	-212	-212
16	21	100		216	-316	-283	-212	-212
17	22	100		216	-316	-283	-212	-212
18	23	100		216	-316	-283	-212	-212
19	24	100		216	-316	-283	-212	-212
20	25	100		216	-316	-283	-212	-212
21	26	100		216	-316	-283	-212	-212
22	27	100		216	-316	-283	-212	-212
23	28	100	70,000	216	69,684	46,617	46,688	46,688
PV of net cashflows					\$5595	\$3065	\$3749	\$3749
PV (purchase price tax deduction)					\$0	\$72	\$88	\$1846
CEV					\$5595	\$3137	\$3837	\$5595

Case 1 - Before-tax cashflows. This is calculated as (Revenues - Costs - Land Rental).

Case 2 - After-tax cashflows (Cost of bush deducted at time of harvest, land rental not deductible). This is calculated as $(0.67 * \text{Revenues} - 0.67 * \text{Costs} - \text{Land Rental})$

Case 3 - After-tax cashflows (Cost of bush deducted at time of harvest, land rental deductible). This is calculated as $(0.67 * \text{Revenues} - 0.67 * \text{Costs} - 0.67 * \text{Land Rental})$

Case 4 - After-tax cashflows ((Cost of bush deducted at time of purchase, land rental deductible). This is calculated as $(0.67 * \text{Revenues} - 0.67 * \text{Costs} - 0.67 * \text{Land Rental})$

Case 2 represents the standard method developed in the NZIF Forest Valuation Standards. It incorporates current tax legislation and assumes that the crop owner also owns the land. The notional land rental is not deductible.

Case 3 is a variation of this in which the crop owner does not own the land. Land rental is tax deductible.

Case 4 extends Case 3 and shows the impact of tax legislation being changed to make the purchase price of a tree crop immediately deductible.

The tax deductions associated with the purchase price are not included in the cashflows. Instead the Present Value is separately identified in order to clearly show the impact of the different tax treatments.

For Case 2, the Present Value of the tax deduction associated with the purchase price can be calculated using equation 1 above. A practical difficulty arises because the present value of the tax deduction is calculated from the purchase price, which is itself dependent on the present value of the tax deduction. This circularity can be overcome using an iterative approach. For the example 5 year-old stand, crop value can be estimated as \$3137, the Present Value of the tax deduction adding \$72 to the PV from the other cashflows which is \$3065.

The present value of the tax deduction can also be mathematically derived:

Let C be the purchase price of the crop
 V be the Present Value of cashflows excluding the tax deduction of the purchase price
 f be the discount factor $((1+r_a)^*(1+i))^{11-n}$
 Then $C = V + 0.33 * C/f$
 By rearrangement we obtain:
 $C = V * (f/(f - 0.33))$

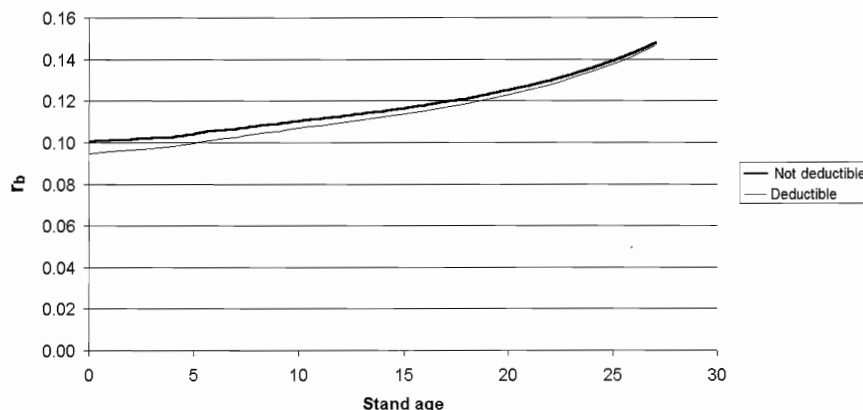
The present value of the tax deduction associated with the purchase price can then be calculated:

$$\begin{aligned} \text{PV}(\text{tax deduction}) &= C - V \\ &= V * (f/(f - 0.33)) - V \\ &= V * (0.33/(f - 0.33)) \end{aligned}$$

