AN ECONOMETRIC MODEL FOR ESTIMATING THE COST OF CAPITAL FOR A PUBLIC UTILITY

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I. INTRODUCTION

Of the many issues that arise in public utility rate cases, probably none is more controversial than the proper estimation of the cost of equity capital. In an earlier paper, we discussed the risk premium approach to measuring equity costs. Now we consider the use of an econometric model based on the Discounted Cash Flow (DCF), or Gordon Model, approach.

We begin with a brief discussion of the traditional DCF approach, after which we consider econometric modelling as a general methodology. Next, we apply the model to a sample of thirteen telephone companies and then illustrate its use in estimating the cost of equity capital. Finally, we apply the model to a sample of electric utilities. Our general conclusions are (1) that the econometric approach is useful, but (2) that substantial judgments are involved both in the development of the model and in deriving from it a company-specific cost of capital. Because of the judgmental elements inherent in the model, it should never be used as the sole criterion for a rate case cost of capital estimate--results generated by the model should always be compared with cost of capital estimates developed by other methods.

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[1]E. F. Brigham and D. K. Shome, "Risk Premiums on Common Stocks," PURC Working Paper 1-79.

The Traditional DCF Approach

The constant growth DCF model as developed by M. J. Gordon has seen wide acceptance in rate cases in recent years. Indeed, we have examined the testimony in over one hundred cases, and we have not seen even one (since the late 1960's) where at least one witness did not use some form of the basic model,

$$k = \frac{D_1}{P_0} + g,$$

where k is the DCF cost of equity, D_1 is the dividend expected during the coming year, P_0 is the current price of the stock, and g is the expected future growth rate.[1]

Although rate of return witnesses sometimes bastardize the model by using past values for the dividend and stock price data, rather than D_1 and P_0 as the theoretical model demands, the biggest problem by far with implementing the traditional DCF approach is to obtain a correct estimate of the value of g that investors at the margin are expecting. Rate of return analysts use a variety of techniques, ranging from simply extrapolating past growth trends to surveying investors, to estimate the g factor. Some of these analysts are very astute and knowlegeable, while others are less so, but it is often hard for utility commissioners to decide who is right and who is wrong when two supposedly expert witnesses make radically different recommendations.

An Econometric Model Approach

Econometric models have two major advantages over the

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[1]For the development of the model, see E. F. Brigham, Financial Management, 2nd Edition, Chapter 4.

pure DCF method. First, the models can help "hold other things constant." It is useful to check estimates by comparisons with other firms. However, because utilities (and other companies) differ from one another with regard to their operating territories, financial leverage, investment opportunities, regulatory climate, and so on, if we are to compare required rates of return among a set of companies, we need to hold constant factors such as these. Econometric techniques can help in this task, and thus aid us in obtaining better estimates of the cost of equity. Second, econometric models can help to quantify the accuracy of cost of capital estimates. Analysts generally estimate a most likely single value of the cost of common equity, and then talk about an arbitrarily specified "range of reasonableness." Econometric techniques can be used both to judge the precision of the point estimate and also to specify more precisely the range within which the "true" figure probably lies.

The econometric model that we use is based on standard DCF concepts. Two key assumptions are made whenever the cost of equity is calculated using the constant growth DCF model:

(1) The model is correctly specified; that is, the sum of the dividend yield plus the single growth rate does, in fact, add up to the required rate of return.

(2) We can obtain correct values for both the dividend yield for the coming year and the constant expected future growth rate. "Correct" means the values that are actually used by marginal investors who set the price of the stock in question.

The validity of these assumptions cannot be tested by applying the DCF equation to a single firm. However, the model can be tested by econometric techniques with a sample of firms. If the model's specification is correct, and if the variables are measured without significant errors, we would obtain a regression equation that had the following properties:

(1) There would be a reasonably good fit between the dependent variable as predicted by the regression equation and the actual values of the dependent variables. The goodness of fit is measured by the coefficient of determination (R^2).

(2) There would be a relatively small standard error of the estimate.

(3) The regression coefficients would be significant, and each would have the correct sign.

(4) The regression equation would satisfy, to a reasonable extent, all the assumptions of least squares regression analysis.

If the model had these properties, then we could be reasonably confident that our estimated cost of capital was close to the true value. Further, we could actually specify confidence limits and use them for establishing a "range of reasonableness" for ratemaking purposes. Even so, we would still want to compare the model-estimated cost of capital with estimates based on other methods. If the various estimates agreed with one another, this would increase our confidence in the results. If they did not agree, we would face the dilemma of choosing between them. In this case, the model's statistical properties should form the basis for assigning weights to the various techniques; if the statistical properties were good, then a heavier weight should be given to the model, and conversely if the model's properties were not particularly good.

Developing the Model

The basic DCF constant growth model (the Gordon Model) states that $k = D_1/P_0 + g$. To use the model, one merely calculates D_1/P_0, the dividend yield term, and adds to it an estimate of the growth term, g. Unfortunately, it is impossible to test the validity of our estimate because it is impossible to observe the true value of k, the expected rate of return. However, it is possible to rewrite the Gordon equation into a testable form. Here we use the price/book ratio (P/B) and develop it as a function of the rate of return on book equity as follows:

1. According to the constant-growth Gordon model,

$$P_0 = \frac{D_1}{k - g}, \tag{1}$$

where

P_0 = current price of a firm's stock,

k = the firm's cost of equity capital,

D_1 = dividends per share expected during the next period, and

g = expected future growth rate in dividends. g is "expectationally constant," meaning that while investors know that the growth rate will actually vary from year to year, the current expectation of the growth rate for any future year is the same as for any other year; that is, $E(g_t) = E(g_{t+1})$ for all values of t.

2. Expected earnings per share in any future year t, E_t, is equal to the expected rate of return, ROE, times the book value at the beginning of the period, B_{t-1}:

$$E_t = ROE(B_{t-1}). \tag{2}$$

3. If a constant fraction of earnings, b, is retained, then the dividend payout ratio (PO) will be equal to (1 - b), and expected dividends per share in any year t can be estimated as follows:

$$D_t = (1 - b)E_t = (1 - b)(ROE)B_{t-1}. \tag{3}$$

4. The expected growth rate in earnings, dividends and share prices, assuming b and ROE are constant, is found as follows:

$$g = b\ (ROE). \tag{4}$$

5. Letting t = 1 and substituting equations (3) and (4) into (1), we see that

$$P = \frac{D_1}{k - g} = \frac{(1 - b)\ (ROE)\ (B_t)}{k - b(ROE)}.$$

Transposing the B term (and dropping the t sub-sucript) produces this expression for P/B:

$$\frac{P}{B} = \frac{(1 - b)\ (ROE)}{k - b(ROE)}. \tag{5}$$

Equation 5 has some interesting and useful implications for rate cases. Note that if (1) commissioners actually identify the true cost of equity, k, and then allow utilities to earn this rate of return on their book equity, then (2) investors will use the allowed ROE as the expected future ROE, and (3) the P/B ratio will be equal to 1.0. If the allowed ROE is below k, then the P/B ratio will be less than 1.0, while if allowed ROE exceeds k, P/B will be greater than 1.0.

