Debt and Water: State-Contingent Creditor Influence in Local Government

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Abstract

This paper asks whether creditor influence through municipal debt contracts affects local government operations. Using a new panel of California local-government water utilities that links financial reports and operating outcomes to hand-collected revenue-bond rate covenants, I show that these covenants matter outside of payment default. During California's exceptional drought, utilities closer to covenant thresholds mitigated drought-driven revenue losses by raising operating revenues. In more tax-resistant communities, covenant-constrained utilities responded by cutting spending, primarily on the water system. Across utilities, covenant-constrained utilities in the most drought-exposed areas report more post-drought system problems, including pipe breaks and water outages.

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1 Introduction

In the aftermath of the Great Recession, U.S. state and local governments faced revenue shortfalls alongside rising on- and off-balance-sheet liabilities. These trends have motivated a growing literature on how state and local public-sector financial structure can affect the fiscal tradeoffs underlying public service provision, emphasizing the magnitude of pension obligations (Novy-Marx and Rauh, 2011, 2014) and debt-market frictions that limit borrowing and investment (Cornaggia et al., 2018; Adelino et al., 2017). Yet this work largely abstracts from a more direct channel of creditor influence: municipal debt contracts embed state-contingent terms that can shape rate- and fee-setting, as well as broader budget decisions. This channel is especially important to understand for essential public services like drinking water provision because fiscal adjustment by local governments can affect service reliability and public health.

This paper provides the first empirical evidence that municipal debt contracts create a state-contingent channel for creditor influence over local government operations. I focus on rate covenants, a common provision in municipal revenue debt contracts that requires borrowers to set rates and fees to maintain a minimum debt service coverage ratio.[1] I show that these covenants matter outside of payment default in a sample of California local government water utilities: when a drought-driven fiscal shock pushes utilities toward their covenant thresholds, utilities that are most constrained by their covenants mitigate the shock by raising revenues through increases in rates and fees. Spending cuts emerge primarily in politically constrained settings where resistance to rate increases is high. These adjustments are followed by more system problems, including more pipe breaks and water outages.

My results are important because although municipal borrowers are often treated as sovereign borrowers (e.g., Myers (2022)), U.S. local governments occupy a hybrid institutional space: municipal debt is governed by domestic law, subject to contractual enforcement, and in some cases, borrowers can access bankruptcy (Gao et al., 2019b). Yet unlike firms, municipalities cannot be liquidated and key operational decisions like rate setting are made under political constraints. As a result, municipal rate covenants can limit local officials' discretion following deteriorating financial performance, constraining pricing and budgeting decisions in a setting where creditor influence is often assumed to be weak.

My analysis centers on a new dataset of California local government water utilities that combines annual enterprise financial reports and operating outcomes with rate-covenant thresholds hand-collected from revenue bond disclosure documents. For each utility-year,

[1] Rate covenants are used in debt contracts for municipal sectors including water, sewer, stormwater, electric/public power, solid waste, toll roads/bridges, airports, ports, parking systems, and public hospitals, among others.

I map the bond indenture's rate covenant threshold to the utility's realized financials to construct a measure of how close the utility is to violating its rate covenant. I then merge the utility panel to county-year measures of exceptional drought exposure and to a measure of utility-level political constraints on rate increases that I refer to as tax resistance. Because California law subjects municipal water rate increases to statutory voter-approval rules, I proxy for local tax resistance using local vote shares opposing Proposition 30, a 2012 statewide ballot initiative that increased sales and income taxes.

Using this dataset, I document three stylized facts about rate covenants. First, rate covenants are ubiquitous in water revenue debt: they appear in roughly 99% of the offering statements and credit agreements I review. Second, covenants bind in practice. The distribution of coverage ratios shows bunching just above covenant thresholds, consistent with active management of revenues and costs to remain in compliance with covenants. (In an Internet Appendix, I also study a sample in which shocks push utilities over the violation threshold and show that utilities respond quickly, increasing operating revenues and reducing spending within a year.) Third, rate covenant usage and terms vary systematically with size and leverage, as in the corporate covenant literature, and with local tax resistance, reflecting the political constraints that shape municipal pricing.

I identify the operational effects of rate covenants by combining plausibly exogenous variation in drought intensity as a fiscal shock with pre-drought differences in how close utilities are to their rate covenant thresholds. California's exceptional multi-year drought during fiscal years 2014 through 2017 reduced water deliveries and operating revenues statewide, tightening utility budgets and increasing the likelihood that rate covenants would bind. I ask whether similarly drought-exposed utilities adjusted differently when they entered the drought period closer to violating their rate covenants ("covenant constrained"), relative to utilities with more distance from their threshold and to utilities without rate covenants. All specifications include utility and year fixed effects; as in other studies of weather shocks, exceptional drought exposure is identified by deviations from utility-specific means within each year. The empirical design compares the sensitivity of revenues and spending to exceptional drought exposure across groups, with flexible controls for pre-drought fiscal dynamics and service-area characteristics that allow for differential responses after exceptional drought onset.

The first result is that rate covenants materially change utilities' revenue responses to drought-driven fiscal shocks. For utilities that are not covenant-constrained, a one–standard deviation increase in exceptional drought exposure reduces operating revenue growth by about 0.4% in the preferred specification. In contrast, utilities that enter the drought period close to their covenant thresholds substantially mitigate this revenue shock: for the same one–standard deviation increase in exceptional drought exposure, their operating revenue growth is 1.2 percentage points higher than for unconstrained utilities, roughly half of the sample average operating revenue growth rate. In an Internet Appendix, I demonstrate that this revenue response reflects both higher effective water prices, about $87 per million gallons per standard deviation of drought exposure, and a shift toward fee-based revenues that are less mechanically tied to water sales.

The second result is that covenants affect spending only for utilities serving more tax-resistant communities, where rate increases are politically costly. On average, I find little evidence that covenant-constrained utilities cut operating spending more than unconstrained utilities under the same drought exposure. But the key heterogeneity is political: the triple interaction of covenant constraints, drought exposure, and tax resistance is large and negative, implying that covenant-constrained utilities in tax-resistant areas reduce operating expense growth by roughly 1.6% per standard deviation increase in exceptional drought exposure. These reductions are concentrated in water system spending (implying a drought effect of about 2.5% per standard deviation for constrained utilities in tax resistant areas), with little adjustment in administrative categories. Together, the results point to a fiscal pecking order: binding rate covenant states push utilities toward revenue actions first, with spending cuts—especially to the water system—emerging where rate increases are politically constrained.

These results are robust to a range of alternative specifications and robustness checks. A central concern is that covenant-constrained and unconstrained utilities differ in ways that would generate different drought-period trajectories absent rate covenants. I address this by interacting baseline fiscal health (and pre-trends), leverage, and service-area characteristics with a drought-period indicator, allowing for differential trajectories during the drought. The estimates are robust when absorbing time-varying local shocks with county-year fixed effects and when conditioning on changes in water deliveries, which helps distinguish fiscal adjustment from mechanical quantity effects. Results are similar when restricting the control group to utilities that also have rate covenants but are unconstrained by them before the drought period. In the Internet Appendix, I use Oster (2019)'s proportional-selection adjustment to show that bias-adjusted estimates are similar to my main estimates, suggesting limited sensitivity of the results to omitted-variable bias. I also corroborate the main empirical patterns using an alternative differences-in-differences design based on state conservation mandates for a subsample of large urban water suppliers.

The final result is that covenant-constrained fiscal adjustment during the drought is associated with worse post-drought service reliability. Using cross-sectional variation in average exceptional drought exposure, I find that after the drought, covenant-constrained utilities in the most drought-exposed counties report about 3.4 additional system problems per 1,000 residents relative to unconstrained utilities facing similar drought exposure. This effect is sizable compared to a sample mean of 7.9 problems per 1,000 residents, where system problems are driven primarily by pipe breaks (with outages and boil-water orders also included). Alongside the spending results, these results are consistent with a link between covenant-constrained fiscal adjustment during the drought, especially weaker water system spending growth, and more system problems in the years that follow.

Taken together, my results show that creditor influence through municipal debt contracts matters for local government operations. Because municipal debt is enforceable under domestic law but key operating choices like rate setting are made in a political environment with taxpayers as a central stakeholder, covenants can shape budget decisions outside of payment default. Consistent with a fiscal pecking order, binding rate covenant states push adjustment to fiscal shocks first toward revenues and, where rate increases are politically costly, toward spending cuts. More broadly, the evidence suggests that covenant-driven fiscal adjustment can affect the reliability of essential public services.[2]

This paper contributes to a growing literature on the real effects of financial constraints in municipal debt markets, by examining the governance role of municipal debt in local government operations. A central finding in this literature is that frictions in municipal debt markets are economically important, so that changes in information and investor demand have real effects on government outcomes. Work on credit ratings shows that mitigating information frictions about municipal credit risk relaxes financial constraints, increasing borrowing and government employment (Cornaggia et al., 2018; Adelino et al., 2017).[3] Related papers exploit shocks to investor demand and market segmentation, arising from mutual fund flows (Adelino et al., 2025; Azarmsa, 2021), bank balance sheet constraints (Dagostino, 2025; Yi, 2021), and tax-driven investor clienteles (Babina et al., 2021), to show that municipal borrowing costs, issuance, and public-sector outcomes respond to shifts in credit supply. More generally, Ivanov and Zimmermann (2024) and Cortes et al. (2023) show that municipal borrowing is increasingly bank-intermediated, reflecting both growth in private bank lending and banks' continued importance as bondholders. This shift implies a more hetero-

[2] I abstract from welfare analysis of these adjustments, leaving the normative evaluation of access to municipal debt markets and creditor discipline versus price increases and service reliability tradeoffs for future work.

[3] Municipal bond insurance provides an example of a bond feature intended to mitigate frictions, though it appears to add limited incremental information beyond credit ratings (Cornaggia et al., 2024). Nonetheless, a small literature has demonstrated that disruptions in the municipal bond insurance market raised borrowing costs and led to reductions in employment and infrastructure investment, with especially pronounced effects in drinking water systems (Amornsiripanitch, 2022; Agrawal and Kim, 2021). Although my setting is municipal water utilities, my findings differ from this literature by emphasizing covenants and ongoing operational decisions rather than debt issuance and investment decisions.

geneous contracting environment, spanning public bonds and relationship-based lending, in which monitoring and covenant terms may be particularly salient. I extend this literature by bringing an agency and creditor control–rights perspective to a setting where prior work has focused primarily on information frictions and market segmentation. First, I study a previously unexplored feature of municipal debt: covenants embedded in outstanding debt contracts. Second, I show that the real effects of these covenants operate through an ongoing governance channel, shaping government operating decisions after issuance, rather than solely through access to external finance or changes in new debt issuance.

This paper also contributes to a literature on how environmental and political risks shape municipal borrowing costs and credit risk. Prior research shows that municipal bond markets price climate-related physical risk and that acute environmental disasters can affect public-issuer borrowing costs (Painter, 2020; Goldsmith-Pinkham et al., 2023; Auh et al., 2023; Lopez et al., 2025). A complementary literature highlights political risk and frictions, such as electoral uncertainty, corruption, and partisan alignment, as determinants of municipal financing conditions (Gao et al., 2019a; Butler et al., 2009; Dagostino and Nakhmurina, 2025). I connect these strands by demonstrating that environmental fiscal stress translates into real adjustments through a debt-contracting channel: covenants in outstanding municipal debt contracts shape operating responses to a drought-induced fiscal shock, and these responses interact with local political constraints.

Finally, this paper relates to the empirical corporate debt covenant literature on creditor governance, which shows that debt contracts shape firm governance both through financial-covenant violations that shift bargaining power in renegotiation (Nini et al., 2012; Ferreira et al., 2018) and through explicit nonfinancial governance terms written into loan contracts (Akins et al., 2020). In that spirit, I bring this contractual control-rights perspective on governance to municipal debt: municipal rate covenants embed explicit, state-contingent revenue rules that affect rates and shape operating choices, while the political environment shapes how this contractual constraint translates into manager budget decisions. Unlike the insulated-bureaucrat view of state-owned enterprises (Shleifer and Vishny, 1997), local officials in my setting remain electorally accountable, so creditor–manager conflicts are mediated by political feasibility. As a result, covenant-driven creditor discipline is borne by taxpayers through rate increases and spending cuts (with service-reliability consequences), paralleling corporate evidence that creditor influence following covenant violations can be borne by other stakeholders, including labor (Falato and Liang, 2016). Municipal covenants thus generate an ongoing governance channel that operates through pricing and spending responses to shocks, not only through payment default.

The paper proceeds as follows. Section 2 provides institutional background on rate covenants and a framework linking binding rate covenant states to changes in operations. Section 3.2 describes the data and key measures, with many more details on data construction, validation, and sample selection included in Internet Appendix I.A. Section 4 documents stylized facts on rate covenant prevalence, design, and salience. Section 5 outlines the empirical design using droughts as a fiscal shock. Section 6 presents the main results, heterogeneity by tax resistance, robustness, and evidence on post-drought system reliability. Section 7 concludes. Additional details are in the Internet Appendix.

2 Municipal Covenants: Practice and Theory

The central hypothesis of this paper is that creditors shape government operating decisions, even outside of states of payment default or bankruptcy. I argue that municipal covenants play an important role in this process. Using rate covenants in municipal enterprise debt contracts, I demonstrate that creditors can limit utilities' rate-setting discretion, influencing government operating decisions.

2.1 Municipal Debt Covenants in Practice: The Rate Covenant

Local governments face unique circumstances: they cannot pledge discrete public assets as collateral that creditors can seize and liquidate, unlike corporate borrowers, but they are still subject to the U.S. bankruptcy system and contract enforcement, unlike sovereign borrowers. In some cases, governments grant liens over streams of revenue in what is known as revenue debt. This debt structure represents about two-thirds of the investment-grade municipal bond market.[4]

In particular, revenue debt is used to support capital-intensive government services known as enterprises, such as municipal water utilities, wastewater utilities, stormwater enterprises, public hospitals, and public transit systems. These revenue debt structures are supported by the inclusion of what are known as rate covenants, a unique feature of municipal debt that is generally not found in corporate debt contracts.

Rate Covenant Description. Municipal enterprises promise in these covenants to maintain rates and fees in order to meet a minimum debt service coverage ratio. As an example, the Stinson Beach County Water District's 2013 private placement Refunding Bond Agreement with Bank of Nevada contains the following clause:

[4] Although the revenue debt category includes sectors such as housing, higher education, and private-activity bonds, revenue-bond structures are also common for core government enterprises and for state issuers: for example, Giesecke (2023) reports that revenue debt represents 22.6% of total state debt outstanding.

> The District shall fix, prescribe, revise and collect rates, fees and charges for the services and facilities furnished by the Enterprise during each Fiscal Year which are sufficient to yield estimated Net Revenues which are at least equal to one hundred twenty-five percent (125%) of the aggregate amount of Debt Service on all Parity Obligations payable from Net Revenues coming due and payable during such Fiscal Year.

In effect, the covenant imposes a minimum debt service coverage ratio requirement: the borrower must set rates and fees so that projected net revenues cover annual debt service by at least 125%. Enterprises are required to report their coverage ratios annually in their audited financial statements and in new debt issuance disclosure documents, meaning that these covenants are maintenance-based covenants rather than incurrence-based covenants.

The coverage ratio used in the rate covenants of water utilities is defined as:

$$\text{Coverage Ratio} = \frac{\overbrace{\text{Gross Revenues - Operation \& Maintenance Costs}}^{\text{Net Revenues}}}{\text{Revenue Bond Principal and Interest Payments}}$$

Gross Revenues include all gross income received or receivable from the ownership and operation of the water utility. This generally includes investment income and excludes grants and other federal or state aid. Operation and Maintenance Costs are defined as the reasonable and necessary costs and expenses paid for maintaining and operating the water utility, excluding depreciation expense and debt service costs. The obligations used in calculating debt service are those obligations that are also secured by a lien on the water utility's net revenues (the numerator in the coverage ratio).

Consequences of Covenant Violations. Violating a rate covenant is typically treated as a technical default rather than an immediate event of default. Indentures generally require corrective actions—most commonly, hiring an independent financial consultant and adopting recommended rate and expense adjustments within a specified period. Many agreements also impose an additional "cure" requirement, such as achieving at least 100% coverage in the subsequent fiscal year; failure to cure can then trigger an event of default. After an event of default, creditors may seek judicial remedies (including actions to compel rate increases); many agreements also permit acceleration of principal. Even outside of default, utilities have incentives to comply with rate covenants in order to avoid rating downgrades. A representative covenant-violation clause is provided in Internet Appendix I.C.1.

Comparison to Corporate Debt Covenants. In corporate lending, financial covenants (including minimum coverage ratios requirements) are typically maintenance-based, and violations commonly trigger renegotiation and creditor intervention (Roberts and Sufi, 2009b;

Denis and Wang, 2014). More broadly, debt contracts can also allocate control rights not only through state-contingent financial covenants but also through explicit nonfinancial governance terms, such as change-of-management restrictions that condition major leadership changes on lender consent (Akins et al., 2020). Consistent with this contracting perspective, covenant design at issuance varies systematically with borrower characteristics: more levered firms face tighter contracts, while larger firms include fewer covenants, consistent with firm size partially substituting for covenant protection (Bradley and Roberts, 2015).

Municipal debt generally operates under different constraints: bondholders are dispersed, renegotiation is uncommon, and rate covenants are designed to induce corrective action without relying on amendments or acceleration. Rate covenants therefore combine a minimum coverage requirement with affirmative obligations to adjust rates and fees when coverage falls short. In this sense, rate covenants play an analogous role to nonfinancial governance provisions by hard-coding a rule-based, state-contingent revenue policy. Although minimum thresholds (often around 120%—see Internet Appendix I.B.2 for descriptive statistics on thresholds) may appear loose by corporate standards, nonprofit constraints and limits on revenue generation can make them binding for municipal utilities. In practice, rate covenants function less as triggers for renegotiation and more as enforceable revenue policies. The next section situates this institutional feature within broader theoretical frameworks.

2.2 Municipal Debt Covenants in Theory

In corporate debt contracting, covenants mitigate conflicts between creditors and shareholders by restricting actions that can reduce pledgeable income and by creating triggers that shift control rights to creditors when firm performance deteriorates (Smith and Warner, 1979; Tirole, 2006; Chava and Roberts, 2008; Roberts and Sufi, 2009a; Matvos, 2013). In municipal settings, debt–manager conflicts interact with a political constraint: revenue adequacy is determined through a political process in which managers report to elected officials who internalize voter preferences, making rate increases politically costly even when financially warranted (Internet Appendix I.C.4 provides narrative examples of this resistance in the context of utilities.)

Rate covenants are naturally suited to this setting because they translate creditor protection into a rule-based revenue policy. Rather than relying on frequent renegotiation among dispersed bondholders, rate covenants limit managerial discretion by committing borrowers to maintain minimum debt-service coverage and to undertake corrective actions when coverage falls short. This contractual structure is consistent with the empirical patterns documented in Section 4: rate covenants are essentially universal in enterprise revenue-bond contracts, and utilities bunch above their violation threshold, indicating that covenant noncompliance is actively avoided. Compared with corporate loan covenant violations, the control-rights mechanism in this setting is narrower and more rule-based, targeting rate- and fee-setting specifically rather than leading to shifts in bargaining power over investment, capital structure, governance, or labor contracts.

These features imply that rate covenants can shape how utilities adjust to adverse fiscal shocks by narrowing the set of feasible budgeting responses. The next section develops predictions about the margins of adjustment, revenues versus spending, by combining this contractual constraint with a simple political-economy view of fiscal adjustment.

2.3 Implications for Operations

What are the implications of rate covenants for utility operating decisions? Rate covenants limit utilities' budgeting and rate-setting discretion, so they can shape operating decisions when fiscal stress requires adjustment. The relevant counterfactual is how local governments adjust to adverse fiscal shocks absent a binding covenant: political actors prefer responses that minimize voter backlash subject to legal and institutional constraints, especially balanced-budget rules that limit deficit financing (Glaeser, 2013; Cromwell and Ihlanfeldt, 2015; Poterba, 1994). A large empirical literature therefore documents a pecking order of fiscal adjustment in response to negative fiscal shocks (see additional references in Internet Appendix I.D).

1. *Reserves and transfers:* draw down on cash reserves, rainy-day funds, and intergovernmental transfers.
2. *Revenue increases:* raise taxes/fees where legally and politically feasible.
3. *Capital and maintenance cuts:* defer investment and maintenance, which is less visible to voters.
4. *Service reductions:* cut service quality as a last resort.

Building on this counterfactual, I test two predictions about how rate covenants shape adjustment to fiscal shocks. First, covenant-constrained utilities should increase operating revenues more in response to the same shock:

Prediction 1 (P1): *Municipal water utilities that are constrained by their rate covenants will increase revenues by more than utilities that are unconstrained by rate covenants, for a given fiscal shock.*

Second, when political resistance limits rate increases, binding rate covenants may shift adjustment toward expenses. I proxy for these political constraints using local tax resistance (Section 3.1):

Prediction 2 (P2): *Municipal water utilities that are constrained by their rate covenants and facing political limitations on their ability to raise rates will implement larger expense reductions compared to unconstrained utilities, for a given fiscal shock.*

3 Background and Data

3.1 Background

California Water Utilities: Organization, Governance, and Finances. Providing safe drinking water is considered an essential public service, and most Californians are served by municipal providers.[5] These providers include city-run utilities and special districts. Governance differs across provider types, but utility managers report to elected principals (e.g., city councils or district boards), so key budget choices remain electorally accountable. Financially, municipal water utilities are commonly organized as enterprise funds, accounted for separately from general government activities and backed primarily by user fees rather than general taxes. Although these public enterprise funds can in principle make transfers to or receive transfers from the general fund, in practice these flows are constrained by law and contracts. Proposition 218 (described in the next subsection) limits the use of "property-related fees," including water-rate revenues, to covering the costs of providing water service, and revenue-bond indentures typically require the enterprise to remain financially self-supporting.

Providing drinking water is capital-intensive, requiring both infrastructure investment and ongoing maintenance. Municipal water utilities commonly finance major projects with tax-exempt water revenue debt secured by user rates and fees. This debt structure provides investors a lien on enterprise revenues and includes a rate covenant intended to preserve the utility's ability to operate as a going concern. Although alternative financing structures exist (including general obligation borrowing, backed by a pledge of government taxing authority, and pay-as-you-go financing), there are legal and institutional incentives to use water revenue debt. In many states, general obligation (GO) borrowing is generally constrained by constitutional debt-limits and/or voter-approval requirements, whereas enterprise revenue

[5] Kristin Dobbin and Amanda Fencl, "Who governs California's drinking water systems?" UC Davis' Center for Watershed Sciences California WaterBlog, September 9, 2019, Available online.

bonds are commonly issued under special-fund frameworks that are treated differently from GO debt.[6]

Water utilities' day-to-day operations have two components: acquiring water (surface purchases or groundwater pumping) and delivering it through transmission and distribution infrastructure. Key operating costs include electricity and system operations, maintenance and repair of pipes and related assets, treatment where applicable, and administration. I map these categories into functional water costs and general and administrative costs in Section 3.2.

California's Political Institutions. California's system of voter-approved fiscal rules, most notably Proposition 13 (1978) and Proposition 218 (1996), makes revenue increases politically and procedurally costly for local governments. Proposition 218 is especially relevant for municipal utilities: although municipal utilities generally have independent authority to set rates through local governing boards (unlike investor-owned utilities, whose rates are regulated by the California Public Utilities Commission), Prop. 218 requires that property-related water rates not exceed the proportional cost of providing service and grants affected property owners the power to block proposed rate increases through a majority protest process.[7] The law effectively enforces a non-profit constraint on utilities, limiting their operational flexibility and exposing them to political uncertainty.

I use this institutional setting in two ways: first, voter constraints make revenue increases politically and procedurally difficult, so fiscal shocks are more likely to trigger the full pecking order (including spending cuts). Second, California's referendum culture makes local tax attitudes measurable through statewide ballot votes on tax increases, which I use as a proxy for the likelihood of voter resistance to water-rate increases.

To measure spatial variation in tax resistance, I use vote shares from statewide tax referenda. I focus on Proposition 30 (2012), a statewide ballot initiative that increased sales taxes (from 7.25% to 7.5%) and high-income taxes (for those earning over $250,000) over seven years to fund K–12 education (Ballotpedia, 2012). Although the proposition passed statewide with 55.4% of the vote, vote shares varied substantially across space, providing a tractable measure of local tax attitudes that I use as a proxy for resistance to revenue-raising policies, including water-rate increases. Section 3.2 describes the construction of the measure, and Section 3.4 documents its variation across water utilities.

[6] Revenue bonds may also benefit from Chapter 9 "special revenues" protections that allow pledged enterprise revenues to continue to be applied to debt service; Detroit's 2013 bankruptcy is a salient example.

[7] Proposition 218 governs not only water rates but also other local revenue tools, including local taxes, assessments, and a broad set of property-related fees and charges. For a narrative example of ratepayer protest over water rates that contributed to a rate covenant violation (Oxnard, CA), see Internet Appendices I.C.3 and I.C.4.

California Droughts. Between the calendar years 2012 and 2016, California experienced a historic drought, peaking in 2014 through 2016. The resulting supply stress lowered reservoir and surface-water availability, diminished groundwater supplies, and reduced allocations delivered through state and federal water distribution systems. I use this drought as a plausibly exogenous fiscal shock to municipal water utilities because it reduced delivered quantities and operating revenues, while many costs and debt-service obligations remained fixed.

The drought lowered municipal water-utility deliveries through two channels. First, it constrained utilities' access to water inputs, especially for utilities reliant on a concentrated set of sources or on wholesale deliveries subject to reduced state and federal project allocations. Water markets existed but were relatively underdeveloped during this period, limiting utilities' ability to offset shortages through purchases; meanwhile, large and rapid price increases were politically and practically difficult. This political constraint is central to Prediction P2 and motivates the heterogeneity analysis in Section 6. Second, California implemented increasingly stringent conservation policies, escalating from emergency declarations and voluntary targets to mandatory restrictions for large urban suppliers (details in Internet Appendix I.E.1 and I.F). Together, these forces generated a plausibly exogenous reduction in delivered quantities, tightening utility budgets through lost sales revenues. I provide additional details on the drought in Internet Appendix I.E.1, along with evidence on the drought's effects on utility budgets in Internet Appendix I.E.2.

3.2 Data Sources and Variable Construction

Water Utility Financial Data. I use California's mandatory reporting of local government finances to develop a measure of rate covenant tightness and to construct the key budget outcome variables. Local governments are required to file annual Financial Transactions Reports (FTRs) with the State Controller's Office, based on audited GAAP financial statements. These reports, available from 2003 to 2019, include detailed income statements, balance sheets, and fund balances. These data have previously been used by Myers (2022) to characterize California city revenues and bonded debt. Using the water proprietary fund schedules, I create a panel of utility revenues and expenses. To ensure consistency, I focus on utilities reporting positive operating revenues and expenses for all 17 years, resulting in a final panel of 569 water utilities. I focus the drought analysis on the years 2010 through 2019, in order to avoid the height of the financial crisis.

From this panel, I construct the Net Revenues component of bond-indenture coverage ratios using the prevailing indenture definitions for each type of utility. I define operating and maintenance (O&M) expenses as total operating expenses minus depreciation. For cities, gross revenues follow the typical indenture definition of total operating revenues plus investment earnings; for special districts, gross revenues follow the corresponding definition of total operating revenues plus investment earnings plus property taxes.

The main budget outcomes of interest are annual growth in operating revenues, operating expenses, water system spending, and general and administrative spending. Spending on the water system, defined as functional water expenses, includes groundwater pumping, water purchases, transmission, distribution, and treatment costs. All other operating expenses, excluding depreciation, are classified as general and administrative expenses. I adjust all revenue and expense variables for inflation. To mitigate the impact of outliers on the empirical results, I winsorize the budget outcomes at the 1% level.

Additionally, Internet Appendix I.A.1 details sample construction and screens; Internet Appendix I.A.7 benchmarks coverage against the Census of Governments; and Internet Appendix I.A.3 documents the 2017 reporting change and the reclassification I use to make consistent aggregates.

Outstanding Debt, Debt Service, and Rate Covenants. To construct the Revenue Debt Service component of bond-indenture coverage ratios, I use the FTR's debt and debt service reporting. I compile this data from the FTR's bonded debt, other long-term debt, and lease schedules, which provide issue-level details such as debt type (e.g., Revenue, General Obligation, Lease, Certificates of Participation), outstanding amounts at the start and end of each fiscal year, principal and interest payments, and adjustments or defeasances. Using this information, I identify outstanding water revenue debt and calculate revenue debt service for each fiscal year.

With the sample of identified water revenue issues and associated debt service, I next identify rate covenant thresholds using the California Debt and Investment Advisory Commission (CDIAC) database of debt issues and issuance documents. California requires all municipalities to report debt issuance to the CDIAC, including private placements and loans since 2012. I hand-match the identified water revenue bond issues to the CDIAC records and collect data on creditor protections, including details on rate covenants. By linking this data to the outstanding debt series, I create a time series of bond requirements for each utility.

More details on constructing revenue debt service are included in Internet Appendix I.A.5. Validation of the data relative to a sample of financial statements is included in Internet Appendix I.A.6. Internet Appendix I.B.1 describes the CDIAC record structure, document availability, and provides descriptive statistics on issuance amounts and water revenue debt outstanding. Internet Appendix I.B.2 reports descriptive distributions of rate-covenant threshold levels and their relationships with issuer and issue characteristics (including credit ratings and interest cost).

Drought Intensity. I obtain drought intensity data from the U.S. Drought Monitor, jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the U.S. Department of Agriculture, and the National Oceanic and Atmospheric Administration. The dataset provides daily county-level measures of exceptional drought: the share of a county's area classified in the most severe category (D4), indicating historically rare dryness conditions (approximately the 1st-2nd percentile of historical indicators such as precipitation and soil moisture, based on multiple measures and expert assessment). I aggregate these data to the county-fiscal-year level by averaging daily values over each fiscal year. The resulting measure is a share; in the main drought analysis, I standardize it to be mean zero and unit standard deviation.

System Problems and Water Deliveries. I obtain data on water utility operations, including water deliveries and system problems, from the California State Water Resources Control Board's electronic annual reports (EAR), which all public water systems in California are required to file. I use the EAR along with state-mandated Drought Conservation Reports to create a consistent measure of annual water deliveries, expressed in million gallons. The EAR water deliveries data covers calendar years 2013 through 2019.[8] Internet Appendix I.A.8 documents unit harmonization and the use of Conservation Reports to reconcile inconsistent EAR delivery units.

The dataset also includes information on system problems such as service connection breaks, main breaks, leaks, water outages, and boil water orders. I construct post-drought system problems by summing these incidents in 2018 and 2019 and normalizing the total per 1,000 residents. I aggregate system problems over 2018-2019 rather than using annual counts because the EAR problems series does not include years in the pre-drought period (it is available only from 2013 onward) and early drought-period reporting appears incomplete and improves over time. Annual counts are also noisy; aggregating across two post-drought years yields a more stable measure of post-drought water system reliability.

Finally, the California State Water Resources Control Board provides water service area boundaries, which I use to construct measures of population size, demographic characteristics, and tax resistance.

