STATE OF NEW HAMPSHIRE
BEFORE THE
PUBLIC UTILITIES COMMISSION

Public Service Company of New Hampshire d/b/a Eversource Notice of Intent to File Rate Schedules	)	Docket DE 24-070

Direct Testimony

Allowed Rate of Return on Equity

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Q. Please state your name, title, and business address.

A. My name is Marc Vatter. I am Director of Economics and Finance for the New Hampshire Office of the Consumer Advocate (OCA), here at 21 South Fruit Street, Suite 18.

Q. Please state your educational achievements and professional designations.

A. I have a B.A. in economics from the University of Oregon (1986) and a Ph.D. in economics from Brown University (2007). Attachment MV-1 is my resume.

Q. Have you previously testified before the New Hampshire Public Utilities Commission, or other regulatory commissions?

A. Yes. I have testified before the New Hampshire PUC, the Energy Facilities Siting Board of the Rhode Island PUC, the Michigan PSC, the Mississippi PSC, and the FERC.

Q. On whose behalf are you sponsoring this testimony?

A. I am testifying on behalf of the OCA.

Q. What is the purpose of your testimony?

A. This is a Capital Asset Pricing Model (CAPM)-based study of the appropriate allowed rate of return on equity (ROE) in Public Service Company of New Hampshire's (PSNH) distribution ratebase in Docket DE 24-070. It is designed to complement the testimony of Aaron Rothschild. It focuses on the target companies: Eversource at the level of the holding company; and PSNH at the level of the utility. Such estimates of appropriate allowed ROE often rely on proxy groups instead of the target company, and I do use data on other holding companies and utilities in combination with data on Eversource and PSNH. However, as the U.S. Court of Appeals for the District of Columbia Circuit explained in *Petal Gas Storage, L.L.C. v. FERC*, the purpose of the proxy group is to "provide market determined stock and dividend figures from public companies comparable to a target company for which those figures are unavailable."[1] In this case, stock and dividend data are available for Eversource (and its predecessor Northeast Utilities), and reported ROEs are available for PSNH, so lack of availability does not restrict consideration to data on proxies only. A second argument for omitting the target company is that inclusion endogenizes the allowed rate of return over time: A higher allowed ROE raises subsequent realized ROE, causing a commission to then increase allowed ROE, and so on. My statistical methods obviate this concern. These and other methods are described in the appendix.

A third issue that surrounds such estimates is the gap between ROEs for holding companies and their subsidiaries. The former often own substantial unregulated and otherwise differentiated assets from the distribution capital on which ROE is being regulated. By forecasting ROEs for both Eversource and PSNH, and including allowed ROE in a statistical model of PSNH, I narrow this gap.

[1] *Petal Gas Storage, LLC v. FERC*, 496 F.3d 695, 699 (CADC 2007).

Q. Please summarize your analysis at the level of the holding company.

A. I made forecasts, using a version of the CAPM with trending betas (βs), of an ROE for Eversource during the DE 24-070 rate period. A "CAPM β" is the fraction of overall risk in the stock market reflected in a particular portfolio, which may consist of a single asset, such as equity in a single holding company. The CAPM equation is shown as Equation (1).

$$\mu_p - r_f = \beta\left(\mu_m - r_f\right) \quad (1)$$

where μ_p is the expected rate of return on a portfolio of assets, μ_m is the expected rate of return on all assets in the market combined, r_f is the "risk-free rate of return", and β relates the two risk premia. By "trending", I mean that β may change over time as historical and forecasted data indicate, in lieu of the Blume (1971, 1975) adjustment, which has been discredited for regulated public utilities by Michelfelder and Theodossiou (2013).[2, 3] "Gombola and Kahl in 1990 found that utility betas are non-stationary and concluded that each utility beta's non-stationarity must be viewed on an individual stock basis, unlike the recommendation of Blume which adjusts all betas for their tendency to approach 1."[4, 5] Hence the trending CAPM βs.

I performed a "panel" study based on daily dividend-adjusted common equity prices on the three holding companies of regulated private electric distribution systems in New Hampshire, and a "time-series" study using daily dividend-adjusted prices on what is now Eversource alone. Panel data

[2] Blume, M. (1971). On the assessment of risk, *Journal of Finance* 26, 1–10
Blume, M. (1975). Betas and their regression tendencies, *Journal of Finance* 30, 785–795.
[3] Michelfelder, R.A. & Theodossiou, P. (2013). Public utility beta adjustment and biased costs of capital in public utility rate proceedings, *Electricity Journal* 26(9), 60-68. https://doi.org/10.1016/j.tej.2013.09.017
[4] Gombola, M. & Kahl, D. (1990). Time-series processes for utility betas: implications for forecasting systematic risk, *Financial Management* 19(3), 84–93. https://www.jstor.org/stable/3665827
[5] Ibid, Michelfelder and Theodossiou, p. 62.

observe variables across both space and time, while time-series data observe variables over time. The panel study uses the single index model equational form used by Blume, but with trending βs, while the time-series study uses the form of Equation (1), but with a trending β. The expected value of an estimate of β is the same using either form. Results are shown along with historical statistics in Table I.

Table I: Historical and forecasted ROEs for what is now Eversource (NYSE ticker ES)

	Nominal	Inflation	Real
1973-2023	7.17%	4.05%	3.13%
1983-2023	8.61%	2.89%	5.72%
1993-2023	7.02%	2.56%	4.46%
2003-2023	10.15%	2.60%	7.55%
2013-2023	7.71%	2.78%	4.93%
Forecast for January 1, 2028*			
Panel	7.66%	2.34%	5.32%
Time-series	7.67%	2.34%	5.33%

* Uses trending CAPM β as of January 1, 2028.

The nominal forecasted ROEs of 7.66 percent and 7.67 percent are not far from the midpoint of Mr. Rothschild's estimated range for comparable ROEs, which is 7.36 percent.

The 2.34 percent forecast of inflation is five-year expected inflation (series EXPINF5YR) from the Federal Reserve Bank of Saint Louis "calculated with a model that uses Treasury yields, inflation data, inflation swaps, and survey-based measures of inflation expectations".[6] As of November, year-over-year inflation in the Consumer Price Index (CPI) was running at 2.73 percent, far below the 8.99 percent observed when the Fed began tightening in June 2022.[7] Investors care about real (net of inflation), not nominal, returns. The forecasted, for January 1, 2028, CAPM β for Eversource in the panel

[6] https://fred.stlouisfed.org/series/EXPINF5YR, accessed January 13, 2025.
[7] https://fred.stlouisfed.org/series/CPIAUCSL#0, accessed January 13, 2025.

study is 0.58, with a 95 percent confidence interval of [0.54, 0.61]; it is also 0.58, with a 95 percent confidence interval of [0.54, 0.61], in the time-series study, robust to the differences in functional form and dataset.

Q. What inputs drive the results at the level of the holding company?

A. A forecast using the CAPM requires: 1) a forecast of a stock's β; 2) a forecast of the equity market risk premium (MRP); and 3) a forecast of the risk-free rate. The MRP is the difference between the rate of return on the market for equity as a whole and the risk-free rate; $\mu_m - r_f$ in Equation (1). The risk-free rate, r_f, is the rate of return on assets with, ideally, no risk of default, fixed payments of interest, and no risk that a change in the market for loanable funds would impose an opportunity cost on an investor. Table II provides a history of the MRP using rates of return on the S&P 500 to measure the rate for the stock market as a whole and the secondary yield on three-month Treasury bills as the risk-free rate. In their seminal paper titled "The equity premium: A puzzle", Mehra and Prescott (1985) used the S&P 500 and three-month T-bills for this purpose.[8]

Monetary policy saw two major shifts during the entire period shown in Table II, from fixed to floating exchange rates for the U.S. dollar in 1973, and a credible commitment to low inflation under Fed Chairman Paul Volcker in the early 1980s, both of which had implications for rates on the low-risk government securities through which the Fed's open market operations are conducted, and the MRP over them.

[8] Mehra, R., Prescott, E.C. (1985). The equity premium: A puzzle, *Journal of Monetary Economics* 15(2), 145-161. https://doi.org/10.1016/0304-3932(85)90061-3.

Table II: Historical market equity risk premia

Decade	MRP	Historical time-horizon	MRP
1960s	0.10%	1963-2023	4.63%
1970s	-2.53%	1973-2023	4.52%
1980s	5.32%	1983-2023	6.71%
1990s	11.60%	1993-2023	6.70%
2000s	-4.95%	2003-2023	8.25%
2010s	11.60%	2013-2023	11.85%
2020s	8.96%		

Returns on stock are volatile, as shown on the left side of Table II. Private investment is the most pro-cyclic component of the Keynesian breakdown of GDP (which also includes private consumption, government purchases, and net exports), and stock prices reflect the outlook of people who acquire, maintain, and retire physical capital, and issue stock to do so. In the long run, though, returns on stock have a strong central tendency: An investor with no special knowledge can diversify, buy, and hold, ride out the fluctuations, and earn a higher return than that on low-risk debt instruments, as shown on the right side of Table II. This is the type of investor that Eversource must be able to offer a competitive rate of return to; it need not pay a high enough ROE for shareholders to "beat the market," though investors with special knowledge sometimes do.

I forecast that the MRP will be lower than it has been since the Great Recession, a period that began with rapid appreciation in the stock market as the economy recovered. Based on the history of the MRP since 1980, soon after Volcker's ascension, I forecast it to be 6.18 percent during the DE 24-070 rate period; this is the average since 1980.[9] Going back to 1980 includes three major macroeconomic

[9] At a conference called "Equity Risk Premium Forum 2021" held by the CFA Institute Research Foundation, a plurality of the experts in attendance gave 4.00% as the estimated long run MRP using the rate on ten-year Treasury

downturns: that in the early 1980s; the Great Recession of the late 2000s; and Covid, but excludes the stagflation of the 1970s from the historical data.

In its Market Probability Tracker,[10] the Federal Reserve Bank of Atlanta reported an expected "three-month compounded average Secured Overnight Financing Rate" of 4.10 percent for September 2027, which should fall well within the DE 24-070 rate period. I use this as a forecast of the risk-free rate. Though I use the secondary market yield on three-month Treasury bills historically, this metric, being "three-month" and "secured," is closely related. The Fed, then, reports that investors expect that the risk-free rate will be higher than it has been since the Great Recession, given the need for a tighter monetary policy to contain inflation post-Covid.

Together, the lower MRP and higher risk-free rate have partially offsetting effects on the forecasted ROEs for Eversource shown in Table I, but $\beta < 1$ in Equation (1) for a holding company of regulated public utilities because their stock is less risky than the market as a whole. Therefore, a given increase in the risk-free rate will raise forecasted ROE for a regulated public utility more than an equivalent decrease in the MRP will lower it.

Q. Please summarize your analysis at the level of the utility.

A. ROE in distribution ratebase for PSNH during the DE 24-070 rate period is the metric being regulated. I used quarterly panel data on allowed and realized ROEs beginning in 2010 for Eversource's

bonds as the risk-free rate, with more experts deviating above than below. When I calculate the mean MRP beginning in 1980 using that risk-free rate, I get 4.23%, supporting 1980 as a starting point. A monograph reporting on the conference is available at https://rpc.cfainstitute.org/sites/default/files/-/media/documents/article/rf-brief/Revisiting-the-Equity-Risk premium.pdf, accessed December 12, 2024.

[10] https://www.atlantafed.org/cenfis/market-probability-tracker, accessed January 13, 2025.

three electric and gas distribution subsidiaries in a variation on Equation (1) that controls for the effect of allowed on realized ROE. Eversource reports actual annual moving average ROEs in the book value of the distribution ratebases of its regulated retail holdings on a quarterly basis to the state commissions that regulate them on what in New Hampshire is Form F-1.[11] I divided these by Eversource's market-to-book ratio (MBR), effectively multiplying the book value of equity in each subsidiary's ratebase by the MBR, inferring the "market determined" ROE described by the court in *Petal Gas Storage*.[12] Realized ROE before and after dividing by MBR, both shown in Table III, are similarly stable.

The MBR varied, but exceeded unity throughout the sample period, and exhibited no trend up or down.[13] The MBR > 1 implies that inferred market ROE was below ROE in the book value of ratebase. Mr. Rothschild discusses the implications of an MBR > 1 in his testimony. This indicates that investors had seen returns on book value of equity in ratebase (almost all of Eversource's returns are regulated) as more than competitive, motivating them to bid up Eversource's share price by buying or holding its stock until they had exploited and eliminated the opportunity for economic profits; with no trend in the MBR, this process was ongoing. Accordingly, the realized inferred market ROE for PSNH could be interpreted as competitive, and the realized ROE in book value of ratebase would then be interpreted as monopolistic.

[11] https://www.eversource.com/content/residential/about/investors/annual-reports-10k/quarterly-roe-filings, accessed August 5, 2024

[12] Using the realized inferred market ROEs, I estimated that the CAPM βs for these Eversource subsidiaries (PSNH, Connecticut Light & Power (CL&P), and Yankee Gas) are not statistically significantly different from one another. Differences in ROE in book value, which also feeds into inferred market ROE, across the three subsidiaries do not undermine application of Eversource's MBR to each one. Realized inferred market ROE for each subsidiary, PSNH in particular, responds to changes in the stock market the same, statistically, as if all three were combined into a single subsidiary. If PSNH did, in fact, issue stock, its MBR would be close to those of CL&P and Yankee Gas (if they also issued stock). The ratebases of the three subsidiaries form a large share, though not all, of Eversource's "portfolio" of assets.

[13] Eversource's MBR spent about 11 months below 1 during the 2000s, but 2 years straight in the 1990s. https://www.capitaliq.spglobal.com/web/client#company/stock?id=4057052&mode=1, accessed January 6, 2025.