Equation 5 forms the theoretical basis for the empirical regression model which we use to estimate the cost of equity. First, note that the relationship between P/B and ROE as expressed in Equation 5 is nonlinear; the exact relationship is graphed in Figure 1 under the assumption that k - 14% and b - 30%. The shape of the graph will vary somewhat depending on the values of k and b, and it will also be different if we assume that new stock is sold at prices significantly different from the book value. However, as a generalization, the graph is not very sensitive to these factors so long as they stay within reasonable bounds.[1]

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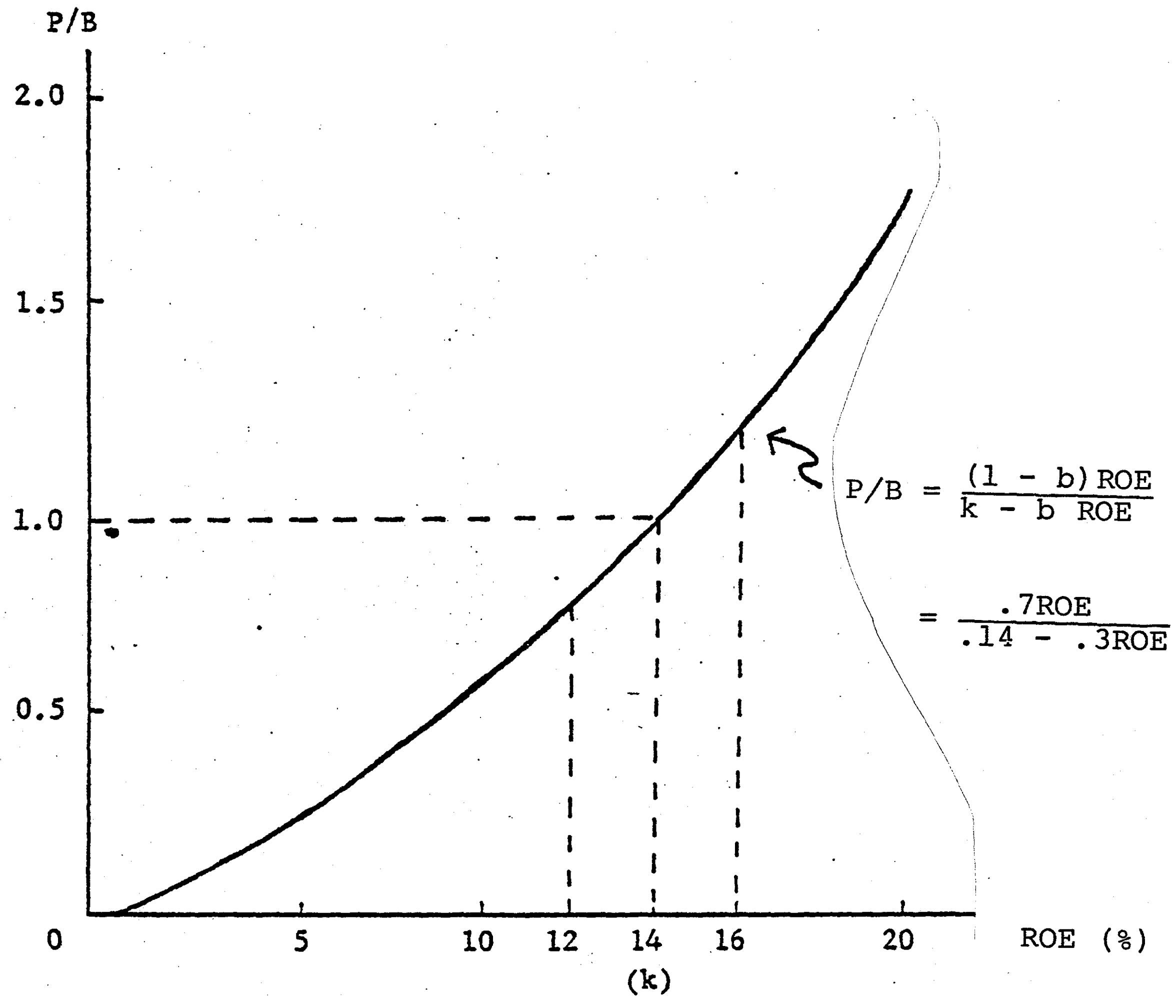
[1]See E. F. Brigham and T. A. Bankston, "The Relationship between a Utility Company's Market Price and Book Value," Public Utility Research Center, University of Florida, November, 1973, for a more detailed discussion of this point. In brief, the curve would be slightly steeper if the retention rate were higher than 30%, less steep if it were lower, but it would still pass through the point P/B = 1.0, ROE = 14%. The effect of a change in the retention rate depends on the level of ROE; changes of 10% or less in the retention rate have very little effect on the curve when ROE is in the range 12% to 16%.

It should also be noted that, if the company is expected to issue stock, then the P/B ratio will be less than 1.0 if ROE = k, with the decline depending on (1) the percentage flotation cost and (2) the amount of stock expected to be sold. Selling stock also causes the curve to be steeper, indicating lower P/B ratios if k $>$ ROE but higher P/B ratios if ROE $>$ k.

Figure 1

Relationship between P/B and
the Allowed Rate of Return
(Assumes k = 14%, b = 30%)



Even though the exact relationship between P/B and r is nonlinear, the curve is, for all practical purposes, linear for values of r within a reasonable range around the appropriate value of k, that is, if ROE is in the range 12 to 16 percent. This being the case, it is appropriate to assume, for purposes of fitting the regression model, that P/B is linearly related to the allowed rate of return. Assuming that a linear approximation is appropriate, we could run a regression of P/B against ROE such as the following:

$$P/B = a_0 + a_1(ROE).$$

If the conditions shown in Figure 1 held exactly, and if investors expected most utilities to earn from 12 to 16 percent on equity, then P/B ratios would range from a low of about 0.80 to a high of about 1.20. The constant term, a_1, would be approximately equal to -0.40, and the slope coefficient, a_2, would be approximately equal to 0.10:

