SELECTING DISCOUNT RATES FOR CASH FLOWS AND REVENUE REQUIREMENTS

David E. Eckmann
Florida Power and Light Company

and

Louis C. Gapenski
University of Florida

AGA/EEI

Presented at the Budgeting and
Financial Forecasting Committee Meeting
Philadelphia, Pennsylvania

August 1992

SELECTING DISCOUNT RATES FOR CASH FLOWS AND REVENUE REQUIREMENTS

The weighted average cost of capital serves an important role in capital investment decisions for firms in all industries. However, among regulated utilities there continues to be considerable debate regarding the calculation of the weighted average cost of capital for use in discounting project cash flows and revenue requirements[1]. In particular, there is disagreement as to whether the debt component of the discount rate should be included on a pre-tax basis or on an after-tax basis. Using some simple algebra and numerical examples, we will clarify that the choice of the appropriate discount rate for project cash flows depends on the structure of the cash flows. Therefore, there is no single discount rate structure which is in some sense mathematically or theoretically superior to all other discount rates. However, for discounting revenue requirements, the appropriate discount rate is the after-tax cost of capital, assuming that the utility's capital ratios are determined based on the book values used for regulatory purposes.

Discounting Cash Flows

The combination of the cash flows and the cost of capital (the discount rate) must account for (1) the risk of the cash flows, (2) the financing mix of the investment, and (3) the tax benefits associated with the use of debt financing. As long as these three elements are properly incorporated into the analysis, the results will be correct. Suppose, for example, that a utility invests in non-depreciable land under the following circumstances:

I	=	the utility's investment
W_e	=	fraction of equity in the utility's capital structure
K_e	=	the utility's cost of equity
W_d	=	fraction of debt in the utility's capital structure
K_d	=	the utility's cost of debt
T	=	the utility's marginal income tax rate

The utility purchases the property using its target mix of capital, $W_e I$ of equity and $W_d I$ of debt. Assuming that there are no operating expenses associated with the land and perpetual annual revenues (R) are collected from customers, the utility's income statement would look as follows:

R	Revenue
$- \; K_d W_d I$	Interest expense
$R - K_d W_d I$	Pre-tax income
$- \; (R - K_d W_d I)T$	Taxes
$(R - K_d W_d I)(1-T)$	Net Income

Since we assume shareholders are made whole, the property must generate sufficient residual earnings to compensate shareholders for their $W_e I$ dollars of investment, so net income must equal $K_e W_e I$. Therefore;

$$(R-K_d W_d I)(1-T)=K_e W_e I$$

or

$$R=\left[\frac{KeWe}{(1-T)}+K_dW_d\right]I$$

When conducting capital investment analyses, utilities typically focus on operating cash flows which must service both debtholders and equityholders rather than income statement flows. The annual operating cash flow to investors, which excludes the tax shield for interest, is:

$$R(1-T) = \text{Cash Flow Excluding Tax Shield} = \text{CFETS}$$

Thus, $$\left[\frac{KeWe}{(1-T)}+K_dW_d\right]I(1-T) = CFETS,\ or;$$

$$[K_eW_e + K_dW_d\ (1-T)]\ I = CFETS$$

The utility must recover its investment (I) in the property. Since we assume perpetual cash flows, the present value of the cash flows is the annual cash flow divided by the discount rate. Therefore:

$$\frac{CFETS}{Discount\ Rate} = \frac{[KeWe+KdWd(1-T)]I}{Discount\ Rate} = I;\ \text{and}\ solving$$

$$K_eW_e + (K_dW_d)\ (1-T) = \text{Discount Rate}$$

Therefore, when focusing on operating cash flows to investors excluding the tax shield, the debt component of the discount rate should be expressed on an after-tax basis. (We'll refer to this discount rate as the "after-tax discount rate" or the "after-tax cost of capital".) Since this cash flow structure does not reflect the tax benefits of debt financing, those benefits are reflected in the discount rate.

Suppose now that the operating cash flows to investors are adjusted to reflect the tax shields for interest:

$$R(1-T) + K_dW_dIT = \text{Cash Flow Including Tax Shield} = \text{CFITS; or}$$

$$\left(\frac{KeWe}{(1-T)} + K_dW_d\right)I(1-T) + K_dW_dIT = CFITS;\ \text{or}$$

$$(K_eW_e + K_dW_d)I = CFITS$$

Once again, for the utility to recover its investment through this perpetual cash flow stream:

$$\frac{CFITS}{Discount\ Rate} = \frac{(KeWe+KdWd)I}{Discount\ Rate} = I;\ \text{and}$$

$$K_eW_e + K_dW_d = Discount\ Rate$$

Therefore, when the flows are structured as cash flows to investors including the tax shield for interest, there is no need to reflect the tax shield in the discount rate. That is, for cash flows which include the tax shield, the debt component of the discount rate should be expressed on a pre-tax basis. (We'll refer to this discount rate as the "pre-tax discount rate" or the "pre-tax cost of capital".)

