Rate of Return Regulation Revisited

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Abstract

Utility companies recover their capital costs through regulator-approved rates of return. Using a comprehensive database of utility rate cases we estimate that utilities' current regulated returns on equity are significantly higher than various benchmarks would suggest. We show that regulated returns on equity respond more quickly to increases in benchmark measures of capital costs than they do to decreases. We then provide evidence that higher regulated returns on equity lead utilities to own more capital. A 1 percentage point rise in the return on equity increases capital investment by 5%. Overall we find excess costs to consumers of $2–20 billion per year.

JEL Codes: Q4, L5, L9

Keywords: Utility, Rate of Return, Regulation, Electricity, Natural Gas, Capital Investment

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1 Introduction

In the two decades from 1997 to 2017, real annual capital spending on electricity distribution infrastructure by major utilities in the United States has doubled (EIA 2018a). Over the same time period annual capital spending on electricity transmission infrastructure increased by a factor of seven (EIA 2018b). The combined total is now more than $50 billion per year. This trend is expected to continue. Bloomberg New Energy Finance predicts that between 2020 and 2050, North and Central American investments in electricity transmission and distribution will likely amount to $1.6 trillion, with a further $1.7 trillion for electricity generation and storage (Henbest et al. 2020).[1]

These large capital investments could be due to the prudent actions of utility companies modernizing an aging grid. They may also be a necessary response to the clean energy transition underway in much of the gas and electric utility sector. However, it is noteworthy that over recent years, utilities have earned sizeable regulated rates of return on their capital assets, particularly when set against the unprecedented low interest rate environment post-2008. When the economy-wide cost of capital fell, utilities' regulated rates of return did not fall nearly as much. This gap raises the prospect that at least some of the growth in capital spending could be driven by utilities earning excess regulated returns.

Utilities over-investing in capital assets as a result of excess regulated returns is an age old concern in the sector (Averch and Johnson 1962). The resulting costs from "gold plating" are then passed on to consumers in the form of higher bills. Capital markets and the utility industry have undergone significant changes over the past 50 years since the early studies of utility capital ownership (Joskow 1972, 1974). In this paper we use new data to revisit these issues. We do so by exploring

1. North and Central American generation/storage are reported directly. Grid investments are only reported globally, so we assume the ratio of North and Central America to global is the same for generation/storage as for grid investments.

four main research questions. First, to what extent are utilities being allowed to earn excess returns on equity by their regulators? Second, what possible mechanisms can explain this divergence? Third, how have excess returns on equity affected utilities' capital investment decisions? Fourth, what impact has this had on the costs paid by consumers?

To answer our research questions, we use data on the utility rate cases of all major electricity and natural gas utilities in the United States spanning the past four decades (Regulatory Research Associates 2021). We combine this with a range of financial information on credit ratings, corporate borrowing, and market returns. To examine possible sources of over-investment in more detail we also incorporate data from annual regulatory filings on individual utility capital spending.

We start our analysis by estimating the size of the gap between the allowed rate of return on equity (RoE) that utilities earn and some measure of the cost of equity they face. A central challenge here, both for the regulator and for the econometrician, is estimating the cost of equity. We proceed by considering a range of approaches: simulating the actual cost of equity based on available measures of capital market returns, the capital asset pricing model (CAPM), and a comparison with regulatory decisions in the United Kingdom. None of these are perfect comparisons; but taken together, our various estimation approaches result in a consistent trend of excess rates of return. These results are necessarily uncertain, and depending on our chosen benchmark the premium ranges from 0.5 to 5.5 percentage points. Importantly though, even our most conservative benchmarks come in below the allowed rates of return on equity that regulators set today.

The existence of a persistent gap between the return on equity that utilities earn and some measure of the cost of capital they face could have a number of explanations. Recent work by Rode and Fischbeck (2019) ruled out a number of financial reasons we might see increasing RoE spreads, such as changes to utilities' debt/equity ratio, asset-specific risk, or the market's overall risk premium. This leaves them looking for other explanations – for example, they highlight that regulators seem to follow some ad-hoc approaches that make them reluctant to set RoE below a nominal 10%. Azgad-Tromer and Talley (2017) also find that allowed rates of return diverge significantly from what would be expected by a standard CAPM approach. They point to a range of non-financial factors that may play an important role, including political goals and regulatory capture. Using data from a field experiment they show that providing finance training to regulatory staff does have a moderate effect on moving rates of return closer to standard asset pricing predictions.

These insights point to the broader challenges inherent in the ratemaking process. Regulators face an information asymmetry with the utilities they regulate when determining whether costs are prudent and necessary (Joskow, Bohi, and Gollop 1989). Utilities have a clear incentive to request rate increases when their costs go up, but do not have much incentive to request a rate decrease when their costs go down. If regulators are too deferential to the demands of the utilities they regulate – perhaps due to a insufficient expertise or regulatory capture (Dal Bó 2006) – we would expect rates to become detached from underlying costs.

We explore this issue by drawing on the literature on asymmetric price adjustments. It has been documented in various industries that positive shocks to firms' input costs can feed through into prices faster than negative shocks (Bacon 1991; Borenstein, Cameron, and Gilbert 1997; Peltzman 2000). This is the so-called "rockets and feathers" phenomenon. We test this hypothesis by estimating a vector error correction model for the relationship between utilities' return on equity and some benchmark measures of the cost of capital (e.g. US Treasury Bond yields). Here we do indeed find evidence of asymmetric adjustment. Increases to the benchmark cost of capital lead to rapid rises in utilities' return on equity, while decreases lead to less rapid falls. This is the first instance we are aware of where this phenomenon has been identified in regulatory decisions regarding financial measures such as the cost of capital.

Excess regulated returns on equity will distort the incentives for utilities to invest in capital. To consider the change in the capital base, we turn to a regression analysis. Here we aim to identify how a larger RoE gap translates into over-investment in capital. Identification is challenging in this setting, so we again employ several different approaches, with different identifying assumptions. In addition to a basic within-utility (fixed effects) comparison, we examine variables that provide instruments for changes in utilities' RoE. For our preferred approach we draw on the intuition that after a rate case is decided, the utility's RoE is *fixed* at a particular nominal percentage for several years. The cost of capital in the rest of the economy, and therefore the cost of equity for the utility, will shift over time. We use these shifts in the timing and duration of rate cases as an instrument for changes in the RoE gap. We also examine a second instrument that exploits an apparent bias of regulators rounding the RoE values they approve, though ultimately this instrument is too weak for us to use.

Across the range of specifications used, we find a broadly consistent picture. In our preferred specification, we find that increasing the RoE gap by one percentage point leads to a five percent increase in the approved change in the rate base. We observe similar effects for the overall size of the approved rate base and find an even larger effect on capital intensity. We therefore provide new potential evidence for the Averch–Johnson effect in the utility sector.

Combining our measures of the RoE gap with the distortions to capital investment, we estimate the cost to consumers from excess rates of return reached around $2–20 billion per year by 2020, with the majority of these costs coming from the electricity sector. These costs have important distributional effects, representing a sizeable transfer from consumers to investors. Increasing the price of electricity also has important implications for environmental policy and efforts to encourage electrification (Borenstein and Bushnell 2022).

2 Background

Electricity and natural gas utility companies are typically regulated by government utility commissions, which allow the companies a geographic monopoly and, in exchange, regulate the rates the companies charge. These utility commissions are state-level regulators in the US. They set consumer rates and other policies to allow investor-owned utilities (IOUs) a designated rate of return on their capital investments, as well as recovery of non-capital costs. This rate of return on capital is almost always set as a nominal percentage of the installed capital base. For instance, with an installed capital base worth $10 billion and a rate of return of 8%, the utility is allowed to collect $800 million per year from customers for debt service and to provide a return on equity to shareholders. State utility commissions typically update these nominal rates every 3–6 years.

Utilities own physical capital (power plants, gas pipelines, repair trucks, office buildings, etc.). The capital depreciates over time, and the set of all capital the utility owns is called the rate base (the base of capital that rates are calculated on). Properly accounting for depreciation is far from straightforward, but we will not focus on that challenge in this paper. This capital rate base has an opportunity cost of ownership: instead of buying capital, that money could have been invested elsewhere. IOUs fund their operations through issuing debt and equity, typically about 50%/50%. For this paper, we focus on common stocks (utilities issue preferred stocks as well, but those form a very small fraction of utility financing). The weighted average cost of capital is the weighted average of the cost of debt and the cost of equity.

Utilities are allowed to set rates to recover all of their costs, including this cost of capital. For some expenses, like fuel purchases, it's easy to calculate the companies' costs. For others, like capital, the state public utilities commissions are left trying to approximate the capital allocation at a cost that competitive capital markets would provide if the utility had been a competitive company rather than a regulated monopoly. The types of capital utilities own, and their opportunities to add capital to their books, varies depending on market and regulatory conditions. Utilities that are vertically integrated might own a large majority of their own generation, the transmission lines, and the distribution infrastructure. Other utilities are "wires only," buying power from independent power producers and transporting it over their lines. Natural gas utilities are typically "pipeline only" – the utility doesn't own the gas well or processing plant, but may still have a substantial rate base.

In the 1960s and 70s, state public utilities commissions (PUCs) began adopting automatic fuel price adjustment clauses. Rather than opening a new rate case, utilities used an established formula to change their customer rates when fuel prices changed. The same automatic adjustment has generally not been the norm for capital costs, despite large swings in the nominal cost of capital over the past 50 years. A few jurisdictions have introduced limited automatic updating for the cost of equity, and we discuss those approaches in more detail in section 4.1, where we consider various approaches of estimating the RoE gap.

Regulators typically employ a "test year," a single 12-month period in the past or future that will be used as the basis for the rate case analysis. Expenses and capital costs in this test year, except those with automatic update provisions, are the values used for the entire rate case.

The cost of debt financing is easier to estimate than the cost of equity financing. For historical debts, it is sufficient to use the cost of servicing those debts. For forward-looking debt issuance, the cost is estimated based on the quantity and cost of expected new debt. Issues remain for forward looking decisions – e.g. what will bond rates be in the future test year? – but these are *relatively* less severe. In our data, we see both the utilities' requested and approved return on debt. It's notable that the requested and approved rates are very close for debt, and much farther apart for equity.

The cost of equity financing is more challenging. Theoretically, it's the return shareholders require in order to invest in the utility. The Pennsylvania Public Utility Commission's ratemaking guide notes this difficulty (Cawley and Kennard 2018):

> Regulators have always struggled with the best and most accurate method to use in applying the [*Federal Power Commission v. Hope Natural Gas Company* (1944)] criteria. There are two main conceptual approaches to determine a proper rate of return on common equity: "cost" and "the return necessary to attract capital." It must be stressed, however, that no single one can be considered the only correct method and that a proper return on equity can only be determined by the exercise of regulatory judgment that takes all evidence into consideration.

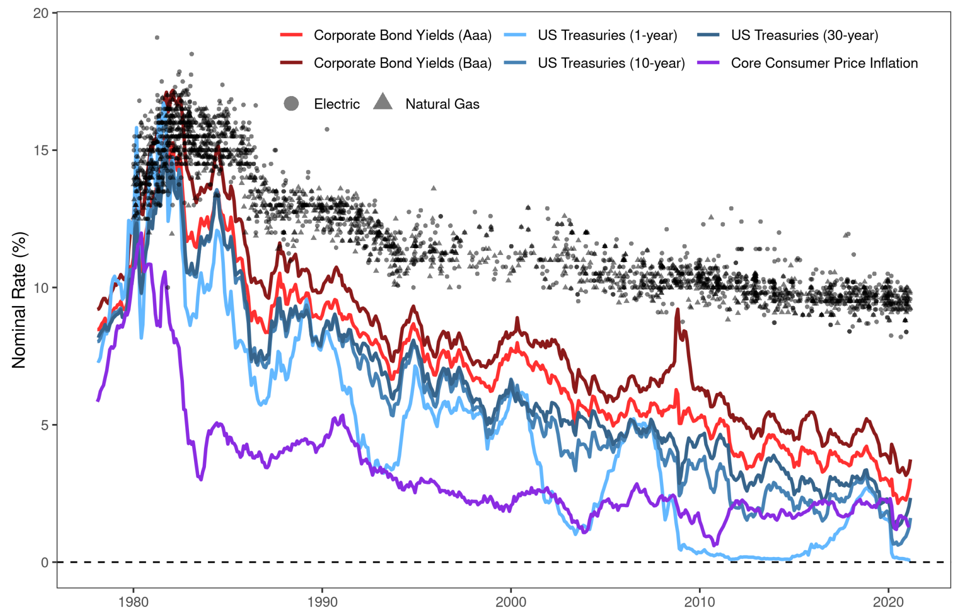
Unlike debt, where a large fraction of the cost is observable and tied to past issuance, the cost of equity is the ongoing, forward-looking cost of holding shareholders' money. Put differently, the RoE is applied to the entire rate base – unlike debt, there's typically no notion of paying a specific RoE for specific stock issues.