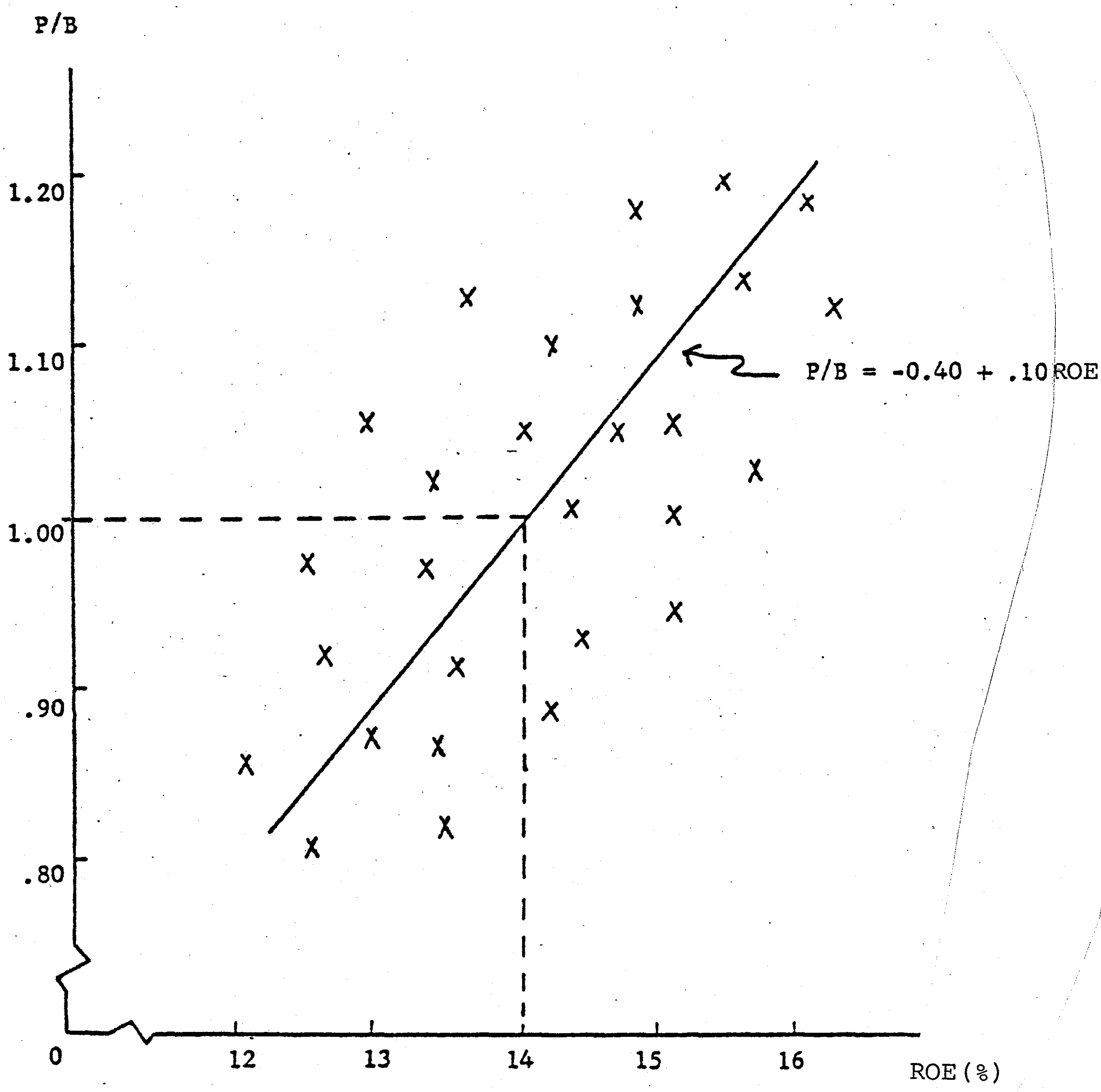
$$P/B = -0.40 + 0.10(ROE).$$

Whereas Figure 1 is theoretically correct, Figure 2 shows how the empirical relationship between P/B and rates of return would look under realistic conditions. The points would plot around a linear regression line, but deviations from the line would occur for these reasons:

1. Earned returns do not match up exactly with commission specified allowed rates of return, so it is not possible to measure exactly the rate of return the average investor

Figure 2

Linear Relationship between P/B and ROE.
(Assumes k = 14%, b = 30%, and expected
ROE ranges from 12% to 16%.)



expects a utility to earn in the future. One could use as a proxy for this expected future return the company's actual earned return in the recent past, an average of returns earned over some longer past period, the rate of return allowed in the latest rate case, rates of return earned by other utilities, or any combination of these returns. Still, the true expected return for many of the companies will be measured with some degree of error, and this will cause actual P/B ratios to deviate from their predicted values.[1]

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[1]If errors in measuring expected ROE are randomly distributed, then there will be no bias in the estimate of the relationship between P/B and ROE as derived from the regression. However, if the errors are not random, then there will be a bias. For example, suppose some event occurred which caused the ROE's of many or all utilities to fall sharply to some level below the true values of k for the different companies. However, suppose investors think the decline in ROE is temporary and that when the current problem is over, ROE's will return to a "normal" level. In this event, the regression line in Figure 2 would be shifted to the left. If this shifted regression line were used as the basis for setting the allowed rate of return, then it would <u>not</u> produce the desired P/B ratio--the P/B would end up below the target P/B.

In our statistical models, we use average values over the past five years in an effort to eliminate this type of bias. Individual companies may have temporarily high or low returns, but, hopefully, the smoothed figures will be sufficiently accurate so as to produce a nonbiased regression line. Unfortunately, we cannot be sure whether the biases are present or not, for if therewere a systematic understatement or overstatement in the data, we could obtain high R^2 values yet still have an invalid model.

2. The companies in the sample will differ in their riskiness as viewed by investors. This, in turn, will cause the true cost of equity, k, to differ among firms. If one company had a high equity ratio, a strong bond rating, conservative accounting methods, and a commission which operates without undue lags, then a given rate of return on equity would produce a relatively high P/B ratio, and the "X" representing this company would plot above the regression line. Opposite conditions would result in a low P/B ratio, and the company's "X" would plot below the regression line.

3. It is often argued that people who invest in utility stocks are more interested in current dividend income than in future capital gains. If this were true (and it has never been proven), then companies that have a high payout ratio would, other things held constant, have high P/B ratios and plot above the regression line in Figure 2.

4. Companies that have significant amounts of unregulated as well as regulated assets (i.e., companies with nonrate base assets) could have P/B ratios that are above or below the regression line, depending on the profitability of these other assets.

Because of these factors, and others, it is apparent (1) that the basic model must be expanded to include risk variables and (2) that measuring the expected ROE is a critical step in the analysis. If n risk variables were included, then our regression model would be in the form

$$P/B = a_0 + a_1 \text{ (ROE)} + \sum_{i=2}^{n+1} a_i x_i,$$

where x_i represents the n risk variables.

We have analyzed a number of risk variables, including (1) times interest earned ratios, (2) equity ratios, (3) allowance for funds used during construction (AFUDC) expressed as a percentage of net income, (4) the company's method of accounting for deferred taxes (flow through vs. normalize), (5) security analysts' ranking of regulatory climate, (6) security analysts' rankings of "quality of earnings," (7) bond ratings, and (8) stability of earnings measures (standard deviations, of ROE and ROI). For the telephone industry, we also used a dummy variable that differentiates between the Bell System companies and the independent telephone companies.

In addition to these risk variables, we also considered a number of ways of estimating the expected ROE's. First, we calculated past realized rates of return over various time periods and then used these values as proxies for current expectations. For example, we looked at last year's ROE as a proxy for expected future ROE's, and at the average of the last two, three, four, and five years, both unweighted and also weighted to give more weight to the most recent data. In addition, we looked at commission-authorized ROE's. Finally, we examined a pair of surrogate variables that should reflect investor's expectations for ROE. The surrogate variables recognize that returns must either be paid out as dividends or retained, so expected ROE can be split into two components, as "dividend yield" component and a "growth-from-retention" component:

$$\text{ROE} = \text{Earnings yield} = \text{Book dividend yield} + \text{Growth yield}$$
$$= \frac{E}{B} = \frac{D}{B} + \frac{R}{B}.$$

Here E = earnings, B = book value, D = dividends, and R = retained earnings.[1] Ther term D/B is defined as the company's book yield, and R/B is equal to the growth rate in earnings (and dividends, assuming the retention rate b is a constant).[2]

Statistically, the book yield plus growth rate surrogate for ROE gave us a better fit in the regression model (higher values of R^2 and more significant regression coefficients) than did any of our other measures of ROE. We can offer two explanations for these results. (1) It may be that investors, when they value utility stocks, treat the dividend yield and growth yield components separately rather than looking at the sum of these two components as reflected in ROE. (2) An alternative explanation is that current dividends provide better information about long-run earnings than do current earnings, especially during times when current earnings, hence reported ROE's, are varying considerably from year to year. If current earnings, hence ROE's, are unstable, and if companies base their dividend payments on normalized earnings, then dividends actually paid will be a better proxy for normalized earnings than are current earnings, and book yield plus growth will be a better proxy for normalized ROE's than are actual ROE's.