Tax Resistance and Other Service Area Characteristics. My measure of tax

[8]The EAR water-deliveries aggregates are reported on a calendar-year basis (ending in December), whereas the financial statements and drought measures are organized by fiscal year (ending in June). To align these reporting periods, I use one-year–lagged calendar-year deliveries when constructing deliveries growth and revenue-based "price" measures. Because water use peaks in late summer and early fall, fiscal-year t revenues are most exposed to deliveries in the second half of calendar year $t-1$. Results in Section 6.2 are similar when using contemporaneous calendar-year deliveries growth instead.

resistance is calculated as the proportion of "no" votes on Proposition 30 relative to the total votes cast on the proposition during the 2012 general election. I construct this measure using Statement of Vote files from the Statewide Database, California's redistricting database hosted by the Institute of Governmental Studies at UC Berkeley. The database provides precinct-level voting data and precinct shapefiles for each election cycle. To allocate precincts to water utilities, I first overlay precinct boundaries with water utility service areas and compute, for each precinct–utility pair, the share of the precinct's area that lies within the utility's service area. I then assign each precinct's full vote totals to the utility whose service area captures the largest share of that precinct's area. After assigning precincts, I aggregate votes to the utility level by summing "no" votes and total votes on the proposition across all precincts in the utility's service area. I divide the total "no" votes by total proposition votes to obtain the utility-level "no" vote share.

An ideal measure of tax resistance for water utilities would capture local opposition to water-rate increases directly. In practice, local tax and fee referenda are not ideal for this purpose because they are endogenous: local political attitudes shape whether proposals are placed on the ballot in the first place, which introduces selection concerns. Using Proposition 30 helps mitigate these issues because it was a statewide, governor-backed initiative that appeared on the ballot across all jurisdictions. The proposition also proposed broad-based increases in both sales and high-income taxes, making it salient to a large share of voters. Finally, the vote occurred during the 2012 general election, when turnout was high due to the national presidential election, and at the onset of the drought but before its peak years, reducing concerns that exceptional drought conditions themselves shaped local tax attitudes.

Other demographic and county employment data are from the Census, the American Community Survey, and the Bureau of Labor Statistics. By merging water system boundaries with Census shapefiles, I extract block-group-level demographic data. I aggregate data across water utility block groups to calculate the total service population and compute area-wide averages to capture the demographic characteristics of water utility user bases.

3.3 Measuring Rate Covenant Tightness

The main variable in the analysis is covenant tightness, which measures how binding a utility's rate covenant is on an annual basis. This measure is motivated by work on corporate loan financial covenants and covenant "slack" calculations (Dichev and Skinner, 2002; Murfin, 2012; Demerjian and Owens, 2016):

$$\text{Covenant tightness}_{it} = -1 \times \frac{\text{Distance to Threshold}_{it}}{SD(\text{Coverage Ratio})_i}$$

Distance to Threshold is the observed coverage ratio minus the rate covenant-specified minimum coverage ratio. The coverage ratio is the bond-indenture-specified debt service coverage ratio, which I winsorize at the 1% level to reduce the influence of outliers. Following the covenant slack literature, I scale Distance to Threshold by the standard deviation of each utility's coverage ratios.[9] Multiplying Distance to Threshold by -1 yields a measure that increases as slack falls: higher values indicate coverage ratios closer to (or below) the covenant threshold, and thus a higher likelihood of being in or near violation.

To document the stylized facts in Section 4, I follow Demerjian and Owens (2016) and construct a measure of covenant tightness at issuance that is based on pre-issuance financial variables. For each revenue-debt issuance, I measure Distance to Threshold in the fiscal year immediately preceding issuance and scale it by the standard deviation of the utility's coverage ratios over the prior four fiscal years (excluding the issue year). This construction requires at least four years of prior coverage data and therefore limits the tightness at issuance sample to FY 2006-2019.

For the drought analysis in Sections 5 and 6, I construct annual covenant tightness using each utility's realized coverage ratio and applicable covenant threshold in fiscal year t. To avoid look-ahead bias, the scaling term $SD(\text{Coverage Ratio})_i$ is computed using only pre-2010 coverage-ratio data. Average pre-drought covenant tightness (used to define treatment status in Section 5) is then constructed by averaging each utility's annual covenant tightness measure over FY 2010-2013, prior to the exceptional drought period.

3.4 Sample Statistics

Table 1 provides summary statistics for the full sample of 569 water utilities, covering fiscal years 2010 to 2019. Among utilities with a rate covenant in effect during the pre-drought period, most are relatively unconstrained by their covenants. Average pre-drought covenant tightness is -0.92 (median: -0.57), indicating that most utilities operate with coverage ratios above their covenant thresholds during this period. Covenant tightness is scaled by each utility's historical variability in coverage ratios. For context, the average pre-2010 utility-level standard deviation of coverage ratios is 211% (median: 139%), reflecting a skewed distribution in which a subset of (typically smaller) utilities exhibit highly volatile coverage ratios. For these utilities, even moderate absolute "slack" can imply a relatively high likelihood of violating covenants, because the the same slack represents a small buffer

[9]While Demerjian and Owens (2016) calculate violation probabilities using a standardized distance-to-threshold measure, I use the standardized measure directly in the analysis. Even in corporate settings with standard databases, Demerjian and Owens (2016) emphasize that coverage-type measures can be noisy proxies for contractual quantities because contract-specific definitions differ from standard accounting constructions.

relative to historical fluctuations of coverage ratios. In the full sample, utilities exhibit moderate operating margins, with an average total revenue-to-expense ratio of 1.2 during the FY 2010-2019 period. The sample is also split relatively evenly by tax resistance: utilities in the high tax-resistance group (above the median) predominantly opposed Proposition 30, with a minimum "no" vote share of 51.9%, while the remaining utilities generally supported the measure.

Panel C in Table 1 presents the cross-sectional distribution of drought intensity in each year for the full sample of utilities. From FY 2010 to 2013, drought intensity is zero across utilities, reflecting no exceptional drought exposure during this time, despite worsening general drought conditions. Exceptional drought exposure begins in FY 2014, with the average utility's county experiencing exceptional drought across 10.6% of its area, and peaks in FY 2015 at 60.2%. The exceptional drought phase effectively ends by FY 2017. For the panel analysis, drought intensity exhibits time-series variation (concentrated in FY 2014–2017) as well as meaningful cross-county variation across California's 58 counties, which together I leverage to identify the effect of binding rate covenants on utilities' operating decisions.

4 Characterizing Municipal Rate Covenants

Rate covenants are essentially universal in municipal enterprise revenue-debt contracts, making them a pervasive contractual channel for creditor influence that operates through an enforceable, state-contingent revenue policy. This section documents stylized facts consistent with this contracting view by characterizing cross-utility patterns in rate covenant use, relating covenant tightness at issuance to financial and political fundamentals, and presenting descriptive evidence that utilities manage revenues and costs around covenant thresholds to maintain compliance.

Prevalence. Rate covenants are nearly universal in water revenue debt. In the set of usable offering and bond indenture documents I locate for the water revenue debt records in my sample, 99% include a rate covenant. Thus, among water revenue-debt issues, rate covenants are essentially universal.

At the utility level, rate covenant exposure is lower because many utilities do not issue water revenue debt over the sample period. Of the 569 utilities in my main sample, 30.5% are subject to a rate covenant at some point between 2003 and 2019. The same share has a covenant in place during the 2010-2019 drought sample window, and 28.5% have a covenant outstanding during the 2010-2013 pre-drought period.[10] Utilities that never operate under a

[10] For a small set of utilities (11), I observe revenue debt outstanding during FY 2010-2019 but cannot recover rate-covenant thresholds due to lack of available documents. I exclude these utilities from this

rate covenant then rely on financing sources other than water revenue debt for capital needs (e.g., taxes, pay-as-you-go financing, GO bond financing, etc.), despite the near-universality of rate covenants.

Extensive margin. Rate covenant use is systematically related to utilities' financial capacity, service-area characteristics, and local political constraints. Figure 1 compares utility characteristics for utilities that ever operate under an observed rate covenant during FY 2010-2019 versus utilities that never do, where each characteristic is constructed as a utility-level mean over FY 2010-2019 and then standardized. Utilities with rate covenants typically serve higher-income areas and have larger service populations (a municipal analog of firm size), consistent with lower financial frictions. They also exhibit slightly weaker operating margins, with lower total revenue-to-total expense ratios (consistent with higher debt-service obligations among revenue-debt issuers).

Politically, utilities without rate covenants serve more tax-resistant populations: Proposition 30 "No" vote shares are higher among utilities without rate covenants, suggesting that these covenants are more common where local politics leaves greater room for revenue-based adjustment. Overall, rate covenant-backed revenue debt is less prevalent among smaller issuers and in more tax-resistant areas, consistent with tighter financing frictions and/or weaker ability to commit to enforceable revenue policies. In the subsequent analysis, I rely on a selection-on-observables assumption for comparisons across utilities with and without rate covenants, and show that the results are similar when I restrict the control group to utilities that ever operate under a rate covenant.

Intensive margin (covenant tightness at issuance). Covenant tightness at issuance varies predictably with leverage, operating margins, issuer size, and credit ratings, consistent with agency-based views of covenant design in the corporate literature. At the same time, covenant tightness is also systematically related to local tax resistance (and weakly to population growth), highlighting that municipal covenant design incorporates political constraints that are largely absent from standard corporate applications.

Figure 2 summarizes issuance-year regressions of covenant tightness at issuance on standardized financial, demographic, political, and underlying credit rating covariates.[11] Across specifications, covenant tightness loads on familiar correlates of financial constraints and

descriptive comparison. They are retained in the main drought analysis and coded as not operating under an observed rate covenant during the exceptional-drought years because they either retire their revenue debt prior to the onset of the exceptional drought or only have revenue debt outstanding after the exceptional-drought period.

[11] The pre-issuance sample links each revenue-debt issuance to the utility's fiscal year immediately preceding issuance and forms an issuance-utility-year sample spanning FY 2006-2019. Because Proposition 30 was on the ballot in November 2012, I also report estimates separately for issuance-years in FY 2013 and later. The full table of estimates for Figures 1 and 2 is provided in Internet Appendix Table I.B.2.

agency costs: higher leverage and weaker operating margins are associated with tighter covenants, and tighter covenants are more common for smaller utilities (measured by service-area population) and for lower-credit-quality issuers, including both below-AA and unrated issuers. Population growth is also positively related to covenant tightness at issuance, consistent with rate covenant design responding to development pressure and prospective financing needs, although the post-2012 estimates are imprecise.

Even though tax resistance makes revenue adjustment politically costly during periods of fiscal stress, higher tax resistance is correlated with looser rate covenants at issuance, which is consistent with political discipline substituting for contractual revenue rules ex ante but not necessarily ex post. Specifically, a higher Proposition 30 "No" vote share is correlated with looser covenants at issuance. This association is statistically significant in the post-2012 subsample, when Proposition 30 vote shares are a more relevant proxy for local tax resistance following the November 2012 election, and it remains so even when conditioning on leverage, operating margins, issuer size, and credit ratings. Because rate-setting and spending/investment choices are jointly determined by utility managers, stronger revenue-side discipline can also limit the scope for inefficient spending or overinvestment, reducing the need for tighter rate covenants at issuance. Ex post, however, the drought evidence in Section 6 indicates that this discipline does not fully substitute for contractual constraints: relative to less tax-resistant utilities without binding rate covenants, utilities without binding rate covenants in *more* tax-resistant areas exhibit weaker revenue adjustment and a relative tilt toward modestly higher (or less reduced) spending on water systems under the same drought exposure.

Covenant thresholds are salient (bunching evidence). A concern is that municipal rate covenants may be weakly enforced: municipal bonds face creditor coordination frictions; intensive monitoring is likely more limited than in bank lending; and, sub-sovereign issuers may face different practical consequences from contract breaches. I provide two pieces of descriptive evidence that rate covenants nevertheless operate as meaningful constraints.

First, I document bunching at the violation threshold. Figure 3 plots the distribution of covenant tightness for utility-year observations with an active rate covenant, where tightness is expressed in utility-specific standard deviations of the coverage ratio and zero corresponds to the covenant threshold. The distribution exhibits a pronounced spike just below zero (tightness in $(-0.2, 0]$), consistent with utilities managing revenues and costs to avoid crossing into violation. In the absence of threshold management, the distribution should be locally smooth around zero; the observed spike is difficult to reconcile with that benchmark unless the violation threshold is salient for utility decision-making. In my sample of utility-years with an active rate covenant (FY 2003–2019), utilities are in technical violation (tightness$>$

0) in about 20% of observations, which is comparable in magnitude to annual firm-year covenant violation rates reported for corporate bank loans (Chava and Roberts, 2008; Falato and Liang, 2016). Second, Internet Appendix I.C.2 examines violation episodes directly and documents rapid subsequent adjustment in revenues and spending following covenant violations, consistent with efforts to restore compliance.

5 Drought Empirical Design

To understand the implications of rate covenants for local government operating decisions, I study how rate covenants affect municipal water utilities' budget adjustments to adverse fiscal shocks. The ideal experiment would be to randomly assign a binding rate covenant across utilities. The key identification challenge is then separating rate covenant-induced responses from changes that would occur mechanically as fiscal health deteriorates: even plausibly exogenous shocks can lead governments to raise revenues and cut spending under balanced-budget constraints (Poterba, 1994). I address this challenge by using the exceptional California drought as a large, plausibly exogenous shock to water deliveries and operating revenues that increased the likelihood that rate covenants became binding. I then estimate a panel specification that compares utilities' drought responses when they were more versus less likely to be rate covenant-constrained at the onset of the drought. This design tests Predictions P1 and P2 by identifying whether binding rate covenants amplify budget adjustment relative to the counterfactual response of otherwise similar utilities facing comparable drought exposure.

5.1 Panel Approach

I estimate a panel specification that interacts county-year exceptional drought exposure with an indicator for whether a utility is covenant-constrained at the onset of the drought period. This design compares utilities that were more versus less likely to be covenant-constrained at the onset of the exceptional drought while facing comparable drought exposure, and it conditions on a rich set of pre-drought fiscal and service-area characteristics to ensure the comparison is among observationally similar utilities. The main regression specification is:

$$\begin{aligned}\Delta \log Y_{ict} = \alpha_i + \alpha_t + \beta \text{Rate Covenant Constrained}_i \times \text{Drought Intensity}_{ct} \\ + \phi_1 \text{Drought Intensity}_{ct} + (\text{Drought Period}_{2014-2017} \times X_i)' \boldsymbol{\phi}_2 + \varepsilon_{ict}\end{aligned} \tag{1}$$

The specification is estimated for utility i in county c in fiscal year t, and includes both utility fixed effects and year fixed effects in the main specifications.[12] $\Delta \log Y_{ict}$ denotes annual growth rates in operating revenues or operating expenses. To allow for heterogeneous drought responses, I interact an exceptional drought-period indicator (2014–2017) with pre-drought fiscal health, leverage, and service-area characteristics X_i measured over 2010–2013. These controls (discussed more in the next section) include: the total revenue to total expense ratio, the change in the revenue-to-expense ratio from 2010 to 2013, average revenue debt outstanding as a proportion of operating revenues from 2010 to 2013, log service area population size, and log median household income of the service area.

The variable Drought Intensity$_{ct}$ is the annual share of county c's area classified as in "Exceptional Drought" by the U.S. Drought Monitor. Following the weather-shocks literature (Dell et al., 2014; Ponticelli et al., 2024), the impact of exceptional drought on budget outcomes is identified by deviations from utility-specific means within each year (net of common year shocks); variation is concentrated in 2014–2017 (see Table 1 panel C). I use the county-year measure because it captures the local drought environment that shaped both physical water availability and the associated policy response, and it varies plausibly exogenously with weather rather than utility decisions. County exposure may imperfectly map into the fiscal shock faced by a particular utility. I therefore interpret Drought Intensity$_{ct}$ as a proxy for drought-driven revenue pressure and provide two forms of evidence that it captures the relevant shock: first, higher county exceptional drought exposure predicts declines in water deliveries and water sales revenues, with corresponding increases in covenant tightness among the control group of unconstrained utilities during the exceptional drought period (Internet Appendix I.E.2). Second, I corroborate results using an alternative design based on conservation mandates (Internet Appendix I.F). Third, I allow the drought response to vary with pre-drought utility characteristics in main specifications and show robustness to county-year fixed effects in Section 6.2.

Conceptually, treatment intensity, which is the degree to which a rate covenant is binding, is determined in this setting by the interaction of the intensity of an exceptional drought shock and whether a utility was constrained by rate covenants prior to the shock. The coefficient of interest to test Prediction P1 is then β on Drought Intensity$_{ct}$ interacted with Rate Covenant Constrained$_i$. The variable Rate Covenant Constrained$_i$ equals one for utilities with an observed rate covenant in place during 2010–2013 that are above the median of average pre-drought covenant tightness, and zero otherwise (including utilities without a covenant and utilities with a covenant that are below the median of average covenant tightness). Because treatment is assigned at the utility level, I cluster standard errors at the

[12] As a robustness check, I substitute the year fixed effect with county-year fixed effects in Section 6.2.

utility level and show robustness to county clustering in Internet Appendix I.E.4.

Following the corporate covenant literature, I assume covenants affect managerial behavior only when utilities are near or in violation of the rate covenant. Utilities without covenants and utilities with substantial pre-drought slack therefore provide a natural counterfactual group: over the realized range of drought exposure, neither is expected to be brought close to a binding threshold. Conditional on pre-drought fiscal health, leverage, and service-area characteristics (and fixed effects), differences in the sensitivity of budgets to drought exposure between constrained and unconstrained utilities are attributed to covenant-induced responses rather than baseline adjustment to fiscal stress.

Identifying variation comes from within-utility changes in county-level drought exposure, comparing the sensitivity of budget outcomes to drought for utilities that were more versus less likely to be covenant-constrained pre-drought. Because exceptional drought is determined by weather rather than utility policy, county exposure is plausibly exogenous to individual utilities' budgets. The identifying assumption is that, conditional on observables and fixed effects, constrained and unconstrained utilities would have exhibited the same relationship between budget responses and drought in the absence of the rate covenant constraint. Under this assumption, the interaction term captures covenant-induced responses. Additionally, because outcomes are annual, I cannot separately identify the direct effects of drought conditions from same-year managerial responses. I therefore take this simultaneity as given and interpret Drought Intensity$_{ct}$ as a sufficient proxy for the magnitude of the underlying fiscal shock, using control utilities' endogenous responses as the counterfactual benchmark. I discuss threats to identification in the next section.

I next test pecking order Prediction P2 by examining whether the effect of binding rate covenants on spending is stronger in more tax-resistant areas. To do so, I run the following regression:

$$\begin{aligned}\Delta \log Y_{ict} = \alpha_i + \alpha_t + \gamma \text{Rate Covenant Constrained}_i \times \text{Drought Intensity}_{ct} \times \text{Tax Resistant}_i \\ + \phi_1 \text{Rate Covenant Constrained}_i \times \text{Drought Intensity}_{ct} \\ + \phi_2 \text{Drought Intensity}_{ct} \times \text{Tax Resistant}_i + \phi_3 \text{Drought Intensity}_{ct} \\ + (\text{Drought Period}_{2014-2017} \times X_i)' \boldsymbol{\phi}_4 + \varepsilon_{ict}\end{aligned} \tag{2}$$

This specification is estimated for utility i in county c in fiscal year t, and includes utility fixed effects α_i and year fixed effects α_t. $\Delta \log Y_{ict}$ now denotes annual growth rates in operating expenses, water system specific operating expenses, and administrative and general operating expenses. Rate Covenant Constrained_i and Drought Intensity_{ct} are measured as they were in the previous specification. The controls are specified in the same way as in (1).

In order to examine heterogeneity based on political constraints, I include Tax Resistant_i, which is a utility-level indicator variable that takes a value of 1 if a utility's measure of tax resistance is in the top half of the sample and 0 otherwise. The coefficient of interest is γ, which captures whether the differential response of covenant-constrained utilities to drought exposure varies systematically with tax resistance. In other words, the triple interaction effect γ isolates the incremental effect of political constraints on the drought-driven adjustment of covenant-constrained utilities.

Proposition 30 vote shares are a tractable proxy for local political resistance to revenue-raising policies, but they may also reflect correlated attributes such as rurality or infrastructure age. The specification addresses this in two ways. First, utility fixed effects absorb time-invariant differences across utilities, including persistent characteristics like rurality that may be correlated with Proposition 30 vote shares. Second, by interacting the drought-period indicator with pre-drought fiscal and service-area characteristics, I allow for differences in 2014–2017 trends that may be correlated with tax resistance. This helps ensure that γ reflects the incremental heterogeneity associated with tax resistance in the drought response of covenant-constrained utilities, rather than broader differences in how utilities with different characteristics evolved during the drought.

5.2 Identification Strategy

The empirical design has two advantages. First, it leverages a fiscal shock to utilities that is less tightly linked to local economic conditions than many other drivers of utility finances (e.g., housing booms and busts, local employment growth, or development cycles). Shocks correlated with local growth and development raise omitted-variable concerns because they can jointly determine covenant tightness and budget outcomes, obscuring whether binding rate covenants or local economic conditions are driving adjustment. The drought instead provides a common, weather-driven fiscal shock that reduced deliveries and revenues across utilities and increased the likelihood that rate covenants would bind. Second, because the drought was broad-based and statewide, affecting virtually all utilities to some extent, I can exploit common support in the key pre-drought financial variables that predict the binding rate covenant treatment assignment. This also yields a large group of unconstrained utilities to serve as a counterfactual for how budgets adjust to a fiscal shock absent binding covenants, conditional on a rich set of controls.

The key concern is then selection into treatment status: utilities closer to rate covenant thresholds may enter the drought with systematically weaker fiscal health or different leverage and service-area characteristics, which could independently shape drought responses. I address this concern in two steps. First, Table 2 assesses balance on key pre-drought covariates across the treated group and (i) the main control group, which pools unconstrained utilities with and without rate covenants, and (ii) an alternative control group that restricts attention to utilities with rate covenants outstanding (see Section 6.2). The groups are similar along several important dimensions, including Proposition 30 vote shares, drought exposure, and pre-drought housing-bust exposure (measured as the percent change in county building permits, 2005–2010), while differing more in leverage, size, and local median household income. Second, I condition flexibly on these covariates by interacting pre-drought characteristics with the drought-period indicator, allowing for differential drought-period dynamics by baseline characteristics.

Because constrained utilities may enter the drought in weaker financial health, sharper revenue or spending adjustments could reflect the effects of low cash flows (or mean reversion) rather than the effect of binding rate covenants. To address this, I measure baseline fiscal health using the pre-drought revenue-to-expense ratio (averaged over 2010–2013) along with its change over the same period, and I interact these measures with the drought-period indicator. Differences in these fiscal-health measures across groups are modest in the balancing table, and controlling for them helps ensure that the estimates compare utilities with similar pre-drought fiscal trajectories. I similarly allow drought-period trends to vary with pre-drought leverage and service-area characteristics (e.g., debt outstanding relative to operating revenues, population, and median income), so identification comes from comparing constrained and unconstrained utilities with similar pre-drought characteristics and drought-period trends.

A related concern is that debt-issuing utilities may be better able to smooth drought-induced revenue shortfalls, potentially attenuating observed responses. Because covenant-constrained utilities are a subset of debt issuers, this channel would bias estimated covenant effects toward zero. This pattern is not reflected in the data: constrained utilities exhibit a significantly stronger positive revenue response to drought than the control group (Table 3). Moreover, municipal debt is primarily used to finance infrastructure investments rather than short-run cash-flow needs, and I find no evidence that issuance increases with drought intensity; issuance instead declines during the peak drought years (Internet Appendix Table I.E.1 and Figure I.E.6).

Beyond these controls, I report additional robustness checks in Section 6.2. A remaining concern is that proximity to the covenant threshold may be correlated with unobserved features, such as governance, managerial capacity, or demand elasticity, that also shape drought responses. In addition to utility fixed effects and flexible controls for pre-drought financial and service-area characteristics, I assess robustness by restricting the control group to utilities with rate covenants (Section 6.2), which is plausibly more comparable on unobserved dimensions related to debt-market participation and financial management. Internet Appendix I.E.6 also assesses robustness to remaining unobservable omitted-variable bias in the main specifications.

6 Drought Results

This section demonstrates that municipal rate covenants shape utilities' budget adjustments to a large drought shock. Internet Appendix I.E.2 demonstrates that exceptional drought exposure reduced delivered quantities and water-sales revenues, tightening budgets and moving utilities closer to covenant thresholds. I next estimate the revenue and spending responses using equations (1) and (2).

6.1 Panel Results

The regression results from equation (1) are reported in Table (3). Columns 1 and 2 present the results for operating revenue growth, while columns 3 and 4 focus on operating expense growth. For unconstrained utilities, a one standard deviation increase in exposure to exceptional drought leads to a decline in operating revenues of 0.5%. This coefficient implies that moving from the 10th to the 90th percentile of drought intensity (about 2.5 standard deviations) results in a revenue growth decline of 1.2%. Given that the average of revenue growth rates over the sample is 2.4%, this means that a move from the 10th to the 90th percentile of the distribution of drought exposure cuts revenue growth rates in half. Controlling for observable characteristics, like leverage, fiscal health, population, and income, reduces the estimate of the drought effect in the unconstrained group to 0.4%.

The unconditional effect of droughts on revenues is significantly mitigated for utilities constrained by rate covenants during the period leading up to the exceptional drought. This finding aligns with Prediction P1 regarding the impact of binding rate covenants on revenues. The estimated effect of the rate covenant, represented by β in equation (1), ranges from 0.009 to 0.012. This suggests that, under the same drought shock, rate covenant-constrained utilities experienced higher revenue growth relative to unconstrained utilities. The bottom panel reports estimates of the effect of the drought on budget outcomes for rate covenant constrained utilities, along with the standard error of the estimate and the associated p-value for testing the null hypothesis that the effect is zero. Specifically, a one standard deviation increase in drought intensity corresponds to a 0.5% to 0.8% increase in operating revenue growth (ϕ+β) for the sample of rate covenant-constrained utilities. I can reject that the effect is 0 when conditioning on observables. Internet Appendix I.E.5.1 provides additional evidence that the increase in operating revenue growth in the covenant-constrained group was driven both by higher water prices—on the order of $87 per million gallons (roughly 2% of average price levels) per standard deviation of drought exposure—and by a modest shift toward revenue sources less dependent on water sales, such as connection fees and service assessment charges, relative to the control group.

Columns 3 and 4 of Table 3 report the results for operating expenses. These columns show that exceptional droughts weakly lead to reduced spending for the control utilities, consistent with the expected impact of a significant budget shock. Moreover, in line with Prediction P2, rate covenants further reduce spending in response to the same drought shock. The overall effect of droughts in the rate covenant constrained group is −0.9% when controlling for observables, which is significant at the 10% level. However, I cannot reject that the effect of the droughts for the constrained group is significantly different from the unconstrained group.

The results estimating equation (2) are reported in Table 4 for operating expenses and subcategories of spending. The coefficient of interest testing P2 is γ on the triple interaction, which captures whether the drought-induced difference between constrained and unconstrained utilities is larger in tax-resistant areas than in less tax-resistant areas. Columns 1–2 report results for operating expense growth, columns 3–4 for water system expense growth, and columns 5–6 for administrative expense growth. The bottom panel reports the implied effect of a one–standard deviation increase in drought exposure for utilities in tax-resistant areas, separately for unconstrained ($\phi_3 + \phi_2$) and constrained utilities ($\phi_3 + \phi_1 + \phi_2 + \gamma$).

Consistent with P2, columns 1 and 2 show that operating expense growth is more sensitive to exceptional drought exposure for covenant-constrained utilities in tax-resistant area. The estimate of γ ranges from −0.016 to −0.018, implying a 1.3%–1.6% decline in operating expense growth per standard deviation of drought exposure for constrained utilities in tax-resistant areas (significant at the 1% level). The effect size is economically meaningful relative to average annual expense growth of 1.9%. Additionally, moving from the 10th to the 90th percentile of drought exposure implies a 3.38% reduction in operating expense growth for covenant-constrained utilities in tax-resistant areas. For unconstrained utilities in tax-resistant areas, the overall effect of drought exposure on operating expense growth is small (about −0.2% to −0.3% per standard deviation in drought intensity) and statistically indistinguishable from zero.

I next explore the drivers of the decline in expense growth rates, focusing on columns 3-6 of Table 4. The analysis suggests that covenant-constrained utilities in tax-resistant areas reduce spending on water systems during drought shocks, with little evidence of changes in administrative and general spending. The estimate of interest, γ, for water spending growth rates is captured by the triple interaction term in columns 3 and 4, ranging from -0.035 to -0.037. This estimate indicates that a one standard deviation increase in drought intensity for rate covenant-constrained utilities in tax-resistant areas results in a 2.4% to 2.5% decline in water system spending growth. These effects are statistically significant at the 10% level. The estimate of the rate covenant effect is economically substantial compared to the unconditional average water system spending growth rate of 0.9% over the sample period. In contrast, for unconstrained utilities in tax-resistant areas, a one standard deviation increase in drought intensity is associated with 0.1% to .2% decline in water system spending growth, although I cannot reject zero. In Section 6.2, I verify that the water-spending results are not a mechanical consequence of reduced water deliveries during the drought.

Turning to administrative spending, the estimated differential effect for constrained, tax-resistant utilities (the γ coefficient in columns 5-6) is small, about 0.003, and statistically indistinguishable from zero. Translating the coefficients into total effects for rate-covenant-constrained utilities in tax-resistant areas, the implied response is also close to zero: in the fully controlled specification, a one–standard deviation increase in drought exposure is associated with about a 0.3% decline in administrative spending growth. These effects are imprecisely estimated, so I cannot reject the null of no effect; at most, the data provide weak evidence that utilities reallocate savings from water system spending into administrative categories.

This composition of spending adjustment is consistent with the pecking-order logic in Section 2.3. When binding rate covenants require utilities to meet minimum coverage ratios through rate and fee actions but tax resistance makes those actions politically costly, utilities appear to adjust on expenditure margins that are more readily deferred and less salient to users in the short run. In this setting, functional water system spending includes some operations and maintenance activities, such as repairs and maintenance, that can be delayed temporarily, whereas administrative and general spending may be relatively rigid (e.g., staffing). The concentration of cuts in water system spending, with little movement in administrative categories, therefore suggests that covenant-driven fiscal adjustment during the drought in tax-resistant areas operates primarily through deferred system operations and maintenance spending, a pattern that is consistent with the post-drought reliability evidence in Section 6.

In Internet Appendix I.E.5.2, I examine whether intergovernmental transfers help explain why utilities without binding rate covenants exhibit weaker or slower fiscal adjustment to drought-driven shocks. Revenue debt and associated rate covenants typically require utilities to be financially self-supporting, which limits reliance on intergovernmental transfers to smooth revenue shortfalls. Consistent with this channel, the effect of drought intensity on intergovernmental transfers is positive in both groups but larger for unconstrained utilities. Although the estimates are imprecise and I cannot reject no difference between constrained and unconstrained utilities, the pattern is consistent with binding rate covenants limiting the use of transfers as a shock-absorption margin.