Table III: ROEs for electric and natural gas distribution subsidiaries of Eversource, 2010:III - 2024:II; percentage points

	Mean	Standard Deviation	Minimum	Maxmimum
PSNH				
Book ROE	8.14	0.90	6.37	9.89
Inferred market ROE	5.41	0.97	3.94	7.63
Connecticut Light & Power				
Book ROE	8.56	0.89	6.28	10.25
Inferred market ROE	5.68	0.95	3.86	7.92
Yankee Gas				
Book ROE	8.93	1.12	6.63	11.65
Inferred market ROE	5.93	1.10	3.86	9.08
Eversource				
Market-to-book ratio	1.52	0.22	1.04	1.95

Sources: Eversource quarterly ROE filings; Macrotrends; Ycharts

I estimated allowed ROEs that would either: 1) equal Vincent Rea's recommended allowed ROE of 10.30 percent; 2) predict a 95 percent upper bound on realized inferred market ROE equal to allowed ROE; 3) predict a realized inferred market ROE equal to the forecasted ROE for Eversource in Table I; 4) equal the upper end of the range for comparable ROEs estimated by Mr. Rothschild; 5) predict a realized inferred market ROE equal to allowed ROE; or 6) predict a realized inferred market ROE equal to the lower end of Mr. Rothschild's range. For all but Case 2), I used the mean MRP since 1980 of 6.18 percent and the expected risk-free rate of 4.10 percent. For Case 2), I used the 95 percent upper bound on the mean MRP since 1980 of 11.10 percent and a risk-free rate of 5.11 percent, which is the upper end of the Atlanta Fed's range for investors' expectations of three-month compounded average Secured Overnight Financing Rates for September 2027.[14]

[14] https://www.atlantafed.org/cenfis/market-probability-tracker, accessed January 13, 2025. I did not use the joint probability that realized ROE, inflation, the real MRP, and the risk-free rate would hit their upper bounds. Had I, the

Table IV shows results. An allowed ROE in book value of ratebase of 10.30 percent is predicted to give PSNH a realized inferred market ROE of 8.30 percent, given the expected MRP and risk-free rate. An allowed ROE in book value of ratebase of 9.34 percent would make the probability of shareholders over-earning over the course of a year five percent, given the high MRP and risk-free rate. An allowed ROE in book value of ratebase of 8.63 percent is predicted to give PSNH a realized inferred market ROE of 7.67 percent, the same as forecasted for Eversource, given the expected MRP and risk-free rate. An allowed ROE of 8.13 percent, the upper end of Mr. Rothschild's range, would predict a realized inferred market ROE of 7.47 percent. At the end of Section VII of his testimony, Mr. Rothschild states: "[T]he Commission should consider [cost of equity] model results based on this proxy group, including my own, to be an upper bound." An allowed ROE of 7.08 percent would predict a realized inferred market ROE of 7.08 percent, the same value, so shareholders would be expected to frequently over-earn. An allowed ROE of 5.80 percent would predict a realized inferred market ROE of 6.60 percent, the lower end of Mr. Rothschild's range.

confidence level associated with the 9.34 percent upper bound on realized ROE would be higher, since the four variables are not perfectly correlated.

Table IV: Allowed and predicted realized market-inferred ROEs for PSNH; percent

Case	Allowed Book Value ROE	Realized inferred market ROE	Standard error of Estimate		+[95% confidence interval]
1)	10.30	8.30	0.10	8.09	8.50
2)	9.34	*9.20	0.08	- ∞	9.34
3)	8.63	7.67	0.08	7.50	7.83
4)	8.13	7.47	0.08	7.33	7.63
5)	7.08	7.08	0.07	6.95	7.21
6)	5.80	6.60	0.05	6.50	6.70

+The confidence intervals take the assumed MRPs and risk-free rates as
*9.20 obtains under the high MRP (11.10 percent) and risk-free rate (5.11 percent) used to find the upper bound of 9.34 percent. Using an allowed ROE of 9.34 percent with the expected MRP and risk-free rate of 6.18 percent and 4.10 percent, respectively, realized inferred market ROE is predicted to be 7.94 percent.

Table V shows over-earning by the Eversource subsidiaries in terms of ROE in book value of distribution ratebase. PSNH has a stronger tendency for realized ROE on book value to fall below allowed ROE than do CL&P and Yankee Gas. The last time realized ROE in book value of distribution ratebase for PSNH exceeded allowed ROE was in 2011:I, when allowed ROE was 9.67 percent and realized ROE was 9.89 percent. Allowed ROE is sometimes thought of as a soft constraint. The purpose of Table IV and Table V is to provide the Commission with information about the implications of different levels of allowed ROE in terms of that softness. The lower the allowed ROE, the softer the constraint. In Case 1) in Table IV, the high allowed ROE is substantially higher than the predicted realized ROE, and PSNH would be unlikely to over-earn. In Case 5), the low allowed ROE equals the predicted realized ROE, and PSNH would over-earn frequently.

Through the rate-setting process, a higher allowed ROE raises revenue, but, as the allowed ROE for PSNH increases in Table IV, less of the additional revenue goes to Eversource's shareholders. A tenable hypothesis is that the shareholders only require the lower ROEs, and that management finds something else to do with the additional revenue.

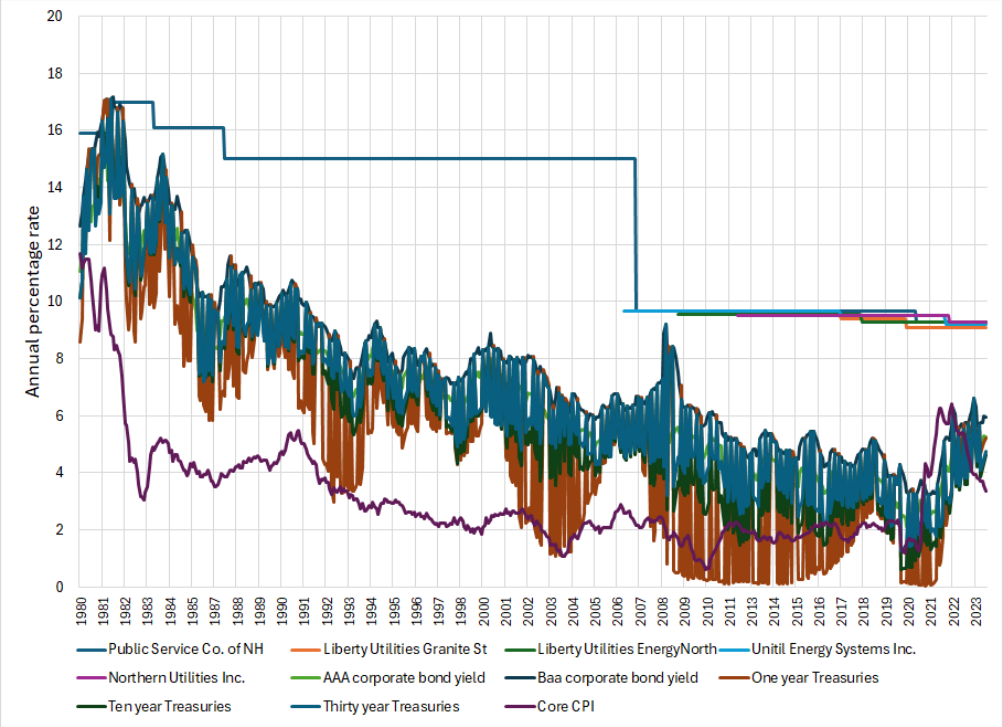
Table V: Over-earning by Eversource subsidiaries, 2010:I - 2024:II; percent

Subsidiary	Mean	Standard Deviation	Minimum	Maximum
PSNH	-1.40	0.87	-3.28	0.22
CL&P	-0.74	0.91	-2.97	0.85
Yankee Gas	-0.28	1.36	-3.59	2.50

Investments in electric distribution are imperfect substitutes for government securities and highly rated corporate bonds because they are all low risk. Figure I shows that rates on low risk securities have fallen more than allowed ROEs for distribution equity in New Hampshire for some time, so the Commission should not dismiss the lower allowed ROEs for PSNH in Table IV on the grounds that they would be lower than allowed ROE has been in the recent past. Figure II shows the same stickiness in the downward direction of allowed ROEs nationwide that Figure I shows in New Hampshire, so the Commission should also not dismiss the lower allowed ROEs in Table IV on the grounds that they would be lower than what other commissions are imposing.[15]

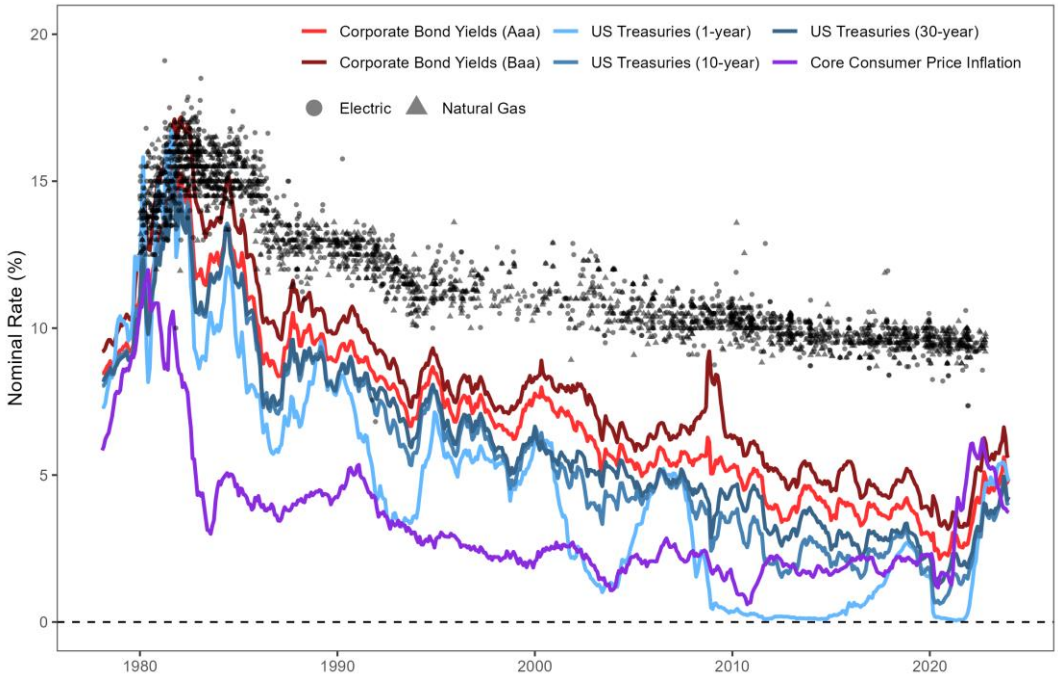
[15] Figure II is reprinted from Werner, K.D. and Jarvis, S. (2024). Rate of return regulation revisited, Energy Institute at Haas Working Paper 329R, p. 14. Available at https://haas.berkeley.edu/wp-content/uploads/WP329.pdf, accessed July 1, 2024.

Figure I: Allowed utility ROEs in New Hampshire and financial indicators



Sources: Standard & Poor's Global and Federal Reserve Bank of Saint Louis

Figure II: Allowed utility ROEs nationwide and financial indicators



8.63 percent as an allowed ROE predicts a realized inferred market ROE for PSNH of 7.67 percent, equal to the forecasted rate of return on Eversource stock. This takes no account of the fact that Eversource owns high voltage interstate transmission assets in addition to distribution plant, and that the FERC tends to allow higher ROEs than state commissions allow. According to Attachment EHC/TMD-2 (Temp) in Docket DE 19-057, on Bates page 000246,[16]

> Four separate complaints have been filed at the FERC by combinations of New England state attorneys general, state regulatory commissions, consumer advocates, consumer groups, municipal parties and other parties (collectively the "Complainants"). In each of the first three complaints, filed on October 1, 2011, December 27, 2012, and July 31, 2014, respectively, the Complainants challenged the NETOs' [New England Transmission Owners'] base ROE of 11.14 percent that had been utilized since 2005 and sought an order to reduce it prospectively from the date of the final FERC order and for the separate 15-month complaint periods. In the fourth complaint, filed April 29, 2016, the Complainants challenged the NETOs' base ROE billed of 10.57 percent and the maximum ROE for transmission incentive ("incentive cap") of 11.74 percent, asserting that these ROEs were unjust and unreasonable.

Rather than dismissing the lower allowed and realized ROEs, the Commission should consider that the 7.67 percent for Eversource, estimated using a long sample period, but with an upward-trending CAPM β, reflects in part the high ROEs handed down by FERC, which do not typify what the market expects from state regulators of distribution service. An allowed ROE below 8.63 percent could be more reasonable. The associated realized ROE of 7.67 percent is considerably higher than the 5.41 percent average realized inferred market ROE for PSNH since 2010 in Table III.

[16] Available at https://www.puc.nh.gov/regulatory/Docketbk/2019/19-057/INITIAL%20FILING%20-%20PETITION/19-057_2019-04-26_EVERSOURCE_ATT_DTESTIMONY_CHUNG_DIXON_TEMP_RATES.PDF..

Q. Do your results comport with the financial risks of owning PSNH's distribution ratebase?

A. Yes. In Case 4), an allowed ROE of 8.13 percent predicts a realized inferred market ROE of 7.47 percent. The Atlanta Fed's take on the expected rate on safe, short term rates of interest is 4.10 percent.[17] Subtracting the 4.10 percent from 7.67 percent gives a forecasted risk premium for PSNH of 7.47 – 4.10 = 3.37 percent, compared to the expected MRP of 6.18 percent. Using Equation (1) and the quarterly moving average inferred market ROEs for PSNH, CL&P, and Yankee Gas, which exclude a spike in Eversource's MBR in 2012:II and a missing datum in 2014:I, I estimate CAPM βs for these subsidiaries of $\underset{0.01}{0.20}$, $\underset{0.01}{0.21}$, and $\underset{0.02}{0.21}$, respectively, where the number below is the standard error of estimate. Their βs are considerably lower than the $\underset{0.02}{0.58}$ estimated for Eversource, β is an asset's share of systematic market risk, and this share is lower for PSNH than for Eversource as a whole.