Regulators employ a mixture of models and subjective judgment. Typically, these approaches involve benchmarking against other US utilities (and often utilities in the same geographic region). There are advantages to narrow benchmarking, but when market conditions change and everyone is looking at their neighbors, rates will update very slowly.

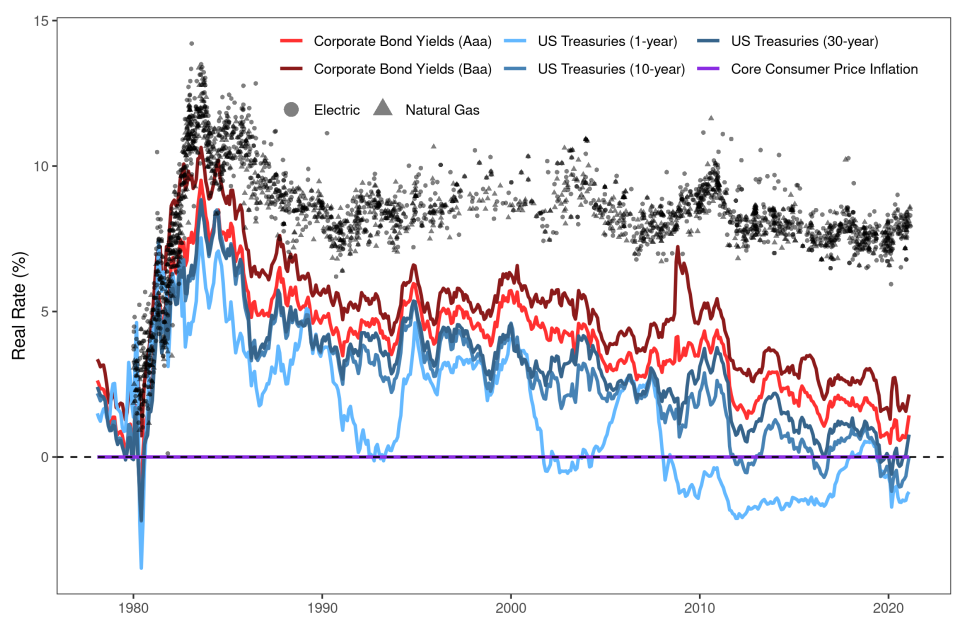
In Figure 1 we plot the approved return on equity over 40 years, with various risky and risk-free rates for comparison. The two panels show nominal and real rates.[2] Consistent with a story where regulators adjust slowly, approved RoE has fallen slightly (in both real and nominal terms), but much less than other costs of capital. This price stickiness by regulators also manifests in peculiarities of the rates regulators approve. For instance, Rode and Fischbeck (2019) note an apparent reluctance from to set RoE below a nominal 10%.

2. We calculate real values by subtracting the monthly core CPI.

Figure 1: Return on Equity and Financial Indicators



(a) Nominal



(b) Real

Notes: These figures show the approved return on equity for investor-owned US electric and natural gas utilities. Each dot represents the resolution of one rate case. Real rates are calculated by subtracting core CPI. Between March 2002 and March 2006 30-year Treasury rates are extrapolated from 1- and 10-year rates (using the predicted values from a regressing the 30-year rate on the 1- and 10-year rates).
SOURCES: Regulatory Research Associates (2021), Moody's (2021a, 2021b), Board of Governors of the Federal Reserve System (2021a, 2021b, 2021c), and US Bureau of Labor Statistics (2021).

That paper, Rode and Fischbeck (2019), is the closest to ours in the existing literature. The authors use the same rate case dataset we do, and note a similar widening of the spread between the approved return on equity and 10-year Treasury rates. That paper, unlike ours, dives into the financial modeling, using the standard capital asset pricing model (CAPM) to examine potential causes of the increase the RoE spread. In contrast, we consider a wider range of financial benchmarks (beyond 10-year Treasuries) and ask more pointed questions about the implications of this growing RoE gap for utilities' investment decisions and costs for consumers.

Using CAPM, Rode and Fischbeck (2019) rule out a number of financial reasons we might see increasing RoE spreads. Possible reasons include utilities' debt/equity ratio, the asset-specific risk (CAPM's β), or the market's overall risk premium. They find that none of these possibilities are supported by the data. A pattern of steadily increasing debt/equity could explain an increasing gap, but debt/equity has fallen over time. Increasing asset-specific risk could explain an increasing gap, but asset risk has (largely) fallen over time. An increasing market risk premium could explain an increased spread between RoE and riskless Treasuries, but the market risk premium has fallen over time.

Prior research has highlighted the importance of macroeconomic changes, and that these often aren't fully included in utility commission ratemaking (Salvino 1967; Strunk 2014). Because rates of return are typically set in fixed nominal percentages, rapid changes in inflation can dramatically shift a utility's real return. This pattern is visible in figure 1 in the early 1980s. Until 2021, inflation has been lower and much more stable.

Many authors have written a great deal about modifying the current system of investor-owned utilities. Those range from questions of who pays for fixed grid costs to the role of government ownership or securitization (Borenstein, Fowlie, and Sallee 2021; Farrell 2019). For this project, we assume the current structure of investor-owned utilities, leaving aside other questions of how to set rates across different groups of customers or who owns the capital.

3 Data

To answer our research questions, we use a database of resolved utility rate cases from 1980 to 2021 for every electricity and natural gas utility that either requested a nominal-dollar rate base change of $5 million or had a rate base change of $3 million authorized (Regulatory Research Associates 2021). Summary statistics on these rate cases can be seen in Table 1. Our primary variables of interest are the rates of return and the rate base.[3] We also merge data on annual number of customers, quantity supplied and sales revenue for the electric utilities in our sample (US Energy Information Administration 2022).

We transform this panel of rate case events into an unbalanced utility-by-month panel, filling in the rate base and rate of return variables in between each rate case. There are some mergers and splits in our sample, but our SNL data provider lists each company by its present-day (2021) company name, or the company's last operating name before it ceased to exist. With this limitation in mind, we construct our panel by (1) not filling data for a company before its first rate case in a state, and (2) dropping companies five years after their last rate case. In contexts where a historical comparison is necessary, but the utility didn't exist in the benchmark year, we use average of utilities that did exist in that state, weighted by rate base size.

We match with data on S&P credit ratings, drawn from SNL's *Companies (Classic) Screener* (2021) and WRDS' *Compustat S&P legacy credit ratings* (2019). Most investor-owned utilities are subsidiaries of publicly traded firms. We use the former data to match as specifically as possible, first same-firm, then parent-firm, then same-ticker.

3. We focus here on proposed and approved rates of return. It is possible that utility's actual rate of return or return on equity might differ from the approved level. In general though, actual returns do tend to track allowed returns quite closely.

Table 1: Summary Statistics

Characteristic	N	Electric[1]	Natural Gas[1]
Rate of Return Proposed (%)	3,324	9.95 (1.98)	10.07 (2.07)
Rate of Return Approved (%)	2,813	9.59 (1.91)	9.53 (1.95)
Return on Equity Proposed (%)	3,350	13.22 (2.69)	13.06 (2.50)
Return on Equity Approved (%)	2,852	12.38 (2.40)	12.05 (2.24)
Return on Equity Proposed Spread (%)	3,350	6.72 (2.18)	6.95 (1.99)
Return on Equity Approved Spread (%)	2,852	5.62 (2.27)	5.68 (2.10)
Return on Debt Proposed (%)	3,247	7.48 (2.11)	7.47 (2.16)
Return on Debt Approved (%)	2,633	7.54 (2.06)	7.44 (2.16)
Equity Funding Proposed (%)	3,338	45 (7)	48 (7)
Equity Funding Approved (%)	2,726	44 (7)	47 (7)
Customers (thous)	1,177	693 (929)	NA (NA)
Quantity (TWh)	1,177	17 (21)	NA (NA)
Revenue ($ mn)	1,177	1,469,519 (2,086,055)	NA (NA)
Rate Base Increase Proposed ($ mn)	3,686	84 (132)	24 (41)
Rate Base Increase Approved ($ mn)	3,672	40 (84)	12 (25)
Rate Base Proposed ($ mn)	2,366	2,239 (3,152)	602 (888)
Rate Base Approved ($ mn)	1,992	2,122 (2,991)	583 (843)
Case Length (yr)	3,364	3.11 (3.97)	3.01 (3.34)
Rate Case Duration (mo)	3,713	9.1 (5.1)	8.1 (4.3)

[1]Mean (SD)

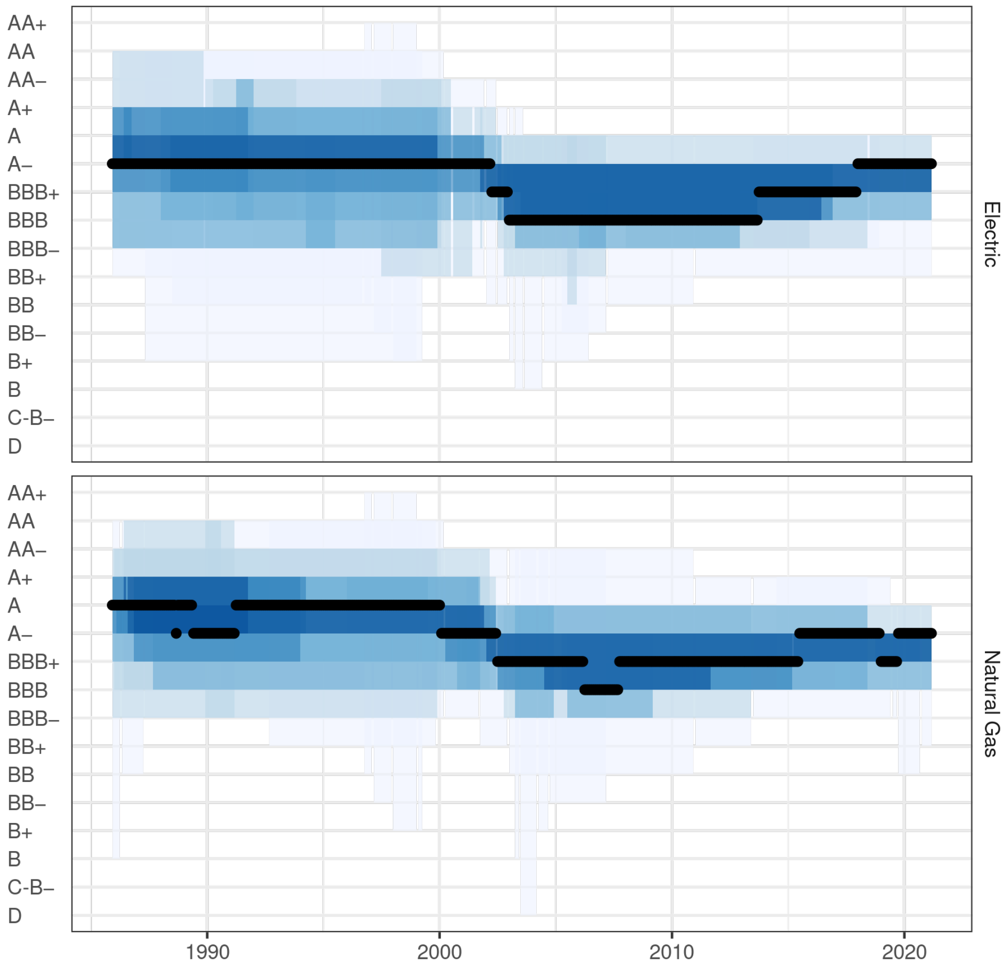
Notes: This table shows the rate case variables in our rate case dataset. Values in the Electric and Natural Gas columns are means, with standard deviations in parenthesis. Approved values are approved in the final determination, and are the values we use in our analysis. Some variables are missing, particularly the approved rate base. The RoE spread in this table is calculated relative to the 10-year Treasury rate.
Source: Regulatory Research Associates (2021), US Energy Information Administration (2022), and author calculations.

