A Review of the Use of Beta in Regulatory Proceedings

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■ The use of β as a measure of risk in rate hearings on public utilities stirs controversy and disagreement among financial researchers. β has been found "wanting" [2, p. 612], suggested as possibly having "some value," [9, p. 247], and thought good enough that it not be "thrown away" [8, p. 627]. Such intellectual support for β might seem rather weak in view of the logic underlying its merit and the volumes of literature it has spawned. But indictment of β, and its defense, continues apace as evidenced by a 1978 symposium of articles in *Financial Management* [*e.g.*, 3].

Entering the fray over β is not the purpose of the present work. Instead, its purpose is to review the usage of β for estimating the cost of equity of public utility companies. Despite the considerable controversy surrounding applicability of β, recent surveys of public service commissions show that its use has not been insignificant [5]. Of the 54 jurisdictions queried in 1978, 11 reported 16 rate relief cases where capital asset pricing model (CAPM) testimony was heard. An updated survey in 1979 uncovered 12 more CAPM cases. Several commissions indicated that they expect the CAPM to be used in the future. Moreover, the use of β is not limited to CAPM cases. Expert witnesses often use β to form groups of companies comparable in risk.

The stakes in making good estimates of equity costs are high: a one-percentage point difference can mean millions of dollars in allowed revenues. Faced with such dollar magnitudes, the vested interests in the regulatory process (utility companies, consumer coalitions, state consumer divisions, state and federal regulatory agencies, investors, and the public at large) have become greatly concerned with the procedures used by financial experts to estimate equity costs.

How witnesses measure and use β to estimate cost of equity capital is the topic of this study. The analysis of 49 pre-filed testimonies (and several accompanying cross-examinations) in which β plays a principal role shows how the difficult decisions have been made. The analysis also reveals the extent to which practice both varies across witnesses and deviates from theory. Despite procedural variations in measuring and using β, *ex ante* return estimates across witnesses are shown to be positively related to β estimates. An important by-product of the analysis is the descriptive listing of testimonies provided in the appendix. One justification typically advanced in a hearing room for using a method is its degree of acceptance in other jurisdictions. The lengthy (relative to previous sources) listing provides information on where and when β testimonies have been filed.

Testimonies in Brief

Analysis of the sample testimonies shows that at least 20 state utility commissions and the Federal Communications Commission have heard testimonies using β.* Although widely dispersed geographically, β testimonies have been presented most frequently in Oregon, South Carolina, and New York. The frequency of β usage in Oregon and South Carolina can be explained primarily by the presence of staff economists who employ the modern theories of portfolio selection and capital markets.

Most of the sample testimonies (all but four) were presented in 1976 or later. The earliest sample testimony, filed in 1971, used β solely as an indicator of relative risk. Relevance of β could thus be argued in the simpler portfolio context without all the theoretical trappings of the CAPM. The earliest testimony in which β was incorporated into the CAPM for estimating cost of equity capital occurred in 1975.

Approximately one-half the β witnesses have affiliations with academic institutions. Commission staff members, some of whom have previously held academic positions, form the second largest group of β witnesses. About three-fourths of the testimonies were provided on behalf of state commissions, consumer agencies, and consumer-coalition groups. Those company witnesses who did use β tended to limit its use to grouping firms of comparable risk; they generally did not use β in the full context of the CAPM.

Estimating Procedures

In the 1909 case of *Willcox v. Consolidated Gas Co.*, the court appeared remarkably prescient in anticipating modern theory: "One who invests his money in a business of a somewhat hazardous character is very properly held to have the right to a larger return without legislative interference, than can be obtained from an investment in Government bonds or other perfectly safe security . . ." [14, p. 49]. The traditional CAPM used by the sample witnesses conforms rather well to this dictum:

$$E(\tilde{R}_u) = R_f + \beta_u[E(\tilde{R}_m) - R_f] \qquad (1)$$

where $E(\tilde{R}_u)$ in equilibrium is the utility's cost of equity, R_f is the risk-free rate, β_u represents the utility's relevant or systematic risk, and $E(\tilde{R}_m)$ is the expected return on the market portfolio.