The standard deviation of PSNH's real quarterly moving-average annual realized ROEs in the book value of ratebase was 90 basis points, and 97 basis points on inferred market value, while that of real rates of return on the S&P 500 was 1,070 basis points. This measure of variation was lower for PSNH than for the secondary yield on three-month Treasury bills, my, and Mehra and Prescott's, measure of the risk-free rate. Removing the period since 2022:III, when the Fed began using such instruments to tighten monetary policy in order to lower inflation post-Covid, renders variation in PSNH's ROE marginally higher than that in the risk-free rate. None of the variation in realized utility ROE is near that in the ROE for the S&P 500. Variation in PSNH's realized ROE compares more closely with that of the yields on corporate bonds, as measured by the Moody's index shown in Table VI, and short term government securities. Investment in PSNH distribution ratebase is low risk, and its allowed ROE should reflect that.

[17] https://www.atlantafed.org/cenfis/market-probability-tracker..

Table VI: Variation in rates of return; basis points

	Standard deviation	
Rate	2010:III -2024:II	2010:III -2022:II
Rate of return on S&P 500	1070	943
Moody's seasoned Baa corporate bond yield	78	72
Secondary yield on three-month Treasury Bills	147	72
Realized ROE in PSNH ratebase	90	80
Realized ROE in (PSNH ratebase/ES MBR)	97	96
Realized ROE in (Yankee Gas ratebase/ES MBR)	110	111
Realized ROE in (CL&P ratebase/ES MBR)	95	95

Q. Have you reviewed the testimony of Vincent Rea?

A. Yes. Mr. Rea submitted testimony on the cost of capital on behalf of PSNH on June 11. For ROE, he performs a meta-analysis by selecting data on other firms in other states from respected sources, including results of analyses done by these sources, and applying qualitative theory and professional judgement in culling and processing these data through discounted cash flow, capital asset pricing, and risk premium models. The data selected and culled are not a random sample, that they include results of analyses performed by other analysts renders the underlying calculations less than transparent, and there is no quantitative test done for bias or precision (a.k.a. inferential "efficiency") in the results. There is no discussion or quantification of the effect of differences in the regional economies served by the selected members of Mr. Rea's electric and gas proxy groups and New Hampshire (other than the regulatory climate), the makeup of which can have a meaningful effect on a utility's share of systematic (market) risk. The OCA issued data requests concerning his testimony in August, and PSNH replied promptly.

Q. Do Mr. Rea's CAPM βs reflect the share of risk in the market for equity assumed by the owners of PSNH's distribution capital?

A. No. Mr. Rea relies largely on Value Line for estimated CAPM βs. Value Line applies Blume's (1971, 1975) adjustment to estimated "raw" βs for regulated public utility holding companies, a practice discredited by Michelfelder and Theodossiou (2013). Blume proposed a simple adjustment to account for the tendency of βs to approach unity: $\beta_{adjusted} = 0.35 + 0.67\beta_{raw}$. Michelfelder and Theodossiou found that the Blume adjustment is inappropriate for regulated utilities because their market power, the regulatory restrictions on their ROE's, and various rate adjustment policy mechanisms, like performance-based ratemaking, stabilize their profits, lowering their risk and keeping their βs below unity. I would add that regulated firms who provide economic necessities to customers face income-inelastic demand in the short run, also lowering their shares of systematic risk because macroeconomic fluctuations, which affect the stock market, have only a moderate effect on the demand for what the utilities sell. "Vendors", like Value Line, "apply Blume's adjustment to raw betas to estimate forward-looking betas."[18] However, "the diagnostic statistics strongly refute the validity of the Blume equation for public utility stocks."[19]

That is not to say that regulated public utility βs do not trend toward some value, if not unity, as observed by Gombola and Kahl (1990), who concluded that each such trend must be quantified separately. The trend in Eversource's β estimated here is shown in Figure VI. It does not near unity, but does move in that direction. Mr. Rothschild's use of the Blume adjustment, then, may be considered "conservative".

[18] Michelfelder and Theodossiou, p. 62.
[19] Ibid, p. 64.

Q. Is Mr. Rea's non-regulated proxy group comparable to PSNH in terms of its share of systematic risk?

A. No. Mr. Rea includes Home Depot in his non-regulated proxy group. In an ordinary least squares CAPM regression using data beginning in 1981 from Yahoo! Finance[20], Home Depot's β with respect to the S&P 500 and three-month T-bills is 1.08, with a 95% confidence interval of [1.05,1.11]. In a regression with a trending β, the estimate is $\beta = 0.98$ as of May 16, 2024, with a 95 percent confidence interval of [0.93, 1.04]. That is, Home Depot imposes about as much systematic risk on its shareholders as does the S&P 500, itself. This is considered unusual, if not implausible, for a regulated public utility. Home Depot serves the construction industry, which is notoriously procyclic and volatile, and sells consumer durables, purchases of which people defer when their incomes fall; quite different from a regulated public utility selling the necessity that is delivery of energy. The response to DR OCA 1-004 states "…the cost of equity estimates derived for Home Depot are closely comparable to the cost of equity estimates derived for the other nine companies included in the Non-Regulated Group." ROE's are increasing in CAPM βs; if Home Depot's ROE is "closely comparable" to the other companies in Mr. Rea's non-regulated group, that calls into question the comparability of the non-regulated group to PSNH. On Bates page 19330, line 14, Mr. Rea imposes a minimum of 0.80 on the CAPM βs in his non-regulated proxy group. This is well above my estimate of Eversource's β of 0.58, and toward the upper end of the range of βs estimated for several holding companies shown in Table VIII, below.

[20] https://finance.yahoo.com/quote/HD/history/?period1=370013400&period2=1721407422, accessed July 19, 2024.

Q. Are Mr. Rea's predicted ROE's robust to his choice of risk-free rate, that on very long term government securities?

A. Not entirely, under current circumstances, because the "yield curve" was inverted through November, and is still rather flat. The yield curve plots the payoff period of a security on the horizontal axis and its yield on the vertical axis. Normally, it slopes upward to the right, but, because the Fed's open market operations are mainly conducted using short term securities, and it has pursued a tight monetary policy since June 2022, the yield curve only reverted to its normal upward slope in December, and remains fairly flat.

Mr. Rea (Bates page 19366, lines 8-10) uses a 30-year Treasury bond rate as a risk-free rate in a CAPM. The forecasted rate is 4.21 percent, which is higher than the expected three-month rate of 4.10 percent that I use from the Atlanta Fed. Though the difference may seem modest, the aggregate effect on residential customers could be considered significant. Long term, the difference is much greater, as shown in Table VII.

Choosing a higher "risk-free" rate raises the predicted ROE on any specific portfolio in the CAPM if $\beta<1$, so it also increases Mr. Rea's results. For example, I calculated Table VII for Eversource (ES) using the S&P 500 for the equity market return over the last 43 years and rates on three-month and 30-year Treasuries, respectively, as the risk-free rate. The estimated (stationary) CAPM β was the same in each case, 0.52 (and this is the same as Mr. Rothschild's historical blended β for the electric proxy group). Mr. Rea outsources the calculation of βs, so they are not sensitive to his choice of (a higher) risk-free rate, either. The MRP was lower when the 30-year rate was used, since it is the difference between the market ROE and the risk-free rate, but the 30-year rate was, of course, higher on average over the sample period. Since the $\beta<1$, which lowers the effect of the MRP relative to the risk-free rate, itself, on the predicted

ROE, the higher, 30-year, risk-free rate gives a higher predicted ROE for Eversource. Data are shown in the ES UTL AQN SP500 3MO tab of the file 24-070_2025-03-25_Exh_1.xlsb.

Table VII: Effect of choice of risk-free rate on predicted ROE

September 1, 1981 - May 16, 2024

Risk-free rate [a]	ES β	Average MRP [b]	Average risk-free rate	ES ROE [c]
30-year	0.5159	2.40%	6.02%	7.26%
Three-month	0.5157	4.50%	3.88%	6.20%

[a] https://fred.stlouisfed.org/series/DGS30 accessed November 26, 2024
[b] https://finance.yahoo.com/quote/%5EGSPC/history/ accessed November 26, 2024
[c] https://finance.yahoo.com/quote/ES/history/ accessed November 26, 2024

Historically, I choose a short term rate, that on three-month Treasury bills. (I assume that the default risk on any U.S. government security is zero.) To understand why, consider two plans for investment over ten years: 1) a sequence of forty newly-issued three-month Treasury bills; and 2) a newly-issued ten-year Treasury bond. Define the rate on three-month T-bills as the "spot price" of loanable funds. More strictly, something like the London Interbank Overnight Rate (LIBOR) would represent a spot price, but three months is also a short period of time. In 1), I trade funds at the spot price continually; in 2) I effectively take 39 positions in futures markets over increasingly long time-horizons, assuming the risk that my security will depreciate because the market rate of interest increases, so that I will be unable to use all of the funds I have tied up in the ten-year bond to earn the higher rate. This is a risk I do not take in Plan 1). Except during times when the yield curve is inverted, ten-year bonds pay a higher rate than three-month bills in part because of this liquidity risk.

Under Plan 1), I do not know the compound rate that I will earn over the ten-year period, as I do under Plan 2), but rates on short and long term Treasuries are similarly volatile: From April 1953 to October 2024, the standard deviation of monthly average rates on three-month Treasuries was 308 basis

points, and 290 on ten-year Treasuries[21], notwithstanding Mr. Rea's statement that "30-year Treasury yields…. are subject to less volatility than shorter-dated Treasury securities." (Bates page 19366, lines 18-20) Moreover, the mean rates were 4.18 and 5.55 percent, respectively. What, if not a risk premium of some kind, does the difference represent? In the secondary market, the term to maturity for three-month T-bills is less than three months on average, implying still less liquidity risk, so I use the secondary market yield on three-month Treasury bills as the risk-free rate, historically.

Mr. Rea's statement is also misleading because what could be termed "systematic risk" with respect to the bond market is much higher for 30-year Treasury bonds than for three-month T-bills. I regressed the first difference in yields on each of these from January 3, 1986 to May 16, 2024 on the first difference in Moody's Seasoned Baa Corporate Bond Yield[22]. The constant terms are statistically insignificant. Dropping them, I get the single index model used by Blume (1971, 1975) in first difference form[23] and re-run the regressions. The estimated "bond market β"[24] using the 30-year bonds is $\underset{0.01}{1.35}$, and $\underset{0.02}{0.23}$ using three-month T-bills, where the number below is the standard error of the estimated bond market β. There is no perfect real-world risk-free rate, but short term Treasuries are a much better hedge of bond market risk than are long term Treasuries, and bonds are an, imperfect, substitute for stocks. In general, the rate on 30-year Treasury bonds is a poor choice to represent the risk-free rate in the CAPM.

Mehra and Prescott used three-month T-bills for a risk-free rate.

[21] https://fred.stlouisfed.org/series/DTB3, accessed November 8, 2024.
[22] https://fred.stlouisfed.org/series/DBAA, accessed January 8, 2025.
[23] At Time t, $r_{ft} = \delta + \beta r_{BAAt}$; at $t-1$, $r_{ft-1} = \delta + \beta r_{BAAt-1}$. Subtracting the second equation from the first, $r_{ft} - r_{ft-1} = \beta\left(r_{BAAt} - r_{BAAt-1}\right)$, and this is the equation I use to estimate β. When the regressions are done in levels, the residuals are not stationary, so the estimated relationships could be spurious; when the regressions are done using first differences, the residuals are stationary.
[24] https://fastercapital.com/content/Bond-Beta-Understanding-Bond-Beta--A-Guide-for-Investors.html#:~:text=other%20market%20factors.-,3.,4, accessed January 9, 2025.

That the real rate of return on three-month T-bills is sometimes negative is not problematic: So long as the nominal rate is higher than the negative of the rate of inflation, these securities deteriorate in purchasing power more slowly than cash, which people also hold. Investors sometimes refer to short term government securities as "cash".

With the three-month rate I use, lower than Mr. Rea's rate on thirty-year bonds, his elimination of "DCF estimates which are lower than, or only marginally higher than, yields available on corporate debt securities" is inconsistent with the CAPM. In Equation (1), the rate of return on a risky asset equals the risk-free rate, $\mu_p = r_f$, if and only if $\beta = 0$, given that $\mu_m > r_f$. The three-month rate is also generally lower than the rates on corporate debt. Between January 3, 1986 and May 16, 2024, the mean secondary yield on three-month T-bills was 2.13 percent, while the mean yield on Baa corporate bonds was 4.94 percent.[25] The mean equity MRP (using the S&P 500 and three-month T-Bills) was 6.64 percent. For $\beta < 0.42$, a low but plausible range, the expected rate of return on a risky asset is $\beta \times 6.64\% + 2.13\% < 4.94\%$. The 95 percent lower bound on the mean equity MRP is 2.55 percent; for $\beta < 1.08$, $\beta \times 2.55\% + 2.13\% < 4.94\%$. Therefore, an asset with a low but positive β, as regulated public utility assets have, could logically pay a rate of return greater than the risk-free rate, but less than the rate on corporate debt, contrary to Mr. Rea's claim that such a result would not pass "fundamental tests of economic logic" (Bates page 19402). Above, I report an estimated $\underset{0.01}{\beta = 0.20}$ for PSNH *per se* using its realized inferred market ROE, the S&P 500, and three-month T-bills in Equation (1).

[25] https://fred.stlouisfed.org/series/DTB3 and https://fred.stlouisfed.org/series/DBAA, accessed January 3, 2025.

Q. Has Mr. Rea estimated the real (net of inflation) ROE for PSNH that investors require to buy and hold stock in Eversource?

A. No. DR OCA 1-001 poses this question: "[W]hat part of the 10.30 percent proposed rate of return is real, and what part represents expected inflation?" The response states "Considering that none of [Mr. Rea's] analytical models/methods require model inputs or assumptions that delineate between real returns and an inflation component of the return, this breakdown cannot be determined." The proposed nominal ROE of 10.30 percent is the sum of the proposed real ROE and investors' expected rate of inflation. Despite writing over four pages on the Federal Reserve's efforts to return annual inflation to 2.00 percent, from Bates pages19312 to 19317, Mr. Rea is unable or unwilling to quantify expected inflation. The Fed reports expected inflation here: https://fred.stlouisfed.org/series/T5YIFR. Recent years were exceptionally inflationary, and any failure on Mr. Rea's part to account for an expected drop in inflation between recent years and the rate period in DE 24-070 biases his results upward.