6.2 Robustness

In this section, I discuss several robustness checks of the main panel results. For each of these robustness tests, I estimate specifications (1) and (2) for the outcomes of interest. I then show how estimates of β in (1) and γ in (2) vary across specifications in Figure 4. Estimates are similar in magnitude to the main estimates across all outcomes for all robustness checks. In addition to these checks, I assess robustness to omitted-variable bias using Oster (2019)'s proportional-selection adjustment in Internet Appendix I.E.6. Finally, Internet Appendix I.F reports results for an alternative research design, which uses exposure to state-mandated conservation standards as a shock to covenant tightness in a differences-in-differences approach for a substantially smaller subsample than what is included in the main text.

Differential Trends. The main estimate of β could reflect differential trends for constrained utilities during the exceptional drought period rather than differential sensitivity to drought intensity. To address this, I augment specifications (1) and (2) with an interaction between the indicator term Drought $\text{Period}_{2014-2017}$, which equals one for years 2014 through 2017 (and is 0 otherwise), and Rate Covenant Constrained_i. This interaction controls for any average divergence between constrained and unconstrained utilities during the exceptional drought period. In specification (2), I add an interaction between Drought $\text{Period}_{2014-2017}$ and Tax Resistant_i.

County-Year Fixed Effects. A concern is that county-level exceptional drought exposure may be correlated with other time-varying local conditions, such as local economic shocks or longer-run drought adaptation, that could differentially affect utilities' budget decisions. For example, utilities in counties with a long history of drought may have already diversified their water-source portfolios or invested in drought-mitigation infrastructure, which could systematically change how budgets respond to drought shocks. To address this, I re-estimate the main specifications with county-year fixed effects, which absorb all shocks common to utilities within the same county in a given year. Identification then comes from comparing covenant-constrained and unconstrained utilities within the same county and year, holding fixed time-invariant utility differences.

The modified regression specification for (1) is then:

$$\begin{aligned}\Delta \log Y_{ict} = \alpha_i + \alpha_{ct} + \beta \text{Rate Covenant Constrained}_i \times \text{Drought Intensity}_{ct} \\ + \phi_1' \text{Drought Period}_{2014-2017} \times X_i + \varepsilon_{ict}\end{aligned} \quad (3)$$

With county-year fixed effects α_{ct} included, the constrained-minus-unconstrained comparison is made within the same county and year, netting out time-invariant utility differences and all county-year shocks. The coefficient β is then identified by how that within-county-year difference varies across county-years with different values of Drought Intensity$_{ct}$; that is, whether the constrained-unconstrained difference in budget adjustment is larger when the county-year drought shock is more severe.

The modified regression specification for (2) is:

$$\begin{aligned}\Delta \log Y_{ict} = \alpha_i + \alpha_{ct} + \gamma \text{Rate Covenant Constrained}_i \times \text{Drought Intensity}_{ct} \times \text{Tax Resistant}_i \\ + \phi_1 \text{Rate Covenant Constrained}_i \times \text{Drought Intensity}_{ct} \\ + \phi_2 \text{Drought Intensity}_{ct} \times \text{Tax Resistant}_i \\ + \phi_3' \text{Drought Period}_{2014-2017} \times X_i + \varepsilon_{ict}\end{aligned} \quad (4)$$

Intuitively, γ is identified from within–county–year comparisons across utilities (tax-resistant vs not, constrained vs not) and measures whether the incremental constrained–unconstrained difference in tax-resistant areas is larger in county-years with more severe drought.

These are the most restrictive specifications and warrant several caveats. Estimating β in (3) requires sufficient variation between treated and control utilities within each county; counties without within-county treatment variation are therefore dropped. Estimating γ in (4) demands even more variation—not only between treated and control utilities, but also within both the high– and low–tax-resistance groups. This substantially reduces the number of counties used to identify γ, limiting the analysis to large counties with many utilities. This restriction does not necessarily diminish the relevance of my estimates, as these counties are home to a large population that relies on these utilities; however, the restriction introduces greater noise into the parameter estimates.

Controlling for Water Quantity Growth. Another concern is that the documented budget effects may partly reflect mechanical responses to reduced water demand. For example, a utility that purchases water from a regional wholesaler may spend less when drought-driven allocation cuts or conservation mandates reduce the quantity purchased. In order to address this concern, I control for each utility's annual growth in water deliveries, which proxies for changes in quantity sold. Because the sample of utilities with water deliveries is smaller, the estimates are less precise than the main estimates.

Alternative Control Group. In the baseline specification, the unconstrained group includes utilities both with and without rate covenants, which allows me to exploit cross-utility variation and flexibly control for observable differences correlated with treatment assignment and drought responses. However, Table 2 shows that control-group utilities with covenants more closely resemble constrained utilities along most observable dimensions. To assess sensitivity of the main results to the inclusion of no-covenant utilities in the unconstrained group, I re-estimate the main specifications using a rate covenant-only control group, restricting the control group to utilities with rate covenants in effect during the drought period. The treated group is unchanged; the control group is restricted to utilities with rate covenants that are in the lower half of the pre-drought covenant-tightness distribution. Because the treated and covenant-only control groups are relatively balanced on observed demographics and the sample is smaller, I include a reduced set of financial controls, including the average pre-period revenue to expense ratio and leverage interacted with the drought-period indicator. As in the earlier robustness check, I also control for water-deliveries growth to absorb mechanical budget changes associated with drought-driven quantity reductions.

6.3 The Effect of Rate Covenants and Drought on System Problems

I next examine whether the budget responses of covenant-constrained utilities during the exceptional drought translated into downstream service-reliability problems. Because water system spending covers water supply, pumping, and treatment, as well as transmission and distribution operations and maintenance, even temporary cutbacks during the drought may have increased subsequent disruptions such as pipe breaks, leaks, boil-water orders, and outages. To assess this channel, I estimate the following cross-sectional specification, where the outcome is population-weighted post-drought system problems per 1,000 residents (defined in Section 3.2):

$$\begin{aligned}\text{Post-Drought System Problems}_i = {} & \beta\text{Rate Covenant Constrained}_i \times \text{Top Quart. Drought}_{ic} \\ & +\phi_1\text{Top Quart. Drought}_{ic} + \phi_2\text{Rate Covenant Constrained}_i + \phi_3' X_i + \varepsilon_{ic}\end{aligned} \tag{5}$$

I measure exceptional drought exposure as the average share of a county's area classified as in "Exceptional Drought" over fiscal years 2014-2017. I define Top Quart. Drought$_{ic}$

as an indicator for utilities located in counties in the top quartile of this distribution. The variable Rate Covenant Constrained_i is defined as in the main panel analysis. The coefficient of interest, β, captures the marginal effect of drought intensity on post-drought system problems for covenant-constrained utilities relative to unconstrained ones. I emphasize the top-quartile because fiscal pressure on utilities was plausibly most severe in these counties and downstream operational consequences should be most detectable.

Because this is a cross-sectional design, observable characteristics may jointly predict treatment assignment (rate covenant-constrained) and post-drought system problems. I therefore include the same utility-level controls used in the main panel analysis. To address pre-existing differences in infrastructure quality and resource availability, I additionally control for the log of average operating revenues from 2010-2013. Including the high-exposure indicator Top Quart. Drought_{ic} absorbs any county-level differences associated with top-quartile exceptional drought exposure (including direct physical or policy responses common to utilities in that county). Standard errors are heteroskedasticity-consistent, and I also report specifications clustering errors at the county level, to allow for correlation within counties.

Table 5 reports the coefficients from estimating (5). Column 1 presents the unconditional specification; columns 2-3 add the controls, with column 3 additionally clustering standard errors at the county level. The estimate of β is positive in all columns and becomes more precisely estimated once controls are included: the point estimate rises from 2.39 in column 1 to 3.39 in columns 2-3. It is statistically significant at the 10% level in column 2 and at the 5% level in column 3. Interpreting magnitudes, utilities in the top quartile of drought exposure that are also covenant-constrained report approximately 3.4 more system problems per 1,000 residents in the post-drought period compared to similarly exposed but unconstrained utilities. Notably, the constrained main effect is negative and significant in the unconditional specification but becomes small and statistically indistinguishable from zero once controls are included, suggesting that baseline differences between constrained and unconstrained utilities are largely accounted for by observables.

Because β is defined relative to unconstrained utilities, the negative coefficient on Top Quart. Drought_{ic} implies that unconstrained utilities in high-exposure counties report fewer post-drought problems than utilities in lower-exposure counties. This effect would be consistent with a channel in which exposed areas receive additional intergovernmental resources that finance improvements (consistent with the positive association between drought exposure and intergovernmental transfers documented in Internet Appendix I.E.5.2). Taken together, the negative main drought effect and positive interaction are consistent with an adaptation or mitigation channel in high-exposure counties that benefits unconstrained utilities, with covenant-constrained utilities experiencing attenuated or forgone improvements rather than large absolute declines in performance.

Overall, these results indicate that covenant-constrained utilities exposed to top-quartile exceptional drought experienced relative post-drought deterioration in system reliability. The operational consequences of binding rate covenants are concentrated in the most severely drought-exposed systems, where fiscal stress is plausibly large enough to translate into measurable service-reliability outcomes.

7 Conclusion

This paper shows that creditor influence over local governments through municipal debt contracts operates on an ongoing, state-contingent basis, shaping local rate and spending decisions well before payment default. Rate covenants function as enforceable revenue policies: when a drought-induced fiscal shock pushes utilities toward covenant thresholds, covenant-constrained utilities adjust more aggressively on the revenue margin. Where political resistance is likely to make rate increases more difficult, fiscal adjustment shifts toward water system spending cuts. More broadly, the findings highlight a governance tradeoff in financing essential public services under climate-related fiscal stress. Stronger creditor protections can expand access to revenue-debt financing and support infrastructure investment, but they also shape fiscal adjustment following shocks, potentially altering the composition of spending toward margins associated with longer-run public service-quality implications. Understanding these tradeoffs is important for other essential municipal enterprises that rely on similar revenue-backed debt contracts.

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Figure 1: Characteristics of Utilities with Rate Covenants

This figure compares utilities that ever operate under an observed rate covenant during FY 2010-2019 ("Covenant") to utilities that do not ("No covenant"). For each characteristic, I first compute the utility-level mean over FY 2010-2019 and then standardize the resulting utility-level values across utilities in the plotted sample to have mean 0 and SD 1. Points report group means of these standardized utility-level values. Whiskers denote 95% confidence intervals for the group means, constructed using the standard error of the mean within each group. Rev/Exp is the ratio of total revenues to total expenses. Log pop. is the log of the service area population in 2010. Log income is the log of median household income. Prop. 30 No is my tax resistance measure, is the Proposition 30 "No" vote share in the utility's service area. Unstandardized group means are reported in Internet Appendix Table I.B.2.

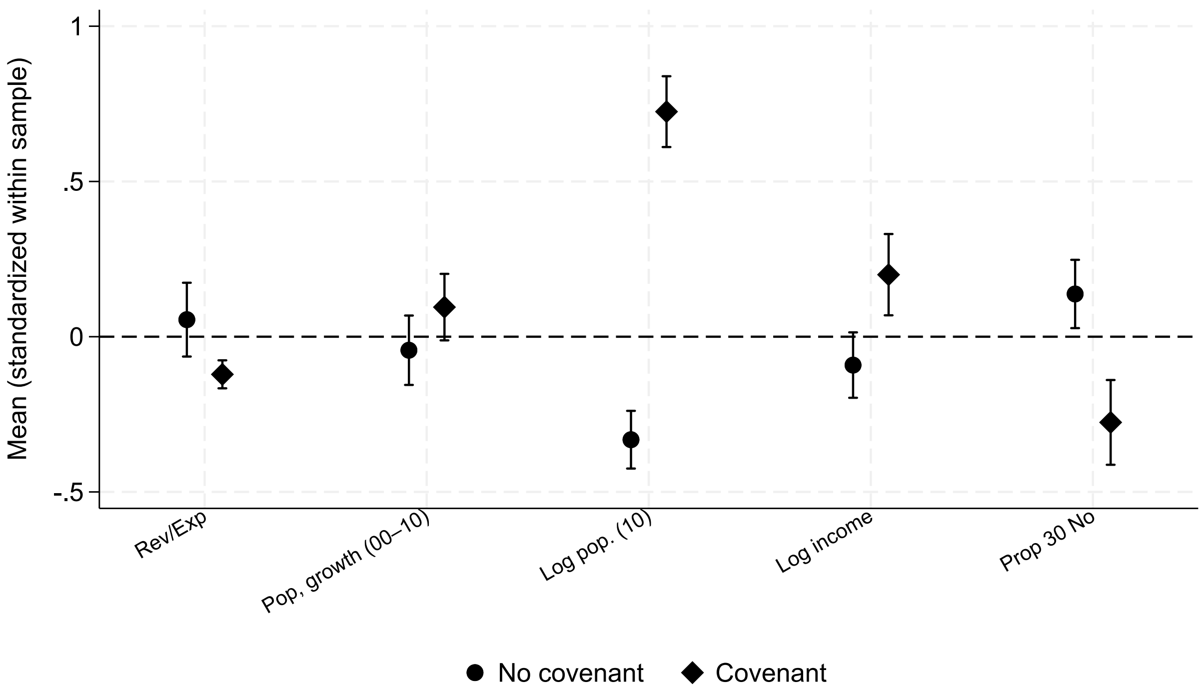


Figure 2: Rate Covenant Tightness at Issuance and Issuer Characteristics

This figure plots coefficient estimates from issuance-utility-year regressions relating covenant tightness at issuance to pre-issuance utility characteristics. The unit of observation is an issuance record j for utility i in fiscal year t; covariates are measured in the fiscal year preceding issuance:

$$\text{Cov. Tightness}_{ijt}^{\text{iss}} = \alpha + \beta' X_{i,t-1} + \gamma' 1\{\text{Underlying rating category}_{ijt}\} + \varepsilon_{ijt}.$$

Cov. Tightness at issuance is constructed from the distance to threshold in FY $t-1$, scaled by the SD of the coverage ratio over FY $t-1$ through FY $t-4$, and multiplied by -1 so higher values indicate tighter covenants. Continuous covariates in $X_{i,t-1}$ are standardized (mean 0, SD 1) in the full issuance-year sample, so coefficients report the change in covenant tightness associated with a one-SD higher covariate. Blue estimates use issuance-years in FY 2006-2019; red estimates restrict to FY $\geq$ 2013 (roughly half the sample). Circles/solid lines denote specifications omitting underlying-rating indicators; diamond/dashed lines denote specifications that add indicators for *below AA* and *NR* (omitted category: *AA or above*). Inner (outer) whiskers show 90% (95%) confidence intervals constructed from robust standard errors. Full regression table reporting coefficients using non-standardized covariates is reported in Internet Appendix Table I.B.2.

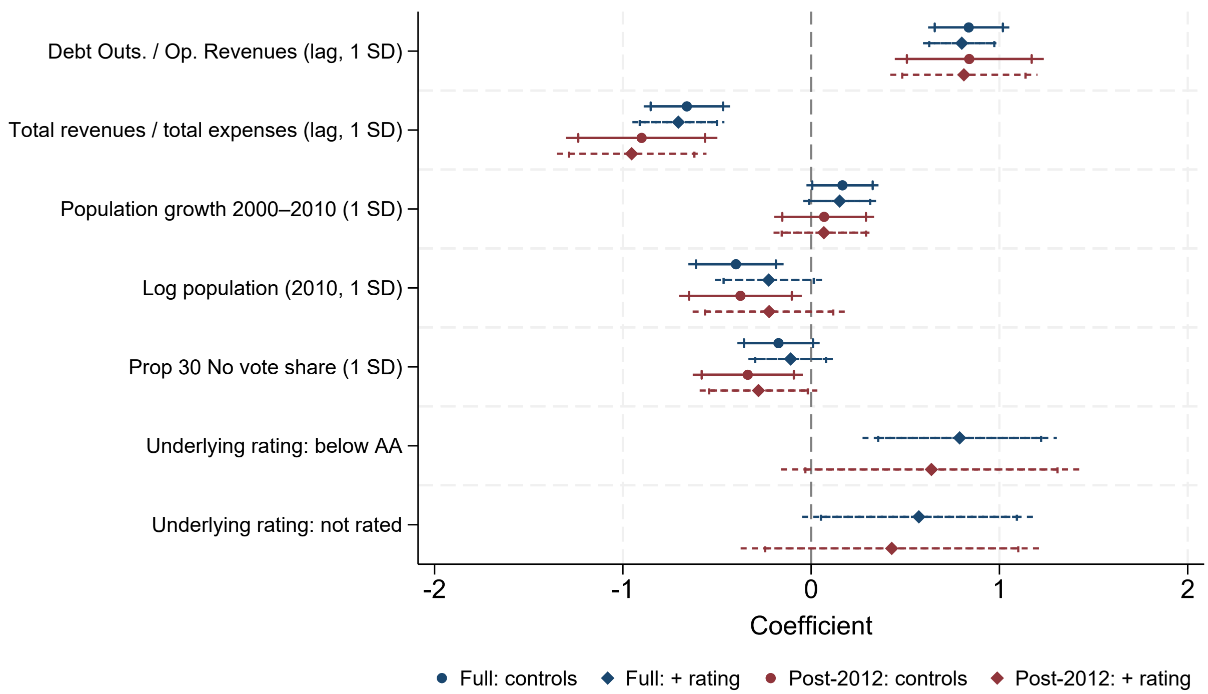


Figure 3: Distribution of Covenant Tightness in Full Sample

I plot the histogram of covenant tightness over 2003 to 2019. For this figure, $SD(\text{Coverage Ratio})_i$ is computed using each utility's full FY 2003-2019 coverage-ratio history. Coverage ratios are winsorized at the 1% level prior to constructing covenant tightness. The histogram uses 30 bins and is truncated to $[-4, 2]$, which covers 98% of observations. Bars for violation observations (tightness > 0) are shown in red; the y-axis reports bin frequencies in percent.

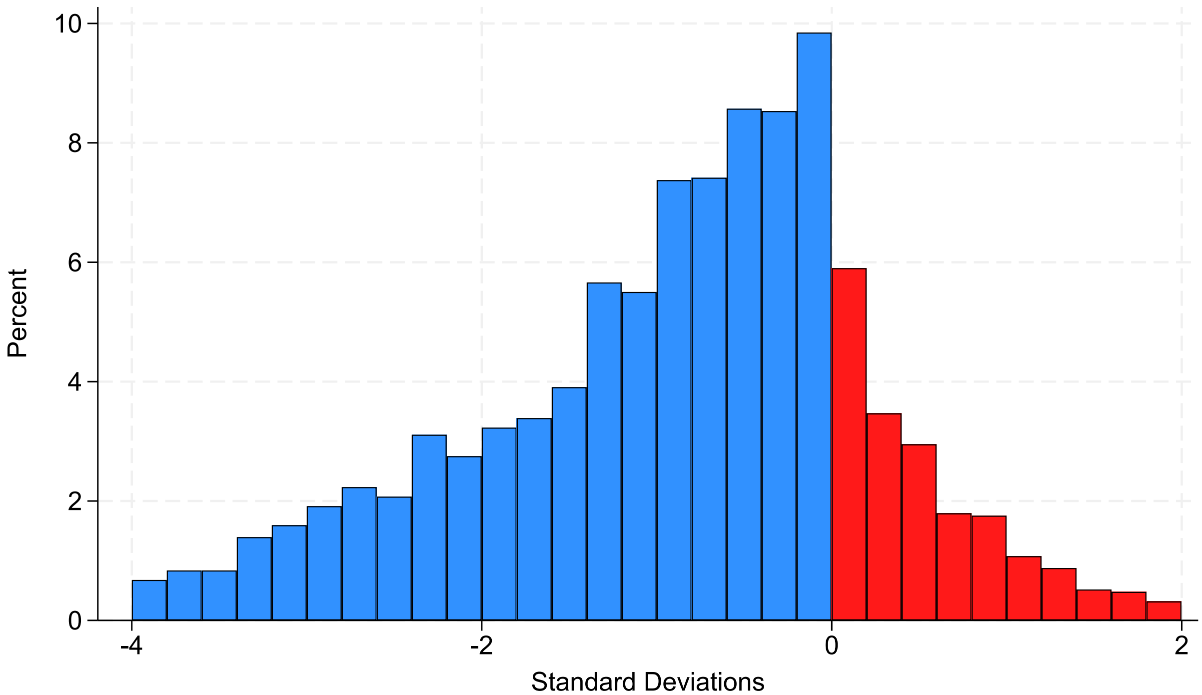


Figure 4: Robustness: Year-to-Year Effects of Rate Covenants During the Drought

This figure plots estimates of the key interaction coefficients, β from equation (1) (revenues) and γ from equation (2) (expense categories), across robustness specifications. Coefficients are shown with 95% and 90% confidence intervals.

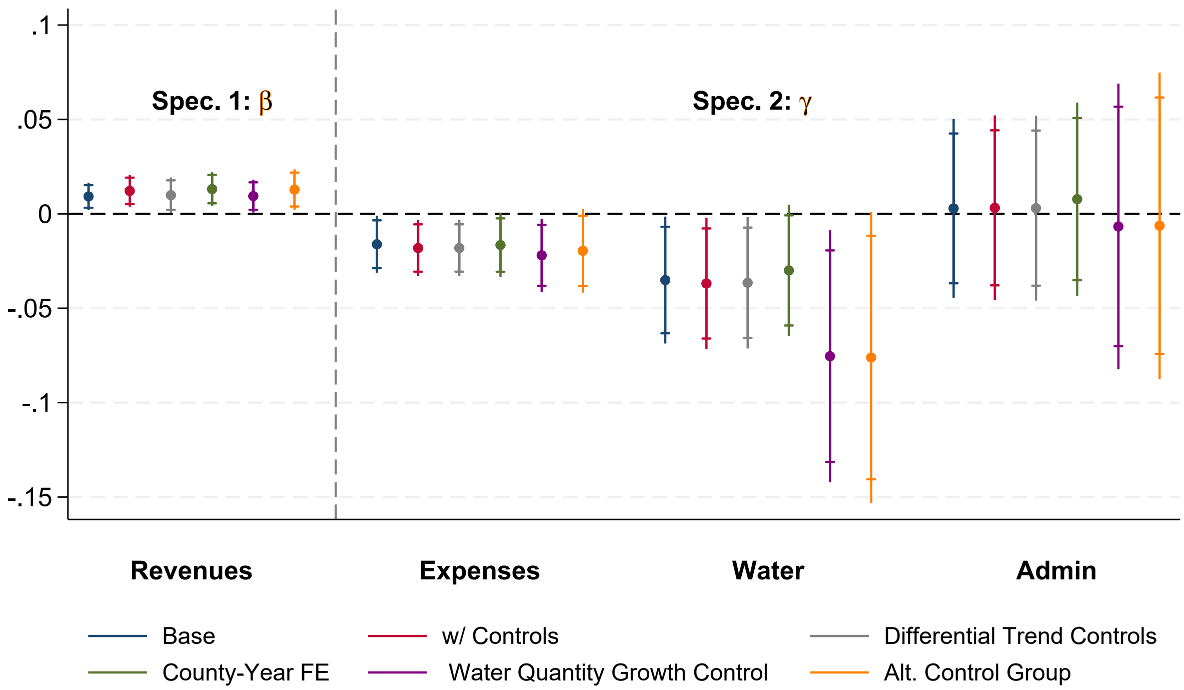


Table 1: Summary Statistics: Full Sample

This table presents summary statistics for the full sample of water utilities. Panel A presents utility-level variables for the 569 water utilities in the main analysis. Panel B presents statistics for 5,690 utility-year level observations, covering the years 2010 to 2019. Budget outcomes are winsorized at the 1% level. Coverage ratios used to construct covenant tightness have been winsorized at the 1% level. Panel C presents the cross-sectional distribution of drought intensity in each year across the sample of utilities. Drought intensity is a county-year measure of the extent of exceptional drought in a county, presented as a percent of county area.

Panel A. Utility-level

	N	Mean	SD	P25	P50	P75
Δ Total Rev/Expense Ratio, 10-13	569	0.082	0.648	-0.087	0.048	0.196
Prop 30 No Vote Share	510	0.507	0.128	0.413	0.519	0.604
Avg. Covenant Tightness Pre Period	155	-0.918	1.903	-1.651	-0.568	-0.019
Coverage Ratio SD, pre-2010	175	211.894	203.938	65.143	139.132	260.187
Population 2010 (000s)	562	60.074	219.122	1.506	10.553	46.229
Population Growth 2000-2010 (%)	562	7.336	28.182	-4.123	4.158	13.917
Median Household Income 05-09	562	61,175	23,425	44,537	56,447	72,532

Panel B. Utility-year level

	N	Mean	SD	P25	P50	P75
Debt Outs. to Op Revs.	5,690	0.569	1.286	0.000	0.000	0.375
Total Revenue to Total Expense	5,690	1.196	1.329	0.947	1.068	1.227
Water Spending to Op. Expenses	5,690	0.488	0.253	0.316	0.513	0.678
Δ Log Op. Revs	5,690	0.024	0.133	-0.041	0.016	0.084
Δ Log Op. Exp.	5,690	0.019	0.165	-0.057	0.016	0.088
Δ Log Water Exp	5,275	0.009	0.290	-0.091	0.014	0.116
Δ Log Admin Exp	5,473	0.018	0.366	-0.099	0.016	0.124

Panel C. Drought Intensity by Year

	N	Mean	SD	P25	P50	P75
2010	569	0.000	0.000	0.000	0.000	0.000
2011	569	0.000	0.000	0.000	0.000	0.000
2012	569	0.000	0.000	0.000	0.000	0.000
2013	569	0.000	0.000	0.000	0.000	0.000
2014	569	10.645	15.406	0.000	0.981	30.154
2015	569	60.169	36.292	37.102	75.339	92.072
2016	569	47.937	40.244	0.341	66.321	87.091
2017	569	15.715	20.713	0.000	0.000	38.165
2018	569	0.000	0.000	0.000	0.000	0.000
2019	569	0.000	0.000	0.000	0.000	0.000

Table 2: Pre-Drought Mean Utility Characteristics, by Treated and Control Group

This table presents the means of observable characteristics for each group of utilities in the drought analysis, along with the p-value from an equality of means test for columns (1) and (2), and (1) and (3). The percent change in county units is the percentage change in the number of housing units associated with residential building permits issued in each county between 2005 and 2010, serving as a measure of exposure to the housing bust.

	Constrained Treat Group (1)	Main Control Group (2)	Alternative Control Group (3)	P-value (1) vs. (2) (4)	P-value (1) vs. (3) (5)
Num utilities.	74	495	81		
Debt Outs. by Op Revs.	3.214	0.264	1.556	0.000***	0.000***
Total Revenues / Total Expenses	1.05	1.182	1.14	0.272	0.000***
Δ Total Revenue/Expense Ratio 2010-13	0.117	0.077	0.052	0.616	0.256
Log Population (2010)	10.571	8.791	10.902	0.000***	0.226
Log Median Household Income 05-09	11.029	10.943	11.027	0.059*	0.97
Population Growth 2000-2010 (%)	11.771	6.674	8.067	0.15	0.244
% Change in County Units 2005-10	-74.207	-75.814	-76.647	0.38	0.273
Prop 30 No Vote Share	0.487	0.511	0.459	0.146	0.128
County Unemployment Rate (%)	11.848	12.167	11.749	0.428	0.87
% of County in Exceptional Drought 2014-17	34.169	33.534	32.596	0.837	0.692

Table 3: Year-to-Year Effects of Rate Covenants During the Drought

This table reports regression coefficients of utility budget outcomes on exceptional drought exposure for rate covenant constrained and unconstrained utilities. Exceptional drought/Drought is the yearly average of each county's area exposed to exceptional drought. This variable has been standardized to have mean 0 and standard deviation 1. Constrained denotes whether a utility has a rate covenant and is in the top half of the average tightness distribution in the pre-drought period. Standard errors are clustered at the utility level. All specifications include utility and year fixed effects. I report the unconditional average of the outcome variable in each specification's sample. The SD row reports the standard deviation of the unstandardized drought exposure measure (in percentage points) used to scale the implied effects. The bottom of the table reports the effect of a standard deviation increase in exceptional drought exposure on the outcomes of interest for the constrained utilities in the sample.

Specification:	Eq 1: Unconditional			
Budget Outcome:	Δ Log Op. Revenues		Δ Log Op. Expenses	
	(1)	(2)	(3)	(4)
Exceptional Drought (std.)	-0.005*	-0.004*	-0.005*	-0.005
	(0.002)	(0.002)	(0.003)	(0.003)
Constrained×Drought	0.009**	0.012***	-0.002	-0.004
	(0.004)	(0.004)	(0.004)	(0.005)
Observations	5,690	5,620	5,690	5,620
R-squared	0.112	0.119	0.035	0.037
Utility FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes
E[Y]	.024	.024	.019	.019
SD[Drought] (%)	28.405	28.475	28.405	28.475
Exceptional Drought Effects (std.)				
Constrained	0.005	0.008*	-0.007*	-0.009*
	(0.004)	(0.004)	(0.004)	(0.004)

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Year-to-Year Effects of Rate Covenants and Tax Resistance on Spending

This table reports regression coefficients of utility spending outcomes on exceptional drought exposure for rate covenant constrained and unconstrained utilities. Exceptional drought/Drought is the county-year average share of area in exceptional drought, standardized to mean 0 and SD 1. Constrained denotes whether a utility has a rate covenant and is in the top half of the average tightness distribution in the pre-drought period. Tax resistant indicates utilities in the top half of Proposition 30 "No" vote share. Standard errors are clustered at the utility level; all specifications include utility and year fixed effects. The table reports the sample mean of the outcome and the (unstandardized) SD of drought exposure (percentage points), used to scale implied effects. The bottom panel reports the implied effect of a one–SD increase in exceptional drought exposure for unconstrained and constrained utilities in tax-resistant areas.

Specification:	Eq 2: Conditioning on Tax Resistance					
Budget Outcome:	Δ Log Op. Expenses		Δ Log Op. Water		Δ Log Op. Admin.	
	(1)	(2)	(3)	(4)	(5)	(6)
Exceptional Drought (std.)	-0.007**	-0.007**	-0.017***	-0.016***	0.007	0.007
	(0.003)	(0.003)	(0.006)	(0.006)	(0.007)	(0.008)
Constrained×Drought	0.006	0.004	0.012	0.013	0.003	-0.007
	(0.006)	(0.006)	(0.010)	(0.012)	(0.020)	(0.020)
Tax Resistant×Drought	0.005	0.005	0.016**	0.014*	-0.010	-0.007
	(0.004)	(0.004)	(0.007)	(0.007)	(0.007)	(0.008)
Constrained×Tax Res.×Drought	-0.016**	-0.018**	-0.035**	-0.037**	0.003	0.003
	(0.008)	(0.008)	(0.017)	(0.018)	(0.024)	(0.025)
Observations	5,100	5,070	4,736	4,716	4,896	4,866
R-squared	0.037	0.038	0.064	0.064	0.049	0.051
Utility FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes
E[Y]	.019	.019	.009	.009	.019	.019
SD[Drought] (%)	28.313	28.33	28.433	28.429	28.18	28.197
Exceptional Drought Effects in Tax Resistant Areas (std.)						
Unconstrained	-0.003	-0.002	-0.001	-0.002	-0.003	0.000
	(0.004)	(0.004)	(0.007)	(0.007)	(0.007)	(0.007)
Constrained	-0.013***	-0.016***	-0.024*	-0.025*	0.016	-0.003
	(0.005)	(0.005)	(0.013)	(0.015)	(0.024)	(0.016)

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Effects of Rate Covenants and Exceptional Drought on Water System Problems

This table reports regression coefficients from Equation 5, which estimates the relationship between exceptional drought intensity, rate covenants, and post-drought water system problems. Post-Drought System Problems is defined as the total number of reported problems in 2018 and 2019, normalized by the utility's 2010 service area population (per 1,000 residents). Top Quart. Drought is an indicator for being in the top quartile of the average share of county area in Exceptional Drought from 2014–2017. Constrained denotes whether a utility had a rate covenant and was in the top half of the pre-drought tightness distribution. The control group includes utilities in the bottom half of the tightness distribution and utilities without a rate covenant in effect during the drought period. Controls include pre-drought financial characteristics and service area demographics from the main panel design, along with pre-drought average operating revenues (log). Standard errors are heteroskedasticity-robust; clustered standard errors at the county level are reported where indicated.