Under cross-examination, CAPM witnesses face at least two general problems peculiar to their approach. First, they must defend their estimates of three inputs — R_f, β_u, and $E(\tilde{R}_m)$. Even what is presumed to be the simplest of the three, R_f, can create considerable debate. Suggested proxies for R_f range from annualized rate of return on Treasury bills to 20-year government bond yields, and occasionally rates on long-term corporate bonds. Computation of β_u (the subject of the next section) also raises numerous questions, specifically about selection of the differencing interval, estimation period, market index, return definition, and whether or not adjustments should be made for regression tendencies in β. Estimation of $E(\tilde{R}_m)$ — or the risk premium, $E(\tilde{R}_m - R_f)$ — normally draws on published studies of stock returns over long periods of time. In some cases the witnesses modify the *ex post* returns with judgments on the current and expected future economic climates.

The second major task facing the CAPM witness is to educate and persuade regulators as to the virtues of the CAPM. Because they have been used only recently in hearing rooms, CAPM concepts place a considerable burden of explanation on the innovative witness. Defending CAPM procedures in terms of theoretical relevance, objectivity, and replicability has met with extremes of both failure and success. Some indication of these extremes is provided by the following excerpts from two commission decisions:

> A review of the record would indicate that the Sharpe-Lintner version of the capital asset pricing model is still subject to considerable controversy among leading economists and that the controversy surrounding this model makes it inappropriate for the Board to place any significant reliance on its use in establishing the required rate of return [New Jersey, Docket No. 7711-1136, 1979].

> . . . It is the . . . breadth of issue coverage which allow(s) reliance on the CAP method as opposed to the less rigorous approaches such as comparative earnings and DCF methods [Oregon, Order #77-776, UF 3339, 1977].

A few witnesses who use the CAPM to estimate equity costs recognize the need to marshall alternative

*Professor Diana R. Harrington, who conducted two surveys of regulatory commissions, kindly provided listings of the CAPM testimonies that she discovered [5]. Moreover, she provided copies of the testimonies themselves in some cases. Other testimonies were collected from utility companies, regulatory commissions, and expert witnesses. Although not a census of all testimonies using β as a risk measure, the sample probably represents a significant proportion of such testimonies for the time period studied.

forms of evidence. They tend to use discounted cash flow (dividend yield plus expected growth) as a secondary method, when one is used, but in numerous cases the CAPM witnesses rely solely on the CAPM. Perceiving more compatibility between the CAPM and DCF than between the CAPM and comparable earnings procedures seems quite reasonable since CAPM and DCF are both market-oriented. In general, the witnesses who use DCF and comparable earnings as their primary methods tend to use alternative estimating procedures more frequently than do CAPM witnesses.

Computation of β

Whether β is used directly in the CAPM or only for identifying firms of comparable risk, β witnesses face the initial decision of computing their own β or using one computed elsewhere. Slightly more than three-fourths of all the sample testimonies contain βs computed by the witnesses themselves. Most of the remaining βs come from sources published by Merrill Lynch or Value Line. All the βs computed by witnesses or others are based on historical rates of return. In one case, however, a published fundamental β was used — *i.e.*, a β predicted from fundamental financial variables. In many hearing rooms the details of β computation are the focal point of interrogation.

Model Type

The difficulties in practice of obtaining *ex ante* distributions force witnesses to use *ex post* distributions as substitutes. These distributions are normally used in one of two models — Sharpe's market model or the risk-premium model. About three-fourths of the sample testimonies contain βs computed from Sharpe's [10] traditional market model:

$$\tilde{R}_{ut} = \alpha_u + \beta_u \tilde{R}_{mt} + \tilde{e}_{ut} \qquad (2)$$

where $\tilde{R}_{ut}$ and $\tilde{R}_{mt}$ represent *ex post* returns on the utility stock and the market portfolio, respectively. Estimation of the model parameters (α_u, β_u) follows in most cases from minimizing $\tilde{e}_{ut}$ by ordinary least squares (OLS). In the two testimonies where generalized least squares was used to correct for possible autocorrelation, only minor departures from OLS estimates resulted.