We match the latter data by ticker only. Then, for a relatively small number of firms, we fill forward.[4] Between these two sources, we have ratings data available from December 1985 onward. Approximately 80% of our utility–month observations are matched to a rating. Match quality improves over time: approximately 89% of observations after 2000 are matched.

These credit ratings have changed little over 35 years. In figure 2 we plot the

4. When multiple different ratings are available, e.g. different ratings for subsidiaries trading under the same ticker, we take the median rating. We round down (to the lower rating) in the case of an even number of ratings.

Figure 2: Credit ratings have changed little in 35 years



Note: Black lines represent the median rating of the utilities active in a given month. We also show bands, in different shades of blue, that cover the 40–60 percentile, 30–70 percentile, 20–80 percentile, 10–90 percentile, and 2.5–97.5 percentile ranges. (Unlike later plots, these *are not* weighted by rate base.) Ratings from C to B– are collapsed to save space.

Source: *Companies (Classic) Screener* (2021) and *Compustat S&P legacy credit ratings* (2019).

median (in black) and various percentile bands (in shades of blue) of the credit rating for utilities active in each month. We note that the median credit rating has seen modest movements up and down over the past decades. The distribution of ratings is somewhat more compressed in 2021 than in the 1990s. While credit ratings are imperfect, we would expect rating agencies to be aware of large changes in riskiness.[5] Instead, the median credit rating for electricity utilities is A−, as it was for all of the 1990s. The median credit rating for natural gas utilities is also A−, down from a historical value of A.

Beyond credit ratings, we also use various market rates pulled from FRED. These include 1-, 10-, and 30-year Treasury yields, the core consumer price index (CPI), bond yield indexes for corporate bonds rated by Moody's as Aaa or Baa, as well as those rated by S&P as AAA, AA, A, BBB, BB, B, and CCC or lower.[6]

Matching these two datasets – rate cases and macroeconomic indicators – we construct the timeseries shown in Figure 1. A couple of features jump out, as we mentioned in the introduction. The gap between the approved return on equity and other measures of the cost of capital have increased substantially over time. At the same time, the return on equity has decreased over time, but much more slowly than other indicators. This is the key stylized fact that motivates our examination of the return on equity that utilities earn and the implications this may have for their incentives to invest in capital and the costs they pass on to consumers.

4 Empirical Strategy

4.1 The Return on Equity Gap

Knowing the size of the return on equity (RoE) gap is a challenge, and we take a couple of different approaches. In general, we are taking the difference between the return on equity observed in our data and some benchmark or hypothetical measure. When these are nominal rates, such as corporate bonds or US Treasuries,

5. For utility risk to drive up the firms' cost of equity but not affect credit ratings, one would need to tell a very unusual story about information transmission or the credit rating process.

6. Board of Governors of the Federal Reserve System (2021a, 2021b, 2021c), US Bureau of Labor Statistics (2021), Moody's (2021a, 2021b), and Ice Data Indices, LLC (2021b, 2021a, 2021f, 2021d, 2021c, 2021g, 2021e).

we compare against nominal RoE. None are perfect, but collectively, they shed light on the question.

4.1.1 Benchmarking to a Baseline Spread

We first consider a benchmark index of corporate bond yields. The goal of this benchmark is to answer the question: What would the RoE be today if the average spread against corporate bond yields had not changed since some baseline date? Here we compare all utilities to the corporate bond index that is closest to that utility's own, contemporaneous debt rating.[7] To calculate the RoE gap we first find the spread between the approved return on equity and the bond index rate for each utility in each state in a baseline period. We then take this spread during the baseline period and apply it to the future evolution of the bond index rate to get an estimate of the baseline RoE. The RoE gap is the difference between a given utility's allowed return on equity at some point in time and this baseline RoE.

The choice of the baseline period influences the gap. Throughout our analysis we use January 1995 as the baseline period. The date chosen determines where the gap between utilities' RoE and baseline RoE is zero. Changing the baseline date will shift the overall magnitude of the gap. As long as the baseline date isn't in the middle of a recession, our qualitative results don't depend strongly on the choice. Stated differently, the baseline year determines when the average gap is zero, but this is a constant shift that does not affect the overall trend. While January 1995 is not special, we note that picking a much more recent baseline would imply that utilities were substantially and continuously under-compensated for their cost of equity for many years of our early sample.

7. We also examined a comparison against a single Moodys' Baa corporate bond index. Moody's Baa is approximately equivalent to S&P's BBB, a rating equal to or slightly below most of the utilities in our data (see figure 2). This avoids issues where utilities' bond ratings may be endogenous to their rate case outcomes. Using a single index also faces fewer data quality challenges. The findings using the single Moody's Baa bond index are broadly equivalent to those using a same rated bond index and our later approach using US Treasuries.

Our second measure adopts a similar approach to the first but benchmarks against US Treasuries. The idea here is to ask: what would the RoE be today if the average spread against US Treasuries had not changed since some baseline date? This measure is calculated in exactly the same way as our first approach except the spread is measured against the 10-year Treasury bond yield in the baseline period, rather than the relevant corporate bond index.

Our third measure continues with using US Treasuries but does so using an RoE update rule. This rule is consistent with the approach taken by the Vermont PUC, and similar approaches have been used in the past in California and Canada. Relative to some baseline period the automatic update rule adjusts the RoE at half the rate that the yield on the 10-year US Treasury bond changes over that time period.[8] The Vermont PUC uses 10-year US Treasuries and set the baseline period as December 2018, for their plan published in June 2019. (*Green Mountain Power: Multi-Year Regulation Plan 2020–2022* 2020). In our case we also use 10-year Treasuries and set the baseline to January 1995. We simulate the gap between approved RoE and what RoE would have been if every state's utilities commission followed this rule from 1995 onward.[9]

4.1.2 Benchmarking to the Capital Asset Pricing Model

Our fourth and fifth measures draw directly on the capital asset pricing model (CAPM) approach. The CAPM approach is widely used by regulators to support their decisions on utility equity returns, alongside other methods such as discounted cash flow. In principle the CAPM provides an objective way to quantify the expected returns for an asset given the risk of that asset and the returns available in the market over-and-above some risk-free rate. In practice its application remains open

8. Define RoE' as the baseline RoE, B' as the baseline 10-year Treasury bond yield, and B_t as the 10-year Treasury bond yield in year t. RoE in year t is then: $RoE_t = RoE' + (0.5 \times (B_t - B'))$

9. Pre-1995 values are not particularly meaningful, but we can calculate them with the same formula.

to a significant degree of subjective interpretation, in large part through the choice of values for its key parameters. As such, even CAPM calculations can form part of the negotiation process between regulators and utilities, with the latter having a clear incentive to lobby for assumptions that result in the CAPM producing higher estimates of the cost of equity.

We calculate predictions of the equity returns for each utility using the standard CAPM formula.

$$RoE = R_f + (\beta \times MRP)$$

Here R_f is the risk-free rate, MRP is the market risk premium and β is the equity β for the asset in question – namely each utility in our sample. Our assumed values for each of these parameters are broadly in line with published data (Damodaran 2022a) and values used by regulators in the UK, Europe, Australia and at the federal level for the US (Australian Energy Regulator 2020; Economic Consulting Associates 2020; UK Regulatory Network 2020). The parameter values used by state PUCs in the US tend to fall at the higher end of the range we examine. We calculate the RoE gap by taking the contemporaneous difference between our CAPM estimate of RoE and each utility's allowed RoE.

Risk-free rate

The risk-free rate, R_f, is intended to capture the base level of returns from an effectively zero risk investment. Yields on government bonds are the common source for this information, although practitioners can differ over the choice of maturity (e.g. 10-year or 30-year) and the use of forecast future yields instead of past or current rates. These decisions can significantly affect the final cost of equity.[10] We use the contemporaneous yield on US Treasury Bonds for our measure of the risk-free rate. In our "low" case we use 10-year Treasuries and in our "high" case

10. For instance, in January 2018 the current yield on 10-year US Treasury Bonds was 2.58%, the average yield from the past 2 years was 2.09%, and the forecast yield from Wolters Klewer (2022) for the next 2 years was 2.97%.

we use 30-year Treasuries.

Market risk premium

The market risk premium, MRP, captures the difference between the expected equity market rate of return and the risk-free rate.[11] This is generally calculated by taking the average of the difference in returns for some market-wide stock index and the returns for the risk-free rate. While this appears relatively straightforward, the final value can vary significantly depending on numerous factors. These can include: the choice of stock market index (e.g. S&P 500, Dow Jones, Wilshire 5000 etc.); the choice of averaging period (e.g. previous 10, 20, 50 years etc.); the return frequency (e.g. monthly, quarterly or annual returns), and the method of averaging (arithmetic, geometric). These decisions can significantly affect the final cost of equity. [12] To capture the uncertainty in the market risk premium, in our "low" case we assume a constant MRP of 6 percent and in our "high" case we assume a constant MRP of 8 percent.

β

A firm's equity β, is a measure of systematic risk and thus captures the extent to which the returns of the firm in question move in line with overall market returns.[13] Regulated firms like gas and electricity utilities are generally viewed as low risk, exhibiting lower levels of volatility than the market as a whole. The calculation of β is subject to many of the same uncertainties mentioned above, including: the choice of stock market index; the choice of calculation period, and the return frequency.

It is also common to take β estimates from existing data vendors such as Merrill Lynch, Value Line and Bloomberg. The choice of β depends on the bundle of comparable firms used and how they are averaged. Furthermore, these vendors

11. $MRP = R_m - R_f$, where R_m is the market return and R_f is the risk-free return.

12. For instance, in January 2018 using annual returns for the S&P 500 compared to the 10-year US Treasury Bond and taking the arithmetic average over the past 5, 25 and 75 years produces market risk premiums of 14.8%, 5.2% and 7.3% respectively (Damodaran 2022b).

13. β is calculated by estimating the covariance of the returns for the firm in question, R_i, and the market returns, R_m, and then dividing by the variance of the market returns: $\beta = \frac{Cov(R_i,R_m)}{Var(R_m)}$

generally publish β values that incorporate the so-called Blume adjustment to deal with concerns about mean reversion.[14] Because utilities generally have βs below one the adjustment serves to increase β and thus increase the estimated cost of equity produced by the CAPM calculation. Therefore, while the adjustment is plausible for many non-regulated firms, some authors have questioned its applicability to regulated firms like utilities (Michelfelder and Theodossiou 2013).

Lastly, the decision on setting β is complicated by the fact that betas calculated using observed stock returns are dependent on each firm's debt holdings and tax rate, which may differ from the particular utility being studied. To deal with this, an unlevered β can be estimated and then the corresponding levered β can be calculated for a specific debt-to-equity ratio, D/E, and tax rate, τ.[15] Here we take τ to be the federal marginal corporate tax rate and we can directly observe the debt-to-equity ratio, D/E, in our data.

To capture the uncertainty in β, in our "low" case we assume a constant $\beta_{\text{unlevered}}$ of 0.3 and in our "high" case we assume a constant $\beta_{\text{unlevered}}$ of 0.5. This generally produces levered βs ranging from 0.6 to 0.9.

