Factors Affecting the Choice of the Discount Rate for Forest Investments

James C. Fortson
School of Forest Resources
University of Georgia

Forest resource managers, like all decision makers, are continually faced with the difficult problem of deciding how to allocate their capital funds optimally. A tract of land and timber can be bought for $1000 per acre. Is this a wise and prudent investment? Fertilization of slash pine plantations may increase yield at harvest by 20 percent. Should the fertilizer be applied?

A common thread runs through all such problems. Dollars of capital are expended today in hopes of receiving a series of cash returns in the future. In general, capital should be invested when the present value of the utility of the inflows exceeds the present value of the utility of the outlays.

It is generally agreed that for most corporations and individuals, the net present value (NPV) is the most nearly correct investment criterion. Brealey and Myers (1981) point out these three virtues:

NPV recognizes that a dollar today is worth more than a dollar tomorrow.

NPV depends solely on forecasted cash flows and the opportunity cost of capital.

NPV is measured in today's dollars, and net present values are additive. Thus, the net present value of two projects is simply the sum of the two. Therefore, NPV(A+B) = NPV(A) + NPV(B).

To calculate NPV for any investment project, the general procedure is to:

Estimate the marginal cash flows generated by the investment,

Discount these cash flow forecasts by the appropriate discount rate,

Fund or adopt the project if the net present value is positive.

Thus, it is obvious that the net present value of any capital expenditure is a function of the amount and timing of the forecasted cash flows and the discount rate. Firms and individuals typically
expend vast amounts of time and energy in estimating the cash flows, but the choice of the discount rate is quite arbitrary. For example, Row, Kaiser, and Sessions (1981) state that since 1969 the Office of Management and Budget (OMB) has required federal agencies to use a real discount rate of 10 percent unless a special rate is set by law. These authors further state that the USDA Forest Service recommends a 4 percent discount rate for economic and social analysis. It is evident that we find conflicting advice. Indeed, if we search the literature we find articles entitled, "The Bogey of Compound Interest," which state as a main conclusion, "Under sustained yield forestry there is no compound interest" (Shepard 1925).

This article reviews the traditional methods of selecting the discount rate and introduces some procedures that are emerging from the financial literature and should interest decision makers evaluating investments in forest land and timber.

Traditional Methods for Determining the Appropriate Discount Rate

Foresters have historically used low discount rates. (Faustmann, writing in the middle of the 19th century, used four percent.) Samuelson (1976) speculates that they have chosen low rates so that the optimum economic rotation age will not differ greatly from the age of maximum sustained yield or maximum mean annual increment.

In the past, the rate often recommended was the weighted average cost of capital—that is, the firm’s cost of acquiring funds. This cost is simply the weighted average of the cost of debt capital and equity capital. Debt capital represents funds that pay a fixed return called interest. Bonds and bank borrowings are good examples of debt capital. Equity capital has no set repayment schedule\(^1\). The major sources of equity capital are common stock and retained earnings. The firm usually pays dividends or common stock but is under no obligation to do so.

The explicit marginal cost of debt is usually easy to calculate since the repayment schedule is known in advance. Suppose firm X issues a 10 year bond that pays 10 percent interest. After deducting costs of issuing, underwriting, and underpricing, the firm nets $935 for each $1000 bond sold. The cost of the debt is found by solving for the discount rate that makes net present value equal to zero\(^2\). In this instance the before-tax cost of this debt capital is 11.11 percent. Since interest payments are a tax-deductible expense, the after-tax cost

\[0 = \sum_{t=1}^{9} \frac{1000}{(1+r_{d})^t} - \frac{1100}{(1+r_{d})^{10}}\]

\(^1\)Preferred stock is an exception. Preferred stock pays fixed dividends, which are not a tax-deductible expense for the firm.

\(^2\)The cost of this debt is found by solving this equation for \(r_{d}\).
of debt is the product of 1 minus the tax rate and the before-tax cost. If the marginal tax rate is 46 percent, the after-tax cost of this debt would be 0.54 x 11.11% = 6.0%.