The alternative model, used in 13% of the testimonies, regresses excess returns of the utility stock ($\tilde{R}_{ut} - R_{ft}$) on excess market returns ($\tilde{R}_{mt} - R_{ft}$):

$$\tilde{R}_{ut} - R_{ft} = \alpha_u' + \beta_u' (\tilde{R}_{mt} - R_{ft}) + \tilde{e}_{ut}'. \qquad (3)$$

This risk-premium procedure explicitly recognizes variation in the risk-free rate R_f over time t. If Equation (3), which is the *ex post* empirical counterpart of Equation (1), properly represents the process governing utility stock returns, Equation (2) contains a potential bias as explained by Miller and Scholes [7]. However, the sample testimonies in which Equation (3) is used to check the Sharpe model reveal no significant differences in the β estimates. In addition, Miller and Scholes have shown that the variance of R_{ft} is so small that the potential bias becomes negligible [7, p. 56]. Thus, the importance of the issue surrounding Equations (2) and (3) appears relatively minor in comparison to other rate-hearing issues.

Market Index

Having selected the model form for estimating β, the witness must choose a suitable proxy for the market portfolio. Relevant risk of a stock is that contributed to the market portfolio, which presumably all investors hold. Theoretically, the market portfolio broadly contains all types of assets having an influence on investor decisions. Ultimately, however, the market portfolio appears elusive, and the appropriate index is difficult to determine.

Although easier to conceive in theory than to identify in practice, the market portfolio must be represented by some index. Conforming to established practice, 87% of the sample testimonies indicate the use of a broad value-weighted stock index — New York Stock Exchange (NYSE) Index and Standard & Poor's 500 Index. Moving toward less diversified indices, one witness used Standard & Poor's Utility Index, and another selected ten utility companies as an index. Such narrowly diversified proxies depart more from theory than do the value-weighted indices. But even the value-weighted indices, which better reflect theoretical requirements than do equal-weighted indices, severely limit coverage to a subset of all assets potentially affecting investor decisions.

Returns, Intervals, and Periods

Sample witnesses most commonly used data from the CRSP tapes (Center for Research in Security Prices), which currently contain price and return data for more than 2,500 stocks. Approximately two-thirds of the testimonies indicate the use of total returns (includes dividend yield) to compute β. The remaining testimonies either exclude dividend yield or simply leave rate of return undefined. Work by Sharpe and Cooper [11, p. 49] suggests that β is quite insensitive to the dividend exclusion, for dividend yields remain relatively constant over time.

Perhaps more important to the rate-of-return definition is the interval over which the rate is defined. Empirical and theoretical research provides little absolute guidance on the choice of interval. The CAPM in principle deals with a future period of indeterminant length. In practice, the CAPM is used for estimation over long periods, and β is estimated from discrete intervals. Merrill Lynch and Value Line, for instance, employ monthly and weekly intervals, respectively. Intervals used in the sample testimonies range from weeks to years. Monthly intervals predominate, however, with weekly intervals a distant second; in only one case were annual intervals used.

Closely linked to the interval-size decision, a specific number of intervals must also be selected to estimate β. This decision involves a tradeoff between choosing a large number of *ex post* intervals to achieve representativeness of the *ex ante* distribution and yet not including intervals so remote in time as to be unrepresentative. The modal number of intervals resulting from this tradeoff by sample witnesses who use monthly intervals is 60. But although 60 months is the most common period, others ranging from 12 to 120 months were frequently employed.