Or for our example:

$$\begin{aligned} f &= (1.09 * 1.03)^{28-5} = 14.324 \\ \text{PV}(\text{tax deduction}) &= 3065 * (0.33/(14.324-0.33)) \\ &= 72 \end{aligned}$$

Fig. 1: Discount rate for before-tax cashflows that is equivalent to 9% for after-tax cashflows for the situations where (Case 2) notional land rental is not deductible; and (Case 3) land rental is deductible



For Case 3 the factor f is the same as in Case 2
 $\text{PV}(\text{tax deduction}) = 3749 * (0.33/(14.324-0.33)) = 88$

For Case 4:
 $f = (1.09 * 1.03)^{5-5} = 1$
 $\text{PV}(\text{tax deduction}) = 3749 * (0.33/(1-0.33)) = 1846$

It is evident from Table 2 that if the purchase price was immediately deductible (and the notional land rental is also treated as being deductible) then the same crop expectation value (CEV) of \$5595/ha is estimated by discounting either after-tax cashflows or before-tax cashflows at 9%. This result would apply generally for other discount rates. Under this specific tax treatment r_b would equal r_a .

However, given the current tax laws r_b will be greater than r_a . Case 2 will be used as the valuation benchmark because it reflects the current tax treatment of the purchase price of a tree crop (and also the NZIF standard assumption about the ownership of land i.e. the crop owner also owns the land and the notional land rental based on LEV is not tax deductible). Case 2 gives a CEV of \$3137/ha with r_a equal to 9%. To get this CEV in Case 1 using before-tax cashflows, the discount rate would have to be increased to 10.43% (and the notional land rental would have to be based on this discount rate; i.e. $2402 * 0.1043 = \$251$).

For age 5 r_b equals 10.43% when $r_a = 9\%$. The same process can be used to determine r_b for different rotation ages. The relationship between r_b and age (for $r_a = 9\%$) is shown in Fig. 1 (curve marked Case 2). Clearly the value of r_b varies with age. The equivalent discount rate to apply to before-tax cashflows increases from 10.1% at age 1 to 14.8% at age 27.

Also shown in Fig. 1 is the equivalent r_b (for $r_a = 9\%$) when land rental is treated as being tax deductible (Case 3).

A sensitivity analysis was carried out in which key factors were varied:

- Discount rate for after-tax cashflows ($r_a = 6\%, 9\%, 12\%$) – see Fig. 2.
- Inflation rate (0%, 3%, 6%) – see Fig. 3.

Fig. 2: Ratio of r_b to r_a for different values of r_a
(Base investment, inflation rate of 3%, tax rate of 33%)

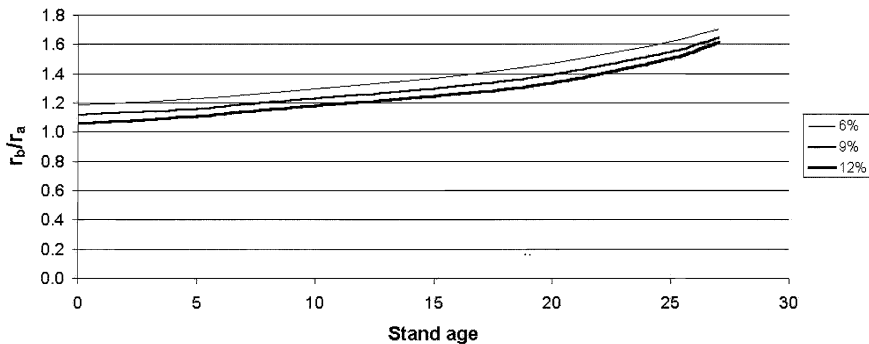


Fig. 3: Ratio of r_b to r_a for different inflation rates
(Base investment, r_a of 9%, tax rate of 33%)

