The Impact of Customer Mix on the Cost of Capital for Electric Utilities

by

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(ABSTRACT)

This dissertation investigates the perceived riskiness of electric utilities based on their mix of residential and industrial customers. While previous studies have attempted to develop a simple measure of the total riskiness of individual customer classes, this study examines the relative riskiness of the total utility as impacted by customer mix. Because the cost of risk is an element in the determination of the utility's revenue requirement, it impacts the set of optimal tariffs derived from a constrained welfare-maximization problem.

The null hypothesis that investors do not base their perception of the riskiness of a utility on the customer mix is tested against the alternatives that residential customers decrease and that industrial customers increase the perceived riskiness of a utility. The hypothesis is examined using cross-sectional data for 1981. The weighted-average, after-tax cost of capital is used to measure the relative riskiness of the utility. In addition to the customer mix variables, the explanatory variables include operational and

regulatory variables. The analysis provides support for the hypothesis that investors do not differentiate the riskiness of a utility based on the size of the residential class. Further, the analysis permits rejection of the alternative hypothesis that investors perceive a utility to be more risky when its customer mix is heavily industrial. The results suggest that, in fact, investors may associate greater risk with an absence of industrial customers.

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CHAPTER 1

INTRODUCTION

Due to the nature of the electric utility industry, public utilities are granted monopoly positions within their markets.[1] As a consequence, the regulatory process is required to establish both the allowable level of revenues and the rate structure through which the revenues are recovered. This task entails determining the value of rate base, the allowed rate of return and the level of operating costs. The level of revenues granted equals the product of the rate base and the rate of return plus the operating costs.[2]

Revenue = (Rate Base x Rate of Return) + Operating Costs

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[1]Joe S. Bain, Industrial Organization (New York: John Wiley & Sons, 1959), pp. 589-594. F. M. Scherer, Industrial Market Structure and Economic Performance (Chicago: Rand McNally College Publishing Company, 1970), pp. 518-542.

[2]The term return on common equity refers to the rate of return on common shareholders equity. The overall rate of return and the rate of return on rate base refer to the weighted average cost of capital; i.e., the cost of debt times the percent of debt in total capitalization plus the cost equity times the percent of equity in capitalization. The return on common equity is the portion of the weighted average cost of capital over which regulators are assumed to exercise control. Risk is defined as variability in the return to common equity holders.

In general, the rate of return on common equity is estimated using one of four methods: Discounted cash flow, capital asset pricing model, comparable risk and risk premium analysis. See for example, A. L. Kolbe, J. A. Read, Jr., and G. R. Hall, The Cost of Capital: Estimating the Rate of Return for Public Utilities (Cambridge, Mass: MIT Press, 1984).

After determining the level of revenues, regulators are required to design the rates used to recover these revenues from the different customer groups. The two phases of a rate case generally are referred to as the revenue requirement phase and the rate design phase.[3]

The riskiness of the utility is an important criterion in the regulator's setting of the allowed level of revenues, because risk affects the return required by investors. In the rate design phase, the question of risk has traditionally been ignored. Comparison of allowed rates of return across customer classes, however, demonstrates that commissions have not granted equal rates of return across classes.[4] Recent regulatory discussions have explained the differentials by asserting that the industrial class is more risky to

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[3]The rights of public utilities to have hearings and to earn a fair rate of return on common equity are guaranteed by the Fifth and Fourteenth Amendments to the United States Constitution. These amendments, which are interpreted to apply to corporations as well as persons, forbid the State and Federal governments, respectively, to deprive any person of their property without due process of law. As a result, public service commissions are enjoined to protect the earnings of public utilities. For a further discussion of regulatory practices see Charles F. Phillips, Jr., The Economics of Regulation (Homewood: Irvin, 1965) or James C. Bonbright, Principles of Public Utility Rates (New York: Columbia University Press, 1961).

[4]Electricity Consumers Research Council, Profiles in Electricity Issues: Cost-of-Service Survey (Washington, D.C.: ELCON, November 1978), No. 6. The cost-of-service studies examined include a variety of embedded and marginal cost studies.

serve than residential and municipal classes.[5] They conclude that because investors perceive utilities with a larger percent of industrial sales to be more risky, the industrial class should be required to earn a rate of return above the system average. This analysis fails to examine an important question. Do investors perceive a utility to be more risky if its customer mix is skewed toward industrial users? Building on the work of previous authors, this dissertation examines the relationship between the perceived riskiness of an electric utility and its customer mix.

The initial section of this chapter traces the historical development of the rate of return as a determinant of the required level of utility revenues. The second section discusses the use of risk to determine the revenue responsibility of individual customer classes in the rate design phase of the regulatory process. The final section identifies the questions to be addressed in the remainder of this study and describes the possible implications for utility regulation.

1.1 The Historical Importance of Rate of Return for Revenue Determination

Under current regulation, state regulatory commissions focus

[5]For a discussion of Commissions that have adopted risk differentials, see An Examination of the Concept of Using Relative Customer Class Risk to Set Target Rates of Return (Washington, D.C.: ELCON, 1981), pp. 15-24.

primarily on the determination of the required rate of return when establishing the utility's allowed level of revenues. Early state regulators, however, at the direction of the Federal Courts, focused upon the valuation of the utility's rate base.[6] This action resulted from an 1898 Supreme Court decision in Smythe vs. Ames wherein the Court stated:

> We hold...that the basis of all calculations as to the reasonableness of rates to be charged by a corporation...must be the fair value of the property being used by it for the convenience of the public. And, in order to ascertain that value, the original cost of construction, the amount expended in permanent improvements, the amount and market value of its bonds and stocks, the present as compared with the original cost of construction, the probable earning capacity of the property, under particular rates prescribed by statute, and the sum required to meet operating expenses, are all matters for consideration, and are to be given such weight as may be just and right in each case. We do not say that there may not be other matters to be regarded in estimating the value of that which it employs for the public convenience. On the other hand, what the public is entitled to demand is that no more be exacted from it...than the services rendered...are reasonably worth.[7]

Subsequent Supreme Court rulings served to amend Smythe vs. Ames. Earning capacity was rejected as a criterion for valuing the rate base in 1913,[8] the value of stocks and bonds was removed from

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[6]The first state regulatory commissions were established in 1907 in New York and Wisconsin. For a more detailed discussion of the evolution of regulation see Clair Wilcox, Public Policies Toward Business (Homewood, IL: Richard D. Irwin, Inc., 1966).

[7]Smythe vs. Ames, 169 U.S. 466, pp. 546-547 (1898).

[8]Minnesota Rate Cases, 230 U.S. 352 (1913).

consideration in 1909,[9] and deductions for depreciation were added to the list in the same case.[10]

Despite the Court's directive to public service commissions not to stray from fair-valued rate base, they never provided a precise definition of fair-value. On their own initiative, state commissions deviated from the Court mandate and beginning in 1923, the Court increasingly upheld decisions not based on fair-value. With the Court's findings in Bluefield Waterworks and Improvement Co. vs. Public Service Commission, the Court's emphasis began to shift away from the valuation of rate base toward the rate of return that a utility should be allowed to earn on its rate base.[11] In 1923, the Court concluded:

> A public utility is entitled to such rates as will permit it to earn a return on the value of the property which it employs for the convenience of the public equal to that generally being made at the same time and in the same general part of the country on investments in other business undertakings which are attended by corresponding risks and uncertainties; but it has no constitutional right to profits such as are realized or anticipated in highly profitable enterprises or speculative ventures.[12]

Finally, in the Federal Power Commission vs. Hope Natural Gas

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[9]Knoxville vs. Knoxville Water Co., 212 U.S. 1 (1909).

[10]Ibid.

[11]Bluefield Waterworks and Improvement Co. vs. Public Service Commission, 262 U.S. 679 (1923).

[12]Ibid., pp. 692-693.

Co., Justice Douglas stilled the debate over fair-value. Authoring the majority opinion, Douglas concluded that:

> [It] is the result reached and not the method employed which is controlling....It is not the theory but the impact of the rate order which counts. If the total effect of the rate order cannot be said to be unjust and unreasonable, judicial inquiry...is at an end....Rates which enable the company to operate successfully, to maintain its financial integrity, to attract capital, and to compensate its investors for risks assumed, certainly cannot be condemned as invalid, even though they might produce only a meager return on the so-called 'fair-value' rate base.[13]

While ending the fair-value controversy, Justice Douglas added fuel to the debate over the appropriate rate of return on rate base. In the FPC vs. Hope order, Justice Douglas also concluded:

> The return to the equity owner should be commensurate with returns on investments in other enterprises having corresponding risks. That return, moreover, should be sufficient to assure confidence in the financial integrity of the enterprise so as to maintain its credit and to attract capital.[14]

The debate over the appropriate rate of return on common equity and the most appropriate technique for measuring the return continues today. The Bluefield and Hope decisions, rendered in 1923 and 1944, continue to govern decisions with respect to the allowable return on common equity.

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[13]FPC vs. Hope Natural Gas Co., 320 U.S. 591, 602 (1944).

[14]Ibid., p. 605.

1.2 The Importance of Risk for Class Revenue Determination

While the court decisions discussed above establish guidelines for the determination of the overall rate of return on common equity, they do not address the issue of the appropriate rate of return to be earned from individual customer classes. That is, they provide guidance for the revenue requirements phase but they do not provide guidance for the rate design phase.

Two schools of thought have developed within the electric utility industry to explain the disparity between customer class rates of return.[15] The first school holds that the disparity reflects an attempt by the industry and its regulators to shift a nonoptimal portion of the burden of providing electricity from residential customers to large power users. In other words, the differentials are not based on either cost-of-service or second best considerations and, therefore, represent price discrimination by the utility. The second school holds that the disparity reflects an attempt by the industry and its regulators to properly recover the costs associated with providing service to the individual customer classes. In other words, the differentials are based on cost and second best considerations and, therefore, represent a proper sharing

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[15]The debate is summarized in Bill Avera and Bruce Fairchild, An Examination of the Concept of Using Relative Customer Class Risk to Set Target Rates of Return in Electric Cost-of-Service Studies, Washington, D.C.: ELCON, 1981.

of costs by the customer classes. The two schools of thought are discussed more fully below. Resolution of the controversy is necessary to ensure that regulators can determine cost-based rates for individual customer classes.

The first school of thought asserts that the differential rates of return are not cost justified. If this school is correct, then the disparity between the rates of return earned by customer classes should be eliminated from the determination of class cost, because it represents price discrimination on the part of regulators and utilities.

The second school of thought asserts that the differential rates of return are cost based. This school attempts to identify a potential source of cost differential, thereby providing a basis for the continued existence of differing customer-class rates of return. As exemplified by a series of articles which have appeared in Public Utilities Fortnightly, a major trade publication, the second school generally argues that a utility whose customer class mix is skewed toward large users (industrial customers) represents a more risky investment than a utility that exhibits either a uniform customer-mix or a customer-mix skewed toward small users (residentials).[16]

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[16] Joseph F. Brennan, "Rate of Return Differentials by Class--A New Dimension to Cost of Service," Public Utilities Fortnightly, Vol. 105 (April 10, 1980), pp. 11-16; Nick S. Poulious, "Rate of Return Differentials by Class Through Revenue Variation? But How?," Public

Therefore, the required return for the high industrial mix utility required revenue from a utility's individual customer classes should be a function of the class's contribution to the overall riskiness of the utility. Therefore, if the marginal risk associated with the industrial class is greater than the marginal risk of the other customer classes, then the industrial class should earn a return greater than the system average rate of return. Class risk generally is measured by the variability of the individual customer class profit relative to the variability of the utility's overall net profit.[17]

The thrust of exisiting empirical work examining the relationship between a utility's overall riskiness and its customer class mix concentrates on estimating relative contribution of the customer classes to the total variability of profits for the utility. Beginning with the assumption that investors consider customer class mix to be an important decision variable, the studies published in

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(Footnote 16 continued)
will be above average. Proponents of this view also suggest that the Utilities Fortnightly, Vol. 106 (July 31, 1980), pp. 28-32; Joseph Brennan, "Clairification of the Concept of Rate of Return Differentials," Public Utilities Fortnightly, Vol. 106 (September 25, 1980), pp. 52-54; Robert Trout, "A Comment on Rate of Return Differentials by Class," Public Utilities Fortnightly, Vol. 107 (January 29, 1981), pp. 24-26.

[17]For a detailed discussion of the methods used to allocate joint costs to customer classes see James Doran et.al., Electric Utility Cost Allocation Manual, Washington, D.C.: NARUC, 1973.

Public Utilities Fortnightly attempt to quantify the variability of net profit from each customer class relative to the overall variability of the utility's net profit. For the most part, the studies assume that investors react to customer mix, but they do not test this hypothesis.

1.3 Focus of this Study

This study investigates the underlying assumption that investors react to customer-mix in their assessment of the overall riskiness of a utility. The null hypothesis to be tested states that investors do not perceive a utility to be less or more risky when its customer-mix is skewed either toward small-users or large-users. This hypothesis is tested against the alternate hypothesis that investors do associate lower risk with utilities whose customer-mix is skewed toward small users and associate higher risk with utilities whose customer-mix is skewed toward large users.

The empirical analysis differs from previous work in three important areas: First, the analysis uses the estimated after-tax cost of capital instead of the published risk measures or market-to-book ratio used in much of the earlier work. This change removes from the analysis the subjectivity associated with the published measures and provides a measure of the impact of both the cost of financing and the importance of the mix of financing instruments. Second, SIC code data is used to develop a measure of customer mix that is consistent across utilities. Previous studies have not attempted to construct a uniform definition of customer mix which may have biased seriously their results. Third, the analysis corrects many of the statistical problems associated with earlier work.

The format of this study is as follows: Chapter 2 reviews the economic and trade literature which serves as the foundation for this research. Chapter 3 discusses the literature on marginal cost pricing which forms the basis for electric utility rate design. Chapter 4 describes the application of the Sharpe-Lintner financial model to electric utilities and illustrates the basis for the empirical investigation. Chapter 5 describes the data used in the analysis. Chapter 6 describes the empirical results. Chapter 7 presents some summary comments and conclusions.

CHAPTER 2

A REVIEW OF THE LITERATURE

This chapter reviews the academic and trade literature which discusses the effects of using relative customer-class risk to set target rates of return. The chapter is divided into three sections. The first section examines the academic literature supporting the hypothesis that required rates of return should reflect an investment's risk. The second section discusses stock equity and bond valuation models. The final section reviews issues related to risk and customer class mix appearing in Public Utilities Fortnightly, and intervenor testimony.

2.1 Risk and the Required Rate of Return

2.1.1 An Introduction to Investor Behavior

An investor who decides to hold a given security must balance the expected return from holding that security against the degree of risk involved.[1] The relevant risk for an investor holding a portfolio of securities is the marginal risk that the addition of the stock adds to the portfolio. The relationship between an individual asset's marginal risk and its expected rate of return is examined by

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[1]The discussion in this section draws upon a review of the literature by Michael C. Jensen, "Capital Markets: Theory and Evidence," The Bell Journal, Vol. 3, No. 2 (Autumn 1972), pp. 357-398.

William Sharpe (1964) and John Lintner (1965). The work of Sharpe and Lintner builds on Markowitz's treatment of portfolio selection as a problem of utility maximization under conditions of uncertainty.[2]

The Sharpe-Lintner models make seven basic assumptions:

1. All investors are single-period, expected-utility-of-terminal-wealth maximizers who choose among alternative portfolios based on the expected mean and variance (or standard deviation) of returns.

2. All investors can borrow or lend an unlimited amount at the exogenous risk-free rate of interest, R_f.

3. All investors have identical expectations of the mean, variance and covariance of returns.

4. All assets are marketable and transactions costs are zero.

5. There are no taxes.

6. All investors are price takers.

7. The quantities of all assets are given.

Figure 2.1 is a graphical representation of the Markowitz mean-variance model. The shaded area represents the combinations of risk and return available to investors where σ_{ER} is the standard deviation of expected returns, ER. The portfolios on the boundary qq' represent the set of efficient portfolios; i.e., they represent

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[2]H. M. Markowitz, "Portfolio Selection," Journal of Finance, Vol. 7, No. 1 (March 1952), pp. 77-91.

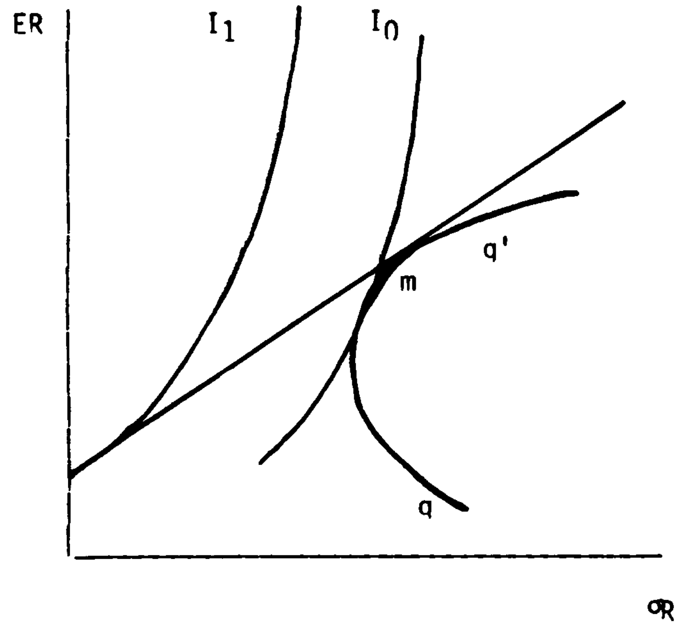

FIGURE 2.1

Maximization of Investory Utility

maximum expected return for a given level of risk or minimum possible risk for a given expected return. The investor chooses the portfolio on the efficient frontier that maximizes utility given the set of available risky assets.

The existence of a riskless asset, f, permits the investor to construct a portfolio p that includes combinations of both the risk-free asset and a portfolio of risky assets. By holding the portfolio, p, the investor can attain any position along the line from R_f to m and a level of utility I(1) > I(0). (If borrowing is permitted, the line will extend beyond point m.)

The point m represents the market portfolio in which the fraction of each asset held equals the proportion of that asset's value to the total value of all assets.[3] The line $R_f m$ represents the capital market line. The investor maximizes utility at the point of tangency between the indifference curve and the capital market line. The actual mix of f and m which maximizes a given investor's utility depends on the individual investor's degree of risk aversion.

The expected return from the efficient portfolio p is a linear

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[3]That is, for j = 1,2,...,n in the market portfolio m, the share of investment j is given by:

$$x_{jm} = \frac{\text{Total market value of all outstanding shares in firm j}}{\text{Total market value of all outstanding shares of all firms}}.$$

See Eugene F. Fama and Merton H. Miller, The Theory of Finance (Chicago: Holt, Rhinehard and Wilson, 1972), pp. 286-295.

combination of the expected return from the market portfolio and the risk-free investment:

2.1 $ER_p = R_f + \{[ER_m - R_f]/\sigma_m\} \cdot \sigma_p,$

where $(ER_m - R_f)/\sigma_m$ is the slope of the capital market line. The equilibrium expected return on asset k is given by the equation:

2.2 $$ER_k = R_f + \lambda \frac{cov_{km}}{\sigma_m^2}$$
$$= R_f + \lambda \frac{rho_{km}\ \sigma_k}{\sigma_m}$$

where $\lambda = (ER_m - R_f)$ is the market risk premium and cov_{km} is the covariance between the return on asset k and the market portfolio, and rho_{km} is the correlation coefficient between asset k and the market portfolio.

As defined by equation 2.2, the equilibrium return on an individual asset is equal to the return on the risk-free asset plus a risk premium equal to the product of the market risk premium and the covariance between the k^{th} investment and the market portfolio.

> Although investors take the variance (or equivalently the standard deviation) of their portfolio returns as an appropriate measure of risk, these results imply that the appropriate measure of the risk of any individual asset is its covariance with the market portfolio, $cov(R_k R_m)$ and not its own variance, $\sigma^2 R_k$.
>
> ...In addition, note that cov(R(j),R(m)) is proportional to the marginal impact of the k^{th} asset on the standard deviation of the market portfolio...[Thus], in

> equilibrium the expected return on an asset is linearly related to its marginal contribution to the total risk to be borne by society, $\sigma(R_m)$. (Emphasis in the original.)[4]

Investors, therefore, are expected to require a higher rate of return as the firm's systematic risk, that is, the security's sensitivity to fluctuations in general market conditions, increases. On the other hand, the investor can manage the risk of his portfolio by combining investments which exhibit differing unsystematic or diversifiable risks. Therefore, the degree of systematic risk, measured by β in equation 2.2, is important to the computation of the required rate of return.

2.1.2 Relaxing the Assumptions of the Model

As noted above, the conclusions derived by Sharpe and Lintner rely upon a number of limiting assumptions which violate observed market conditions. For the most part, the results of attempts to build less restrictive models have produced similar results. Several of these attempts are discussed below. This discussion is meant to demonstrate the robustness of the basic conclusions of the model and is not exhaustive.

In Eugene Fama's (1970) analysis of the multiperiod consumption investment model, he provides additional support for the single-period utility of consumption and terminal wealth model. The

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[4]Jensen (1972), pp. 362-3.

investor in Fama's model maximizes lifetime utility by choosing levels of consumption over his lifetime subject to various states of nature. As a result, the investment decision in Fama's model is a function of desired consumption and the various exogenous states of nature. To alleviate this complication, Fama assumes that (a) investors behave as if future investment and consumption activities are known and (b) tastes are independent of the state of nature. Fama concludes that the behavior of a risk-averse, multiperiod consumer will be "indistinguishable from that of a risk-averse expected utility maximizer who has a one-period horizon."[5]

Several authors have examined the implications of the assumption of unlimited borrowning and lending at the risk-free rate.[6] In a model with borrowing and lending, in which investors have homogeneous expectations, Fama (1971) demonstrates that the linearity of the risk-return relationship holds. Because Fama's model does not include a riskless asset, it does not permit the derivation of an equation equivalent to 2.2.

In a model with similar assumptions and unrestricted short

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[5]Fama (1970), p. 164.

[6]In a model with consumption and a fixed quantity of the risk free asset, Long (1970) demonstrated that the riskless rate is endogenous to the model. In equilibrium, the marginal rate of substitution of current for future consumption becomes one plus the riskless rate.

selling, Black (1970) shows that the equilibrium expected return on asset j is given by the linear combination of two portfolios:

2.3 $ER_j = (1 - \beta_j)ER_z + \beta_j ER_m$,

where ER_z and ER_m are the expected returns on the portfolio z and the market portfolio m. In this equation, the portfolio z exhibits zero covariance with the market portfolio, m. The return on the portfolio z replaces the risk-free return and equation 2.3 is essentially equivalent to equation 2.2. Investors purchase combinations of portfolios z and m to achieve points on the frontier ZAM. Short-selling of z, i.e., borrowing, permits the investor to reach the points beyond m.

The existence of transactions costs and illiquidity of assets is addressed by Mayers (1972), who examines the impact of the liquidity assumptions on a single-period market in which only two types of goods exist, a perfectly liquid asset and a perfectly nonliquid asset. Mayers is able to derive a simple equilibrium relationship given by the equation:

2.4 $ER_j = R_f + \delta\text{cov}(R_j, R_m^* + R_H^*)$,

where R_H^* is the total dollar return on all nonmarketable assets, R_m^* is the total dollar return on the market portfolio, and δ is the "market price" per unit of risk. Equation 2.4, which is comparable to equation 2.2, states that the risk of an individual asset is a function of its covariance with the sum of the market portfolio and all nonmarketable assets.

Mayers' work supports an additional interesting result. Even under the assumption of homogeneous expectations, investors are found to hold differing portfolios of marketable assets when the probability distribution of returns from their nonmarketable assets differ. Thus, investors hold portfolios that differ from the market portfolio and vary across investors, an important departure from the previous results.

The introduction of taxes into the model is examined by Brennan (1970) and by Black and Scholes (1970). Their work shows that:

> Thus, the introduction of taxes changes the intercept and the slope of the risk-return relations and introduces the dividend yield as a new variable in the determination of expected returns.[7]

His analysis demonstrates that the introduction of taxes into the model impacts the expected return, but it does not alter the initial conclusion that systematic risk is the relevant measure of the riskiness of an individual investment and that the risk-return relationship is linear.

Black and Scholes, on the other hand, argue that differential taxes will not impact the expected return. They assert that firms

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[7]Jensen (1972), p. 28.

will adjust their dividend payments such that the marginal investor is indifferent between the receipt of cash dividends or capital gains. While their conclusions are contradictory, both Brennan and Black-Scholes provide empirical verification of their positions.

The implications of relaxing the assumptions associated with homogeneous expectations have been examined by several authors.[8] Overall, the removal of this assumption does not change markedly the conclusions of the simple model. Most of these models prove impractical for empirical examination, however, because it is impossible to eliminate the impact of individual preferences.

This review suggests that, overall, the implications of the simple model are robust. While the specific equations obtained differ when the various underlying assumptions of the simple model are relaxed, the conclusions drawn generally demonstrate that the relevant measure of risk for investment k remains the covariance between investment k and the market portfolio, which can be expressed as the product of the correlation coefficient and the relative standard deviations of k and m.

2.2 Empirical Analysis of the Determinants of the Risk Premium

The risk premium shown in equation 2.2 is a function of the

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[8]See, for example, John Lintner, "The Aggregation of Investor's Diverse Preferences in Purely Competitive Securities Markets," Journal of Finance and Quantitative Analysis, Vol. 4 (December 1969), 347-400.

various types of risk that firms face such as financial risk, operating risk and managerial risk. Fred Arditti (1967) investigates the relationship between the cost of equity capital and various measures of investment risk. Arditti defines two types of risk indicators: The first type measures business risk. This set of variables includes the second and third moments about the mean of the distribution of the stock's return and the correlation coefficient between the return on a given stock and a market portfolio. The second set of risk indicators measures financial risk. This set includes the debt-equity ratio and the dividend-earnings ratio.

Arditti estimates his model using the regression equation:

2.5 $$Y_i = a_0 + a_1x_{i1} + a_2x_{i2} + a_3x_{i3} + a_4x_{i4} + a_5x_{i5} + e_i,$$

where Y is the required return, proxied by the geometric average of the annual rates of return. The term x_{i1} is the variance of the i^{th} stock, x_{i2} is the measure of the skewness of the stock's return, x_{i3} is the correlation coefficient between the i^{th} stock and the market portfolio, x_{i4} is the relevant debt-equity ratio and x_{i5} is the relevant dividend earnings ratio. Arditti posits that, a priori, $a_1 > 0$, because investors avoid high variance in returns. The coefficient a_2 is hypothesized to be negative, because investors will accept a lower rate of return when the distribution is skewed in a positive direction. The coefficient a_3 also is hypothesized to be negative, because stocks with returns that are correlated positively with the market portfolio increase the overall portfolio risk. The coefficient of the debt-equity ratio, a_4, is hypothesized to be positive, because increased levels of debt relative to equity imply greater variability in income available for dividend payments. Finally, no a priori sign is given for a_5, the coefficient on the dividend-earnings ratio.