The cost of equity capital is much more difficult to estimate, because the future cash flows are not known. In theory, this cost is the internal rate of return earned by investors who purchase the firm's common stock. The problem here is to estimate future dividends and future stock prices. If the assumption is made that dividends grow at a constant compound growth rate (g), the problem is amenable to solution. If dividends are expected to grow at a constant compound growth rate, then it can be shown that

\[ r_e = \frac{D_0(1+g)}{P_0} + g \]

where

- \( r_e \) = the cost of common stock or equity capital,
- \( P_0 \) = the current stock price,
- \( D_0 \) = the current dividend, and
- \( g \) = the compound rate of growth in dividends.

Like many assumptions, that of a constant perpetual compound growth rate is naive and somewhat unreasonable. It is highly unlikely that any firm can maintain a constant compound growth rate forever. To illustrate, consider the following data for Weyerhaeuser Co. Using a model of the form \( D_t = e^{gt} \) where \( D_t \) equals the dividends in year \( t \), \( g \) is the compound growth rate in dividends and \( e \) is the base of the natural logarithms. The estimate of \( g \) is 7.79 percent. If we use the 1980 closing price of $34.10 and the 1980 dividend of $1.30, the estimate of the cost of common stock for Weyerhaeuser is

\[ r_e = \frac{1.30(1.0779)}{34.10 \times 7.79\%} = 11.90\% \]

\[ \sum_{t=1}^{n} \frac{D_t}{(1+r_e)^t} - \frac{P_n}{(1+r_e)^n} = 0 \]

for \( r_e \). In this equation

- \( P_0 \) = the net proceeds from the sale of a share of common stock
- \( D_t \) = dividends per share paid in year \( t \)
- \( P_n \) = price per share of the stock in year \( n \).
<table>
<thead>
<tr>
<th>Year</th>
<th>Dividends ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>61</td>
<td>.30</td>
</tr>
<tr>
<td>62</td>
<td>.30</td>
</tr>
<tr>
<td>63</td>
<td>.30</td>
</tr>
<tr>
<td>64</td>
<td>.30</td>
</tr>
<tr>
<td>65</td>
<td>.30</td>
</tr>
<tr>
<td>66</td>
<td>.35</td>
</tr>
<tr>
<td>67</td>
<td>.35</td>
</tr>
<tr>
<td>68</td>
<td>.35</td>
</tr>
<tr>
<td>69</td>
<td>.39</td>
</tr>
<tr>
<td>70</td>
<td>.40</td>
</tr>
<tr>
<td>71</td>
<td>.40</td>
</tr>
<tr>
<td>72</td>
<td>.415</td>
</tr>
<tr>
<td>73</td>
<td>.47</td>
</tr>
<tr>
<td>74</td>
<td>.80</td>
</tr>
<tr>
<td>75</td>
<td>.80</td>
</tr>
<tr>
<td>76</td>
<td>.80</td>
</tr>
<tr>
<td>77</td>
<td>.80</td>
</tr>
<tr>
<td>78</td>
<td>.85</td>
</tr>
<tr>
<td>79</td>
<td>1.075</td>
</tr>
<tr>
<td>80</td>
<td>1.30</td>
</tr>
</tbody>
</table>

If it is assumed that the before-tax cost of debt is 10 percent and that Weyerhaeuser maintains a capital structure of 1/3 debt and 2/3 equity, the weighted average cost of capital\(^4\) would be estimated as

\[
\bar{r}_w = \frac{1}{3}(1 - .46) \cdot .10 + \frac{2}{3}(.119) = 9.73\%.
\]

The weighted average cost of capital is then used as the discount rate for calculating the net present value for all investments of the firm. This weighted average cost of capital is valid if and only if the project being considered is a clone of the firm. If a firm has projects whose risks vary widely, the use of a constant discount rate is not appropriate. Brealey and Myers (1981) state on page 166, "Company costs of capital are nearly useless for diversified firms." Also the weighted average cost includes investors' expectations concerning inflation. The price that investors are willing to pay for stocks or bonds, or the interest rate required by bankers, includes expected inflation.