4.1.3 Benchmarking to UK utilities

Finally, our sixth measure involves benchmarking against allowed returns on equity for gas and electric utilities in the United Kingdom. Here we consider the contemporaneous gap in nominal allowed RoE between the US and UK. Of course many things are different between these countries, there's no particular reason to think the UK regulator is setting the correct RoE, and it's not fair to say all US utilities should adopt UK rate making, but we think this benchmark provides an interesting comparison. The data on UK RoE are taken from various regulatory reports published by the Office of Gas and Electricity Markets (Ofgem). We were

14. The Blume Adjustment equation is: $\beta_{adjusted} = 0.333(1) + 0.667(\beta)$

15. The Hamada equation relates levered to unlevered β as follows: $\beta = \beta_{unlevered} \times \left[1 + (1 - \tau)\frac{D}{E}\right]$

able to find information on allowed rates of return dating back to 1996. The relevant disaggregation into return on debt and return on equity was more readily available for electric utilities over this entire time period. For natural gas utilities we have this information from 2013 onwards. Importantly, UK rates are set in real terms and so we converted to nominal terms using the inflation indexes cited by the UK regulator.

4.2 Asymmetric Adjustment

The existence of a persistent gap between the return on equity that utilities earn and various measures of the cost of capital they face could have a number of explanations. One possibility is that utilities are able to present arguments that regulators find more compelling or urgent than the arguments from consumer advocates. One indication of this pattern is strongly asymmetric adjustments to increases or decreases in underlying costs. The asymmetric adjustment process we estimate will mechanically find that in the long run, cost increases or decreases have the same magnitude, so in this way, they do not explain very persistent gaps, but they do provide some insight to how the regulatory process plays out.

It has been documented in many industries that positive shocks to firms' input costs can feed through into prices faster than negative shocks. This pattern has been most extensively studied in the gasoline sector – see Kristoufek and Lunackova (2015) and Perdiguero-García (2013) for reviews of the literature. Building on early work by Bacon (1991) and Borenstein, Cameron, and Gilbert (1997), there are now a wealth of studies examining how positive shocks to crude oil prices lead to faster increases in retail gasoline prices than negative shocks to crude oil prices lead to decreases in retail gasoline prices. This is the so-called "rockets and feathers" phenomenon. A range of explanations for this have been explored, most notably tacit collusion and market power or the dynamics of consumer search.

In our setting we do observe that a change in some benchmark index (e.g. US Treasuries or corporate bonds) appears to feed through into the return on equity for utilities. This can be seen most clearly in Figure 1 where relatively short-run spikes in US Treasuries or corporate bond yields correlate strongly with corresponding spikes in allowed returns on equity. We have also already discussed the sluggish pace at which returns on equity have come down over the longer-term when compared to various benchmark measures of the cost of capital. It therefore seems plausible to think that this relationship may function differently depending on whether it is a positive or a negative shock. To test this we follow the literature on asymmetric price adjustments and estimate a vector error correction model.

Many studies of asymmetric price adjustments work with single time series of their variables of interest. In our case we have a panel of rates of return that are divided up across utilities and states. In our main specification we conduct our analysis at the state level as this allows us to have a usefully balanced panel, while still maintaining the resolution of where decisions are being made: state public utilities commissions. To do this we collapse our company-state panel to a state panel. We do this by averaging the returns on equity from any rate cases decided in a given state in a given month, and then filling forward for any months where there are no new rate cases decided in a state. We then include state fixed effects throughout our analysis, and estimate a set of adjustment coefficients common to all states. As a robustness check we also examine versions of the analysis at the original company-state panel level and find essentially the same core findings. See the appendix for further details.

To estimate the vector error correction model we first estimate the long-run relationship between the return on equity for unit i in period t ($RoE_{i,t}$) and a lagged benchmark index of the cost of capital ($Index_{i,t-1}$). [16] We also include unit fixed

16. We also conduct unit root tests. Because of the panel setting we use a panel unit root test developed by Maddala and Wu (1999). Our tests fail to reject non-stationarity in levels and reject non-stationarity in first differences.

effects, σ_i, which in our preferred specification are at the state level.[17]

$$RoE_{i,t} = \phi Index_{i,t-1} + \sigma_i + \varepsilon_{i,t}$$

In the second step we then run a regression of the change in RoE on three sets of covariates: (1) m lags of the past changes in RoE, (2) n lags of the past change in the index, and (3) the residuals from the long-run relationship, $\hat{\varepsilon}_{i,t}$, lagged from the previous period. To examine potential asymmetric adjustment, each of these three sets of covariates is split into positive and negative components to allow the coefficients for positive changes to differ from the coefficients for negative changes. Once again we include unit fixed effects, σ_i.

$$\begin{aligned}\Delta RoE_{i,t} = &\sum_{j=1}^{m} \gamma_j^{+} \Delta RoE_{i,t-j}^{+} + \sum_{j=1}^{m} \gamma_j^{-} \Delta RoE_{i,t-j}^{-} + \\ &\sum_{j=1}^{n} \beta_j^{+} \Delta Index_{i,t-j}^{+} + \sum_{j=1}^{n} \beta_j^{-} \Delta Index_{i,t-j}^{-} + \\ &\theta^{+} \hat{\varepsilon}_{i,t-1}^{+} + \theta^{-} \hat{\varepsilon}_{i,t-1}^{-} + \sigma_i + \upsilon_{i,t}\end{aligned}$$

Statistical tests on these coefficients can reveal whether positive or negative shocks to the underlying index produce a more rapid adjustment in the dependent variable. However, a more intuitive way of presenting the results is by plotting a cumulative adjustment function. This shows how rates of return respond to a shock to the underlying benchmark index. To do this we rely on the methodology set out by Borenstein, Cameron, and Gilbert (1997) and use bootstrapping to derive 95% confidence intervals. We block bootstrap at the state level, using 1000 draws.

17. It is notable that the coefficient estimates we find for ϕ are generally close to the adjustment factors used in the automatic update rules employed by the Vermont PUC and California PUC (discussed earlier). This suggests these rules appear to largely formalize existing trends.

4.3 Rate Base Impacts

Next, we turn to the rate base the utilities own. To the extent a utility's approved RoE is higher than their actual cost of equity, they will have a too-strong incentive to have capital on their books (the Averch–Johnson effect). In this section, we investigate the change in rate base utilities request and receive. The change is a flow variable while the total rate base is the stock of all previous rate base changes. It includes both new investment and depreciation of existing assets. We primarily focus on the effect on the *change* in the rate base, rather than the entire rate base, because the former is actively decided in each rate case and the data is more complete. However, we observe similar effect sizes when looking at the entire rate base. We consider both the requested change and the approved change, though the approved value is our preferred specification. We estimate $\hat{\alpha}$ from the following, where we regress the rate base increase (RBI) on the estimated RoE gap, various controls, and fixed effects.

$$\log(RBI_{i,t}) = \alpha RoE_{i,t}^{gap} + \delta X_{i,t} + \sigma_i + \lambda_t + \epsilon_{i,t} \tag{1}$$

where an observation is a utility rate case for utility i in year-of-sample t. The dependent variable, $RBI_{i,t}$, is the increase in the rate base, and we take logs.[18] The ideal independent variable would be the gap between the allowed RoE and the utilities' costs of equity. Because the true value is unobservable, we use $RoE_{i,t}^{gap}$, the gap between the allowed RoE and the baseline RoE. Unlike section 4.1, for this analysis we care about differences in the gap between utilities or over time, but do not care about the overall magnitude of the gap. For ease of implementation, we begin by considering the gap as the spread between the approved rate of return and the 10-year Treasury bond yield. We do not expect the actual cost of equity to be equal to the 10-year Treasury yield, but our fixed effects account for any constant

18. Cases where the rate base remains unchanged or shrinks are uncommon, representing around 12% of observations. We drop these cases, but note that we get qualitatively similar results when we do not drop these rows and estimate the regression in levels.

differences. We calculate $RoE_{i,t}^{gap}$ by taking the difference between the allowed RoE and the average of the time-varying baseline RoE, over the D years the rate case is in place.

$$RoE_{i,t}^{gap} = RoE_{i,t}^{allowed} - \frac{1}{D}\sum_{t}^{t+D} RoE_{i,t}^{benchmark} \tag{2}$$

4.3.1 Fixed Effects Specifications

Our goal is to make causal claims about $\hat{\alpha}$, so we are concerned about omitted variables that are correlated with both the estimated RoE gap and the change in rate base. We begin with a fixed-effects version of the analysis. Our preferred version includes time fixed effects, λ_t, at the year-of-sample level and the unit fixed effects, σ_i, are at the service type, utility company and state level. Utilities that operate in multiple states still file rate cases with each state's utility regulator. Our state fixed effects account for constant differences across states, including any persistent differences in the regulator. Here, the identifying assumption is that after controlling for state and year effects, there are no omitted variables that would be correlated with both our estimate of the RoE gap and the utility's change in rate base. The identifying variation is the differences in the RoE gap within the range of rate case decisions for a given utility, relative to the annual average across all utilities.

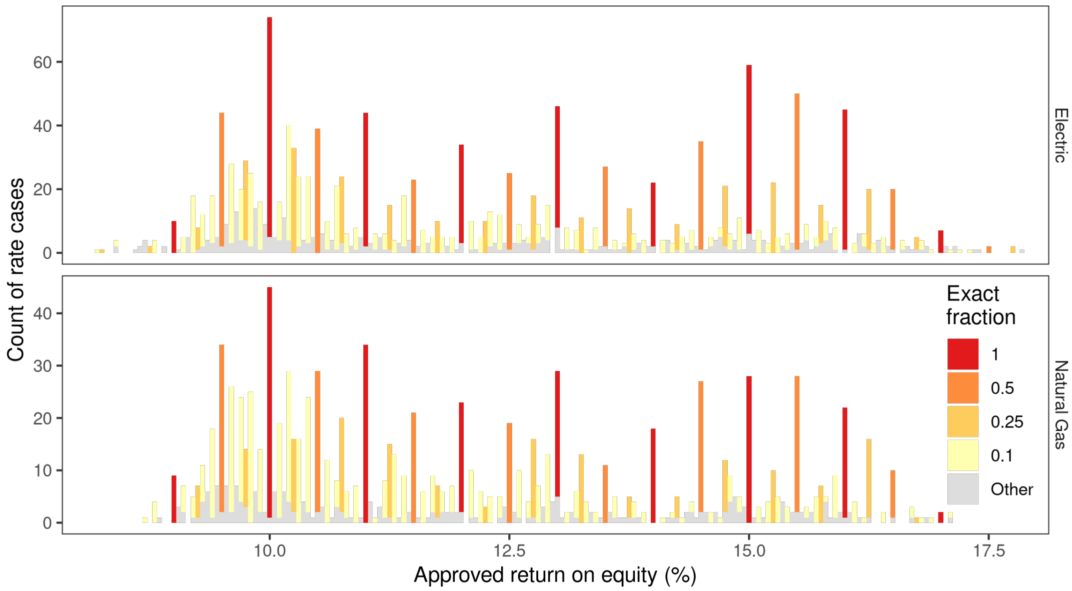
The fixed effects handle some of the most critical threats to identification, such as macroeconomic trends, technology-driven shifts in electrical consumption, or static differences in state PUC behavior. Of course, potential threats to causal identification remain. One possibility is omitted variables – perhaps regulators in some states change their posture toward utilities over time, in a way that is correlated with both the RoE and the change in rate base. Another possibility is reverse causation – perhaps the regulator pushes for more capital investment (e.g. aiming to increase local employment) and the utility, facing increasing marginal costs of capital, needs a higher RoE.

4.3.2 Instrumental Variables Specifications

To try and further deal with concerns regarding identification, we examine an instrumental variables approach based on the timing and duration of rate cases. The average utility has ten rate cases over the course of our sample period and the average rate case is in effect for about three years. Our IV analysis takes the idea that market measures of the cost of capital move around in ways that aren't always easy for the regulator to anticipate. For instance, if the allowed return on equity is set in year 0 and financial conditions change in year 2 such that the RoE gap increases, then we would expect the utility to increase their capital investments in ways that are unrelated to other aspects of the capital investment decision. For this instrument to work, it needs to be the case that these movements in capital markets are conditionally independent of decisions that the utility is making, except via this return on equity channel. We control for common year fixed effects, and then the variation that drives our estimate is that different utilities will come up for their rate case at different points in time.