Arditti calculates the variables in his model using data for the 18-year period beginning in 1946. Arditti performs the analysis in two steps. First, he estimates separately equations for the business risk variables and the financial risk variables. Second, he estimates equations including both sets of variables. Results are reported in Table 2.1. "Under the assumption that the stock market received what it expected..., the actual return for each stock in the Standard & Poor's composite index (industrial, railroads, and utilities) is used as the measure of the required return...."[9]

The regression results indicate that the variables for variance and skewness are statistically significant at the one percent level and, therefore, are important measures of risk. The correlation coefficient variable was statistically significant at the 10% level.

The dividend-earnings ratio appears with a significant, negative

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[9]Arditti (1967), p. 19.

TABLE 2.1

Business and Financial Risk Determinants of the Required Return on Common Stock*

	Business Risk Variables	Financial Risk Variables	Business and Financial Risk Variables
Constant	0.1297 (11.68)	0.1472 (19.37)	0.1375 (9.42)
Variance	0.1900 (5.22)		0.2632 (32.35)
Skewness	-0.0522 (-3.84)		-0.0658 (-4.06)
Market Correlation Coefficient	-0.0312 (-1.54)		-0.0279 (-1.41)
Debt/Equity Ratio		-0.0080 (-0.76)	-0.0165 (-1.60)
Dividend-to-Earnings Ratio		-0.0247 (-2.31)	-0.0179 (-1.72)

R-squared	0.069	0.021	0.107
F-statistic	11.20	2.92	6.64
(degrees of freedom)	(3,455)	(2,279)	(5,276)

*The dependent variable is the actual return for each stock in the Standard & Poor's Composite Index. T-statistics are shown in parentheses.

Source: Fred Arditti, "Risk and the Required Return on Equity," The Journal of Finance, Vol. 22 (1967), Table 1, p. 25; Table 5, p. 33; and Table 6, p. 34.

coefficient, suqqestinq that investors are willinq to forego hiqher relative returns for larqer dividend payouts. Proponents of the theory that the dividend-payout ratio is an important decision variable arque that:

> Since the variability of dividends is less than the variability of stock prices, any substitution of dividends for capital qains in the overall return received by the shareholder will reduce the variability of this return. This reduction in risk induces a reduction in the required return.[10]

The result conflicts with the hypothesis of Miller and Modiqliani. Miller-Modiqliani arque that individuals who are dissatisfied with the dividend stream because of uncertainty about the stock's future earninqs stream alter the relationship between cash flow and capital qains by sellinq a portion of their holdinqs.[11] As discussed above, the variability of the over-all return is reduced because a portion of the return is shifted from the more variable capital qains into current cash earninqs.

While insiqnificant, the coefficient of the debt-equity ratio is neqative, counter to the hypothesized siqn. Arditti suqqests that this coefficient estimate may be biased due to the omission of other relevant risk measures. Arditti concludes that the likely omitted

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[10]Ibid., p. 22.

[11]Merton Miller and Franco Modqliani, "Dividend Policy, Growth and the Valuation of Shares," Journal of Business, October 1961, pp. 411-433.

variables are financial variables, because the majority of the information about the probability distribution of income, associated with business risk, is contained in the first three moments.

Arditti's work examines the relative importance of business and financial risk in the determination of the required return. Arditti's regressions across industries suggest that the difference in required return across firms can be explained by the variables measuring business risk. When his analysis is performed on an intra-industry basis, the results suggest that the financial variables are more important. Arditti's work highlights the need to examine a range of feasible risk measures.[12]

A similar analysis of the determinants of investor perceived risk with respect to corporate bonds is performed by Lawrence Fisher (1959). Fisher also identifies two groups of risk indicators: The first group measures the risk of default, that is, the risk that the company will have insufficient earnings to pay its debts. Fisher uses three proxies to measure the risk of default: (1) the coefficient of variation, measuring the variability of income relative to its mean, (2) the length of time during which the

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[12]For a similar examination of the relationship between rates of return and business risk, see Paul H. Cootner and Daniel M. Holland, "Rate of Return and Business Risk," The Bell Journal of Economics and Management Science (Autumn 1970), p. 211-226. Their analysis uses book data and concentrates on business risk variables, similar to Arditti. The data are for the period 1948-1960.

company has operated without a default and (3) the equity to debt ratio. The second risk group measures the marketability of the company's bonds; that is, the ability of the bond holder to redeem the bonds before maturity. The marketability of the firm's bonds is measured by the total market value of the firm's traded bonds.

The dependent variable in Fisher's analysis is the risk premium on the company's bonds. This variable is defined as the difference between the bond's market yield to maturity and the yield on a riskless bond having the same maturity date. The latter is based on the yield on fully taxable United States Treasury Bonds. Fisher estimates an equation of the form:

2.6 $$Y_i = a_0 + a_1x_{i1} + a_2x_{i2} + a_3x_{i3} + a_4x_{i4} + e_i,$$

where Y is the risk premium defined above, x_{i1} is the measure of earnings variability, x_{i2} is the measure of solvency, x_{i3} is the equity-debt ratio, and x_{i4} is the measure of marketability. All variabiles are expressed in logarithms.

The estimated coefficient a_1 is hypothesized to be positive, because a firm with a lower variation in its income stream is less likely to experience earnings that are insufficient to service its debt. The coefficient a_2 also is hypothesized to be negative, because as the length of time since the company experienced its last default increases, investors should gain confidence in the current solvency of the firm. Investors also will examine the relationship between the firm's income-earning assets and their total debt. For a given level of debt, a lower equity-debt ratio indicates that a smaller quantity of income earning assets are being used to support the company's debt. The lower the equity-debt ratio, the smaller the decline in the value of equity necessary to render the firm insolvent. Thus, the coefficient a_3 is expected to be negative. Finally, the value of traded bonds outstanding provides a measure of the availability of traders in the firm's bonds. As the availability of traders declines, the probability of being forced to sell the bond at a loss increases. Consequently, the coefficient a_4 is expected to be negative.

Fisher estimated the log linear model shown in equation (2.6) using ordinary least squares for the years 1927, 1932, 1937, 1949 and 1953. The coefficients in all years are correctly signed, but they exhibit a wide variation in size from year to year. The results are shown in Table 2.2.

Like the work by Arditti, Fisher's analysis suggests the need to examine a variety of risk characteristics when investigating the relevant measures of risk. In addition to the risk measures that are characteristic of all industries, it will be important to identify risk characteristics that are electric utility-specific. For example, the quality of regulation and the fuel mix are important

TABLE 2.2

Determinants of the Risk Premium on Corporate Bonds*

	Year 1927	Year 1932	Year 1937	Year 1949	Year 1953
Intercept	0.841	1.014	0.949	0.711	1.012
Variability of Earnings	0.233	0.248	0.286	0.228	0.228
	(0.048)	(0.128)	(0.051)	(0.100)	(0.091)
Solvency Period	-0.269	-0.067	-0.254	-0.124	-0.300
	(0.062)	(0.114)	(0.061)	(0.076)	(0.089)
Equity/Debt Ratio	-0.404	-0.531	-0.491	-0.426	-0.474
	(0.039)	(0.092)	(0.060)	(0.084)	(0.085)
Bonds Outstanding	-0.169	-0.286	-0.271	-0.329	-0.363
	(0.031)	(0.071)	(0.038)	(0.046)	(0.043)

R-squared	0.756	0.726	0.731	0.786	0.773

*The dependent variable is the risk premium on corporate bonds. The standard errors are reported in parentheses.

Source: Lawrence Fisher, "Determinants of Risk Premiums on Corporate Bonds," The Journal of Political Economy, Vol. 67, No. 3 (1959), Table 1, p. 221.

determinants of risk across utilities.

The stability over time of the relationship between the valuation variables and the future price of a security is examined by Burton Malkiel (1970). Malkiel estimates the equation:

2.7 $(P/E)_i = a_0 + a_1 g_i + a_2 (D/E)_i + a_3 [F/(E+F)]_i + e_i,$

where P/E is the price-earnings ratio which is regressed on the expected long-term growth rate of earnings per share, g, the dividend payout ratio, D/E, and a leverage variable, F/(F+E). Malkiel uses normalized earnings to measure both the dependent variable and the dividend payout ratio. Normalizaton removes the effect of cyclical earnings which impacts utilities dissimilarly. The expected growth in earnings per share is based on the actual predictions of nine major security firms. The leverage variable used is the ratio of fixed charges per share to earnings plus fixed charges per share. The standard leverage variable -- the debt-equity ratio -- is avoided because of the potential for simultaneity. Results for 1961 through 1967 are reported in Table 2.3. As shown, the estimated coefficients vary significantly over time for Malkiel's model.

Malkiel's results suggest that the specific conclusions drawn from an empirical analysis of stock valuation may vary across years. It is significant, however, that while specific conclusions may vary across years, the signs of the estimated coefficients are consistent

TABLE 2.3

Cross-Sectional Analysis of the Determinants of Common Stock Valuation*

	Year 1961	Year 1962	Year 1963	Year 1964	Year 1965	Year 1966	Year 1967
Constant	8.11	3.86	-2.56	-1.23	3.42	2.42	-1.70
Growth Rate	2.63 (0.33)	2.31 (0.28)	3.01 (0.24)	3.04 (0.24)	2.49 (0.24)	2.32 (0.23)	2.08 (0.20)
Dividend Payout	1.95 (7.58	9.37 (5.65)	17.88 (4.70)	14.66 (4.62)	6.48 (4.54)	1.93 (3.37)	4.51 (3.13)
Leverage	-0.17 (8.39)	-3.75 (5.45)	-15.23 (4.53)	-11.23 (4.24)	-6.06 (4.11)	-3.79 (3.18)	0.76 (2.74)
R^2	0.79	0.76	0.86	0.87	0.85	0.76	0.70
F-statistic (degrees of freedom)	30.64 (3,25)	30.88 (3,30)	63.75 (3,30)	66.67 (3,30)	57.77 (3.30)	59.84 (3,57)	44.12 (3,57)

*The dependent variable is the price-earnings ratio. Standard errors are reported in parentheses.

Source: Burton Malkiel, "The Valuation of Public Utility Equities," The Bell Journal of Economics and Management Science, Vol. 1, No. 1 (Spring 1970), Table 5, p. 154.

across time.

2.3 Risk and Electric Utility Customer Classes

2.3.1 A Review of the Literature

As discussed in Chapter 1, the rate of return is an important determinant of the utility's allowed level of revenues. Traditionally, however, the rate of return has not been a factor in the rate design phase of rate cases. The hypothesis normally adopted within the rate-making process is that the risk to the utility of serving its different customer classes does not vary significantly between customer classes. Joseph Brennan (1980) put forth the competing hypothesis that customer mix is an important determinant of the overall riskiness of a utility and that risk varies significantly across customer classes. The question is important within the rate-making arena, because second-best pricing theory suggests that the cost of capital assigned to each class should reflect the added cost of investment to serve the riskier customer class if the risk differential exists.

To test this alternative hypothesis, Brennan examined the variability of class revenues by regressing the natural logarithm of revenue by customer class for Delmarva Power and Light Company on time for the 15-year period 1964 to 1978. The conclusion drawn from the evidence is that the utility faces higher business risk to serve its industrial customers, because the industrial class exhibits higher revenue variability. In contrast, the lowest risk is associated with the street lighting class of customers. Residential and commercial customers fall between the boundaries established by industrial and lighting customers. Unfortunately, Brennan provides no statistical support for his use of revenue variability as a measure of return variability. Only later, in Arkansas Docket No. U-3108 is an attempt made to demonstrate that revenue is an adequate proxy for return.[13]

As an additional test of his hypothesis, Brennan asserts that business risk also can be judged by the capital structure of a firm.[14] Because a firm with a high degree of business risk will be unable to secure fixed cost financing, its debt-equity ratio will be low. Brennan argues that:

> If a utility company served only industrial customers, its capital structure would reflect the business risk of serving such customers as a group and, thus, it would be financed in a manner similar to an industrial company.[15]

In order to quantify the risk differential, Brennan constructs a capital structure for three representative utilities, as shown in Table 2.4. Utility A, assumed to be the yardstick, is represented by

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[13]Arkansas Public Service Commission Docket No. U-3108, Direct Testimony of A. Gerald Harris.

[14]Brennan (1980), p. 5.

[15]Ibid., p. 14.

TABLE 2.4

Comparison of Overall Rate of Return
Given Various Capital Structures

Type of Capital	Capital Structure Ratio	Component Cost Rate	Weighted Component Post-Income Tax	Weighted Component Before-Income Tax
Utility A				
Debt	50.0%	7.7%	3.85%	3.85%
Preferred Stock	12.0%	7.2%	0.86	1.56
Common Equity	38.0%	14.0%	5.32	9.67
			10.30%	15.08%
Utility B				
Debt	25.0%	7.7%	1.92%	1.92%
Preferred Stock	5.0%	7.2%	0.36	0.65
Common Equity	70.0%	14.5%	10.14	18.43
			12.42%	21.00%
Utility C				
Debt	80.0%	7.7%	6.16%	6.16%
Preferred Stock				
Common Equity	20.0%	16.9%	3.39	6.16
			9.55%	12.32%

Source: Joseph Brennan, "Rate of Return Differentials by Class -- A New Dimension of Cost of Service," Public Utilities Fortnightly, Vol. 105, No. 8 (1980), p. 15.

Delmarva Power and Light Company's 1978 debt-equity ratio of approximately 50% debt and 50% equity (common plus preferred). The high risk utility, Utility B, has a debt-equity ratio of 25% debt and 75% equity, which approximates the debt-equity ratio of the 1978 Standard and Poor's 400 industrials. The low risk utility, Utility C, has a debt-equity ratio of 80% debt and 20% equity, characteristic of a municipal utility. As shown in Table 2.4, the before-income-tax rates of return range from 12.32% for the low-risk utility, or 0.8 times the yardstick rate of return, to 21% for the high risk utility, or 1.4 times the yardstick rate of return. Brennan concludes that:

> The computations above establish what I believe to be the range of the parameters of before-income tax overall rate of return for Delmarva's customer classes....These data suggest, without regard to other consideration, that the rate of return expressed on a before-income tax basis for the industrial class should be about 1.4 times (21.00 percent divided by 15.08 percent) the company overall composite, and that the lighting class should be about 0.8 times the company overall composite (15.08 percent divided by 12.32 percent.[16]

Brennan does not attempt to verify that the debt-equity ratio is inversely related to customer mix.

In testimony before the Delaware Public Service Commission, A. Gerald Harris presented testimony and empirical evidence in an attempt to support Brennan's hypothesis.[17] Harris used the return

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[16]Ibid., p. 15.

[17]Delaware Public Service Commission Docket No. 81-12, Direct Testimony of A. Gerald Harris.

over a ten-year period for customer classes of Delmarva Power and Light Company in Delaware.[18] Harris concluded that:

> The Residential, General Service and Lighting classes had similar variations in rate of return. The standard deviation of returns for retail classes is lowest for Residential, at 1.01 percentage points. The highest, for Rate Q, was 7.71. General Service and Lighting fell between the extremes at 3.08 and 4.19, respectively. These data would indicate that the rate of return is far less variable for the Residential class than for any other. However, over the period studied, the Residential class has exhibited a consistently lower rate of return than have other classes. In order to adjust for the magnitude of return rate, a coefficient of variation was calculated. This measure of relative variation yields a lower value for the Lighting class, with the Rate Q class remaining relatively high. On this basis, there is little difference among Lighting, General Service, and Residential.[19]

On this basis, Harris concluded that before-tax income from the industrial class, Rate Q, exhibited greater variation over time, which indicated that greater business risk is associated with supplying service to industrial customers.

Harris' analysis exhibits several flaws. First, Harris' use of hypothetical usage data with actual revenue data may introduce

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[18]Harris based the calculation of class return on a fully distributed embedded cost-of-service model. Joint costs classified as demand-related (fixed costs) are allocated to customer classes based on the average and excess demand method. Energy-related (variable costs) and customer costs are allocated based on various measures of total consumption and number of customers, respectively. For a more detailed discussion of costing methods, see Russell Caywood, Electric Utility Rate Economics, New York: McGraw-Hill, 1956 and the Electric Utility Cost Allocation Manual.

[19]Delaware PSC, Harris, pp. 7-8.

variation into the return calculation. In order to calculate the returns for the ten years, Harris used class usage characteristics from 1978 to create the annual data necessary to perform the cost allocation. As a result, the relationship between kilowatts (maximum rate of consumption per hour) and kilowatt hours (total consumption) is assumed to remain constant over the 10 year period. Under this assumption, the relationship between revenues derived from demand charges and revenues derived from energy charges also would remain constant. Because the revenue data used in the analysis was based on actual consumption patterns and because usage characteristics did evolve over time, the assumption results in a mismatching of cost and revenue. This mismatch may account for some of the variation in the return calculations. Second, Harris failed to recognize specific company cost-of-service methods on which tariffs were based.[20] The problems associated with the construction of the data and the small sample size do not permit Harris to produce meaningful results.

Two articles critiquing Brennan appeared in Public Utilities Fortnightly. Nick Poulious (1980) criticized the static nature of Brennan's statistical evidence and examined the relationship between a utility's bond rating and the ratio of industrial to residential customers. Poulious concludes that:

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[20]Delaware Public Service Commission Docket No. 81-12, testimony of Alan Chalfant.

> This analysis shows in a quantifiable manner that utilities with large industrial sales are not treated unfavorably by investors, and in an economic sense they do not present any more risk than utilities which serve mainly residential customers.[21]

Poulious bases his conclusions on the results of two sets of analysis. First, he compared the coefficients of variation by class for revenue, number of customers and electricity sales. Second, he regressed bond ratings on the customer class-mix ratio. Data for the coefficients of variation was taken from Virginia Electric and Power Company for the years 1968 through 1978. Data for the regression analysis include 35 randomly selected electric or combination electric and gas utilities for 1978.

The class coefficients of variation for revenue, number of customers and electricity sales are summarized in Table 2.5. Poulious' calculations indicate that the revenue variation of the industrial class of customers exceeds the overall revenue variability for the utility. The industrial class, however, exhibits the lowest customer growth variation and electricity sales variation. The results for the residential class exhibit below average revenue variability and above average customer growth and electricity sales variation.

As additional support for his hypothesis, Poulious used

[21]Poulious, p. 31.

TABLE 2.5

Coefficients of Variation of Historical Trends in Revenue, Customer and Sales Growth*

Customer Class	Revenue Growth	Customer Growth	Sales Growth
Residential	.54810	.09635	.21789
Commercial	.57416	.06645	.22464
Industrial	.60260	.02783	.14580
Other	1.35723	.16234	.23214
Total	.58823	.09395	.20912

*Data are for Virginia Electric Power Company for the years 1968 through 1978.

Source: Nick Poulious, "Rate of Return Differentials by Class Through Revenue Variation? But How?" _Public Utilities Fortnightly_, Vol. 106, No. 3 (1980), Table 1, p. 28.

regression analysis to examine the relationship between customer-mix and bond ratings. For the dependent variabile, bond ratings, Poulious assigned numeric values to each rating as follows: Aaa = 5, Aa = 4, A = 3, Baa = 2, and A/Baa = 1. The independent variable, customer mix, is the ratio of either (1) industrial kWh sales or (2) industrial and commercial kWh sales to residential kWh sales. As the percent of sales to industrial (or industrial and commercial) customers increases, the customer-mix ratio increases. The estimated coefficients are shown below:

2.8 Bond Rating = 2.129 + 0.518 ratio

If the utility's customer mix is evenly distributed between residential and industrial, the ratio would equal one and the estimated bond rating would equal 2.647. Thus, based on Poulious' ranking, a utility with an equal distribution of customers across classes would exhibit a bond rating of Baa to A. If the ratio exceeds one, that is, the level of industrial sales exceeds the level of residential sales, then the expected bond rating increases.

Several problems mar the usefulness of Poulious' results. First, the relevant significance levels and summary statistics are not available.[22] Also, the independent variable for thirty of the

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[22]Poulious provides no supporting statistics for his results. Attempts to obtain the supporting statistics were unsuccessful.

thirty-five utilities contains both industrial and commercial sales in the denominator of the ratio. This latter problem is especially damaging to Poulious' conclusion that utilities with a high percentage of industrial customers relative to residential customers have higher bond ratings, because the independent variable is not defined consistently with the conclusion reached. Thus, the hypothesis that a larger proportion of total sales made to the industrial class enhances a utility's bond rating is not strongly supported by his empirical analysis. Finally, Poulious assumes a strict linear relationship between bond ratings and risk.

Robert Trout (1981) argues that Brennan has failed to establish the theoretical basis for his analysis. Trout suggests that customer classes of the utility should be viewed as elements in a portfolio of energy sales units. He suggests that future research should examine individual customer class risk in terms of the capital asset pricing model, wherein the overall rate of return for the utility multiplied by the estimated risk factor would define the required class rate of return. Trout does not attempt to apply his technique to a utility.

In October 1981, the Electricity Consumers Resource Council (ELCON) published An Examination of the Concept of Using Relative Customer Class Risk to Set Target Rates of Return in Electric Cost-of-Service Studies prepared by Financial Concepts and

Applications, Inc. (FINCAP).[23] In addition to an empirical investigation of the customer class risk hypothesis, FINCAP surveyed two groups. First, regulatory agencies were polled to determine their degree of awareness and acceptance of the customer class-risk hypothesis. Second, investment analysts were queried to determine the import of customer mix in their determination of the risk of a given utility. Though regulatory agencies in general were familiar with the concept of class risk differentials, the belief that such differentials actually exist or have significant effects was not widespread. This position is revealed in the statement:

> The fact that relative rates of return for residential customers typically tended to be lower than the utility system average, and rates of return for industrial customers were generally higher than average, appeared more the result of historical practice than the acceptance of any relative risk concept.[24]

The survey of investment analysts indicated that customer mix as an element of a utility's overall riskiness was overshadowed by general economic and capital market conditions, financial and operating factors specific to the utility and the regulatory environment. Summarizing the survey results for this group, the

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[23] Bill Avera and Bernice Fairchild, _An Examination of the Concept of Using Relative Customer Class Risk to Set Target Rates of Return in Electric Cost-of-Service Studies_ (Washington, D.C.: ELCON, 1982). The study is referred to throughout this research as the FINCAP study.

[24] FINCAP, p. 24.

FINCAP study notes that "only when a utility's customer mix is extreme or if revenues are dominated by economically vulnerable customers, do analysts become concerned."[25] Furthermore, investment analysts surveyed felt that the risk associated with serving large-use customers was attenuated by tariff design features, such as demand ratchets, minimum bills and long-term contracts. The survey of investment analysts suggests that other financial variables should be considered for inclusion in any empirical model which attempts to explain differences in perceived riskiness across customer classes.

The empirical analysis in the FINCAP report investigates the relationship between customer mix and risk using bivariate correlation and multiple regression analysis. The cross-sectional studies use annual data for the years 1977, 1978, and 1979. Each year was examined separately. Several risk measures, each from a published source, are used. The risk measures include bond ratings produced by Moody's, Standard & Poor's and Duff and Phelps as well as the Standard & Poor's common stock ranking. The study also used the Value Line variables for the financial strength, Beta, price stability and earnings predictability. In all cases, the risk variables have been expressed such that a higher value indicates a greater level of perceived riskiness.

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[25]Ibid., p. 50.

The customer-mix variables are defined as class revenue as a percent of total revenue and as two alternate ranking variables. The first ranking variable groups the utilities into quintiles and assigns a value to the utility based upon the quintile in which it is located. The second ranking variable is a zero-one variable which indicates only utilities with extremely skewed customer mixes; that is, utilities in the first and fifth quintiles. The data used to define the customer-mix variables is taken from the Annual Report of Class A and B electric utilities to the Federal Energy Regulatory Commission (FERC Form 1). As discussed more fully below, this results in inconsistent definitions across customer classes.

The eight risk measures were correlated with customer-mix variables using Spearman rank correlation coefficients and Pearson product-moment coefficients. These results are shown in Tables 2.6 through 2.8. Based on these correlations, the authors of the study conclude that:

> On balance, these empirical tests suggest that as the proportion of revenues attributable to the residential customers on an electric utility system increase, so does the risk of the company and, conversely, the larger the portion of revenues derived from industrial customers, the less risky the utility.[26]

The results, however, are not consistent across the three years

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[26]Ibid., pp. 65-66.

TABLE 2.6

Correlation Coefficients for Customer Mix
and Alternative Risk Indicators
1977

Risk Indicator	REVENUES AS A PERCENTAGE Residential		Industrial		Comm. and Ind.	
	Pearson	Spearman	Pearson	Spearman	Pearson	Spearman
Moody's Bond Rating Correlation Coefficient	.1602	.1492	-.1592	-.1304	-.1806*	-.1642
Standard & Poor's Bond Rating Correlation Coefficient	.3472**	.3665**	-.1567	-.1562	-.2127*	-.1825*
Duff and Phelps Bond Rating Correlation Coefficient	Data not available					
S&P Common Stock Ranking Correlation Coefficient	.2449**	.2484**	-.1403	-.0951	-.0862	-.0026
Value Line Financial Strength Correlation Coefficient	.1589	.1183	-.0921	-.0802	.0065	.0314
Value Line Beta Correlation Coefficient	.0683	.0327	-.0798	-.0100	-.0959	-.1297
Price Stability Index Correlation Coefficient	-.0398	-.0110	.1186	-.0520	-.0663	-.0751
Earnings Predictability Index Correlation Coefficient	-.1196	-.1140	.2035*	.1958*	.0787	.0500

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TABLE 2.6

Risk Indicator	Res. Pearson	Ind. Pearson	Comm. & Ind. Pearson
	REVENUES AS QUINTILES		
Moody's Bond Rating Correlation Coefficient	.1637	-.0821	-.1576
Standard & Poor's Bond Rating Correlation Coefficient	.3590**	-.1140	-.0785
Duff and Phelps Bond Rating Correlation Coefficient	Data not available		
S&P Common Stock Ranking Correlation Coefficient	.2433**	-.0682	-.0623
Value Line Financial Strength Correlation Coefficient	.1624	-.0570	.0048
Value Line Beta Correlation Coefficient	.0316	-.0057	-.1880*
Price Stability Index Correlation Coefficient	-.0203	.0265	-.0429
Earnings Predictability Index Correlation Coefficient	-.1509	.1698*	.1249

(continued on next page)

TABLE 2.6

Risk Indicator	EXTREME LOW REVENUES Res. Pearson	Ind. Pearson	Comm. & Ind. Pearson	EXTREME HIGH REVENUES Res. Pearson	Ind. Pearson	Comm. & Ind. Pearson
Moody's Bond Rating Correlation Coefficient	-.1479	.2158*	.1657	.1462	-.0208	-.0668
Standard & Poor's Bond Rating Correlation Coefficient	-.1258	.1593	.1480	.3534**	-.0599	-.1136
Duff and Phelps Bond Rating Correlation Coefficient	Data not available					
S&P Common Stock Ranking Correlation Coefficient	-.0601	.1504	.0578	.2913**	-.0674	-.1290
Value Line Financial Strength Correlation Coefficient	-.0844	.1375	-.0210	.2294*	.0873	.0297
Value Line Beta Correlation Coefficient	-.0773	.0871	.0032	-.0212	-.0178	-.1335
Price Stability Index Correlation Coefficient	.0449	-.2256*	-.0554*	.0449	-.0327	-.1532
Earnings Predictability Index Correlation Coefficient	.1475	-.0508	-.0509	-.0358	.1661	.0742

*Significant at the .05 level
**Significant at the .01 level

Source: FINCAP, Inc. *An Examination of the Concept of Using Relative Customer Class Risk to Set Target Rates of Return in Electric Cost of Service Studies* (Washington, D.C.: ELCON, 1982) Table 6, p. 64.