As investment projects of major forest-based industries vary widely in risk, it is illogical to require all projects to earn the same rate of return. For example, forest land is a low risk investment and one that has been an excellent hedge against inflation. Forest land is a "non-wasting" asset and does not depreciate, is not subject to technological obsolescence and cannot be destroyed by fire, windstorm and other "acts of God." Since forest land is relatively fixed in supply, it has appreciated in value at or above the general level of inflation during the past decade. During the 1960-1978 period, farmland values grew at an annual compound rate of 8.72%. During the same growth period, the annual inflation rate was 4.48% and the compound

\(^4\)Assume the marginal income tax rate for Weyerhaeuser is 46%.
growth rate of common stock, as measured by the Standard and Poors 500 Stock Index, was slightly less than 3% (Federal Reserve Bank of Richmond, 1978 Annual Report). Historically, farmland, and undoubtedly forest land, has been an excellent hedge against inflation.

As previously noted, the weighted average cost of capital contains a factor to adjust for anticipated inflation. In the appraisal of land and timber, foresters have often used current stumpage rates to transform expected future timber yields into cash flows. The cash flow streams are in constant or un inflated dollars. This un inflated cash flow stream is then discounted by the firm's weighted average cost of capital, which includes a premium for expected inflation. It is difficult to justify the acquisition of timber land by this incorrect approach. I am confident that investment in forest land is less than optimal because of this error.

For example, consider a hypothetical situation. An investor is appraising a tract of land supporting a 5-year-old pine plantation. The intention is to harvest the stand 25 years from now and immediately sell the land for $300 per acre. Ad valorem and management costs are estimated to be $3.00 per acre annually. Current stumpage rates are $25 per cord. Yield at harvest is estimated to be 45 cords per acre and the firm's weighted average cost of capital is 15 percent. If the land and timber are appraised on the bases of discounted cash flows, the estimated value is

\[ V_o = \frac{(45 \times 25 + 300)}{(1.15)^{25}} - 3\left(\frac{(1.15^{25} - 1)}{(0.15)(1.15)^{25}}\right) \]

\[ V_o = $23.90 \text{ per acre} \]

Extremely low appraised values like $24 per acre result when cash flows are estimated from constant prices and the discount rate includes anticipated inflation. The nominal rate of interest is usually defined as

\[(1 + k) = (1 + i)(1 + g) \quad \text{(Klemperer 1979)}\]

where

- \( k = \) the nominal rate
- \( i = \) the pure or real rate
- \( g = \) the expected inflation rate

In this hypothetical example, the expected rate of inflation is 10 percent. The real or inflation-free discount rate would be 4.5 percent. With a real discount rate of 4.54 percent, the net present value is

\[ V_o = \frac{(45 \times 25 + 300)}{1.0454^{25}} - 3\left(\frac{(1.0454^{25} - 1)}{(0.0454)(1.0454)^{25}}\right) \]

\[ V_o = $425.33. \]

During periods of high inflation firms have rejected economically attractive forest investments by failing to adjust properly for expected inflation (Gregersen 1975).
One must use extreme care in attempting to adjust for risk by increasing the discount rate. This is especially true for long-term investments such as those in timber land (Foster 1979). The use of a risk-adjusted discount rate assumes that risk is increasing over time at a compound rate. Clutter et al. (1983) advocate the use of certainty equivalent coefficients to adjust for risk. Chang (1980) advocates that one should discount expected utility of the future cash flows.

The Opportunity Cost Approach. The opportunity cost approach is a preferred alternative to the weighted average cost of capital. In general, opportunity costs reflect the returns foregone by investing in a given project rather than some other project of comparable risk. Row, Kaiser, and Sessions (1981, p. 367) state that these factors should be included when estimating an opportunity cost of capital: marginal investments (adjusted for income taxes), general inflation, allowances for risk, and allowances for environmental protection.

The opportunity cost approach recognizes that risk varies among projects and that some adjustment must be made for it. Brealey and Myers (1981) state, "Each project should be evaluated at its own opportunity cost of capital; the true cost of capital depends on the use to which the capital is put." This statement implies that a given stream of expected cash flows should have identical value to all firms. Each project should be evaluated as if it were a mini-firm, i.e. a firm whose only asset is the project under consideration. The total value of the firm would then be the sum of the net present values of all the projects.