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[1]These values can be expressed either as totals or on a per share basis; ROE is the same either way.

[2]To see why R/B = g, first recall that g = b(ROE), and then note that

$$b = \frac{E - D}{E} \text{ and } ROE = \frac{E}{B}.$$

Therefore, with R = E - D, we have

$$g = b(ROE) = \frac{E - D}{E} \cdot \frac{E}{B} = \frac{E - D}{B} = \frac{R}{B}.$$

Since the book yield model is just as sound as the earnings yield model from a theoretical standpoint, and since it is superior from a statistical standpoint, we focus most of our attention on book yields.[1]

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[1]Our model is similar in this respect to that of D. A. Burkhardt and M. A. Viren, "Investor Criteria for Valuing Utility Common Stocks," Public Utilities Fortnightly, July 20, 1978, and also to the Salomon Brothers model described in their quarterly reports.

II. THE TELEPHONE INDUSTRY

We applied the model to the thirteen domestic telephone companies for which data are reported on the Compustat tapes. The sample consists of AT&T, the six publicly owned Bell affiliates (Cincinnati Bell, Mountain Bell, New England Telephone, Pacific Northwest Bell, Pacific Telephone, and Southern New England Telephone), and the six largest independent companies (Central Telephone, Continental Telephone, GT&E, Mid-Continent Telephone, Rochester Telephone, and United Telecommunications).

As noted in the preceding section, we examined a number of different risk variables and a number of different methods for estimating the value of ROE expected by investors. As we shall see in a later section, for the electric utilities several of the risk variables have significant effects on the P/B ratio, hence on the estimated cost of equity. Included are the equity ratio, the proportion of AFUDC included in net income, whether or not a company uses flow through accounting, the ranking of the regulatory climate in a company's operating territory, and analysts' appraisal of the overall quality of a firm's earnings. However, in the telephone industry, none of these variables show up as being significant. The reasons for the variables' insignificance are all simple and straightforward: (1) The Bell Companies all have very similar equity ratios, as do the independents. There is a pronounced difference between Bell and non-Bell companies, but not much difference within the groups. Therefore, equity ratios really measure Bell versus non-Bell status. (2) None of the telephone companies have very much AFUDC (as compared to the average electric company), and there is very little difference in the AFUDC/Net income ratios among companies.

(3) Flow through versus normalization, regulatory climate ranking, and earnings quality ranking generally reflect conditions in the state in which a utility operates. These variables show up as being significant for the electric companies, but since most of the telephone companies operate in several states, or in states with "average" conditions, these variables are not significant for the telephone industry.[1]

Although the above-mentioned variables did not help much in explaining P/B ratios, a dummy variable set equal to zero for Bell and 1.0 for non-Bell companies did show up as being strongly significant. Therefore, our regression model for the telephone industry was specified as follows:

$$P/B = a_0 + a_1(\text{Book yield}) + a_2(\text{Growth}) + a_3(\text{Dummy}).$$

In the next several sections we describe how the variables used in the model were estimated.

The P/B Ratio

We measured the P/B ratio in two ways:

$$P/B_1 = \frac{\text{Average stock price during December 1978}}{\text{1978 year-end book value per share}},$$

and

$$P/B_2 = \frac{\text{1978 year-end closing price}}{\text{1978 year-end book value per share}}.$$

The point here was to test the sensitivity of the results to

[1]Also, note that with a sample of only thirteen companies, we are limited in the number of variables that can be included in the analysis without significant loss of degrees of freedom, hence statistical significance.

the use of a spot price versus an average of recent prices.

Book Yield and Growth rate

We measured the expected book yield (BKYLD) as the product of the expected ROE times the expected dividend payout rate (PO):[1]

$$BKYLD = (ROE)(PO).$$

We measured the expected growth rate (GROBR) as the product of the expected retention rate [b = (1 - PO)] times the expected ROE:

$$GROBR = (1 - PO)(ROE) = b(ROE).$$

It is apparent that the values of ROE, PO, and b which investors expect in the future are critical for the measurement of both book yield and growth. However, data are available only for the past, not for the future. We can use historic data as a basis for forming expectations about future patterns, but (1) there are different procedures for setting up time series models to predict future values from past data, (2) we have no way of telling *a priori* what procedure most investors actually use, and (3) in any event, subjective, nonquantifiable inputs as well as past data go into real world formations of expectations about future events.[2] Accordingly, we considered several different procedures for estimating expected retention rates, payout rates, and ROE's:

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[1] Note that

$$BKYLD = \frac{D}{B} = \left(\frac{E}{B}\right)\left(\frac{D}{E}\right) = (ROE)(Payout).$$

[2] L. D. Brown and M. S. Rozeff, in the lead article in the March 1978 issue of the Journal of Finance ("The Superiority of Analyst Forecasts as Measures of Expectations: Evidence from Earnings," pages 1-16) prove conclusively that security analysts, using judgmental inputs and knowledge about specific companies and industries, can predict earnings growth better than even quite sophisticated time series models that use only historic data. With this in mind, we plan to extend our econometric analysis using explicit analyst growth forecasts rather than a model based purely on historic data such as the one described in the current version of this paper.

1. Current levels. If we assume that the best estimates of future values for ROE's and payout ratios are represented by the most recent levels of these variables, then

$$ROE_1 = \frac{\text{Earnings over most recent 12 month period}}{\text{Average common equity during that period}}$$

and

$$PO_1 = \frac{\text{Dividends during most recent 12 month period}}{\text{Earnings during most recent 12 month period}},$$

We used year-end 1978 values for the runs reported in this paper.[1]

With ROE and PO measured as described above, we then calculate book yield and growth as follows:

$$BKYLD_1 = (ROE_1)\ (PO_1),$$

and

$$GROBR_1 = (1 - PO_1)\ (ROE_1).$$

These values form the basis for Model 1, or Equation 1.