TABLE 2.7

Correlation Coefficients for Customer Mix
and Alternative Risk Indicators
1978

Risk Indicator	REVENUES AS A PERCENTAGE					
	Residential		Industrial		Comm. and Ind.	
	Pearson	Spearman	Pearson	Spearman	Pearson	Spearman
Moody's Bond Rating Correlation Coefficient	.1834*	.1395	-.1255	-.0877	-.1574	-.1068
Standard & Poor's Bond Rating Correlation Coefficient	.3365**	.3459**	-.1258	-.1115	-.1967*	-.1372
Duff and Phelps Bond Rating Correlation Coefficient	.1500	.1787*	-.0071	-.0147	.0306	.0340
S&P Common Stock Ranking Correlation Coefficient	.1890*	.1993*	.0605	.0706	.1139	.2196*
Value Line Financial Strength Correlation Coefficient	.1902*	.1805*	-.0304	-.0022	.0949	.1188
Value Line Beta Correlation Coefficient	.0876	.0249	-.0681	.0339	-.0111	-.0279
Price Stability Index Correlation Coefficient	-.0607	-.0567	.1028	-.1068	-.1426	-.1713*
Earnings Predictability Index Correlation Coefficient	-.0814	-.0756	.1227	.1362	.0047	.0116

(Continued on next page)

TABLE 2.7

Risk Indicator	REVENUES AS QUINTILES Res. Pearson	Ind. Pearson	Comm. & Ind. Pearson
Moody's Bond Rating Correlation Coefficient	.1487	-.0898	-.0965
Standard & Poor's Bond Rating Correlation Coefficient	.3481**	-.0975	-.1146
Duff and Phelps Bond Rating Correlation Coefficient	.1644	-.0138	.0413
S&P Common Stock Ranking Correlation Coefficient	.2095*	.0882	.2148*
Value Line Financial Strength Correlation Coefficient	.2167*	-.0197	.1205
Value Line Beta Correlation Coefficient	.0000	-.0101	-.0577
Price Stability Index Correlation Coefficient	-.0088	.0088	-.1589
Earnings Predictability Index Correlation Coefficient	-.0941	.1336	-.0517

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TABLE 2.7

Risk Indicator	EXTREME LOW REVENUES Res. Pearson	Ind. Pearson	Comm. & Ind. Pearson	EXTREME HIGH REVENUES Res. Pearson	Ind. Pearson	Comm. & Ind. Pearson
Moody's Bond Rating Correlation Coefficient	-.0463	.2185*	.1282	.2038*	-.0386	-.0564
Standard & Poor's Bond Rating Correlation Coefficient	-.1630	.1572	.1761*	.3650**	-.0788	-.0610
Duff and Phelps Bond Rating Correlation Coefficient	-.0837	.1036	.0186	.2464**	.0699	.0349
S&P Common Stock Ranking Correlation Coefficient	-.1200	.0931	-.0043	.2564**	.1153	.1734*
Value Line Financial Strength Correlation Coefficient	-.1512	.0759	-.1470	.2529**	.0635	.0268
Value Line Beta Correlation Coefficient	-.0424	.0211	-.0236	.0059	-.0293	-.0288
Price Stability Index Correlation Coefficient	-.0628	-.1436	.0574	-.0674	-.0548	-.1804*
Earnings Predictability Index Correlation Coefficient	.0621	-.0416	.0137	-.0525	.1084	-.0523

*Significant at the .05 level
**Significant at the .01 level

Source: FINCAP, Inc. An Examination of the Concept of Using Relative Customer Class Risk to Set Target Rates of Return in Electric Cost of Service Studies (Washington, D.C.: ELCON, 1982) Table 6, p. 63.

TABLE 2.8

Correlation Coefficients for Customer Mix
and Alternative Risk Indicators
1979

Risk Indicator	REVENUES AS A PERCENTAGE					
	Residential		Industrial		Comm. and Ind.	
	Pearson	Spearman	Pearson	Spearman	Pearson	Spearman
Moody's Bond Rating Correlation Coefficient	.1531	.1622	-.0731	-.0307	-.1306	-.1133
Standard & Poor's Bond Rating Correlation Coefficient	.2778**	.3078**	-.1164	-.0800	-.1237	-.0979
Duff and Phelps Bond Rating Correlation Coefficient	.1134	.1372	-.0258	-.0225	-.0121	-.0077
S&P Common Stock Ranking Correlation Coefficient	.1304	.1923*	.0626	.0539	.1586	.2280*
Value Line Financial Strength Correlation Coefficient	.1517	.1535	-.0389	-.0831	-.0214	-.0351
Value Line Beta Correlation Coefficient	.0051	-.0536	-.0289	.0575	.1116	.1344
Price Stability Index Correlation Coefficient	-.0699	-.0100	.0330	-.0159	-.1204	-.1075
Earnings Predictability Index Correlation Coefficient	-.0938	-.1076	.0951	.1017	.0403	.0320

(Continued on next page)

TABLE 2.8

Risk Indicator	REVENUES AS QUINTILES Res. Pearson	Ind. Pearson	Comm. & Ind. Pearson
Moody's Bond Rating Correlation Coefficient	.1630	.0311	-.0930
Standard & Poor's Bond Rating Correlation Coefficient	.3084**	-.0429	-.0660
Duff and Phelps Bond Rating Correlation Coefficient	.1299	-.0126	.0045
S&P Common Stock Ranking Correlation Coefficient	.2145*	.0817	.2404*
Value Line Financial Strength Correlation Coefficient	.1541	-.0243	-.0060
Value Line Beta Correlation Coefficient	-.1013	.0736	.0724
Price Stability Index Correlation Coefficient	-.0591	-.0688	-.1326
Earnings Predictability Index Correlation Coefficient	-.1399	-.0888	.0480

(continued on next page)

TABLE 2.8

Risk Indicator	EXTREME LOW REVENUES Res. Pearson	Ind. Pearson	Comm. & Ind. Pearson	EXTREME HIGH REVENUES Res. Pearson	Ind. Pearson	Comm. & Ind. Pearson
Moody's Bond Rating Correlation Coefficient	-.0363	.0471	.1696*	.2027*	-.0560	-.1378
Standard & Poor's Bond Rating Correlation Coefficient	-.1272	.0713	.0832	.3194**	-.1491	.1271
Duff and Phelps Bond Rating Correlation Coefficient	.0230	.0970	.0747	.0241*	.0121	.0027
S&P Common Stock Ranking Correlation Coefficient	-.0777	.0294	-.1179	.1788*	.1095	.1485
Value Line Financial Strength Correlation Coefficient	-.0394	.0946	.0688	.1283	.0056	-.0624
Value Line Beta Correlation Coefficient	-.0289	.0695	.0674	-.0817	.0511	.0966
Price Stability Index Correlation Coefficient	.0160	-.0621	.1544	-.1186	.0034	-.0861
Earnings Predictability Index Correlation Coefficient	.0387	-.0493	-.0762	-.0289	.1130	.0935

*Significant at the .05 level
**Significant at the .01 level

Source: FINCAP, Inc. <u>An Examination of the Concept of Using Relative Customer Class Risk to Set Target Rates of Return in Electric Cost of Service Studies</u> (Washington, D.C.: ELCON, 1982) Table 4, p. 62.

tested. More important, only 25.81% of the paired correlations are statistically significant at the 5 percent level, a result that suggests a weak relationship may exist between risk and customer mix.

To control for other factors that may influence the risk measures, FINCAP estimated eight equations that regressed the risk variables on various combinations of the customer-mix variables and other financial and operating variables. In these tests, the financial and operating indicators included quality of regulation, common dividend coverage, interest coverage including allowance for funds used during construction (AFUDC), quality of earnings, average 10-year growth of earnings, effective tax rate, common equity as a percent of capitalization, internal cash generation, dividend payout ratio and dummy variables for muclear generation, method of tax accounting and fuel type.[27] No explanation of the technique used to design the base model is provided and no <u>a priori</u> signs are ascribed to the variables. The regression analysis was performed in two steps. In the first step, the base model was estimated without the customer-mix variables. These results are shown in Table 2.9. Following estimation of the base model, the customer-mix variables

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[27]The quality of regulation variable is produced by Salomon Brothers. The variables take on values from 1 (high) to 5 (low). The ratings are published periodically in Salomon Brothers Inc.'s <u>Electric Utility</u> newsletter.

TABLE 2.9

Analysis of Electric Utility Risk Based on Various Published Risk Measures; Aggregate Data 1978-1979

VARIABLES*	RISK INDICATOR							
	Moody's Bond Rating	S&P Bond Rating	D&P Bond Rating	S&P Common Stock Ranking	Value Line Financial Strength	Value Line Beta	Value Line Price Stability Index	Value Line Earnings Predictability Index
Quality of Regulation Salomon Brothers	.1492 (.004)	.1894 (.000)	.4587 (.000)	.1066 (.021)	.2302 (.000)	-.0213 (.001)	1.4152 (.004)	
Common Dividend Coverage			-.3064 (.035)	.2009 (.002)	.3889 (.000)	.0298 (.001)	-2.9879 (.000)	-5.5235 (.001)
Interest Coverage Including AFUDC	-.3642 (.000)	-.3193 (.000)	-.5347 (.022)		-.5135 (.000)			6.3597 (.002)
Nuclear Generation Dummy	.2787 (.009)	.2271 (.015)	.4764 (.013)	.1621 (.089)			-1.7994 (.080)	
Quality of Earnings Salomon Brothers	.2471 (.010)		.5235 (.004)		.4410 (.000)	.0310 (.009)	-2.9678 (.001)	
Average 10-Year Growth in Earnings	4.6918 (.055)		-18.2813 (.001)	-14.1322 (.000)				
Flow-through/Normalized Dummy		-.3392 (.002)	-.6939 (.007)					6.2676 (.023)
Gas/Oil Generation Dummy						.0302 (.028)	-3.4601 (.001)	5.3301 (.023)
Effective Tax Rate			-2.2086 (.039)	-1.5219 (.000)				

(continued on next page)

TABLE 2.9

VARIABLES*	RISK INDICATOR: Moody's Bond Rating	S&P Bond Rating	D&P Bond Rating	S&P Common Stock Ranking	Value Line Financial Strength	Value Line Beta	Value Line Price Stability Index	Value Line Earnings Predictability Index
Common Equity as a Percent of Capitalization			-11.7111 (.000)					
Internal Cash Generation							-9.3102 (.001)	
Divident Payout Ratio			-2.1834 (.003)					
Constant	2.4855 (.000)	3.3297 (.000)	12.2656 (.000)	3.1087 (.000)	1.7203 (.009)	.5974 (.000)	113.0018 (.000)	64.1569 (.000)
Coefficient of Determination (R^2)	.338	.371	.715	.339	.374	.148	.300	.128
F-Statistic	16.341	23.783	38.850	16.394	24.061	6.991	11.339	5.891
Number of Cases	300	300	200	300	300	300	300	300

*The number in parentheses below the estimated coefficient is the significance level.

Source: FINCAP, Inc. An Examination of the Concept of Using Relative Customer Class Risk to Set Target Rates of Return in Electric Cost of Service Studies (Washington, D.C.: ELCON, 1982) Table 7, p. 68.

were added. The estimated coefficients of the customer-mix variables are shown in Table 2.10. (The FINCAP report does not report the estimated results for the full equations including the customer-mix variables.) Overall, the models do not appear to provide strong evidence upon which to build conclusions, because few of the estimated coefficients of the customer-mix variables are significant and they exhibit inconsistent signs.

In the final step of their analysis, FINCAP examined the impact of customer mix on the cost of debt, preferred stock and common stock. The models for the cost of debt and preferred stock included variables measuring the market rate of interest and the company's operating and financial risk. The debt-equation variables included Moody's Aaa industrial bond yield, interest coverage allowance for funds used during construction, long term debt as a percent of capitalization, quality of regulation and dummy variables for the accounting method and nuclear generation. Variables in the preferred stock equation included Moody's Aaa industrial bond yield, long-term debt as a percent of capitalization, quality of regulation and preferred dividend coverage. The dependent variable in the debt equation is the yield-to-maturity of newly-issued debt adjusted for flotation costs. The dependent variable in the preferred stock equation is the yield on newly-issued preferred stock adjusted for flotation costs. The results for the base equations are reported in

TABLE 2.10

Customer Mix and Descriptive Risk Models
Aggregate Data 1977-1979

	Revenues as a Percentage					Revenues as a Quintile		
Risk Indicator	Res.	Comm.	Ind.	Comm. & Ind.	Other	Res.	Ind.	Comm. & Ind.
Moody's Bond Rating	1.2298	-.0355	.0311		1.2120	.0345	-.0355	-.0778
	1.2116			.0130	1.2062			
Standard and Poor's Bond Rating	1.1673	-1.2528	-.8754		-.1666	.0871*	.0190	-.0497
	1.0975			-.9466	-.1799			
Duff and Phelps Bond Rating	6.4494	5.5663	6.0878		6.2400	.0319	.0142	-.0187
	6.1641			5.7860	6.0383			
S&P Common Stock Rating	1.7378	2.8361	2.3068		.7712	.0737*	-.0364	.1279**
	1.9281			2.5040	.8836			
Value Line Financial Strength	-9.0381	-9.3947	-9.6668*		-11.0510*	.0771	-.0161	.0597
	-8.9254			-9.5610	-10.9860*			
Value Line Beta	.6141	.5413	.4888		.4780	.0003	.0033	-.0038
	.6312			.5054	.4857			
Price Stability Index	-64.3851	-72.6762	-61.5339		-52.8787	-.3963	.2287	-.8355
	-68.0933			-65.0336	-54.7426			
Earnings Predictability Index	158.0290	141.4717	159.1367		160.7880	-.2245	1.2952	-.9325
	151.3874			152.7286	157.7128			

(continued on next page)

TABLE 2.10

Risk Indicator	Extreme Low Revenues: Res.	Extreme Low Revenues: Ind.	Extreme Low Revenues: Comm. & Ind.	Extreme High Revenues: Res.	Extreme High Revenues: Ind.	Extreme High Revenues: Comm. & Ind.
Moody's Bond Rating	-.0596	.1929	.1738	.1371	.1513	-.1170
Standard and Poor's Bond Rating	-.1199	.1240	.1093	.3553**	.0184	.0243
Duff and Phelps Bond Rating	-.1021	.6617*	.3912	.1882	.4482	.3225
S&P Common Stock Rating	.0393	.3514**	-.1776	.3533**	.1533	.2897*
Value Line Financial Strength	-.1206	.3865*	-.1662	.3881*	.4912*	-.1305
Value Line Beta	-.0234	.0121	.0038	-.0046	-.0019	.0127
Price Stability Index	.2849	-3.1346*	1.6297	-2.0209	-.6298	-2.5493
Earnings Predictability Index	-1.5594	-1.9462	.0021	-1.1757	2.5914	-2.8946

*Significant at the .05 level
**Significant at the .01 level

Source: FINCAP, Inc. <u>An Examination of the Concept of Using Relative Customer Class Risk to Set Target Rates of Return in Electric Cost of Service Studies</u> (Washington, D.C.: ELCON, 1982) Table 8, p. 70.

Table 2.11 and 2.12. The equations in Table 2.11 are labelled Individual, Basic and All-Inclusive. Individual refers to the individual year model which provided the best explanatory power in each year. The basic model includes only those variables common to all of the individual year models. The all-inclusive model contains any variable that proved significant in any model.

The model used to explain the cost of common stock includes variables to measure dividend yield, dividend growth and operating and financial risk. The variables include the dividend yield on book value, the average 10-year growth in earnings, the average return on common equity, the earnings retention ratio, common dividend coverage, common equity as a percent of capitalization, allowance for funds used during construction as a percent of net income and dummy variables for gas and oil generation, nuclear generation and accounting method. The dependent variable is the market to book ratio. Results of the base model are shown in Table 2.13.

The estimated coefficients for the customer-mix variables are shown in Table 2.14. Two equations are reported for each model. Equation A defines the customer-mix variables as residential, commercial, industrial and other. Equation B defines the customer-mix variables as residential, commercial/industrial and other. In general, the estimated coefficients are not consistently signed or sized across either time periods or customer-mix variables.

TABLE 2.11

Senior Long-Term Debt Valuation Models

VARIABLE*	1977 Individual	Basic	All Inclusive
Moody's Aaa Industrial Bond Yield	-.0126 (.109)	-.0160 (.050)	-.0129 (.123)
Interest Coverage Including AFUDC	-.0013 (.006)	-.0022 (.000)	-.0012 (.031)
Long-term Debt as a Percent of Capitalization	.0238 (.019)		.0245 (.024)
Quality of Regulation Salomon Borthers	.0005 (.054)		.0006 (.051)
Flow-through/Normalized Accounting Dummy			-.0010 (.293)
Nuclear Generation Dummy			-.0002 (.678)
Preferred Dividend Coverage			
Constant	.0769 (.000)	.0936 (.000)	.0768 (.000)
STATISTICS			
Coefficient of Determination (R^2)	.462	.393	.473
F-Statistic	14.359	22.328	8.666
Number of Cases	76	76	76

(continued on next page)

TABLE 2.11

VARIABLE*	1978 Individual	Basic	All Inclusive
Moody's Aaa Industrial Bond Yield	1.1790 (.000)	1.1790 (.000)	1.1523 (.000)
Interest Coverage Including AFUDC	-.0026 (.000)	-.0026 (.000)	-.0017 (.023)
Long-term Debt as a Percent of Capitalization			-.0361 (.062)
Quality of Regulation Salomon Borthers			.0003 (.548)
Flow-through/Normalized Accounting Dummy			-.0021 (.229)
Nuclear Generation Dummy			.005 (.575)
Preferred Dividend Coverage			
Constant	.0005 (.976)	.0005 (.976)	-.0174 (.452)
STATISTICS			
Coefficient of Determination (2)	.476	.476	.539
F-Statistic	23.864	23.864	7.591
Number of Cases	65	65	65

(continued on next page)

TABLE 2.11

VARIABLE*	1979 Individual	Basic	All Inclusive
Moody's Aaa Industrial Bond Yield	1.5301 (.000)	1.5608 (.000)	1.5367 (.000)
Interest Coverage Including AFUDC	-.0039 (.000)	-.0043 (.000)	-.0039 (.001)
Long-term Debt as a Percent of Capitalization			-.0080 (.668)
Quality of Regulation Salomon Borthers			.0004 (.508)
Flow-through/Normalized Accounting Dummy			-.0029 (.120)
Nuclear Generation Dummy			.0037 (.011)
Preferred Dividend Coverage			
Constant	-.0234 (.007)	-.0264 (.016)	-.0215 (.139)
STATISTICS			
Coefficient of Determination (2)	.898	.867	.900
F-Statistic	92.872	143.338	45.054
Number of Cases	48	48	48

*The number in parentheses below the estimated coefficient is the significance level.

Source: FINCAP, Inc. An Examination of the Concept of Using Relative Customer Class Risk to Set Target Rates of Return in Electric Cost of Service Studies (Washington, D.C.: ELCON, 1982) Table 10, p. 77.

TABLE 2.12

Preferred Stock Valuation Model

VARIABLE*	Preferred Stock 1977-1979 Pooled
Moody's Aaa Industrial Bond Yield	1.125 (.000)
Interest Coverage Including AFUDC	
Long-term Debt as a Percent of Capitalization	.0753 (.000)
Quality of Regulation Salomon Borthers	.0018 (.002)
Flow-through/Normalized Accounting Dummy	
Nuclear Generation Dummy	
Preferred Dividend Coverage	-.0036 (.010)
Constant	-.0410 (.005)
STATISTICS	
Coefficient of Determination (R^2)	.728
F-Statistic	51.601
Number of Cases	83

*The number in parentheses below the estimated coefficient is the significance level.

Source: FINCAP, Inc. An Examination of the Concept of Using Relative Customer Class Risk to Set Target Rates of Return in Electric Cost of Service Studies (Washington, D.C.: ELCON, 1982) Table 10, p. 77.

TABLE 2.13

Common Equity Security Valuation Models

VARIABLE*	1977 Individual	Basic	All Inclusive
Dividend Yield on Bond Value	7.0193	9.5828	6.8740
	(.000)	(.000)	(.000)
Average 10-Year in Earnings	1.8780	2.4966	1.6599
	(.000)	(.000)	(.000)
Average Return on Common Liquity	1.7599		1.6697
	(.003)		(.004)
Earnings Retention Ratio	-.2273		-.2153
	(.029)		(.040)
Common Dividend Coverage	-.0228	.0085	-.0236
	(.043)	(.353)	(.041)
Common Equity as a Percent			-.1551
of Capitalization			(.388)
AFUDC as a Percent of Net Income	-.1413		-.1526
	(.001)		(.001)
Quality of Regulation			-.0096
Salomon Bros.			(.124)
Gas/Oil Generation Dummy	-.0265		-.0245
	(.052)		(.081)
Nuclear Generation Dummy			-.0088
			(.527)
Flow-through/ Normalized	.0657		.0627
Accounting Dummy	(.000)		(.000)
Constant	.3039	.0977	.4248
	(.000)	(.202)	(.000)
STATISTICS			
Coefficient of Determination	.814	.712	.822
F-Statistic	42.052	67.533	30.996
Number of Cases	100	100	100

(continued on next page)

TABLE 2.13

VARIABLE*	1978 Individual	1978 Basic	1978 All Inclusive
Dividend Yield on Bond Value	9.4251 (.000)	9.6443 (.000)	9.1626 (.000)
Average 10-Year in Earnings	1.7455 (.000)	2.1131 (.000)	1.6158 (.000)
Average Return on Common Liquity			.2109 (.647)
Earnings Retention Ratio			.0225 (.649)
Common Dividend Coverage	.0143 (.011)	.0155 (.013)	.0069 (.364)
Common Equity as a Percent of Capitalization	.2752 (.053)		.2572 (.098)
AFUDC as a Percent of Net Income			-.0044 (.856)
Quality of Regulation Salomon Bros.	-.0167 (.000)		-.0159 (.000)
Gas/Oil Generation Dummy			-.0137 (.116)
Nuclear Generation Dummy			-.0093 (.265)
Flow-through/ Normalized Accounting Dummy			.0156 (.117)
Constant	-.0547 (.463)	-.0396 (.417)	-.0358 (.687)
STATISTICS			
Coefficient of Determination	.890	.859	.902
F-Statistic	141.078	180.794	67.453
Number of Cases	100	100	100

(continued on next page)

TABLE 2.13

VARIABLE*	1979 Individual	1979 Basic	1979 All Inclusive
Dividend Yield on Bond Value	7.9934 (.000)	8.2266 (.000)	8.1992 (.000)
Average 10-Year in Earnings	1.5617 (.000)	1.8379 (.000)	1.6205 (.000)
Average Return on Common Liquity			-.0453 (.907)
Earnings Retention Ratio			.0317 (.601)
Common Dividend Coverage	.0207 (.002)	.0249 (.000)	.0188 (.049)
Common Equity as a Percent of Capitalization	.4029 (.024)		.3628 (.086)
AFUDC as a Percent of Net Income			.0058 (.807)
Quality of Regulation Salomon Bros.			-.0036 (.554)
Gas/Oil Generation Dummy			-.0153 (.202)
Nuclear Generation Dummy	-.0289 (.005)		-.0266 (.019)
Flow-through/ Normalized Accounting Dummy			-.0012 (.924)
Constant	-.1541 (.034)	-.0560 (.303)	-.1443 (.156)
STATISTICS			
Coefficient of Determination	.840	.813	.847
F-Statistic	75.386	102.797	31.701
Number of Cases	100	100	100

*The number in parentheses below the estimated coefficient is the significance level.

Source: FINCAP, Inc. An Examination of the Concept of Using Relative Customer Class Risk to Set Target Rates of Return in Electric Cost of Service Studies (Washington, D.C.: ELCON, 1982) Table 11, p. 78.

TABLE 2.14

Customer Mix and Capital Cost Models

SECURITY VALUATION MODEL	Revenues as a Percentage: Res.	Revenues as a Percentage: Ind.	Revenues as a Percentage: Comm. & Ind.	Revenues as a Quintile: Res.	Revenues as a Quintile: Ind.	Revenues as a Quintile: Comm. & Ind.
<u>Senior Long-Term Debt</u>						
1977 Individual: A	.0112*	.0037		-.0001	.0002	-.0005*
B	.0021		-.0058			
1977 Basic: A	.0101	.0018		.0001	.0000	-.0003
B	.0041		-.0040			
1977 All-Inclusive: A	.0087	.0042		-.0002	.0002	-.0005*
B	-.0006		-.0058			
1978 Individual: A	.0000	-.0062		.0002	.0007*	-.0006
B	.0000		-.0044			
1978 Basic: A	.0000	-.0062		.0002	.0007*	-.0006
B	.0000		-.0044			
1978 All-Inclusive: A	.0000	-.0066		.0000	.0009*	-.0008*
B	.0000		-.0048			
1979 Individual: A	-.0011	.0000		-.0001	-.0003	.0005
B	-.0019		.0000			
1979 Basic: A	.0065	.0000		.0004	.0002	.0001
B	.0067		.0000			
1979 All-Inclusive: A	-.0004	.0000		-.0001	-.0003	.0005
B	-.0008		.0000			
Preferred Stock: A	.0789	.0764		-.0002	.0002	-.0005
B	.0781		.0765			

(continued on next page)

TABLE 2.14

SECURITY VALUATION MODEL	Extreme Low Revenues Res.	Extreme Low Revenues Ind.	Extreme Low Revenues Comm. & Ind.	Extreme High Revenues Res.	Extreme High Revenues Ind.	Extreme High Revenues Comm. & Ind.
<u>Senior Long-Term Debt</u>						
1977 Individual: A	.0004	.0013	.0009	.0005	.0003	.0000*
B						
1977 Basic: A	.0008	.0008	.0005	.0010	-.0000	-.0002
B						
1977 All-Inclusive: A	.0006	.0011	.0009	.0004	.0003	-.0001
B						
1978 Individual: A	-.0002	-.0007	.0005	.0010	.0017	-.0015
B						
1978 Basic: A	-.0002	-.0007	.0005	.0010	.0017	-.0015
B						
1978 All-Inclusive: A	.0000	-.0002	.0010	.0002	.0022	-.0018
B						
1979 Individual: A	-.0025	.0037	-.0057	-.0014	.0020	-.0008
B						
1979 Basic: A	-.0052**	.0036	-.0051	-.0021	.0033	-.0019
B						
1979 All-Inclusive: A	-.0023	.0037	-.0055	-.0012	.0021	-.0008
B						
Preferred Stock: A						
B	.0017	-.0009	-.0003	.0008	-.0001	-.0015

(continued on next page)

TABLE 2.14

SECURITY VALUATION MODEL		Revenues as a Percentage			Revenues as a Quintile		
		Res.	Ind.	Comm. & Ind.	Res.	Ind.	Comm. & Ind.
Common Equity							
1977 Individual:	A	-6.1064*	-6.2096		-.0001	.0014	-.0070
	B	-1.0948		-1.2026			
1977 Basic:	A	-.7479	-.8314		-.0040	.0114	-.0171*
	B	-.2399		-.3083			
1977 All-Inclusive:	A	-5.8871	-6.0666		.0039	.0001	-.0059
	B	-.8178		-1.0007			
1978 Individual:	A	-.5949	-.6719		.0006	.0050	-.0072*
	B	-.6234		-.7036			
1978 Basic:	A	-.6568	-.7149		-.0014	.0064	-.0095*
	B	-.6932		-.7512			
1978 All-Inclusive:	A	-.8350*	-.9815**		.0018	.0024	-.0069
	B	-.8473*		-.9966**			
1979 Individual:	A	.0315	.0769		.0023	.0009	.0043
	B	-.0101		.0402			
1979 Basic:	A	-.0754	-.0243		-.0004	-.0003	.0027
	B	-.1139		-.0570			
1979 All-Inclusive:	A	.1430	.1638		.0037	.0005	.0047
	B	.0768		.1034			

(continued on next page)

TABLE 2.14

SECURITY VALUATION MODEL	Extreme Low Revenues Res.	Extreme Low Revenues Ind.	Extreme Low Revenues Comm. & Ind.	Extreme High Revenues Res.	Extreme High Revenues Ind.	Extreme High Revenues Comm. & Ind.
Common Equity						
1977 Individual: A	.0035	.0130	.0022	-.0123	-.0102	-.0113
B						
1977 Basic: A	.0106	.0231	.0044	-.0336	.0268	-.0456
B						
1977 All-Inclusive: A	-.0036	.0131	-.0071	-.0030	-.0236	-.0060
B						
1978 Individual: A	-.0036	-.0151	.0154	-.0169	.0139	-.0290*
B						
1978 Basic: A	-.0033	-.0129	.0189	-.0212	.0179	-.0325*
B						
1978 All-Inclusive: A	-.0033	-.0159	.0147	-.0096	.0035	-.0280*
B						
1979 Individual: A	.0173	-.0297*	-.0097	.0230	-.0244	.0217
B						
1979 Basic: A	.0163	-.0288	-.0032	.0131	-.0192	.0159
B						
1979 All-Inclusive: A	.0111	-.0390*	-.0183	.0282	-.0352	.0192
B						
Preferred Stock: A						
B						

*Significant at the .05 level.
**Significant at the .01 level.