A second IV strategy we consider is to exploit an apparent bias toward round numbers, where regulators tend to approve RoE values at integers, halves, quarters, and tenths of percentage points. Unfortunately this instrument does not produce a strong first-stage and so is not a core focus of our subsequent analysis. Even so, the existence of such an arbitrary phenomenon in our setting is relevant, and can be seen clearly in figure 3. Small deviations created by rounding have large implications for utility revenues and customer payments. If for instance, a PUC rounds in a way that changes the allowed RoE by 10 basis points (0.1%), the allowed revenue on the existing rate base for the average electric utility in 2019 would change by $114 million (the median is lower, at $52 million).

Figure 3: Return on equity is often approved at round numbers



Colors highlight values of the nominal approved RoE that fall exactly on round numbers. More precisely, values in red are integers. Values in dark orange are integers plus 50 basis points (bp). Lighter orange are integers plus 25 or 75 bp. Yellow are integers plus one of {10, 20, 30, 40, 60, 70, 70, 80, 90} bp. All other values are gray. Histogram bin widths are 5 bp. Non-round values remain gray if they fall in the same histogram bin as a round value. In that case, the bars are stacked.

Source: Regulatory Research Associates (2021).

5 Results

5.1 Return on Equity Gap Results

Beginning with the RoE gap analysis from section 4.1, we find there has been an increase in the gap between utilities' allowed return on equity and various measures of their estimated cost of capital. Our results on the RoE gap show this has increased over time and are summarized in Table 2. To explain these large gaps, one of three things must be true: (1) historically, utilities were under-compensated for their capital costs, (2) today, utilities are over-compensated for their capital costs, or (3) the structure of utilities' capital costs – and their relationship with other capital markets – has changed dramatically over time.

When benchmarking against changes in market measures of the cost of capital (e.g. 10-year US Treasury bonds or same-rated corporate bonds) the RoE gap is

Table 2: Return on Equity gap, by different benchmarks (percentage points)

A: Electric	Corp	UST	UST auto	CAPM low	CAPM high	UK
1985	0.693	0.415	1.39	1.50	−2.84	
1990	−0.238	0.459	0.412	1.36	−3.09	
1995	0.788	1.09	0.139	2.09	−2.49	
2000	0.666	1.41	0.153	2.42	−1.76	2.79
2005	2.99	2.84	0.722	3.91	−0.552	1.93
2010	3.04	3.21	0.517	4.50	−0.448	−0.585
2015	3.57	3.64	0.416	4.99	0.446	2.77
2020	4.25	4.49	0.706	5.60	0.786	1.88
B: Natural Gas						
1985	1.14	0.798	1.78	1.68	−2.35	
1990	−0.0272	0.848	0.819	1.59	−2.50	
1995	0.873	1.18	0.238	1.99	−2.27	
2000	0.757	1.35	0.0924	2.18	−1.65	
2005	2.85	2.70	0.623	3.54	−0.635	
2010	3.25	3.35	0.707	4.31	−0.516	
2015	3.98	4.01	0.850	5.04	0.646	2.43
2020	4.58	4.86	1.09	5.67	1.06	1.55

Note: Gap percentage figures are a weighted average across utilities, weighted by rate base. “Corp” compares to same-rated corporate bonds. “UST” compares to 10-year US Treasuries. “UST auto” compares to 10-year Treasuries with 50% passthrough. For cases where it’s relevant (Corp and USTs) the benchmark date is January 1995. See text for details of each benchmark calculation.

around 4–4.5 percentage points.

It is not clear that the cost of equity should necessarily move in a one-for-one manner with these two measures of bond yields. Using an automatic update rule that adjusts at *half* the rate of changes in bond yields, produces an RoE gap by 2020 of around 0.5–1 percentage points. Whether adjusting at 50% of the change in bond yields is the correct approach is unclear. For instance, Canada has used a 75% adjustment ratio in the past. What is clear is that even using this lower range, we still see a divergence between allowed equity returns today and changes in the benchmark cost of capital.

Benchmarking against changes in bond yields relative to some baseline year is necessarily quite simplistic. Our two implementations of the CAPM approach allow us to see how a standard method used in the industry performs. Our "low" version of the CAPM uses assumptions for the risk-free rate, β and market risk premium that are on the lower end of what has been historically used in the industry. This is particularly true when looking at the practices of US regulators, which appear to utilize higher values than regulators in the UK, Europe and Australia. The result is an RoE gap by 2020 of around 5.5 percentage points.[19] Looking back to the 1980s and 1990s though, the RoE gap becomes much smaller, with predictions of the cost of equity from our "low" CAPM version only showing a 2 percentage point gap against allowed rates of return.

Our "high" version of the CAPM uses assumptions for the risk-free rate, β and market risk premium that are on the higher end of what has been historically used in the industry. This produces an RoE gap by 2020 of around 1 percentage points. Allowed rates of return are therefore still above the predictions from our "high" CAPM case, although much more closely aligned with the current approach of US state PUCs. Notably though, projecting this same approach back in time appears

19. At this point average allowed RoE for US utilities is around 10%, compared with a CAPM prediction for the cost of equity of 4–5%.

to suggest that past allowed returns in the 1980s and 1990s were well below the estimated cost of equity. This seems implausible given the large capital expenditures the industry has continued to engage in over the last four decades.

Lastly, when comparing against UK utilities we see a fairly consistent premium, with an RoE gap in 2020 of around 2 percentage points. A similar premium would likely emerge when comparing to utilities in other countries in Europe which have tended to approve similar rates of return to those we find for the UK. There are good reasons to think that US state PUCs should not simply adopt UK rates of return – there are many differences between the utility sector and investor environment in the US and UK. Even so, it is striking that other countries are able to attract sufficient investment in their gas and electric utilities while guaranteeing lower regulated returns than are available in the US context.

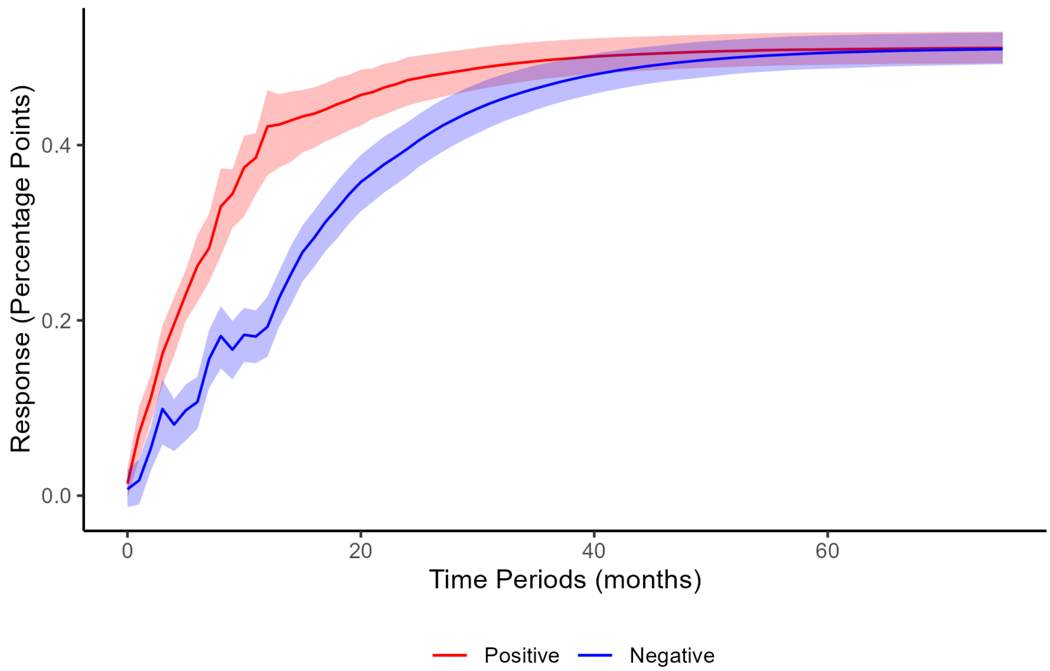
5.2 Asymmetric Adjustment Results

One pattern we document in allowed returns is an asymmetric adjustment of allowed return on equity to underlying benchmark rates of return. Figure 6 provides the results of this analysis.

Here we simulate the impact on the utility rate of return from a one percentage point shock to the underlying benchmark index. In this case we conduct our analysis at the state level using approved rates of return and nominal 10-year US Treasuries as our benchmark rate. The change in the nominal rate of return on equity is then plotted over the subsequent six years.

As can be seen in Figure 6, we do find evidence of asymmetric adjustment. Rates of return adjust faster to a positive shock (red line) than to a negative shock (blue line). In the long-run both converge to a roughly 50% pass-through rate, as noted previously. This pattern is consistent with the incentives firms face to increase their allowed return on equity where the opportunity arises (i.e. when benchmark indices

Figure 4: Asymmetric Cumulative Adjustment Path following Shock to Benchmark Index



Lines represents the cumulative adjustment path following a one percentage point change to the benchmark index. Red is for an increase in the index and blue is for a decrease. 95% confidence intervals are estimated via bootstrapping. The plotted results use approved rates of return and a benchmark index of 10-year US Treasuries. Analysis is conducted at the state level. See calculation details in section 4.2.

rise), and avoid decreases to their allowed return on equity when it may be justified (i.e. when benchmark indices fall). Further asymmetric adjustment results can be found in the appendix, including comparisons of the asymmetry in proposed versus approved rates and of different levels of panel aggregation.

5.3 Rate Base Impact Results

Table 3: Relationship Between Approved Rate of Return and Approved Rate Base Increase

	Fixed effects specs.			IV
Model:	(1)	(2)	(3)	(4)
Variables				
RoE gap (%)	0.0551***	0.0752***	0.0867***	0.0523**
	(0.0200)	(0.0240)	(0.0225)	(0.0252)
Fixed-effects				
Service Type	Yes	Yes	Yes	Yes
State	Yes	Yes	Yes	Yes
Year		Yes	Yes	Yes
Company			Yes	Yes
Fit statistics				
Observations	2,491	2,491	2,491	2,491
R^2	0.33	0.36	0.69	0.69
Within R^2	0.01	0.004	0.01	0.009
Wald (1st stage), RoE gap (%)				69.1
Dep. var. mean	38.63	38.63	38.63	38.63

Clustered (Year & Company) standard-errors in parentheses
Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

Notes: The table uses approved RoE. The dependent variable is log of the utility's rate base increase in millions of $. Columns 1–3 show varying levels of fixed effects. Column 4 is the IV discussed in section 4.3. Our preferred specification is column 4 of table 3. First-stage *F*-statistic is Kleibergen–Paap robust Wald test.

We next consider how the RoE gap affects capital ownership in Table 3. Across our fixed effects specifications (columns 1–3) we find broadly consistent results. A 1 percentage point increase in the approved RoE gap leads to a 5.6–8.7% higher increase in approved rate base. Our IV specification using rate case timing (column 4) has a strong first stage (Kleibergen–Paap *F*-stat of 69).[20] Using this approach we find an effect of 5.3% which broadly aligns with our fixed effects estimates. This is our preferred specification.

Table 4: Relationship Between Approved Rate of Return and Approved Total Rate Base (both absolute and per MWh; electric utilities only)

Model:	Total, FE (1)	Total, IV (2)	per MWh, FE (3)	per MWh, IV (4)
Variables				
RoE gap (%)	0.0548***	0.0774***	0.1202**	0.1204
	(0.0199)	(0.0275)	(0.0571)	(0.0751)
Fixed-effects				
Service Type	Yes	Yes	Yes	Yes
State	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Company	Yes	Yes	Yes	Yes
Fit statistics				
Observations	1,878	1,878	706	706
R^2	0.85	0.85	0.84	0.84
Within R^2	0.006	0.005	0.02	0.02
Wald (1st stage), RoE gap (%)		24.0		21.2
Dep. var. mean	1,521.9	1,521.9	379.3	379.3

Clustered (Year & Company) standard-errors in parentheses
Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

Notes: The table uses approved RoE. Dependent variables are the total rate base in millions of $ (Columns 1–2) and the rate base per quantity delivered in $ per MWh (Columns 3–4). The FE results correspond to the specification used for column 3 in table 3 and the IV results correspond to the specification used for column 4 in table 3. First-stage *F*-statistic is Kleibergen–Paap robust Wald test.