2. "Normalized values." Year-to-year fluctuations often occur in earnings data, so there is a great deal of logic in assuming that investors form expectations about future events on the basis of average data over the recent past. With this in mind, we also measured PO and ROE as follows:

$$PO_2 = \text{A simple average of payout rates over the past 5 years}$$

$$= \left(\sum_{t=1974}^{1978} PO_t\right)/5.$$

$$ROE_2 = \frac{\text{Expected EPS}}{\text{Expected average book value per share}}$$

$$= \left(\frac{\text{Expected DPS}}{\text{Expected PO}}\right)\left(\frac{1}{\text{Expected book value}}\right)$$

[1]In a later version, we plan to obtain data going back in time to determine how stable the model is over time. We have done time series studies with a similar model, but not with the model version reported herein.

$$= \frac{DPS_{1978}(1 + g)}{(PO_2)(\text{Average book value}_{1978})(1 + g)}$$

$$= \frac{DPS_{1978}}{(PO_2)(\text{Average book value}_{1978})}.$$

This ROE estimate makes use of the facts (1) that dividends are far more stable than earnings and (2) that dividends may be used as a basis for estimating "normalized" EPS. In any event, we can use PO_2 and ROE_2 to develop a second set of book yield and growth rate estimates:

$$BKYLD_2 = (ROE_2)(PO_2),$$

and

$$GROBR_2 = (ROE_2)(1 - PO_2).$$

3. Trended Estimates. Investors are often sensitive to trends in key variables and therefore give greater weight to more recent data than to earlier data. With this in mind, we developed exponentially smoothed weighted averages for the payout ratio and then used these values in our estimates of book yield and growth:

PO_3 = Exponentially smoothed 5 year average payout.

$$ROE_3 = \frac{DPS_{1978}}{(PO_3)(\text{Average book value}_{1978})}.$$

$$BKYLD_3 = (ROE_3)(PO_3).$$

$$GROBR_3 = (ROE_3)(1 - PO_3).$$

Dummy Variable

As noted earlier, the types of risk variables that are useful for distinguishing riskiness among the electric utilities are not useful for the telephone companies. Rather, the factor which seems to best capture differences among the telephone companies is a dummy variable set equal to 0 for Bell System Companies and to 1.0 for independent telephone companies.

Data Sources

We obtained 1978 data from individual company annual reports, and data for earlier years from the Compustat tapes.

Regression Equations

We ran a total of six regression equations as shown in Table 1, after which we derived the estimated cost of equity figures shown in Table 2. The R^2 values shown in the table (which have been corrected for degrees of freedom) are all highly significant, which indicates that the regression equation predicts P/B ratios with a relatively high degree of accuracy. From 82 to 90 percent of the variability in P/B ratios among the sample companies is explained by the model. The regression coefficients all have the correct signs--companies with higher book yields and growth rates have higher P/B ratios, and the negative signs of the dummy variable coefficients indicate that Bell System Companies, other things held constant,

Table 1. Telephone Company Regression Equations

$$[P/B = a_0 + a_1(BKYLD) + a_2(GROBR) + a_3(Dummy)]$$

Model Description	a_0	a_1	a_2	a_3	R^2	Standard Error
I. P/B Based on Dec. Avg. Price $[P/B_1]$						
1. 1978 data $[ROE_1, PO_1, BKYLD_1, GROBR_1]$	-0.4725 (-2.105)	16.621 (5.695)	1.9951 (2.301)	-0.0425 (-0.794)	.88	.0551
2. 5-year avg. $[ROE_2, PO_2, BKYLD_2, GROBR_2]$	-0.3941 (-1.936)	15.082 (5.933)	3.6057 (3.024)	-0.1240 (-1.939)	.89	.0537
3. Exponential smoothing $[BKYLD_3, GROBR_3]$	-0.2250 (-0.946)	13.440 (4.229)	2.0168 (1.627)	-0.0475 (-0.691)	.82	.0670
II. P/B Based on 1978 Year-end Price (P/B_2)						
4. 1978 data $[ROE_1, PO_1, BKYLD_1, GROBR_1]$	-0.4553 (-1.965)	16.399 (5.445)	2.0621 (2.305)	-0.0498 (-0.901)	.87	.0569
5. 5-year avg. $[ROE_2, PO_2, BKYLD_2, GROBR_2]$	-0.4055 (-2.215)	14.963 (6.545)	4.1866 (3.905)	-0.1461 (-2.540)	.90	.0483
6. Exponential $[BKYLD_3, GROBR_3]$	-0.2128 (-0.910)	13.036 (4.222)	2.4418 (2.002)	-0.0590 (-0.873)	.82	.0659

Note: t values are shown in parentheses

Table 2. Cost of Capital Estimates for the Telephone Companies Using Alternative P/B Models

Company (R^2)	Model 1 (.88)	Model 2 (.89)	Model 3 (.82)	Model 4 (.87)	Model 5 (.90)	Model 6 (.82)
1. AT&T	13.78%	13.00%	13.72%	13.75%	12.93%	13.70%
2. Cincinnati Bell	18.77	15.14	17.60	18.67	14.88	17.26
3. Mountain States Bell	13.99	12.94	13.96	13.96	12.87	13.93
4. New England States T&T	12.45	11.14	12.68	12.44	11.20	12.72
5. Pacific Northwest Bell	14.52	12.98	14.43	14.49	12.91	14.36
6. Pacific T&T	11.27	12.04	11.93	11.27	12.04	12.02
7. Southern New England T&T	15.15	12.24	13.99	15.11	12.23	13.95
Bell System Mean (Standard Deviation)	14.28% (2.37)	12.78% (1.24)	14.04% (1.79)	14.24% (2.34)	12.72% (1.14)	13.99% (1.65)
8. Central Telephone Corporation	14.75	15.38	15.20	14.79	15.41	15.26
9. Continental Telephone Corp.	14.05	13.81	13.86	14.09	13.95	14.00
10. GT&E	15.00	14.87	15.18	15.04	14.94	15.24
11. Mid Continental Telephone	15.42	14.69	15.35	15.46	14.77	15.39
12. Rochester Telephone	14.80	16.05	16.28	14.84	16.03	16.27
13. United Telecommunications	15.53	14.58	15.55	15.56	14.67	15.58
Independent Company Mean (Standard Deviation)	14.93% (0.53)	14.90% (0.76)	15.24% (0.79)	14.96% (0.53)	14.96% (0.71)	15.29% (0.74)

tend to sell at higher P/B ratios. This suggests that AT&T and the other Bell Companies are regarded as being less risky than the independent telcos. This is reasonable in view of the Bell Companies' higher equity ratios.

We used the models to derive cost of capital estimates as shown in Table 2. These estimates were calculated as follows:

1. We demonstrated earlier that if a firm's expected ROE is equal to its cost of equity, then the company will sell at its book value, that is P/B = 1.0.
2. Assuming that our regression models accurately describe the valuation process (and the high R^2 values suggest that they do), then we can set P/B = 1.0 and find the value of ROE that produces this solution. That ROE value is an estimate of the DCF cost of equity, k.
3. Set BKYLD = (ROE)(PO) and GROBR = (ROE)(1 - PO), and then insert these values into the regression equation with P/B = 1.0:

   $$P/B = 1.0 = a_0 + a_1[ROE \times PO] + a_2[ROE(1 - PO)] + a_3[Dummy].$$
4. For AT&T, using values for Model 1 for 1978, we have

$$1.0 = -0.4725 + 16.621[ROE \times 0.5943] + 1.9951[ROE(1 - 0.5943)] + 0$$
$$= -0.4725 + 9.8779[ROE] + 0.8094[ROE]$$
$$10.6873 ROE = 1.4725$$
$$ROE = 1.4725/10.6873 = 13.78\%.$$

Therefore, according to Model 1, if AT&T were allowed to earn 13.78%, then the stock would sell at a P/B ratio of 1.0.