Source: FINCAP, Inc. An Examination of the Concept of Using Relative Customer Class Risk to Set Target Rates of Return in Electric Cost of Service Studies (Washington, D.C.: ELCON, 1982) Table 12, p. 80.

The authors conclude that:

> In light of the various contradictions and limited number of statistically significant cases in these results, this empirical analysis does not indicate that there exists any identifiable relationship between an electric utility's customer mix and its cost of capital.[28]

In the construction of their model, Avera and Fairchild state that:

> No variable was included in the models which might reflect differences in customer composition (i.e., bond ratings, common stock ratings, and other risk indicators). This precautionary deletion was at the expense of some explanatory power since these variables tend to account for a multitude of factors not incorporated elsewhere. Nonetheless, this caution...assured the customer mix variables ample opportunity to be reflected as statistically significant if they in fact relate to capital costs.[29]

Despite this precaution, the authors overlook the potential endogeneity of many of the financial variables included in the model. For example, while the stock price is hypothesized to depend on the capitalization ratio, the capitalization ratio by definition is a function of the stock price.[30] In the analysis in Chapter 6, the financial variables are excluded from the model to remove the

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[28] FINCAP, p. 81.

[29] Ibid., pp. 75-76.

[30] For a discussion of the interrelatedness of financial variables, see for example Burton Malkiel (1970). For a discussion of the problems associated with the use of the debt-equity ratio, see A. Barges, The Effect of Capital Structure on the Cost of Capital (Englewood Cliffs, NJ: Prentice-Hall, 1965).

possibility of endogeneity.

2.3.2 A Review of State Regulatory Proceedings

Beginning in 1980, testimony on the relationship between capital cost and customer mix began to appear with regularity in state regulatory proceedings. Typically, the testimony followed the lead of Brennan and ignored the work, such as the FINCAP report, which did not support the Brennan hypothesis. Testimony presented by Kenneth A. Hagstrom in Minnesota Docket No. E015/GR-80-76, regarding customer class and rate of return typified this work.[31]

The hypothesis put forth by Hagstrom states that:

> An individual customer class' *consumption* [of electricity] and *profitability* affects *the revenue and earnings* of the *utility*. *The* greater the uncertainty *associated* with a customer class' *sales and earnings* the greater the relative risk of that *class*.[32] (emphasis added)

Inherent in Hagstrom's hypothesis is the assumption that the variability of sales and revenue mirrors the variability of earnings. If regulatory rate design successfully shields the utility from consumption variability and if costs vary directly with consumption, then earnings variability may be only weakly related to revenue or sales variability. Hagstrom provides no evidence to support the

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[31]Minnesota Public Service Commission, Docket No. E015/GR-80-76, Testimony of Kenneth A. Hagstrom.

[32]Ibid., p. 7.

inherent assumption that the variability of earnings is strongly and directly related to the variability of either sales or revenues.

Hagstrom examines the relative risk of customer classes of Minnesota Power and Light Company by examining total energy consumption (MWh) and total demand (kW) by customer class, energy consumption per customer and the trend growth of energy consumption over eight years. Based on his examination, Hagstrom testified that the large power class is more risky because:

> Each Large Power customer has almost as much potential impact as any class in the system. There are so few Large Power customers that variation in the energy usage or demand of any one of them can create significant variance in total company energy sales or demand.[33]

In addition, Hagstrom contends that "take-or-pay" provisions, demand ratchets and minimum bills do not insulate the utility from risk.[34]

In testimony presented on behalf of the Staff of the Public

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[33]Ibid., p. 9.

[34]Take-or-pay provisions, demand ratchets and minimum bills are techniques used by utilities to stabilize the revenue flow from a particular customer. A take-or-pay provision requires the customer to pay for a minimum amount of electic usage (usually stated as a percent of the contract quantity) even if power is not taken.

Demand ratchets are used to determine the level of billing demand. Many utilities, for example, base their rates on the customer's maximum hourly usage during the current and preceding eleven months.

A minimum bill provision, like a take-or-pay provision, establishes a minimum monthly charge. Minimum bills vary widely across utilities and tend to be less onerous than take-or-pay provisions.

Service Commission of the State of Delaware in D.P.S.C. Docket No. 81-12, A. Gerald Harris provided new supporting evidence for the theoretical hypothesis that Brennan had put forth earlier.[35] For each general class of service, Harris regressed the before-tax cost of capital -- computed using a discounted cash flow model -- on class revenue as a percent of total revenue, allowance for funds used during construction as a percent of total revenue and total capital. The data set consisted of 49 privately-owned utilities for the year 1978. Harris' regression results indicated that the coefficient of relative industrial revenues is larger than the corresponding coefficients on relative commercial or residential sales. Based on this, Harris concluded that industrial customers are relatively more risky.

The Harris results, however, are based on a model that suffers from two basic problems. First, the data for the percent class revenue variables is drawn from the Edison Electric Institute's Uniform Statistical Report. Utilities may report the data as either Residential/Commercial/Industrial or Residential/Small Light and Power/Large Light and Power. In his rebuttal testimony in the above titled Docket, Paul S. Gerritsen of Delmarva Power and Light Company

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[35]Joseph Brennan and A. Gerald Harris, On Class Rate of Return Differentials by Customer Class for Electric Utility Services Rendered by Delmarva Power and Light Company: A Report to the Delaware Public Service Commission, 1981.

explains the potential problem:

> From Mr. Harris' own data we can see an apparent classification difference: Consider Philadelphia Electric with 14% Commercial revenue and Boston Edison with 49.8% Commercial revenue. Both are utilities serving major metropolitan areas of similar population. One would expect not to find a variation of from 14% to 49.8% for 'commercial' revenue mix for these two utilities. I called my counterparts at PE and Boston Ed and discovered that their classifications are entirely different; suspicions confirmed. PE chooses that 'small/large' option and includes in the 'large' group, or the 'industrial' class as Mr. Harris has used it, the revenues from all customers served on two rates, 'PD' and 'HT', whether they are commercial, industrial or other, and places secondary voltage level users regardless of size in the 'small' group, or the 'commercial' class as Mr. Harris has used it. On the other hand, Boston Edison uses the 'commercial' and 'industrial' SIC code revenue class breakdowns, without regard to size or voltage level.[36]

Because the data used by Harris are not defined consistently across utilities, the results must be interpreted cautiously.[37]

In conjunction with their reporting of class revenue data, most utilities identify industrial revenues and consumption by Standard Industrial Classification (SIC) codes. The SIC code data for mining and manufacturing industries can be used to define industrial

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[36]Delaware Public Service Commission, Docket No. 81-12, Testimony of Paul Gerritsen.

[37]In general, the measurement error associated with the independent variables biases toward zero the estimated coefficients. (See, for example Levi (1973).) In this case, however, a consistently defined measure of customer class mix is available. This variable is discussed at greater length in Chapter 5. For a further discussion of errors in variables see Gujarati (1978), Chapter 15.

revenues and to assure that all utilities have comparable industrial class definitions.

The second problem associated with Harris' evidence is the specification of the regression equations. To avoid the potential perfect multicollinearity problems associated with the use of the three percentage-class-revenue variables in a single equation, Harris specified separate equations for each customer class. The elimination of the other classes from an equation, however, may bias the individual class results.[38]

A more tenable solution to the perfect multicollinearity problem is the elimination of a class of service variable. In the analysis in Chapter 6, the commercial class is eliminated from the analysis to avoid the perfect multicollinearity problem. In addition, customer-mix variables based on extreme customer mixes are introduced into the analysis.

Determination of the appropriate rate of return differential is only the first step in the regulatory application. The differential or "multiplier" must be applied to the return on equity or the return on assets to determine the appropriate class rate of return. Brennan, et al., apply the differential to the overall rate of return

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[38]The percentage used by Harris does not sum to 1.00, because the Other Class, lighting and sales for resales, has been eliminated.

on assets. Richard Laurito, in testimony before the Washington Utilities and Transportation Commission, argues that the differential should be applied only to the risk premium on the company's common equity return. He states that:

> The application of a class covariance index to the before-tax overall rate of return a Commission finds reasonable, as Mr. Harris would have us do, contains an implicit assumption that is patently false. The assumption is that 100% of the before-tax overall rate of return represents compensation for risk.[39]

Charles Spencer and Ruth Maddigna (1983)[40] investigate the percent of the overall return which is compensation for business risk. They conclude that:

> ...[I]t would appear that business risk is responsible for approximately one percent of total nonmarket risk. Its percentage of the sum of market and nonmarket risk would naturally be even lower.[41]

Building on the arguments of Laurito and the findings of Spencer and Maddigna, if differential risk is found to exist among customer classes, it must be applied in a manner consistent with the definition of business risk. Therefore, while accepting the Brennan hypothesis that different customer classes impose differing risk,

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[39]Washington Utilities and Transportation Commission, Cause No. U-83-26, Direct testimony of Richard Laurito, p. 7.

[40]Charles Spencer and Ruth Maddigna, "On Customer Class Rate of Return Differentials," <u>Public Utilities Fornightly</u>, Vol. 112, No. 12 (1983), pp. 19-25.

[41]Ibid., p. 25.

Spencer and Maddiqna conclude that:

> Taken in the context that business risk appears to be only approximately one percent of total risk, the justification for unequal marqins is considerably less than earlier studies suqqest. Based on this analysis, there is no justification for more than 5 percent variation in the rates of return of the three customer classes being studied.[42]

Thus, while some authors may find support for a risk differential, their evidence does not justify the large differentials in the class rates of return proposed by Brennan.

Overall, the empirical analysis presented in the trade journals and state regulatory proceedings presents inconclusive and conflicting results. In general, however, the models exhibit basic structural problems which limit their effectiveness. The empirical model presented in Chapter 6 attempts to correct problems with the construction of the dependent variable, the selection of the independent variables and the consistency of the customer-mix variables.

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[42]Ibid., p. 25.

CHAPTER 3

THE SUPPLY OF ELECTRICITY AND THE STRUCTURE OF PRICES

The framework of utility regulation introduced in Chapter 1 recognizes that regulators must determine the total cost associated with the production of electricity and the design of tariffs. The difficulty of tariff design arises because of the unique characteristics of electric utilities. First, up to that level of usage at which capacity places a constraint on output, the utility experiences decreasing average costs. Second, because customer classes exhibit different usage characteristics, a utility can be characterized as a multiproduct monopoly. This chapter reviews the current state of the theory of electric utility pricing.[1] The first section examines the constraints on marginal cost pricing and the development of a second-best solution. The second section describes the development of nonuniform two-part tariffs. The third section focuses on pricing for the multiproduct firm with particular emphasis on cross-subsidization and the emergence of a zero-subsidy tariff. The final section relates the pricing problem to the issues discussed in Chapter 2.

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[1]This chapter draws heavily on Eckel (1983), Crew and Kleindorfer (1979) and Brown and Sibley (1986).

3.1 Constrained Optimal Pricing

For an electric utility unemcumbered by a revenue constraint, maximization of the social welfare function leads to a marginal cost pricing solution.[2] This familiar result, which is necessary for an efficient outcome in a competitive market, exhibits a significant shortcoming in the framework of a natural monopoly. Because average cost is greater than marginal cost over the relevant range of outputs, marginal cost pricing will lead to a revenue deficit. This introduces new difficulties into the maximization problem. Hotelling (1938) suggests offsetting the deficit through a non-distorting tax levied on the customers of the natural monopoly. The viability of this solution depends on the identification of both a non-distorting tax and the customers of the monopoly, because the allocative distortions resulting from a nonneutral tax may be more severe than those produced by simple average cost pricing. Given the constraint that total revenue equal total cost, a second-best solution is required.[3]

The second-best pricing rules generally rely on one of two constraints: (1) The total revenue level is constrained to cover

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[2]The unconstrained welfare maximization problem is developed from earlier work, for example, Willig (1976), Kaldor (1939), and Hotelling (1938).

[3]For a discussion of the second-best solution see Lipsey and Lancaster (1956).

total cost or (2) the total revenue level is constrained to yield a "fair" rate of return. Under the first framework, the second-best solution is found by maximizing the social welfare function subject to a break-even constraint. As demonstrated by Baumol and Bradford (1970), the resulting second-best price produces a proportional reduction from the welfare-maximizing level for each consumer. The amount of deviation from marginal cost is based on the price elasticity of demand, following Ramsey's earlier development of an optimal excise tax.[4] The last is the so-called inverse elasticty rule which says that the percentage deviation of price from marginal cost should be inversely proportional to elasticity.

The intuitive rationale for the elasticity rule is that in achieving a required level of profit in a welfare optimal fashion those prices ought to be raised the most which least distort the resulting output pattern from the socially efficient pattern obtainable through marginal-cost pricing. This suggests that contributions toward covering the deficit should be extracted more from products with inelastic demands than from those which are more price sensitive.[5]

It is important to note that the simple Ramsey inverse

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[4]Ramsey (1926).

[5]Crew and Kleindorfer (1979), p. 17.

elasticity rule does not hold as the model becomes increasingly sophisticated and cross-elasticities become more important. In particular, if the price markup for a particular good will cause large distortions in other markets, then a low markup is preferred irrespective of the price elasticity of demand.[6]

Alternatively, the total revenue of the welfare-maximizing utility can be constrained to produce a "fair" return as established by regulators (see, for example, Marino 1981). The Baumol-Bradford break-even constraint and Marino's fair return constraint will produce identical results when the allowed rate of return equals the cost of capital. This approach, however, may produce incentives for managers of the utility to use resources inefficiently in order to limit the earned return.[7]

Numerous authors have provided extensions of the constrained maximization problem addressed by Boiteux (1964) and (1971) and Baumol and Bradford. See for example Diamond and Mirlees (1971a) and (1971b), Diamond (1975), Hartwick (1978), Feldstein (1972a), Munk (1977) and Guesnerie (1980).

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[6]Brown and Sibley (1986) discuss this problem in Chapter 3, pp. 39-41.

[7]For a discussion of x-inefficiency see Leibenstein (1970).

3.2 Nonuniform Tariffs

A two-part tariff consisting of an entry fee and a usage fee provides an alternate to the inverse elasticity solution. Oi (1971) derives the optimal two-part tariff for a profit-maximizing price-discriminating monopolist. In this model, price is set equal to marginal cost and the entry fee is designed to extract all of the consumer surplus. If the monopolist is limited to a uniform entry fee, however, their price per unit may deviate from marginal cost. In addition, some consumers will be excluded from the market.

Extensions of Oi which focus on maximizing welfare instead of profit also find that price may deviate from marginal cost under a two-part tariff. In Feldstein (1972b), the second-best two-part tariff yields an optimal marginal price proportional to and greater than marginal cost. The deviation from marginal cost depends on price elasticity of demand and distributional considerations. In Ng and Weisser (1974), price generally will exceed marginal cost. Only if the number of consumers is price inelastic will marginal price and marginal cost be equal. Sherman and Visscher (1982) provide a further extension of Ng and Weisser. Based on relative elasticities with respect to the entry fee and the marginal price, they conclude that the entry fee will be increased more than the marginal price under a break-even constraint. In Schmalensee (1981b), a general model incorporating consumer diversity and income effects examines the two-part tariff when the end-users are firms. His results imply that "either the fixed or the variable input price can exceed or fall short of marginal cost, but neither will be negative."[8] Generally, the work of these authors supports the conclusion that the optimal two-part tariff may not yield marginal-cost pricing of marginal units.

3.3 Zero-Subsidy Pricing

As discussed above, an electric utility is a multiproduct firm engaged in the production of non-homogeneous outputs (e.g., summer consumption and winter consumption) for various customer groups. Baumol (1977) demonstrates that a multiproduct firm is a natural monopoly if its cost function is strictly subadditive. In other words, declining cost is not necessary or sufficient for natural monopoly for a multiproduct firm. Strict subadditivity implies that the cost function exhibits economies of joint production such that the cost of supplying electricity through a single supplier to two or more customer groups is less than the total cost of supplying electricity to each group separately. Faulhaber (1975) uses a similar concept to define subsidy-free pricing:

> If the provision of any commodity (or group of commodities) by a multicommodity enterprise subject to a

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[8]Eckel (1981), p. 18.

profit constraint leads to prices for the other commodities no higher than they would pay by themselves, then the price structure is subsidy-free.[9]

While economists have focused on the efficiency considerations inherent in the development of optimal nonuniform or second-best tariffs, policy makers have focused on the equity of price structures. They ask the question:

> Does a proposed price structure for the multicommodity enterprise "unduly" favor the consumers of one commodity at the expense of the purchasers of another commodity, i.e., does the price structure result in cross-subsidy?[10]

The cooperative game developed by Faulhaber examines the conditions required to achieve subsidy-free pricing and permits a comparison of the zero-subsidy price solution and the welfare-maximizing solution.

In Faulhaber's model, the cost of joint production $C(q^{S+T})$ is at most equal to the cost of separate production $C(q^S) + C(q^T)$ for all levels of output.[11] When the inequality is strict, a single producer is the most efficient production method. The policy maker, therefore, is interested in the set of prices that will perserve the "coalition of the whole." In other words, the price must be set to remove the incentive for any customer group to defect and attempt to

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[9]Faulhaber (1975), p. 966.

[10]Ibid.

[11]This is a restatement of the subadditivity condition. Faulhaber also assumes that utility profits are constrained to zero.

"stand alone." Intuitively, when there are economies of joint production, a price structure that distributes these economies to all customers will induce all customer groups to remain a part of the whole. On the other hand, if policy makers establish prices exhibiting cross-subsidies and if entry into the market is possible, then some coalitions of customers will have the incentive to identify an alternative entrepreneur willing to supply their electric requirements.

In the context of current policy discussions, two customer groups can be identified: captured customers and cogenerators. Captured customers are typically residential and small commercial customer which are prohibitively expensive to serve on a stand alone basis. The cogenerators, especially industrial customers who use as an input to their production process, have identified an alternate supplier and can leave the system if they perceive that regulators are forcing them to subsidize the consumption of other customer groups. Because they no longer contribute to the payment of joint costs, the total cost that must be met by the captured customers, given a revenue constraint, will be higher. This may lead to further customer defections. For policy makers concerned about the cost of electricity for the captured customer, the incentive is great to keep the system "whole."

The outcomes of the second-best solution and the zero-subsidy pricing solution may be incompatible. The Baumol-Bradford result, for example, depends upon marginal cost and demand elasticities and explicitly prohibits entry into the market. The model emphasizes distributional considerations. The zero-subsidy model assumes that entry is possible; a more realistic assumption following the passage of The Public Utility Regulatory Policy Act. The zero-subsidy model emphasizes the elimination of inefficient production processes and ignores welfare considerations. Policy makers must balance the two objectives. The discussion in Chapter 2, however, demonstrates the importance placed on zero-subsidy pricing by regulators and intervenors.

3.4 Conclusions

The development of subsidy-free prices holds important implications for the pricing of electric utility output by customer classes. If the hypothesis of Brennan, et al., is incorrect and the industrial class is not more risky to serve, then the stand-alone cost for industrial customers is lower than suggested by Brennan. Thus, a cross-subsidy may occur if this customer class is expected to assume an arbitrarily greater share of the joint cost of risk.[12] If

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[12]Meyer (1976) further demonstrates that the structure of pricing under risk depends on the marginal risk contributed by each group of customers. He concludes that customers who exhibit lower marginal risk should pay lower prices. Thus, if the industrial class exhibits below average marginal risk, then they should contribute a lower revenue relative to marginal cost.

this cross-subsidy induces some customers to leave the system, then the share of the cost of risk bourne by remaining customers will rise.[13] If an objective of regulators is to keep the system "whole," then arbitrary cross-subsidies based on hypothesized risk differences are self-defeating.

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[13]If the industrial class exhibits below average marginal risk, then defection of the class to an alternate supplier may increase the total risk of the utility. The share of cost that must be bourne by nondefecting customers will increase because the fixed cost of risk is being spread over a smaller number of customers and because the total cost of risk increases with the defection of the industrial class.

CHAPTER 4

AN EXTENSION OF THE SHARPE-LINTNER MODEL TO ELECTRIC UTILITIES COST OF CAPITAL

Drawing upon the theoretical foundations discussed in Chapters 2 and 3, this chapter extends the basic financial model developed by Sharpe and Lintner to explain the relative rates of return allowed electric utilities. The first section discusses the assumptions and definitions underlying the model. For convenience, we rely upon the simplest version of the Sharpe-Lintner model. The second section develops the model and discusses its theoretical implications. The final section develops the empirical model.

4.1 Electric Utilities and Investor Behavior

An electric utility is assumed to be an investor-owned enterprise providing electric service under the authority of at least one regulatory agency. The utility is assumed to engage in both the production and distribution of electricity, though a portion of its power may be obtained through purchases. The utility is assumed to conduct business in a variety of markets. These markets include electric service rendered to the retail customer classes; the sale of electricity for resale, such as the sale of power to distribution companies; related electric sales, such as electric appliance sales and service; and nonelectric revenues, such as cable television and natural gas franchises and the mining of gas, coal and lignite.

The retail customer classes that the utility serves are differentiated by their power usage patterns. These different classes consist of residential, commercial, and industrial and municipal customers. At one extreme, the residential class exhibits low use per customer, low load factors and generally takes service at low voltage levels. At the other extreme, the industrial class exhibits high use per customer, high load factors and takes service at high voltage levels.[1] Generally, the consumption pattern of the residential class is relatively more seasonal, while the industrial class follows a relatively more cyclical pattern. Small commercial customers, such as retail stores, tend to exhibit usage patterns similar to residential customers, while larger commercial customers, such as hospitals, tend to exhibit usage patterns similar to industrial users.

For simplicity, we rely upon the assumptions underlying the models of Sharpe and Lintner which were enumerated in Chapter 2. These assumptions are restated below:

(1) Investors are assumed to be single-period expected utility of terminal wealth maximizers who choose among alternative portfolios based on the expected mean and standard deviation of returns;

(2) Investors can borrow or lend an unlimited amount at the exogenous risk-free rate of interest, R_f;

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[1]Load factor equals the ratio of the average usage for a time period and the maximum usage for the period. The load factor provides a measure of the constancy of usage.

(3) All investors have homogeneous expectations of the mean, standard deviation and covariance of returns;

(4) All assets are marketable and there are no transactions costs;

(5) There are no taxes;

(6) All investors are price-takers; and

(7) The quantities of all assets are given.

While the assumptions are very restrictive, relaxation does not alter significantly the basic conclusion that the relevant measure of risk for individual securities is the asset's covariance with the market portfolio.

The trade-off between return and risk follows from the utility-maximizing behavior of investors. Following Markowitz, wealth-maximizing, risk-averse investors are assumed to maximize their utility by choosing those investments that exhibit the highest expected return given their risk class or equivalently, those investments that exhibit the lowest possible risk given their expected return. These investors seek to maximize the utility function

4.1 $EU = f[ER_k, \sigma_k]$,

that is, expected utility, EU, is a function of the expected return, ER_k, and risk, σ, of investment k.

The expected return of the investment is the sum of the products of the possible returns times their respective probabilities; that is, the expected return is a measure of the average or central tendency of returns. The expected return for investment k is defined by

$$4.2 \quad ER_k = \sum_i R_{ik}\delta_i,$$

where R_{ik} is the expected return of investment k given the i^{th} state of the economy, and δ_i is the probability associated with the occurence of the i^{th} possible state of the economy.

In general terms, risk is defined as the "possibility of suffering harm or loss."[2] For the investor, risk measures the probability that the earned return from an investment will deviate from the expected return. In other words,

> The wideness of a probability distribution of rates of return is a measure of uncertainty or risk. That is, the more an investment's return varies, around its expected return, the larger is the investor's uncertainty.[3]

Therefore, an increase in the width of the probability distribution of returns signals an increase in the perceived riskiness of the investment.

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[2]Henry Bosley Woolf, Editor in Chief, Webster's New Collegiate Dictionary (Springfield, MS: G. & C. Merriam Company, 1979), p. 992.

[3]Jack Francis Clark, Investment, Analysis and Management, (St. Louis: McGraw-Hill Book Company, 1972), p. 313.

The standard deviation provides a quantitative measure of the riskiness of an investment, where the total risk is defined as

4.3 $\sigma_k = [\sum_i \{R_{ik} - ER_{ik}\}^2 \delta_i]^{1/2}$,

and R_k is the standard deviation of returns from investment k. The standard deviation measures the <u>total</u> risk associated with the investment in asset k.