Real, not nominal, returns are what matter to investors, but Mr. Rea is unable or unwilling to quantify the real rate of return that they require from PSNH to buy and hold Eversource's stock. In terms of realized ROE, using the expected five-year inflation of 2.34 percent p.a. from the Saint Louis Fed, I would say "7.47 – 2.34 = 5.13 percent". Mr. Rea is proposing a real allowed ROE of 10.30 – 2.34 = 7.96 percent. Using the model at the level of the utility, an allowed ROE of 10.30 percent predicts a realized inferred market ROE of 8.30 percent, or 5.96 percent real. The average real ROE on the S&P 500 since 1980 has been 5.75 percent. Required ROEs for regulated public utilities are thought to be lower than those for the market for equity as a whole.

Q. In December, the Illinois Commerce Commission applied an 8.91 percent allowed ROE to the distribution capital of Commonwealth Edison. Can ComEd still raise equity capital?

A. Yes. On Bates page 19311, lines 13-21, Mr. Rea criticizes the 8.91 percent allowed ROE for ComEd for being too low. Figure III shows the share price and trading volume for Exelon, ComEd's holding company, since December. Markets punished the lower-than-expected allowed ROE, but the share price quickly stabilized. Trading volume has also been robust. The response to DR OCA 1-006 states "Mr. Rea does not agree with the statement that Exelon's share price 'quickly stabilized' after initially falling 16.0 percent during December 2023 (from closing prices of $41.00 to $34.45) as a result of Commonwealth Edison's lower-than-expected ROE order by the Illinois Commerce Commission ("ICC"). In fact, Exelon's trading valuation has not returned to its pre-ICC order trading level (approx. $41.00) during the seven-plus months that have passed since December 2023." By confusing a return to the previous price with stabilization, the response fails to address the DR. The price stabilized at a lower level.

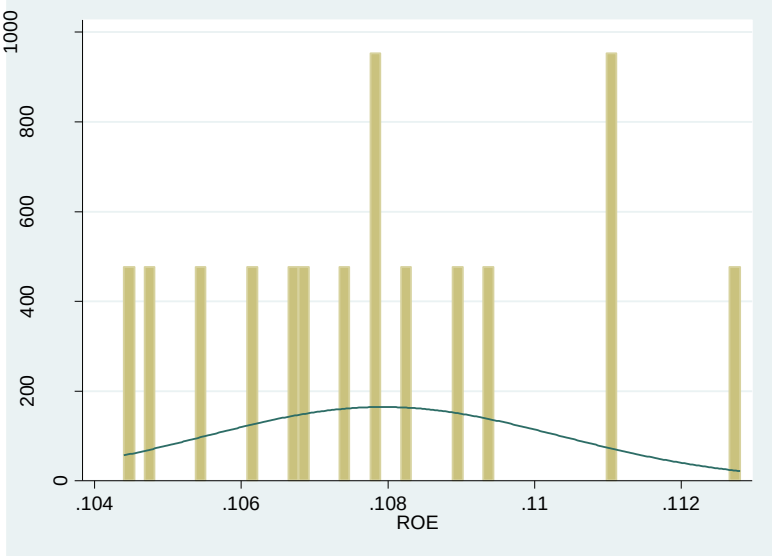
Figure III: Exelon share price and trading volume, 2024

Source: Yahoo! Finance

Q. Has Mr. Rea relied substantially on professional judgement to derive his recommended 10.30 percent allowed ROE for PSNH?

A. Yes. The response to DR OCA 1-003 states that it was not necessary to modify any quantitative results for Mr. Rea's proxy groups for purposes of recognizing qualitative arguments, but, on Bates page 19308 of his testimony, he refers to "the range of reasonableness indicated by his quantitative and qualitative evaluations". Figure IV is a density plot of his fifteen estimates of an appropriate ROE, from which he infers the "the range of reasonableness", with a normal density curve superimposed.

Figure IV: Density plot of Rea's fifteen estimates of PSNH's ROE



These estimates are more uniformly than normally distributed. There is almost no central tendency in Mr. Rea's estimates.

Q. Has Mr. Rea allowed the exercise of market power to raise his recommended allowed ROE for PSNH above the competitive level?

A. Possibly. DR OCA 1-004 states: "[S]ome firms earn greater than competitive rates of return for their owners because they exercise market power…. Do holders of utility stocks have the option to earn greater than competitive rates of return elsewhere in the stock market, or do the barriers to entry that sustain market power extend to the stock market?" The response states "Yes, holders of utility stocks have the option to pursue greater than competitive rates of return elsewhere in the stock market." By substituting "pursue" for "earn", the response fails to address the question as posed by the OCA, which asks what Mr. Rea has done to prevent the exercise of market power from affecting his results. One would expect investors holding shares in a firm exercising market power before its market power became evident to others to earn monopoly profits, then for the share price to be bid up until the rate of return available to new shareholders was competitive. PSNH only needs to offer returns high enough to attract investors who demand a competitive ROE, not those earning greater-than-competitive ROEs because they own firms who exercise market power.

The OCA asked: "Is the exercise of market power productive?" PSNH responded that "the exercise of market power can be productive to the extent that the costs of duplicative facilities and infrastructure can be eliminated and/or when economies of scale can be realized .... This concept is consistent with the 'regulatory compact' for rate-regulated utilities." This is not correct. The regulatory compact is supposed to prevent the exercise of market power, wherein price would be raised above both marginal and average total cost. The regulatory compact is struck to exploit economies of scale, but to restrict the exercise of the market power they confer. By confusing reductions in average total cost

associated with economies of scale with the exercise of market power, the response fails to address the DR.

Q. Does that conclude your testimony on this subject?

A: Yes.

APPENDIX: METHODS

The Capital Asset Pricing Model

The CAPM equation is

$$\mu_p - r_f = \beta\left(\mu_m - r_f\right) \quad (1)$$

where μ_p is the expected rate of return on a portfolio of assets, μ_m is the expected rate of return on all assets in the market combined, r_f is the "risk-free rate of return" on an asset that pays that rate with certainty, and β relates the two risk premia. In application, β is estimated from data and captures "signal" around which there may be statistical "noise".

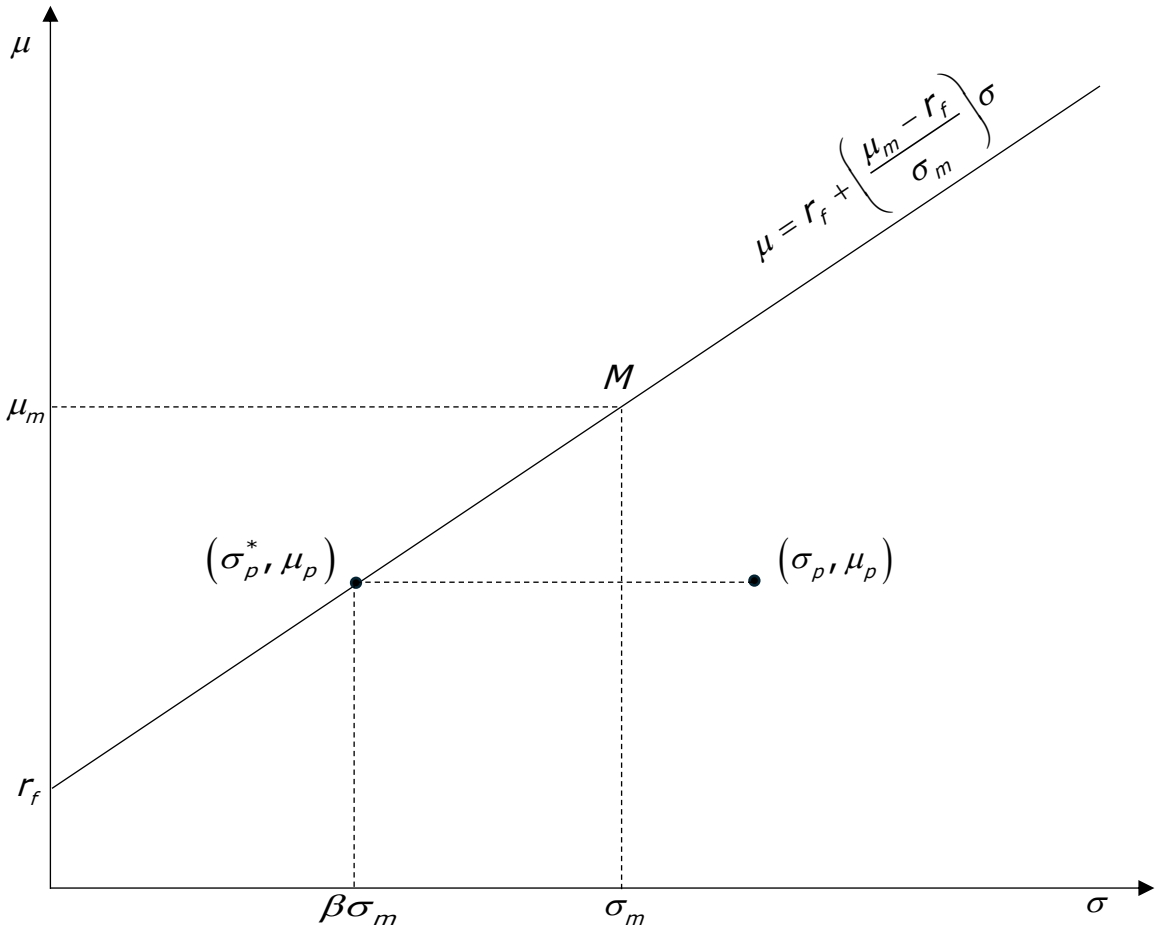
Consider a relationship between μ_p and the risk associated with that portfolio as measured by the expected standard deviation, σ_p, of that rate of return, r_f, μ_m, and the expected standard deviation of that rate of return, σ_m. σ_m is referred to as "systematic risk".

By allocating investments between the risk-free asset and the market, one can achieve any combination of expected risk and return along the line

$$\mu = r_f + \left(\frac{\mu_m - r_f}{\sigma_m}\right)\sigma \quad (2)$$

in Figure V, and such that $\mu \leq \mu_m$ and $\sigma \leq \sigma_m$. The parenthetical term in (2), the slope, is sometimes referred to as "the price of risk". Rate of return, μ, is an economic good, and risk, σ, is an economic bad. The slope is the change in rate of return per unit change in risk in the market as a whole as investments are reallocated from the risk-free asset to the market as a whole. If the market for increases in μ is competitive, all investors with will pay the same price for any increase in μ in terms of an increase in risk: $\left(\mu_m - r_f\right)/\sigma_m$; so the slope of (2) reflects the trade-off offered by the market between risk and return for portfolios in general, including portfolios that include specific, risky assets for which $\mu > \mu_m$ and $\sigma > \sigma_m$. An investor trades expected risk for return at the rate the market offers, regardless of which assets are being used. The line, then, extends upward and to the right of Point M, and into the third and fourth quadrants (not shown). Combinations of risk and return above the line are not available to an investor, and combinations below the line are suboptimal because for any given rate of return (level of risk), risk (return) could be decreased (increased). "Idiosyncratic risk" is risk that can be reduced without any reduction in the expected rate of return, such as the horizontal distance $\sigma_p - \sigma_p^*$, starting from Portfolio p, in Figure V. An investor can, for example, do this by liquidating Portfolio p and using the proceeds to purchase a combination of the risk-free asset and the market as a whole that pays μ_p with risk σ_p^*, though other diversification strategies may be used.

Figure V



Solving (2) for σ with $\mu = \mu_p$ gives

$$\sigma_p^* = \frac{\mu_p - r_f}{\mu_m - r_f}\sigma_m \tag{3}$$

Define

$$\beta \equiv \left(\mu_p - r_f\right)/\left(\mu_m - r_f\right) \tag{4}$$

or

$$\mu_p - r_f = \beta\left(\mu_m - r_f\right) \tag{1}$$

the CAPM equation. Substituting (4) into (3) gives

$$\beta = \frac{\sigma_p^*}{\sigma_m} \tag{5}$$

as shown in Figure V. If p is an investment in the market as a whole, $\sigma_{pm} = \sigma_m^2$, so $\beta = 1$.

A portfolio with $\beta < 0$ would be represented by a point in the third or fourth quadrant such that either $\mu_p < r_f$ or $\mu_m < r_f$, but not both. This theoretical model is static, but if observations of the numerator and denominator in (4) differ in sign frequently enough and to a large enough degree, a portfolio's empirically estimated β will be negative. Mas-Colell, Whinston, and Green (1995) write:

> This constitutes the simplest version of a powerful theme of finance theory: that contingent instruments…are comparatively more valuable if their returns…are negatively correlated with the "market return".[26]

Given an average *absolute return* on an asset, if the returns are negatively correlated with the market, $\sigma_{pm} < 0$, the asset will be "more valuable" (command a higher price), so the *rate of return* will be lower, consistent with a negative CAPM β. For this reason, stocks with negative βs may competitively pay rates of return lower than the rate of interest on corporate debt. In the CAPM, such stocks pay less than the risk-free rate; with $\mu_m > r_f$, $\mu_p < r_f$ if and only if $\beta < 0$, by Equation (1). If the rate on corporate debt exceeds the risk-free rate, then stocks with low but positive βs may pay lower rates than corporate debt.

β is Portfolio p's share of systematic risk. Total risk to Portfolio p is the sum of its share of systematic risk and its idiosyncratic risk;

$$\sigma_p = \underbrace{\beta\sigma_m}_{\substack{\text{systematic} \\ \text{risk to p}}} + \underbrace{\sigma_p - \beta\sigma_m}_{\substack{\text{idiosyncratic} \\ \text{risk to p}}} \tag{6}$$

Portfolio p is suboptimal because its idiosyncratic risk can be diversified away without any reduction in expected rate of return μ_p: $\sigma_p^* = \beta\sigma_m$; the systematic risk to p.