Similar calculations were made with the other models for AT&T, and for the other companies, and the derived cost of capital estimates for the thirteen companies are shown in Table 2. Significant features of the table include the following:

1. The Bell System Companies, on average, seem to have lower costs of capital than the independents. This is consistent with the hypothesis that the independents are riskier because of their generally higher debt ratios.

2. The independent telcos have calculated costs of capital that are closer to one another than do the Bell System Companies. This point is reflected in the standard deviations for the two groups.

3. Models 1 and 4, which use 1978 data only, show more variability across companies (that is, the range from the lowest to the highest cost company is larger) than is true for Models 2, 3, 5, and 6, which are based on data averaged over five years. This reflects the fact that earnings, hence payout ratios, do tend to vary over time. This averaging effect tends to improve the R^2's as shown at the top of each column.

4. The derived cost of capital estimates tend to be higher in Models 1 and 4 than in the others. This reflects primarily the fact that rates of return have been trending up in recent years, and this upward ROE trend has caused payout ratios to decline. The

most critical element in the model is the book yield proxy, (ROE) (PO). If PO is relatively low, this tends to produce a high estimated cost of equity, and vice versa.

5. While it is impossible to say that any of the data or cost of capital estimates are obviously "good" or "bad," or "right" or "wrong," some of the figures in Table 2 are at least highly suspicious. For example, Pacific Telephone is widely regarded as being riskier than either AT&T or the other Bell System Companies, yet its calculated cost of capital in most of the model runs is the lowest of any telephone company. Similarly, there is no obvious reason why Cincinnati Bell should have such a high cost of capital in comparison to the other Bell Companies. Indeed, most of the evidence we have seen (other than the model output presented here) suggests that, with the exception of Pacific Telephone, all of the Bell System Companies are equally risky, hence they should have about the same costs of capital. Quite possibly, the observed differences reflect random errors in measuring expectations. If we examine the underlying data, we see that Cincinnati Bell in 1978 had a very low payout ratio (about 40%) while Pacific Tel had a high ratio (about 75%). Thus, the model's sensitivity to high or low payout ratios, combined with random variations in these ratios, is probably producing erroneous cost of capital estimates.[1]

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[1]When we examine the electric company data, we see even more clear-cut cases of incorrect cost of capital estimates.

6. A virtue of Models 2, #3, #5, and 6, which are based on five-year average data, is that they avoid the extremes that come with the use of data for a single year. Thus, the apparent problems with Pacific Tel and Cincinnati Bell are much less pronounced in Models 2, #3, #5, and 6. On the other hand, using the five-year average data is less important for the geographically diversified telephone companies, as their diversification causes them to be less cyclical, especially with regard to regional economic developments and rate case decisions.

7. In spite of the problems noted above, the high R^2 values show that the models do, on balance, provide useful insights if not exact values for the cost of capital. In this connection, we should point out that the kinds of problems noted above could also exist in traditional cost of capital estimates, but the estimating techniques are such that the problems are not so apparent. Because they are so specific, models are easy to attack, but this should not be regarded as a weakness.

8. Having defended the models above, we should mention yet another potential problem. As noted, averaging past data smoothes out aberiations in the data, which results in somewhat better statistical "fits" as measured by R^2 and the regression coefficients' t statistics. However, these statistical properties could mislead us into choosing the wrong model, hence the wrong cost of capital estimate. To see what is involved

here, first refer back to Figure 2 and note that if the actual, plotted ROE's for all (or most) companies were systematically lower than the expected long-run ROE's then the fitted regression line would be shifted to the left of the true line of relationship by the amount of the average understatement. This would be reflected in a systematic understatement of the model's cost of capital estimates from the true values of k. We have no way of knowing for sure that a downward bias is reflected in the cost of capital estimates derived from Models 2, #3, #5, and 6, but this bias could indeed exist. If it does, then the cost of capital estimates derived from Models 1 and 4 would be more accurate in spite of their slightly poorer statistical fits.

III. THE ELECTRIC UTILITY INDUSTRY

In our empirical studies, we followed essentially the same procedures for the electric utility industry as for the telephone industry. However, there were some differences: (1) There are many more large, publicly-traded electric companies than telephone companies. Thus, our sample size is much larger for the electrics. (2) There is no dichotomy in the electric industry as there is between Bell and non-Bell telephone companies. Rather, with regard to size, debt ratios, and so on, the electrics show a more or less continuous range of values. (3) Although there are some multi-state electric holding companies, most of the electrics operate within a single state. (Even when holding companies cross boundaries, their several states, being contiguous, have similar economic and often political characteristics.) (4) While different telephone companies may use somewhat different technology, from an investment standpoint there is less difference between telephone companies than between electric companies with radically different generating systems (coal versus oil versus nuclear versus hydro), and with regard to the phase of their construction cycles, hence the amount of construction work in progress (CWIP) included in total assets.

Because of these differences, it is logical to expect a somewhat different set of variables to be significant in the regression analysis, and this is indeed the case. Here we use as risk-differentiating variables the equity ratio , AFUDC, a dummy variable to distinguish flow through from normalizing companies, and another dummy variable to distinguish among utilities' "regulatory climates."

Our electric sample consisted of the one hundred largest electric utilities as reported by Salomon Brothers in their monthly publication Electric Utility Common Stock Market Data. The one hundred companies are listed in Appendix A.

The regression equation used is

$$P/B = a_0 + a_1(\text{BKYLD}) + a_2\ (\text{GROBR}) + a_3(\text{EQRATIO}) + a_4(\text{AFUDC}) + a_5(\text{Flow through dummy}) + a_6\ (\text{Commission rank dummy}),$$

and the exact variable definitions are given below:

P/B = 1978 year-end price dividend by 12/31/78 book value. Since the telephone sample results showed little sensitivity to whether we used year-end or December average prices, and since the year-end price is both more reflective of conditions as of the estimating date and easier to obtain, we did not analyze December average prices for the one hundred electrics.

BKYLD = BKYLD_1 and BKYLD_2 as defined in the telephone section. BKYLD_1 is based on 1978 data only, while BKYLD_2 is based on data over the period 1974-1978. We dropped the exponential smoothing approach for electrics because, in the telephone company analysis, it produced it produced poorer results than the unweighted averages.

<u>GROBR</u> = $GROBR_1$ and $GROBR_2$ as defined in the telephone section.

<u>EQRATIO</u> = 12/31/78 Common equity divided by the sum of 12/31/78 Common equity, Preferred stock, Long-term debt, and Short-term interest bearing debt.

<u>AFUDC</u> = 1978 AFUDC divided by 1978 Net income available to common stockholders.

<u>Flow through Dummy</u> = 1.0 for companies that use flow through accounting for accelerated depreciation and zero for companies that normalize.

<u>Commission Rank Dummy</u> = 1.0 for companies whose commissions are ranked high (A or B) by Salomon Brothers and zero for all other companies.

Therefore, for the electrics, we ran two models, one with book yields and growth rates based only on 1978 data and one in which these variables are based on data from 1974 through 1978.

We obtained data from the following sources: Salomon Brothers [(1) <u>Electric Utility Common Stock Market Data</u>; (2) <u>Electric Utility Quality Measurements and Earnings Forecasts</u>; and (3) <u>Electric Utility Coverages</u>], the <u>Wall Street Journal</u>, and Compustat tapes for pre-1978 data.