Stationarity Tests

Selection of intervals and periods has an important impact on the practical usefulness of β [12]. The usefulness of β is delimited not only by its stability (over different intervals) but also by its stationarity (from period to period). The empirical evidence indicates considerable (more than 50%) unexplained variation in moving from historical to future βs [1]. Although some evidence suggests more stationarity in utility βs [4], mechanical extrapolation from historical βs still presents a significant danger. Without careful testing of stationarity and stability, and the superimposition of judgment on the historical β, the witness may unknowingly provide misleading testimony. Approximately one-half of the sample witnesses dealt with the potential dangers by conducting stationarity tests. By default, the remaining witnesses placed a great deal of confidence in the one particular period used to estimate β. In almost all cases, the issue of stability (sensitivity to interval) was ignored, although a few witnesses compared the most recent 52-week β with the 5-year monthly β.

Regression Adjustments

Besides using judgment developed from analyzing the stationarity and stability of a utility β, some witnesses also used statistical adjustments to improve their β estimate. The common adjustment made to historical βs involves reduction of inefficiency in the β estimate caused by regression tendencies. Klemkosky and Martin have demonstrated the importance of this adjustment by showing that inefficiency constitutes 40% of the mean square error in some periods [6, p. 1124]. Witnesses in 11 of the 49 testimonies attempted to reduce this error by employing Vasicek's Bayesian approach [13]. This approach requires prior information (mean and variance) from a cross-sectional distribution of relevant βs. Distributions considered relevant by the witnesses for adjusting historical βs include Moody's 24 utilities, all utilities on the New York Stock Exchange, and certain other utility groupings. The second adjustment procedure frequently used follows the regression procedure established by Blume [1]. In all, witnesses made adjustments for regression tendencies in 19 of the 49 sample testimonies. Some of the testimonies in which published βs were employed also reflect adjustments (*e.g.*, Merrill Lynch). Approximately one-half of all the testimonies reflect adjustment for regression by either the witness or publisher of β.

Estimated Cost of Equity Versus $E(\tilde{\beta}_u)$

The numerous decisions required to estimate β are frequently used in rate hearings as the basis for questioning the reliability and practicality of β. So many operational decisions, it is argued, may well lead to an erroneous quantification of risk and the false appearance of certitude. But legal dicta state that cost of equity capital *should* bear a positive relationship to risk. And descriptive theory of competitive markets in equilibrium indicates that cost of equity capital $[E(\tilde{R}_u)]$ *will* be a positive function of risk $[E(\tilde{\beta}_u)]$. To reflect compliance with such legal and economic principles, the estimating procedures used by the sample witnesses should produce a positive relationship between $E(\tilde{R}_u)$ and $E(\tilde{\beta}_u)$.

The sample testimonies contain *ex ante* estimates based on extensive study by a cadre of expert witnesses. These expectational data, however, do contain several sources of random disturbances. As shown earlier in Equation (1),

$$E(\tilde{R}_u) = f[R_f, E(\tilde{\beta}_u), E(\tilde{R}_m)] \quad (4)$$

where $E(\tilde{\beta}_u)$ replaces β_u in Equation (1) to emphasize the futurity of risk. Expected return can be related to expected risk by the following regression model:

$$\widetilde{E(\tilde{R}_u)}_i = \gamma_0 + \gamma_1 \widetilde{E(\tilde{\beta}_u)}_i + \tilde{\epsilon}_i \qquad (5)$$

where (i=1,2, . . . , n), and n is the number of testimonies. γ_0 and γ_1, respectively, represent estimates of R_f and $(E(\tilde{R}_m) - R_f)$ implied by *ex ante* risk–return estimates of the witnesses. The error term $\tilde{\epsilon}_i$ reflects procedural variations in estimating $E(\tilde{\beta}_u)$ and $E(\tilde{R}_m)$, and in selecting R_f. Part of the error stems from the testimonial estimates spanning a nine-year (1971–79) period during which interest rates and other economic variables changed greatly. In addition, the functional relationship denoted by Equation (4) is primarily aplicable to those testimonies wherein β was used in the CAPM. For testimonies in which β was used to form comparable risk groups or for some other lesser role, the following notation is more appropriate:

$$E(\tilde{R}_u) = f[E(\tilde{\beta}_u), X_i] \qquad (6)$$

where X_i represents all those factors other than $E(\tilde{\beta}_u)$ impacting on $E(\tilde{R}_u)$. These factors, for example, would include dividend yields, expected growth rates, and the witnesses' evaluation of financial statements. Omission of these factors from Equation (5) contributes to $\tilde{\epsilon}_i$. Since all $E(\tilde{R}_u)$ are taken prior to any explicit ad hoc adjustments (*e.g.*, for market pressure and flotation costs), random errors from these sources have been eliminated.