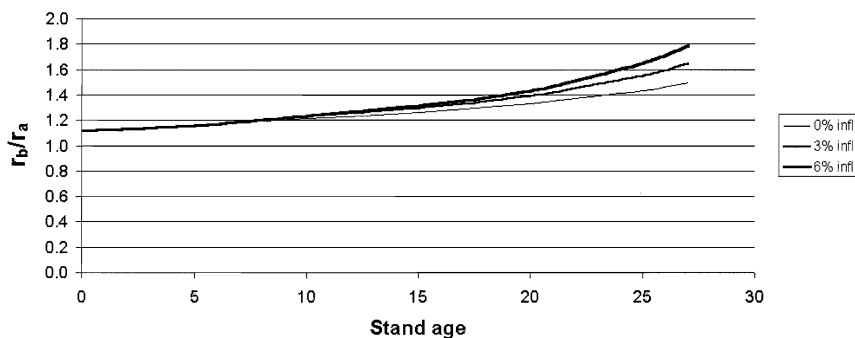
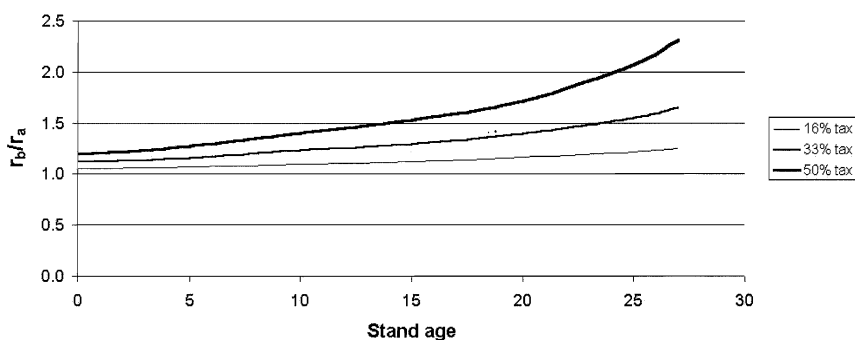


Fig. 4: Ratio of r_b to r_a for different tax rates.
(Base investment, r_a of 9%, inflation rate of 3%)



- Tax rate (16%, 33%, 50%) – see Fig. 4.

Figs. 2 to 4 use the ratio r_b to r_a as the y-variable in order to allow comparison of the results of the different analyses. The results show that the ratio between r_b to r_a increases as discount rate decreases, inflation rate increases or tax rate increases.

In addition, two variations of the forest investment were considered in which (a) the establishment cost was increased from \$1,000 to \$1,500 and the clearfell revenue was reduced from \$70,000 to \$40,000; and (b) establishment cost was reduced to \$500, silvicultural costs in years 5 to 10 were reduced to zero, overhead costs were reduced to \$50, and clearfell revenue was

reduced to \$25,000. The r_b for the investment variations is lower, for a given r_a , than that of the base investment for younger ages. However, after silvicultural costs have been incurred, trends are very similar for all three investments.

Forest-level examples

An analysis was carried out on data for the 43 State plantations sold in 12 different transactions by the Crown in 1990. The value of each forest was estimated by discounting future cashflows on an after-tax basis using a standard set of assumptions including:

- A discount rate of 9% applied to after-tax cashflows;
- tax legislation of 2002 applied (i.e. silvicultural costs immediately deductible);
- a tax rate of 33%; and
- an inflation rate of 3%.

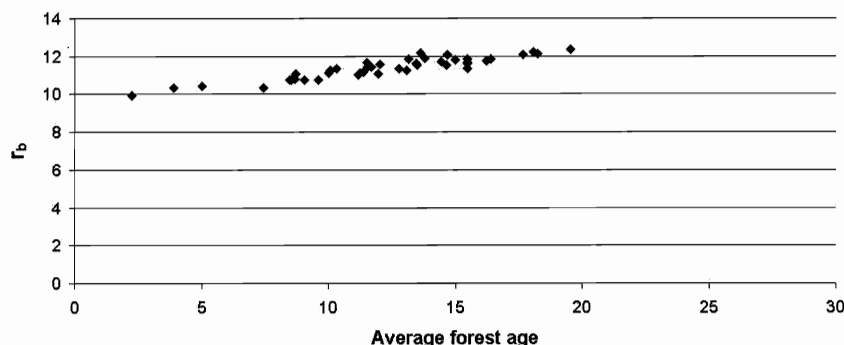
The general approach followed that of the NZIF Forest Valuation Standards. For example, the taxation conventions described in the Standards were followed. The one major deviation from the Standards was that land was not considered to be freehold. Instead land rental was calculated on the basis of a Crown Forest Licence and was treated as being tax deductible.