Discounting Revenue Requirements

In a world of perfect ratemaking, revenues are established so that utility investors will recover their cost of capital. Therefore, with perfect ratemaking, every investment decision yields a net present value of zero to the investors. While none of us operate in such a world, generally we assume that if regulation is not perfect, it is at least fair. So typically we assume that for the most part the investor will be made whole, and we focus on minimizing the cost to our customers which is measured in terms of the present value of revenue requirements (PVRR). The question then arises as to what is the appropriate discount rate for revenue requirements.

To answer that question, consider the example of a utility with revenues of R_n in Year n. Suppose those revenues are deferred to Year n+1, and the amount of the deferred revenues, R_{n+1}, will be increased to compensate for the deferred receipt of the revenue. How much larger must R_{n+1} be so that the investors are indifferent? Without the deferral, the operating cash flow to investors in Year n would be:

$$R_n(1-T)$$

With deferral, the utility must replace the delayed cash flow with new funds raised in the capital markets in accordance with its optimal capital structure:

$$R_n(1-T)W_d \text{ of debt and}$$

$$R_n(1-T)W_e \text{ of equity}$$

In Year n+1 the shareholder's incremental cash flow due to the loss of revenues in Year n will be:

$$\underbrace{(1-T)(R_{n+1} - R_n(1-T)\ WdKd)}_{\text{Term 1}} - \underbrace{R_n(1-T)Wd}_{\text{Term 2}}$$

The first term represents the after-tax cash flow from the delayed revenues less interest payments, and the second term represents the repayment of the principle on the loan incurred as the result of the delayed receipt of revenues. For the shareholder to be made whole, the cash flow in Year n+1, discounted at the cost of equity, must be equivalent to the cash flow foregone in Year n:

$$R_n(1-T)W_e = \frac{(1-T)(R_{n+1} - R_n(1-T)W_dK_d) - R_n(1-T)W_d}{1 + K_e}$$

Multiplying both sides of the equation by $(1+K_e)/(1-T)$

$$R_nW_e(1+K_e) = R_{n+1} - R_n(1-T)W_dK_d - R_nW_d \text{ ; or}$$

$$R_nW_e(1+K_e) = R_{n+1} - R_nW_d\,(1+K_d\,(1-T)) \text{; or}$$

$$R_n\,(W_e(1+K_e)+W_d\,(1+K_d\,(1-T))) = R_{n+1} \text{ ; and}$$

Recognizing that $W_e + W_d = 1$

$$R_n(1 + W_eK_e + W_dK_d\,(1-T)) = R_{n+1}$$

Therefore, if the firm maintains the assumed capitalization ratios, then the appropriate rate for discounting revenue requirements - that is to say the appropriate rate for adjusting the time value of revenue requirements - is the after-tax discount rate. Note that revenues do not reflect the tax shield for interest since each additional dollar of interest expense requires one dollar of additional revenue regardless of the tax rate. Consequently, the discount rate for revenues must reflect the tax shield.

Numerical Example

At this point, it would be useful to provide a numerical example to illustrate the general results developed algebraically. For that purpose, we've used an example provided by Kenneth R. Meyer in a recent article on this same subject, the calculation of a utility's cost of capital for investment analysis purposes.[2]

In this illustration a utility has a target capital structure of 50% debt and 50% common equity, and a tax rate of 40%. The firm's cost of debt is 10% and its cost of equity is 14%. As shown in Table 1, the pre-tax discount rate and after-tax discount rate are 12% and 10%, respectively.

Table 1
Numerical Example
Pre-Tax and After-Tax Discount Rates

Debt Weight (W_d)	50.0%
Cost of Debt (K_d)	10.0%
Equity Weight (W_e)	50.0%
Cost of Equity (K_e)	14.0%
Tax Rate (T)	40.0%
Pre-tax Discount Rate	12% = (.5)(.10)+(.5)(.14)
After-tax Discount Rate	10% = (.5)(.10)(1-.4) + (.5)(.14)

Now assume that the utility is evaluating a 5-year project which requires an investment of $100. The project has annual cash operating costs of $25 and book and tax depreciation of $20 per year. In accordance with the firm's target capital structure, the project will be financed using 50% debt and 50% equity. So $50 of equity and $50 of 10% coupon debt will be used. The debt is assumed to be a term loan, with straight line amortization of the principal amount. Consequently, $10 of principal will be retired in each of the 5 years, and the annual interest payment, which starts at $5, will be reduced accordingly. To remain at the target capital ratios, $10 of equity capital will be retired in each year as well.