Despite the many variations in estimating procedures and differing time frames encompassed by the testimonies, significantly positive relationships prevail between estimated return and risk. The following estimate of Equation (5) results from using all the testimonies:

$$\overline{E(\tilde{R}_u)}_i = 9.47\% + (3.51\%)\ \overline{E(\tilde{\beta}_u)}_i \qquad (7)$$

with both estimates of γ_0 and γ_1 different from zero at the .01 level and R^2 = .20. Summing the two parameters $(\gamma_0 + \gamma_1)$ implies an expected return on the market portfolio of 12.98%. As expected, variation in estimating procedures and differing time periods associated with the testimonies lead to a pronounced unexplained variance.

Unexplained variance caused by the X_i in Equation (6) should be reduced by excluding those testimonies in which β is used only for grouping comparable risk firms. β tends to play a background role in these testimonies, while innumerable other financial and economic factors help forge the estimate of equity cost. Additionally, including only the latest testimony given by each witness provides a sample of testimonies fairly recent and quite close in time to each other. This further homogenization of the sample produces the following estimate of Equation (5):

$$\overline{E(\tilde{R}_u)}_i = 8.83\% + (5.37\%)\ \overline{E(\tilde{\beta}_u)}_i \qquad (8)$$

with both estimates of γ_0 and γ_1 different from zero at the .01 level, and R^2 = .47. Variation in estimated equity cost explained by expected risk jumps from .20 in Equation (7) to .47 in Equation (8) because of the additional refinements in the sample.

In general, Equations (7) and (8) provide a measure of confidence in the use of β in regulatory proceedings. In conformance to theory, risk expected by witnesses appears to be the motivating force for their estimated expected return, or cost of equity. If the estimates of expected risk and return across witnesses had not produced a significant positive relationship, consistency of implementation and the use of β would have been more questionable.

Summary

Introducing theory into the world of practical affairs sometimes brings with it more heat than light. The use of β during the 1970s in utility rate hearings illustrates the point. Surrounded by controversy in the academic community, β creates even more disagreement in regulatory proceedings. Some rate-hearing advocates would ignore the quantification of risk altogether, retreating to the safe haven of inscrutable judgment. Witnesses who measure risk with β, however, must expose and explain each of the numerous steps in their estimation procedure.

Employed primarily by academicians serving as expert witnesses, β is typically used directly in the CAPM or, alternatively, for grouping comparable risk firms. In lieu of using published sources, most witnesses choose to defend their own computation of β. This defense normally centers around the type of model used to estimate β, the index employed, the intervals and periods from which rate-of-return measurements are taken, the sensitivity of the estimate to those periods and intervals, and the impact of adjusting for mean regression. Although procedures vary considerably across testimonies, five-year monthly βs using a value-weighted index in Sharpe's market model are most common. Approximately one-half of the testimonies contain tests for stationarity and adjustment for regression tendencies. Despite the great variations in estimating procedures across testimonies, regression analysis reveals a significantly positive, linear relationship between estimated equity cost and β. This finding presents a benchmark challenge to alternative measures of risk.

References

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Appendix. Rate-Hearing Testimonies Using β