In addition to looking at the increase in the rate base, for electric utilities, we also look at the total rate base and the total rate base per megawatt-hour (MWh) delivered. These results are in Table 4. We find similar effects for the total rate base. The effects for total rate base per MWh are potentially even larger, indicating a

20. Our IV specification using rounding has a weak first stage (Kleibergen–Paap *F*-stat of 2.1) and so is not presented here.

pronounced increase in capital intensity. However, in both cases these findings are less precisely estimated, in part due to data quality challenges.[21] Overall we take these results as providing evidence that higher equity returns do lead utilities to increase their capital holdings.[22]

As a caveat, we note that an utility can increase their capital holdings in two distinct ways. One option is to reshuffle capital ownership, either between subsidiaries or across firms, so that the utility ends up with more capital on its books, but the total amount of capital is unchanged. The second option is to actually buy and own more capital, increasing the total amount of capital that exists in the state's utility sector. We do not differentiate between these two cases. Because we don't differentiate, we consider excess payments by utility customers, but we remain agnostic about the socially optimal level of capital investment.

5.4 Excess Consumer Cost Results

Table 5 summarizes our estimates of the excess cost for utility customers. Here we multiply the rate base by the RoE gap to come up with a measure of the additional payments made to cover the premium in equity returns. We present results that take the observed rate base as a given – the "fixed" rows – and also present results that include the rate base with the additional increases estimated above – the "adjust" rows. The increment from the "fixed" to "adjust" rows is meaningful (billions of dollars in many specifications), but smaller than the gap documented in the "fixed" rows.

To ensure these excess costs are calculated for all utilities in our sample, we must remedy the missing rate base data for some utilities, particularly in the earlier

21. The total rate base data is less complete. Also when calculating on a per MWh basis, we are only able to merge quantity data for a subset of years for electric utilities.

22. The equivalent results from looking at the proposed changes to the rate base can be found in the appendix.

Table 5: Excess costs, by different benchmarks (2019$ billion per year)

A: Electric		Corp	UST	UST auto	CAPM low	CAPM high	UK
Fixed	2000	1.03	2.37	0.250	4.21	−2.74	4.71
	2020	8.58	9.40	1.43	11.8	1.83	3.90
Adjust	2000	1.06	2.55	0.252	4.76	−2.48	5.42
	2020	10.5	11.7	1.49	15.4	1.91	4.29
B: Natural Gas							
Fixed	2000	0.165	0.371	0.0226	0.620	−0.415	
	2020	2.44	2.76	0.624	3.24	0.655	0.886
Adjust	2000	0.171	0.398	0.0227	0.693	−0.378	
	2020	3.05	3.48	0.661	4.23	0.692	0.959

Note: Excess payments are totals for all investor-owned utilities in the US, in billions of 2019 dollars per year. Missing rate base data for utilities in our sample was interpolated based on the estimated average growth rate of the rate base over time. The “fixed” rows take the observed rate base as fixed and estimates excess payments. The “adjust” rows also account for changes in the rate base size, as estimated in table 3 column 4. For cases where it’s relevant the benchmark date is January 1995. See text for details of each benchmark calculation.

years of our sample.[23] To do this we interpolate using an estimate of the average growth rate for the rate base over time.[24]

Across our five benchmark measures and using the existing rate base we find excess costs to consumers in 2020 of $2–15 billion per year. These excess costs, like the RoE gap, depend on the choice of baseline. The economic welfare loss is likely smaller than these excess cost measures – the excess capital provides non-zero benefit, and the ultimate recipients of utility revenues place some value on the

23. Approved rate base data is available for 95% of utilities in 2020 and 65% of utilities in 2000.

24. We regress approved rate base on time, controlling for utility by state by service type fixed effects. Within each grouping of utility, state and service type, we start with the first non-missing value and linearly interpolate backwards assuming the rate base changes from period to period according to our estimated growth rate.

additional income.[25]

Accounting for the way the RoE gap can affect capital ownership increases our estimate of the excess cost to consumers to $2–20 billion per year. The majority of these costs come from the electricity sector.[26]

6 Conclusion

Utilities invest a great deal in capital, and need to be compensated for the opportunity cost of their investments. Getting this rate of return correct, particularly the return on equity, is challenging, but is a task of first-order importance for utility regulators.

Our analysis shows that the RoE that utilities are allowed to earn has changed dramatically relative to various financial benchmarks in the economy. We estimate that the current approved average return on equity is substantially higher than various benchmarks and historical relationships would suggest. These results are necessarily uncertain, and depending on our chosen benchmark for the cost of equity the premium ranges from 0.5–5.5 percentage points. Put another way, even our most conservative benchmarks come in below the allowed rates of return on equity that regulators set today.

We link this divergence to the apparent asymmetric adjustment of rates to changes in market measures of the cost of capital. Increases to benchmark measures of the cost of capital lead to faster rises in utility returns on equity than is the case for decreases. This is the so-called "rockets and feathers" phenomenon and could

25. The RoE gap will ultimately affect utility rates, including the costs of buying electricity, but the ultimate impact on consumption decisions will depend on each utility's rate structure. Analyzing these is outside the scope of this paper.

26. For comparison, total 2019 electricity sales by investor owned utilities were $204 billion, on 1.89 PWh of electricity (US Energy Information Administration 2020a). Natural gas sales to consumers are $146 billion on 28.3 trillion cubic feet of gas US Energy Information Administration 2020b. These figures include sales to residential, commercial, industrial, and electric power, but not vehicle fuel. They also include all sales, not just those by investor owned utilities.

be indicative of regulators being more responsive to pressures from the utilities they regulate than from consumers' demands to keep prices down.

We then turned to the Averch–Johnson effect, and estimated the additional capital this RoE gap generates. In our preferred specification, we estimate that an additional percentage point in the RoE gap leads to 5% higher rate base increases. Depending on our chosen benchmark for the gap, the excess rates collected from consumers could amount to $2–20 billion per year.

If utilities are earning excess equity returns, a key challenge is to identify what changes to the ratemaking process may help remedy this. Regulators have taken numerous steps over the past few decades to improve the way costs are passed through into rates. For instance, explicit benchmarking and automatic update rules were introduced for fuel costs decades ago. It seems plausible that they could also be used to help equity costs adjust more quickly to changing market conditions, and do so in ways that are less prone to the subjective negotiations of the ratemaking process.

However, the cost of equity is unlikely to perfectly track any single benchmark in the same way as the cost of fuel. Also the automatic update rules for equity returns that have already been put in place by some PUCs have done little to prevent the trends we highlight.[27] As such, a significant degree of regulatory judgment is inevitable in this area.

A clear first step for improving the decisions regulators make over the cost of equity is to avoid some of the arbitrary "rules of thumb" that have been employed to date – see for instance the evidence we find of whole number rounding, or the reluctance to set rates below a nominal 10% that Rode and Fischbeck (2019) highlight.

27. For instance, regulators at the California PUC feel that the rule, called the cost of capital mechanism (CCM), performed poorly. "The backward looking characteristic of CCM might have contributed to failure of ROEs in California to adjust to changes in financial environment after the financial crisis. The stickiness of ROE in California during this period, in the face of declining trend in nationwide average, calls for reassessment of CCM." (Ghadessi and Zafar 2017)

Bolstering the financial expertise of regulators is another promising path forward.[28] Seemingly objective methods like the capital asset pricing model cannot provide a definitive answer on the cost of equity. As we have documented, a range of plausible input assumptions can lead to widely divergent estimates of the cost of equity. When incorporating evidence from these methods regulators need to have the expertise to understand their limitations and push back on the assumptions utilities put forward when using them.

Lastly, process reforms may also be beneficial. In most rate case proceedings, utilities submit their planned expenditures and then regulators decide whether they are prudent. This relies on the notion that utilities are best placed to forecast their detailed needs for labor, materials and equipment (e.g. numbers of new transformers needed and where). However, it is less clear that utilities possess the same unique level of insight when it comes to the cost of equity, especially given that this is so dependent on wider market forces, the performance of peer companies and general investor sentiment. For this component of utility costs the regulator could conduct its own independent internal analysis of the cost of equity first, and then consult on their proposals. In this way it is the regulator that is anchoring the starting point of the discussion, not the utility.

Our findings have important implications beyond just the additional cost they place on consumers. From a distributional standpoint, higher rates create a transfer from ratepayers to utility stockholders. A high rate of return for *regulated* utilities may also lead to a reshuffling of which assets are owned by regulated versus non-regulated firms. Finally, efficiently pricing energy has important implications for environmental policy, particularly with regard to encouraging electrification which is a key component of efforts to tackle climate change.

28. Azgad-Tromer and Talley (2017) found that providing finance training to regulatory staff did have a moderate effect on moving rates of return closer to standard asset pricing predictions.

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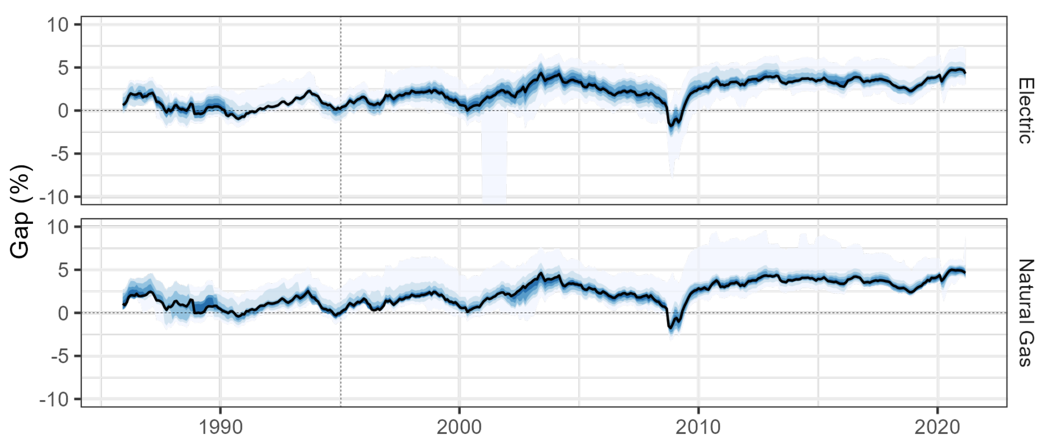
Online Appendix

A Detail on RoE gap benchmarks

For each of the strategies we utilize, we plot the timeseries of the RoE gap. These are plotted in figures 5, 6, 7, 8, 9, and 10.

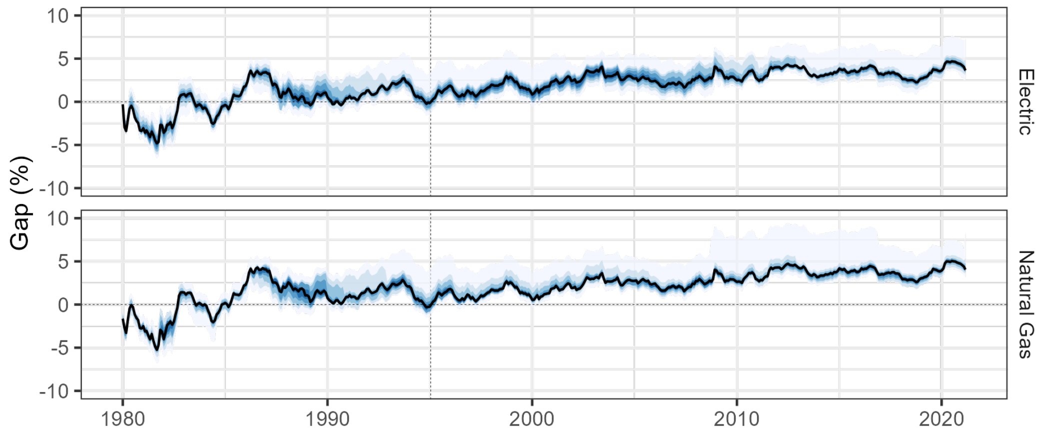
In each plot, we present the median of our RoE gap estimates, weighting by the utility's rate base (in 2019 dollars). Our goal is to show the median of rate base dollar value, rather than the median of utility companies, as the former is more relevant for understanding the impact of the RoE gap. We also show bands, in different shades of blue, that cover the 40–60 percentile, 30–70 percentile, 20–80 percentile, 10–90 percentile, and 2.5–97.5 percentile (all weighted by rate base).