The regression equations for the electrics are given in Table 3. As with the telephone sample, the most important determinants of the P/B ratio are book yields and growth rates. In addition, the ranking of each utility's commission is highly significant. The other variables are not significant at the 5 percent confidence level, although they do contribute to the estimation of P/B ratios and their coefficients do have the expected signs. The R^2 values (about 0.75) are lower than in

Table 3. Electric Utility Regression Models

$$P/B = a_0 + a_1[\text{BKYLD}] + a_2[\text{GROBR}] + a_3[\text{EQRATIO}] + a_4[\text{AFUDC}] + a_5[\text{Flow through Dummy}] + a_6[\text{Commission Rank Dummy}]$$

	a_0	a_1	a_2	a_3	a_4	a_5	a_6	R^2	Standard Error
Model 1. Current (1978) Data	-0.1018	9.3911	1.3232	0.3656	-0.0401	-0.0007	0.0847	0.74	0.0564
	(-1.003)	(14.223)	(4.156)	(1.705)	(-1.390)	(-0.051)	(5.686)		
Model 2. Average (1974- 1978) Data	-0.01125	8.4084	1.1822	0.3578	-.02341	-0.0244	0.0785	0.75	0.0561
	(-0.116)	(14.650)	(3.225)	(1.652)	(-0.819)	(-1.822)	(5.191)		

Note: t values are in parentheses.

the telephone sample, but they nevertheless show that the model is reasonably accurate as a predictor/explainer of the P/B ratios.

We can use the regression data to derive cost of capital estimates for the individual electric companies. Table 4 shows values for two companies, Wisconsin Public Service and Portland General Electric. These two were selected to illustrate the results for a company whose data are relatively stable (Wisconsin Public Service) and for one whose recent data have been highly unstable (Portland General Electric). The method of calculating the costs of capital is the same as was described for AT&T, so sample calculations are not given here.

Some of the electric companies have had highly variable earnings over the last few years. They tend to maintain or even increase dividends over time, even in the face of an earnings decline, if they think the earnings decline is only temporary. Under such conditions, the dividend payout ratio will become quite large, as it has been for PGE in recent years. Further, since the derived cost of capital is highly sensitive to the payout ratio, if a company has an abnormally high or low payout ratio, its calculated cost of capital will tend also to be abnormally high or low.

The relationship between the payout ratio and the calculated cost of capital explains why PGE's cost of capital is so much lower than WPS's. The terms (ROE)(PO) and ROE(1 - PO) are in the basic regression equations which we use to find the cost of capital:

Table 4. Sample Costs of Capital for Electric Companies: Wisconsin Public Service (WPS) and Portland General Electric (PGE)

	Estimated Cost of Capital	
	WPS	PGE
Model 1 (Current data)	13.51%	8.71%
Model 2 (1974-1978 data)	13.07%	11,35%

	Payout Ratios	
	WPS	PGE
1978	62.5%	128.0%
Average 1974-1978	66.1%	98.0%

indeed, we set P/B = 1.0, solve the equation for ROE, and then assume that this solution value is equal to k, the cost of capital. Yet if we are measuring PO with error--that is, if the value we use is not approximately equal to the average investor's long-run expected payout ratio, then our estimated cost of equity will be erroneous. Clearly, that is what is happening with PGE, for PGE's true cost of equity is certainly above its cost of debt!

Wisconsin Public Service has had more stable earnings, and the combination of relatively stable earnings and a stable dividend policy has produced a stable, "reasonable" payout ratio. This stable payout, when used in the model, produces a cost of capital that is not obviously unreasonable. We cannot say that WPS's estimated cost of capital, which lies in the range of 13.1% to 13.5%, is truly accurate, but neither can we say that it is obviously wrong.

Of course, if our estimates were as bad for all companies as they are for PGE, then our R^2 would probably be close to zero. The fact that $R^2 = 0.75$ therefore indicates that the model does have some utility for deriving cost of capital estimates for electric utilities. Clearly, the model-derived cost of capital estimates should not be accepted without question or without checking them against cost of capital estimates produced by other methods, but equally clearly, the model's output should be given some weight.

IV. FURTHER RESEARCH

As we noted at the outset, this paper is part of an ongoing study, and we plan to do further work on the econometric model approach to estimating the cost of capital. Some specific planned research is outlined below.

Tests of the Models' Statistical Properties

We have already carried out preliminary tests to check the models' statistical validity. For example, we have examined the simple correlation matrix to check for multicollinearity and have made plots of residuals against independent variables to check for heteroscedasticity and autocorrelations. These tests are good preliminary indicators, but a more in-depth analysis is clearly needed. We plan to carry out quantitative tests to determine whether all the assumptions of the random error model are satisfied. Specifically, we will test for multicollinearity, autocorrelation, heteroscedasticity, measurement errors, and specification errors.

Stability of the Model over Time

Our analysis so far has been for a single cross-section year. We need to study the stability of the model over time. We plan to run the regressions with data going back ten years or so in order to see whether the coefficients are stable and the "fits" are good. We ran such tests with an earlier version of the model, but we have not done so with this version.

Incorporation of a Firm-Effect Variable in the Model

The R^2 values, which measure the goodness of fit, were considerably lower for the one hundred electrics than for the telephone companies (R^2 = 0.75 for the electrics versus R^2's generally in the range of 0.82 to 0.90 for the telephone companies). When we test for the model's stability over time, if we see stable (and large) residuals for certain companies, we will attempt to improve the model's specification by adding a "firm-effect variable." The logic behind using the firm-effect variable is developed next.

The most likely reasons for obtaining a poor fit are these:

1. Ommission of a relevant variable. It is difficult to identify and include all the variables that help to explain the P/B ratio of a company. This is particularly true of the variables that measure risk.

2. Errors in Measurements of Variables. The DCF model, like all cost of capital models, is an ex ante model in which the stock price depends on expected earnings and expected growth rates. Since we use past data to develop proxies for expected values, there is always a possibility that measurement errors exist.

If it can be established that omitted variable and/or measurement errors have a consistent influence from one year to the next, then the use of residuals from year t - 1 as a variable in year t should help to correct for the omission and/or measurement errors. This added variable is called a "firm-effect variable." Essentially, the firm-effect variable is designed to account for some unidentifiable aspect of risk and/or to correct for errors in measurement which may distinguish some stocks consistently from others. For example, one of the assumptions we made in measuring growth rates (GROBR) is that the effects of stock financing on growth rates can be ignored because new issues are made at a P/B ratio nearly equal to 1.0. However, we can see from available data that some utilities have had P/B ratios consistently greater than 1.0 while others had ratios consistently below 1.0. Similar patterns could also exist for other variables.

Whether or not there is a consistent influence that is not being picked up by the independent variables can be judged by observing the correlation coefficients between the residual error terms for a company from one year to the next. If the coefficients are consistently high, then the use of the firm-effect variable is justified. The technique has been used in similar studies in the past.[1]

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[1]For examples of the use of the firm-effect variable, see

(1) Friend, Irwin, and M. Puckett, "Dividends and Stock Prices," The American Economic Review, September 1964, pages 656-682.