As shown in Table 2, from the shareholder's perspective, the net cash flows from the project result in a net present value of zero. In each year, the shareholder earns the required 14% return on the outstanding equity investment:

TABLE 2
Net Cash Flow to Equityholders

	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues	$61.67	$58.33	$55.00	$51.67	$48.33
Cash Operating Costs	(25.00)	(25.00)	(25.00)	(25.00)	(25.00)
Depreciation	(20.00)	(20.00)	(20.00)	(20.00)	(20.00)
Earnings Before Interest	16.67	13.33	10.00	6.67	3.33
Interest	(5.00)	(4.00)	(3.00)	(2.00)	(1.00)
Earnings Before Taxes	11.67	9.33	7.00	4.67	2.33
Taxes (40%)	(4.67)	(3.73)	(2.80)	(1.87)	(0.93)
Net Income	7.00	5.60	4.20	2.80	1.40
Adding Back Depreciation	20.00	20.00	20.00	20.00	20.00
Less Debt Principal Repaid	(10.00)	(10.00)	(10.00)	(10.00)	(10.00)
Net Cash Flow to Equity*	$17.00	$15.60	$14.20	$12.80	$11.40
Net Income (see above)	$7.00	$5.60	$4.20	$2.80	$1.40
Equity Investment	$50.00	$40.00	$30.00	$20.00	$10.00
Return on Equity (net income/equity investment)	14%	14%	14%	14%	14%

*NPV of Net Cash Flow to Equity discounted at 14% = $0.00.

As we indicated earlier, if the appropriate discount rate is used for a given set of cash flows, then the results will be correct. Consistent with results shown in Table 2, Table 3 shows that the net present value of the project is zero using the after-tax discount rate and pre-tax discount rate to value operating cash flows to investors, excluding and including the tax shield on interest, respectively.

TABLE 3 Project Cash Flows	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues	$61.67	$58.33	$55.00	$51.67	$48.33
Cash Operating Costs	(25.00)	(25.00)	(25.00)	(25.00)	(25.00)
Depreciation	(20.00)	(20.00)	(20.00)	(20.00)	(20.00)
Earnings Before Interest	16.67	13.33	10.00	6.67	3.33
Taxes (not reflecting interest deduction)	(6.67)	(5.33)	(4.00)	(2.67)	(1.33)
Adding Back Depreciation	20.00	20.00	20.00	20.00	20.00
Cash Flow to Investors Excluding Tax Shield on Debt (CFETS)*	30.00	28.00	26.00	24.00	22.00
Tax Shield (interest expense * 40%)	2.00	1.60	1.20	0.80	0.40
Cash Flow to Investors Including Tax Shield on Debt (CFITS)**	$32.00	$29.60	$27.20	$24.80	$22.40

* NPV of Cash Flow to Investors Excluding Tax Shield (CFETS) discounted at 10% (the after-tax discount rate) = $0.00.

** NPV of Cash Flow to Investors Including Tax Shield (CFITS) discounted at 12% (the pre-tax discount rate) = $0.00.

The algebra presented earlier indicated that revenue requirements should be valued using the after-tax discount rate. To illustrate this result, we could calculate the single, lump-sum revenue requirement in Year 5 which would be equivalent to the series of five revenue requirements used in the example. This lump-sum revenue requirement would be calculated by summing the future values of the five revenue requirements. Using the after-tax discount rate of 10%, the future value in Year 5 turns out to be $339.65. As demonstrated in Table 4, this lump-sum revenue requirement is equivalent to the series of five revenue requirements in the sense that the shareholder's net present value is zero in either case. This illustration confirms that the after-tax discount rate should be used to compare the value of revenues received at different points in time.