Figure 5: Return on equity gap, benchmarking to same-rated corporate bonds



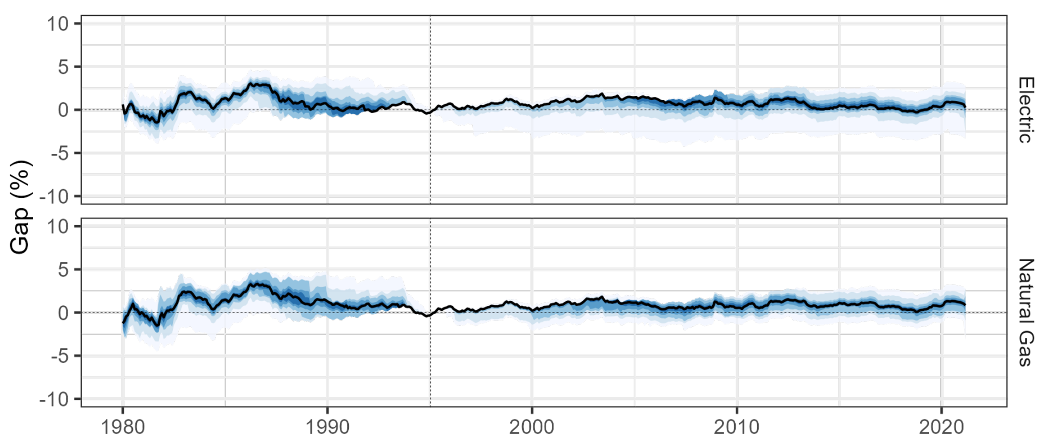
Base year is 1995. Line represents median; shading represents ranges that cover the central 20, 40, 60, 80, and 95% of total investor-owned utility rate base. See calculation details in section 4.1.

Figure 6: Return on equity gap, benchmarking to 10-year Treasuries



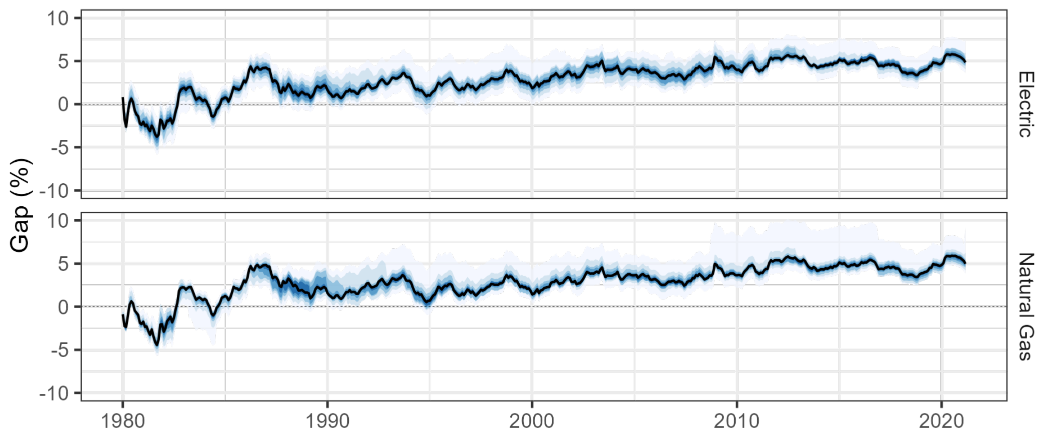
Line represents median; shading represents ranges that cover the central 20, 40, 60, 80, and 95% of total investor-owned utility rate base. See calculation details in section 4.1.

Figure 7: Return on equity gap, using automatic update rule



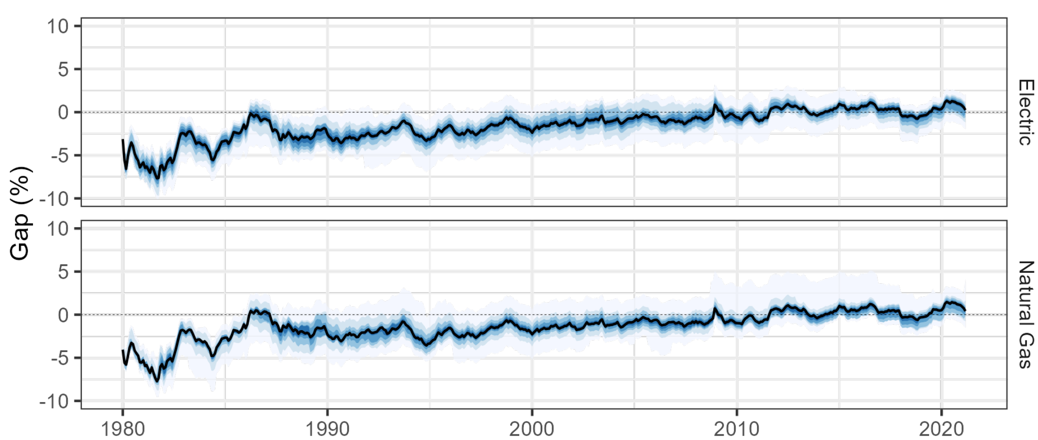
Line represents median; shading represents ranges that cover the central 20, 40, 60, 80, and 95% of total investor-owned utility rate base. See calculation details in section 4.1.

Figure 8: Return on equity gap, benchmarking to CAPM (low)



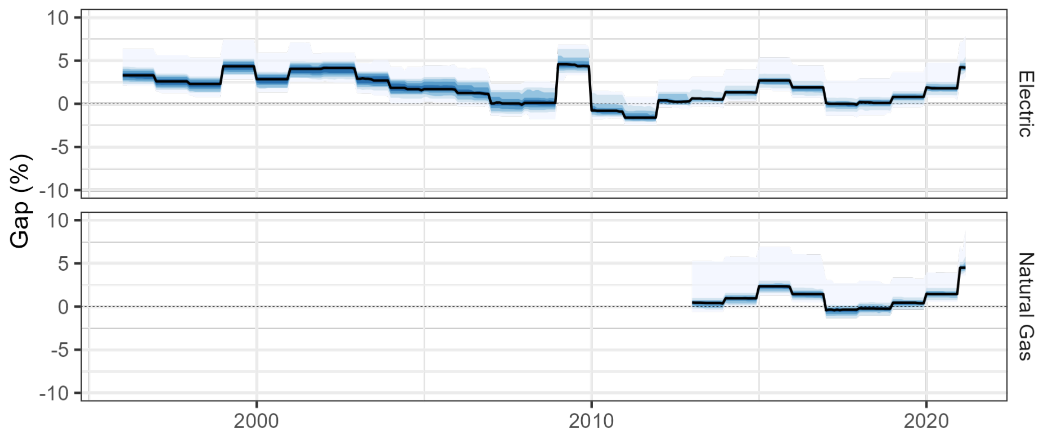
Line represents median; shading represents ranges that cover the central 20, 40, 60, 80, and 95% of total investor-owned utility rate base. See calculation details in section 4.1.

Figure 9: Return on equity gap, benchmarking to CAPM (high)



Line represents median; shading represents ranges that cover the central 20, 40, 60, 80, and 95% of total investor-owned utility rate base. See calculation details in section 4.1.

Figure 10: Return on equity gap, compared to UK utilities



Line represents median; shading represents ranges that cover the central 20, 40, 60, 80, and 95% of total investor-owned utility rate base. See calculation details in section 4.1.

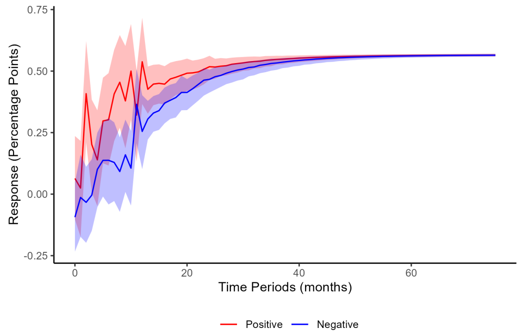
B Detail on Asymmetric Adjustment

Here we include additional information on the asymmetric adjustment analysis. The preferred specification presented in the main paper uses approved rates of return, a benchmark index of 10-year US Treasuries, and aggregates rate case decisions to the state level. Two key sources of variation in the results come from the use of proposed or approved rates of return, and the level of aggregation of the panel dataset. To illustrate this we present here robustness analysis across both proposed and approved rates and at three different levels of panel aggregation.

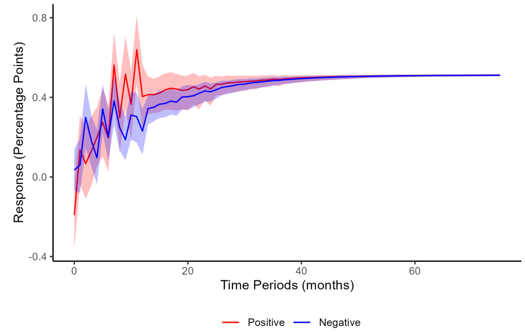
Figure 11 presents the same results as Figure 4 but across a range of specifications. Analysis across the three panel rows is conducted at varying levels of panel aggregation. Analysis across the two panel columns is conducted with either proposed or approved rates of return.

Consistently the results show a divergence, with rates of return adjusting more quickly to positive shocks to the benchmark index than is the case for negative shocks. The divergence is potentially more pronounced when looking at adjustments to proposed rates than approved rates. This seems consistent with firms being quick

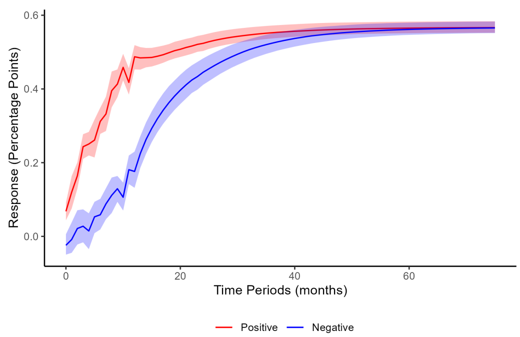
Figure 11: Asymmetric Cumulative Adjustment Path following Shock to Benchmark Index by Aggregation Level



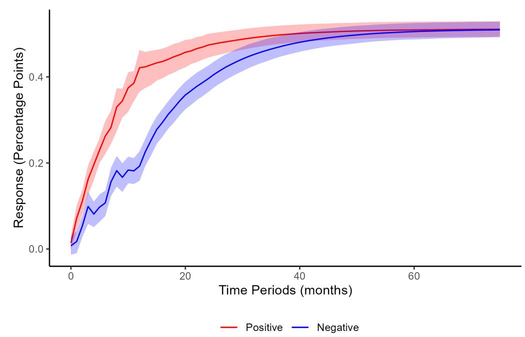
(a) National Time Series, Proposed Rates



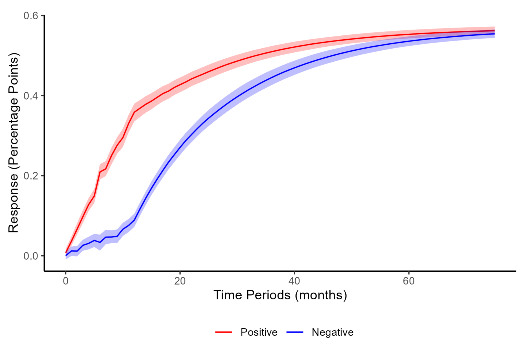
(b) National Time Series, Approved Rates



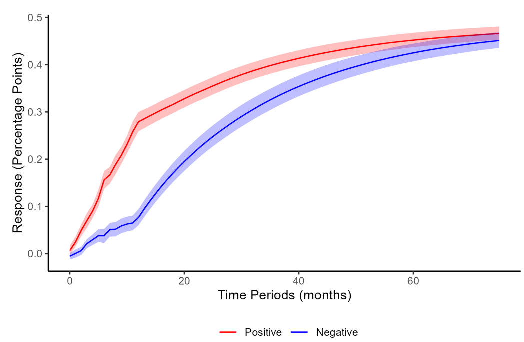
(c) State Panel, Proposed Rates



(d) State Panel, Approved Rates



(e) Utility-State Panel, Proposed Rates



(f) Utility-State Panel, Approved Rates

Lines represents the cumulative adjustment path following a one percentage point change to the benchmark index. Red is for an increase in the index and blue is for a decrease. 95% confidence intervals are estimated via block bootstrapping on states, with 1000 replications. The plotted results use a benchmark index of 10-year US Treasuries. Analysis across the three panel rows is conducted at varying levels of panel aggregation. Analysis across the two panel columns is conducted with either proposed or approved rates of return. See calculation details in section 4.2.

to request upward adjustments to their return on equity while being relatively slow to request downward adjustments. Regulators do appear to somewhat moderate this divergence, but clearly do not come close to eliminating it.