Specification:	Eq 5: Cross-sectional Results		
Budget Outcome:	Post-Drought System Problems per 1000 People		
	(1)	(2)	(3)
Constrained×Top Quart. Drought	2.392	3.388*	3.388**
	(1.915)	(2.023)	(1.519)
Top Quart. Drought	-4.475***	-5.669***	-5.669***
	(1.243)	(1.437)	(1.977)
Constrained	-3.418***	-0.848	-0.848
	(1.268)	(1.236)	(0.869)
Constant	9.043***	84.199***	84.199***
	(0.929)	(25.418)	(24.649)
Observations	525	525	525
R-squared	0.014	0.115	0.115
Controls	No	Yes	Yes
Cluster	None	None	County
E[Y]	7.883	7.883	7.883

Robust/clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Internet Appendix

I.A Data Appendix

I.A.1 Sample Construction

My sample consists of water utilities that are either part of cities, towns, or special districts in California and that report positive operating revenues and expenses in the water enterprise schedule of the Financial Transaction Report (FTR) at some point during 2003 to 2019. City (and town) water utilities are typically housed within a city's public works or utilities department but are operated as standalone enterprise funds, meaning they are financially separate from the city's general government functions and largely independent of general tax revenues. (In practice, some cities use interdepartmental transfers to support enterprise functions, especially when no specific revenues are pledged in bond indentures.) Similarly, special districts are independent government entities formed to meet specific local needs and are typically responsible for fewer services than cities. These districts are governed by publicly elected boards and can raise taxes, but their water enterprises are financially separate from any other enterprise activities, such as wastewater or electricity.

To ensure data quality and consistency, I exclude entities with fewer than 17 years of available data in the FTR or that are lacking Comprehensive Annual Financial Reports (CAFRs), which I use to supplement missing years in the FTR.[13] I further remove special districts that are unlikely to be water providers based on key terms in the entity name.[14] Because the central economic question in this paper concerns how debt contracts shape local government operating decisions, particularly in water provision, I retain irrigation districts and other entities that may serve very small populations and include controls for population size in the regressions. For this reason, I also require a utility to have a public water system ID, which which allows me to merge the financial data with several additional data sources from the California State Water Resources Control Board. I exclude utilities that cannot be matched to a county using the Water Resources Control Board's Water System Area Boundaries dataset.

Finally, I exclude entities that either have incomplete debt data or that report revenue-bond debt service but for which I cannot locate a corresponding bond indenture with a rate covenant. This last group consists of 61 utilities that appear to have only small amounts

[13]Infrequent reporters are also more likely to be inconsistent reporters of expense categories. This screen ensures that the sample consists of reliable reporters.

[14]Key terms that are dropped include: "STORAGE", "MAINTENANCE", "RESORT", "WATERSHED", "CONSERVATION", "FLOOD", "STORAGE", "BANK", "SITES PROJECT", "DESALTER", "CONTRACTORS", "RECLAMATION", "REPLENISHMENT", "RECREATION", "RIVER", "GROUNDWATER", "WATER MANAGEMENT", "WATER AND POWER", "WATER QUALITY", "AQUEDUCT", "CANAL", "WATER FACILITIES", and "CLEAN WATER". I also remove city financing authorities.

of legacy revenue debt outstanding. Because I cannot reliably measure covenant tightness for these utilities in the pre-exceptional drought period, I do not include them in the main drought experiment. This group is distinct from the small set of utilities excluded from Figure 1 only: those 11 utilities either have legacy revenue debt outstanding in 2010 that is fully repaid by 2013, or they issue new revenue debt only after the exceptional-drought period; accordingly, they are not excluded from the drought regressions and are coded as not under an active covenant during the exceptional-drought years. By contrast, utilities that simply never issue revenue debt during the sample are retained and form part of the "no covenant" control group in the main analysis.

The base sample for my analysis consists of 569 water utilities. At this point, I use the Water Resources Control Board's Water System Area Boundaries mapping file to link each utility in the sample to geographic boundary data, which allows me to merge in demographic characteristics and my measure of tax resistance when boundary geometries are available. Second, I use the public water system ID to merge with Electronic Annual Report (EAR) data from the same agency. Not all utilities in the sample have boundary data available (even if they appear in the California State Water Resources database and have a designated county), a smaller subset have debt service and constructed covenant tightness data, and an even smaller subset has consistently and reliably reported water deliveries data (see Section I.A.8 for more details on construction of the water deliveries data). Even within the core financial dataset, not all utilities report the full set of operating revenue and expense subcategories (see Section I.A.2 for more details on these subcategories).

To clarify sample coverage, Table I.A.1 reports the number of utilities and years of data available across each relevant subsample in Panel B. I also provide a waterfall accounting of sample counts for each step of the data cleaning process in Panel A, starting with the raw FTR Water Fund Schedule data. Summary statistics for the subsamples with available data on covenant tightness and water deliveries are shown in Tables I.A.2 and I.A.3, respectively.

Table I.A.1: Sample Coverage of Various Datasets

This table presents the coverage of various datasets used in the analysis. I first present a waterfall accounting of how the various data filters affect the sample. I then I present the number of utilities appearing in the final cleaned dataset, the average years of sample coverage for utilities appearing in the dataset, and the median years of sample coverage for utilities appearing in the dataset. "Financials" refers to the Financial Transaction Reports Data. Admin Operating Expenses and Water System Operating Expenses report the data coverage for utilities that report at least one year's worth of spending in each respective category.

	Num. Utilities	Avg. Years of Coverage	Median Years Coverage
Panel A: Starting FTR Sample			
Raw data	1,346		
Positive op. revenues & expenses	1,217		
17 years of data	914		
SD key term filter	824		
Dropping fin. authorities & utils w/ data issues	817		
PWS ID and county available	630		
Filter out utils w/ rev. debt & w/o bond documents	569		
Panel B: Base Sample			
Financials	569	17	17
Admin. Op. Expenses	561	17	17
Water System Op. Expenses	544	17	17
Water Deliveries	295	7	7
Covenant Tightness	155	16	17
Demographic Sample	562	-	-

Table I.A.2: Statistics by Covenant Sample

This table includes summary statistics for the sample of utilities with a rate covenant outstanding during the drought analysis. This filter requires that: (1) utilities have coverage ratios available prior to 2010, in order to form a utility-level standard deviation; (2) have coverage ratios available for at least part of the period of 2010-2013; (3) and have a rate covenant outstanding with an identifiable threshold in the year prior to the onset of exceptional drought in 2013. There are 155 utilities in the covenant sample.

	N	Mean	SD	p25	p50	p75
Utility-Level Characteristics						
Covenant Tightness Pre Period	155	-0.918	1.903	-1.651	-0.568	-0.019
Prop 30 No Vote Share	151	0.472	0.113	0.389	0.467	0.561
Population Growth 2000-2010 (%)	154	9.823	19.637	-0.383	4.868	15.177
Median Household Income 05-09	154	64,811	21,392	49,400	61,838	75,521
Tax Resistant	151	0.358	0.481	0.000	0.000	1.000
Rate Covenant Constrained Indicator	155	0.477	0.501	0.000	0.000	1.000
Water Expenses Sample	155	0.968	0.177	1.000	1.000	1.000
Admin Expenses Sample	155	0.987	0.113	1.000	1.000	1.000
Water Quantity Sample	155	0.787	0.411	1.000	1.000	1.000
Demographic Sample	155	0.994	0.080	1.000	1.000	1.000
Utility-Year Financials						
Debt Outs. by Op Revs.	1,550	1.987	1.756	0.750	1.576	2.669
Op. Rev to Op. Exp.	1,550	1.120	0.240	0.986	1.087	1.208
Admin Spending by Total Spending	1,550	0.320	0.224	0.169	0.270	0.406
Utility-Year Outcomes						
Δ Log Op. Revs	1,550	0.022	0.113	-0.039	0.021	0.086
Δ Log Op. Exp.	1,550	0.018	0.136	-0.045	0.016	0.080
Δ Log Water Exp.	1,461	0.004	0.265	-0.076	0.011	0.099
Δ Log Admin Exp.	1,495	0.031	0.376	-0.082	0.016	0.123

Table I.A.3: Statistics by Water Deliveries Sample

This table includes summary statistics for the sample of utilities with water deliveries data available. Please see section I.A.8 for more details on how the sample was constructed. There are 295 utilities in the water deliveries sample.

	N	Mean	SD	p25	p50	p75
Utility-Level Characteristics						
Covenant Tightness Pre Period	122	-0.892	1.905	-1.760	-0.577	-0.026
Prop 30 No Vote Share	281	0.486	0.128	0.389	0.490	0.590
Population Growth 2000-2010 (%)	294	11.467	26.668	-0.512	5.149	16.059
Median Household Income 05-09	294	67,509	23,683	50,006	62,289	80,190
Tax Resistant	281	0.434	0.497	0.000	0.000	1.000
Rate Covenant Constrained Indicator	295	0.193	0.395	0.000	0.000	0.000
Water Expenses Sample	295	0.956	0.206	1.000	1.000	1.000
Admin Expenses Sample	295	0.993	0.082	1.000	1.000	1.000
Covenant Sample	295	0.414	0.493	0.000	0.000	1.000
Demographic Sample	295	0.997	0.058	1.000	1.000	1.000
Utility-Year Financials						
Debt Outs. by Op Revs.	2,950	0.838	1.479	0.000	0.000	1.345
Op. Rev to Op. Exp.	2,950	1.129	0.378	0.973	1.076	1.208
Admin Spending by Total Spending	2,950	0.327	0.227	0.172	0.276	0.422
Utility-Year Outcomes						
Δ Log Op. Revs	2,950	0.025	0.117	-0.037	0.022	0.086
Δ Log Op. Exp.	2,950	0.017	0.131	-0.043	0.018	0.075
Δ Log Water Exp.	2,763	0.006	0.248	-0.072	0.016	0.095
Δ Log Admin Exp.	2,865	0.021	0.348	-0.083	0.016	0.113

I.A.2 Constructing Expense and Revenue Categories

Subcategories of operating expenses and revenues are not standardized across utilities. This variation occurs partly because cities and special districts file different versions of the Financial Transactions Report (FTR). While aggregate items such as total operating expenses and total operating revenues are comparable across all utilities, reporting of subcategories may differ substantially. Even within the same utility type, variation in the scope of water services leads to differences in how cities and districts report expense components. I therefore make several adjustments to the data in order to allow for a consistent time series of water system expenses.

I group treatment, transmission and distribution, source of water, groundwater, and pumping expenses into a single functional category of water system expenses. Treatment and transmission/distribution are directly tied to delivering water to retail customers, while pumping and source-related costs reflect the acquisition of adequate supply. This aggregation helps smooth over reporting inconsistencies across years, as utilities often revise how they classify these expenses over time. For entities where I hand-collect data to fill in missing FTR values, I record total operating expenditures and depreciation. I then reconstruct functional expense categories using the prior year's share of each subcategory (excluding depreciation), applying these proportions to the CAFR-reported total operating expenses net of depreciation. I also minimize reporting errors caused by isolated utility-level breaks in reporting by adjusting the series to account for cases where a utility has previously reported positive and disaggregated functional water (admin) expenses but then briefly reports either no functional water (admin) expenses or consolidates all expenses under that category. For these cases, I hand-correct the affected years using audited CAFR totals or the utility's typical functional split in nearby years; for example, reallocating a one-off spike in "administrative" spending back to water-system categories, or reversing a year in which all expenses are mistakenly assigned to water. In the main drought analysis, I focus on the aggregate water system expenses rather than individual components, due to a major break in subcategory reporting that occurred during the middle of the exceptional drought period (see Section I.A.3).

Operating revenue subcategories differ by entity type. Special districts report sales revenues by customer class, while cities distinguish between residential sales revenues from within and outside city limits. I also disaggregate total operating revenues into those likely tied to water sales versus those derived from fees and other sources. For special districts, sales categories include residential, business, industrial, irrigation, interdepartmental, resale to other utilities, and other water sales. For cities, sales categories include retail sales (which is the sum of residential sales within and outside city limits), wholesale sales to other water utilities, interdepartmental sales, and other water-related sales. In some cases, utilities may historically report connection fees or standby charges within sales categories but then list them separately elsewhere in the report. To minimize errors from such inconsistencies, I use an algorithm trained on flagged cases to detect likely reporting breaks, optimizing for F1 score. When a utility shows clear shifts in categorization, typically marked by offsetting changes across categories, I adjust the sales series to smooth these transitions. In cases where reporting changes are too large or erratic to correct, such as when fees and sales are combined in inconsistent ways, I aggregate fees and sales into a single total to preserve comparability. While rate covenants generally require utilities to raise both rates and fees to meet debt obligations, this decomposition provides additional insight into how operating decisions respond to creditor protections.

Finally, I collect certain nonoperating revenue items that are frequently classified as gross revenues in bond indentures. These include investment and interest income for all reports, and certain property taxes for special districts only. The property taxes include secured and unsecured property taxes apportioned by the county. This leaves out property assessments made on a non-ad valorem basis, special assessments, and voter-approved taxes. I use total operating revenues plus investment earnings as my measure of gross revenues for cities, and total operating revenues plus investment earnings and property taxes for special districts.

I.A.3 Accounting for a Large Series Break

There were two major changes to reporting in the California Transactions Report over the time period. These occurred in both the special district and cities report forms.

1. In 2016, the instructions required reporting to be based on audited financial statements. This was a request in the previous reporting, and many entities complied. The effect of this on average was small.

2. In 2017, the report form changed and included several new categories so that the reports would be more aligned with GAAP reporting. Many entities did not change their reporting, but others did. The operating expense items added were:

    - Personnel services: salaries, wages, and related employee benefits.
    - Contractual services: "all services rendered by outside agencies, individuals, or businesses under contractual agreement to perform such services."
    - Materials and supplies: "Tangible goods that are acquired for use in a productive process. Articles and commodities that are consumed or materially altered when used (e.g., office supplies, operating supplies, repair and maintenance supplies)."
    - Other operating expenses: "All other operating expenses for which a specific reporting category has not otherwise been provided." (This category was included in special district report forms historically.)

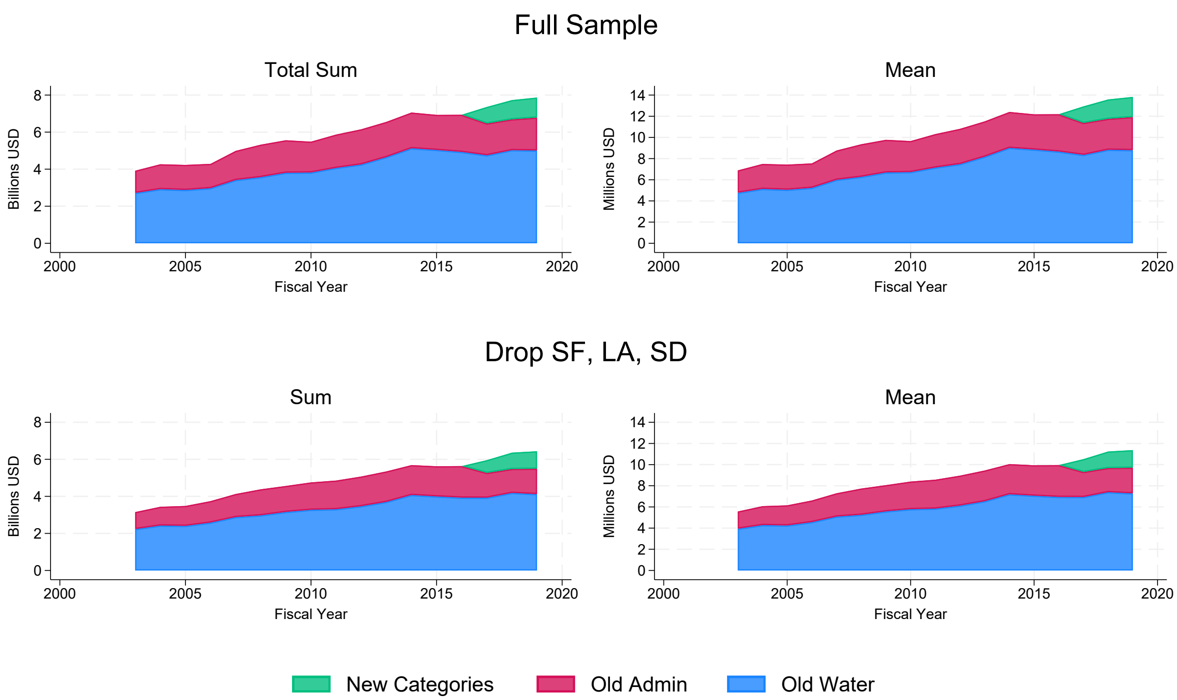
To demonstrate the series break effect, I classify expenses as follows:

- Old water: Water supply, pumping, treatment, transmission and distribution.
- Old admin: Administrative and general, customer accounting and collection, and sales promotion (not included in special district report forms, but included in city report forms).

- New categories: personnel services, contractual services, materials and supplies, other operating expenses

Effects are illustrated in Figure I.A.1. I depict the sum and the mean of expenses, and I also drop the largest cities in the bottom panels. Importantly, both water supply and administrative expenses decline in 2017. In other words, the introduction of the new categories mechanically pulls spending out of both the "old water" and "old admin" accounts, creating a break in the functional series that must be repaired before analyzing spending patterns over time.

Figure I.A.1: Effect of Series Break: All Utilities



I make the following proposed adjustments, based on the definitions of the new reporting categories:

- New water: Water supply, pumping, treatment, transmission and distribution, contractual services, materials and supplies.

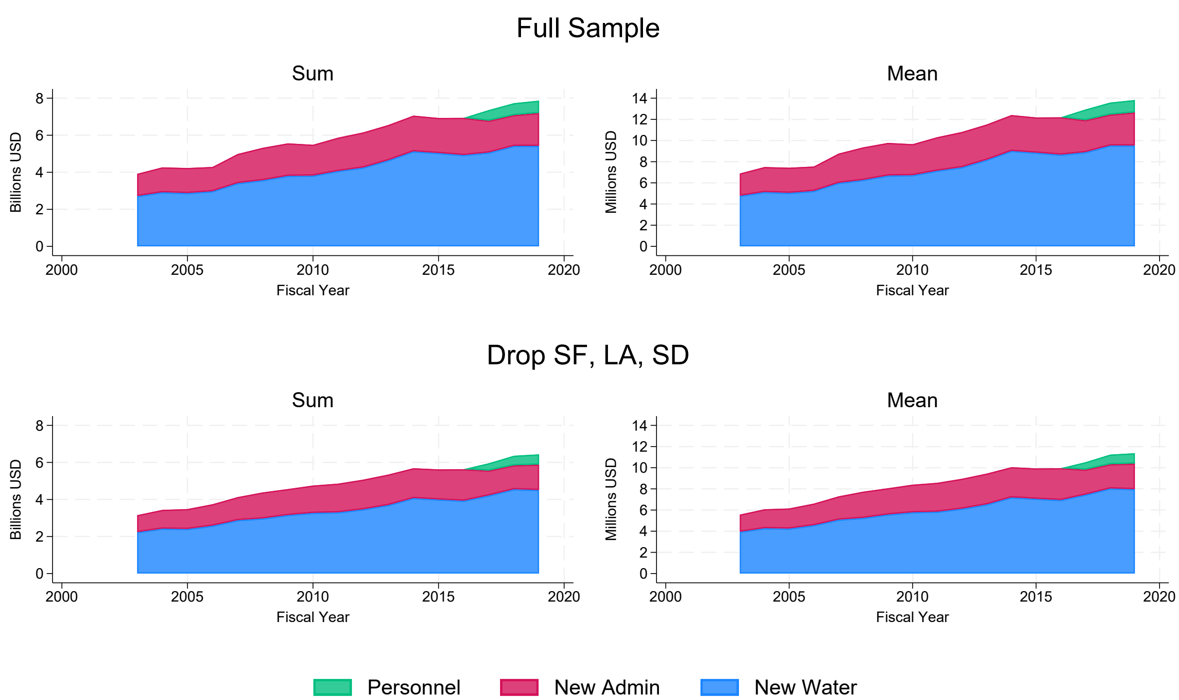
- New admin (non-personnel): Administrative and general, customer accounting and collection, sales promotion, other operating expenses.

- Personnel services: assigned to the administrative bucket in the adjusted series; shown separately in Figure I.A.2 to highlight its contribution.

The proposed categories are presented in Figure I.A.2. In terms of both averages and sums, the breakdown appears to capture the time series variation in these expense categories. There is a slight uptick in water expenses outside of the three largest cities, but this appears to capture the overall trend in operating expenses. Two considerations motivate this specific mapping. First, the examples in the report form point to "Materials and supplies" and "Contractual services" as items closely related to system operations (e.g., operating supplies, repair and maintenance supplies, and outside services), which historically would have been charged to functional water accounts and now are broken out for GAAP alignment. Second, the series-break figures show that allocating these two categories back to "water" restores the pre-2017 level and trend of water-system spending much more closely than alternative classifications.

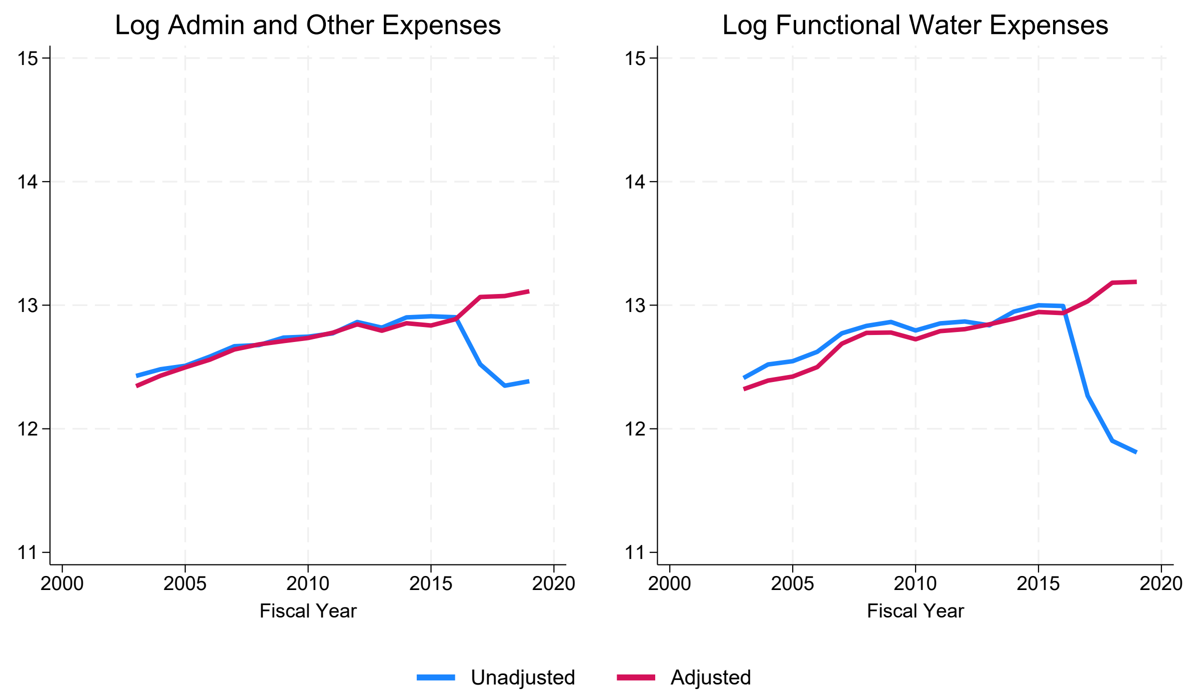
In the adjusted series used in the analysis, personnel services is included in administrative spending. "Personnel services" is explicitly defined as salaries and benefits, and in practice is likely to capture spending on overhead positions (e.g., management, finance, HR, legal). For this reason, and to be conservative about reallocating labor costs across functional categories, I include personnel services in the administrative bucket rather than assigning it to water-system spending.

Figure I.A.2: Proposed Categories: All Utilities



I plot the log of the adjusted and un-adjusted series for both the administrative/other expense category and functional water expenses in Figure I.A.3. Importantly, when implementing the 2017 series-break reclassification, I readjust the proposed series so that if a utility consistently reports zero functional water expenses or zero admin expenses over the sample period, they continue to do so. That is, the global reclassification of new 2017 categories is constrained not to create water or admin spending where a utility has always reported none; this is distinct from the one-off reporting-break corrections described in Section I.A.2.

Figure I.A.3: Proposed New Categories: Final Time Series (Log 1+ X)



I.A.4 Identifying Revenue Bonds

I identify debt backed by a pledge of water-system revenues in order to construct a hand-collected dataset of rate covenants, their thresholds, and pledged revenue bond debt service. I start from the debt service schedules reported in the FTR rather than issuance data, because many cities and special districts issue bonds through conduit entities (such as joint powers or financing authorities) that can be difficult to trace from issuance records alone. Beginning with debt service records provides a clearer picture of each utility's actual payment obligations, including those associated with conduit-issuer debt.

For cities, I identify water revenue bonds by filtering the debt schedules to include only certificates of participation and revenue bonds. I then perform string searches to flag obligations related to water. Wastewater bonds are excluded, and when water and wastewater are jointly pledged, I disaggregate the obligations using information from bond official statements where available; if a joint pledge cannot be separated, I conservatively exclude the obligation from analysis. Because most revenue bonds issued by California cities prior to 2017 appear on the capital lease obligation schedule, I apply the same string-search methodology to that schedule as well. These certificates of participation are ultimately backed by utility revenues but are structured as lease agreements, typically between a city and a conduit issuer such as a financing authority in order to avoid certain legal or voter approval requirements. Although these obligations function economically like traditional revenue bonds, they are often reported under capital lease obligations rather than as bonded debt in the FTR.[15] I exclude equipment leases from the analysis, since they are typically backed by the financed asset rather than utility revenues. I treat the Construction Financing and Other Long-Term Debt Schedules as a secondary source: I draw on these schedules only when an issue is inconsistently reported across schedules or years, is known from bond documents to be a revenue bond, or can be traced to a revenue-bond or capital-lease schedule at some point in time.

Because special districts provide a narrower range of services than cities, identifying water revenue bonds involves fewer steps. I begin with the same long-term debt and capital lease schedules from the special district reports, filtering to revenue bonds and certificates of participation. While special districts report fewer bonds under capital leases compared to cities, they report more bonds under other types of debt classifications. Since most special district bonds are backed by water-system revenues, I start with the full set of bonds and then remove those that are explicitly backed by other revenue sources; aside from this step, the identification process mirrors the one used for cities.

After this FTR-based pass, I verify and refine the list of candidate water revenue bonds using the California Debt and Investment Advisory Commission (CDIAC) database. First, I hand-match identified bonds to the CDIAC database of debt issuances, using information like the total principal amount, the offer year, and the city or special district name (or the corresponding financial authority). After matching, I confirm that the identified bond proceeds are designated for Water Supply, Storage, and Distribution or for Public Works and Capital Improvements, and that the debt type is classified as a revenue bond or certificate of participation. I also use the CDIAC database to identify additional water-related bond issues that may have been missed in the initial FTR filtering and then locate those issues in the "other liability" schedules. I exclude any bonds backed by tax assessments, lease payments without a lien on revenues, or classified as general obligation bonds.

[15] Analyses based solely on bonded debt totals in the historical FTR data would significantly understate cities' true bonded obligations due to this practice.

I.A.5 Constructing Pledged Debt Service

I construct pledged revenue bonded debt service by summing principal and interest payments made in each fiscal year for the set of identified bonds. In cases where debt is defeased but the defeased amount is incorrectly reported as a principal payment rather than as an adjustment, I recode the principal payment to zero. I also check for consistency in reported outstanding balances across years. When defeased debt is removed from the balance sheet but the corresponding refunding debt does not appear until the following fiscal year, I adjust the year-end outstanding amount to account for the timing gap. These adjustments ensure continuity in the measurement of outstanding debt.

I also take several steps to clean the data. In cases where debt service information is missing for a limited number of years, I hand-collect the data from CAFRs and bond indentures (e.g., the City of San Diego in 2006 and 2010). If a city has substantial gaps in its data and no CAFRs available to verify outstanding amounts, I exclude it from the sample altogether. I correct common reporting errors, such as duplicate debt obligations reported simultaneously under both bond and lease schedules, and inconsistencies in carrying forward beginning outstanding balances, which can affect the reported principal payments in some cases. I include state and federal loan debt service only when the utility also has an outstanding revenue bond and the bond indenture explicitly lists these loans as prior obligations. As an additional data quality filter, I drop utilities where revenue debt service exceeds revenue debt outstanding.

For special districts, issue-level interest payments are not reported from 2003–2016. In these cases, I rely on total interest expense at the water fund level. This approach may overstate interest payments for large districts with taxing authority that also issue general obligation bonds. As a sensitivity check in Table I.A.4, I examine how much water fund interest expense exceeds interest paid on water revenue debt between 2017 and 2019 for a large sample of special districts, when both items were included in the FTR report. I normalize this difference by water revenue debt outstanding at the end of the year. At the 25th through the 50th percentiles, the discrepancy between these two categories is zero, indicating that the approximation is very close for the bulk of the sample; the mean is driven by a small number of outliers in the tails (at the 1st and 99th percentiles). On average, the discrepancy is less than 1% of revenue debt outstanding (21.3 bps on average).

I.A.6 Verifying Coverage Ratios using Financial Statements

This paper is the first, to my knowledge, to construct debt service coverage ratios for a large sample of local government entities. To do so, I leverage data from the California

Table I.A.4: Interest Expense Sensitivity CHeck

	count	mean	sd	p25	p50	p75
Int. Expense - Int. Paid as % of Revenue Debt Outs.	388	0.213	13.077	0.000	0.000	0.882

Financial Transactions Report (FTR), which allows for broad coverage across cities and special districts. The FTR offers several advantages. First, it is filed close to the fiscal year-end reporting deadlines used by bondholders to evaluate financial performance, increasing its relevance for covenant compliance. Second, because the FTR is not as widely scrutinized or publicized as annual financial statement filings, it is less likely to be shaped by incentives to present overly optimistic financial results.