TABLE 4
Lump Sum Revenue Requirement
Net Cash Flow to Equityholders

Operating Cash Flows	Year 1	Year 2	Year 3	Year 4	Year 5
Revenues	$0.00	$0.00	$0.00	$0.00	$339.65
Cash Operating Costs	(25.00)	(25.00)	(25.00)	(25.00)	(25.00)
Depreciation	(20.00)	(20.00)	(20.00)	(20.00)	(20.00)
Interest (10% * beginning debt balance - see below)	(5.00)	(5.85)	(6.79)	(7.81)	(8.94)
Earnings for Tax Purposes	(50.00)	(50.85)	(51.79)	(52.81)	285.71
Taxes (40%)	20.00	20.34	20.71	21.13	(114.28)
Adding Back Depreciation	20.00	20.00	20.00	20.00	20.00
Cash Flow to Equity from Operations	(10.00)	(10.51)	(11.07)	(11.69)	191.42
Dividends (see below)	8.50	9.35	10.29	11.31	(89.45)
Net Cash Flows to Equity*	$(1.50)	$(1.16)	$(0.79)	$(0.37)	$101.97
Equity Investment and Borrowing Levels					
Beginning Equity Balance	$50.00	$58.50	$67.85	$78.13	$89.45
Net Income (14% *beginning equity balance)	7.00	8.19	9.50	10.94	12.52
Equity Investment During Year Required for Operations	10.00	10.51	11.07	11.69	(191.42)
Equity Prior to Dividends	67.00	77.20	88.42	100.74	(89.45)
Less Dividends Paid (to Balance Capital Structure)**	(8.50)	(9.35)	(10.29)	(11.31)	89.45
Ending Equity Balance	$58.50	$67.85	$78.13	$89.45	$0.00
Beginning Debt Balance	$50.00	$58.50	$67.85	$78.13	$89.45
New Borrowing**	8.50	9.35	10.29	11.31	(89.45)
Ending Debt Balance	$58.50	$67.85	$78.13	$89.45	$0.00

* NPV of Net Cash Flow to Equity discounted at 14% = $0.00.

** To balance the capital structure, a cash dividend is paid and new borrowing is added to replace the cash dividend in an amount equal to half the difference between the debt and equity balances.

Notice that in Table 4 the utility's borrowings were adjusted to maintain the target levels of debt and equity which were measured in terms of the book values used for regulatory purposes. In other words, the financing practice of the firm is to adjust capital ratios continually to achieve the desired targets (50% debt and 50% equity). We believe that most utilities follow this type of financing policy, at least in the long run. However, if the firm uses a different financing policy, then the mixture of capital will differ from the 50/50 debt and equity capitalization assumed for purposes of calculating the discount rate. In that event, the after-tax discount rate may be inappropriate for purposes of valuing revenue requirements.

In a draft EPRI report, Jamie Reid considered the possible situation where accounting book value differs from book value as recorded for regulatory purposes with respect to assets upon which a utility earns a regulated return[3]. In most cases accounting book value will be closely correlated to regulatory book value. However, in Jamie Reid's example, the debt capacity of the firm is a function of the firm's accounting book value and is independent of the cost recovery procedures used for regulatory purposes. Under these circumstances the financing policy of the firm would be to maintain debt at a constant percentage of accounting book value, and the pre-tax discount rate would be used for discounting revenue requirements. In most cases, however, regulatory book value is the basis of the cost recovery pattern of a regulated utility. Therefore, regulatory book value is the major determinant of a utility's future cash flow, which in turn determines its market value and debt capacity. Consequently, we believe that most utilities will adjust their capitalization ratios based on regulatory book value. Furthermore, as we demonstrated earlier, to the extent that capitalization ratios are based on regulatory book values, the after-tax discount rate would be appropriate for discounting revenue requirements.

As a point of clarification, "regulatory book value" in this context means the total value, as measured by the regulators, of those assets upon which the utility is currently earning a return (rate base assets) together with those assets upon which the utility will earn a return in the future (such as construction work in progress). One final point is that, as a practical matter, many utilities adjust capitalization ratios based on accounting book values, which are readily available and which are closely tied to regulatory book values. Nonetheless, in these cases, we think that the capitalization ratios are based implicitly on regulatory book value. In other words, we believe that if a significant difference arose between the accounting and regulatory book values, then generally the utility would base its targets on regulatory book value, which would be the better indicator of debt capacity.

Summary

As we've seen the appropriate discount rate depends on how the cash flows are structured for analytical purposes. If the capital mix is based on the utility's book values as measured for regulatory purposes, and if the capital mix remains constant, then discount rates should be selected as follows:

- Cash flows to investors excluding the tax shield on interest should be discounted using the after-tax discount rate.
- Cash flows to investors including the tax shield on interest should be discounted using the pre-tax discount rate.
- Revenue requirements should be discounted using the after-tax discount rate.

With the proper selection of the discount rate the analysis will reflect three essential factors: (1) the risk of the cash flows, (2) the financing mix, and (3) the tax benefits associated with the use of debt financing.

Notes

1. See, for example, Kenneth R. Meyer, "A Needed Change in the Utility Financial Model", in the October 26, 1989 issue of *Public Utilities Fortnightly*.

2. Ibid

3. See Jamie Read, "Capital Budgeting for Utilities: Tax Adjusted Discount Rates", Draft Final Report, EPRI Project 1920-3, September 1989, pages 32 through 38.