The main specification was conducted on a panel that had been aggregated to the state level, and these results are reproduced in the second panel row of Figure 11. Here we provide the results of repeating the analysis with the original monthly utility-state panel dataset in the third panel row of Figure 11. As with the state-level approach, unit root tests fail to reject non-stationarity in levels and reject non-stationarity in first differences. Using the original utility-state panel also does not radically alter the core findings, with the asymmetric adjustment clearly visible. In fact, because this approach captures both the state-level nature of PUC decision-making and the utility-level variation in how and when rate case decisions are made, the slower pace of adjustment we observe makes sense.

Lastly, we also provide results from repeating the analysis after fully aggregating the original monthly utility-state panel to a single national monthly time series. As with the state-level approach, unit root tests fail to reject non-stationarity in levels and reject non-stationarity in first differences. Using a single national time series implies a faster speed of adjustment with less of a pronounced divergence between positive and negative shocks. However, such an approach effectively imagines a situation where rates of return are decided by a single federal regulator for a single national utility, which is clearly not realistic.

For further detail on the results, Table 6 provides various summary information on the different regression specifications. The coefficients are too numerous to be presented here, and are better summarized through their combined effect on the cumulative adjustments plotted in the earlier figures. Nevertheless, the table still provides useful information, including a number of F-tests on the different types of coefficients in the vector error correction model.

Table 6: Asymmetric Adjustments in Return on Equity

Model:	(1)	(2)	(3)	(4)	(5)	(6)
Prop. or Appr.	Prop.	Appr.	Prop.	Appr.	Prop.	Appr.
Group (State)			Yes	Yes	Yes	Yes
Group (Company)					Yes	Yes
ϕ	0.5658	0.5116	0.5669	0.5111	0.5695	0.4832
$\sum\beta$+=$\sum\beta$- Fstat	23.18	3.267	14.28	18.21	12.89	14.75
$\sum\beta$+=$\sum\beta$- pval	2.05×10^{-6}	0.0714	0.0002	1.99×10^{-5}	0.0003	0.0001
$\sum\gamma$+=$\sum\gamma$- Fstat	0.4560	1.231	3.188	1.835	0.7992	2.170
$\sum\gamma$+=$\sum\gamma$- pval	0.4999	0.2678	0.0742	0.1756	0.3713	0.1407
θ+=θ- Fstat	8.201	0.0032	2.781	4.637	0.6221	11.12
θ+=θ- pval	0.0044	0.9548	0.0954	0.0313	0.4303	0.0009
Fit statistics						
Observations	482	482	23,452	23,452	106,847	106,847
R^2	0.49	0.47	0.07	0.06	0.03	0.02

Clustered (Year) standard-errors in parentheses
Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

NOTES: "Group" refers to the level of panel aggregation used for the analysis, and fixed effects are always included at this level where relevant. β coefficients are those on the lagged differenced index terms. γ coefficients are those on the lagged differenced rate of return terms. θ coefficients are those on the error correction term. "Fstat" and "pval" refers to the results of an F-test on the relevant coefficients. ϕ refers to the long-run coefficient from the initial first step regression. See calculation details in section 4.2.

C Detail on Rate Base Impacts

Here we include additional information on our analysis of rate base impacts. We present two sets of tables: using proposed (rather than approved) return on equity, and some heterogeneity across utilities.

The proposed values shed some light on the bargaining process between the utility and PUC, though it's the approved values that ultimately matter for capital investment and revenues. Tables 7 and 8 mirror the main text tables 3 and 4, except 7 and 8 use utilities' proposed changes in the rate base and proposed return on equity. The results tend to be broadly similar, and often larger, than our main results, though the preferred IV specification of table 7 is smaller and statistically insignificant.

Tables 9 and 10 examine potential heterogeneity across utilities. Here, we interact various indicator variables with the RoE gap, which allows us to examine whether the effect of the RoE gap on rate base increase differs across these groups. For the most part, the coefficients we estimate are small (relative to the overall average effect) and statistically insignificant.

"Electric" captures whether a utility provides electric or gas service. "Vertically Integrated" captures whether a utility is vertically integrated, with the alternatives being ones that operate solely in distribution or transmission. "PUC Ranking" captures whether a state PUC is rated as having a constructive, lower risk regulatory environment for investors.[29] "Litigated" captures whether a rate case decision was fully litigated. "Lengthy Case" captures whether a rate case decision takes longer than average.[30]

29. This is based on a rating system produced by S&P RRA. It rates state PUCs in a manner similar to a credit rating, with three categories of Below Average, Average and Above Average. There are three step levels (1, 2 or 3) within each rating category. The final ratings produce a roughl,y normal distribution. This is converted to a binary variable that equals one where a state PUC scores above Average level 2.

30. This is a binary variable that equals one if a rate case takes longer than the median rate case duration.

Table 7: Relationship Between Proposed Rate of Return and Proposed Rate Base Increase

	Fixed effects specs.			IV
Model:	(1)	(2)	(3)	(4)
Variables				
RoE gap (%)	0.0670***	0.0436*	0.0672***	0.0353
	(0.0134)	(0.0217)	(0.0151)	(0.0215)
Fixed-effects				
Service Type	Yes	Yes	Yes	Yes
State	Yes	Yes	Yes	Yes
Year		Yes	Yes	Yes
Company			Yes	Yes
Fit statistics				
Observations	3,210	3,210	3,210	3,210
R^2	0.37	0.39	0.73	0.73
Within R^2	0.02	0.002	0.01	0.008
Wald (1st stage), RoE gap (%)				50.9
Dep. var. mean	63.69	63.69	63.69	63.69

Clustered (Year & Company) standard-errors in parentheses
Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

Notes: The table uses proposed RoE. The dependent variable is log of the utility's rate base increase in millions of $ Columns 1–3 show varying levels of fixed effects. Column 4 is the IV discussed in section 4.3. First-stage *F*-statistic is Kleibergen–Paap robust Wald test.

Table 8: Relationship Between Proposed Rate of Return and Proposed Total Rate Base (both absolute and per MWh)

Model:	Total, FE (1)	Total, IV (2)	per MWh, FE (3)	per MWh, IV (4)
Variables				
RoE gap (%)	0.0354	0.0600*	0.1487**	0.1555**
	(0.0237)	(0.0341)	(0.0708)	(0.0720)
Fixed-effects				
Service Type	Yes	Yes	Yes	Yes
State	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
Company	Yes	Yes	Yes	Yes
Fit statistics				
Observations	2,262	2,262	927	927
R^2	0.82	0.82	0.82	0.82
Within R^2	0.002	0.001	0.03	0.03
Wald (1st stage), RoE gap (%)		20.6		15.4
Dep. var. mean	1,589.4	1,589.4	401.8	401.8

Clustered (Year & Company) standard-errors in parentheses
Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

Notes: The table uses proposed RoE. Dependent variables are the total rate base in millions of $ (Columns 1–2) and the rate base per quantity delivered in $ per MWh (Columns 3–4). The FE results correspond to the specification used for column 3 in table 3 and the IV results correspond to the specification used for column 4 in table 3. First-stage *F*-statistic is Kleibergen–Paap robust Wald test.

These variables could affect several parts of the ratemaking process simultaneously. For instance, a PUC that has a high rating on the S&P RRA scale may increase or reduce the Averch–Johnson effect, but may also influence RoE and the utility's rate base in other ways.

Table 9: Relationship Between Approved Rate of Return and Approved Rate Base Increase with Differential Effects

Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
RoE gap (%)	0.0811***	0.1017***	0.0743***	0.1075	0.0780**	0.0879***
	(0.0243)	(0.0286)	(0.0239)	(0.1064)	(0.0300)	(0.0270)
RoE gap (%) × Electric		-0.0314				
		(0.0229)				
RoE gap (%) × Vertically Integrated			-0.0020			
			(0.0208)			
RoE gap (%) × PUC Ranking				-0.0271		
				(0.0493)		
RoE gap (%) × Litigated					0.0037	
					(0.0263)	
RoE gap (%) × Lengthy Case						-0.0071
						(0.0190)
Fixed-effects						
Service Type	Yes	Yes	Yes	Yes	Yes	Yes
State	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Company	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	2,617	2,617	2,617	2,101	2,617	2,617
R^2	0.69	0.69	0.70	0.69	0.69	0.69
Within R^2	0.009	0.01	0.03	0.010	0.009	0.01
Dep. var. mean	39.18	39.18	39.18	39.09	39.18	39.18

Clustered (Year & Company) standard-errors in parentheses
Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

NOTES: The table uses approved RoE. The dependent variable is log of the utility's rate base increase in millions of $ All specifications use the same preferred set of fixed effects. Columns each capture differential effects for a range of interactions. "Electric" captures whether a utility provides electric or gas service. "Vertically Integrated" captures whether it is an electric utility, rather than a gas utility. "PUC Ranking" captures whether a state PUC is rated as having a constructive, lower risk regulatory environment for investors. "Litigated" captures whether a rate case decision was fully litigated. "Lengthy Case" captures whether a rate case decision takes longer than average.

Table 10: Relationship Between Proposed Rate of Return and Proposed Rate Base Increase with Differential Effects

Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
RoE gap (%)	0.0625***	0.0842***	0.0665***	0.0766***	0.0726***	0.0699***
	(0.0167)	(0.0207)	(0.0178)	(0.0280)	(0.0206)	(0.0178)
RoE gap (%) × Electric		-0.0356*				
		(0.0177)				
RoE gap (%) × Vertically Integrated			-0.0108			
			(0.0174)			
RoE gap (%) × PUC Ranking				-0.0210		
				(0.0187)		
RoE gap (%) × Litigated					-0.0107	
					(0.0222)	
RoE gap (%) × Lengthy Case						-0.0076
						(0.0151)
Fixed-effects						
Service Type	Yes	Yes	Yes	Yes	Yes	Yes
State	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Company	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	3,402	3,402	3,402	2,776	3,402	3,402
R^2	0.73	0.73	0.74	0.72	0.73	0.73
Within R^2	0.009	0.01	0.04	0.008	0.01	0.01
Dep. var. mean	65.53	65.53	65.53	65.12	65.53	65.53

Clustered (Year & Company) standard-errors in parentheses
Signif. Codes: ***: 0.01, **: 0.05, *: 0.1

Notes: The table uses approved RoE. The dependent variable is log of the utility's rate base increase in millions of $ All specifications use the same preferred set of fixed effects. Columns each capture differential effects for a range of interactions. "Electric" captures whether a utility provides electric or gas service. "Vertically Integrated" captures whether it is an electric utility, rather than a gas utility. "PUC Ranking" captures whether a state PUC is rated as having a constructive, lower risk regulatory environment for investors. "Litigated" captures whether a rate case decision was fully litigated. "Lengthy Case" captures whether a rate case decision takes longer than average.

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