4.2 Measuring the Security's Systematic Risk

As discussed in Chapter 2, the total risk of any investment can be dichotomized into systematic and nonsystematic risk. Systematic risk is "that portion of the variability of an individual security's return that is caused by factors affecting the market as a whole."[4] Systematic risk is sometimes referred to as nondiversifiable risk, because systematic risk cannot be reduced by holding a diversified portfolio. Mathematically, systematic risk is measured by the covariance between the return of an individual security and the return of the market portfolio. This result is derived below.[5]

For an efficient portfolio P, the expected return is calculated

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[4]R. Charles Moyer, James R. McGuigan, and William J. Kretlow, <u>Contenporary Financial Management</u>, 2nd Edition, (New York: West Publishing Company, 1984), p. 115.

[5]This discussion follows the development found in Jensen (1972).

as the weighted average of the expected individual security returns, where the weights are the proportion of funds invested in each security. That is,

$$4.4 \quad ER_p = \sum_K X_K ER_K + (1-\sum_K X_K)R_f$$

where ER_p is the expected return of the portfolio p, ER_k is the expected return of the k^{th} risky security, X_k is the proportion of investor's total funds that are invested in security k, and R_f is the return of the risk-free asset.[6] The risk of the portfolio is defined by its standard deviation:

$$4.5 \quad \sigma_p = [\sum_j \sum_k x_j x_k \, cov_{jk}]^{1/2},$$

where σ_p is the risk of the portfolio.[7]

While the total risk given by equation 4.3 is relevant to an investor holding a single security, the investor holding a diversified portfolio judges a security on the basis of its marginal contribution to the riskiness of a portfolio of investments. To derive the marginal risk of the k^{th} security, we examine the change

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[6]The expected return on the portfolio can be expressed as a weighted average of the returns of the market portfolio and the risk-free asset. Let $\lambda_K = h_K/\Sigma h_K$ be the proportion of asset k in the market portfolio. The the return on the market portfolio equals $ER_m = \lambda_K ER_K$. Then equation (4.4) can be written as $ER_p = \alpha + ER_m + (1-\alpha) + R_f$, where $\alpha = \Sigma h_K$.

[7]From footnote 6, it follows that $R_p = \alpha * \sigma_m$.

in expected return and standard deviation of the portfolio as the investor increases the investment in security k, while decreasing the investment in the risk-free asset.

Taking the derivative of the investor's preference function (Equation 4.1) with respect to the weight x_K under the assumption that the investor is currently maximizing utility yields the equation

$$4.6 \quad \frac{\partial U}{\partial ER_p} \cdot \frac{\partial ER_p}{\partial x_K} + \frac{\partial U}{\partial \sigma_p} \cdot \frac{\partial \sigma_p}{\partial x_K} = 0.$$

From Chapter 2, we know that the slope of the indifference curve must equal the slope of the capital market line. Setting the marginal rate of substitution of risk for return,

$$\theta = - [\frac{\partial U}{\partial \sigma_p}] \ / \ [\frac{\partial U}{\partial E_p}]$$

equal to the slope of the capital market line yields

$$4.7 \quad \frac{\partial ER_p}{\partial x_K} = \theta \frac{\partial \sigma_p}{\partial x_K}.$$

Taking the derivatives of equation 4.4 and 4.5, we can rewrite 4.7 as

$$4.8 \quad ER_K - R_f = \theta \frac{cov_{km}}{\sigma_m}.$$

Rearranging terms yields the definition of the expected return of an individual security[8]

4.9 $ER_K = R_f + \Theta = R_{ct}\ \Theta\ rho_{km}\ \sigma_k.$

Equation 4.9 defines the expected return on asset K as a function of the market risk premium,

$$[ER_m - R_f]/\sigma R_m,$$

weighted by the relative covariance of asset k's return with the market. Therefore, the relative required return for an electric utility security is a function of both its correlation with the market return and its standard deviation. Factors which influence the sensitivity of a utility's return to market fluctuations are discussed in the next section where the estimating equation is derived.

4.3 Development of the Empirical Model

As discussed above, the expected return from a given security is

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[8]Taking the derivative of equation 4.4 yields the equation

$$\frac{\partial ER_p}{\partial h_k} = ER_k - R_f.$$

Taking the derivative of equation 4.5 yields the equation

$$\frac{\partial sR_p}{\partial h_k} = \sum_k x_K cov(R_j R_k)/\sigma R_p.$$

Rewriting the numerator as

$$\sum_K x_K cov(R_j R_k) = cov(R_j, \sum_K x_K R_k)$$

allows simplification of the equation to

$$\frac{\partial \sigma_p}{\partial h_k} = a\ cov(R_j R_m)/a\sigma_m$$

$$= cov(R_j R_m)/\sigma_m.$$

a function of the security's systematic risk or market sensitivity. The capital asset pricing model (CAPM) defines the expected return on asset K as

4.10 $R_K = \beta_0 + \beta_{1K}\phi_K + e_K$,

where the intercept term, β_0, equals the risk-free rate, ϕ equals the risk premium on the market portfolio, β_{1K} is an estimate of market sensitivity or systematic risk of investment k, and the error term, e_k, is a measure of the nonsystematic risk of investment k. Equation 4.10 defines the security market line (SML) for asset k.

If investors base their expectation of the return of asset k on equation 4.10, then the factor or factors that influence the sensitivity of the individual security's return to market fluctuations become important. Building from the CAPM, the arbitrage pricing theory (APT) expresses systematic risk as a function of sensitivity factors.[9] For the electric utility industry, the sensitivity factors are those features of electric utility operation and environment which increase the relative sensitivity of a given utility's return to general market movements. For example, a utility in the midst of a construction program is more sensitive to changes

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[9]For an introduction to APT, see Richard Roll and Stephen Ross, "Regulation, the Capital Asset Pricing Model and the Arbitrage Pricing Theory," Public Utilities Fortnightly, May 26, 1983, 22-28.

in the cost of debt-financing than its counterparts with little or no construction.

Following the APT, the return on a stock is given by the equation

4.11 $R_K = ER + \sum_i \beta_{ik} F_{ik} + e_k$,

where R_k is the expected return of utility k, ER is the expected return on electric utilities' stock, F_i is a vector of sensitivity factors that determine the level of systematic risk and e_k is the idiosyncratic or nonsystematic risk. The estimated factor betas, β_{ik}, measure the sensitivity of a given utility k to changes in the factors F_i.

In this study, the sensitivity factors include regulatory environment, nuclear activity, generation mix and customer mix. Each of these factors measures an aspect of a utility's operation that influences it covariance with the market. For example, if the investor perceives the regulatory environment to be above average, then the actions of the commission should dampen the covariance between the utility and the market. In other words, an above average regulatory environment is expected to reduce the utility's systematic risk. Utilities engaged in the construction and operation of nuclear plants, on the other hand, are expected to exhibit higher systematic risk.

The alternative hypothesis developed above in Chapter 1 states that investors require a lower rate of return if the utility's customer mix is skewed toward residential customers and a higher ratio of return if the utility's customer mix is skewed toward industrial customers. In other words, a greater proportion of residential customers, that is, customers exhibiting seasonal rather than cyclical usage patterns, is expected to reduce the utility's systematic risk. A higher percentage of industrial customers, that is, customers exhibiting a cyclical consumption pattern, is expected to increase the utility's correlation with the market.

Table 4.1 lists the sensitivity factors adopted for this analysis. The second column lists the expected impact of the sensitivity factors. As discussed above, improvements in the quality of regulation are expected to reduce systematic risk; the required return is expected to decline as the regulatory environment improves. Nuclear operation and construction are expected to produce increases in systematic risk; therefore the required return is expected to increase with increases in nuclear involvement. Dependence on natural gas also is expected to increase the systematic risk; therefore the required return is expected to increase with increased dependence on natural gas. Finally, a predominantly residential customer mix should reduce systematic risk, while a predominantly industrial customer mix should increase systematic risk. Therefore, a utility's required return is expected to increase as the customer

TABLE 4.1

Electric Utility Specific Sensitivity Factors

Sensitivity Factor	Expected Sign
Quality of Regulation	Negative
Nuclear Activity	Positive
Generation Mix	Positive
Customer Class Mix:	
Residential	Negative
Industrial	Positive

mix shifts from predominantly residential to predominantly industrial. The variables used to measure the sensitivity factors are introduced in Chapter 5.

CHAPTER 5

DISCUSSION OF THE DATA

This chapter describes the estimating equation developed from the discussion in Chapter 4, the individual variables included in the model and the construction of the data set. After a brief discussion of the estimating equation, the chapter is divided into four broad sections. The first section discusses the dependent variable. This section describes both the dependent variable used in the FINCAP model and an alternate dependent variable. Section 5.3 addresses the customer mix variables developed for this study. Section 5.4 describes the independent variables. This discussion describes both the variables used in the FINCAP model and additional variables. Finally, Section 5.5 discusses the construction of the data set.

5.1 The Estimating Equation

The estimating equation is:

5.1 $$ER_K = ER + B_1Req + B_2Nuke + B_3Gen + B_4Cust + e_K,$$

where

ER_K is a measure of utility k's expected cost of capital;

ER is the expected average cost of capital of electric utilities;

Req is a measure of regulatory quality;

Nuke is a measure of nuclear exposure;

Gen is a measure of generating mix;

Cust is a measure of customer mix; and

e_K is a measure of idiosyncratic risk and noise.

Four variables are used to measure exposure to regulatory risk. They include two quality rankings produced by the Value Line Investment Survey, a measure of accounting treatment and firm size. Nuclear exposure is measured by the size of the company's nuclear construction project. Two variables are used to measure the company's generation mix; these variables measure the dependence of the utility's generation on natural gas or nuclear fuel. Finally, four variables are used to measure customer mix. All of the variables are discussed in more detail in Section 5.3.

5.2 Dependent Variables

Numerous dependent variables have been used in past customer mix analyses. The variables fall into three broad categories: published risk measures,[1] the market to book ratio, and the required return on common equity calculated using the discounted cash flow model (DCF). The analysis performed by Brennan and Harris relied upon published risk measures and, in a single instance, a DCF cost of equity

[1]Published risk measures include Moody's Bond Rating, Standard and Poor's Bond Rating, Duff and Phelps Bond Rating, Standard and Poor's Common Stock Ranking, Value Line Financial Strength, Beta, Price Stability Index and Earnings Predictability Index.

calculation.[2] The FINCAP model used published risk measures and the market-to-book ratio.

While the published risk measures are widely used and readily available, they exhibit three major drawbacks. First, the techniques used to calculate the published measures are not defined clearly; the exact criteria used to establish a utility's common stock or bond ranking is unknown. Second, the rankings include a subjective element. For example, the beta calculations performed by Value Line are adjusted before publication and bond rating agencies acknowledge the inclusion of a subjective element in the awarding of bond ratings. Third, the ratings provide only a broad definition of risk. To avoid the potential distortions associated with the published measures, this analysis relies upon a weighted-average measure of the cost of capital. In addition, the market-to-book ratio is used in the reestimation of the FINCAP models.

5.2.1 Market-to-Book Ratio

The market-to-book (MTB) ratio is the ratio of the market value or current selling price of the firm's outstanding common stock relative to the book value of equity. The market value of the stock is assumed to equal the present value of the expected cash flow to

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[2]Harris used a cost of capital variable in testimony before the Delaware PSC in Docket No. 81-12.

stockholders discounted at the current cost of capital associated with the stock's risk level.[3] Equation 5.2 summarizes this relationship.

$$5.2 \quad \text{Market Value (MV)} = \sum_{t=1}^{\infty} [CF_t/(1-k)^t]$$

where CF_t is the cash flow per share to stockholders in period t and k is the cost of capital.[4]

Using two simplifying assumptions, the relationship between the expected return on equity and the allowed return on equity (the cost of capital) can be derived. First, the utility is assumed to be in a no growth steady state; i.e., all earnings are paid out as dividends, and depreciation allowances are sufficient to enable the utility to maintain its capital equipment. Under this assumption, earnings per share (E) equals cash flow for dividends per share (CF). Further, this assumption allows forecasted dividends to be treated as perpetual annuities. Second, the regulatory rate base is assumed to equal the net book value of assets.[5]

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[3]Moyer, et al., pp. 94-99.

[4]The cash flow per share or dividend per share equals earnings per share times the dividend payout ratio. The relationship is discussed in greater detail in the section on the discounted cash flow model.

[5]The equality depends on accounting and rate base conventions adopted by individual commissions.

Invoking the first assumption that dividends are perceived as a perpetual annuity, equation 5.2 can be rewritten as

5.3 $MV = CF/k$.

Under the assumption that rate base (RB) equals book value (BV), then earnings (E) equals the product of the overall rate of return allowed by regulators (r), and the utility's rate base, i.e.,

5.4 $E = r * RB = r*BV$.

Finally, because all earnings are paid out as dividends, equation 5.4 can be rewritten as

5.5 $CF = r * BV$.

Substituting from 5.5 into equation 5.3 yields

5.6 $MV = (r * BV)/k$.

Rearranging terms yields

5.7 $MV/BV = r/k$.

In other words, the market-to-book ratio equals the ratio of the allowed return on equity to the required return on equity.

When the market-to-book ratio equals one, the expected return on the book value of equity equals the cost of capital. When the market-to-book ratio exceeds one, the allowed return, r, exceeds the required cost of common equity capital, k. When the market-to-book ratio is less than one, the required cost-of-common equity capital exceeds the allowed return. Equation 5.8 summarizes the relationship:

$$5.8 \quad \text{if } MV/BV \gtrless 1, \text{ then } r \gtrless k.$$

In reality, almost all of the assumptions which underly the market-to-book ratio discussion are violated. Utilities do not payout all of their earnings in dividends, the book value of assets for a regulated firm does not equal the rate base and debt-financing is used. All of these factors impact the calculated market-to-book value for an individual firm and render the measure less suitable as a proxy for the cost of capital.

The market-to-book ratio is used as the dependent variable in the FINCAP model under the very stringent assumptions that (1) regulators do not recognize customer mix as a determinant of the cost of capital and (2) regulators attempt to set the allowed rate of return such that the market-to-book ratio equals at least one. If investors perceive customer mix to be an important determinant of the riskiness of the utility, then the market-to-book ratio will be lower for firms with risky customer mixes, because regulators do not give adequate consideration to this factor. The market-to-book ratio falls below one, because investors' expectations are incorporated in the current price of the stock. If the commission grants a rate of return below the cost of capital (because it ignores the risk associated with customer mix), then the expectations of investors are fulfilled. The equation assumes, however, that the stock was sold at book value at some point.

An additional shortcoming of the FINCAP model is that the dependent variable in this model measures only the cost of equity capital. While some attempts are made in their analysis to find proxies for the cost of debt and preferred stock, no attempt is made to calculate an overall cost-of-capital variable. Brennan has argued that customer mix affects both the cost of individual capital components and the quantity of capital components. Therefore, the FINCAP variable, because it ignores the capital structure of individual utilities, does not measure fully the capital cost differences across utilities.

5.2.2 Weighted Average Cost of Capital

The second measure of capital cost is the weighted average after-tax cost of capital. The cost of common equity capital is derived using the discounted cash flow model. The marginal cost of debt and preferred stock are based on the company's debt and preferred stock ratings. Because the construction of the DCF estimate relies on market data and a measure of stockholder expectations, it does not require the strong assumptions about regulatory behavior invoked in the discussion of the market-to-book ratio. For this reason, the variable is expected to provide a more accurate measure of the relative cost of capital across utilities.

The value of a common stock is a function of its ability to generate a future cash return.[6] The future return is derived from dividend payments throughout the holding period and capital gains realized at the time the stock is sold. In the simple discounted cash flow model, the value of the common stock is determined by capitalizing the income stream as defined by the equation

$$5.9 \qquad P_0 = \sum_{t=1}^{n} \frac{D_t}{(1+k)^t} + \frac{P_n}{(1+k)^n},$$

where P_0 is the stock price in period t=0, P_n is the price at which the stock is sold in period n, D_t is the expected dividend payment in period t and k is the required rate of return commensurate with the stock's risk. Because the price of the stock at the time of the sale, P_n, also equals the capitalized value of the future income stream, that is,

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[6]Stock valuation is discussed in Roger A. Morin, Utility's Cost of Capital, Arlington, VA: Public Utilities Reports, Inc., 1984; Myron Gordon, The Cost of Capital to a Public Utility, East Lansing, MI: Michigan State University, 1974; A. L. Kolbe, et al., The Cost of Capital: Estimating the Rate of Return for Public Utilities, Cambridge, Mass: MIT Press, 1984.

5.10 $$P_n = \sum_{t=n+1}^{m} \frac{D_t}{(1+k)^t} + \frac{P_m}{(1+k)^m},$$

equation 5.9 can be rewritten as an infinite sum, i.e.,

5.11 $$P_0 = \sum_{t=1}^{\infty} \frac{D_t}{(1+k)^t}.$$

In other words, the value of the stock is defined as the sum to infinity of the discounted value of the expected dividend stream.

The valuation model can be further simplified.[7] Under the assumption that dividends grow at a constant rate, g, equation 5.11 can be rewritten as

5.12 $$P_0 = \sum_{t=1}^{\infty} D_0(1+g)^t/(1+k)^t.$$

If the required return, k, exceeds the expected growth rate, g, equation 5.12 is algebraically equivalent to the model[8]

5.13 $$P_0 = \frac{D_1}{k-g}.$$

Solving equation 5.13 for the required return yields

5.14 $$K = \frac{D_1}{P_0} + g.$$

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[7]The assumption of a constant growth rate is sometimes relaxed. See, for example, Richard Wilson, APSC Docket No. 84-175-U.

Equation 5.14 defines the required rate of return as the sum of the expected dividend yield, D_1/P_0, and the expected growth rate, where the growth rate measures the investors' expected capital gains. Equation 5.14 provides the basis for estimating the required return using the discounted cash flow model.

Application of equation 5.14 requires data for the current price, the expected dividend payment in the next period and the expected growth rate of dividends. Each of these inputs is discussed below.

The current price was calculated by taking the average of the monthly high and low prices for the year. While the discounted cash flow analysis argues for the use of a current price, the averaging removes any spurious fluctuations that may appear in the data when relying on spot prices.[9]

The dividend payment used in the discounted cash flow formula is the dividend payment that investors expect to receive in the next year. The expected dividend is calculated using the formula

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[8] Myron J. Gordon, The Cost of Capital to a Public Utility, (East Lansing, MI: Michigan State University, 1974), p. 33. When $k < g$, the model explodes. This possibility is eliminated by assuming that g represents the expected long-term growth of dividends. While investors may expect periods of high short-term growth, they do not expect the rate to be sustained in the long run.

[9] The efficient markets hypothesis supports the use of a current spot price. To make the data comparable across utilities and to avoid the use of different dates for individual utilities, the average price was adopted.

5.15 $D_1 = D_0(1+g)$.

Calculation of the growth rate is discussed below. The annual dividend paid in 1981 is taken from Value Line.

Four alternate measures of the expected growth of dividends per share are developed. Two of the four measures are based on forecasted rates of growth of earnings per share and book value per share and two of the measures are based on historic growth rates. Because the level of dividends is related to the levels of earnings per share and book value per share through the dividend payout ratio and because the level of dividends per share can be manipulated easily by the company, the rates of growth of book value per share and earnings per share are used as proxies for the rate of growth of dividends per share.

The forecasted measures of expected dividend growth are drawn from the Value Line Investment Survey. The historic growth rate is a simple compound growth rate calculated using the equation

5.16 $g = [\frac{x_{t+5}}{x_t}]^{1/5} - 1$,

where x_t and x_{t+5} are based on averages of three years data. Value Line argues that the averaging of three base years and three forecasted years lessens the possibility of skewing the growth rate calculation because a qiven year is distorted by noise.[10]

The historic measures of the expected growth of dividends are based on the levels of earnings per share and book value per share from 1971 to 1981. The calculate the average rate of growth for the historic period, the actual values are regressed on a time trend variable. The fitted values from the estimated equation are calculated and the fitted values for 1971 and 1981 are used to compute the compound average growth rate. This method eliminates distortions that may result from year-to-year fluctuations in earnings. For some utilities, the method yields negative growth rates.

In addition to the marginal cost of common equity, the capital cost calculation requires an estimate of the marginal cost of debt and preferred stock. Because the cost of debt can be expensed for income tax purposes, the relevant cost is the after-tax cost of debt.

To estimate the marginal cost of debt and preferred stock, the average cost of utility debt and preferred stock issued during 1981 were calculated based on Moody's rating categories. The current bond rating was taken from the Merrill Lynch investor survey. The bond rating was used to estimate the preferred stock rating based on the

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[10]For a discussion of the method used to develop the growth rates see Morin (1984).

relationships illustrated on the upper portion of Table 5.1. The average cost of debt and preferred stock issued in 1981 is given on the lower portion of Table 5.1. To calculate the after-tax cost of debt, the cost of debt is multiplied by one minus the effective tax rate.

The weighted average cost of capital is defined by the equation

5.17 $R = \frac{1}{TC} * \{[d * R_d * (1-t)] + p * R_p + e * R_e\}$,

where R is the weighted average cost of capital, R_d is the marginal cost of debt, R_p is the marginal cost of preferred stock, R_e is the marginal cost of common equity capital, t is the effective tax rate, and TC is total capitalization, where

$$TC = d + p + e$$

or total capitalization equals the sum of debt, preferred stock and common equity capital. The capital structure is taken from Value Line.

5.3 Customer Mix Variable

As discussed in Chapter 2, utilities do not use a uniform standard to distinguish between the broad customer categories of residential, commercial and industrial. Difficulties arise primarily because utilities do not classify commercial and industrial customers uniformly. Previous studies have ignored this problem. Because the

TABLE 5.1

Marginal Cost of Debt and Preferred Stock

Rating Categories

Debt		Preferred Stock
Moody's	Standard & Poor's	Moody's
Aaa	AAA	-------
Aa	A	aa
A	A	a
Baa	BBB	baa

Cost of Debt and Preferred Stock

Moody's Debt Rating	Cost of Debt	Cost of Preferred
Aaa	15.90%	*
Aa	15.97	14.19%
A	16.36	14.66
Baa	17.20	15.36

*No utility preferred stock fell into this rating category during 1981.

objective of this study is to test the impact of customer mix on the required cost of capital, uniform definitions of the customer classes are considered essential. Therefore, industrial customers are defined as mining and manufacturing customers based on the standard industrial classification (SIC) codes.

The data to construct the customer mix variable is drawn from the Edison Electric Institute's Uniform Statistical Report. As discussed briefly in Chapter 2, the Uniform Statistical Report permits reporting utilities to choose between two classification methods when recording kwh consumption and sales revenues for large volume users. Customers may be classified as commercial and industrial, or as small light and power and large light and power. The Report requires the utility to identify the exact criterion used to divide large volume users between these alternative categories. Generally, utilities use one of three criteria. First, some utilities classify customers on the basis of the nature of the customers' business. For example, Illinois Power Company defines "manufacturing companies which transform raw materials into a 'product for resale' as industrial customers." Other nonresidential customers are classified as commercial.[11]

The second standard classification method is based on the type

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[11]Uniform Statistical Report, Illinois Power Company, p. E-14.

of tariff schedule under which the customer receives service. For example, Central Illinois Public Service Company defines a customer as industrial if service is taken under a demand-metered rate.[12] Finally, some utilities classify customers based solely on size. For example, Commonwealth Edison Company classifies customers as industrial if the customer registers demands greater than 1000 kwh per month.[13] Because of differences in the definition of industrial customer across utilities, the data on industrial customer mix used in previous analysis does not represent accurately the differences in customer-mix across utilities.

The Uniform Statistical Report also requests that utilities report large volume sales by Standard Industrial Classification. Table 5.2 lists the 2-digit categories used by the Edison Electric Institute. This data is used to provide a definition of industrial sales that is independent of individual definitions and, therefore, provides a more consistent definition of the industrial category across utilities. Industrial users are defined in this study as mining and manufacturing customers as reported in the Uniform Statistical Report.

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[12] Uniform Statistical Report, Central Illinois Public Service Company, p. E-14.

[13] Uniform Statistical Report, The Commonwealth Edison Company, p. E-14.

TABLE 5.2

Classification of Industrial Kilowatt-Hour Sales and Revenues by Standard Industrial Classification Code

Type of Industry	S.I.C. No.(a)
MINING	
Metal Mining	10
Coal Mining	11 & 12
Oil & Gas Extraction	13
Mining & Quarrying of Nonmetallic Min. (except fuels)	14
MANUFACTURING	
Food and Kindred Products	20
Tobacco Manufacturers	21
Textile Mill Products	22
Apparel & Other Finished Products made from fabrics & similar materials	23
Lumber & Wood Products except furniture	24
Furniture and Fixtures	25
Paper & Allied Products	26
Printing, Publishing & Allied Industries	27
Chemicals & Allied Products	28
Petroleum Refining and Related Industries	29
Rubber and Miscellaneous Plastic Products	30
Leather & Leather Products	31
Stone, Clay, Glass and Concrete Products	32
Primary Metal Industries productions of coke -	
Total*	33
(without electric furnaces)	33
(with electric furnaces)	33
Fabricated Metal Products except machinery & transportation equipment	34
Machinery, except Electrical	35
Electrical and Electronic Machinery, Equipment & Supplies	36
Transportation Equipment	37
Measuring Analyzing & Controlling Instruments; Photographic, Medical & Optical Goods: Watches & Clocks	38
Miscellaneous Manufacturing Industries	39

Source: Uniform Statistical Report, p. E-14.

The customer mix variable is specified using two alternative forms. The first specification produces two variables based on residential and industrial revenues as a percentage of total electric revenues; it is used to test the hypothesis that investors require a higher return as the percentage of the utility's revenues that are derived from the industrial class rise, and as the percentage of the utility's revenues that are derived from the residential class fall.

The second specification produces four variables based on extreme high and extreme low percentage residential and industrial revenues. The investment survey undertaken by FINCAP suggests that, while investors do not associate greater risk with sales to industrial customers, they may associate greater risk with utilities that have extreme customer mixes, e.g., a low percentage of either industrial or residential customer revenues.[14] The second specification of the customer mix variable allows examination of this hypothesis. The extreme high and low percent residential and industrial revenues are defined as greater than one standard deviation from the mean. This method identifies 13 extreme low and 9 extreme high percent residential customers and 9 extreme low and 9 extreme high percent industrial customers. The remaining customers include commercial, minicipal and wholesale.

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[14]FINCAP, p. 50.

5.4 Independent Variables

The discussion of the independent variables is broken into two parts. First, the variables included in this analysis are described. Second, the set of independent variables used in the FINCAP study but excluded from this study are discussed. The excluded variables are discussed briefly, because the FINCAP model is replicated in Chapter 6.

The data used in the analysis are largely accounting data; therefore, accounting nomenclature is used throughout the following discussion. In particular, net income before income taxes refers to gross operating revenue less operating expenses, interest expense, depreciation and revenue-related taxes. Net income refers to net income before income taxes less income tax expense.[15]

5.4.1 Measurement of the Sensitivity Factors

Regulation

More than 20 agencies rate the quality of the regulatory environment in state jurisdictions.[16] Investors are concerned with the way in which state regulators control the factors under their

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[15]Ralph Estes, Dictionary of Accounting (Cambridge, Mass: The MIT Press, 1985), p. 90.