I now show that $\sigma_p^* = \sigma_{pm}/\sigma_m$. Consider a Portfolio q that combines investment in Portfolio p with an investment in proportionate shares of all risky assets; "the market" m. The expected rate of return on Portfolio q is μ_q, and the risk to that rate of return is measured by the standard deviation of that rate of return; σ_q. The expected rate of return on such a portfolio is

$$\begin{aligned} \mu_q &= \alpha\mu_p + (1-\alpha)\mu_m \\ &= \alpha(\mu_p - \mu_m) + \mu_m \end{aligned} \tag{7}$$

[26] Mas-Colell, A., Whinston, M.D., & Green, J.R. (1995). *Microeconomic Theory*, Oxford University Press, New York, Oxford, p. 693.

where $\alpha \in [0,1]$. Let r_p and r_m be random variables whose expected values are μ_p and μ_m, whose standard deviations are σ_p and σ_m, respectively, and whose covariance is σ_{pm}. The variance of the rate of return on the portfolio, σ_q^2, is derived as follows:

$$\begin{aligned}
\sigma_q^2 &= E\left(\left(\alpha r_p + (1-\alpha) r_m\right)^2\right) - E^2\left(\alpha r_p + (1-\alpha) r_m\right) \\
&= E\left(\alpha^2 r_p^2 + 2\alpha(1-\alpha) r_p r_m + (1-\alpha)^2 r_m^2\right) - \left(\alpha\mu_p + (1-\alpha)\mu_m\right)^2 \\
&= E\left(\alpha^2 r_p^2 + 2\alpha(1-\alpha) r_p r_m + (1-\alpha)^2 r_m^2\right) \\
&\quad -\left(\alpha^2\mu_p^2 + 2\alpha(1-\alpha)\mu_p\mu_m + (1-\alpha)^2\mu_m^2\right) \\
&= \alpha^2 \underbrace{\left(E\left(r_p^2\right) - \mu_p^2\right)}_{\sigma_p^2} + 2\alpha(1-\alpha)\underbrace{\left(E\left(r_p r_m\right) - \mu_p\mu_m\right)}_{\sigma_{pm}} + (1-\alpha)^2 \underbrace{\left(E\left(r_m^2\right) - \mu_m^2\right)}_{\sigma_m^2} \\
&= \alpha^2\sigma_p^2 + (1-\alpha)^2\sigma_m^2 + 2\alpha(1-\alpha)\sigma_{pm} \\
&= \alpha^2\left(\sigma_p^2 + \sigma_m^2 - 2\sigma_{im}\right) + 2\alpha\left(\sigma_{pm} - \sigma_m^2\right) + \sigma_m^2
\end{aligned} \tag{8}$$

The risk to Portfolio q, as measured by the standard deviation of its rate of return, then, is

$$\sigma_q = \sqrt{\alpha^2\left(\sigma_p^2 + \sigma_m^2 - 2\sigma_{pm}\right) + 2\alpha\left(\sigma_{pm} - \sigma_m^2\right) + \sigma_m^2} \tag{9}$$

Dividing (7) by (9) and multiplying by σ_q gives a relation among μ_q, σ_q, and α.

$$\mu_q = \frac{\alpha\left(\mu_p - \mu_m\right) + \mu_m}{\left(\alpha^2\left(\sigma_p^2 + \sigma_m^2 - 2\sigma_{im}\right) + 2\alpha\left(\sigma_{pm} - \sigma_m^2\right) + \sigma_m^2\right)^{1/2}}\sigma_q \tag{10}$$

Both μ_q and σ_q vary with α, so I calculate the slope(s) of the relation in $\left(\sigma_q, \mu_q\right)$ space using (7) and (9) as

$$\begin{aligned}
\frac{d\mu_q}{d\sigma_q} &= \frac{d\mu_q}{d\alpha}\frac{d\alpha}{d\sigma_q} = \frac{d\mu_q}{d\alpha}\Big/\frac{d\sigma_q}{d\alpha} \\
&= \frac{\mu_p - \mu_m}{\frac{1}{2}\left(\sigma_q^2\right)^{-1/2}\left(2\alpha\left(\sigma_p^2 + \sigma_m^2 - 2\sigma_{pm}\right) + 2\left(\sigma_{pm} - \sigma_m^2\right)\right)} \\
&= \frac{\mu_p - \mu_m}{\alpha\left(\sigma_p^2 + \sigma_m^2 - 2\sigma_{im}\right) + \sigma_{pm} - \sigma_m^2}\sigma_q
\end{aligned} \tag{11}$$

(11) is the rate at which an investor achieves increases in expected rate of return by accepting increases in risk as she increases her investment in Portfolio p and decreases her investments in the rest of the market. Any combination of values for σ_q and μ_q, risk and return, is located along or below what the market offers along the line

$$\mu_q = r_f + \left(\left(\mu_m - r_f\right)/\sigma_m\right)\sigma_q \tag{12}$$

The slope in (12), $\left(\mu_m - r_f\right)/\sigma_m$, is the rate at which expected rate of return rises per unit increase in risk when allocating investments between a risk-free asset with rate of return r_f and proportionate shares of all risky assets. If that relationship is determined in a competitive market, all investors will optimally trade these attributes at that rate, regardless of which assets they buy, sell, or hold in order to do so.

At $\alpha = 0$, there is no investment in Portfolio p, so $\mu_q = \mu_m$, $\sigma_q = \sigma_m$, and

$$\left.\frac{d\mu_q}{d\sigma_q}\right|_{\alpha=0} = \frac{\mu_p - \mu_m}{\sigma_{pm} - \sigma_m^2}\sigma_m \tag{13}$$

(13) is the quotient of the increase in the expected rate of return on and the increase in risk to Portfolio q after an infinitesimal investment in Portfolio p. This quotient equals the quotient of the decrease in the expected rate of return on and the decrease in risk along the straight line (12) after an infinitesimal investment in the risk-free asset.

Equating (13) to the slope in (12) gives

$$\frac{\mu_p - \mu_m}{\sigma_{pm} - \sigma_m^2}\sigma_m = \frac{\mu_m - r_f}{\sigma_m} \tag{14}$$

Rearranging (14) gives

$$\mu_p - r_f = \frac{\sigma_{pm}}{\sigma_m^2}\left(\mu_m - r_f\right) \tag{15}$$

which is the standard form of the CAPM equation, (1), with $\beta \equiv \sigma_{pm}/\sigma_m^2$. Combining this with (5),

$$\beta = \frac{\sigma_p^*}{\sigma_m} = \frac{\sigma_{pm}}{\sigma_m^2} \tag{16}$$

So $\sigma_p^* = \sigma_{pm}/\sigma_m \therefore$

σ_{pm}/σ_m^2 is the expected value of the coefficient in a linear regression of μ_p on μ_m, which is the single index model used by Blume and in the time-series study at the level of the holding company. Therefore,

the expected value of an estimate of β is the same whether using a regression of the form of Equation (1), used in the panel study at the level of the holding company, or the form used in the time-series study.

Estimation at the level of the holding company

Form of the estimated equation

I estimated trending CAPM βs. The CAPM βs are allowed to trend up or down as the data indicate. Blume hypothesized that the β for all stocks would tend toward unity over a long period of time, perhaps because corporate management would endeavor to make it so, or perhaps because firms would diversify their holdings over time. Since we are interested in the ROE for a subsidiary, Blume's second explanation casts doubt on the relevance of this hypothesis to this proceeding. Blume used a single index model

$$\mu_p = \delta + \beta^{SIM}\mu_m \tag{17}$$

where μ_p is still the expected rate of return on Portfolio p, μ_m is still the expected rate of return on the market, and δ is a constant term. The relationship between β from Equation (1) and the "raw" β^{SIM} from Equation (17) is

$$\beta = \frac{\beta^{SIM}\mu_m - r_f + \delta}{\mu_m - r_f} \tag{18}$$

and the two, static, theoretical models give the same $\beta = \beta^{SIM}$ if and only if $\delta = r_f\left(1 - \beta\right)$. Over time, empirically, though, there is variation in any measure of r_f, and I showed in Equation (15) that $\beta = \sigma_{pm}/\sigma_m^2$, which is the expected value of the coefficient in a linear regression of μ_p on μ_m; Equation (17), so a CAPM regression equation can take either the form of Equation (1) or Equation (17).

Blume proposed a simple adjustment to account for the tendency of βs to approach unity: $\beta_{adjusted}^{SIM} = 0.35 + 0.67\beta_i^{SIM}$. Michelfelder and Theodossiou (2013) found that the Blume adjustment is inappropriate for regulated public utilities because their market power, the regulatory restrictions on their ROE's, and various rate adjustment policy mechanisms, like performance-based ratemaking, stabilize their profits, lowering their risk and keeping their βs below unity. I would add that regulated firms who provide economic necessities to customers face income-inelastic demand in the short run, also lowering their shares of systematic risk because macroeconomic fluctuations, which affect the stock market, have only a moderate effect on the demand for what the utilities sell. "Vendors", like Value Line, "apply Blume's adjustment to raw betas to estimate forward-looking betas."[27] However, "the diagnostic statistics strongly refute the validity of the Blume equation for public utility stocks."[28]

[27] Michelfelder and Theodossiou, p. 62.
[28] Ibid, p. 64.

That said, "Gombola and Kahl in 1990 found that utility betas are non-stationary and concluded that each utility beta's non-stationarity must be viewed on an individual stock basis, unlike the recommendation of Blume which adjusts all betas for their tendency to approach 1."[29] Accordingly, I estimate trending CAPM βs. In the panel study, I use a variation on Equation (17):

$$r_{HCt} = \delta_{HC} + \beta^{U}_{HC}\left(\ln\left(\frac{t}{T}\right)+1\right)r_{mt} + \beta^{D}_{HC}\left(\ln\left(\frac{T}{t}\right)+1\right)r_{mt} + \varepsilon_{HCt} \qquad (19)$$

where t is in trading days, T is May 16, 2024, the last day of the sample period, r_{HCt} is the expected rate of return at t for Holding Company HC, r_{mt} is the expected rate of return at t for the stock market as a whole, $\beta^{U}_{HC}\left(\ln\left(t/T\right)+1\right)$ is the upward-trending component of the holding company's CAPM β, $\beta^{D}_{HC}\left(\ln\left(T/t\right)+1\right)$ the downward-trending component, and ε_{HCt} is an error term that is correlated across the holding companies, an attribute that is used to lower the standard errors of the estimated βs.[30] HC may assume values ES for Eversource, UTL for Unitil, or AQN for Algonquin Power & Utilities (Algonquin). At any Time t, Equation (21) simplifies to Equation (17) with $\beta = \beta^{U}_{HC}\left(\ln\left(t/T\right)+1\right) + \beta^{D}_{HC}\left(\ln\left(T/t\right)+1\right)$, and $\beta = \beta^{U}_{HC} + \beta^{D}_{HC}$ at $t = T$, May 16, 2024. The estimated relationship for Eversource is

$$r_{ESt} = \underset{0.00011}{0.00010} + \underset{0.01839}{0.33994}\left(\ln\left(\frac{t}{T}\right)+1\right)r_{mt} + \underset{0.00712}{0.22747}\left(\ln\left(\frac{T}{t}\right)+1\right)r_{mt} \qquad (20)$$

where the number below is the standard error of the estimated coefficient.

In the time-series study, I use a variation on Equation (1):

$$r_{ESt} - r_{ft-1} = \beta^{U}_{ES}\left(\ln\left(\frac{t}{T}\right)+1\right)\left(r_{mt} - r_{ft-1}\right) + \beta^{D}_{ES}\left(\ln\left(\frac{T}{t}\right)+1\right)\left(r_{mt} - r_{ft-1}\right) + \varepsilon_{ESt} \qquad (21)$$

where r_{ft} is the risk-free rate at Time t, r_{ESt} is the expected rate of return at t for Eversource, $\beta^{U}_{ES}\left(\ln\left(t/T\right)+1\right)$ is the upward-trending component of Eversource's CAPM β, $\beta^{D}_{ES}\left(\ln\left(T/t\right)+1\right)$ the

[29] Ibid, Michelfelder and Theodossiou, p. 62.
[30] Parks, R.W. (1967). Efficient estimation of a system of regression equations when disturbances are both serially and contemporaneously correlated, *Journal of the American Statistical Association* 62(318), 500-509; https://www.jstor.org/stable/2283977. To illustrate how correlation of residuals from one equation with another can lower the variance of both, note that, when errors e_{it} and e_{jt} are correlated, their expected values are still zero, but, given a random sample, $E\left(e_{it}\right) = E\left(e_{it} \mid e_{jt}\right) - \frac{s_{e_{it}e_{jt}}}{s^2_{e_{jt}}}\left(e_{jt} - E\left(e_{jt}\right)\right) = 0$, where $E\left(e_{it}\right)$ is the expected value of e_{it}, $E\left(e_{it} \mid e_{jt}\right)$ is the expected value of e_{it} given e_{jt}, $s_{e_{it}e_{jt}}$ is the sample covariance of e_{it} and e_{jt}, and $s^2_{e_{jt}}$ is the sample variance of e_{jt}, so that estimates under which this equation is badly violated are ruled out, shrinking the likely range of the estimates.