	Expert Witness	Company	State or Agency	Case or Docket No.	Year*
1.	J.L. Bicksler	Southern Bell Telephone and Telegraph	South Carolina	76-352-C	1976
2.	J.L. Bicksler	South Central Bell Telephone	Mississippi	U-3066	1976
3.	J.L. Bicksler	Southern Bell Telephone and Telegraph	Georgia	2944-U	1976
4.	J.L. Bicksler	Pacific Power & Light	Oregon	UF3232	1976
5.	J.L. Bicksler	Lincoln Telephone and Telegraph	Nebraska	32290	1977
6.	J.L. Bicksler	Community Public Service	New Mexico	1378	1977
7.	B.L. Copeland	Arkansas Western Gas	Arkansas	U-2647	1975
8.	W.P. Dukes	Southwestern Bell Telephone	Texas	Unknown	1976
9.	W.P. Dukes	Southwestern Bell Telephone	Arkansas	Unknown	1976
10.	S. Enkara	Ohio Edison	Ohio	77-1249-EL-AIR	1978
11.	S. Enkara	Dayton Power & Light	Ohio	78-92-EL-AIR	1979
12.	S. Enkara	Ohio Power	Ohio	78-67-EL-AIR	1979
13.	D. Fitzpatrick	Utah Power & Light	Idaho	U-1009-100	1979
14.	I. Friend	New York Telephone	New York	26775	1975
15.	I. Friend	Michigan Bell Telephone	Michigan	U-5125	1976
16.	I. Friend	Bell Telephone of Pennsylvania	Pennsylvania	367	1976
17.	I. Friend	New Jersey Bell Telephone	New Jersey	7711-1136	1977
18.	I. Friend	Northwestern Bell Telephone	Minnesota	P/421/GR-79-388	1978
19.	I. Friend	New York Telephone	New York	27469	1978
20.	I. Friend	Michigan Bell Telephone	Michigan	U-6002	1979
21.	M.H. Freise	New York Telephone	New York	27569	1979
22.	K. Harrison	Portland General Electric	Oregon	UF3339	1977
23.	P.J. Hess	Northwestern Bell Telephone	Iowa	U-555	1976
24.	C.D. Hobbs	Portland General Electric	Oregon	UF3443	1978
25.	D.E. Logue	Public Service Company	New Hampshire	DR 77-49	1977
26.	D.E. Logue	Granite State Electric	New Hampshire	DR 77-63	1977
27.	J. McTaggart	Portland General Electric	Oregon	UF3443	1978
28.	S.C. Myers	American Telephone and Telegraph	F.C.C.	19129	1971
29.	S.C. Myers	Communications Satellite	F.C.C.	16070	1973
30.	C.E. Olson	Duke Power	North Carolina	E-7, SUB237	1978
31.	D.E. Peseau	Cascade Natural Gas	Oregon	UF3246	1976
32.	D.E. Peseau	California Pacific Utilities	Oregon	UF3275	1977
33.	D.E. Peseau	Portland General Electric	Oregon	UF3339	1977
34.	D.E. Peseau	Pacific Power & Light	Oregon	UF3351	1977
35.	R.G. Rhyne	South Carolina Electric & Gas	South Carolina	75-645-E	1977
36.	R.G. Rhyne	Carolina Pipeline	South Carolina	77-668-G	1977
37.	R.G. Rhyne	Peoples Natural Gas	South Carolina	78-290-G	1978
38.	R.G. Rhyne	Southern Bell Telephone and Telegraph	South Carolina	78-353-C	1978
39.	R.G. Rhyne	Carolina Power & Light	South Carolina	77-354-E	1978
40.	R.G. Rhyne	Duke Power	South Carolina	78-189-E	1978
41.	R.E. Simmons	Interstate Power	Minnesota	E001/GR-78-1065	1979
42.	P.J. Strebel	Columbia Gas of New York	New York	27306	1978
43.	D.K. Whitcomb	New Jersey Bell Telephone	New Jersey	7711-1136	1978
44.	J.P. Williamson	Central Vermont Public Service	Vermont	4230	1977
45.	J.P. Williamson	Narragansett Electric	Rhode Island	1288	1978
46.	S. Yoon	Rochester Gas & Electric	New York	2730	1978
47.	S. Yoon	New York State Electric & Gas	New York	27361	1978
48.	T.M. Zepp	Northwest Natural Gas	Oregon	UF3309	1977
49.	T.M. Zepp	Portland General Electric	Oregon	UF3518	1979

*Best estimate of year in which testimony was given; may not coincide with filing year, which may be one year earlier in some cases.