However, there may be questions regarding the accuracy of FTR-based coverage ratios, particularly when compared to the audited reports submitted to bondholders under indenture agreements. These concerns echo common challenges in the corporate covenant literature, where researchers have documented challenges in consistently measuring maintenance covenants like coverage ratios due to small but impactful variations in construction and limited disclosure of those details in standard databases (Demerjian and Owens, 2016).

To assess the validity of the FTR-based ratios, I hand-collect debt service coverage ratios from Comprehensive Annual Financial Reports (CAFRs) for a subset of utilities. All CAFRs include a statistical section, and most with pledged revenue bonded debt include a "Pledged Revenue Coverage" table. This table typically breaks out debt service coverage ratios by revenue stream (e.g., water vs. sewer bonds) and may report up to ten years of historical data. While this section is not audited, the calculations are more like to be derived from the audited financials presented elsewhere in the CAFR.

I identify utility-year pairs with FTR-based coverage ratios using my constructed debt service data. For these utility-year pairs, I then try to retrieve corresponding CAFRs through the MSRB's EMMA website and from city and special district websites. When historical CAFRs are unavailable, I use the historical data within the earliest CAFR to backfill the series. I also track revisions in reported ratios across successive CAFRs to capture any restatements or corrections.

Coverage of this CAFR data is limited by both disclosure practices and reporting format. Cities are more likely than special districts to publish full CAFRs rather than abbreviated financial statements, which tilts the sample towards cities. On average, I am able to collect CAFR-based coverage for 128 utilities, of which 88 are cities, matching 58% of the utility-years covered by the FTR data (median: 65%). To more easily compare the distributions, I winsorize coverage ratios at the 1% level to address extreme right-tail values in the CAFR data.

Figure I.A.4 compares the distribution of coverage ratios derived from FTR and CAFR data. The distributions are broadly similar, but differences remain. Notably, CAFR-based ratios appear more optimistic: they are more likely to show coverage just at or above the 100% threshold, suggesting sufficient pledged net revenues to meet debt service. The CAFR distribution also has a slightly longer right tail, consistent with selective reporting of strong financial performance.

The effect of using CAFR-based coverage ratios is to shift the entire distribution of covenant tightness to the left, implying that utilities appear less constrained by their rate covenants, on average, than what the FTR data would suggest. However, because treatment assignment in the main analysis depends on the relative ranking of utilities rather than the absolute level of covenant tightness, this shift should not meaningfully affect treatment assignment. Although limited data availability prevents a perfect comparison, I provide evidence in Figure I.A.5 that the CAFR-based tightness measure distribution is generally left-shifted for most utilities in this subsample.[16] This pattern is evident among utilities close to the treatment threshold, which in the main sample corresponds to a covenant tightness measure of approximately -0.56 standard deviations.

The figure plots the histogram of the difference between CAFR-based covenant tightness measures and FTR-based covenant tightness measures for utilities in the matched subsample whose FTR-based tightness measure falls within two standard deviations of their covenant thresholds. A negative number in this difference means that the CAFR tightness measure is more negative, and thus "looser". Among the 74 utilities in this subsample, 69% would be classified as less constrained (i.e., looser) when using the CAFR-based data. Among the group of utilities that would appear more constrained under the CAFR measure, no utilities would be newly classified as treated given the CAFR data and using the -0.56 standard deviation threshold for treatment assignment that appears in the main sample.

[16] Calculating covenant tightness requires coverage ratio histories from 2010–2014, as well as pre-2010 data to compute historical standard deviations.

Figure I.A.4: Comparison of FTR Coverage Ratios to CAFR Coverage Ratios

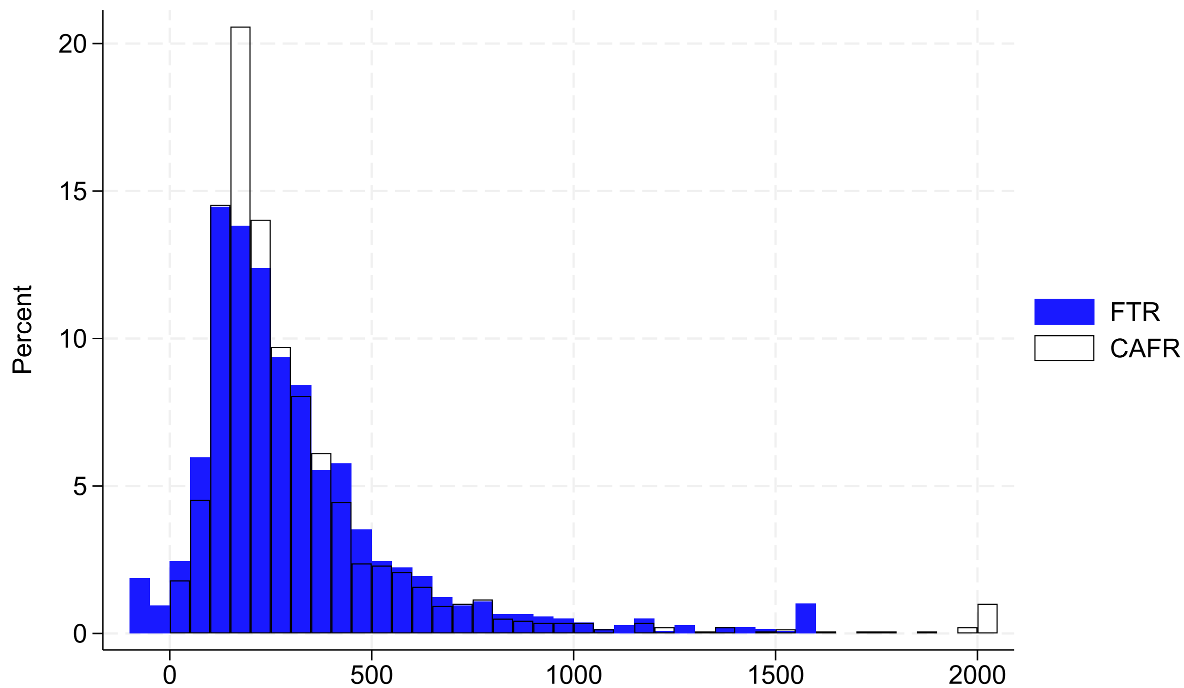
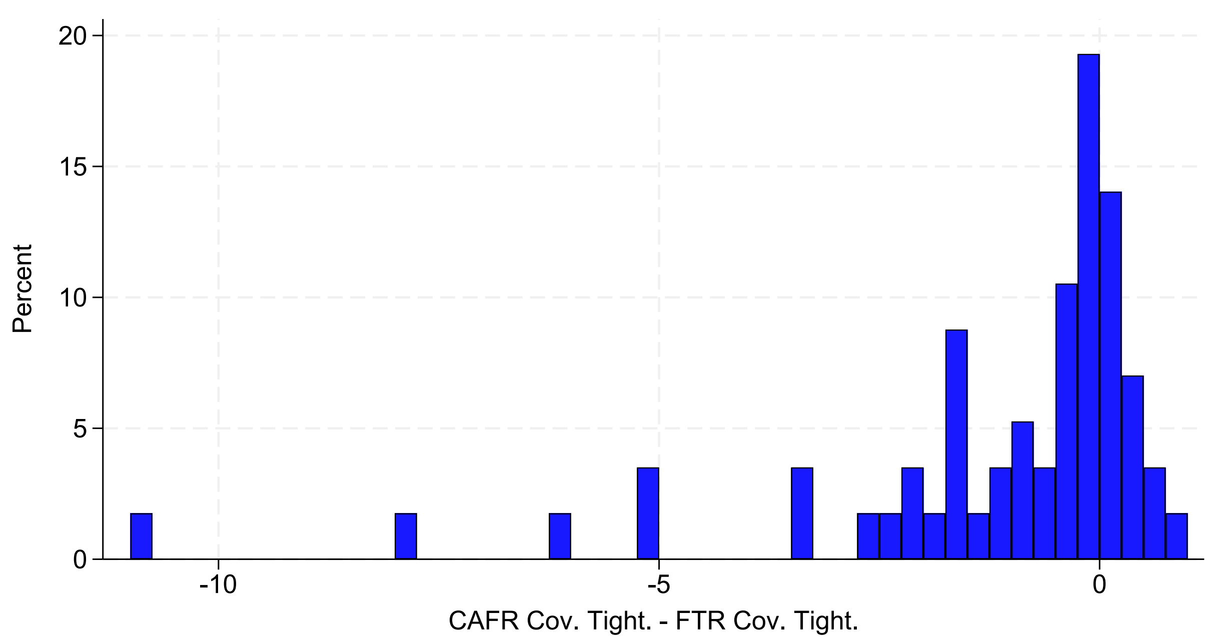


Figure I.A.5: Comparison of FTR Covenant Tightness to CAFR Covenant Tightness



Note: Difference presented for utilities within 2 SD of covenant thresholds, using FTR measures.

I.A.7 Comparison to the Local Government Census

The Financial Transactions Report dataset has several advantages relative to existing government finance databases, like the Census of Governments. First, the FTR includes more frequent reporting for small government entities than the Census, which is biased toward larger governments in its annual coverage. Second, the fund-level data allows entities to classify operating expenses according to an operating function, allowing for a breakout between administrative spending and other water system spending.

To assess relative data coverage, I begin by matching the government Census data to the cleaned FTR data. This allows me to evaluate how many utilities are missing from each dataset and compare reporting patterns.[17] I use the Government Finance Database from Pierson et al. (2015), which provides a standardized version of the Census of Governments data. I define the Census sample as all utilities that reported positive water utility revenues in at least one year between 2002 and 2019.[18] I also apply the same keyword-based filter used in the main sample to remove special districts that are likely not water providers (see Section I.A.1). I manually clean and match name strings across the two datasets.

Out of 1,059 utilities appearing in either the FTR or Census data, 78 utilities in my initial FTR sample do not appear in the Census. In my final drought analysis sample of 569 utilities, 36 utilities do not appear as Census reporters.[19] Conversely, 242 utilities appear in the Census but are not covered by the FTR data. However, most of these missing utilities are not annual reporters in the Census. The Census of Governments generally collects annual data from larger governments, while smaller entities report only every five years.

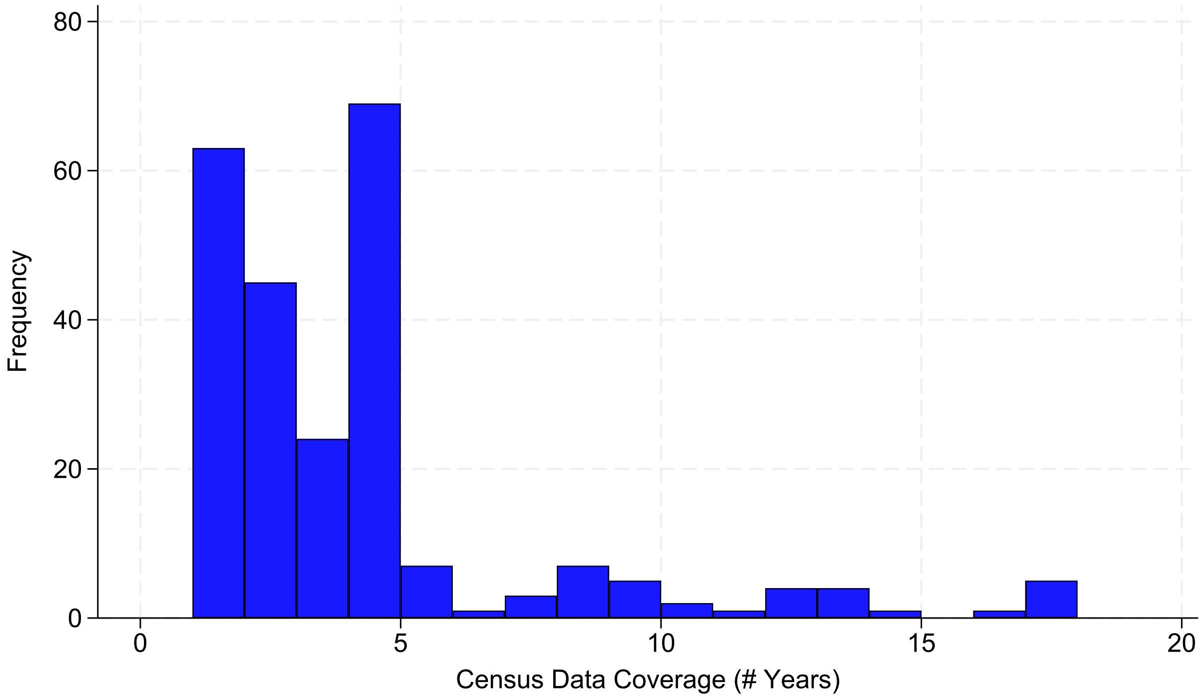
For the 242 utilities that appear in the Census but are not covered by the FTR, Figure I.A.6 shows the distribution of utilities by number of years reported in the Census. Eighty-three percent of these Census-only utilities appear in four or fewer years (typically Census years 2002, 2007, 2012, and 2017). Only two of these Census years fall within the drought sample period of 2010-2019, and none capture the peak years of exceptional drought (2015-2016). Moreover, only five of these Census-only utilities would meet my FTR sample data quality threshold of 17 years of full reporting.

[17] This comparison is based on the sample prior to applying final filters, which exclude entities not matched to California State Water Resources Control Board data or lacking complete rate covenant data.

[18] I include 2002, even though it falls outside the FTR's sample period, in order to avoid understating coverage due to the Census's five-year schedule (years ending in 2 and 7).

[19] These are primarily county service areas and individual county waterworks, which are more sparsely covered in the Census.

Figure I.A.6: Coverage of Census Data for Entities not in the FTR Data

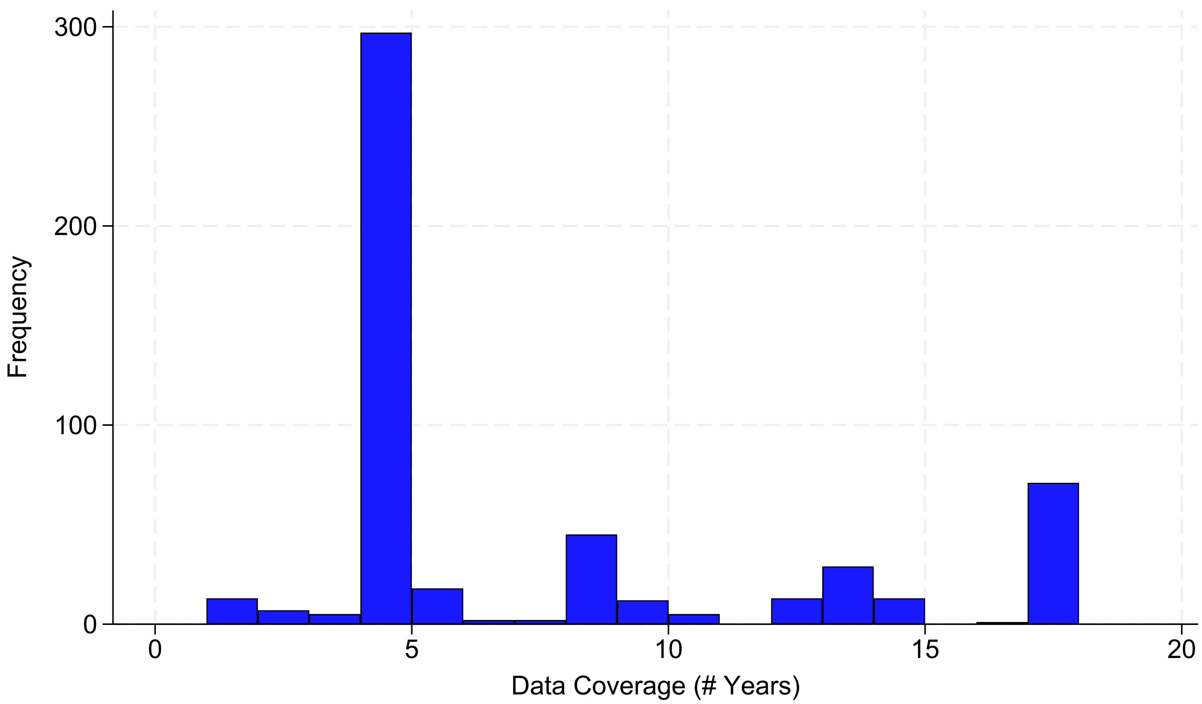


I next examine data coverage and quality for the subset of utilities that appear in both the Census and the FTR. For this comparison, I restrict the sample to the 569 utilities included in the drought analysis. Figure I.A.7 summarizes Census coverage for this drought-sample subset. As in the full FTR data sample, coverage in the Census is more limited: 56% of these utilities report only in the five-year Census, and only 71 have at least 17 years of data. To assess consistency across these two sources, I merge the final drought dataset to the Census data for the years 2010 through 2019. In Table I.A.5, I compare FTR-reported operating revenues and operating expenses to their equivalents in the Census dataset, representing the difference in percentage terms. On average, the two series differ by less than 5%, with a difference of zero at both the median and 25th percentile. While there are some outliers, as reflected in the large standard deviations, most discrepancies appear to originate from rounding differences.

Table I.A.5: FTR Comparison to Census Data

	count	mean	sd	p25	p50	p75
% Diff in Op. Revenues	2,011	2.527	19.036	0.000	0.000	1.917
% Diff in Op. Expenses	2,011	4.738	53.493	0.000	0.000	0.826

Figure I.A.7: Coverage of Census Data for Drought Sample Utilities



I.A.8 Constructing Water Deliveries Data

There are two main sources of water quantities data reported by California water utilities. The California Water Boards Electronic Annual Reports (EAR) are required to be filed by all public water systems on an annual basis, and are available for years 2013 through 2019. The report form has changed since its inception, but it has always required utilities to report on both quantities of water produced as well as metered water deliveries. The main advantages of this data are its granularity and the coverage. For all public water systems in California, I can measure aggregate metered water deliveries in addition to water deliveries by sector (single-family residential, multi-family residential, industrial, commercial, etc.). However, a disadvantage of this data is that units of water are not standardized across water utilities or across reports. As an added complication, many water utilities report inconsistent units across time or report incorrect units that misrepresent the total quantities of water deliveries.

The California Water Boards has also periodically mandated that public water systems submit Drought and Conservation Reports. Drought and Conservation Reports include information on: total potable water production (which excludes deliveries to other water systems); commercial agricultural water usage, commercial, industrial, and institutional water usage; and daily residential water usage in gallons per capita. Large urban water systems have been required to submit this report on a monthly basis since 2014, with review by the California Water Board staff to audit and verify the data. Small water water systems were required to submit this report twice, in 2015 and 2016, with little auditing by staff. Both large and small water systems report water quantities data relative to 2013 numbers, so the data is available for years 2013 and 2015 through 2019. Data is only available for the second half of 2014, because reporting was mandated in June 2014.

However, both sets of Drought and Conservation Reports have consistent treatment of units (gallons) across utilities and years. Table I.A.6 below provides summary statistics on the utility-level standard deviation of water quantities measured in million gallons from both the Electronic Annual Reports in the first row and the Drought and Conservation Reports in the second row for a sample of 275 large urban water suppliers. On average, there is much more within-utility variation in the Electronic Annual Reports. This reflects substantial reporting inconsistencies that remain even after converting water quantities to million gallons using the EAR-reported units.

Table I.A.6: Distribution of Within-Utility Standard Deviation of Water Quantities Delivered

This table presents the cross-sectional distribution of utility-level standard deviation of annual water quantities reported in million gallons (MG) data for three different sources. The first row is Electronic Annual Reports data, after converting to million gallons using the units provided in the report. The second row is the Conservation Reports production data excluding agricultural water for Large Urban Water Systems, reported in MG. The third row is the Electronic Annual Reports data after using the adjustment factor as described in the appendix.

	count	mean	std	25%	50%	75%
EAR Annual Data (MG)	327	22,349,267.13	183,778,028.66	73.82	266.31	690.93
Conservation Reports Annual Data (MG)	275	831.53	1776.35	199.02	433.63	899.27
EAR Annual Data Cleaned (MG)	327	405.36	778.08	74.42	196.21	470.18

To deal with this issue, I construct monthly aggregates in the EAR data and merge these aggregates to the Drought and Conservation Reports. I construct an "adjustment factor", which is defined as a utility's total monthly potable production excluding agricultural reported in the Drought Reports, divided by a utility's total monthly water deliveries, excluding agricultural deliveries and deliveries to other water systems, as reported in the EAR. When a utility does not have Drought Report data available, for example, in the systematic first-half 2014 gap, I create a pseudo adjustment factor based on the average adjustment factor for the same utility, for the same EAR-reported unit of measure, in the same reporting year.[20] My measure of total monthly deliveries for 275 utilities with monthly Conservation Reports is constructed as the product of the reported metered water delivery times the relevant adjustment factor in a particular month, which is equal to the Drought Conservation Report total by construction when the Conservation Reports are available. Because the Conservation Reports report water production, this may differ from actual delivered volumes due to distribution losses (e.g., leaks or theft). The interpretation of the results relies on the assumption that these losses are small and/or relatively stable over time, so that changes in production primarily reflect changes in customer use. Throughout the paper, I refer to this measure as "deliveries" for simplicity.

I supplement this data with an additional 52 utilities that only have small water supplier Conservation Reports available. These water supplier reports have monthly data available, but only for the years 2013, 2015, and 2016. The small water supplier reports also report total potable production, which includes water sold to agriculture but does not include water thefts, leaks, or water sold outside of supplier service areas. I use these limited Conservation Reports as a data-quality screen for the EAR reports for small utilities.

I first convert monthly EAR data to gallons using the reported units of measure and construct a total potable production proxy by adding agricultural water to the potable water total. I then merge the EAR totals to the Conservation Reports in the overlap years (2013, 2015, 2016) and compute, for each utility, the average monthly absolute deviation between EAR and Conservation quantities, normalized by EAR potable water. Because these small utilities have Conservation Reports only in limited overlap years (2013, 2015, 2016), the merged data is too sparse to estimate a reliable utility-specific adjustment factor; I therefore use the Conservation Reports only as a data-quality screen. I retain only utilities with seven years of EAR data (2013–2019) whose average deviation in the overlap years is below 25% of EAR potable water; for the 52 utilities that meet this screen, I use the EAR data as reported in all years.

This procedure is designed to exclude small utilities with large and persistent reporting problems, but it cannot rule out isolated misreports in non-overlap years. The 25% threshold

[20]In the small number of cases with isolated missing months within a report year and unit of measure (rather than the first-half 2014 gap), I use the average adjustment factor for the same utility and the same EAR-reported unit of measure.

helps to ensure that only utilities whose EAR data track Conservation Report quantities reasonably well enter the final water sample.

Throughout the analysis, the water sample is defined by intersecting the cleaned EAR -Conservation dataset with the final cleaned financials dataset, resulting in 327 utilities, rather than with the full drought-analysis sample. When I apply the final data filters, there are 295 utilities in the drought sample that have water data available.

The third row in Table I.A.6 reports the within-utility standard deviation of water quantities using the adjustment factor as well as the small water suppliers that pass the data quality threshold. At the mean and across all percentiles, there is much less variation and reporting variability when using both the Conservation Reports and the EAR to create a measure of water deliveries.[21] Therefore, I am less likely to introduce substantial measurement error into my data by using this method. This data also has the advantage that I have a full time series of annual water quantity data from 2013-2019, including sectoral breakouts, that would not be available from using the Conservation Reports alone. Finally, I construct annual sector-level water quantities. To do this, I apply the adjustment factors to the monthly EAR sector-level delivery data, covering commercial and institutional, industrial, landscape irrigation, multi-family residential, single family residential, agriculture, other, and other public water systems. I then sum these monthly values to the annual level by sector for each utility in a given year.

[21]The larger variability in the Conservation Reports relative to the cleaned EAR series primarily reflects missing data from the first half of 2014.

I.B Descriptive Evidence on Rate Covenants and Issuance

I.B.1 CDIAC Issuance Data Descriptive Statistics and Coverage

With the sample of identified water revenue issues and associated debt service, I hand match bonds to the California Debt and Investment Advisory Commission (CDIAC) database of debt issues. California requires all municipalities to report debt issuance to the CDIAC, including private placements since 2012. Features of the dataset include the issuer name, type, project, rating, source of revenues pledged, as well as pricing information and the purchaser/lender. The CDIAC also posts the issuance documents for bond issues. Using this database of issuance documents, I hand collect data on bondholder protections, including details on rate covenants. CDIAC numbers identify filings in CDIAC's database and do not map one-to-one to distinct bonds or offering documents; multiple CDIAC-number records can reference the same offering document or issue. The level of analysis in this appendix is CDIAC-record. In my matched data, 921 CDIAC-number records are linked to water revenue debt between 2003 and 2019, and I am able to locate usable offering documents for 585 of these records. Records associated with debt issued prior to 2003 are substantially less likely to have publicly available documents.

In Figure I.B.1, I show the distribution of debt records by issuance year for the sample of utilities with debt service data available in the left plot. There was an overall increase in the number of debt records during the 2000s and from 2018-2019, along with a drop-off from 2014 to 2016. The covenant tightness measure in the draft depends on hand-collected data on rate covenant thresholds. Unfortunately, not all debt records have readily available issuance documents. Therefore, I plot the sample of debt records that have details on bondholder protections in the right plot of Figure I.B.1. Coverage of bondholder protections is spotty for bonds issued prior to 2000, due to the absence of publicly available issuance documents for this subset of bonds. The sample is most comprehensive for bonds issued during or after the year 2004.

I next plot the time series of total annual issuance of revenue debt for water utilities in the sample against my measure of revenue debt outstanding in Figure I.B.2. Annual issuance through the debt markets rises from about $1 billion per year in the 1990s to a peak of roughly $5 billion in 2010. Over the later period of the sample, total debt outstanding in the sample increases from around $8 billion in 2003 to about $20 billion in 2019.

To benchmark these patterns against the broader municipal market, Figure I.B.2b plots total municipal debt outstanding using the Federal Reserve's Z.1 release.[22] The bottom-left

[22]Due to a structural break in the Flow of Funds data, I start the plot in 2005.

panel shows that municipal debt outstanding increased through the 2000s, with a pronounced rise around 2010, coinciding with American Recovery and Reinvestment Act (ARRA) provisions that supported municipal borrowing. Debt levels then contract somewhat between 2013 and 2015. The bottom-right panel compares trends in debt outstanding in the national municipal market and in my sample of California water utilities by indexing both series to a 2005 base year. Debt levels for California water utilities expand more rapidly than in the broader municipal market, reflecting the importance of ARRA and related policies for infrastructure finance, but growth in new debt slows in both series after 2011.

Figure I.B.1: Distribution of Sample Issuance Years

I plot the number of debt records that I match to the debt service sample by the year of issuance. The left plots the full distribution of debt records. The right plot limits the sample of debt records to those with issuance documents readily available.

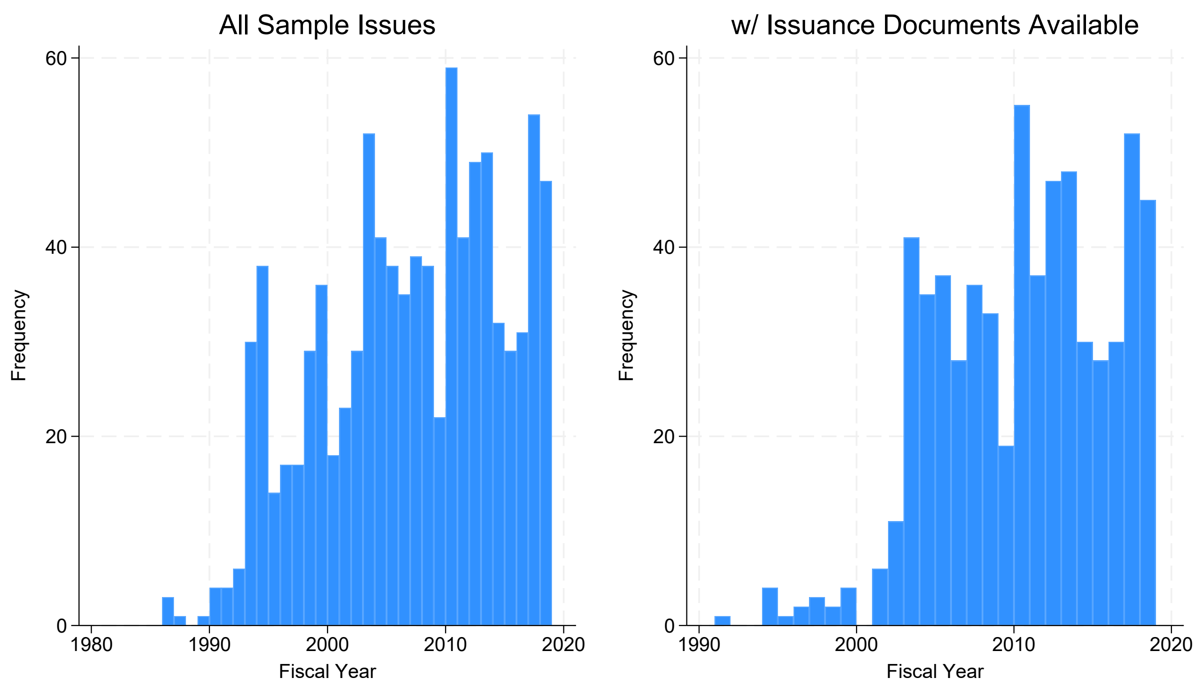
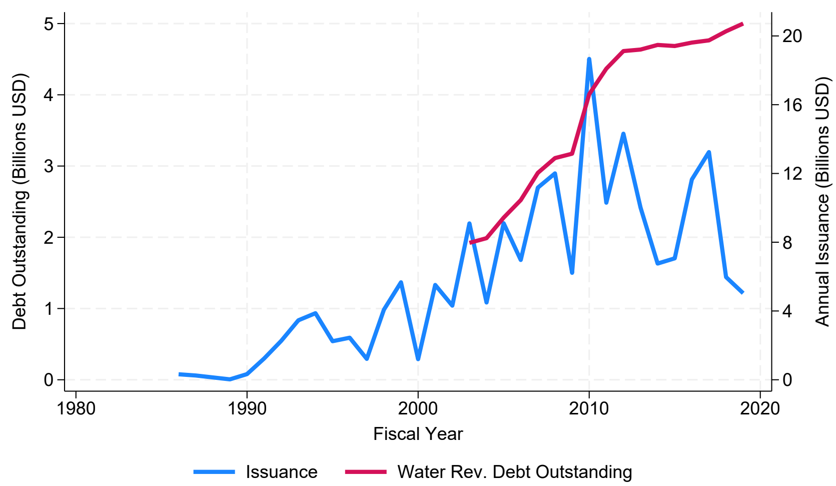


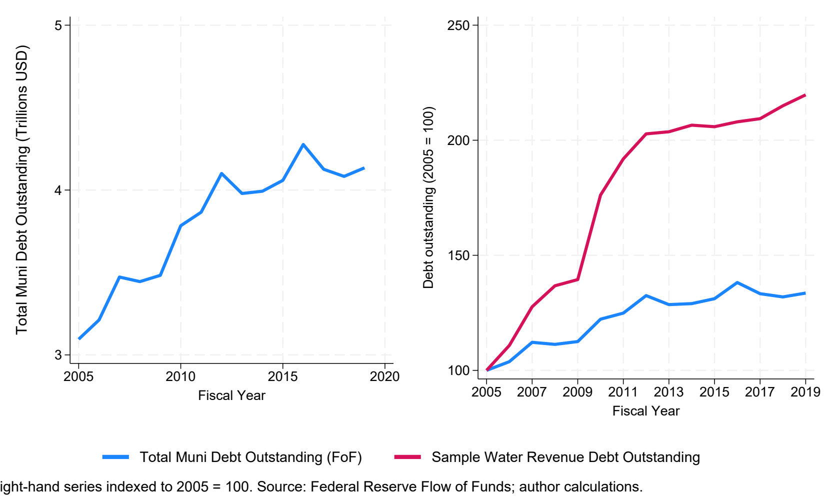
Figure I.B.2: Sample Water Revenue Debt Outstanding and Issuance

The top panel plots total annual issuance in billions of dollars against total water revenue debt outstanding for my sample of California water utilities. Issuance is shown from the earliest available issue year, 1986, through the end of the sample in 2019. The bottom panels use data on all municipal securities from the Federal Reserve Board's Z.1 release, series FL893062005.Q, only keeping the fiscal year end. The bottom left panel plots total municipal debt outstanding in trillions of dollars over 2005–2019. The bottom right panel compares trends in total U.S. municipal debt outstanding and my sample of water revenue debt outstanding, with both series indexed to 100 in 2005.