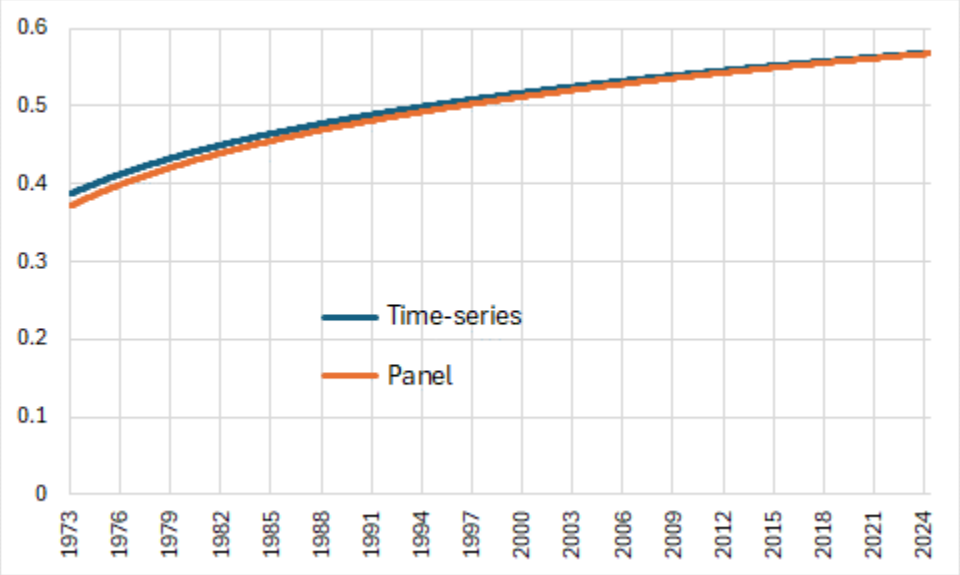
downward-trending component, and ε_{ESt} is an error term. At any Time t, Equation (21) simplifies to Equation (1) with $\beta = \beta_{ES}^{U}\left(\ln\left(t/T\right)+1\right) + \beta_{ES}^{D}\left(\ln\left(T/t\right)+1\right)$, and $\beta = \beta_{ES}^{U} + \beta_{ES}^{D}$ at $t = T$, May 16, 2024. The estimated relationship is

$$r_{ESt} - r_{ft-1} = \underset{0.01978}{0.33671}\left(\ln\left(\frac{t}{T}\right)+1\right)\left(r_{mt} - r_{ft-1}\right) + \underset{0.00774}{0.23216}\left(\ln\left(\frac{T}{t}\right)+1\right)\left(r_{mt} - r_{ft-1}\right) \quad (22)$$

where the number below is the standard error of the estimated coefficient.[31]

Figure VI shows the trending CAPM βs for Eversource during the sample period. Neither curve is near unity, consistent with Michelfelder and Theodossiou's rejection of the Blume adjustment as applied to regulated public utilities, but the trends are non-trivial, consistent with Gombola and Kahl.

Figure VI: Trending CAPM βs for Eversource



[31] The "ECAPM" modifies Equation (1) as follows: $\mu_p - r_f = \alpha\left(1-\beta\right) + \beta\left(\mu_m - r_f\right)$. If I add a constant term and a trend of the form t, $\ln\left(t/T\right)+1$, or $\ln\left(T/t\right)+1$ to (21), they are all statistically insignificant (at the 75 percent level).

Panel study estimation

Selection of the cross sectional units

The cross section is focused on New Hampshire because differences in regional economies, including that of New Hampshire, can be unique, and this can have a significant effect on the βs associated with their regulated public utilities. By focusing on New Hampshire, I fail to account for comparatively few of these differences. Table VIII shows CAPM βs for 46 holding companies of electric and natural gas distribution estimated using time-series, Prais-Winsten regressions of Equation (21).[32] Of course, they differ in terms of attributes other than the regional economies they serve, but the Southern Company has the lowest CAPM β of 0.46, as of May 16, 2024, and, therefore, predicted ROE of 5.65 percent. Its service area includes Georgia, the Florida panhandle, southern Alabama, and southeastern Mississippi, shown in Figure VII. When I regress annual per capita personal consumption for each of the fifty states from 1997 to 2023 on that for the United States, the lowest coefficient is 0.64, for Alabama.[33] That for Georgia is 0.70, and 0.78 for Mississippi. Florida's is unity, but the panhandle is a small part of SoCo's service area, and Alabama is at its center. The economy of this region is comparatively insensitive to changes in the national economy, and the ROE for SoCo is comparatively insensitive to changes in the national stock market.

American Electric Power (AEP) has the fifth-to-the-lowest estimated CAPM β of 0.55, as of May 16, 2024, and, therefore, predicted ROE of 6.23 percent. Figure VIII shows that its service areas coincide with U.S. shale plays, including the Permian Basin, Eagle Ford, Bend, Woodford, Excello-Mulky, Haynesville, and Marcellus, and with coal-producing areas in and around West Virginia. Supply-driven increases in prices for fossil fuels slow the national economy and, therefore, cause the stock market to depreciate (or appreciate less), but as incomes and consumption rise where the fuels are produced, increasing, or moderating the decline in, demand for AEP's distribution services. Consequently, AEP's ROE is comparatively insensitive to variation in the stock market.

Vincent Rea's electric proxy group is highlighted in blue, and Eversource in green. Eversource's β, as of May 16, 2024 is 0.57, while the simple average of the βs in Mr. Rea's electric proxy group is 0.67. Nine of his eleven proxies have higher βs than Eversource.

[32] Yahoo! Finance, https://finance.yahoo.com/quote/ES/history/?period1=99153000&period2=1715817600, accessed December 6, 2024. Substitute company ticker for "ES" in the URL. Equity premia are shown in the Proxy RPs tab of the file 24-070_2025-03-25_Exh_2.xlsb.

[33] https://apps.bea.gov/itable/?ReqID=70&step=1#eyJhcHBpZCI6NzAsInN0ZXBzIjpbMSwyOSwyNSwzMSwyNiwyNywzMCwzMF0sImRhdGEiOltbIlRhYmxlSWQiLCI1MjUiXSxbIk1ham9yX0FyZWEiLCIwIl0sWyJTdGF0ZSIsWyIwIl1dLFsiQXJlYSIsWyJYWCJdXSxbIlN0YXRpc3RpYyIsIjEiXSxbIlVuaXRfb2ZfbWVhc3VyZSIsIkxldmVscyJdLFsiWWVhciIsWyItMSJdXSxbIlllYXJCZWdpbiIsIi0xIl0sWyJZZWFyX0VuZCIsIi0xIl1dfQ==, accessed November 20, 2024. The coefficients are shown in Excel Column AD of the Real tab of 24-070_2025-03-25_Exh_2.xlsb.

Table VIII: CAPM βs for electric and natural gas distribution holding companies

Holding company	β as of May 16, 2024	Expected ROE at MRP of 6.18% and risk-free rate of 2.81%
Otter Tail Corporation	0.90	8.37%
Black Hills Corporation	0.86	8.10%
Sempra Energy	0.85	8.07%
New Jersey Resources Corporation	0.81	7.83%
FirstEnergy Corporation	0.80	7.74%
Algonquin Power & Utilities	0.80	7.73%
MGE Energy Inc.	0.79	7.72%
PNM Resources, Inc. (Holding Co.)	0.79	7.70%
Southwest Gas Holdings Inc.	0.78	7.62%
Ameren Corporation	0.77	7.56%
Pacific Gas & Electric Co.	0.76	7.54%
UGI Corporation	0.74	7.42%
Exelon Corp	0.73	7.34%
Edison International	0.73	7.34%
Chesapeake Utilities Corporation	0.73	7.31%
PP&L Corporation	0.73	7.31%
NorthWestern Energy Group Inc.	0.71	7.22%
Allete, Inc.	0.70	7.15%
Avista Corporation	0.69	7.11%
Evergy	0.69	7.10%
Agere Systems Inc	0.69	7.09%
Portland General Electric Company	0.69	7.09%
Northern Indiana Public Service Company	0.69	7.08%
Spire Inc.	0.69	7.08%
OGE Energy Corporation	0.69	7.06%
Public Service Enterprise Group Inc.	0.68	7.03%
CenterPoint Energy, Inc (Holding Co)	0.68	7.02%
Atmos Energy Corporation	0.68	7.00%
IDACORP, Inc.	0.67	6.95%
CMS Energy Corporation	0.67	6.95%
ONE Gas Inc.	0.66	6.88%
Northwest Natural Holding Company	0.65	6.85%
DTE Energy Company	0.64	6.78%
Alliant Energy Corporation	0.64	6.77%
NextEra Energy Inc.	0.63	6.68%
Dominion Resources, Inc.	0.60	6.52%
Entergy Corporation	0.59	6.45%
Xcel Energy Inc.	0.59	6.43%
Eversource	0.57	6.33%
Hawaiian Electric Industries, Inc.	0.56	6.28%
Duke Energy Corporation	0.56	6.28%
American Electric Power Company, Inc.	0.55	6.23%
Unitil Corporation	0.55	6.23%
Wisconsin Energy Corporation	0.50	5.90%
Consolidated Edison, Inc.	0.50	5.89%
Southern Company (The)	0.46	5.65%

Rea electric proxy group

Figure VII: Service areas of The Southern Company and Black Hills Corporation

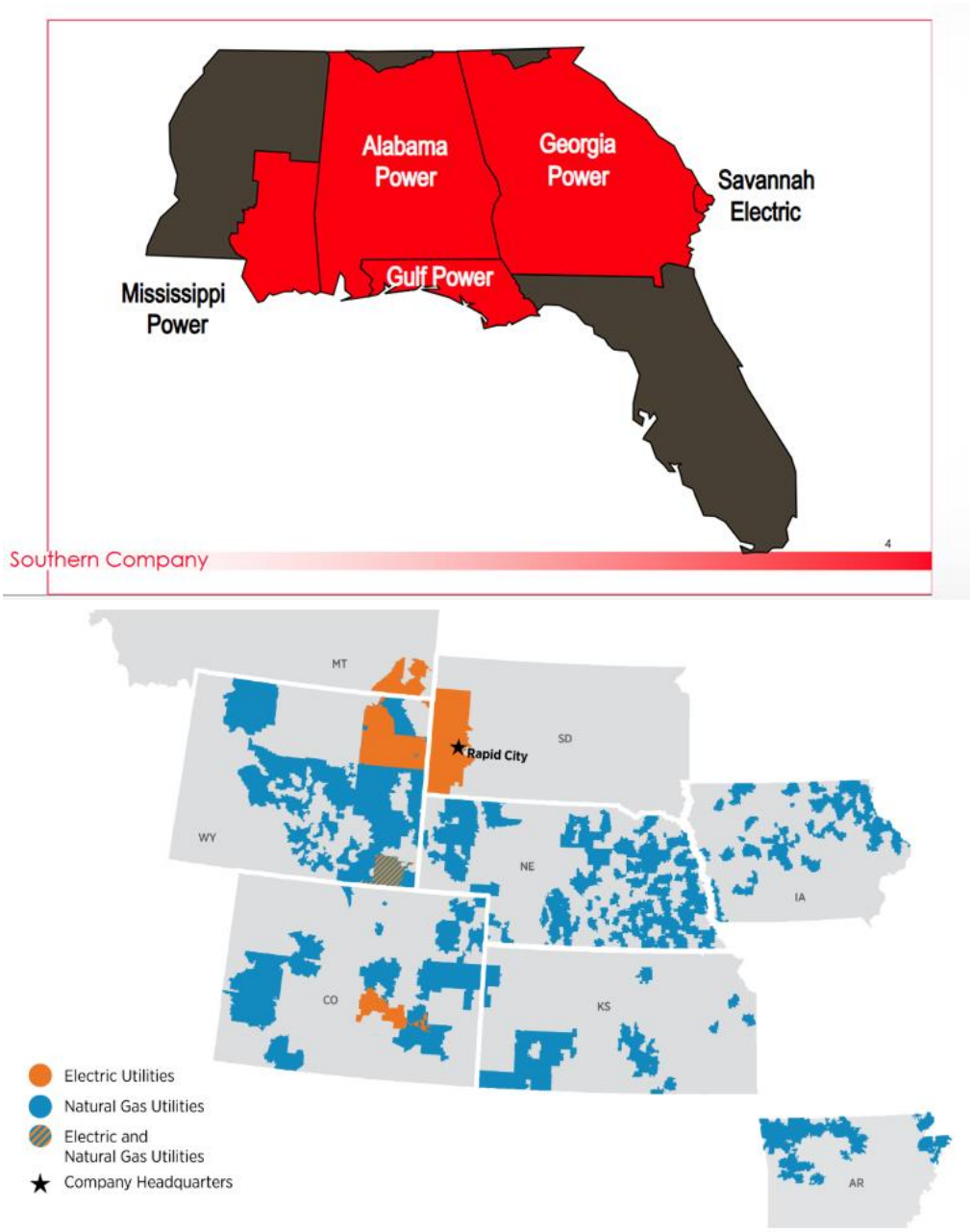


Figure VIII: Service area of American Electric Power and U.S. shale plays

Sources: https://www.aep.com/economic-development/properties/service-territory; https://www.eia.gov/analysis/studies/usshalegas/, accessed November 26, 2024

Otter Tail Corporation has the highest CAPM β and predicted ROE, but, unlike SoCo and AEP, it is heavily invested in manufacturing in addition to electric distribution. Black Hills Corporation has the second highest β of 0.86, as of May 16, 2024, and predicted ROE of 8.10 percent. According to its website, "Black Hills Corp. (NYSE: BKH) is a customer-focused, growth-oriented utility company…. Based in Rapid City, South Dakota, we serve 1.3 million natural gas and electric utility customers in eight states…."[34] Figure VII reveals that the territory is concentrated in South Dakota, Wyoming, Colorado, and Nebraska. The personal consumption coefficients for those states are 1.21, 1.21, 1.15, and 0.93, respectively.

The personal consumption coefficients for New Hampshire, Massachusetts, Maine, Vermont, and Connecticut are 1.22, 1.23, 1.23, 1.07, and 0.98, respectively. Based on the macroeconomy of its service area alone, Eversource should have a high-to-moderate β, but it is also a heavily regulated company. The New Hampshire cross section does exhibit heterogeneity in terms of the geographical footprints, regulatory status, industrial diversity, and degrees of vertical integration of its members. In particular, Algonquin is more diverse and less regulated than Eversource and Unitil. Yahoo! Finance provides the following descriptions of the three holding companies:

> Eversource Energy, a public utility holding company, engages in the energy delivery business. The company operates through Electric Distribution, Electric Transmission, Natural Gas Distribution, and Water Distribution segments. It is involved in the transmission and distribution of electricity, solar power facilities, and distribution of natural gas. The company operates regulated water utilities that provide water services to approximately 241,000 customers. It serves residential, commercial, industrial, municipal and fire protection, and other customers in Connecticut, Massachusetts, and New Hampshire. The company was formerly known as Northeast Utilities and changed its name to Eversource Energy in April 2015. Eversource Energy was incorporated in 1927 and is headquartered in Springfield, Massachusetts.[35]
>
> Unitil Corporation, a public utility holding company, engages in the distribution of electricity and natural gas. It operates through two segments: Utility Electric Operations; Utility Gas Operations. The company distributes electricity in the southeastern seacoast and state capital regions of New Hampshire and the greater Fitchburg area of north central Massachusetts; it distributes natural gas in southeastern New Hampshire and portions of southern and central Maine, including the city of Portland and the Lewiston-Auburn area, as well as electricity and natural gas in the greater Fitchburg area... It also operates 86 miles of interstate underground natural gas transmission pipeline that provide interstate natural gas pipeline access and transportation services primarily in Maine and New Hampshire. In addition, the company provides real estate management services. It serves approximately 108,100 electric customers and 87,500 natural gas customers. Unitil Corporation was incorporated in 1984 and is headquartered in Hampton, New Hampshire.[36]
>
> Algonquin Power & Utilities Corporation operates in the power and utility industries in the United States, Canada, and other regions. The company operates in two segments, Regulated Services Group and Renewable Energy Group. The company primarily owns and operates regulated electric, water distribution and wastewater collection, and natural gas utility systems and transmission operations. As of December 31, 2023, it provided distribution services to

[34] https://ir.blackhillscorp.com/, accessed November 26, 2024.
[35] https://finance.yahoo.com/quote/ES/profile/, accessed July 8, 2024.
[36] https://finance.yahoo.com/quote/UTL/profile/, accessed July 8, 2024.