[16]Jeffrey A. Dubin and Peter Navarro, "The Effect of Rate Suppression on Utilities' Cost of Capital," Public Utilities Fortnightly, Vol. 111, No. 7, 1983, p. 19.

purview, because the actions of commissions directly impact the variability of utility net income. As one study noted,

> A higher allowed rate of return, a future test year that adjusts for inflation, regulatory response time that prevents earnings attrition, and a full, automatic fuel adjustment clause that immediately passes fuel charges through to customers tend to raise a utility's rate of return (ROR) and reduce the uncertainty that the Company will realize the ROR allowed by its regulators. CWIP and the normalization of tax benefits help a utility's cash flow, thereby raising the probability that a company will meet its debt obligations. Moreover, investors should clearly prefer the "sure" cash return from CWIP over the "paper earnings" from AFUDC, even if CWIP and AFUDC are equivalent on a discounted cash-flow basis (as they should be if AFUDC is calculated fairly). A future test year and an automatic FAC also reduce the variability of the real return by acting as an automatic adjustment for inflation.[17]

As the foregoing discussion suggests, the regulatory environment should be recognized when judging the sensitivity of a utility's return. Three variables are used in this study to measure regulatory environment. These include two dummy variables for the quality of regulation as measured by Value Line, an accounting method dummy variable, and a measure of firm size.

The regulatory quality ranking used in this analysis is drawn from the Value Line Investment Survey, which ranks Commissions as (1) below-average, (2) average or (3) above-average. The regulatory

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[17]Leonard Hyman and Rosemary Avellis, Utility Industry: Quarterly Regulatory Report (New York: Merrill Lynch Capital Markets Securities Research Division, 1981).

quality variable is designed to measure regulation from the investor's perspective. The regulatory quality variables enter the equation with a value of zero or one. High regulatory quality is represented by a variable assigned a value of one if the commission is rated above-average and zero otherwise. Low regulatory quality is indicated by a variable assigned a value of one if the commission is rated below-average and zero otherwise. The estimated coefficient on the high-quality variable is expected to be negative, because an above average regulatory climate should reduce the sensitivity of net income to general economic fluctuations and, therefore, reduce the required return on common equity. Conversely, the uncertainty associated with a below-average regulatory climate is expected to yield a positive coefficient on the low-quality variable.

The FINCAP report uses the five rankings of regulatory environment provided by Salomon Brothers.[18] The regulatory rankings are assigned values from one to five and are entered in the regression analysis as a single variable. This technique assumes that a change in the regulatory environment has a constant relationship to changes in the cost of capital irrespective of the current regulatory environment. In other words, an increase in

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[18]Mark D. Luftig and Neal Kurzner, "Electric Utility Regulation--Semiannual Review," Salomon Brothers, Inc. Stock Research report, February 26, 1985, pp. 4-5.

raking from 1 (lowest) to 2 is assumed to impact the cost of capital in a manner identical to an increase in raking from 4 to 5 (highest). As discussed by Dubin and Navarro, investors seem to respond to the difference between high quality and low quality regulation. Therefore, a simple linear relationship is not expected and the qualitative measure discussed above is preferred.

In addition to the regulatory quality ranking, the analysis includes a zero-one variable for regulatory jurisdictions that require flow-through accounting.[19] Under the Economic Recovery Tax Act of 1981, utilities are allowed to adopt accelerated depreciation schemes for tax purposes, while retaining straight-line depreciation for regulatory book purposes.[20] Under the Tax Equity and Fiscal Responsibility Act of 1982, utilities are also allowed to take investment tax credits against their federal tax liability for qualifying assets acquired during the tax year.[21] In jurisdictions requiring flow-through accounting, any benefits of accelerated depreciation or investment tax credits are passed through to current customers. In jurisdictions allowing normalized accounting, the

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[19]Flow-through is an accounting method used to recognize the effect of investment tax credits and deferred taxes in the year the expense is incurred. Under tax normalization, the tax impacts are spread over the asset's useful life. Estes, p. 55.

[20]Estes, p. 46.

[21]Estes, p. 136.

utility is allowed to use straight-line depreciation for regulatory purposes and to amortize investment tax credits and deferred tax liability.

Opponents of flow-through accounting argue that the method increases financial risk, because it deprives the utility of the internal cash generation and financial flexibility provided by accelerated depreciation and ITC allowances. (In addition, the accounting variable provides a further measure of the Commission's attitude toward utilities. Because flow-through accounting transfers all of the immediate financial advantages of tax policy to utility customers, it provides additional evidence of the shareholders' inability to gain from tax policy.) The accounting method variable takes a value of one if the jurisdiction requires flow-through accounting and zero otherwise. As the accounting method is expected to increase financial risk and, therefore, to increase the required cost of capital, the variable is expected to carry a positive sign.

The final regulatory environment variable measures the relative size of the firm. Hagerman and Ratchford (1978) argue that:

> Large companies may have greater expertise in dealing with regulators in terms of legal assistance, and other centralized resources. This may lead to higher allowed returns for the large companies.[22]

Their results support this hypothesis.

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[22]Hagerman and Ratchford (1978), p. 48.

Alternatively, the greater public visibility of a large utility may force regulators to act more strictly toward utilities during economic downturns; therefore, the return of large utilities may exhibit greater sensitivity to fluctuations in general economic conditions. Because of these conflicting effects, the expected sign of the estimated coefficient is ambiguous.[23]

The nuclear construction exposure variable equals the expected cost at completion of the nuclear plant divided by total common equity capital.[24] This variable recognizes the influence of construction delays and changes in nuclear regulation on cost, and measures the size of the project relative to the total current capital. Indirectly, the variable also provides a measure of the

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[23]Some authors argue that the inadequacy of information about small firms relative to large firms implies increased riskiness associated with investment in small firms. As a result, the size variable should exhibit a positive coefficient. See for example, Rolf W. Banz, "The Relationship Between Return and Market Value of Common Stocks," Journal of Financial Economics, Vol. 9, No. 1, 1981, pp. 3-18; Marc R. Reinganum, "Misspecification of Capital Asset Pricing: Empirical Anomolies Based on Earnings, Yields and Market Values," Journal of Financial Economics, Vol. 9, No. 1, 1981, pp. 19-46; Richard Roll, "A Possible Explanation of the Small Firm Effect, "Journal of Finance, September 1981, pp. 879-888; and Ivan L. Lustig and Phillip A. Leinbach, "The Small Firm Effect," Financial Analysts Journal, May-June 1984, p. 48.

[24]See for example, the Prefiled Direct Testimony of Richard S. Wilson on behalf of the Arkansas State's Attorney General in Docket No. 84-175-U, December 21, 1984, p. 10. The variable is constructed from cost data included in "New Generating Plants," Power Engineering, April, 1985. The capitalization data is taken from Value Line.

potential impact upon ratepayers of placing the completed plant into the utility's regulatory rate base.

In a speech before the 1981 Iowa State Regulatory Conference, Leonard S. Hyman summarized investor attitudes toward nuclear constructon:

> They (investors) worried about the long lead time, delays, ambiguity of the government's position, changes of mind within the NRC, capital intensity during a period of high capital costs, and the zeal and determination of the anti-nuclear forces. To make matters worse, much of the construction budget was going into nuclear generation just when it became questionable how much of that construction was needed at all.[25]

The nuclear accident at General Public Utilities Corporation's Three Mile Island (TMI) reactor No. 2 in March 1979 led to increased nuclear awareness on behalf of investors and increased significantly the perceived riskiness of utilities with nuclear plants under construction.

The delays associated with nuclear construction stemmed from two sources: First, the utility industry in the United States did not act as a unified group. Unlike the French who use only two standard plant designs, each individual U.S. utility designed its own

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[25]Leonard S. Hyman, Three Mile Island Two Years Later: The Consequences of TMI for the Utility Industry, a presentation to the 1981 Iowa State Regulatory Conference, May 19, 1981, p. 4.

individual nuclear plant.[26] Approximately 50 different nuclear plant architects and contractors have designed and built various sizes and types of nuclear plants.[27] As a result, each utility engaged in a nuclear construction project has faced its own unique learning curve. The nuclear construction industry has not had the opportunity to learn from its own mistakes.

Federal and state regulators have provided the second source of construction delays. Following the TMI accident, hundreds of new safety regulations were established by the Nuclear Regulatory Commission requiring utilities to refit partially-completed plants and redesign plants in the early stages of design and construction. Duke Power Company's construction Vice President, Bob Dick, complained that "we are really putting in with one hand and taking out with the other."[28] Some states also imposed moratoriums on nuclear construction.[29] Whatever the source, construction delays increase the cost of financing a construction project and, therefore, the sensitivity of utility returns to fluctuations in interest

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[26]James Cook, "Nuclear Follies," Forbes, 11 February 1985, p. 100.

[27]"New Generating Plants," Power Engineering, April 1985.

[28]Cook, p. 89.

[29]William T. Gormley, Jr., The Politics of Public Utility Regulation, (Pittsburgh: The University of Pittsburgh Press, 1983), p. 18.

rates.

The nuclear construction exposure variable also provides a measure of the capital intensity of a utility's construction project; i.e., the extent to which the utility's total investment in plant at the time the project is completed will be associated with a single asset. As the capital requirements for a given project relative to current capacity increase, the perceived risk to the investor increases for two reasons: first, the ability of the utility to obtain financing at reasonable terms decreases as their capital requirements increase; second, the risk that the utility will be unable to meet its financial obligations increases as the utility's total revenue stream becomes more concentrated in a single revenue source.[30]

The problem of asset concentration was demonstrated most graphically by the Three Mile Island accident. The incident forced General Public Utilities Corporation to remove from service and its regulatory rate base both the damaged and the undamaged TMI units. The forced abandonment of plants under construction without the opportunity to earn an equity return provides another example of the potential impact of revenue loss associated with heavy dependence on

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[30]Daniel Scotto, "Post-Operational Phase-in of Utility Plant: Prolonging the Inevitable," Public Utilities Fortnightly, September 1, 1983, p. 29.

a single revenue generating asset.[31]

Indirectly, the construction exposure variable measures the potential "rate shock" associated with the completion of a nuclear plant.[32] If the potential rate increase looms large relative to current revenue levels, the regulatory commission may require the utility to phase-in the plant, i.e., spread the revenue impact of new investment into the post-operative years.[33] Phase-in plans have arisen as a politically-acceptable response to the large increases associated with all types of large, new generating capacity. The greatest risk associated with a phase-in appears to be the possibility that the phase-in plan will be altered before full cost recovery is achieved.[34]

All of the influences measured by the nuclear construction exposure variable measure increased risk associated with investment in a nuclear utility. Therefore, the estimated coefficient of

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[31]See for example, Jersey Central Power & Light Co. v. Federal Energy Regulatory Commission (1984)--US App DC--730 F2d 816 and Iowa-Illinois Gas and Electric Company, Docket No. RPU-83-22, February 21, 1984.

[32]Thomas Stauffer, "The Costs of Nuclear Electricity: Economic Values and Political Calculations," Paper presented at the Uranium Institute Ninth Annual Symposium, London, 5-7 September 1984, p. 1.

[33]Scotto, p. 28.

[34]Scotto, pp. 29-30. The Financial Accounting Standards Board currently is attempting to redesign the rule, SFAS 71, governing phase-in plans.

nuclear construction exposure is expected to be positive. In combination with the generation mix variable discussed next, this variable allows the division of utilities into three nuclear categories; i.e., (1) no nuclear, (2) nuclear operation only, and (3) nuclear construction.

Generation Mix

Two dummy variables are included to signify a utility's dependence on either gas and oil or nuclear as a fuel source. The price of fuel oil and natural gas was relatively constant until the first oil embargo in 1973. Throughout the 1970s, the prices of fuel oil and natural gas rose, while the reliability of supply declined. In addition, the Public Utility Regulatory Policy Act of 1978 (PURPA) placed limitations on the use of natural gas as a boiler fuel.[35] Because of the uncertainty surrounding both the cost of petroleum fuels and the reliability of supply, dependence on oil and natural gas is expected to increase the variability of income. Consequently, a dummy variable is included in the model to identify utilities whose generation mix includes more than 33% gas and oil fueled generating

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[35]For a discussion, see David J. Barain, "Real and Imagined Restrictions on Electric Utility Fuel Use of Natural Gas," Public Utilities Fortnightly, March 21, 1985, pp. 27-31.

capacity.[36] The estimated coefficient is expected to be positive, because increased dependence on natural gas and oil increases the risk associated with operations and, therefore, the required cost of capital.

Industry analysts divide the electric utility industry into three broad nuclear categories: First are the utilities with no existing nuclear capacity and no nuclear plant under construction. Second are the utilities with operating nuclear capacity and no nuclear construction. Third are the utilities with nuclear construction programs still in progress.[37] A report by Merrill Lynch, published in May 1983, indicates that investors perceive the three categories of utilities as having different associated levels of risk.

> On average, during our chosen review period, the market paid the least (not much less) for utility shares with nuclear plant under construction. The group whose shares were accorded the highest relative price tags were those companies with no nuclear involvement whatsoever. Landing in the market-to-book middle were shares with operating nuclear plants, but with no plans for additional nuclear units. In other words, if three utilities were equal financially, the one with nuclear power would be in the middle, and the one building nuclear facilities would

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[36]This is the percentage used in the FINCAP model. FINCAP does not provide an explanation for their decision to use this percentage. Industry-wide, gas and oil accounted for approximately 24% of total generation in 1981.

[37]Doris A. Kelley, Electric Utility Industry--Nuclear Power, Merrill Lynch, May 1983, p. 1.

have the lowest market-to-book ratio.[38]

An operating nuclear generating plant is hypothesized to increase the required cost of capital, because it increases the investors' perception of the risk associated with operation. Therefore, a dummy variable is included to identify those utilities whose generation mix includes greater than 10% nuclear generation.[39] The operational risks exist primarily because of the large size of most nuclear plants, the lower cost of nuclear fuel relative to replacement fuel and the continuing cost of complying with changes in safety regulations. For example, as one study has noted,

> When a nuclear plant in services goes out of service the results are quickly apparent due to the need to pass on the higher cost of replacement power through the fuel adjustment clause. ...The stakes are big, and errors of operation that would not be noticed otherwise, might be seized upon as an excuse to prevent pass-on of higher costs.[40]

Thus, because nuclear plants are large relative to total requirements and because they exhibit the lowest marginal operating costs, the existence of nuclear capacity presents a potential source of substantial income variability if the plant experiences an unplanned outage. As a result, investors require a relatively higher return

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[38]Ibid., p. 2.

[39]Industry-wide, nuclear capacity accounted for slightly more than 10% of total generation in 1981.

[40]Hyman, p. 4.

from utilities with operating nuclear units.

5.4.2 The FINCAP Model

Two categories of explanatory variables were included in the FINCAP study.

> The first group were those necessary to specify the valuation mechanism... Dividend yield on book value and growth variables were used to specify the common equity models. The second category of variables considered was intended to capture differences between utilities in their capital structures, quality of earnings, coverage levels, quality of regulation, generation mixes, and accounting methods. To assure that customer mix variables had every opportunity to prove significant, no variable was included in the models which might reflect differences in customer composition (i.e., bond ratings, common stock rankings, and other risk indicators.)[41]

Specifically, the valuation variables include the earnings retention ratio, the average ten-year growth in earnings per share, dividend yield on book value, and the earned return on common equity. The second set of variables, used to measure differences in financial and operating characteristics, includes the dividend coverage ratio, the equity capitalization ratio, and allowance for funds used during construction as a percent of net income.

Valuation Variables

The value of a common stock is the present value of the future income stream that the stockholder receives. As discussed more fully

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[41]FINCAP, p. 75.

above, the income stream from a common stock depends on both the dividend payments made over the holding period and the capital gain or loss realized when the stock is sold.[42] The value of a stock will fluctuate with relative changes in dividend policy, the stock's price and investor's expectations.

The flow of dividends received by stockholders is tied to earnings through the earnings retention ratio, i.e., the percentage of earnings retained for reinvestment. This ratio equals one minus the dividend payout ratio, where the dividend payout ratio is the ratio of dividends per share to earnings per share.

> If earnings (or some part of earnings) are retained within the corporation, stockholders are deprived of the current dividends that could have been paid with those earnings. This is a cost to the stockholder. On the other hand, there are some benefits, the valuation of which will depend upon what the corporation does with the funds. Suppose they are retained by the corporation. If, as a result, there is an immediate and lasting increase in the value of the stock, that more than offsets the lower current dividend, stockholders will be better off than if the funds had not been retained and they had received the cash dividends.[43]

Thus, the earnings retention ratio is an important determinant of stock valuation.

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[42] R. Charles Moyer, James R. McGuigan, and William J. Kretlow, Contemporary Financial Management (New York: West Publishing Company, 1984), pp. 94-99.

[43] Harold Bierman, Jr. and Seymour Smidt, The Capital Budgeting Decision (New York: The Macmillan Company, 1971), p. 153.

As discussed in Chapter 2, the expected effect of the earnings retention ratio on the cost of capital is not unambiguous. Some authors argue that dividend payments are important to investors and that a high retention ratio will increase the required cost of capital. Others argue that dividends do not count and that the prospect of higher future income acts as compensation for foregone current income. In other words, the retention ratio can impact the price of the stock through either the dividends paid or the growth expected as a result of earnings retained. Therefore, no *a priori* sign is given to the coefficient of the retention ratio.

The expected growth in earnings per share is measured by the ten-year average growth rate of earnings per share. As expectations of the earnings potential of a given stock improve, the price will increase and the prospective return will increase. This appreciation in the value of the stock occurs because investors can realize a greater potential capital gain through the sale of their stock. The expected sign of the estimated coefficient on growth is ambiguous, because increases in the expected growth rate will impact the required cost of capital both directly through the growth rate and indirectly through the expected dividend yield. No *a priori* sign is given to the coefficient of the expected growth in earnings per share.

The dividend yield on book value and the return on common equity provide two different approaches to measuring the value of the stock relative to the book value per share. The dividend yield on book value is simply the dividend yield per share divided by book value per share. The return on common equity is the earnings per share for the year divided by the average of year-beginning and year-ending book value per share. Both measures provide estimates of the stock's embedded or historic value, i.e., the yield and return to current holders as opposed to the yield and return expected by prospective investors. A strong yield and return based on the historic value of the stock indicates its ability to maintain its value over time. Therefore, the expectation is that the coefficients of dividend yield and return should be negative.

The dividend coverage ratio provides an estimate of the company's ability to pay dividends. Indirectly, this variable measures the company's internal cash flow. The estimated coefficient is expected to be negative, because good cash flow and the ability to pay dividends should reduce the investors' risk associated with holding the stock.

The equity capitalization ratio, E/(D+E), is used as an indicator of the utility's financial leverage, where E is the dollars of capital financed through equity and D is the dollars of capital financed through debt. Leverage measures of a firm's use of lower cost, secured debt capital in place of higher cost, common equity capital. As shown in equation 5.17, the use of debt financing lowers the overall cost of capital, r, to the utility, because the cost of debt, r_d, is lower than the cost of equity capital, r_e.

The use of debt financing also increases the variability of the returns to stockholders. This occurs because the cost of debt financing is fixed and does not vary with the level of earnings. Therefore, when earnings decline, the income available for payment to common stockholders also declines. In addition, after some point, the contractual demands on the utility's cash flow to meet fixed interest payments and the scarcity of unmortgaged assets make the increased use of debt a threat to the financial viability of the utility.

Miller and Modigliani argue that the overall cost of capital for a group of firms with identical risk is constant across all firms. Rearranging equation 5.17 demonstrates the impact of changes in leverage on the cost of equity. As the use of debt financing increases, the cost of common equity also increases,

$$R_e = R + [R-R_d(1-t)]D/E$$

Conversely, because the fixed claims on earnings are perceived as burdensome and because the ability to attract additional debt financing quickly and cheaply is limited by the absense of unsecured assets, increases in the equity capitalization ratio lower the perceived riskiness of the utility. Therefore, the estimated coefficient on the equity capitalization ratio is expected to be negative.

Allowance for funds used during construction (AFUDC) is an accounting entry used to capitalize the carrying charges associated with construction work in progress (CWIP).[44] In most regulatory jurisdictions, utilities are not allowed to earn a return on an investment, unless the investment has been declared "used and useful."[45] In other jurisdictions, however, the utility is allowed to earn a return on a portion of their construction-related expenditures. In some jurisdictions, a utility may be allowed a return on CWIP, if the utility's financial health otherwise will be jeopardized, while in other jurisdictions, CWIP is allowed if the

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[44]AFUDC is a subdivision of Other Income representing amounts concurrently credited for interest charged to the cost of constructing new plant, based generally on the amount expended to date on particular projects. Construction work in progress is an amount of construction expenditure booked. _Glossary of Electric Utility Terms_ (Washington, D.C.: Edison Electric Institute, 1983), p. 19 and 47.

[45]Generally, constructed facilities are defined as used and useful when they begin commercial operation. See for example, Public Service Company of Colorado, Docket No. 1425, Decision No. C80-2346, December 12, 1980 and Iowa-Illinois Gas and Electric Company, Docket No. RPU-83-22, February 21, 1984.

project is within twelve months of its scheduled completion date.[46]

AFUDC allows the utility to accumulate the return on CWIP which is not allowed in rate base. Capitalizing interest expenses associated with debt financing does not impact the calculation of net income associated with nonconstruction activities.[47] As shown below, calculated net income remains unchanged when an AFUDC account is added to the income statement.

Net Operating Income	$10,000,000
Less: Interest expense associated with construction	4,000,000
Add: AFUDC-Debt	4,000,000
Operating Income	$10,000,000

Most jurisdictions, however, recognize that a return to common shareholders' equity is a cost of operation and, therefore, include both the interest expense on debt and a return to equity in the AFUDC charges. Because the return to equity does not represent a cash expenditure, the inclusion of a return to equity in AFUDC inflates the calculation of net income. As demonstrated below, the utility's

[46]See for example, Elizabethtown Water Co., BPU Docket No. 8312-1072, OAL Docket No. PUC 9897-83, September 24, 1984 and Duke Power Company, Docket No. E-7, Sub 373, June 13, 1984. See for example, Hawaiian Telephone Company, Docket No. 4588, Decision and Order No. 8042, August 14, 1982 and The Toledo Edison Company, Case No. 83-1450-EL-Air, September 17, 1984.

[47]Electricity Consumers Resource Council, Profiles in Electricity Issues: Should CWIP be Included in an Electric Utility's Rate Base? (Washington, D.C.: ELCON, 1981), No. 9.

net income will increase during periods of construction, if AFUDC including a return on equity is used.

Net Operating Income	$10,000,000
Less: Interest expense associated with construction	4,000,000
Add: AFUDC-Debt	4,000,000
AFUDC-Equity	6,000,000
Net Income	$16,000,000

Despite the reported increase in earnings, AFUDC does not represent a cash contribution to current income. Therefore, the use of AFUDC reduces the quality of the utility's reported earnings. To the extent that the utility's current earned rate of return is calculated including AFUDC, the earned return will be overstated.

As noted above, AFUDC reduces the quality of earnings because it reduces the proportion of cash included in reported earnings. In other words, AFUDC indicates the extent to which reported earnings are inflated by the inclusion of noncash revenue, measures the extent of the company's involvement in construction projects, and increases the cost of financing by lessening the ability of the company to produce internally generated funds.

AFUDC as a percent of net income is included as an explanatory variable in the model. When AFUDC as a percent of net income rises, the quality of earnings declines and financial risk increases. Therefore, the estimated coefficient is expected to be positive.

5.5 Sample

The data set used in the anlysis includes 72 investor-owned electric and combination electric and gas utilities, which are engaged in the provision of electric service at the retail level. All utilities in the sample produce some portion of their own supply, though purchases may represent a large percentage of their total electric requirements. The companies included in the study are listed on Table 5.3. All utilities are publicly held and all utilities except El Paso Electric Company and Otter Tail Electric Company, which are traded in the over-the-counter market, are traded on the New York Stock Exchange. The utilities range in size, measured in total megawatthour sales, from 1.6 million megawatthours for Montana-Dakota Utilities to 60.3 million megawatthours for The Commonwealth Edison Company. Thirty different state regulatory jurisdictions are represented in the sample.

The original data set included the 112 utilities reported in Standard & Poor's Compustat Services, Inc.'s data base for 1981. Utilities were eliminated from the data set for four reasons: First, all holding companies with more than one electric utility subsidiary were removed from the sample. A holding company was not excluded, however, if only one resale electric or combination electric and gas operating company was included among its affiliates.

The holding companies pose unique problems for the analysis.

TABLE 5.3

Sample of Electric Utilities

Atlantic City Electric Company	Arizona Public Service
Carolina Power and Light	Baltimore Gas and Electric
Central Main Power	Central Hudson
Cleveland Electric Illuminating	Central Illinois Light
Commonwealth Edison Company	Central Illinois Public Service
Detroit Edison Company	Cincinnati Electric and Gas
El Paso Electric	Consolidate Edison of New York
Empire District Electric	Consumers Power
Florida Power and Light	Dayton Power and Light
Florida Progress Corp	Delmarva Power and Light
Gulf States Utilities	Illinois Power
Houston Lighting and Power	Iowa Electric Light and Power
Idaho Power	Iowa-Illinois Electric and Gas
Indianapolis Power and Light	Iowas Public Service
Kansas City Power and Light	Kansas Power and Light
Kansas Gas and Electric	Long Island Lighting
Kentucky Utilities	Louisville Gas and Electric
Minnesota Power and Light	Missouri Public Service
Nevada Power	Montana Power
New England Electric	New York State Electric and Gas
Oklahoma Gas and Electric	Niagara Mohawk
Otter Tail Power	Northern Indiana Public Service
Pennsylvania Power and Light	Northern States Power
Potomac Electric	Pacific Gas and Electric
Public Service Company of Indiana	Philadelphia Electric
Puget Sound Power and Light	Public Service Electric and Gas
Savanah Electric and Power	St. Joseph Electric
Southern California Edison	San Diego Electric and Gas
TECO	Sierra Pacific
TNP	South Carolina Electric and Gas
Toledo Edison	Southern Indiana Gas and Electric
Tucson Electric	Washington Water Power
Union Electric Company	Wisconsin Electric
United Illuminating	Wisconsin Public Service
Utah Power and Light	Montana-Dakota Utilities
Virginia Electric and Power	Public Service of New Hampshire

The financial and operating risk associated with investment in the parent company is unlikely to equal exactly the sum of the risks associated with the individual operating companies. When investment occurs at the level of the parent company, however, many of the risks associated with operations are a function of the individual actions of the subsidiaries. The sometimes conflicting policies and positions of the operating companies demonstrate that they are not a unified or homogeneous entity. Therefore, to avoid the potential problems associated with consolidating the data from the operating companies, all holding companies with multiple electric or combination electric and gas affiliates were removed from the sample.

Second, companies were excluded from the sample if they were not included in the 1981 Value Line Investment Survey. These companies are removed because historical and forecast data from Value Line are required to calculate the cost of capital variable.