Emerging Concepts in the Cost of Capital

The Capital Asset Pricing Model (CAPM). The Capital Asset Pricing Model (CAPM) is a useful theoretical construct to evaluate the relationship between risk and expected return. In the mid-1960's, Sharp (1964), Lintner (1965), and others published pioneering works concerning this model. The CAPM model may be briefly stated as

\[ r_j = r_f + \beta_j (r_m - r_f) + \epsilon_j \]

where

- \( r_j \) = required return by investors in asset \( j \)
- \( r_f \) = the risk-free rate of return
- \( r_m \) = the return of a portfolio comprised of all securities
- \( \beta_j \) = the beta or regression coefficient for asset \( j \)
- \( \epsilon_j \) = a random error term, which is assumed to be normally distributed with mean 0 and variance \( \sigma_j^2 \).

The beta coefficient or beta value, \( \beta_j \), is the simple linear regression coefficient which relates changes in excess return to the market \( (r_m - r_f) \) to excess returns to security \( j \) \( (r_j - r_f) \). That is, \( (r_j - r_f)^\text{Mark} = \beta_j (r_j - r_f) \). \( \beta_j \) is a measure of the systematic risk of the security. The risk it measures is termed systematic because it is a
gauge of the risk in the security returns due to general economic conditions. If capital markets are efficient, the other component of risk, the unique risk, can be reduced to a negligible level through diversification of investments. Therefore, the only risk of concern to diversified investors is the systematic risk measured by $\beta_j$.

If the excess returns to security $j$ behave exactly like the excess returns to the market, then the expected value for $\beta_j$ would be 1.0. Assets or securities whose $\beta_j$ is $> 1.0$ are usually termed risky. Conversely, securities with $\beta_j < 1.0$ are considered relatively low risk assets. The beta, or $\beta_j$, value is useful in quantifying the relationship between risk and return. If $r_j$ is the return expected by investors in security $j$, then $r_j$ is an estimate of the cost of equity capital for the firm. The expected value of $r_j$ is

$$E(r_j) = E(r_f) + \beta_j E(r_m - r_f).$$

The expected return to any asset is a linear combination of the expected risk free rate and the expected return to the market. Suppose firm A has a beta value of 1.50 and B has a beta of .8. If the expected risk-free rate is 10 percent and the expected return to the market is 15 percent, it follows that

$$E(r_A) = .10 + 1.50(.15 - .10) = 17.5 \text{ percent}$$

$$E(r_B) = .10 + 0.80(.15 - .10) = 14.0 \text{ percent}$$

Thus, firm A is more risky than B and investors require additional return as compensation for additional risk.

The CAPM model provides a more objective procedure for estimating the required rate of return for an individual project. The Value Line Investment Survey lists beta values for corporations traded on major exchanges. A partial listing is shown in Table 1. These data indicate that investors perceive Kimberly-Clark as being less risky than, say, Louisiana Pacific. If the risk-free rate is 8 percent and the expected return to the market is 12%, then investments in projects similar to Kimberly-Clark should earn $.08 + .85(.12 - .08) = 11.14 \text{ percent}$, while investments in projects similar to Louisiana Pacific should earn $.08 + 1.30(.12 - .08) = 13.2 \text{ percent}$.

The CAPM procedure recognizes that risk and return are directly related and that high-risk projects should be discounted by a rate that reflects the degree of risk. The true cost of capital for a project depends upon the use to which the capital is put, and the CAPM is a useful theoretical approach that enables the analyst to objectively estimate the opportunity cost of funds for a project.