(a) Total Issuance by Year



(b) Comparison to Muni Debt Outstanding from the Flow of Funds



I.B.2 Rate Covenant Threshold Descriptive Statistics

In this appendix, I describe the numeric rate covenant threshold and how it varies across issues. The purpose of this appendix is to document that rate covenant thresholds capture contract terms that are not mechanically redundant with credit ratings. Details on the rate covenant itself are included in the draft. As in the previous appendix, the level of analysis in this appendix is CDIAC-record.

Figure I.B.3 depicts the distribution of CDIAC record-level rate covenant thresholds for all historical by utilities from the main drought sample, restricting to CDIAC records where the threshold can be recovered from issuance documents. The median threshold in both plots is 120% and the average threshold is 118.3%. Splitting the sample by the type of utility also does not change the sample distribution: the median city and median special district record both have rate covenant thresholds of 120%.[23] These thresholds are very persistent at the utility-level. Even though Figure I.B.3 depicts record-level data, only 11% of utilities change their rate covenant thresholds during the sample. These utilities typically only change their thresholds once, with most changes occurring in 2017, and the thresholds are increased 2% on average and 5% at the median. Almost all of the variation in thresholds is across utilities.

Next, I examine the distribution of rate covenant thresholds by underlying rating in Table I.B.1. I use underlying ratings because they reflect issuer credit quality net of external credit enhancement (e.g., bond insurance and other guarantees). Using the insured rating would classify about 43% of records as AAA. Although the relationship is not entirely linear, there is an increase in the average rate covenant threshold by underlying rating. However, the underlying rating is not the only determinant of the threshold; there is still variation in thresholds within each rating bucket. This sample is defined at the CDIAC-record level and therefore differs from the issuance–utility-year regression sample used in the main analysis. Because underlying ratings are not reported for all matched CDIAC records with recoverable covenant thresholds, the number of observations in Table I.B.1 is smaller than the total CDIAC record counts reported in Section 4.

I depict in Figure I.B.4 how rate covenant thresholds vary with issue characteristics such as interest costs, total amount issued, and issuance costs (such as rating fees) as a percentage of the total principal issued. Each plot is a bin scatter of rate covenant thresholds on the x-axis and each characteristic on the y-axis. In all plots, the left plot includes the raw data. The right bin scatter plot absorbs each issue's rating. Panel I.B.4a shows thresholds by net interest cost (using true interest cost when net interest cost is not available). Panel I.B.4b

[23]Special districts also have more leniency in terms of the definition of gross revenues in the coverage ratio: they generally are allowed to include any ad valorem property taxes that have not been pledged for the purpose of other bonded debt.

shows thresholds by the log of the principal amount issued. Panel I.B.4c shows thresholds by issuance costs, which is presented as a percentage of total principal amount. In general,higher rate covenant thresholds are associated with lower interest costs, lower principal amounts, and higher issuance costs as a proportion of principal amount. These relationship are also more apparent after controlling for the issue's rating. Much like previous literature has suggested, how tight rate covenants are is likely co-determined with the cost of debt as well as the total amount borrowed. In general, especially after accounting for credit ratings, it appears that utilities can lower their cost of debt by pledging a higher minimum annual debt service coverage ratio.

Figure I.B.3: Distribution of Rate Covenant Thresholds

This figure plots the distribution of rate covenant thresholds for the sample of CDIAC records where I recover a rate covenant from issuance documents. Blue segment length scales with the empirical frequency (mass) in each rating bucket. The red line denotes the average threshold.

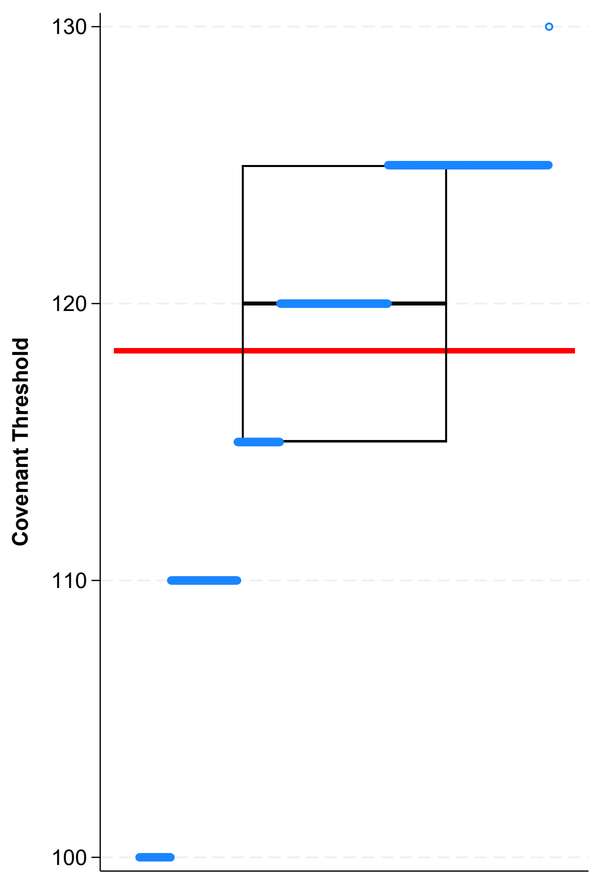


Table I.B.1: Distribution of Rate Covenant Thresholds by Underlying Rating

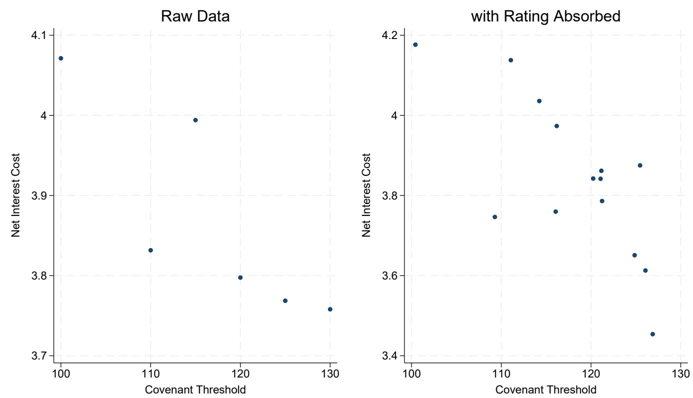
This table reports statistics at the CDIAC reocrd-level on rate covenant thresholds, broken out by the underlying rating of the issuance. I use the S&P rating when available; otherwise, I use Moody's or Fitch. "NR" means that the issue is unrated from any credit rating agency.

	N	Mean	Min	Median	Max
AAA	50	116.800	110	112	125
AA+	61	117.787	100	120	125
AA	103	116.942	100	120	130
AA-	103	121.068	100	125	125
A+	50	120.500	100	125	125
A	39	117.949	100	120	125
A-	18	119.167	100	120	125
BBB+	5	120.000	110	120	125
BBB	4	120.000	115	120	125
BBB-	3	123.333	120	125	125
NR	61	117.049	100	120	125
Total	497	118.511	100	120	130

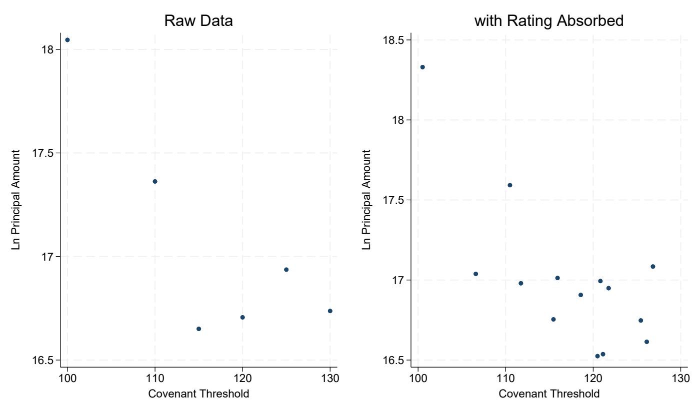
Figure I.B.4: Distribution of Rate Covenant Thresholds by Issue Characteristics

This figure presents bin scatter plots of rate covenant thresholds against various issue characteristics. In all plots, the left plot includes the raw data. The right bin scatter plot absorbs each issue's rating. Panel I.B.4a shows thresholds by net interest cost (using true interest cost when net interest cost is not available). Panel I.B.4b shows thresholds by the log of the principal amount issued. Panel I.B.4c shows thresholds by issuance costs, which is presented as a percentage of total principal amount.

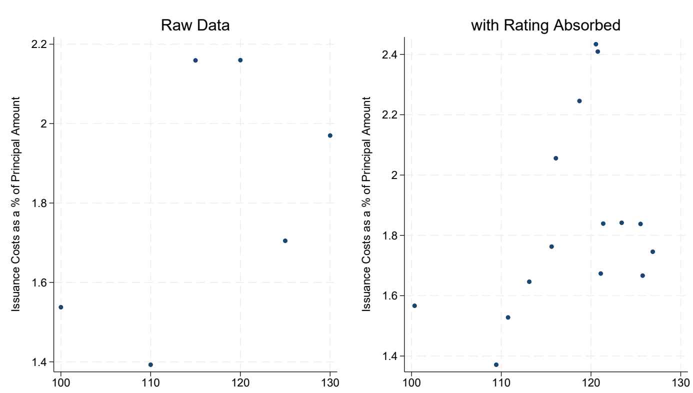
(a) Net Interest Cost



(b) Principal Amount



(c) Issuance Costs



I.B.3 Rate Covenant Usage and Tightness at Issuance

Table I.B.2: Characteristics of Municipal Rate Covenants

This table reports the estimates summarized in Figures 1 and 2 in Section 4. Panel A reports utility-level means (not standardized) over FY 2010-2019 by whether the utility ever operates under an observed rate covenant during FY 2010–2019; P(Difference) reports the p-value from a t-test of equality of means. Panel B reports issuance-utility-year regressions relating covenant tightness at issuance to pre-issuance utility characteristics:

$$\text{Cov. Tightness}^{\text{iss}}_{ijt} = \alpha + \beta X_{i,t-1} + \gamma 1\{\text{Underlying rating category}_{ijt}\} + \varepsilon_{ijt}.$$

Here j indexes issuances by utility i in fiscal year t, and $X_{i,t-1}$ is measured in the fiscal year preceding issuance. Tightness at issuance is based on distance to threshold in FY $t-1$, scaled by the SD of the coverage ratio over FY $t-1$ through FY $t-4$, and multiplied by -1 so higher values indicate tighter covenants at issuance. Columns 1-2 use FY 2006-2019 issuance-years with at least four prior years of coverage data; columns 3-4 shows the second half of the sample (FY $\geq$ 2013). Underlying-rating indicators are for *below AA* and *NR* (omitted: *AA or above*).Robust standard errors are reported in parentheses.

Panel A. Utility-level

	Covenant	No Covenant	P(Difference)
Num. utilities	174	384	
Total Revenues/Total Expenses	1.134	1.226	0.054*
Log Population	10.660	8.285	0.000***
Log Med. House. Income	11.027	10.920	0.001***
Δ Pop. (%) '00-'10	.103	.064	0.131
Tax Resistance (Prop 30 No Share)	47.177	52.479	0.000***

Panel B. Pre-Issuance Utility-Year level

	Full Sample		Post-2012	
	(1)	(2)	(3)	(4)
Debt Outs. to Op. Revenues (lag)	0.355***	0.339***	0.356***	0.344***
	(0.046)	(0.044)	(0.085)	(0.084)
Total Revenues/Total Expenses (lag)	-2.360***	-2.521***	-3.219***	-3.409***
	(0.417)	(0.444)	(0.728)	(0.720)
Population Growth 2000-2010 (%)	0.009*	0.008	0.004	0.004
	(0.005)	(0.005)	(0.007)	(0.007)
Log Population (2010)	-0.221***	-0.125	-0.207**	-0.123
	(0.071)	(0.080)	(0.091)	(0.114)
Prop 30 No Vote Share (%)	-0.015	-0.009	-0.029**	-0.024*
	(0.009)	(0.010)	(0.013)	(0.013)
Underlying Rating below AA		0.789***		0.639
		(0.262)		(0.405)
Underlying Rating NR		0.572*		0.428
		(0.315)		(0.406)
Constant	3.534***	2.009	5.026***	3.778**
	(1.163)	(1.339)	(1.590)	(1.882)
Observations	305	305	161	161
R-squared	0.242	0.268	0.316	0.331

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

I.C Rate Covenant Enforcement and Political Constraints

I.C.1 Example of Rate Covenant Violation Remedies

The Stinson Beach County Water district agreement from the main text provides relevant remedies in the event of a violation:

> Such violation shall not, in and of itself, be a default under this Loan Agreement and shall not give rise to a declaration of an Event of Default so long as (i) Net Revenues...are at least equal to the Debt Service coming due and payable...(ii) within 120 days after the date of the violation is discovered, the District...hires an Independent Financial Consultant to review the revenues and expenses of the Enterprise, and abides by such consultant's recommendations to revise the schedule of rates, fees, expenses and charges, and to revise any Maintenance and Operation Costs insofar as practicable...

In addition to these common remedies, this utility was also allowed to comply with the bond agreement by transferring cash from other funds, if available. In my sample of bond documents, I found evidence of these Rate Stabilization Fund transfer allowances in around 50% of CDIAC records.

I.C.2 Event Study on Adjustments Following Rate Covenant Violations

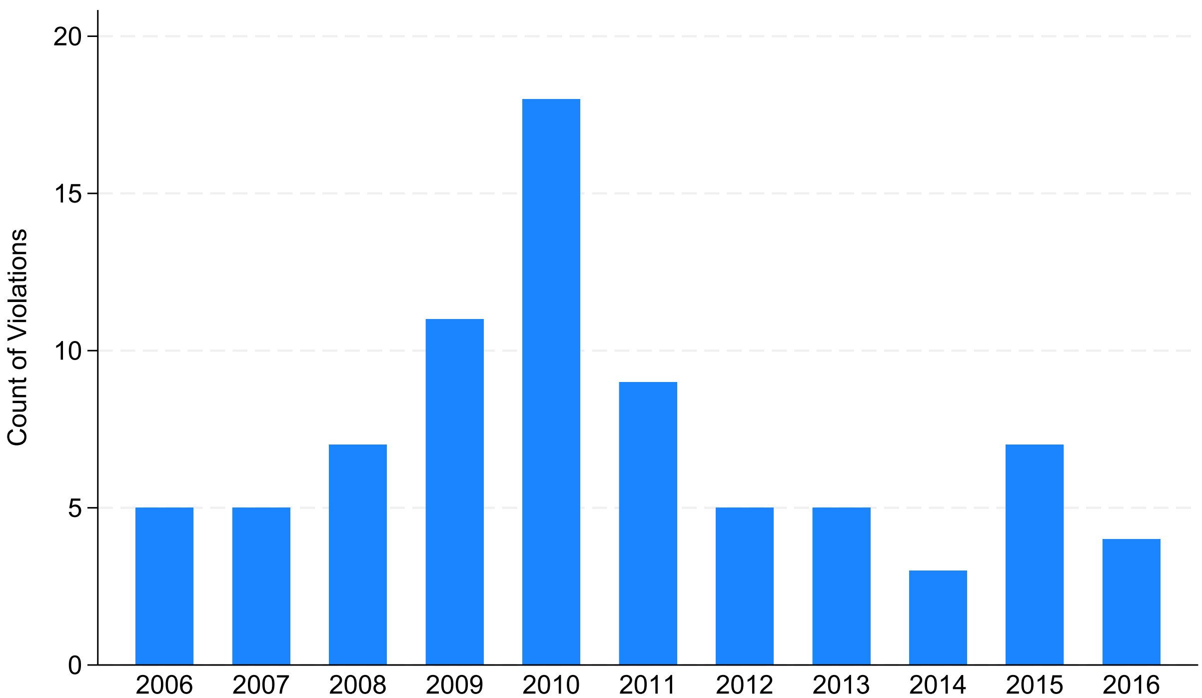
This appendix reports an event-study analysis of utility operating decisions around covenant violations. If utilities are indifferent to violating their rate covenant, post-violation trends in revenues and expenses should reflect pre-violation trends. On the other hand, if the violation is a salient event for utility officials, there should be substantial adjustment: utilities would raise fees and rates to increase revenues and potentially curb costs to comply with the minimum debt service coverage ratio.

Using the main dataset of water utility finances for 569 water utilities from 2003 to 2019, I identify a sample of likely first-time covenant violations. A violation year is defined as a year in which a utility's coverage-ratio tightness measure exceeds zero. To isolate the effects of a first violation, I restrict attention to violation years with no other violations in the preceding three years. I further require a complete seven-year window of data around each violation (three years before and three years after), which limits the sample to violations occurring between fiscal years 2006 and 2016. To limit the impact of outliers, I drop violations associated with extreme changes in operating expenses (top and bottom 5th percentile), which may reflect misclassified capital expenditures. I also present results that include 10 violations occurring in bond-issuance years; the results are robust to dropping these violations.

This sample includes 79 violation events, 51 of which occur in city utilities. Figure I.C.1 plots the frequency of these violation events by year and shows that roughly half occur between fiscal years 2009 and 2011, in the aftermath of the Great Recession.

Figure I.C.1: Frequency of violations by Year

This figure provides frequency of violations in the event study sample by fiscal year.

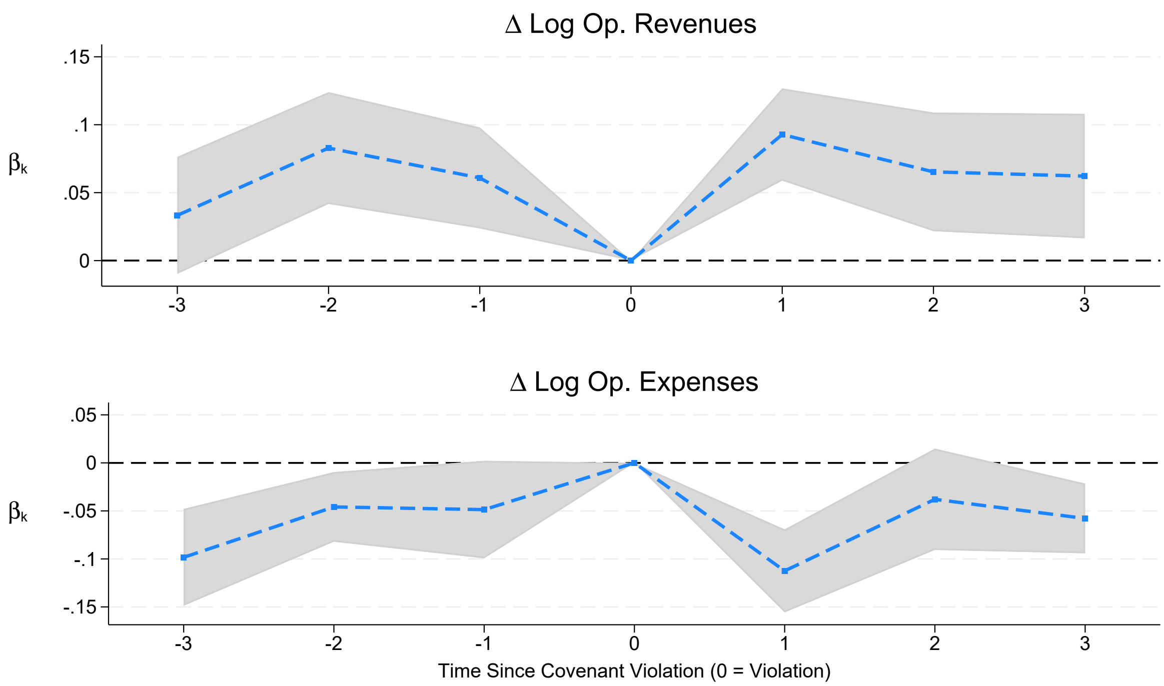


I present graphs of both the year-over-year change in log operating revenues and operating expenses in the three years in Figure I.C.2. These graphs plot the coefficients β_k from the following regression specification, which is at the utility i, county j, fiscal year t, time since covenant violation k level:

$$\Delta(Y_{ijtk}) = \gamma_i + \delta_t + \beta_k + \varepsilon_{ijtk} \tag{1}$$

Y_{ijtk} denotes the log of the outcome of interest. I include both utility-level fixed effects γ_i to account for unobservable time-invariant features of utility and fiscal-year fixed effects δ_t to account for the macroeconomic environment. I normalize the event-time indicators by omitting $k = 0$ (the fiscal year of first violation), so the reported β_k coefficients are measured relative to the violation year. Thus, β_k can be interpreted as the average difference in year-over-year log growth in event time k compared with the violation year. Standard errors are clustered at the utility level and I present 95% confidence intervals around the point estimates.

Figure I.C.2: Event Study Coefficients: Changes in Operating Revenues and Expenses



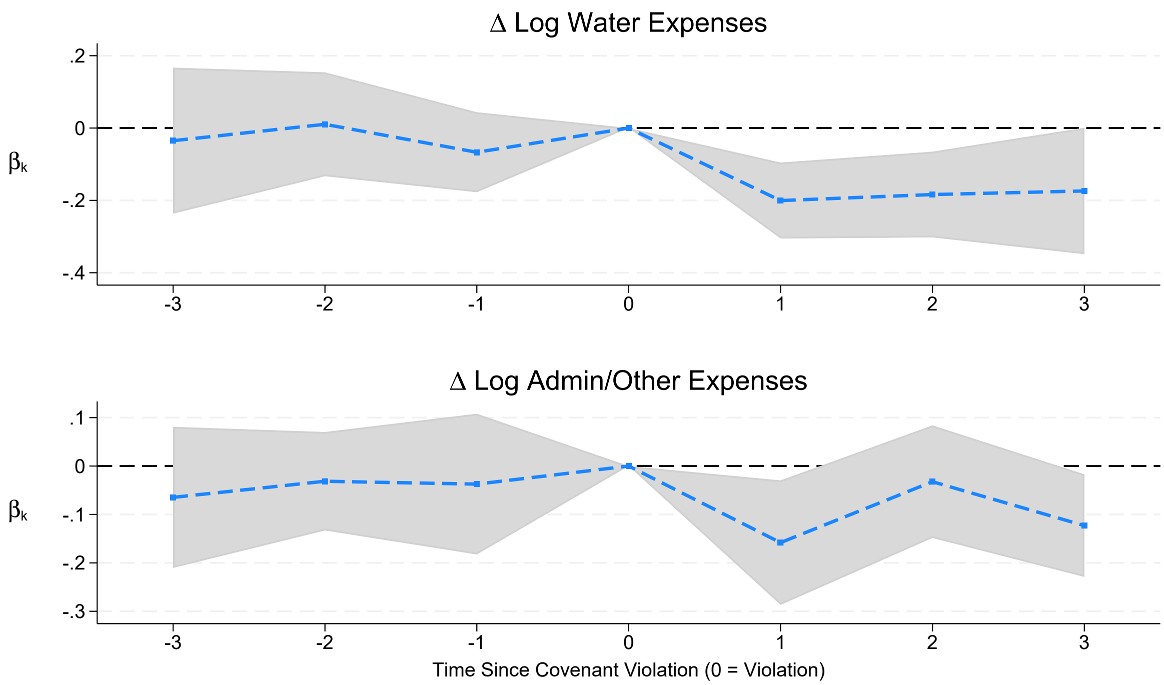
The top panel of Figure I.C.2 shows event-time estimates for operating revenue growth rates around covenant violations. Revenues grow modestly from periods -3 to -2, then revenue growth slows in period -1 and drops sharply in the violation year (0). In the year after the violation, revenue growth rebounds to at least its pre-violation pace and remains elevated through periods 2 and 3. In levels, this pattern implies a drop in revenues between periods -2 and 0, followed by a steady recovery. On average, operating-revenue growth in years $+1$ to $+3$ is about 5 percentage points higher than in the pre-period (including the violation year). These dynamics suggest that violations are partly driven by a shortfall in revenue growth, and that utilities respond by raising revenues after a violation to restore compliance with the covenant.

Although the rate covenant is framed as a requirement to set rates and fees, a minimum debt service coverage ratio also gives utilities incentives to curb costs rather than implement unpopular rate increases. The bottom panel of Figure I.C.2 examines whether expenses continue their pre-violation trajectory after a rate covenant violation. As with revenues, a sharp downward adjustment in expenses would be inconsistent with the view that rate covenants are inconsequential. From periods 3 to 1, expenses accelerate, and expense growth in the violation year (0) is significantly higher than in periods 3 and 2. In the years following a violation, growth rates fall well below their period-0 level and are, on average, 6.2 percentage points lower than in the pre-period. In levels, expenses rise up to the point of violation and then flatten, consistent with utilities tightening costs after breaching the covenant.

On which margins do utilities adjust operating spending after a covenant violation? Figure I.C.3 reports event-study estimates for spending on the water system and on administrative and general activities. For both categories, growth rates rise modestly in the run-up to a violation, but these pre-trends are statistically indistinguishable from zero. After the violation, there is a sharp and persistent reduction in water-system spending growth. On average, water system expense growth rates are 17.7 percentage points lower than before, with all post-violation coefficients significantly below the violation-year growth rate. Administrative spending shows a more modest average decline in growth of 10.1% and a more transient pattern: a one-time drop followed by a return toward prior growth rates, although these estimates are generally noisier.

The overall picture of the pre-violation period is one of deteriorating financial health: revenues fall and expenses increase. In contrast to what one would expect if utilities are indifferent about violating their covenants, I find that utilities improve their financial health by increasing revenues and curbing expenses following a violation. The presence of these sharp adjustments away from pre-violation trends suggests that the penalty associated with continued violation of rate covenants following a first-time violation is severe enough that public officials not only raise rates, but also curb costs to ensure future compliance.

Figure I.C.3: Event Study Coefficients: Spending Adjustments



I.C.3 Narrative Evidence About Rate Covenant Violations

A natural question is: why do utilities violate their covenants if they bunch at the violation threshold? There are several reasons why violations happen. Violations may occur if there are management deficiencies and institutional stress. For example, following periods of large turnover in staff, new officials may not be aware of bond indenture requirements or may not be paying attention to financial deficiencies. Dramatic changes in water usage patterns also precipitate violations. Following the financial crisis, utilities that had anticipated large amounts of housing development and pledged developer fees were no longer able to depend on that income. In California, drought shocks to water supply also dramatically change water usage: utilities institute mandatory reductions in consumption, leading to large drops in revenues. Finally, utilities may be unable or unwilling to raise prices sufficiently. This occurs when voters veto rate increases. However, it can also occur when public officials are pressured by political interest groups.

After a rate covenant violation in 2016, S&P downgraded Oxnard's water obligations. The city council explicitly stated the consequences of not raising rates in its agenda report for a April 18, 2017 meeting to discuss proposed water rate increases, available here: "If water rates are not raised, the water enterprise fund soon will not have sufficient revenue to cover expenses beginning this coming fiscal year 2017-2018. The fund will not be able to meet bond coverage requirements which could result in another credit downgrade and increased cost for funding required maintenance projects."

I.C.4 Narrative Evidence on Political Constraints and Rate-setting

This section provides examples of popular resistance to utility rate increases.

Oxnard, California faced intense popular opposition to water and wastewater rate hikes in 2016. This political backlash culminated in a voter-approved reversal of a 2015 increase through Measure M in 2016. Public distrust, fueled by past financial mismanagement and ethics violations, led to further resistance, including an unsuccessful recall effort against city officials. The city argued that without rate increases, it would fail to meet its bond covenant requirements. During public comments, the resident that was responsible for launching the ballot initiative to repeal the hikes said: "These (water) rate increases are basically abusive...They are meant to cover extravagant expenditures."[24]

The Metropolitan Water District of Southern California voted in 2024 to increase water rates by 8.5% each year in 2025 and 2026. The District also increased its property tax assessment for the first time in 30 years. District leaders cited conservation efforts, water sourcing and treatment costs, and make upgrades to existing infrastructure. The decision was met with controversy, with the mayor of the city of Moorpark stating that "the dramatic rate increases are 'very problematic for our citizens' and reflect 'poor management'."[25] Representatives from Los Angeles also opposed the proposed property tax rate hike: "Metropolitan hasn't demonstrated that raising the AV tax rate is necessary to maintain fiscal integrity. Before proposing a raise in the AV tax rate, Metropolitan needs to clearly explain why property tax is needed for fiscal integrity, have a discussion on what is needed to maintain fiscal integrity, and exhaust all other options to collect sufficient revenue. The Los Angeles delegation requests Metropolitan bring back to the Board for consideration, analyses on our recommended options above, and continue to explore ways to establish fair, transparent, and equitable rate increases that cover Metropolitan's full cost-of-service." [26]

In 2024, the city of Los Angeles in California approved a phased sewer rate increase, setting a trajectory for residential sewer fees to double by 2028. City officials cited the rising

[24]Quote is from: Leung, Wendy (2016-0719), "Oxnard decides against raising water rates at least for now," *Ventura County Star*. For more details on the political situation in Oxnard, see Webster, Keeley (2018-11-29), "How Oxnard got a refunding deal done after years of turmoil," *The Bond Buyer*.

[25]See James, Ian (2024-04-10), "SoCal will see spike in water rates, taxes to cover rising costs and conservation efforts,"*Los Angeles Times*.

[26]Los Angeles' response to the Metropolitan Water District's budget is available here.

costs of construction, materials, and labor as the reasons for the rate increase. Business groups like the Apartment Association of Greater Los Angeles, primarily representing landlords who are unable to pass on water costs to rent-stabilized units, were unhappy with the rate increases: "There's no end in sight for such a mismanaged city with its bloated salary and overall cost structure, wasted resources and insatiable appetite to seek new and higher taxes and impose significantly higher fees on ratepayers."[27]

I.D Literature on Fiscal Adjustments

For evidence on the elasticity of spending adjustments to cash reserves and intergovernmental transfers, see Feler and Senses (2017) and Green and Loualiche (2021). On the response of tax and millage rates to fiscal shocks, see Poterba (1994), Glaeser (2013), and Giesecke and Mateen (2022). Giesecke and Mateen (2022) in particular find that fiscal shocks are entirely offset by tax rate increases with no spending cuts. On the effect of negative revenue shocks on capital expenditure, maintenance, and deferred spending, see Helm and Stuhler (2024) and Cromwell and Ihlanfeldt (2015). For a model of "shrouding" in the context of public pensions, see Glaeser and Ponzetto (2014). Evidence on severe cuts to public services following fiscal shocks is more limited. In one example, Feler and Senses (2017), find that the exposure to the China trade shock affected spending on public welfare and public housing, with much smaller effects on public education spending, and no effects on public safety spending.