Third, companies that do not report or would not supply customer classification data were excluded from the sample. Industrial class data by Standard Industrial Classification are not published in a publicly available source. Therefore, the Uniform Statistical Report to the Edison Electric Institute, which reports revenue and consumption data by SIC code, was requested from all utilities in the initial sample. Some utilities did not comply with the request for data. Other utilities do not report their industrial sales data by SIC code.

Finally, two utilities, The Citizen's Utility Board and CP National, were removed, because they do not receive the majority of their revenue from electricity sales. In both cases, the utilities have shifted the emphasis of their operations into the provision of telecommunication services. Moreover, Citizen's is unique, because it issues two classes of common stock.

CHAPTER 6

TESTS OF THE HYPOTHESIS

In the previous chapter, the data used in the FINCAP model and the alternate dependent and independent variables are discussed. The dependent variable used in the FINCAP model was the market-to-book ratio. The alternate model uses a direct, market-based measure of the overall after-tax cost of capital. In addition to the eleven operation and finance explanatory variables used in the FINCAP model, two additional independent variables based upon firm size and nuclear construction exposure are developed. In the first section of this chapter, the FINCAP model is reestimated for the updated year 1981. In the second section, the alternate specifications are introduced. In the final section, I test the hpothesis that accounting for the mix of customer revenues significantly increases the explanatory power of the model.

6.1 Re-estimation of the FINCAP Model

The vector of financial and operating characteristics, Z, in the FINCAP model includes the dividend yield on book value, the average 10-year growth in earnings per share, the average return on common equity, the earnings retention ratio, common dividend coverage, common equity as a percent of capitalization, AFUDC as a percent of net income, quality of regulation, a gas/oil generation dummy, a nuclear generation dummy and an accounting dummy. The dependent variable, used to proxy the cost of common equity capital, is the market-to-book ratio. When the market-to-book ratio is the dependent variable, the expected signs of the estimated coefficients are the opposite of those discussed in Chapter 4. This occurs because increases in the market-to-book ratio indicate that expect the allowed rate of return to move closely approximate the cost of capital. The model is estimated using ordinary least squares.

6.1.1 Sensitivity of Results to Time Period Examined

To examine the sensitivity of the results to the data set used, the FINCAP model, which originally was estimated for 1977, 1978, and 1979, is re-estimated using the 1981 data. In addition to the timing difference, the 1981 sample of sirms differs in size from the FINCAP study because of the omission of 32 utilities and the addition of 4 utilities. The utilities added and deleted from the FINCAP sample are listed in Table 6.1.

Table 6.2 compares the estimated coefficients for the years 1977, 1978, and 1979 as reported in the FINCAP study to the estimated coefficients for the 1981 sample. (The comparison reported does not allow us to distinguish between charges resulting from alteration of the sample and changes stemming from the use of 1981 data.) The estimated equation for 1981 exhibits a marked decrease in overall significance relative to the FINCAP years. The F-statistics range from 1.581 for 1981 to 67.453 for 1979. While the estimated equation for 1981 is not significant at the 10% level, the estimated equations

TABLE 6.1

Differences Between the FINCAP Sample and the 1981 Sample

A. Utilities Eliminated from the FINCAP Study

1. Allegheny Power
2. American Electric Power
3. Boston Edison
4. Central Louisiana Energy
5. Central and Southwest
6. Central Vermont Public Service
7. Columbia and Southern Ohio Electric
8. Community Public Service
9. Duke Power Company
10. Duquense Light Company
11. General Public Utilities
12. Hawaiian Electric
13. Interstate Power
14. Iowa Resources
15. Iowa Southern Utilities
16. Kentucky Power and Light
17. Madison Gas and Electric
18. Middle South Utilities
19. New England Gas and Electric
20. Northeast Utilities
21. Northwestern Public Service
22. Ohio Edison
23. Orange and Rockland
24. Pacific Power and Light
25. Portland General Electric
26. Public Service of Colorado
27. Public Service of New Mexico
28. Rochester Gas and Electric
29. Southern Company
30. Southwestern Public Service
31. Texas Utilities
32. Wisconsin Power and Light

B. Utilities Added to the FINCAP Study

1. Kentucky Utilities
2. Missouri Public Service Company
3. St. Joseph Electric
4. Texas-New Mexico Power

TABLE 6.2

Comparison of the Estimated Coefficient in the
FINCAP Model and the 1981 Model
Dependent Variables: Market-to-Book Ratio

Description	FINCAP RESULTS 1977	1978	1979	Range of Estimated Coefficients	1981
Constant	0.4248*	-0.0358	-0.1443	-.14 to .42	0.4654
Dividend Yield On Book Value	6.8700*	9.1626*	8.1992*	6.87 to 9.16	-1.3738
Average 10-Year Growth in EPS	1.6600*	1.6158*	1.6205*	1.62 to 1.66	1.6411
Return on Common	1.6700*	0.2109	-0.0453*	-.05 to 1.67	1.2669
Earnings Retention Ratio	-0.2153*	0.0225	0.0317	-.22 to .03	-0.3972
Dividend Coverage	-0.0236*	0.0069	0.0188*	-.02 to .02	-0.0255
Equity Ratio	-0.1551	0.2572*	0.3628*	-.16 to -.00	0.0105
AFUDC as Percent of Net Income	-0.1526*	-0.0044	0.0058	-.15 to .01	-0.1142
Regulatory Quality	-0.0096	-0.0159*	-0.0036	-.02 to -.00	
High					0.0258
Low					0.0317
Gas/Oil Generation	-0.0245*	-0.0137	-0.0153	-.02 to -.01	0.0726
Nuclear Generation	-0.0088	-0.0093	-0.0266*	-.03 to -.01	-0.0707
Flow-through vs. Normalized Acct.	0.0627	0.0156	-0.0012	-.00 to .06	0.0131
R^2	0.822	0.902	0.847		0.243
$\bar{R}^2$	0.800	0.890	0.828		0.089
F-Statistic	30.996	67.453	31.701		1.581
Standard Error of Equation					0.155
Observations	100	100	100		72

An asterisk (*) indicates significance at the 5 percent level.

Source: FINCAP, Table 11, p. 78.

for the FINCAP years are all significant at the 1% level.

A comparison of the estimated coefficients within the FINCAP years reveals inconsistencies in the signs as well as size of the estimated coefficients. Column 4 of Table 6.2 reports the range of the estimated FINCAP coefficients. In half of the cases in which direct comparison is possible, the estimated coefficient for 1981 is within the range of the estimates for the FINCAP years. As indicated by the calculated t-statistics, however, none of the 1981 estimated coefficients are significant at the 5 percent level.

The increase in the explanatory power of the FINCAP model after the addition of the customer-mix variables is examined in Table 6.3. Three sets of customer-mix variables were examined: (1) percent class revenue; (2) extreme low percent class revenue; and (3) estreme high percent class revenue. A joint F-statistic is used to test the hypothesis that the addition of the two customer mix variables (that is, residential and industrial) contributes significantly to the explanatory power of the model. Suifficient information is not provided in the FINCAP report to allow a similar hypothesis test for the FINCAP years. In parallel with the FINCAP report, only the estimated coefficients for the customer-mix variables are reported.

The estimated coefficients for the customer mix variables vary in both sign and magnitude across the years tested. Significant coefficients are obtained only when customer mix is measured by percent class revenue (1978) and extreme low percent industrial

TABLE 6.3

Comparison of the Estimated Customer Mix Coefficients in the FINCAP Model and the 1981 Model Dependent Variable: Market-to-Book Ratio

Description	FINCAP MODEL 1977	1978	1979	1981
Percent Class Revenue:				
Residential	-5.8871	-0.8350*	0.1430	-0.2780
Industrial	-6.0666	-0.9815*	0.1638	0.0819
R^2				0.2650
Adjusted R^2				0.0840
Equation F-Statistic				1.4650
Standard Error of Equation				0.1560
Joint F-Statistic				0.8230
Observations	100	100	100	72
Extreme Low Class Revenue:				
Residential	-0.0036	-0.0033	0.0111	-0.3675
Industrial	-0.0131	-0.0159	-0.0390*	-0.9875
R^2				0.312
Adjusted R^2				0.143
Equation F-Statistic				1.847
Standard Error of Equation				0.150
Joint F-Statistic				2.850
Observations	100	100	100	72
Extreme High Class Revenue:				
Residential	-0.0030	-0.0096	0.0282	-0.0916
Industrial	-0.0236	0.0035	-0.0352	0.3830
R^2				0.253
Adjusted R^2				0.070
Equation F-Statistic				1.381
Standard Error of Equation				0.157
Joint F-Statistic				0.383
Observations	100	100	100	72

An asterisk (*) indicates significance at the 10% level.

Source: FINCAP, Table 12, p. 80.

revenue (1979). The former results suggest that risk increases when the percent of revenues from either customer group increases. The latter results suggest from risk increases when the percent of industrial revenues is very low. Based on the evidence from 1977 through 1979, the FINCAP report concludes that

> In light of the various contradictions and limited number of statistically significant cases in these results, this empirical analysis does not indicate that there exists any identifiable relationship between an electric utility's customer mix and its cost of capital.[1]

Examination of the results for 1981 reported in column 4 of Table 6.3 does not support conclusions differing from those drawn by the FINCAP authors. Only when a utility derives an extremely low percentage of its total revenues from a single class does the 1981 data support a statistically significant relationship between customer mix and the market-to-book ratio. Wehn the revenue mix is skewed away from a single class, the 1981 data suggests that investors demand a higher return on their investment.

6.1.2 Sensitivity of Results to Exclusion of Specific Variables or Data Points

An examination of the matrix of correlation coefficients shown in Table 6.4 revelas that there is some degree of correlation between many of the FINCAP variables. To test the sensitivity of the regression results to the inclusion of the multicollinear variables, the ratios for earnings retention and dividend coverage were deleted

TABLE 6.4

Correlation Matrix of FINCAP Variables

Variable	Market to Book Ratio	Earnings per Share	Return on Common Equity	Retention Ratio	Equity Ratio	AFUDC as a Percent of Net Income	Regulatory Quality Low	Regulatory Quality High
Market to Book Ratio	1.0000							
Earnings per Share	0.3602	1.0000						
Return on Common Equity	0.1637	0.4790	1.0000					
Retention Ratio	-0.0628	0.6338	0.6850	1.0000				
Equity Ratio	0.3104	0.2771	0.0086	0.2494	1.0000			
AFUDC as a Percent of Net Income	0.0273	-0.1216	0.2083	-0.1685	-0.1504	1.0000		
Regulatory Quality:								
Low	-0.1042	0.0724	0.0728	0.0431	-0.4001	0.0182	1.0000	
High	0.3031	0.3520	-0.0218	0.1487	0.3018	0.0521	-0.2586	1.0000
Gas/Oil Dummy	0.0550	0.0370	0.2746	0.1231	0.0641	0.1787	-0.1815	0.2066
Nuclear Dummy	-0.2527	-0.0183	-0.0675	0.0835	0.0395	-0.0493	-0.0676	0.0458
Accounting Dummy	-0.1318	0.0430	0.2144	0.1833	0.2521	0.0634	-0.0963	-0.1208
Dividend Yield on Book Value	0.4357	-0.3196	-0.0129	-0.6122	-0.0555	0.4246	-0.1261	-0.1171
Dividend Coverage	-0.1668	0.2297	-0.0329	0.3181	-0.1520	-0.6461	0.1976	0.0540
Percent Customer Mix:								
Residential	0.2661	0.0505	0.0027	-0.1804	-0.1361	0.0744	-0.0827	0.2773
Industrial	-0.2533	0.1071	0.1476	0.2684	-0.0593	-0.0298	0.1224	-0.2309

(continued on next page)

TABLE 6.4

Variable	Gas/Oil Dummy	Nuclear Dummy	Accounting Dummy	Dividend Yield Book Value	Dividend Coverage
Market to Book Ratio					
Earnings per Share					
Return on Common Equity					
Retention Ratio					
Equity Ratio					
AFUDC as a Percent of Net Income					
Regulatory Quality:					
Low					
High					
Gas/Oil Dummy	1.0000				
Nuclear Dummy	-0.0637	1.0000			
Accounting Dummy	0.1612	-0.2532	1.0000		
Dividend Yield on Book Value	0.1158	0.1198	0.0088	1.0000	
Dividend Coverage	-0.0109	-0.1769	-0.3045	-0.5629	1.0000
Percent Customer Mix:					
Residential	0.1539	0.0948	-0.1261	0.2683	-0.0655
Industrial	-0.0952	-0.0859	0.0002	-0.1802	0.1164

from the model and the 1981 equations were re-estimated. As shown in Table 6.5, the elimination produces no dramatic changes in the estimated coefficients or the summary statistics. The adjusted R^2 falls from 0.089 to 0.083 and the F-statistics rises from 1.581 to 1.642. Based on the joint F-statistic of 1.216, the hypothesis that jointly the two variables do not increase the total explanatory power of the model can not be rejected.

The estimated coefficients of the customer mix variables again are compared in Table 6.6 after the exclusion of the ratios for earnings retention and dividend coverage. The estimated coefficients for the two equations have identical signs and are of similar magnitudes. Unlike the full specification, however, the extreme low percent industrial revenue variable fails to attain significance in the reduced equation. The F-statistic for the joint hypothesis, however, continues to support the conclusion that including the extreme low percent revenue variables increases the explanatory power of the model. Because the elimination of the two ratios, (earnings retention and dividend coverage) does not significantly reduce the explanatory power of the model or alter the conclusions with respect to customer mix, these two variables are omitted throughout the remainder of the analysis.

An examination of the residuals from the two equations for 1981, reported in Table 6.5 revealed four outliers. The companies --

TABLE 6.5

Estimated Coefficients Using the Full FINCAP Equation
and the Reduced FINCAP Equation
Dependent Variable: Market-to-Book Ratio

Description	Full FINCAP Equation	Reduced FINCAP Equation
Constant	0.4654	0.3117
Dividend Yield on Book Value	-1.3738	2.3866*
Average 10-Year Growth in EPS	1.6411	1.3237*
Return on Common	1.2669	-0.9838
Earnings Retention Ratio	-0.3972	
Dividend Coverage	-0.0255	
Equity Ratio	0.0105	0.0092*
AFUDC as Percent of Net Income	-0.1142	-0.0369
Regulatory Quality:		*
High	0.0258	0.0195
Low	0.0317	0.0253
Gas/Oil Generation	0.0726	0.0633
Nuclear Generation	-0.0707	-0.0687
Flow-Through vs. Normalized Acct	0.0131	0.0379
R^2	0.243	0.212
Adjusted R^2	0.089	0.083
F-Statistic	1.581	1.642
Standard Error of Equation	0.155	0.156
Joint F-Statistic	1.216	
Observations	72	72

TABLE 6.6

Impact of Customer Mix Variables in the Full and Reduced FINCAP Equation
Dependent Variable: Market-to-Book Ratio

Description	Full FINCAP Equation	Reduced FINCAP Equation
Percent Class Revenue:		
Residential	-0.2780	-0.3405
Industrial	0.0819	0.0420
R^2	0.265	0.236
Adjusted R^2	0.084	0.081
Equation F-Statistic	1.465	1.523
Standard Error of Equation	0.156	0.156
Joint F-Statistic	0.823	0.941
Observations	72	72
Extreme Low Class Revenue:		
Residential	-0.3675*	-0.3524*
Industrial	-0.9875*	-0.9186
R^2	0.312	0.275
Adjusted R^2	0.143	0.127
Equation F-Statistic	1.847	1.86
Standard Error of Equation	0.15	0.152
Joint F-Statistic	2.85	2.537
Observations	72	72
Extreme High Class Revenue:		
Residential	-0.0916	-0.1121
Industrial	0.3830	-0.1015
R^2	0.253	0.227
Adjusted R^2	0.07	0.07
Equation F-Statistic	1.381	1.446
Standard Error of Equation	0.157	0.157
Joint F-Statistic	0.383	0.576
Observations	72	72

An asterisk (*) indicates that the estimated coefficient is significant at the 10% level.

Southern California Edison, Texas-New Mexico Power, Montana Power Company and Pacific Gas & Electric Company, all exhibit market-to-book ratios greater than one. This contrasts with the other utilities in the sample, which have market-to-book ratios strictly less than one. To see if these four observations influence the regression results, the four utilities were eliminated from the sample and the equation was re-estimated.

Table 6.7 presents the estimated coefficients for 1981 using the reduced sample. The supporting test statistics improve markedly after the removal of the high market-to-book ratio firms: The adjusted R-squared increases dramatically from 0.083 to 0.545, the F-statistic attains a high level of significance after increasing five-fold from 1.642 to 9.010, and the standard error of the equation falls from 0.156 to 0.058. In addition, the size and sign of several of the estimated coefficients are affected by the elimination of the high market-to-book ratio firms. While the full sample estimation yielded no significant coefficients, six of the estimated coefficients are significant after the outliers are omitted from the sample.

Table 6.8 compares the customer mix variables using the full sample and the reduced sample. Even though removing the outliers enchanced the model's explanatory power, none of the customer mix variables are individually or jointly significant in the reduced

TABLE 6.7

Estimated Coefficients Using the Full and Reduced Samples
Dependent Variable: Market-to-Book Ratio

Description	Full FINCAP Equation	Reduced FINCAP Equation
Constant	0.3117	0.0263
Dividend Yield on Book Value	2.3866	4.7507*
Average 10-Year Growth in EPS	1.3237	1.2620*
Return on Common	-0.9838	0.3096
Equity Ratio	0.0092	0.0058*
AFUDC as Percent of Net Income	-0.0369	-0.0596*
Regulatory Quality:		
High	0.0195	0.0381*
Low	0.0253	0.0119
Gas/Oil Generation	0.0633	-0.0078
Nuclear Generation	-0.0687	-0.0260
Flow-Through vs. Normalized Acct	0.0379	-0.0502*
R^2	0.212	0.613
Adjusted R^2	0.083	0.545
F-Statistic	1.642	9.010
Standard Error of Equation	0.156	0.058
Observations	72	68

As asterisk (*) indicates that the estimated coefficient is significant at the 10% level.

TABLE 6.8

Impact of Customer Mix Variables in the Full and Reduced Samples
Dependent Variable: Market-to-Book Ratio

Description	Full FINCAP Equation	Reduced FINCAP Equation
Percent Class Revenue:		
Residential	-0.3405	-0.0683
Industrial	0.0420	-0.1049
R^2	0.236	0.628
Adjusted R^2	0.081	0.546
Equation F-Statistic	1.523	7.724
Standard Error of Equation	0.156	0.058
Joint F-Statistic	0.941	1.116
Observations	72	68
Extreme Low Class Revenue:		
Residential	-0.3524*	-0.0817
Industrial	-0.9186	-0.0557
R^2	0.275	0.619
Adjusted R^2	0.127	0.536
Equation F-Statistic	1.86	7.46
Standard Error of Equation	0.152	0.059
Joint F-Statistic	2.537	0.504
Observations	72	68
Extreme High Class Revenue:		
Residential	-0.1121	0.0280
Industrial	-0.1015	-0.0443
R^2	0.227	0.621
Adjusted R^2	0.07	0.539
Equation F-Statistic	1.446	7.516
Standard Error of Equation	0.157	0.058
Joint F-Statistic	0.576	0.634
Observations	72	68

An asterisk (*) indicates that the estimated coefficient is significant at the 10% level.

sample.

6.1.3 Conclusion

The re-estimation of the FINCAP model using data for 1981 provides additional support for the conclusions reached by the FINCAP authors, that is, the analysis does not provide support for the hypothesis that customer mix is an important determinant of differences in the market-to-book ratios across firms. The addition of the extreme low percent class revenue variables, however, consistently increase the explanatory power of the model. This allows the tentative conclusion that investors perceive utilities to be more risky if their customer mix is skewed heavily away from a single customer class. Because non of the other customer-mix variables proved significant, more general conclusions are not supported by the results.

Both general economic conditons and specific factors impacting the electric utility industry may explain the differences between the FINCAP results and the results for 1981. Generally, interest rates and inflation were at record levels in 1981. Specifically, utilities faced a declining customer base as a result of the oil embargoes of the late 1970s, faced high financing costs for generating plants that might not have been required once load forecasts were updated, and suffered the negative impacts of regulatory lag. As a result, the financial condition of the industry in general deteriorated between

1977 and 1981, as evidenced by the market-to-book ratios. Because the variables included in the FINCAP model do not recognize differences in operating and regulatory conditions, the model can not explain the difference in market-to-book ratios in 1981.

6.2 Estimation of the Alternate Model

The analysis in this section differs from the FINCAP model in three respects: First, the model substitutes a direct, market-based measure of the overall after-tax cost of capital for the indirect measure used by FINCAP. As discussed in Chapter 5, the alternate dependent variable is a weighted average after-tax cost of capital variable. Five specifications of the dependent variable, each of which uses an alternate measure of the expected dividend growth rate to calculate the cost of common equity, are used. Second, the model introduces two additional explanatory variables; namely, nuclear construction exposure and firm size. Nuclear exposure is designed to measure the size of the nuclear construction project. Firm size measures visability and recognizes the small firm effect. Third, all financial variables are removed from the model. This eliminates the potential problems that may result if the financial variables are not truly exogenous to the model.

Table 6.9 reports the means and standard deviations for the explanatory variables used in the alternate model. The net plant variable is expressed in millions of dollars and the nuclear

TABLE 6.9

Mean and Standard Deviation of Explanatory Variables in the Alternate Model

	Mean	Standard Deviation
Percent Residential	0.276	.114
Percent Industrial	0.331	.122
Net Plant (millions of dollars)	23,206	22,401
Nuclear Construction (thousands of dollars)	800,359	1,382,294

Other variables used in Tables 6.10 through 6.15 enter the equations as zero-one variables.

construction variable is measured in thousands of dollars. The remainder of the noncustomer-mix variables enter the equations as zero-one variables.

Table 6.10 presents the estimated results from the base models using the alternate dependent variable. Each equation is discussed briefly before turning to the hypothesis tests of interest.

6.2.1 Cost of Capital Based on the Historic Growth of Earnings per Share

Column 1 of Table 6.10 reports the estimation results using a cost-of-capital variable based on the historic growth of earnings per share. The adjusted R-squared for the equation is 0.172 and the F-statistic of 3.107 is significant at the 5% level.

Theory permits us *a priori* to sign six of the seven independent variables. The estimated coefficients of two of these variables, low regulatory quality and gas/oil generation, are signed incorrectly. Neither of the estimated coefficients, however, is statistically different from zero. Based on a one-tailed test, nuclear generation mix and the accounting method are signed correctly and are significant at the 5 percent level. The two new variables nuclear exposure and firm size, are both insignificant, and the joint F-statistic for the inclusion of these two variables is insignificant.

TABLE 6.10

Estimated Equations for 1981 Using Alternate Model and Various Measures of Cost of Capital

	Cost of Capital Based on Historic			Cost of Capital Based on Value Line Growth Rates	
Description	Growth of EPS	Growth of BPS	Average Growth	EPS	BPS
Constant	0.1320	0.1340	0.1330	0.1440	0.1395
	(35.9028)	(46.2274)	(42.0062)	(43.4769)	(39.0779)
Regulatory Quality:					
High	-0.0026	-0.0041	-0.0034	-0.0087	-0.0090
	(0.5546)	(1.1196)	(0.8345)	(2.0548)	(1.9771)
Low	-0.0032	-0.0086	-0.0059	-0.0103	-0.0089
	(0.6284)	(2.1563)	(1.3521)	(2.2528)	(1.8065)
Gas/Oil Generation	-0.0009	-0.0001	-0.0005	-0.0008	-0.0022
	(0.2073)	(0.0135)	(0.1265)	(0.2012)	(0.5166)
Nuclear Generation	0.0098	0.0065	0.0082	0.0047	0.0051
	(2.1779)	(1.8332)	(2.1036)	(1.1520)	(1.1621)
Flow-Through vs Normalized Acct	0.0221	0.0120	0.0170	0.0120	0.0156
	(4.0157)	(2.7612)	(3.5952)	(2.4267)	(2.9151)
Nuclear Exposure	0.27E-8	.43E-8	.35E-8	.44E-8	.16E-8
	(1.2207)	(2.4514)	(1.8310)	(2.1697)	(0.7442)
Firm Size	-0.1994 E-6	-0.2897E-6	-0.2445E-6	-0.1638E-6	-0.1392E-6
	(1.3481)	(2.4836)	(1.9197)	(1.2298)	(0.9685
R^2	0.254	0.233	0.248	0.272	0.219
Adjusted R^2	0.172	0.149	0.165	0.192	0.134
F-Statistic (7,64)	3.107	2.778	3.010	3.418	2.570
Standard Error of the Equation	0.015	0.012	0.013	0.014	0.015
Joint F-Statistic	0.889	3.849	1.984	2.546	0.455

The absolute values of the t-statistics are reported in parentheses.

6.2.2 Cost of Capital Based on the Historic Growth of Book Value per Share

Column 2 reports the outcome using a cost-of-capital variable based on the historic growth of book value per share. The adjusted R-squared of the equation is 0.149 and the F-statistic is 2.778 is significant at the 5% level. The coefficients are signed consistently with those reported in column 1. In this equation the only variables which are not significant at the 5% level are high regulatory quality and gas/oil generation. The new explanatory variables now are both significant, and the joint F-statistic for the inclusion of these two variables is 3.849, which is significant at the 5 percent level.

6.2.3 Cost of Capital Based on the Average Historic Growth Rates

Column 3 reports the results using average historic growth rates of earnings and book value per share to calculate the cost of capital. The adjusted R-squared for the equation is 0.165, and the F-statistic is 3.010. All estimated coefficients are signed as before and only high regulatory quality and gas/oil generation are not significant at the 5 percent level.

The results using this cost of capital measure are similar to those using historic growth of book value per share (column 2). The two additional variables are marginally significant and of similar magnitude. the F-statistic testing their joint importance, however, is 1.98 which is not significant at the 10 percent level.

6.2.4 Cost of Capital Based on the Forecasted Growth of Earnings per Share

Column 4 reports the estimation results using a cost of capital measure based on teh forecasted growth of earnings per share. The adjusted R-squared for the equation is 0.192, and the F-statistic is 3.418. With the exception of the gas/oil generation variable, all estimated coefficients are signed consistently with columns 1 through 3. While correctly signed, the gas/oil generation variable remains insignificant at any acceptable level. For the first time, the high regulatory quality variable achieves statistical significance (t=2.06) and is signed correctly. Other significant variables include low regulatory quality, which continues to exhibit an incorrect sign, accounting method, and nuclear construction. The F-statistic for the joint inclusion of the two new variables is 2.546, which is significant at the 10 percent level.

6.2.5 Cost of Capital Based on Forecasted Growth of the Book Value per Share

Column 5 reports the results using the cost of capital measure based on the forecasted growth of book value per share. The adjusted R-squared is 0.134 and the F-statistic is 2.570. This final equation exhibits the weakest results of the five alternative specifications. The estimated signs are consistent with those of the first three equations reported. Only three variables achieve significance: high and low regulatory quality and accounting method. Neigher of the new variables is significant, and the F-statistic for their joint inclusion is only 0.455.