The data set was chosen because it represents a significant number of forests that could be valued using consistent assumptions. Note that the values derived are not the values for which the forests sold (i.e. r_a is set to 9% rather than the market-implied discount rate).

The equivalent discount rate for before-tax cashflows (r_b) was then calculated for each forest. These are plotted against average forest age in Fig. 5. (Average forest age is calculated using the method described in Manley and Bell (1992) which takes into account species differences). There is an overall trend of increasing r_b with increasing average forest age. However, the variation in r_b for a given age is also evident.

The trend of r_b with age shown in Fig. 5 is different from that shown in Fig. 1 for the equivalent taxation conventions (Case 3 line). Although both show increasing r_b with increasing age, the values of r_b for the forest-level examples fall on or above the Case 3 line for the stand-level example. Differences arise not only because of a fixed 7% land rental being applied in the forest-level valuations but also because Fig. 1 is based on a single regime whereas Fig. 5 is based on the range of regimes implemented in each forest. Probably more importantly, the data shown in Fig. 5 reflects the distribution of age-classes within each forest rather than a single stand of one age.

Fig. 5: Discount rate for before-tax cashflows that is equivalent to 9% for after-tax cashflows for forest-level examples



Discussion

The results presented illustrate that there is no simple relationship between r_a and r_b . Although there is a clear general trend of increasing r_b (for a given r_a) with age, the equivalent r_b is specific to the particular stand or forest being valued and varies with the discount rate, inflation rate and tax rate assumed.

As observed in the NZIF Forest Valuation Standards: "It is evident that there is no single and universal adjustment between the discount rates [r_b and r_a] in the case of plantation forests in New Zealand. The relationship is affected by the impact of the cost-of-bush because of such factors as the maturity of the forest at the time of purchase and the assumed level of inflation.

Accordingly, it is preferable to model the effects of tax explicitly in order to produce after-tax NPVs"

References

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letters

Douglas fir or Douglas-fir?

Sir,

Throughout the world, *Pseudotsuga menziesii* is known by several common names, such as "Douglas fir", "Oregon pine", "Douglas-spruce", "false hemlock", "red-fir", "sapin de Douglas", "Pin d'Orégon", "Douglastanne", "Douglasie", and "Douglas-fir". Most dictionaries do not hyphenate "Douglas fir" and neither do most researchers in Europe, Africa, Asia or Australia. However, researchers, botanists, foresters and others in North America often hyphenate "Douglas-fir" to let readers know this tree is not a "true fir". Horticulturists in the U.S. started hyphenating Douglas-fir around 1923.

In 1979, Elbert Little, Jr. published U.S. Forest Service principles regarding hyphenation and word compounding of common U.S. tree names (www.forestry.auburn.edu/south/appendix6.pdf). However, these principles "do not apply to other countries or to international commerce". Therefore, non-hyphenated names like "Douglas fir" are permitted in lumber yards in the U.S. and New Zealand (Little 1979; p. 344).

Eight years ago, some researchers in New Zealand adopted the hyphen for Douglas-fir but not for other "misapplied" common names like "hoop-pine". Two

years later, in a letter on this topic (NZ Journal of Forestry, February 1996), one of us (WJL) indicated the Seventh International Botanical Congress at Stockholm passed international laws regarding the hyphenation of vernacular names. However, to date we have not been able to verify this claim, and now recognise that was incorrect information. Rules regarding common names were not published in the 1950 proceedings (Regnum Vegetabile Vol. 3, 228p.). We contacted several experts and, none said the International Botanical Congress addressed vernacular names.

Therefore, we retract the statement that international laws say we ought to hyphenate. We agree with Elbert Little Jr. who said the U.S. Forest Service principles do not apply to other countries. We also note that two of the professional taxonomists consulted said, in effect, that they have enough trouble enforcing scientific names, and thus the decision to refrain from codifying common names has at various times been carefully considered and rejected. However, they noted that it is a good idea to use a hyphen (or compound words) to let readers know a common name is not taxonomically correct (i.e. uses the wrong genus name).

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