I.E Drought Appendix: Background, Robustness, and Additional Results

I.E.1 Additional Background on the Drought

Drought Severity in the U.S. Drought Monitor. By August 2014 (fiscal year 2015), approximately the entire state of California was experiencing severe drought, and 58% of the state was exposed to exceptional drought according to the U.S. Drought Monitor (see Figure I.E.1). Severe drought denotes that physical indicators, such as precipitation and dryness, are in the 10th percentile range relative to historic numbers as aggregated by the National Drought Mitigation Center. Exceptional drought is the most extreme classification, signifying historically rare conditions in the 1st to 2nd percentile range for physical indicators and

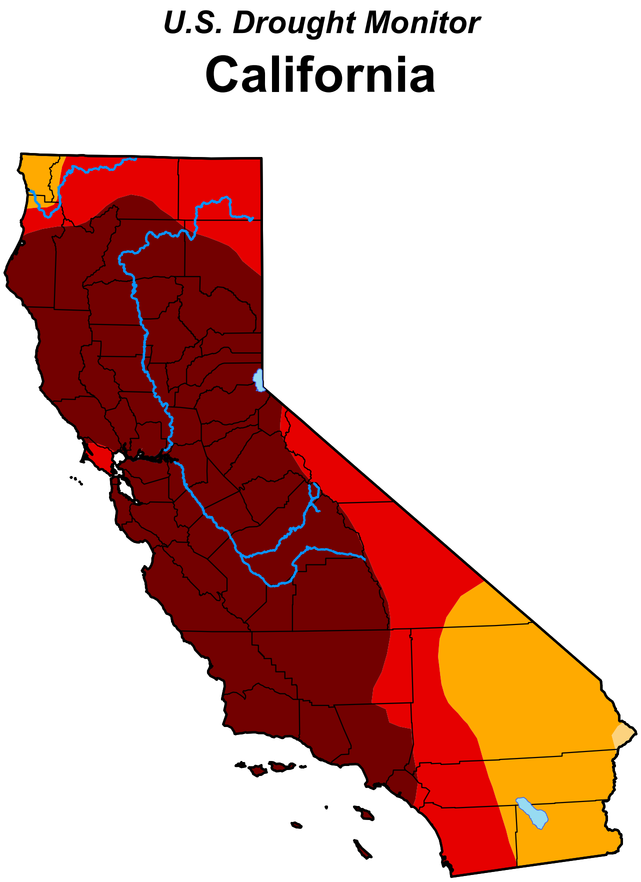
[27] See Dakota, Smith (2024-05-14), "L.A. City Council backs plan to double sewer fees," *Los Angeles Times*.

confirmed by multiple indicators and expert consensus. The extent of exceptional drought continued from fiscal years 2014 through 2017: Figure I.E.2 depicts each county's annual average share of area exposed to exceptional drought during the duration of the peak of the drought.

Water Use Restrictions. Starting in 2014, the state of California issued multiple edicts restricting water use in the residential sector. The first was a state of emergency declaration in January 2014, which was followed by three executive orders calling for voluntary reductions in water use in 2014. In June 2015, mandatory restrictions were enacted to achieve a statewide reduction in residential water use per capita to 25% of 2013 levels. These restrictions applied to urban water suppliers with greater than 3,000 connections. Urban water suppliers were sorted into 9 tiers based on residential gallons per day, measured in 2014. Each tier was mandated to reduce residential gallons by some percentage of 2014 usage, varying from 4% in Tier 1 to 36% in Tier 9. Additionally, California required urban water suppliers to submit monthly conservation reports on water production, sectoral breakouts, and average residential use per day. Non-compliers were first issued a warning and then fined. The emergency declaration was lifted on April 2017, but some water conservation requirements were made permanent in May 2016.

Figure I.E.1: August 2014 U.S. Drought Monitor Map of California

This figure provides the U.S. Drought Monitor's map of drought conditions for California, released on August 12, 2014. The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. Map courtesy of NDMC.



August 12, 2014

(Released Thursday, Aug. 14, 2014)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	100.00	99.80	81.92	58.41
Last Week 08-07-2014	0.00	100.00	100.00	99.80	81.92	58.41
3 Months Ago 05-15-2014	0.00	100.00	100.00	100.00	76.68	24.77
Start of Calendar Year 01-02-2014	2.61	97.39	94.25	87.53	27.59	0.00
Start of Water Year 10-03-2013	2.63	97.37	95.95	84.12	11.36	0.00
One Year Ago 08-15-2013	0.00	100.00	98.23	93.86	11.36	0.00

Intensity:

- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. For more information on the Drought Monitor, go to https://droughtmonitor.unl.edu/About.aspx

Author:

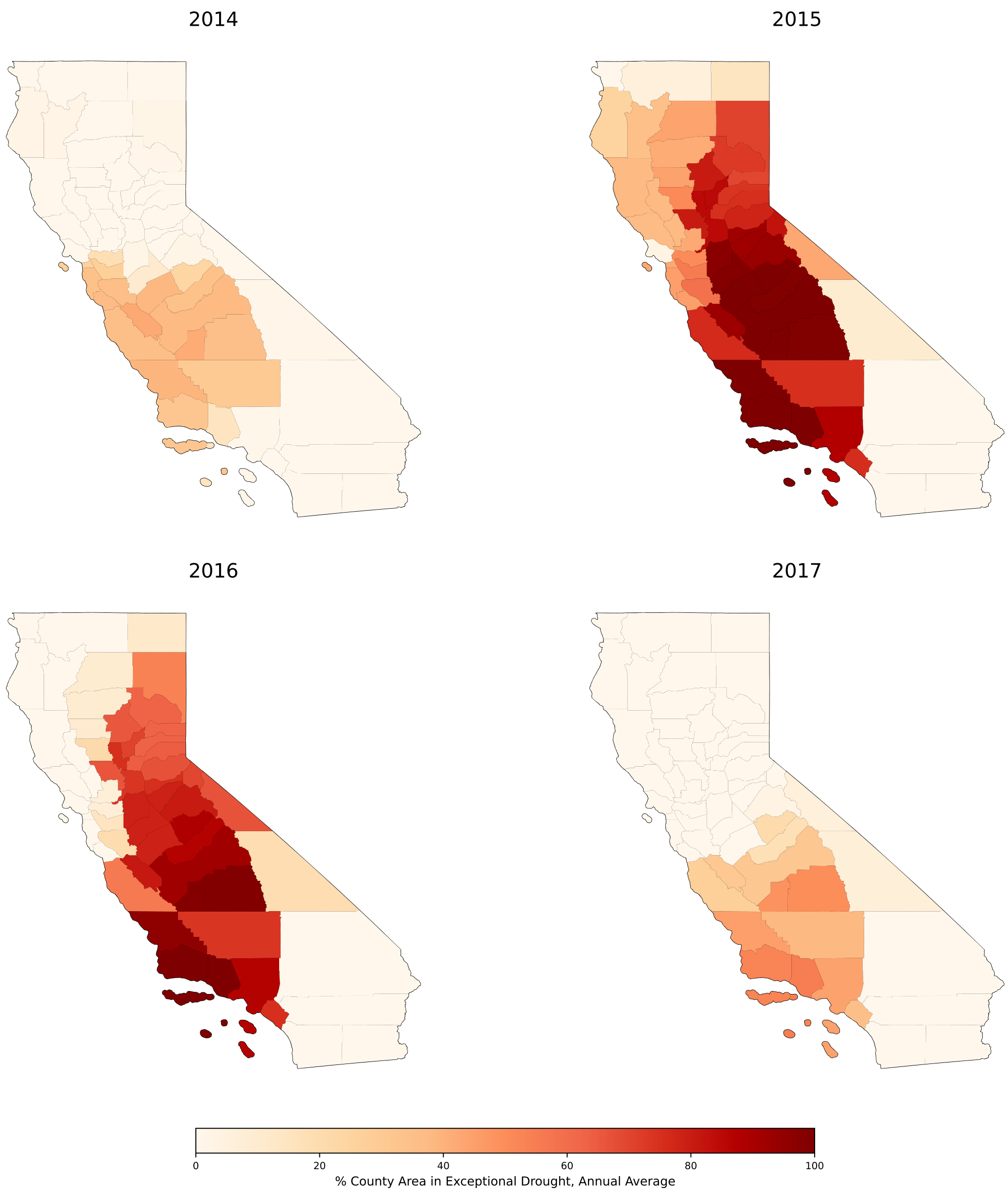
Richard Tinker

CPC/NOAA/NWS/NCEP

droughtmonitor.unl.edu

Figure I.E.2: Share of County Area Experiencing Exceptional Drought by Year

This figure plots, for each fiscal year, the county-level average share of land area classified as experiencing exceptional drought (D4). I plot the county-level averages in each year during the peak of the drought, from 2014 through 2017. Data are collapsed using daily data from the U.S. Drought Monitor. The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration.



I.E.2 Drought Validation: Deliveries, Revenues, and Covenant Tightness

I demonstrate in this appendix that drought intensity reduces water deliveries and water sales revenue, pushing utilities closer to their covenant thresholds. Figure I.E.3 illustrates a negative relationship between various measures of drought intensity and both water deliveries and water sales growth. To highlight this relationship, I plot drought intensity against these outcomes during the primary drought period of 2014–2017, focusing on the extent of exceptional drought. Additionally, I examine the historical relationship between at least moderate drought intensity and water system performance before the onset of the exceptional drought in the main sample. Here, "at least moderate drought intensity" refers to the percentage of a county experiencing moderate or worse drought conditions as defined by the U.S. Drought Monitor. The results indicate a strong negative correlation between drought conditions and both the log of water deliveries and water sales revenue growth. Moreover, the decline in water sales revenue is more pronounced in response to exceptional drought than to moderate drought intensity.

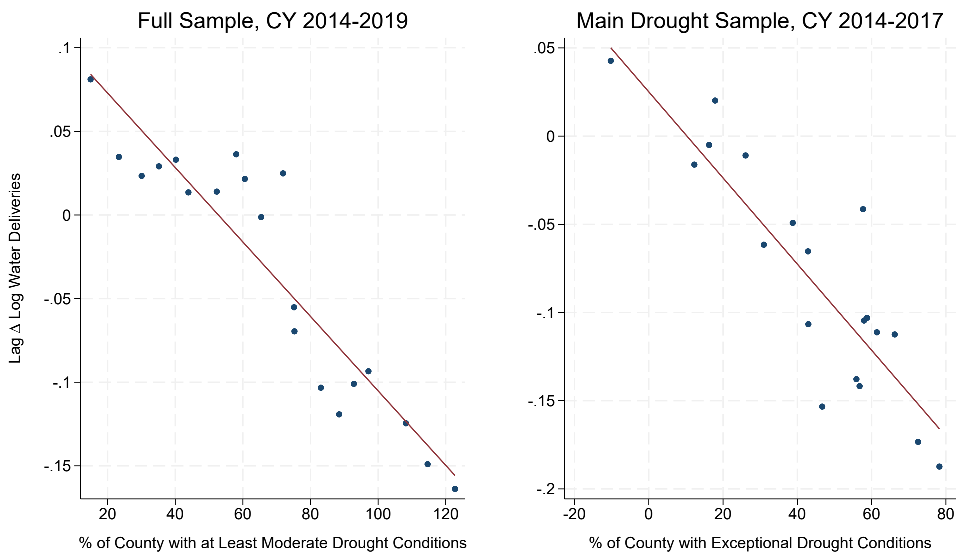
I next show that drought intensity pushes utilities closer to their covenant thresholds. Figure I.E.4a presents a binscatter illustrating a positive relationship between covenant tightness and the percentage of a county experiencing exceptional drought during the period 2014 to 2017. Figure I.E.4b displays the time series of median covenant tightness for both rate covenant-constrained (treated) and unconstrained (control) utilities from 2010 to 2019.

Prior to the onset of exceptional drought in 2014, utilities in both groups were moving away from their covenant thresholds, though constrained utilities remained consistently closer to their thresholds throughout the sample period. During the peak drought years of 2015 and 2016, both groups moved closer to their thresholds, reflecting increased financial pressure from declining water sales revenue growth. However, the magnitude of this shift differed significantly between groups. Unconstrained utilities experienced a much larger move toward their thresholds than constrained utilities, as shown in Figure I.E.5. This difference suggests that constrained utilities, already near their covenant thresholds, faced greater financial pressure and had stronger incentives to take corrective action. I formally test these patterns in the main text.

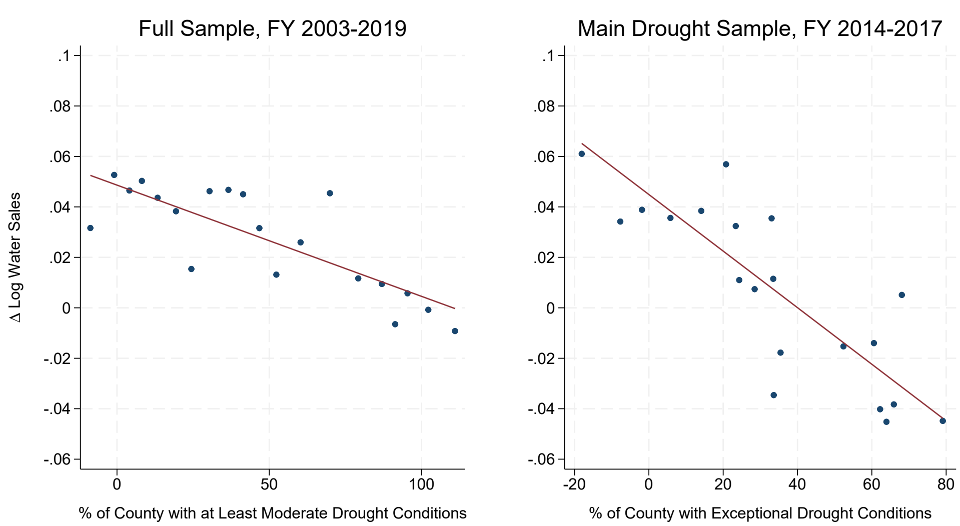
Figure I.E.3: The Relationship between Drought Intensity, Water Deliveries, and Water Sales Growth

This figure shows binscatter plots of utility outcomes against measures of drought intensity. The top panels plot lagged log water-deliveries growth against drought intensity. The left panel uses the percent of a county exposed to at least moderate drought; the right panel uses the percent exposed to exceptional drought during the exceptional-drought period. Water deliveries are measured in calendar years (CY) 2013–2019. Drought exposure is measured in fiscal years (FY). I assign FY t drought exposure to deliveries growth from CY $t-1$ to CY t (so the first plotted growth observation uses CY 2013–2014 deliveries and FY 2013 drought exposure). The figures in the bottom panel show the same measures of drought intensity plotted against water sales revenue growth. All plots absorb utility fixed effects. Revenue growth is winsorized at the 1% level as in the main analysis.

(a) Water Deliveries Growth



(b) Water Sales Revenue Growth

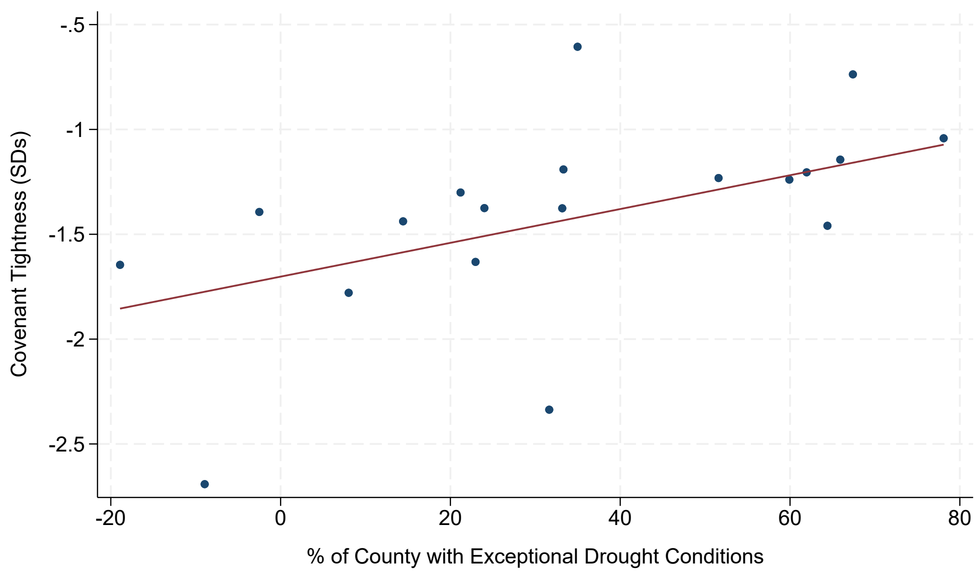


Note: Absorbs utility fixed effects.

Figure I.E.4: The Relationship Between Drought Intensity and Covenant Tightness

This figure illustrates the relationship between drought intensity and covenant tightness. The top panel is a binscatter of covenant tightness against the percent of a county experiencing exceptional drought. The time period for this plot is 2014-2017, during the period of exceptional drought. Utility-level fixed effects are absorbed in this panel. The bottom panel plots the time series of covenant tightness for both the rate covenant constrained group and the rate covenant unconstrained group from the main analysis. Covenant tightness is reported in utility-level standard deviations of coverage ratios prior to 2010. I take the median of each group in each year. The period of exceptional drought is denoted by the shaded gray region.

(a) Covenant Tightness and Exceptional Drought, 2014-2017



(b) Time Series of Median Covenant Tightness, 2010-2019

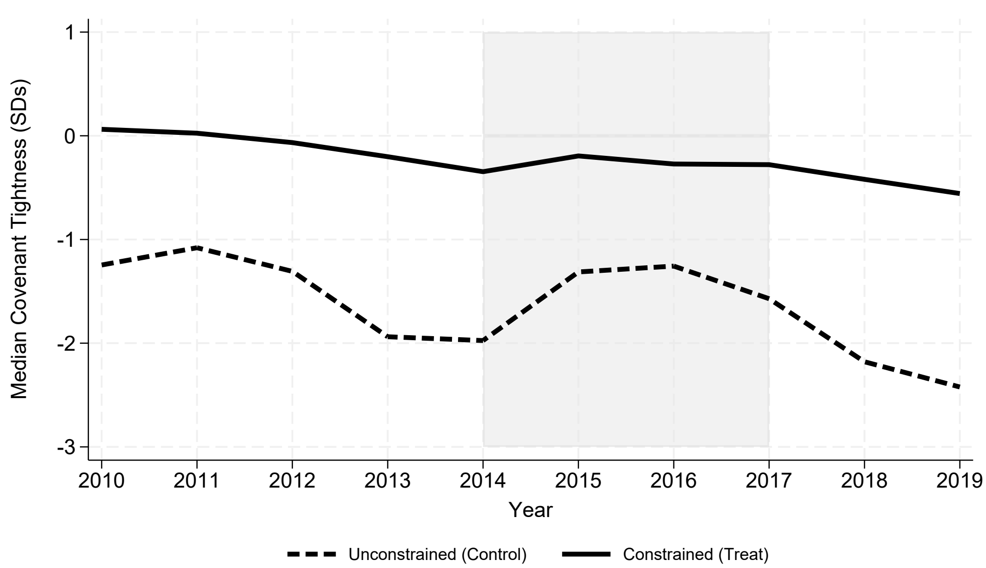
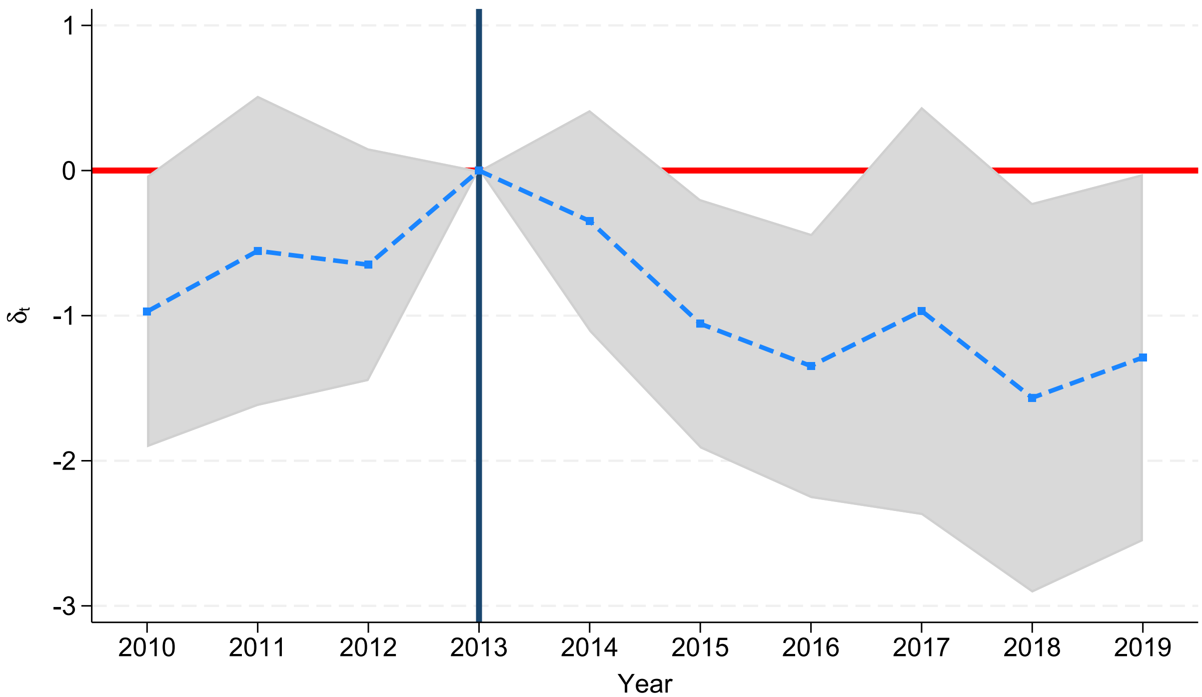


Figure I.E.5: Covenant Tightness by Year

This figure presents the coefficients δ_t from the following regression:

$$\text{Cov. Tightness}_{it} = \alpha_i + \alpha_t + \sum_{t=2010}^{2019} \delta_t \times \text{Rate Covenant Constrained}_i + \varepsilon_{it}$$

The base year is 2013, prior to the onset of exceptional drought conditions. 95% confidence interval bands are also shown. The sample includes 155 utilities, which is the subset of the main sample that has rate covenants in effect over the time period. Covenant tightness, defined as in the text, is measured using the pre-2010 utility-level standard deviation of coverage ratios.



I.E.3 Drought Validation: Debt Issuance

A potential concern is that utilities with active access to municipal bond markets may be better able to smooth drought-driven revenue shortfalls—through reserves management or financing choices—so that observed revenue responses reflect selection into debt issuance rather than the effect of binding rate covenants. This concern is especially relevant because the constrained group is a subset of debt-issuing utilities. To assess whether drought exposure is systematically related to issuance behavior in a way that could confound the main design, I examine whether utilities are more likely to issue revenue debt in years and places experiencing greater drought intensity. The results provide little support for a positive relationship: issuance is not significantly increasing in either moderate-or-worse or exceptional drought exposure (Table I.E.1), and issuance declines during the peak exceptional-drought years (Figure I.E.6).

Figure I.E.6: Number of Sample Utilities Issuing Debt by Year

This figure plots the number of utility-year observations that include a new issue of municipal revenue debt across years. During the height of the exceptional drought from 2014-2016, municipal debt issuance was lower.

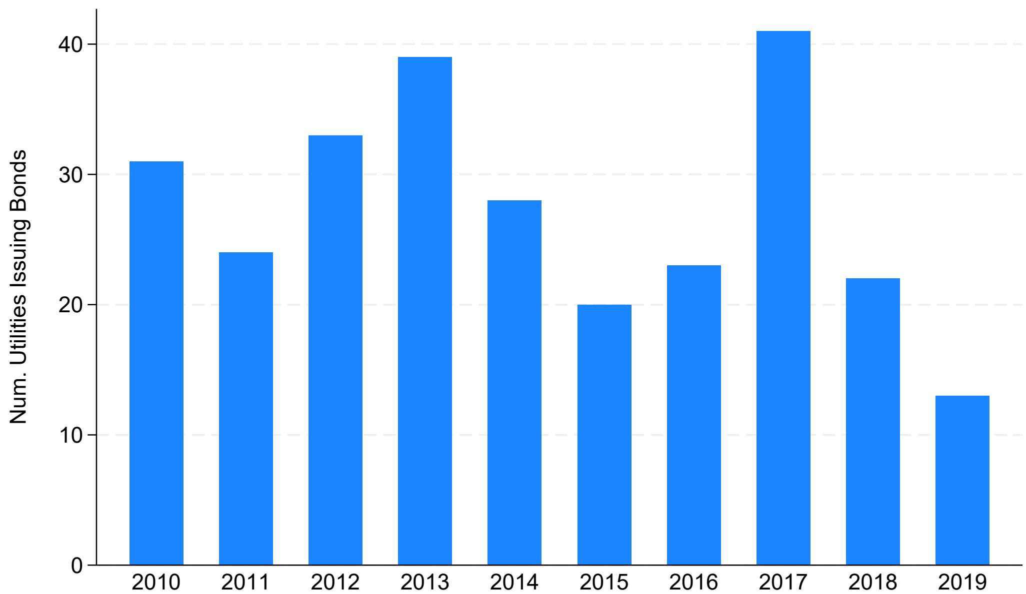


Table I.E.1: Relationship between Drought Exposure and Issuance

This table reports the relationship between drought exposure and the likelihood that a utility issues debt in a given year and drought exposure. The sample is limited to utilities with a rate covenant in effect during the main sample period of the text. The first two columns examine the relationship between issuance and county exposure to at least minimum drought. The second two columns examine the relationship between issuance and county exposure to exceptional drought. Standard errors are clustered at the county-level.

	Issue Year = 1			
	(1)	(2)	(3)	(4)
% County w/ at least Moderate Drought	-0.000	0.000		
	(0.000)	(0.000)		
% County w/ Exceptional Drought			-0.001*	-0.000
			(0.000)	(0.000)
Observations	2,384	2,384	2,384	2,384
R-squared	0.133	0.150	0.133	0.150
Utility FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	Yes
Cluster	County	County	County	County
Sample	2003-2019	2003-2019	2003-2019	2003-2019
E[Y]	.172	.172	.172	.172

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

I.E.4 Alternative Clustering Results

Table I.E.2: Year-to-Year Effects of Rate Covenants During the Drought

This table reports regression coefficients of utility budget outcomes on exceptional drought exposure for rate covenant constrained and unconstrained utilities. Exceptional drought/Drought is the yearly average of each county's area exposed to exceptional drought. This variable has been standardized to have mean 0 and standard deviation 1. Constrained denotes whether a utility has a rate covenant and is in the top half of the average tightness distribution in the pre-drought period. Standard errors are clustered at the county level. All specifications include utility and year fixed effects.

Specification:	Eq 1: Unconditional			
Budget Outcome:	Δ Log Op. Revenues		Δ Log Op. Expenses	
	(1)	(2)	(3)	(4)
Exceptional Drought (std.)	-0.005	-0.004	-0.005	-0.005
	(0.003)	(0.003)	(0.004)	(0.004)
Constrained×Drought	0.009**	0.012***	-0.002	-0.004
	(0.004)	(0.004)	(0.003)	(0.003)
Observations	5,690	5,620	5,690	5,620
R-squared	0.112	0.119	0.035	0.037
Utility FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes
E[Y]	.024	.024	.019	.019
SD[Drought]	28.405	28.475	28.405	28.475

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table I.E.3: Year-to-Year Effects of Rate Covenants and Tax Resistance on Spending

This table reports regression coefficients of utility spending outcomes on exceptional drought exposure for rate covenant constrained and unconstrained utilities. Exceptional drought/Drought is the yearly average of each county's area exposed to exceptional drought. This variable has been standardized to have mean 0 and standard deviation 1. Constrained denotes whether a utility has a rate covenant and is in the top half of the average tightness distribution in the pre-drought period. Tax resistant/Tax Res. captures whether a utility is in the top half of the tax resistance distribution, as measured by no votes on Proposition 30. Standard errors are clustered at the county level. All specifications include utility and year fixed effects.

Specification:	Eq 2: Conditioning on Tax Resistance					
Budget Outcome:	Δ Log Op. Expenses		Δ Log Op. Water		Δ Log Op. Admin.	
	(1)	(2)	(3)	(4)	(5)	(6)
Exceptional Drought (std.)	-0.007	-0.007	-0.017**	-0.016**	0.007	0.007
	(0.005)	(0.004)	(0.007)	(0.007)	(0.007)	(0.007)
Constrained×Drought	0.006	0.004	0.012	0.013	0.003	-0.007
	(0.004)	(0.004)	(0.010)	(0.012)	(0.017)	(0.017)
Tax Resistant×Drought	0.005	0.005	0.016*	0.014	-0.010	-0.007
	(0.004)	(0.004)	(0.009)	(0.010)	(0.007)	(0.007)
Constrained×Tax Res.×Drought	-0.016**	-0.018***	-0.035**	-0.037**	0.003	0.003
	(0.007)	(0.007)	(0.016)	(0.016)	(0.019)	(0.019)
Observations	5,100	5,070	4,736	4,716	4,896	4,866
R-squared	0.037	0.038	0.064	0.064	0.049	0.051
Utility FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes
E[Y]	.019	.019	.009	.009	.019	.019
SD[Drought]	28.313	28.33	28.433	28.429	28.18	28.197

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

I.E.5 Mechanism Decompositions

I.E.5.1 Effect of the Rate Covenant on Components of Operating Revenues

This appendix provides additional evidence that the increase in operating revenue growth in the covenant constrained group in response to drought shocks was driven both by higher water prices and by a shift toward revenue sources less dependent on water sales relative to the control group. In this analysis, I run the following regression for each of the outcomes of interest, which is analogous to 1 in the text (but adapted for different dependent variables):

$$\begin{aligned} Y_{ict} = \alpha_i + \alpha_t + \beta \text{Rate Covenant Constrained}_i \times \text{Drought Intensity}_{ct} \\ + \phi_1 \text{Drought Intensity}_{ct} + \phi_2 \text{Drought Period}_{2014-2017} \times X_i + \varepsilon_{ict} \end{aligned} \tag{2}$$

I include the same controls as in the main specification. The estimate of interest is β, which is the difference in drought responses between rate covenant constrained utilities and unconstrained utilities.