> approximately 1,256,000 customer connections in the electric (approximately 309,000 customer connections), water and wastewater (approximately 572,000 customer connections), and natural gas sectors (approximately 375,000 customer connections). The company's electrical distribution utility systems and related transmission and generation assets are located in the states of Arkansas, California, Kansas, Missouri, Nevada, New Hampshire, and Oklahoma, and in Bermuda. Its regulated water distribution and wastewater collection utility systems are located in the states of Arizona, Arkansas, California, Illinois, Missouri, New York and Texas, and in Chile. The company's regulated natural gas distribution utility systems are located in the province of New Brunswick and the states of Georgia, Illinois, Iowa, Massachusetts, Missouri, New Hampshire and New York. It also owns and operates generating assets with a gross capacity of approximately 2.0 gigawatt (GW) and has investments in generating assets with approximately 0.3 GW of net generation capacity. The company generates and sells electrical energy, capacity, ancillary products, and renewable attributes produced by its renewable and clean power generation facilities. It has economic interests in hydroelectric, wind, solar, renewable natural gas, and thermal facilities. As of December 31, 2023, it had a combined net generating capacity attributable to the Renewable Energy Group of approximately 2.7 GW. The company was incorporated in 1988 and is headquartered in Oakville, Canada.[37]

I include the "target" holding company, Eversource, in the cross section. As the court explained in *Petal Gas Storage, L.L.C. v. FERC* (p. 5), the purpose of a "proxy group" is to "provide market determined stock and dividend figures from public companies comparable to a target company for which those figures are unavailable." In this case, data are available for Eversource (and Northeast Utilities), so lack of availability does not restrict consideration to data on proxies only. A second argument for omitting the target company is that inclusion endogenizes the allowed rate of return over time: A higher allowed ROE raises subsequent realized ROE, causing a commission to subsequently increase allowed ROE, and so on. In Equation (21), this would show up as an autocorrelated error term. The seemingly unrelated regression (SUR) estimator I use is consistent and efficient in the presence of autocorrelated errors, and the sample contains 12,921 trading days for Eversource, 9,877 for Unitil, and 3,619 for Algonquin, so the endogenous allowed ROE is not a concern in the panel study.

I estimated Equation (19) simultaneously for Eversource, Unitil, and Algonquin using SUR with daily dividend-adjusted closing prices from Yahoo! Finance from February 23, 1973 for Eversource, March 9, 1985 for Unitil, and December 31, 2009 for Algonquin to May 16, 2024.[38] The data are shown in the ES UTL AQN SP500 3MO tab of the file 24-070_2025-03-25_Exh_1.xlsb. I extrapolated the trends to January 1, 2028, assuming that to be well within the DE 24-070 rate period. The time variable $t = 17026$ on that day, and the forecasted CAPM βs for that day are $\beta_{ES} = \underset{0.01768}{0.57653}$, $\beta_{UTL} = \underset{0.02257}{0.60055}$, and $\beta_{AQN} = \underset{0.06108}{0.88134}$, where the numbers below are the standard errors of estimate. The 95 percent confidence intervals are $[0.54188, 0.61117]$, $[0.55632, 0.64477]$, and $[0.76163, 1.00106]$, respectively. Eversource is the largest[39] and most regulated of the three and has

[37] https://finance.yahoo.com/quote/AQN/profile/, accessed July 8, 2024.
[38] Yahoo! Finance; https://finance.yahoo.com/quote/ES/history/, https://finance.yahoo.com/quote/AQN/history/, and https://finance.yahoo.com/quote/UTL/history/, accessed August 19, 2024.
[39] On Bates page 19370 of his direct testimony, Vincent Rea uses the following block quote (*2023 SBBI Yearbook*, (Kroll LLC); p. 143):

> One of the most remarkable discoveries of modern finance is the finding of a relationship between company size and return, generally referred to as the "size effect". The size effect is based on the empirical observation that companies of smaller size tend to have higher returns than do larger companies.

the lowest estimated CAPM β. Algonquin is the least regulated and most industrially and geographically diverse and has the highest β. Despite differences, the cross correlations of the residuals from estimation of Equations (19) for Eversource, Unitil, and Algonquin in Table IX are positive and non-trivial, affirming the use of SUR as a way to lower the standard errors of the estimates. Eversource and Unitil are more similar to each other geographically, regulatorily, industrially, and in terms of vertical integration than they are to Algonquin, and the correlation between them is higher than those between them and Algonquin.

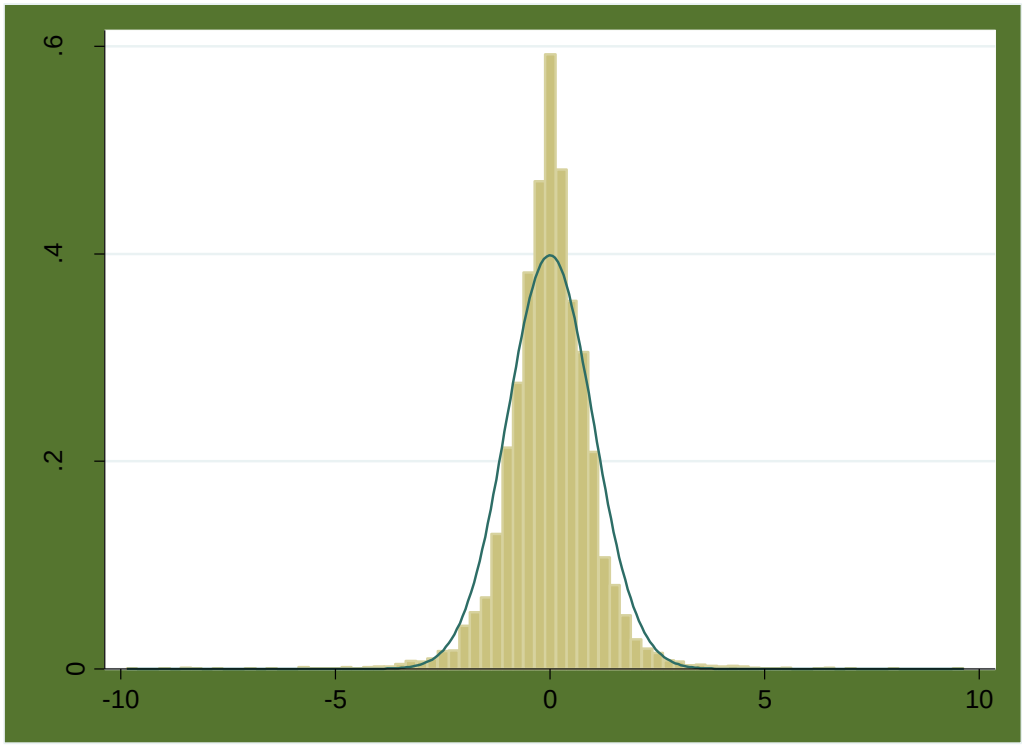
Table IX: Correlation matrix of residuals using adjusted closing prices of holding companies and secondary yields on three-month T-bills

	ES	UTL	AQN
ES	1.00		
UTL	0.24	1.00	
AQN	0.18	0.18	1.00

Normality

Standardized residuals for Eversource are normally distributed, but with more residuals falling close to zero than under a normal distribution. Figure IX shows a histogram of these residuals with a normal density curve overlayed. Whatever "fat tails" the distribution of Eversource's stock price exhibits are modeled in Equation (19), rather than being left to the error term; there are no fat tails visible in Figure IX.

Figure IX: Normality of New Hampshire SUR CAPM residuals for Eversource



Time-series estimation

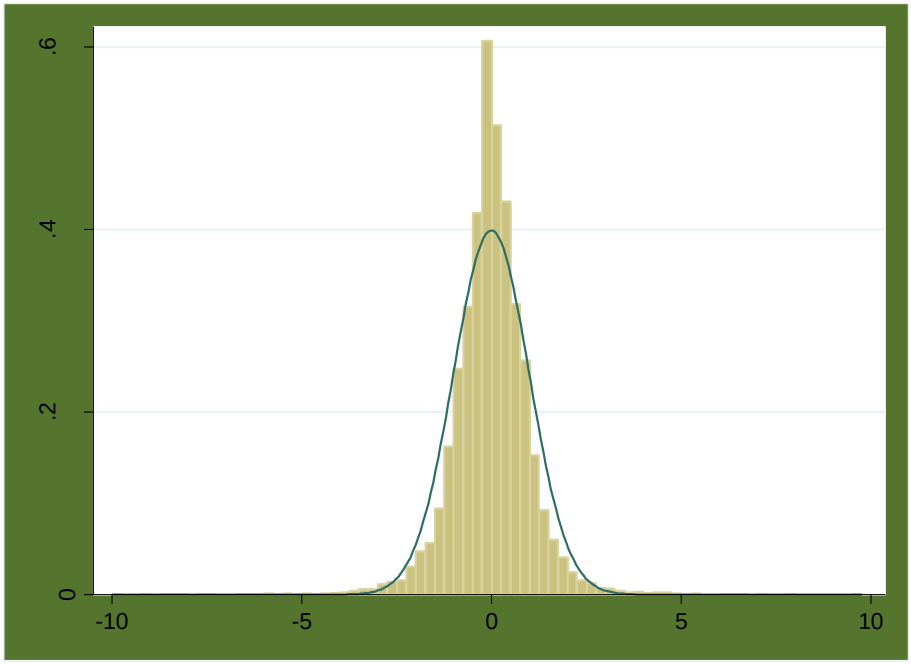
I estimated Equation (21) for Eversource alone using the time-series contained in the panel. The data are shown in the ES UTL AQN SP500 3MO tab of the file 24-070_2025-03-25_Exh_1.xlsb. I extrapolated the trend to January 1, 2028, assuming that to be well within the DE 24-070 rate period. The time variable $t = 17026$ on that day, and the forecasted CAPM β for that day is $\beta_{ES} = \underset{0.01897}{0.57735}$, where the number below is the standard error of estimate. The 95 percent confidence interval is $[0.54017, 0.61452]$. The point estimate of β_{ES} and confidence interval are virtually the same as in the panel case, even though the form of the equation is different and data on Unitil and Algonquin are not used.

I correct for autocorrelation in the residuals of -0.06766 at the first lag by using a Prais-Winsten estimator. The corrected residuals test as statistical "white noise" at the 85 percent level in a Bartlett test. This obviates any concern that an analysis of the target company would endogenize its ROE through the Commission's decisions, since such a process would show up as an autocorrelated error term.

Normality

The standardized residuals are nearly normally distributed, but with more residuals falling close to zero than under a standard normal distribution. Figure X shows a histogram of these residuals with a normal density curve overlayed. Whatever fat tails the distribution of Eversource's stock price exhibits are modeled in Equation (21) using the time-series, not left to the error term; just as in the panel case, there are no fat tails visible in Figure X.

Figure X: Normality residuals from Prais-Winsten regression for Eversource



Estimation at the level of the utility

Form of the estimated equation

I estimated stationary CAPM βs using a variation on Equation (1), Equation (23), with panel data on PSNH, CL&P, and Yankee Gas (YG).

$$r_{St}^{R} - r_{ft-1} = \beta_S \left(r_{mt} - r_{ft-1} \right) + \alpha_S r_{St}^{A} + \varepsilon_{St} \tag{23}$$

where t is in calendar quarters, r_{St}^{R} is realized inferred market rate of return on equity in distribution ratebase at t for Eversource Subsidiary S, r_{ft} is the risk-free rate at Time t, r_{mt} is the expected rate of return at t for the stock market as a whole, r_{St}^{A} is the allowed rate of return on equity in book value of ratebase for Subsidiary S at Time t, β_S is the estimated "CAPM β" holding r_{St}^{A} constant, α_S is the effect of allowed ROE on realized ROE holding the market equity risk premium, $r_{mt} - r_{ft-1}$, constant, and ε_{St} is an error term that is correlated across the subsidiaries, an attribute that is used to lower the standard errors of the estimated coefficients.[40] All data, though reported quarterly, are annual moving averages.

I correct for autocorrelation at the first lag by including residuals from prior runs of the regression in the final regression. I use an SUR estimator, but this is not a large sample, so I do not rely entirely on SUR's consistency and efficiency in large samples to handle autocorrelation. The size of the sample is also the reason for estimating stationary, rather than trending, βs. The estimated relationship for PSNH is

$$r_{PSNHt}^{R} - r_{ft-1} = \underset{0.00760}{0.05102} \left(r_{mt} - r_{ft-1} \right) + \underset{0.01282}{0.37717}\, r_{PSNHt}^{A} \tag{24}$$

where the number below is the standard error of the estimated coefficient. The coefficient on the MRP is small, as CAPM βs go, highlighting the low risk of investment in PSNH. As noted, though, it is higher when the main regulatory risk, allowed ROE, is not controlled for.