6.2.6 General Conclusions

The results reported in Table 6.10 permit several general conclusions: First, all of the equations are significant at the 5 percent level based on the equation F-statistic. Therefore, the improved dependent variable and the alternate specification of the equation permit greater differentiation across utilities. Second, with the exception of the gas/oil generation variable, all of the variables are consistently signed across equations. Some of the results, however, merit further examination.

The regulatory quality variable enters the equation through dummy variables that identify commissions that received the highest and the lowest quality ratings. The estimated coefficient of the high regulatory quality is expected to be negative, while the low regulatory quality is expected to be positive. The low regulatory quality variable exhibits a negative sign in all equations. The equations can be divided into two groups. In equations 1 through 3, the dependent variable is based strictly on market data. The regulatory quality variables achieve significance in only one of these equations, where low quality is incorrectly signed. In equations 4 and 5, on the other hand, the investment service preparing the growth estimates introduces a subjective element into the calculation. The significant coefficients suggest that greater weight is placed on regulatory quality.

The incorrectly signed low regulatory quality variable is not easily explained. An examination of regulatory rankings in immediately preceeding and ensuing years indicated a consistency of rankings over time. Therefore, expected changes in regulatory quality do not explain the perverse results. Because 1981 is a nonelection year, differences in actual regulatory quality may diminish as regulators act without the political pressures imposed by campaigning politicians. If regulatory quality improves in low quality states during nonelection years, the simple zero-one variable introduced here may not be sufficient to measure differences across utilities.

The gas/oil and nuclear generation variables are signed correctly in all equations. While the gas/oil generation variable does not achieve significance in any equation, the nuclear variable is significant at the ten percent level in equations 1 through 3. The relative magnitudes of the coefficients suggest the growing concern among investors about nuclear generation and the diminishing concern about dependence on oil and gas.

The accounting variable is signed correctly and significant in all of the equations. The estimated coefficients are large relative to the variables previously discussed. This result suggests that investors perceive the utility's riskiness to increase significantly when tax accounting advantages must be flowed immediately to customers.

The nuclear exposure variable is significant in three of the five equations. The estimated coefficient suggest that a one million dollar increase in the cost of a construction project increases the cost of capital by 0.16 to 0.44 percentage points. This represents a significant impact on the utility's overall capital cost.

The firm size variable is signed correctly throughout and significant in two of the five equations. The size of the estimated coefficient suggests that the size variable is a minor determinant of capital cost. For a one million dollar increase in plant size, the cost of capital declines by only 0.001 to 0.003 percentage points.

6.3 Testing the Hypotheses

Tables 6.11 through 6.15 report the estimated results associated with testing the hypothesis that investors consider customer mix when assessing the riskiness of a utility investment. Two specific sets of hypotheses are tested: First, equation 2 is used to test the hypothesis that investors do not consider customer mix when assessing the riskiness of utility investments. This base hypothesis is tested against the alternative hypotheses that (1) investors associate less

TABLE 6.11

Estimated Equations Using Various Measures of Customer Mix

Dependent Variables: Weighted Average After-Tax Cost of Capital Equity Capital Based on the Historic Growth of Earnings Per Share

Description	Equation #1	Equation #2	Equation #3	Equation #4
Constant	0.1320 (35.9028)	0.1152 (8.5957)	0.1308 (33.9312)	0.1303 (36.1160)
Regulatory Quality:				
High	-0.0026 (0.5546)	-0.0022 (0.4665)	-0.0030 (0.6411)	-0.0018 (0.3974)
Low	-0.0032 (0.6284)	-0.0038 (0.7498)	-0.0026 (0.5047)	-0.0028 (0.5634)
Gas/Oil Generation	-0.0009 (0.2073)	-0.0018 (0.3941)	-0.0013 (0.2894)	-0.0013 (0.2963)
Nuclear Generation	0.0098 (2.1779)	0.0085 (1.8329)	0.0095 (2.0813)	0.0101 (2.3262)
Flow-Through vs. Normalized Acct	0.0221 (4.0157)	0.0213 (3.7737)	0.0222 (3.8723)	0.0216 (4.0569)
Nuclear Exposure	0.27E-8 (1.2207)	0.22E-8 (0.9505)	0.25E-8 (1.1391)	0.34E-8 (1.5470)
Firm Size	-0.1994E-6 (1.3481)	-0.1369E-6 (0.8750)	-0.1874E-6 (1.2553)	-0.2688E-6 (1.8297)
Percent Customer Mix Variables				
Residential		0.0390 (1.4157)		
Industrial		0.0081 (0.4425)		

(continued on next page)

TABLE 6.11

Description	Equation #1	Equation #2	Equation #3	Equation #4
Extreme High Percent Customer Variables:				
Residential			0.0086 (0.7386)	
Industrial			0.0116 (0.8587)	
Extreme Low Percent Customer Variables:				
Residential				0.0281 (1.3799)
Industrial				0.1188 (2.2657)
R^2	0.254	0.277	0.267	0.325
Adjusted R^2	0.172	0.172	0.161	0.227
Standard Error of the Equation	0.015	0.015	0.015	0.015
F-Statistic	3.107	2.640	2.515	3.322
Joint F-Statistic		0.972	0.566	3.190

The absolute values of the t-statistics are reported in parentheses.

TABLE 6.12

Estimated Equations Using Various Measures of Customer Mix

Dependent Variables: Weighted Average After-Tax Cost of Capital Equity Capital Based on the Historic Growth of Book Value Per Share

Description	Equation #1	Equation #2	Equation #3	Equation #4
Constant	0.1340 (46.2274)	0.1282 (11.4808)	0.1328 (43.9761)	0.1326 (46.8773)
Regulatory Quality:				
High	-0.0041 (1.1196)	-0.0041 (1.0797)	-0.0046 (1.2387)	-0.0033 (0.9348)
Low	-0.0086 (2.1563)	-0.0087 (2.1210)	-0.0079 (1.9464)	-0.0084 (2.1862)
Gas/Oil Generation	-0.0001 (0.0135)	-0.0003 (0.0812)	-0.0004 (0.1222)	-0.0005 (0.1396)
Nuclear Generation	0.0065 (1.8332)	-0.0062 (1.6735)	0.0063 (1.7652)	0.0069 (2.0097)
Flow-Through vs. Normalized Acct	0.0120 (2.7612)	0.0019 (2.6434)	0.0123 (2.7419)	0.0117 (2.7943)
Nuclear Exposure	0.43E-8 (2.4514)	0.41E-8 (2.2067)	0.41E-8 (2.3266)	0.48E-8 (2.7989)
Firm Size	-0.2897E-6 (2.4836)	-0.2672E-6 (2.1366)	-0.2775E-6 (2.3732)	-0.3390E-6 (2.9436)
Percent Customer Mix Variables				
Residential		0.0117 (0.5323)		
Industrial		0.0051 (0.3520)		

(continued on next page)

TABLE 6.12

Description	Equation #1	Equation #2	Equation #3	Equation #4
Extreme High Percent Customer Variables:				
Residential			0.0075 (0.8224)	
Industrial			0.0132 (1.2498)	
Extreme Low Percent Customer Variables:				
Residential				0.0168 (1.0525)
Industrial				0.1064 (2.5903)
R^2	0.233	0.237	0.258	0.315
Adjusted R^2	0.149	0.126	0.150	0.216
Standard Error of the Equation	0.012	0.012	0.012	0.012
F-Statistic	2.778	2.139	2.391	3.171
Joint F-Statistic		0.152	0.995	3.321

The absolute values of the t-statistics are reported in parentheses.

TABLE 6.13

Estimated Equations Using Various Measures of Customer Mix

Dependent Variables: Weighted Average After-Tax Cost of Capital
Equity Capital Based on the Historic Growth

Description	Equation #1	Equation #2	Equation #3	Equation #4
Constant	0.1330 (42.0062)	0.1217 (10.4733)	0.1318 (39.8392)	0.1316 (42.5772)
Regulatory Quality:				
High	-0.0034 (0.8345)	-0.0031 (0.7665)	-0.0038 (0.9388)	-0.0026 (0.6604)
Low	-0.0059 (1.3521)	-0.0063 (1.4096)	-0.0053 (1.1823)	-0.0056 (1.3307)
Gas/Oil Generation	-0.0005 (0.1265)	-0.0010 (0.2646)	-0.0009 (0.2244)	-0.0009 (0.2371)
Nuclear Generation	0.0082 (2.1036)	-0.0073 (1.8278)	0.0079 (2.0182)	0.0085 (2.2798)
Flow-Through vs. Normalized Acct	0.0170 (3.5952)	0.0166 (3.3936)	0.0172 (3.5075)	0.0166 (3.6506)
Nuclear Exposure	0.35E-8 (1.8310)	0.31E-8 (1.5649)	0.33E-8 (1.7254)	0.41E-8 (2.1861)
Firm Size	-0.2445E-6 (1.9197)	-0.2020E-6 (1.4891)	-0.2324E-6 (1.8145)	-0.3039E-6 (2.4176)
Percent Customer Mix Variables				
Residential		0.0253 (1.0614)		
Industrial		0.0066 (0.4173)		

(continued on next page)

TABLE 6.13

Description	Equation #1	Equation #2	Equation #3	Equation #4
Extreme High Percent Customer Variables:				
Residential			0.0081 (0.8057)	
Industrial			0.0124 (1.0707)	
Extreme Low Percent Customer Variables:				
Residential				0.0225 (1.2880)
Industrial				0.1126 (2.5105)
R^2	0.248	0.261	0.267	0.329
Adjusted R^2	0.165	0.154	0.161	0.231
Standard Error of the Equation	0.013	0.013	0.013	0.013
F-Statistic	3.010	2.434	2.510	3.376
Joint F-Statistic		0.546	0.582	3.632

The absolute values of the t-statistics are reported in parentheses.

TABLE 6.14

Estimated Equations Using Various Measures of Customer Mix

Dependent Variables: Weighted Average After-Tax Cost of Capital Equity Capital Based on the Historic Growth of Earnings Per Share

Description	Equation #1	Equation #2	Equation #3	Equation #4
Constant	0.1440	0.1432	0.1432	0.1418
	(43.4769)	(11.7467)	(41.2551)	(46.1765)
Regulatory Quality:				
High	-0.0087	-0.0084	-0.0090	-0.0073
	(2.0548)	(1.9647)	(2.1153)	(1.8799)
Low	-0.0103	-0.0109	-0.0102	-0.0108
	(2.2528)	(2.3365)	(2.1887)	(2.4352)
Gas/Oil Generation	-0.0008	-0.0006	-0.0005	-0.0000
	(0.2012)	(0.1393)	(0.1177)	(0.0006)
Nuclear Generation	0.0047	-0.0041	0.0041	0.0053
	(1.1520)	(0.9665)	(1.0014)	(1.4313)
Flow-Through vs. Normalized Acct	0.0120	0.0111	0.0114	0.0117
	(2.4267)	(2.1601)	(2.2039)	(2.5754)
Nuclear Exposure	0.44E-8	0.46E-8	0.44E-8	0.49E-8
	(2.1697)	(2.1679)	(2.1444)	(2.6764)
Firm Size	-0.1638E-6	-0.1658E-6	-0.1537E-6	-0.2266E-6
	(1.2298)	(1.1648)	(1.1440)	(1.8126)
Percent Customer Mix Variables				
Residential		0.0088		
		(0.3521)		
Industrial		-0.0099		
		(0.5926)		

(continued on next page)

TABLE 6.14

Description	Equation #1	Equation #2	Equation #3	Equation #4
Extreme High Percent Customer Variables:				
Residential			0.0114 (1.0851)	
Industrial			0.0054 (0.4441)	
Extreme Low Percent Customer Variables:				
Residential				0.0166 (0.9561)
Industrial				0.1694 (3.7982)
R^2	0.272	0.280	0.287	0.413
Adjusted R^2	0.192	0.176	0.183	0.328
Standard Error of the Equation	0.014	0.014	0.014	0.013
F-Statistic	3.418	2.685	2.773	4.845
Joint F-Statistic		0.346	0.625	7.194

The absolute values of the t-statistics are reported in parentheses.

TABLE 6.15

Estimated Equations Using Various Measures of Customer Mix

Dependent Variables: Weighted Average After-Tax Cost of Capital Equity Capital Based on the Historic Growth of Book Value Per Share

Description	Equation #1	Equation #2	Equation #3	Equation #4
Constant	0.1395 (39.0779)	0.1345 (10.1892)	0.1389 (36.8621)	0.1378 (39.7027)
Regulatory Quality:				
High	0.0090 (1.9771)	-0.0090 (1.9482)	-0.0092 (1.9910)	-0.0079 (1.7979)
Low	-0.0089 (1.8065)	-0.0087 (1.7284)	-0.0083 (1.6445)	-0.0088 (1.8573)
Gas/Oil Generation	-0.0022 (0.5166)	-0.0024 (0.5360)	-0.0024 (0.5443)	-0.0029 (0.6931)
Nuclear Generation	0.0051 (1.1621)	0.0050 (1.0986)	0.0052 (1.1604)	0.0056 (1.3358)
Flow-Through vs. Normalized Acct	0.0156 (2.9151)	0.0159 (2.8550)	0.0162 (2.8865)	0.0153 (2.9813)
Nuclear Exposure	0.16E-8 (0.7442)	0.13E-8 (0.5818)	0.15E-8 (0.6571)	0.21E-8 (1.0177)
Firm Size	-0.1391E-6 (0.9685)	-0.1178E-6 (0.7643)	-0.1339E-6 (0.9179)	-0.1936E-6 (1.3709)
Percent Customer Mix Variables				
Residential		0.0075 (0.2783)		
Industrial		0.0083 (0.4591)		

(continued on next page)

TABLE 6.15

Description	Equation #1	Equation #2	Equation #3	Equation #4
Extreme High Percent Customer Variables:				
Residential			0.0007 (0.0656)	
Industrial			0.0083 (0.6286)	
Extreme Low Percent Customer Variables:				
Residential				0.0154 (0.7863)
Industrial				0.1399 (2.7770)
R^2	0.219	0.222	0.224	0.309
Adjusted R^2	0.134	0.109	0.112	0.209
Standard Error of the Equation	0.015	0.015	0.015	0.014
F-Statistic	2.570	1.969	1.993	3.081
Joint F-Statistic		0.109	0.191	3.890

The absolute values of the t-statistics are reported in parentheses.

risk with utilities whose customer mix is more heavily dependent on residential revenues and (2) investors associate greater risk with utilities whose customer mix is more heavily dependent on industrial revenues, that is,

Ho: $B(I) = B(R) = 0$
Ha: $B(I) > 0$
$B(R) < 0.$

Second, equations 3 and 4 are used to test the hypothesis that investors associate greater risk with customer mix only when the mix is extremely skewed, that is,

Ho: $B(HI) = B(HR) = B(LI) = B(LR) = 0$
Ha: $B(HI) > 0$
$B(HR) > 0$
$B(LI) > 0$
$B(LR) > 0.$

6.3.1 Cost of Capital Based on the Historic Growth of Earnings per Share

The estimated coefficients and supporting statistics for the model using the dependent variable based on the historic growth of earnings per share are reported on Table 6.11. For convenience, the base equation is reproduced as equation 1. Hypothesis 1 is tested using equation 2. Hypothesis 2 is tested using equations 3 and 4, where the impact of extreme high customer mix is examined in equation 3 and the impact of extreme low customer mix is examined in equation 4.

A comparison of the test equations is the base model illustrates the robustness of the estimated coefficients of the base variables across specifications. It is interesting to note that only in equation 4 do the firm size and nuclear construction variables, which were insignificant in the base model, achieve significance. The estimated coefficients are of similar magnitude and identical sign.

The estimated coefficient of the percent residential customer mix variable in equation 2 is significant at the 10 percent level based on a one-tailed test. The estimated sign, however, is inconsistent with the alternative hypothesis that investors associate a lower capital cost with utilities exhibiting a relatively greater dependence on residential revenues. The estimated coefficient of the percent industrial customer mix variable is correctly signed, but insignificant. Thus, based on equation 2 we cannot reject the null hypothesis that customer mix is not a relevant decision variable for investors.

Equations 3 and 4 test the alternative hypothesis that a higher cost of capital is associated with extreme customer mixes. Therefore, a priori all of the estimated coefficients of the extreme customer mix variables are expected to exhibit positive coefficients. Based on a one-tailed test, both of the extreme low percentage class revenue variables in equation 4 are signed correctly and are significant at the 10 percent level. Indeed, the joint F-statistic reported for equation 4 indicates that these variables significantly increase the explanatory power of the equation. Given the relative significance level of each variables, we can reject the null hypothesis. In equation 3, however, both of the extreme high percent variables are insignificant at any reasonable level of significance, indicating a failure to reject the null hypothesis.

The estimation results using the cost of capital variable based on historic earnings per share suggest that extreme customer mixes impact the cost of capital, though the results appear somewhat inconsistent. Based on the strong results in equation 3, a significant positive coefficient on high percent residential revenue (the converse of low percent industrial) was expected. Failure to achieve this result suggests that the absence of industrials is an important consideration for investors, while the presence of residential revenues is not.

6.3.2 Cost of Capital Based on the Historic Growth of Book Value per Share

The estimated coefficients and supporting statistics for the model using the dependent variable based on the historic growth of book value per share are reported in Table 6.12. Comparison of equations 2 through 4 to the base model again demonstrates the consistency of the results. In equation 2, neither customer mix variable is significant and the residential variable exhibits a positive coefficient. The only extreme customer mix variable to achieve significance in equations 3 and 4 is the extreme low industrial revenues variable. The variable is significant at the 5 percent level based on a one-tailed test and exhibits the correct sign.

As above, only when the extreme low variables are added is their joint effect on the base equation significant; the joint F-statistic is 3.32. Again, this reflects primarily the effect of the low industrial variable. This suggests that, based on this measure of the cost of capital, extreme low industrial revenue is perceived as increasing the riskiness of a utility as an investment. Thus, we can reject the null hypothesis that customer mix is not an important decision variable except when the customer mix exhibits a paucity of industrial revenues.

6.3.3 Cost of Capital Based on the Average Historic Growth Rate

The estimated coefficients and relevant statistics for the model using the dependent variable based on the average historic growth rate are reported in Table 6.13. Again a comparison of the four equations demonstrates the robustness of the results. The only customer mix variable which achieves significance is the extreme low industrial revenues: Its estimated coefficient is significant at the 5 percent level and displays the anticipated sign. Again this variable appears to dominate the extreme low revenue variables. The joint F-statistic for their inclusion of 3.63 is significant. Thus, these equations support the null hypothesis that investors do not examine customer mix to assess the riskiness of a utility, except when the utility's revenues are heavily skewed toward nonindustrial.

6.3.4 Cost of Capital Based on the Forecasted Rate of Growth of Earnings per Share

The estimated coefficients for the model using a dependent variable based on the forecasted growth of earnings per share are reported on Table 6.14. Inclusion of the overall customer mix variables does not alter appreciably the results obtained in the base model. Examination of equation 2 reveals that the estimated coefficients of both customer mix variables, though insignificant, exhibit incorrect signs. As seen earlier, only the extreme low industrial variable achieves significance in equation 4, with the coefficient on the low industrial revenue variable (0.169) taking a t-value of 3.8. This highly significant effect is reflected in the joint F-statistic, which is calculated to be 7.2.

6.3.5 Cost of Capital Based on the Forecasted Growth of Book Value per Share

The estimated coefficients and supporting statistics for the final model using the dependent variable based on the forecasted growth of book value per share are reported on Table 6.15. The estimated results are consistent across equations and exhibit consistency with the equations discussed previously. The customer mix variables in equation 2 are both positive and insignificant. The only significant extreme customer mix variable, in equation 4, is the variable for extreme low industrial revenues.

6.3.6 General Conclusions and Observations

Four general observations can be drawn from the results in Tables 6.11 through 6.15. First, the relationship stated in the null hypothesis between overall customer mix and the cost of capital is supported by ;the analysis presented in equation 2. At the 10 percent level, the estimated coefficient of the percent residential is significant only in Table 6.11, where it exhibits an incorrect sign. The estimated coefficient of percent industrial revenue never attains significance.

Second, the estimated coefficients, while consistently signed, are not sized consistently across equations. Closer scrutiny reveals that the estimated coefficients appear to exhibit greater similarity of magnitude within the subgroups based on historic and forecasted growth rates. This result lends tentative support to the conclusion that the more subjective, forecased growth rates may focus on specific characteristics of the utility, such as nuclear exposure, that are not incorporated in the historic growth rate estimated.

Third, examination of the estimated signs for the residential percent revenue variables suggests that the theoretical foundation for the expected negative coefficient should be reexamined. In all specifications of the model, the estimated coefficient is positive, contrary to theoretical expectations. This result allows acceptance of the null hypothesis that investors do not associate a lower cost of capital with those utilities whose customer mix is skewed toward residential customers. With respect to industrial mix, all of the equations support acceptance of the null hypothesis that investors do not associate a higher cost of capital with utilities whose customer mix is skewed toward industrial customers.

Fourth, equations 3 and 4, reported in Tables 6.11 through 6.15 support rejection of the null hypothesis that investors are indifferent to customer mix that is skewed awav from industrial customers. Because industrial consumption and pricing patterns tend to yield a more stable revenue stream throughout the year, this result suggests that investors may associate greater uncertainty with revenue streams that do not include a stable industrial component. Conversely, the high percent residential variable is expected to exhibit a significant positive coefficient. While all of the estimated coefficients of high percent residential revenues have the anticipated sign, none of the estimated coefficients are significant at any reasonable leve. Neither the high percent industrial revenues nor the low percent residential revenues exhibit significant coefficients in any of the equations tested.

One cautionary note merits attention. As noted briefly in Chapter 2, rate design tools may be used to stabilize the revenue stream associated with industrial consumption. This stabilization may take several forms: First, industrial tariffs tend to include three parts -- customer charge, demand charge and energy charge. The customer charge acts as an entry fee. The demand charge is designed to collect fixed costs. To stabilize the collection of costs throughout the year, many utilities have incorporated ratchets into industrial tariffs. The ratchet requires the customer to pay a demand charge based on a percentage of the highest hourly consumption over a historic period. As a result, monthly fluctuations in industrial kw consumption are masked.

Second, many industrial tariffs include minimum bill provisions. Customers are required to make a minimum monthly payment irrespective of the actual level of consumption. Like the demand ratchet, this feature helps to stabilize the industrial revenue stream.

The use of the rate design tools is expected to bias the results toward acceptance of the null hypothesis except when a utility exhibits an absence of industrial revenues. If the utility has succeeded in dampening any revenue variation associated with industrial usage patterns, then investors should be indifferent to the existence of industrial customers. To the extent that industrial revenues, however, form a stable revenue base that does not fluctuate dramatically with either economic or climatic conditions, investors should be concerned when industrial customers are absent from the customer mix.

Overall, the reported results do not permit rejection of the null hypothesis except when the customer mix is heavily skewed away from industrial customers. The study indicates, contrary to results discussed in Chapter 2, that investors are generally indifferent to customer mix. The one exception to this general rule occurs when the utility's customer base lacks industrial customers. As discussed above, if investors perceive the industrial base to provide a relatively stable revenue stream, the absence of industrial customers would increase the riskiness of the utility.

CHAPTER 7

SUMMARY AND CONCLUSIONS

This study investigates the impact of customer mix on the cost of capital for electric utilities. If customer mix contributes to the perceived riskiness of a utility, then the required rate of return should be adjusted upward for those utilities with "risky" customer-mixes. Some authors have extended this relationship from the revenue determination phase of the rate process to the rate design phase. They argue that the industrial customer class is more risky to serve, therefore, cost of service considerations require this class to bear a greater proportion of the utility's capital costs. Because the cost of capital represents a significant portion of the utility's cost of providing service, allocation of an above average share of capital costs to any class can raise their revenue responsibility significantly. While most of the research in this area has focused on estimating the size of the risk differential for the customer classes, this study examines an important underlying assumption, that customer mix impacts the perceived riskiness of the utility and therefore its cost of capital.

Chapter 2 provides a review of the literature that develops the risk-return relationship. The relevant risk for the investor holding a diversified portfolio is shown to be the systematic or marginal risk. The systematic risk, however, may result from a variety of sources, such as financial risk, business risk and operating risk. Several articles that specifically investigate the possible sources of risk are reviewed. These articles demonstate the need to use a variety of risk measures.

The remainder of Chapter 2 discusses the research on customer class risk differentials presented in intervenor testimony and trade journals. The authors obtain varied and frequently conflicting results. A review of their work, however, demonstrates two points. First, the choice of the dependent variable can influence greatly the achieved results. Because many published risk measures are highly subjective, it is important to obtain a measure of capital cost that is constructed from market data. The study adopts a cost of capital measure in which the cost of equity capital is based on the discounted cash flow model. This technique uses readily available market data and is used frequently in rate proceedings. The marginal cost of debt and preferred stock are based on the current cost of debt and preferred stock at the company's present bond rating.

The second criticism of this earlier work focuses on the measure of customer mix. The customer mix variable, percent industrial, is not defined consistently within the studies discussed in Chapter 2. The potential impact of using a consistent definition is discussed. This study uses SIC code data provided by utilities to the Edison Electric Institute to construct a uniform definition of industrial revenues.

Chapter 3 discusses marginal cost pricing for electric utilities and develops the concept of subsidy-free pricing. The pricing structure exhibits a subsidy when a customer can obtain the service on a stand-alone basis at a lower cost. The concept of subsidy-free pricing and the structure of pricing are discussed with in the context of both marginal cost pricing and fully distributed cost pricing.

Building on the theory of the security market line and the arbitrage pricing model, Chapter 4 demonstrates the relationship between risk and the required rate of return for the utility. The hypotheses to be tested are identified. First, I wish to test the hypothesis that utilities with an above average percentage of residential customers should exhibit a below average level of risk, because the usage pattern of residentials exhibits a low degree of systematic risk. Second, I wish to test the hypothesis that utilities with an above average percentage of industrial customers should exhibit an above average level of risk, because the usage pattern of industrial customers is very cyclical. Third, I wish to test the hypothesis that an extreme customer mix may impact the riskiness of the utility, because the customer classes of a well diversified utility provide offsetting risk features which are eliminated when the customer mix is heavily skewed toward a single class.

The equation used to test the hypotheses introduced in Chapter 4 is identified in Chapter 5. In addition to a discussion of the cost of capital variables and the customer mix variables, this chapter describes the variables for financial and operating risk used in the estimation. Two variables not used in previous analysis are introduced.

Chapter 6 details the tests of the hypotheses. Overall, the results provide mixed support for the hypotheses. Investors do not appear to associate lesser levels of risk with customer mixes that are skewed toward residential or higher levels of risk with customer mixes that are skewed toward industrial users. The results do provide support for the conclusion that investors associate greater risk with utilities that exhibit an extreme low percentage of revenue from industrial customers. The reported results appear to be invariant across the cost of capital variables used.

Overall, the analysis presented here fails to provide support for the assumption underlying the use of risk differentials to adjust customer rates of return. Investors do not appear to associate greater risk with a utility if its customer mix is skewed toward industrial customers or lower risk with a utility if its customer mix is skewed toward residential. Therefore, the overall cost of capital is not impacted by the utility's customer mix and the rates of individual customer classes should not reflect differing levels of responsibility for the utility's capital costs.

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