Y_{ict} denotes either (i) water prices (levels) or (ii) the change in the non-sale share of operating revenue. Water prices serve as an empirical proxy for the unit cost of water and are calculated as water sales revenues divided by the volume of water deliveries, measured in million gallons. While this measure is based on available data, it abstracts from the complexity of real-world rate structures, which typically include both fixed and variable components and vary across customer classes. Water sales revenues are defined as the sum of reported retail sales (residential, business, industrial, and irrigation), wholesale revenues, interdepartmental sales, and other sales. To limit the influence of extreme values, I winsorize the water price variable at the 1% level. The resulting unit of measurement is dollars per million gallons of water delivered and the average price per million gallons of water in the sample is around \$5,000. Importantly, this variable is only available for the subset of the sample that has water deliveries data available. I examine both contemporaneous water prices in year t, when the exceptional drought shock occurs, and water prices in the following year $t+1$, to assess whether the price adjustment is immediate or persistent over time.

Non-sales operating revenues are calculated as total operating revenues minus water sales revenues and include items such as connection fees, groundwater replenishment fees, fire prevention fees, standby charges, and service assessments. To assess changes in revenue composition, I examine the change in the non-sales share of total operating revenues from $t-1$ to t for the contemporaneous response, and $t-1$ to $t+1$ to examine persistence of the adjustment. These two variables are reported in percentage points.

Results are presented in Table I.E.4. Among unconstrained utilities, a one standard deviation increase in drought intensity is associated with a \$29 decline in water prices per million gallons in the year of the drought shock (column 1), narrowing to a $4 decline in the following year. While neither estimate is statistically significant, the pattern suggests a muted price and revenue response among unconstrained utilities. In contrast, rate covenant–constrained utilities exhibit a stronger and statistically significant adjustment relative to unconstrained utilities. The interaction term in column 1 implies that, for a one–standard deviation increase in drought intensity, constrained utilities set water prices about $87 per million gallons higher than unconstrained utilities exposed to the same drought shock. This price effect persists into the following year. Constrained utilities exposed to similar levels of drought maintain water prices that are $78 higher than unconstrained utilities per standard deviation increase in exceptional drought exposure. In this sample, moving from the 10th to the 90th percentile of drought intensity corresponds to roughly 2.5 standard deviations. For constrained utilities, the total effect of a one–standard deviation increase in drought is therefore the sum of the main effect and the interaction effect ($-29 + $ 87). Applying the 10th–to–90th percentile benchmark to this total drought effect, the estimated constrained effect in column 1 implies an increase in water prices of about $143 per million gallons for utilities experiencing extensive exceptional drought conditions relative to those utilities experiencing milder conditions, which is about 3% of average price levels during the time period. Using the coefficient estimates in column 2, the corresponding constrained effect for a 10th–to–90th percentile move in drought intensity is approximately $184 per million gallons. This suggests that rate covenant-constrained utilities responded to the fiscal shock by increasing rates, relative to unconstrained utilities.

Columns 3 and 4 examine the change in the share of operating revenues derived from non-sales sources. Constrained utilities significantly increased the non-sales revenue share by 31.9 basis points relative to unconstrained utilities during the drought (column 3). Column 4 demonstrates that this shift persisted beyond the initial year of the exceptional drought shock. Although the estimated effects are modest in absolute terms, they are large relative to the typical change in the non-sales revenue share over time: 4.5 basis points for the one-year change and 9.6 basis points for the two-year change.

Table I.E.4: Year-to-Year Effects of Rate Covenants During the Drought on Operating Revenue Components

	Water Price per MG_t (1)	Water Price per MG_{t+1} (2)	Δ Non-Sales Share (3)	$\Delta_{t-1\rightarrow t+1}$ Non-Sales Share (4)
Exceptional Drought (std.)	-29.352	-3.559	-0.051	0.123
	(21.575)	(26.097)	(0.068)	(0.115)
Constrained×Drought	87.327**	78.051*	0.319*	0.386*
	(43.481)	(45.152)	(0.172)	(0.220)
Observations	2,057	2,057	5,616	5,055
R-squared	0.941	0.941	0.041	0.105
Utility FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
E[Y]	$4,985	$4,985	.045	.096
SD[Drought]	32.542	32.542	28.464	29.624

Clustered standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

I.E.5.2 Intergovernmental Transfers

The pecking order of fiscal adjustment, discussed in Section 2.3, suggests that governments prioritize using rainy day balances and intergovernmental transfers to absorb fiscal shocks before adjusting taxes or spending. The main results show that unconstrained utilities in the control group experienced revenue declines in response to exceptional drought shocks, accompanied by negligible expense adjustments. This raises the question: how did unconstrained utilities adjust to the fiscal shock if they did not significantly alter revenues or spending? While I cannot observe rainy day balances at the water enterprise level or intragovernmental transfers (e.g., transfers from the general city government to the water enterprise) due to the limitations of the FTR data structure, I can test whether unconstrained utilities relied on intergovernmental transfers from federal, state, county, and other government sources. To measure intergovernmental transfers, I use data from the nonoperating revenues section of the FTR report. This excludes capital contributions that are classified as fund equity, as these funds are restricted to the purposes of the acquisition and construction of capital assets. Given the lumpy nature of these transfers, I construct the dependent variable as total intergovernmental transfers divided by lagged total revenues.

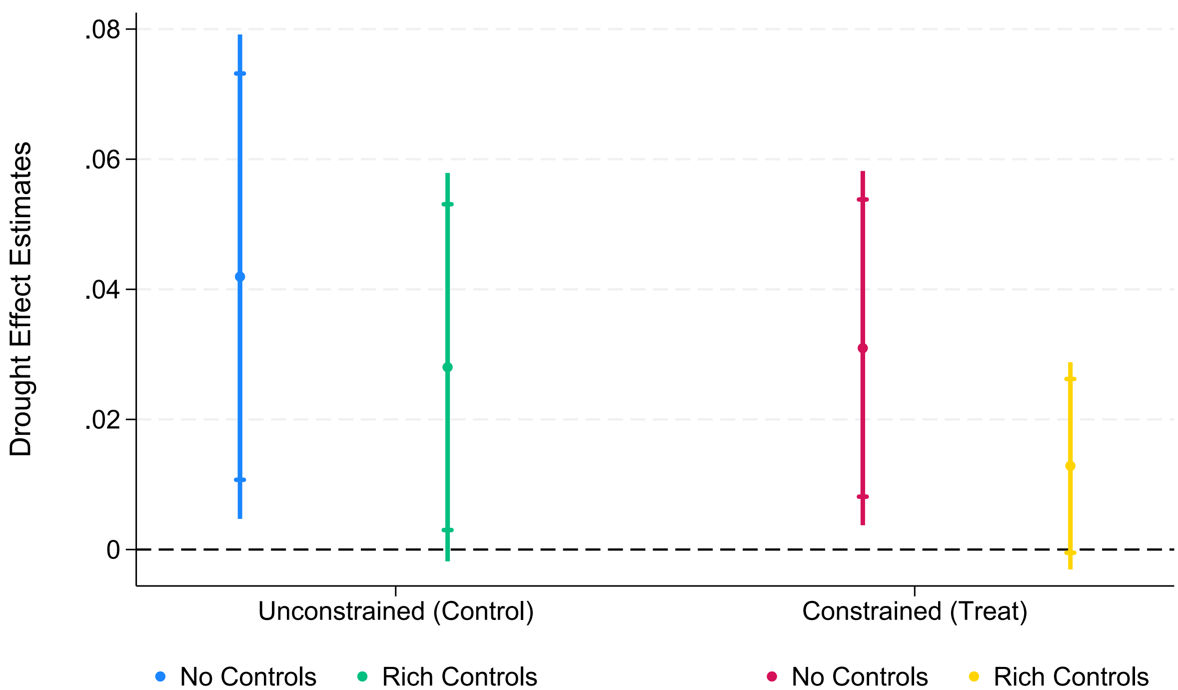
Results are presented in Figure I.E.7. The results, presented in Figure I.E.7, show that a one standard deviation increase in drought intensity for unconstrained utilities is associated with a 2.8%–4.1% increase in intergovernmental transfers as a share of lagged total water utility revenues. While I cannot reject that there is no difference between the unconstrained and constrained group due to the large standard errors of estimates, I do find that the constrained group has lower intergovernmental transfers per standard deviation increase in exceptional drought intensity than the unconstrained group. In the specification with rich controls, constrained utilities increase intergovernmental transfers by 1.3% of total revenues for a standard deviation increase in drought intensity, though this effect is not statistically significant at the 10% level.

Figure I.E.7: Intergovernmental Transfers and Exceptional Drought

This figure plots coefficients from the following regression:

$$\frac{\text{Intergov. Transfers}_t}{\text{Total Revenues}_{t-1}} = \alpha_i + \alpha_t + \beta \text{Rate Covenant Constrained}_i \times \text{Drought Intensity}_{ct} + \phi_1 \text{Drought Intensity}_{ct} + \phi_2 \text{Drought Period}_{2014-2017} \times X_i + \varepsilon_{ict}$$

The Unconstrained coefficients presented are ϕ_1; the Constrained coefficients are $\phi_1 + \beta$. I present coefficients from the base specification and also with rich controls as mentioned in the main text.



I.E.6 Selection on Unobservables

In this appendix, I follow Altonji et al. (2005) and Oster (2019) to assess the robustness of the estimated treatment effects to omitted-variable bias using coefficient stability and bias-adjusted estimates under proportional selection. I implement this procedure using specifications (3) and (4), which include county-year fixed effects.

For each outcome, I estimate two regressions that differ in the set of observed controls included, as required by Oster (2019). The uncontrolled specifications include utility and year fixed effects, while the controlled specifications replace year fixed effects with county–year fixed effects and add interacted pre-period covariates. I treat utility fixed effects as nuisance parameters, rather than observable controls. The *uncontrolled* regression testing the robustness of β is the following:

$$\begin{aligned}\Delta \log Y_{ict} = \alpha_i + \alpha_t + \beta_{\text{uncontrolled}}\, \text{Rate Covenant Constrained}_i \times \text{Drought Intensity}_{ct} \\ + \phi_1 \text{Drought Intensity}_{ct} + \varepsilon_{ict}.\end{aligned}$$

Similarly, the uncontrolled regression testing the robustness of γ is:

$$\begin{aligned}\Delta \log Y_{ict} = \alpha_i + \alpha_t + \gamma_{\text{uncontrolled}}\, \text{Rate Covenant Constrained}_i \times \text{Drought Intensity}_{ct} \times \text{Tax Resistant}_i \\ + \phi_1 \text{Rate Covenant Constrained}_i \times \text{Drought Intensity}_{ct} + \\ + \phi_2 \text{Tax Resistant}_i \times \text{Drought Intensity}_{ct} + \varepsilon_{ict}.\end{aligned}$$

The *controlled* regressions include the interaction terms, county-year fixed effects, and a vector X_i of utility-level pre-exceptional-drought covariates (the total revenue to total expense ratio, average revenue debt outstanding as a proportion of operating revenues, log service area population, and log median household income), interacted with the drought-period indicator. The controlled regression estimating β is:

$$\begin{aligned}\Delta \log Y_{ict} = \alpha_i + \alpha_{ct} + \beta_{\text{controlled}}\, \text{Rate Covenant Constrained}_i \times \text{Drought Intensity}_{ct} \\ + \phi_1 \, \text{Drought Period}_{2014-2017} \times X_i + \varepsilon_{ict},\end{aligned}$$

and the controlled regression estimating γ is:

$$\begin{aligned}\Delta \log Y_{ict} = \alpha_i + \alpha_{ct} + \gamma_{\text{controlled}}\, \text{Rate Covenant Constrained}_i \times \text{Drought Intensity}_{ct} \times \text{Tax Resistant}_i \\ + \phi_1 \, \text{Rate Covenant Constrained}_i \times \text{Drought Intensity}_{ct} \\ + \phi_2 \, \text{Drought Intensity}_{ct} \times \text{Tax Resistant}_i \\ + \phi_3 \, \text{Drought Period}_{2014-2017} \times X_i + \varepsilon_{ict}.\end{aligned}$$

Table I.E.5 reports bias-adjusted treatment-effect estimates following Oster (2019). Under Oster's proportional-selection framework, these adjusted coefficients correspond to the benchmark assumption that selection on unobservables is as strong as selection on the included observables ($\delta = 1$), given a choice of $R_{\max}$. The adjustment uses the joint movement of the coefficient of interest and the regression R^2 when moving from the uncontrolled to the controlled specification to quantify how large omitted-variable bias would have to be, relative to observed selection, to materially change the estimates. I follow Oster (2019) in setting $R_{\max} = \min\{1.3\,\tilde{R}, 0.99\}$, where $\tilde{R}$ is the within R^2 from the fully specified fixed-effects regression.

Across outcomes, the bias-adjusted coefficients evaluated at $\delta = 1$ remain close to the baseline controlled estimates. For operating revenues, the bias-adjusted estimate is 0.017, compared with 0.012 in Table 3. For spending outcomes in tax-resistant areas, the bias-adjusted coefficients remain negative for operating expenses and water-system spending (-0.016 and 0.027, respectively), similar to the preferred-specification estimates of 0.018 and 0.037 in Table 4. The bias-adjusted estimate for administrative spending remains positive (0.009). Taken together, the bias-adjusted estimates suggest that the main results are unlikely to be driven by omitted-variable bias under the equal-selection benchmark, even after absorbing county-level shocks with county–year fixed effects and allowing for differential drought responses by pre-period utility characteristics.

Table I.E.5: Oster Bias-Adjusted Estimates

This table reports bias-adjusted treatment-effect estimates following Oster (2019) for the main drought specifications with county-year fixed effects and interacted controls. I compute bias-adjusted coefficients under the benchmark assumption that selection on unobservables is as strong as selection on observables ($\delta = 1$). The maximum hypothetical R^2 is set to $R_{\max} = \min\{1.3\,\tilde{R}, 0.99\}$, where $\tilde{R}$ is the within R^2 from the fully specified fixed-effects regression. I treat utility fixed effects as nuisance parameters.

Specification:	Eq 1: Unconditional	Eq 2: Conditioning on Tax Resistance		
	β Estimate		γ Estimate	
Budget Outcome:	Δ Log Op. Revenues	Δ Log Op. Expenses	Δ Log Op. Water	Δ Log Op. Admin.
	(1)	(2)	(3)	(4)
Bias-adjusted estimate ($\delta = 1$, FE partialled out)	0.017	-0.016	-0.027	0.009

I.F Alternative Drought Experiment

In this appendix, I present an alternative empirical strategy that continues to use droughts as a fiscal shock but focuses on a different mechanism in a more selected sample. Rather than exploiting variation in exceptional drought exposure, I use state-mandated conservation standards implemented during California's exceptional drought as a shock to covenant tightness, which operates through an exogenous shock to demand and corresponding declines in revenues. The goal of this appendix is to compare how utilities near their rate covenant thresholds respond to this demand shock relative to those much further away from their thresholds. This design is motivated by findings from the corporate covenant literature, which document strong nonlinearities in firm behavior depending on proximity to covenant thresholds.

I.F.1 Background

In this section, I exploit the effect of California's conservation mandates on the residential water sector as a demand shock. Starting in 2014, the state of California issued multiple edicts restricting water use in the residential sector. The first was a state of emergency declaration in January 2014, which was followed by three executive orders calling for voluntary reductions in water use in 2014. In June 2015, mandatory restrictions were enacted to achieve a statewide reduction in residential water use per capita to 25% of 2013 levels. These restrictions applied to urban water suppliers with greater than 3,000 connections. Urban water suppliers were sorted into 9 tiers based on residential gallons per day, measured in 2014. Each tier was mandated to reduce residential gallons by some percentage of 2014 usage, varying from 4% in Tier 1 to 36% in Tier 9. Additionally, California required urban water suppliers to submit monthly conservation reports on water production, sectoral breakouts, and average residential use per day. Non-compliers were first issued a warning and then fined. The emergency declaration was lifted on April 2017, but some water conservation requirements were made permanent in May 2016. Because residential water use is on average 70% of urban water suppliers' total usage, the drought restrictions represented a shock to the revenue base of water utilities.

I.F.2 Research Design

I employ a differences-in-differences design, using the introduction of conservation mandates in fiscal year 2015 as a shock to how close utilities are to their rate covenant thresholds. I create a treated and control group by sorting urban water suppliers into the top and bottom 50th percentiles based on the distribution of average covenant tightness measures in the period prior to the enactment of conservation mandates.[28] The intuition of the design is to compare two utilities exposed to the same demand shock, but one utility is closer to its rate covenant threshold. The drought shock should push utilities closer to their rate covenant thresholds on average, but the treated group is pushed into the nonlinear space of the distribution where rate covenants are most binding. I call this treatment designation $Constrained_i$. The constrained group are those in the top 50% of the covenant tightness distribution; the control group is the bottom 50%. There are 65 utilities in the treated group and 64 utilities in the control group.[29]

I run the following regression specification for the sample of urban water suppliers at the utility i, county j level:

$$\Delta \log(Y_{ij}) = \beta \text{Constrained}_i + \phi X_i + \varepsilon_{ij} \tag{3}$$

This is a first-difference specification, where I collapse outcome variables (Y_{it}) into their pre-period and post-period averages, take the log transformation of these variables, and then the first difference. Based on the timing of the drought restrictions, I define my pre-period to be fiscal years prior to the enactment of drought restrictions (2010-2014) and post-period to be years following the drought restrictions (2015-2019). $Constrained_i$ is my measure of rate covenant tightness, corresponding to the treatment designation. The vector X_i includes controls for heterogeneity in the the conservation mandates and in underlying utility characteristics: a linear control for the conservation standard (the percent reduction associated with each Tier) and population growth between 2000 and 2010, which differs systematically between constrained and unconstrained utilities. The main outcomes are the change in log operating revenues and the change in log water "prices", where water prices are measured as water sales revenues divided by delivered volume (in million gallons). The coefficient β captures how much more (or less) conservation mandates affect these outcomes for covenant-constrained utilities relative to unconstrained utilities.

I also test whether heterogeneity in a population's resistance to tax increases affects constrained utilities' spending decisions, using the tax-resistance measure from the main

[28] I compute the standard-deviation denominator using all available pre-mandate observations from 2003–2014. Using the longer pre-period yields a more stable utility-specific standard deviation for the urban-supplier subsample while remaining fully pre-determined (the conservation mandates begin in 2015).

[29] As in the main design, I do not include utilities that appear to have debt service outstanding, but no identifiable rate covenant.

paper. To test this, I run the following specification:

$$\Delta \log(Y_{ij}) = \gamma \text{Constrained}_i \times \text{Tax Resistant}_i + \phi_1 \text{Constrained}_i + \phi_2 \text{Tax Resistant}_i + \phi_3 X_i + \varepsilon_{ij} \tag{4}$$

The outcomes are changes in log operating expenses, separately for water-system expenses and administrative spending. Tax Resistant$_i$ is an indicator variable representing whether a utility is in the top half of the distribution in terms of the share of no votes on Proposition 30.[30] In this specification, the coefficient of interest is γ, which captures how the effect of being covenant-constrained differs between utilities in more tax-resistant and less tax-resistant areas. It is the incremental impact of tax resistance on the budget response of covenant-constrained utilities to the drought shock, analogous to the interaction design used in the main text. The control vector X_i again includes the conservation standard and population growth; in some specifications I also add the change in log water deliveries to check whether the results simply reflect mechanical reductions in water production and delivery.

An advantage of this strategy is that the demand shock in this setting is largely generated by state-mandated conservation requirements, so assignment of the demand shock is less likely to be driven by unobserved local economic conditions that may be correlated with a utility's fiscal health. Notably, this research design is very similar to the design in the main text; however, I use a different shock to demonstrate a similar relationship between rate covenant constraints and budget decisions in a smaller subset of utilities. However, there are limitations to this experiment. The set of utilities most affected by the drought restrictions are all large urban water suppliers. This greatly reduces statistical power. The sample composition also introduces external validity concerns. In particular, large urban water suppliers are those that have the most flexibility to raise rates and prices and are therefore less likely to cut spending.

I.F.3 Identification/Pre-Trends Analysis

The identifying assumption in this analysis is parallel trends, conditional on observables. I examine how reasonable this assumption is in Figure I.F.1 for a variety of outcomes. These figures plot coefficients β_t from the regression:

$$\log(Y_{it}) = \alpha_i + \alpha_t + \beta_t \text{Constrained}_i + \varepsilon_{it} \tag{5}$$

[30] This indicator variable is formed based on only this sample of urban water suppliers, rather than the full universe of water utilities, in order to have enough power for estimation.

I include utility fixed effects α_i and year fixed effects α_t.

Panels I.F.1a and I.F.1b demonstrate how covenant constrained utilities adjust their revenues and an empirical proxy for water prices. Importantly, pre-trends are insignificant in both plots, supporting the parallel trends assumption. and I find a sizeable positive increase in gross revenues following the drought emergency declaration in 2014. I find more of a delay in price adjustment in the treated group: constrained utilities start to increase prices significantly relative to the unconstrained group in 2016. In panel I.F.1d, I show that this adjustment is not mechanically related to a change in the water provided: there are no years in the post-drought period where the constrained group is significantly different from the unconstrained group.

The main threat to identification is violation of the parallel trends assumption. In particular, the main challenge in the analysis is that water utilities in the constrained group might be differentially exposed to the drought shock. The treatment effect estimate may be biased if variation that drives utilities close to their rate covenant thresholds in the pre-period is correlated with drought exposure. I discuss characteristics of the constrained group that likely determined their treatment status.

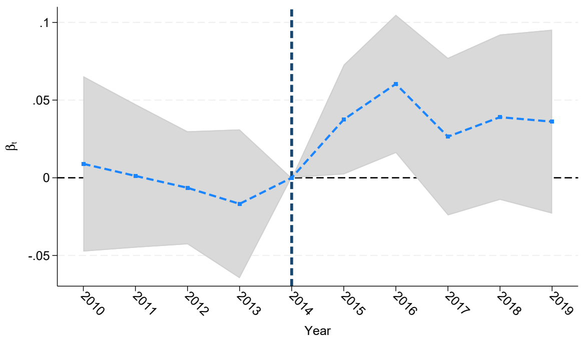
I report summary statistics in Table I.F.1. The two groups are similar in important ways. First, I find that population size and median household income are similar between the constrained and unconstrained group. I fail to reject that the differences in means are significant on these dimensions. I also fail to reject a difference in exposure to the commercial sector. However, the constrained group experienced significantly higher population growth between 2000 and 2010. They also experienced more building in the run-up to the financial crisis (reflected in a larger percent increase in county building permits), although not significantly so. As reported in the main text, constrained utilities had higher debt loads as a proportion of revenues, reflecting this development and growth prior to 2010. To address this potential source of bias, I control for population growth.

I also analyze whether water utilities in the constrained group were differentially exposed to the drought, either through conservation mandates or more generally. I first examine whether constrained utilities were more likely to be affected by the exceptional drought shock in the main text by examining the percentage of their county in exceptional drought during the height of the drought period. I cannot reject that there is no difference between the two groups in this dimension. However, the constrained group is more likely to be in a higher conservation mandate tier, which is significant at the 10% level. Therefore, I control for the conservation standard imposed, as well as the change in water deliveries in some specifications in order to control for differential exposure to conservation mandates and the drought more generally.

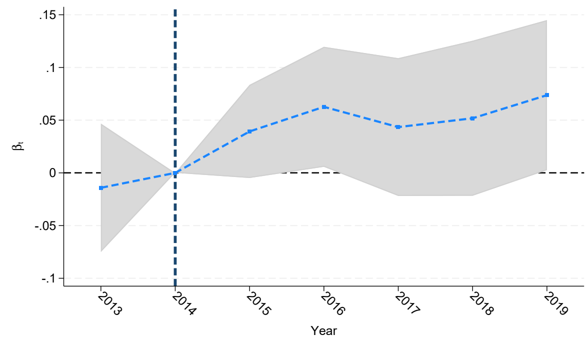
Figure I.F.1: Pretrend Analysis

This figure presents coefficients β_t from regression 5. I present results for the log operating revenues, log “prices” (water purchase sales per water deliveries in MG), log operating expenses, log water deliveries, and covenant tightness. Water deliveries data is only available for 2013-2019 for a subset of 116 out of the 129 utilities in the sample.

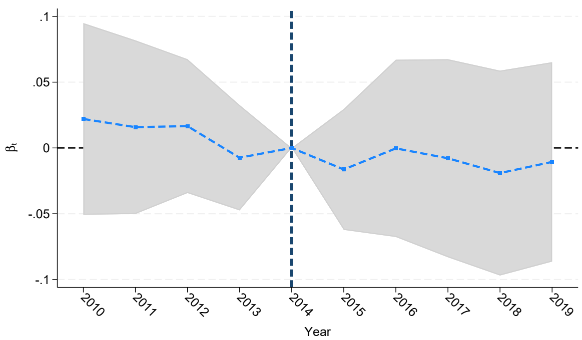
(a) Log Op. Revenues



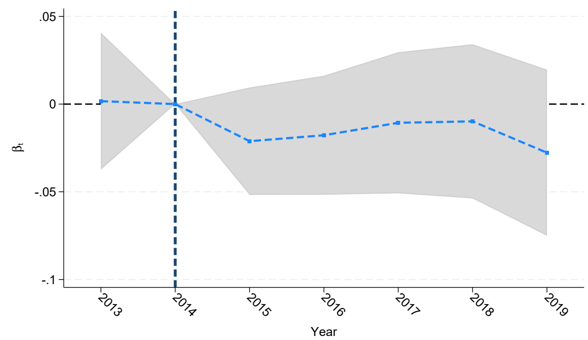
(b) Log “Price”



(c) Log Op. Expenses



(d) Log Water Deliveries (MG)



(e) Covenant Tightness

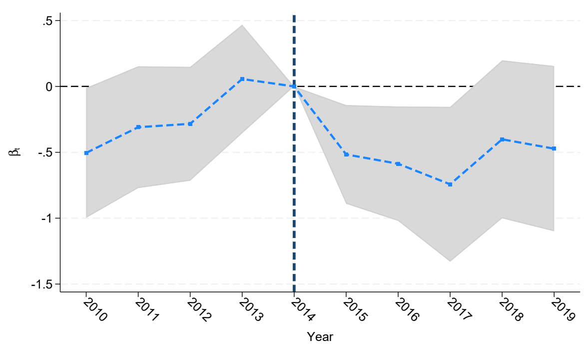


Table I.F.1: Balancing Table and Summary Statistics

	Unconstrained	Constrained	P(Difference)
Num. utilities	64	65	
Covenant Tightness	-1.66	-0.04	0.00***
Log Operating Revenues	16.6	16.33	0.17
Commercial, Institutional, Industrial Share of Water	0.18	0.16	0.43
Log Population	11.18	10.98	0.37
Log Med. House. Income	11.05	11.07	0.78
Δ Pop. (%) '00-'10	6.58	13.39	0.02**
Δ County Building Permits (%, units) '00-'05	40.76	49.29	0.5
County Unemployment Rate (%)	10.42	11.04	0.29
Tax Resistance (Prop 30 No Share)	0.45	0.48	0.18
% of County in Exceptional Drought 2014-17	30.48	34.8	0.32
Drought Restriction Tier	5.67	6.34	0.06*
Num. utilities w/ water data	56	58	
Num. utilities w/ admin spending data	64	64	
Num. utilities w/ water spending data	62	59	

I.F.4 Results

Table I.F.2 reports the main results from the alternative drought experiment, comparing utilities above and below the median of pre-period covenant tightness. Constrained utilities respond to the conservation-induced demand shock by significantly increasing operating revenues: across specifications, the estimated effect ranges from 4.0% to 4.6% (columns 1–2), and these magnitudes are robust to controlling for the conservation standard and population growth. I also find that constrained utilities raise effective water "prices" by about 6.0–6.2% (columns 4–5). When I include the pre-period average covenant tightness directly, a one–standard deviation increase in tightness is associated with a 2.4% increase in operating revenues and a 2.7% increase in water prices (columns 3 and 6). Overall, these results indicate that constrained utilities adjusted to the conservation mandates more strongly on the revenue side than unconstrained utilities, via higher prices and revenues.

Panel I.F.1c of Figure I.F.1 shows that, prior to the imposition of conservation standards, average spending levels for constrained and unconstrained utilities were very similar and statistically indistinguishable. Table I.F.3 examines whether tax resistance shaped the spending responses of constrained utilities once the conservation mandates were enacted. The coefficient on the interaction term implies that, conditional on any average spending response associated with tax resistance, constrained utilities in more tax-resistant areas reduce operating expenses more during the mandate period than constrained utilities in less tax-resistant areas (columns 1–2). The differential response is larger for water-system expenses (columns 5–7), where the interaction term indicates substantially larger cuts; these estimates are significant at the 10% level in the baseline specifications and at the 5% level once I control for changes in water deliveries. In contrast, the estimates for administrative expenses (columns 3–4) are positive but imprecise. Taken together, these results suggest that where political resistance to higher rates is stronger, covenant-constrained utilities are more likely to absorb fiscal shocks by cutting spending, especially on water-system activities, in addition to raising revenues. These findings are consistent with the exceptional drought results in the main text.

Table I.F.2: Effects of Rate Covenants and Conservation Standards

Specification:	Eq 3: Unconditional					
Budget Outcome:		Δ Log Op. Revenues			Δ Log "Prices"	
	(1)	(2)	(3)	(4)	(5)	(6)
Constrained	0.040*	0.046**		0.060*	0.062*	
	(0.021)	(0.020)		(0.032)	(0.034)	
Conservation Standard		-0.242*	-0.207		0.005	0.038
		(0.134)	(0.136)		(0.185)	(0.181)
Δ Log Pop. '00-'10		0.000	0.000		-0.000	-0.000
		(0.001)	(0.001)		(0.001)	(0.001)
Cov. Tightness (Pre)			0.024**			0.027*
			(0.010)			(0.014)
Constant	0.073***	0.127***	0.163***	0.111***	0.112**	0.157**
	(0.019)	(0.038)	(0.039)	(0.020)	(0.051)	(0.059)
Observations	129	129	129	116	116	116
R-squared	0.025	0.047	0.054	0.040	0.041	0.037

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table I.F.3: Interactions with Tax Resistance for Spending Outcomes

Specification:	Eq 4: Conditioning on Tax Resistance						
Budget Outcome:	Δ Log Op. Expenses		Δ Log Admin Expenses		Δ Log Water Expenses		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constrained × Tax Res.	-0.072*	-0.079*	0.095	0.116	-0.228*	-0.244*	-0.265**
	(0.043)	(0.044)	(0.187)	(0.184)	(0.118)	(0.127)	(0.116)
Constrained	0.017	0.017	-0.005	-0.033	-0.022	-0.005	-0.053
	(0.025)	(0.028)	(0.176)	(0.169)	(0.085)	(0.086)	(0.083)
Tax Resistant	0.015	0.027	-0.189**	-0.266**	0.174**	0.227***	0.193*
	(0.041)	(0.052)	(0.078)	(0.126)	(0.065)	(0.082)	(0.100)
Conservation Standard		-0.165		0.624		-0.500	-0.670
		(0.201)		(0.718)		(0.425)	(0.450)
Δ Log Pop. 00-10		0.001*		0.002		-0.000	0.000
		(0.000)		(0.002)		(0.003)	(0.003)
Δ Log Water Deliveries							-1.107
							(0.656)
Constant	0.105***	0.132***	0.259***	0.140	0.006	0.099	0.021
	(0.024)	(0.032)	(0.077)	(0.120)	(0.049)	(0.091)	(0.114)
Observations	128	128	126	126	120	120	109
R-squared	0.028	0.039	0.021	0.032	0.055	0.064	0.109

Clustered standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1