Eversource reports actual annual rates of return on equity in the book value of the distribution systems of its regulated retail holdings on a quarterly, annual moving average, basis to the state commissions that regulate them on Form F-1.[41] I use these data for r_{St}^{R} in Equation (23). State commissions effectively report the allowed ROEs used for r_{St}^{A}.[42] r_{ft} is the secondary yield on three-month T-bills reported by the Federal Reserve Bank of Saint Louis, and r_{mt} is the rate of return on the S&P 500 index using dividend-adjusted closing prices reported by Yahoo! Finance.[43] The data cover 2010:I through 2024:II and are shown in the PSNH CLP YG SP500 3MO tab of the file 24-070_2025-03-25_Exh_1.xlsb.

[40] Ibid, Parks.
[41] https://www.eversource.com/content/residential/about/investors/annual-reports-10k/quarterly-roe-filings, accessed August 5, 2024
[42] https://www.puc.nh.gov/ and https://portal.ct.gov/pura, accessed November 12, 2024.
[43] Yahoo! Finance; https://finance.yahoo.com/quote/%5EGSPC/history/?period1=-1325583000&period2=1724090581, accessed August 19, 2024.

Selection of the cross-sectional units

The cross section is focused on Eversource because the subsidiaries represent a portfolio of investments in distribution capital that management has chosen on behalf of shareholders; they have been judged to be complementary goods in this sense, so their prices are related. Moreover, these subsidiaries are geographically, regulatorily, and industrially (energy) similar. All three serve customers in New England and are regulated by state commissions, natural gas is usually "on the margin" in generation of electricity, and the two forms of energy are substitutes in end-uses such as space heating, cooking, and hot-water. These close relationships engender cross-correlations in realized ROEs that are used in the SUR regression to lower the standard errors of the estimates.

The cross correlations of the residuals from estimation of Equation (23) for PSNH, CL&P, and YG in Table X are positive and non-trivial, consistent with the use of SUR as a way to lower the standard errors of the estimates.

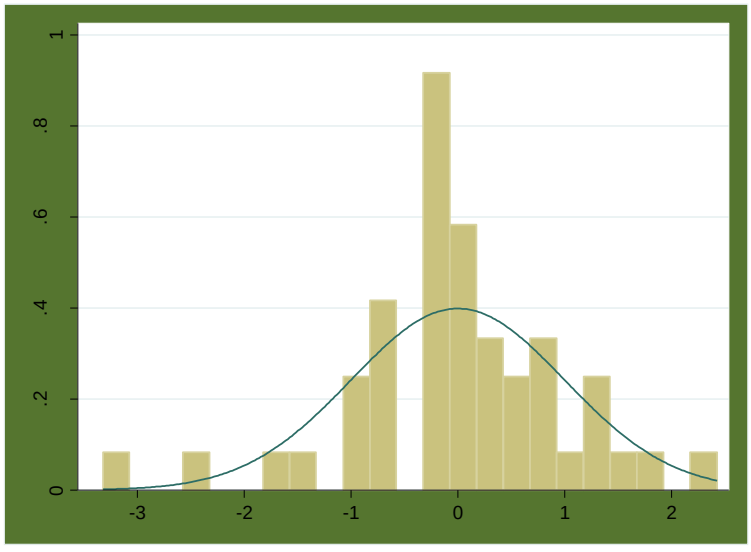
Table X: Correlation matrix of residuals for Eversource subsidiaries

	PSNH	CL&P	YG
PSNH	1.00		
CL&P	0.56	1.00	
YG	0.51	0.60	1.00

Normality

The standardized residuals for PSNH are fairly normally distributed. A skewness/kurtosis test for normality fails to reject normal skewness and kurtosis at the 99 percent level, both individually and jointly. Figure IX shows a histogram of these residuals with a normal density curve overlayed.

Figure XI: Normality of Eversource SUR residuals for PSNH



EDUCATION

Ph.D. in Economics, Brown University, Providence, RI, 2007
M.A. in Economics, Brown University, Providence, RI, 1999
B.A. in Economics with departmental honors, University of Oregon, Eugene, OR, 1986

EXPERIENCE

New Hampshire Office of the Consumer Advocate, Concord, NH, August 2023 – present
- Expert testimony and analysis in regulatory proceedings on behalf of residential customers of public utilities in New Hampshire
- Education of customers

Rivier University, Nashua, NH, January 2020 – present
- Teach business economics and macroeconomics

The Economic Utility Group, Nashua, NH, February 2021 – June 2021, July 2022 – July 2023
- Forecasted wages and employment in the skilled trades with Senior Economist at Construction Industry Resources
- Forecasted volatile upstream fuel prices and climate damages
- Forecasted electric vehicle and non-EV electrification load for Hitachi Energy USA

Hitachi Energy USA, Nashua, NH, June 2021 – June 2022
- Analysis, modeling, forecasting, and reporting on wholesale power markets, especially in Mexico, using PROMOD® (a production cost model)

Elevation Direct Corporation, Nashua, NH, July 2015 – January 2021
- Jointly sponsored testimony before the Rhode Island PUC on the employment impacts of Clear River Energy Center (CREC) for the Rhode Island Building and Construction Trades Council; individually sponsored rebuttal testimony on the need for CREC
- Used Aurora® (a capacity expansion and production cost model) to evaluate potential purchase of Termoelectrica de Mexicali, a combined cycle natural gas-fired generator
- Used Aurora to forecast wholesale electric prices in Michigan and sponsored testimony on behalf of Michigan Public Service Commission staff in a case regarding a purchased power agreement for the output of the Palisades nuclear plant
- Work in restructured wholesale power market in Mexico
  - Provided forecasts of gross state product, loads, and fuel, energy, congestion, loss, ancillary service, and capacity prices, as well as prices of clean energy certificates and social costs of emissions in evaluations of pumped storage, combined-cycle gas, internal combustion, and wind and solar facilities; co-authored market studies done using Aurora, Plexos, and Encompass (capacity expansion and production cost models)
  - Assembled Mexican database and used Aurora to model expansion and operation of power grid for several independent generators
  - Co-authored a report on the economics of introducing liquefied natural gas to southern Baja California
  - Estimated a weighted average cost of capital to Comisión Federal de Electricidad (CFE)
  - Trained employees of CFE in load forecasting
  - Estimated Herfindahl-Hirschman indices of market concentration following breakup of CFE under Mexican energy reform

Universidad del Pacifico, Jesús María, Lima, Peru, September 2014
- Taught topical graduate course in energy economics

Economic Insight, Portland, OR, January 2010 – March 2013

- Used Aurora to model electric resource planning in the Pacific Northwest
- Used Aurora to estimate trade benefits of Entergy and South Mississippi Electric Power Association joining regional transmission organizations, sponsored testimony before the Mississippi Public Service Commission (MPSC)
- Assessed application to install pollution controls on a coal plant; jointly testified with Sam Van Vactor before the MPSC
- Estimated dollars of spending per employee by generating technology
- Analyzed issues regarding pricing and royalties in geothermal and natural gas leases in California and Texas;
- Analyzed pricing and alleged use of market power in California power crisis
- Estimated lost earnings in a wrongful death lawsuit and testified to report
- Editor of scholarly research written by non-native speakers of English (intermittent)

Pacific University, Forest Grove, OR, August 2008 - May 2009

- Taught principles of microeconomics, environmental economics, and international trade

New York Department of Public Service, Albany, NY, August 2006 - December 2007

Eastern Connecticut State University, Willimantic, CT, August 2005 - May 2006

- Taught principles of microeconomics

Allan M. Feldman, Ph.D., Providence, RI, 2002-2003

- Worklife evaluation for litigation related to personal injury or wrongful death

Brown University, Providence, RI, 1999-2002

- Research and teaching assistance in valuation of individual earning capacity, industrial location in Indonesia, and principles of microeconomics and macroeconomics

Synapse Energy Economics, Cambridge, MA, July 1998 - February 1999

- Evaluated forecasts of electricity prices submitted in "stranded-cost" claim by four Maryland utilities

Bonneville Power Administration, Portland, OR, September 1988 - June 1997

- Authored and testified to marginal cost analysis in 1996 rate case before FERC
    - Helped prepare inputs to and interpreted and applied results of Power Marketing Decision Analysis Model (PMDAM) to rate design and to planning and evaluation of resources
    - Prepared and conducted public meetings on analysis and its implications for rate design
    - Fielded and incorporated comments from a variety of participants
    - Authored rate case study, documentation, and testimony
- Research on marginal costs of generating and marketing hydropower on the West Coast
- Prepared workshop briefing material, rate case studies, and documentation supporting marginal cost analysis and other rate-related issues as assigned
- Evaluated contracts for disposition of wholesale power

Economic Insight, Portland, OR, May 1988 - September 1988

- Surveyed forecasts of electricity prices and estimates of demand elasticities related to litigation over Washington Public Power Supply System bond defaults

ECO Northwest, Eugene, OR, July 1986 - August 1987

- Worklife evaluation for litigation related to personal injury and wrongful death; wrote company training manual on the subject

Changsha Normal University of Water Resources and Electric Power, Changsha, Hunan, PRC, August 1987 - January 1988; Brown University, Providence, RI, Summer 2001

- Taught English as a second language

RESEARCH

Vatter, M. (2024). Is LNG a bridge fuel in the mitigation of global warming: a critical review of studies at the EDF, NRDC, and Bloomberg, *IAEE Energy Forum*, 1st quarter 2024, https://www.iaee.org/newsletter/issue/116

Vatter, M. (2022). Pricing global warming as a mortal threat. United States Association for Energy Economics (USAEE) Working Paper No. 21-491, http://ssrn.com/abstract=3821603, and IAEE Conference Proceedings, online, June 7-9, 2021, https://www.iaee.org/proceedings/article/17059

Vatter, M., Van Vactor, S., and Coburn, T. (2022). Price responsiveness of shale oil: a Bakken case study. *Natural Resources Research*, 31:1, https://doi.org/10.1007/s11053-021-09972-9, and IAEE Conference Proceedings, Montreal, May 29-Jun 1, 2019, https://www.iaee.org/proceedings/article/16313

Vatter, M. (2020). Stratified zoning in central cities. *Journal of Housing Economics*, 50, https://doi.org/10.1016/j.jhe.2020.101716

Vatter, M. (2019). OPEC's risk premia and volatility in oil prices. *International Advances in Economic Research*, 25:2, DOI: 10.1007/s11294-019-09734-7

Vatter, M., Suurkask, D. (2018). The impact of trade with the United States on electric loads in Mexico. *Heliyon*, 4:8, https://doi.org/10.1016/j.heliyon.2018.e00717, and *IAEE Energy Forum*, 2nd quarter 2017, https://www.iaee.org/en/publications/newsletterdl.aspx?id=406

Vatter, M. (2017). OPEC's kinked demand curve. *Energy Economics*, 63, https://doi.org/10.1016/j.eneco.2017.02.010

Vatter, M. (2017). Stockpiling to contain OPEC. USAEE Working Paper No. 17-136, http://ssrn.com/abstract=912311, and USAEE Conference Proceedings, New Orleans, December, 2008, https://www.iaee.org/proceedings/article/17512

Vatter, M. (2017). Social discounting with diminishing returns on investment, http://ssrn.com/abstract=1078502

Vatter, M., Barney, F. (2016). Macroeconomic risk and residential rate design. USAEE Working Paper No. 15-208, http://ssrn.com/abstract=2596258

Vatter, M. (2008). OPEC's demand curve, http://ssrn.com/abstract=1127642, reviewed at http://knowledgeproblem.com/2008/05/14/

Peer Reviewer for *Land Economics*: effects of endowments of petroleum resources on corruption, 2008; hedging in coal contracts under the acid rain program, 2010-11; suburban agriculture as an amenity, 2012; prorationing versus unitization in the U.S. petroleum industry in the 20th century, 2013

STREAMING MEDIA

International Atlantic Economic Society video: Nice world economy you have there; be a shame if something should happen to it, temporarily available at https://www.iaes.org/, accessed June 15, 2022

IAEE webinar: Is another oil price shock possible, and would it matter? January 11, 2021, https://www.iaee.org/en/webinars/webinar_vatter.aspx

USAEE podcast: OPEC as a destabilizing influence, July 21, 2020, https://www.usaee.org/podcasts.aspx

Video: Discussing transmission costs with New Hampshire Senate Energy and Natural Resources Chair Kevin Avard, https://www.youtube.com/watch?v=QRkLdLplz9Y&feature=youtu.be&fbclid=IwAR2Euva286vNRa5Lit0RstjHwtPuV5a_t439Cml4Z8S2WHYptXNdJ40vkZs

Video: Discussing manufacturing, net metering rate design, and transmission costs on *Perspectives* with David Schoneman, https://youtu.be/m9YRY3U-DzM

AWARDS

Twelve monetary awards for job performance at Bonneville Power Administration
Award for best undergraduate research project in economics at University of Oregon; examined deregulation of U.S. airline industry

OTHER ACTIVITIES

Monitored the House Science, Technology, and Energy Committee in Concord, NH for the Northeast Energy and Commerce Association
Founded and managed "Micro Lunch" seminar, Brown University, 2001-2002
Role of expert witness in Lewis & Clark Law School's mock personal-injury litigation, 1996
Peer Advisor, Department of Economics, University of Oregon, 1984-1986

MEMBERSHIPS

International and United States Associations for Energy Economics; Northeast Energy and Commerce Association; Northeast Energy and Commerce Association; New Hampshire Business and Industry Association, Manufacturing and End Users Policy Committee

TESTIMONIALS

"We asked Marc to provide us with a forecast of future locational marginal prices under two different scenarios, which he managed very well. He provided us with testimony that was on point and met our needs." Lauren Donofrio, Assistant Attorney General, Public Service Division, State of Michigan

"Marc Vatter provided joint testimony with Sam Van Vactor on behalf of Staff in 2010 regarding Mississippi Power's application to install pollution controls on the Victor J. Daniel coal-fired generator. He brought to light critical issues regarding uncertainty over natural gas prices that bore on the decision to

install scrubbers. We hired the two again in 2012 in a proceeding on integrating Entergy's transmission assets into a regional transmission organization. Marc added significant detail representing the state of Mississippi to a production cost and capacity expansion model that he used to quantify the effects of integration. A number of consultants engaged in similar efforts, and Marc's analysis was of superior quality." Dr. Christopher Garbacz, Director, Economics and Planning Division, Mississippi Public Utilities Staff