(2) Bower, R. S., and D. H. Bower, "Risk and Valuation of Common Stock," The Journal of Political Economy, May-June 1969, pages 349-362.

(3) Chung, P. S., "An Investigation of the Firm-Effects' Influence in the Analysis of Earnings to Price Ratios of Industrial Common Stocks," Journal of Financial and Quantitative Analysis, December 1974, pages 1009-1029.

Our "firm-effect" analysis would actually involve the following steps:

1. Run the regression equation using cross section data for several past years.
2. Determine the correlation coefficients between the residuals obtained for each year.
3. If these coefficients are consistently high, we can use the firm-effect variable as an additional explanatory variable. The firm-effect variable used in year t would be residual in year t - 1 (RES_{t-1}).
4. The final model in any year t would be of the form

$$P/B_t = a_0 + a_1(BKYLD)_t + a_2(GROBR)_t + a_3(EQRATIO)_t + a_4(AFUDC)_t + a_5(FTD)_t + a_6(COMRK)_t + a_7(RES)_{t-1}.$$

We expect that the inclusion of this additional variable would improve the R^2's for the electrics, but that it would not have much effect on the R^2's for the telephones, which are already high. We will report our findings in a future working paper.

Pooling of Electrics and Telephone Companies

One problem with our analysis of telephone companies is that the sample size is so small. To get around this problem, we will study a pooled sample of electrics and telephones. However, rather than use all the electrics, we will probably select from the electric sample the "high grade electrics," defined as those with bond ratings of double and triple A, and use these in a model with the double and triple A telephone companies. The object of this procedure is to obtain a more homogeneous risk class while still having a reasonably large sample size. Other variables that could be used to help screen for risk class would include S&P stock ratings, earnings variability, and perhaps beta coefficients, although we are not optimistic about the latter.

Further Analysis of Flow Through and AFUDC

Earlier studies done at PURC have given some indication of the effects on the cost of capital of the use of flow through versus normalization.[1] Our model in this study includes a flow through dummy for the electrics. The sign of the variable in our regression is negative, indicating that companies on flow through have a higher cost of capital than those which normalize, but neither the t statistic nor the regression coefficient is high, indicating that the effect of flow through is not terribly important. However, this conclusion is probably not warranted; the flow through dummy is correlated with certain other risk variables, so multicollinearity problems may well be distorting the true effects of flow through. We plan to look further at this issue.

Exactly the same problems seem to hold for the AFUDC variable--its coefficient is negative, indicating a higher cost of capital for firms with a higher percentage of AFUDC to net income, but (1) neither the economic nor the statistical significance of the

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[1]E. F. Brigham and J. L. Pappas, Liberalized Depreciation and the Cost of Capital (East Lansing: Michigan State University, 1970); E. F. Brigham and T. J. Nantell, "Normalization versus Flow Through for Utility Companies Using Liberalized Tax Depreciation," The Accounting Review, July 1974. Pages 436-447.

coefficients are high and (2) multicollinearity problems may well be biasing downward the true effects of AFUDC. A PURC-supported Ph.D. dissertation now nearing completion has investigated this issue further, and when it has been completed we plan to explore the AFUDC/CWIP issue to an even greater extent.

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[1]Geraldine Westmoreland, Electric Utilities' Accounting for Construction Work in Progress: The Effects of Alternative Methods on the Financial Statements, Utility Rates, and Market to Book Ratios. This dissertation is scheduled to be completed in August, 1979.

APPENDIX A

THE ELECTRIC UTILITY SAMPLE

1 ALLEGHENY POWER
2 AMERICAN ELEC PWR
3 ARIZONA PUBLIC SVC
4 ATLANTIC CITY ELEC
5 BALTIMORE GAS & EL

6 BOSTON EDISON
7 CAROLINA PWR & LT
8 CENTRAL HUDSON G&E
9 CENTRAL ILL LIGHT
10 CEN ILL PUB SVC

11 CENTRAL LA ENERGY
12 CENTRAL MAINE PWR
13 CENTRAL SOUTH WEST
14 CENTRAL VT PUB SVC
15 CINCINNATI G & E

16 CLEVELAND EL ILLU
17 COL & SO OHIO ELEC
18 COMMONWEALTH ED
19 COMMUNITY PUB SVC
20 CONSOLIDATED ED

21 CONSUMERS POWER
22 DAYTON POWER & LT
23 DELMARVA PWR & LT
24 DETROIT EDISON
25 DUKE POWER

26 DUQUESNE LIGHT
27 EL PASO ELECTRIC
28 EMPIRE DIST ELEC
29 FLORIDA POWER CORP
30 FLORIDA PWR & LT

31 GENERAL PUB UTILS
32 GULF STATES UTILS
33 HAWAIIAN ELECTRIC
34 HOUSTON INDUSTRIES
35 IDAHO POWER

36 ILLINOIS POWER
37 INDIANAPOLIS P & L
38 INTERSTATE POWER
39 IOWA ELEC LT & PWR
40 IOWA-ILL GAS & EL

41 IOWA POWER & LIGHT
42 IOWA PUBLIC SVC
43 IOWA SOUTHERN UTIL
44 KANSAS CITY P & L
45 KANSAS GAS & ELEC

46 KANSAS POWER & LT
47 KENTUCKY UTILITIES
48 LONG ISLAND LTNG
49 LOUISVILLE G & E
50 MADISON GAS & ELEC

51 MIDDLE SOUTH UTILS
52 MINNESOTA PWR & LT
53 MONTANA DAKOTA UT
54 MONTANA POWER
55 NEVADA POWER

56 NEW ENGLAND ELEC
57 NEW ENG G & E ASSO
58 NEW YORK STATE E&G
59 NIAGARA MOHAWK PWR
60 NORTHEAST UTILS

61 NORTHERN IND P S
62 NORTHERN STATES PR
63 NORTHWESTERN P S
64 OHIO EDISON
65 OKLAHOMA GAS & EL

66 ORANGE & ROCK UTIL
67 OTTER TAIL POWER
68 PACIFIC GAS & ELEC
69 PACIFIC POWER & LT
70 PENNSYLVANIA P & L

71 PHILADELPHIA ELEC
72 PORTLAND GEN ELEC
73 POTOMAC ELEC POWER
74 PUB SVC COLORADO
75 PUB SVC ELEC & GAS

76 PUB SVC INDIANA
77 PUB SVC NEW HAMP
78 PUB SVC NEW MEXICO
79 PUGET SOUND P & L
80 ROCHESTER GAS & EL

81 SAN DIEGO GAS & EL
82 SAVANNAH ELEC & PR
83 SIERRA PAC PWR CO
84 SOUTH CAROLINA E&G
85 SOUTHERN CALIF ED

86 SOUTHERN COMPANY
87 SOUTHERN IND G & E
88 SOUTHWESTERN P S
89 TAMPA ELECTRIC
90 TEXAS UTILITIES

91 TOLEDO EDISON
92 TUCSON GAS & ELEC
93 UNION ELECTRIC
94 UNITED ILLUMINATNG
95 UTAH POWER & LIGHT

96 VIRGINIA ELEC & PR
97 WASHINGTON WTR PWR
98 WISCONSIN ELEC PWR
99 WISCONSIN PWR & LT
100 WISCONSIN PUB SVC