The CAPM model used in conjunction with the opportunity cost of capital recognizes that the use of a single discount rate for all projects is, in general, inappropriate. Consider a forest products firm that is choosing between building a new office complex in a downtown area and buying land and timber. Further assume that there are firms whose primary business is building and leasing office space and there

173
Table 1. Beta Values for Forest Based Industries. (Source: Value Line, August 6, 1982.)

<table>
<thead>
<tr>
<th>Firm</th>
<th>Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kimberly Clark</td>
<td>0.85</td>
</tr>
<tr>
<td>Union Camp</td>
<td>0.95</td>
</tr>
<tr>
<td>Westvaco</td>
<td>1.00</td>
</tr>
<tr>
<td>Scott</td>
<td>1.05</td>
</tr>
<tr>
<td>Champion</td>
<td>1.10</td>
</tr>
<tr>
<td>Georgia Pacific</td>
<td>1.15</td>
</tr>
<tr>
<td>Mead</td>
<td>1.20</td>
</tr>
<tr>
<td>Weyerhaeuser</td>
<td>1.25</td>
</tr>
<tr>
<td>Louisiana Pacific</td>
<td>1.30</td>
</tr>
</tbody>
</table>

are firms whose primary line of business is the production of timber. As seen in Figure 1, if the weighted average cost of capital for the forest products firm were used as the discount rate, it is likely that the office building would be funded and the land and timber investment rejected. The weighted cost of capital ignores risk and is of limited use for a diversified firm. If adjustment for risk, as measured by beta, is included, then the land and timber acquisition would be accepted and the office complex rejected.

The Adjusted Present Value Concept. Traditional investment rules assume that the investment decision and the financing decision are independent. Each project is evaluated as a mini-firm. Each project is discounted by its opportunity cost of capital and the total value of the firm is assumed to be equal to the sum of the net present values of the projects funded. Brealey and Myers (1981) suggest that the investment or capital budgeting decision is not totally independent of the financing decision. These authors contend that certain projects have higher debt capacity than others. Since the interest charges associated with debt are deductible from ordinary income taxes, the after-tax cost of debt is cheaper than the cost of equity capital. Therefore, the side-effects of the debt capacity of the firm must be recognized.

Consider two investment alternatives with identical amounts of expected cash flows. One investment is a tract of forest land and timber. The other is an investment in research. It seems obvious that the land investment would add more to the debt capacity of the firm than an equivalent investment in research and development. Shouldn't the side-effects of the debt capacity of the land investment be recognized?

Brealey and Myers (1981) advocate recognition of the debt capacity of the project and introduce the concept of Adjusted Net Present Value, ANPV. Adjusted Net Present Value is defined as follows:

\[ \text{ANPV} = \text{BCNPV} + \text{FNPV} \]
FIGURE 1. COMPARISON OF PROJECT SELECTION USING THE WEIGHTED AVERAGE COST OF CAPITAL AND THE RISK ADJUSTED DISCOUNT RATE
where

BCNPV is the base case net present value
FNPV is the sum of the side-effects of financial arrangements resulting from funding the project.

The base case net present value, BCNPV, is the net present value of the expected cash flows discounted by the opportunity cost discount rate for an all-equity-financed project of similar risk. The appealing aspect of the adjusted present value is that it attempts to take into account three factors that surely affect the value of an investment: (1) the amount and timing of the cash flows, (2) the risk inherent in the cash flow stream, and (3) the additional debt capacity generated by accepting the project.

Consider the following example. Firm XYZ can invest $100,000 in a given project. Expected cash flows, net of taxes, are shown in Table 2. Assume the firm's marginal income tax rate is 46 percent, the discount rate for an all-equity-financed project of similar risk is 15 percent, and before-tax cost of debt is 12 percent. The firm maintains a debt-to-equity ratio of 40 percent. Thus, 40 percent of the book value of the asset can be financed by debt. The firm uses straight-line depreciation to estimate book values. The salvage value can be assumed to be zero. In Table 2, the book values are calculated as the original cost less accumulated depreciation charges. Since straight-line depreciation was used, the book value declines by $25,000 per year. The interest tax shield is calculated as the tax rate times the interest costs. Thus, an interest charge of $4,800 generates $2,208 in tax savings. The adjusted net present value, ANPV, can be calculated as:

\[
ANPV = -\$100,000 + \sum_{t=1}^{4} \frac{\$40,000}{(1.15)^t} + \$2208/1.12^t
\]

\[
= \$1656/1.12^2 + \$1104/1.12^3 + \$552/1.12^4
\]

\[
ANPV = -\$100,000 + \$114,199 + \$4428
\]

\[
ANPV = \$14,199 + \$4428 = \$18,627
\]

In this case, the base case net present value is $14,199 and the side-effects of the debt capacity of the investment are $4,428.

In land and timber investments, the side-effects of the marginal debt are considerable. To reiterate, land is excellent collateral. Land is a "non-wasting" asset and can be financed to a large degree with debt. Since the book value of land does not decline, the land investment can support debt over an extended planning horizon. For example, if the preceding investment were in land, the book value would remain constant. If the proportion of debt financing were still 40 percent, then the marginal debt capacity of the project would be a constant $40,000 per year. The tax shield generated by the interest payments would be $2,208 per year. The present value of the
Table 2. Cash Flows for a Hypothetical Investment.

<table>
<thead>
<tr>
<th>Year</th>
<th>Cash Flow $</th>
<th>Book Value $</th>
<th>Debt Capacity $</th>
<th>Interest Costs @ 12% $</th>
<th>Interest Tax Shield $</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-100,000</td>
<td>100,000</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>40,000</td>
<td>75,000</td>
<td>40,000</td>
<td>4800</td>
<td>2208</td>
</tr>
<tr>
<td>2</td>
<td>40,000</td>
<td>50,000</td>
<td>30,000</td>
<td>3600</td>
<td>1656</td>
</tr>
<tr>
<td>3</td>
<td>40,000</td>
<td>25,000</td>
<td>20,000</td>
<td>2400</td>
<td>1104</td>
</tr>
<tr>
<td>4</td>
<td>40,000</td>
<td>0</td>
<td>10,000</td>
<td>1200</td>
<td>552</td>
</tr>
</tbody>
</table>

Side-effects of financing would increase from $4,428 to $6,706, and the adjusted net present value would increase from $18,627 to $20,905.

Since the interest tax shield is relatively risk free, the cost of debt is the appropriate discount rate to use in computing the net present value of the side-effects of financing.

A simpler approximation to adjusted net present value is the procedure developed by Miller and Modigliani (1966). They propose the use of an adjusted discount rate, \( r^*_j \), where

\[
    r^*_j = r_j (1 - t_c L_j).
\]

In this equation

- \( r^*_j \) = the adjusted discount rate,
- \( r_j \) = the opportunity cost of capital for an all-equity financed project of comparable risk,
- \( t_c \) = the firm's marginal corporate income tax rate,
- \( L_j \) = the project's marginal contribution to the debt capacity of the firm as a proportion of the project's present value.

If \( L_j = 0 \) the \( r^*_j \) is the opportunity cost of equity capital for the project. This simplified procedure is only an approximation and strictly speaking, is valid only for projects which generate permanently level cash flows and which support permanent debt. A fully regulated forest would meet these assumptions. The adjusted discount rate proposed by Miller and Modigliani is an approximation but it does recognize two basic and important points: (1) the discount rate for a project should vary directly with the risk of a project, and (2) projects which can add to the debt capacity of the firm should be discounted at a lower rate.
Summary

There is no magic formula to calculate the "correct" discount rate for an investment project. However, the task should not be ignored or incorrectly oversimplified just because it is difficult. The true cost of capital for an investment should be a function of the risk in the cash flows generated by the investment and the marginal debt capacity of the investment. Forest-based industries have often issued directives which state that all investment projects shall be discounted by a constant discount rate that is thought to be the firm's marginal weighted average cost of capital. Since land and timber are capable of supporting large amounts of long term debt and since land investments are relatively low risk when used in the production of timber, many firms have rejected land and timber purchases that undoubtedly should have been funded if the discount rate had been adjusted to properly reflect risk and debt capacity.

The adjusted-present-value rule is an improvement over the traditional weighted average cost of capital. Acceptance and use of the adjusted present value rule should increase the attractiveness of investment in land and timber and ultimately benefit the shareholders of forest-based industries.
Literature Cited


