Inefficiencies in Local Infrastructure: Evidence from Drinking Water in California

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Infrastructure investment

- Growing concerns about infrastructure investment
- Local governments shape investment in infrastructure
  - $\sim$ half a trillion dollars annually on transportation and water infrastructure
- Local policymakers may face limited discipline from elections, or weak *electoral accountability*
  - Muted electoral competition at the local level: often uncontested
  - Limited media scrutiny of local policy decisions

  $\Rightarrow$ Investment may be insufficiently responsive to residents' welfare

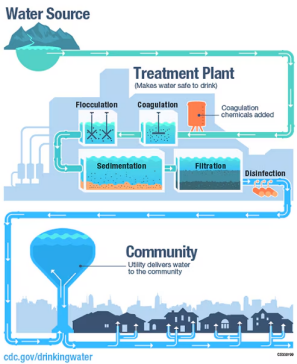
Empirical context: Investments in drinking water in California

- Drinking water infrastructure
  - cities and special districts own and operate drinking water systems
  - much of the infrastructure was built in the 1970s and 1980s
  - 10% of Americans exposed to health-based violations Map
  - despite substantial federal and state subsidies (e.g. $41.1 billion from since 1997 through Safe Drinking Water Act)

- **This paper**
  1. Quantifies **misallocation** in investment driven by weak electoral accountability.
  2. Shows that weak accountability **undermines the effectiveness** of federal subsidies, by lowering take-up where it matters most

Setting & Data

Provision of drinking water



- 273 cities and 551 special districts
  - ~ 12 districts per county; 2 per schools district
- Infrastructure investment
  - determined by elected officials: city council, county supervisors (dependent districts), district boards (independent districts) Campaign Voter response
  - financed by long-term debts (70%) + grants
  - cost is paid by water rate/fee
- Regulated by the Safe Drinking Water Act (1974)
  - 90 pollutants by maximum contaminant levels (MCL)
  - mandates timely public notifications of violations

Data sources, 2003-2022

- **Government investment** and **water rates** Stat
  - long-term debts (FTR), borrowing terms (CDAIC), federal loans/grants (DWSRF)
  - rates (FTR, eAR, manually collected)
- **Water pollution** Stat
  - contaminants concentration readings (CASWRCB), health standards violations (EPA)
- **Residents preferences for water quality**:
  - house prices (CoreLogic) & house/buyer char. (HMDA + ACS + LEHD), PWS boundaries
- **Local political environment**:
  - elections (CEDA, manually collected), individual turnout (L2)
  - local newspaper presence (3DLNews)

Anecdotal example: Nitrate contamination in San Joaquin valley

- East Orosi totals 99 health based violations since 2003, mainly nitrates from agriculture

"Imagine children knowing that water only comes from a bottle and not from their own tap."

— Eddie Valero, Tulare County

- Despite documented health risks, in our data Orosi Public Utilities District has
  - no investment during the study period
  - no election records until 2024, since a 2008 recall over alleged misuse of office

Motivating Evidence

Does political environment affect water quality?

- **Outcome**: % of pollutant readings above federal limits (pollutant-jurisdiction-year level)
- **Political environment**
  - competition (% contested elections) and information (local newspaper presence)
- **Challenge**: Political environment correlated with demand and costs
- **Identification: Election timing reform + controls**
  1. e.g., CA Voter Participation Act (2015): move to on-cycle elections
     → higher turnout and more challengers Mechanism DiD
     → interpreted as a shifter for accountability without directly affecting investment fundamentals
  2. controls for factors affecting costs/benefits of investment (e.g., water source, ..)

Political environment matters

	Average % above MCL			
	(1)	(2)	(3)	(4)
Frequency of contested elections	-0.229*			
	(0.132)			
Any local newspaper within 20 miles		-0.327**		
		(0.145)		
Frequency of on-cycle elections			-0.384**	
			(0.127)	
Holding on-cycle elections				-0.121**
				(0.064)
Median household income (standardized)	-0.228***	-0.233**	-0.233**	-0.0701
	(0.066)	(0.065)	(0.065)	(0.068)
Demographics, system attributes, precipitation stats	Yes	Yes	Yes	Yes
Pollutant-Year FE, County FE	Yes	Yes	Yes	No
Pollutant-Year FE, **Pollutant-Jurisdiction FE**	No	No	No	**Yes**
Number of observations	346,196	346,196	346,196	346,196

- Suggest investment is not aligned with welfare $\Rightarrow$ a model to quantify misallocation Cost

Model & Estimation

Model: Accountability and investment

- **Residents**: Value water quality (q_{jt}) vs. cost (r_{jt}) in jurisdiction j with income y_i

$$u(q_{jt}, r_{jt}; y_i) = \omega(y_i)\, q_{jt} - r_{jt}$$

- **Policymaker**: Chooses investment ($a_{jt} \in \{0, 1\}$) each period, with per-period payoff:

$$\underbrace{\{-\kappa_j + \epsilon_{jt}\}}_{\text{Private cost, limited govt capacity}} \quad a_{jt} + \sum_{i \in \mathcal{I}_{jt}} \lambda_j \pi_{jt}(y_i) \underbrace{\mathbb{E}\left[u(q_{jt}, r_{jt}, y_i) | a_{jt}\right]}_{\text{Residents' welfare}}$$

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- **Accountability:** Weight on resident welfare depends on political environment Micro
  - * entry cost of challenger ⇒ prob. of contested elections
  - * voter responsiveness (salience of water issues)
  - ⇒ Higher accountability (λ_j) ⇒ stronger response to welfare gains
  - * relative turnout $\pi_{jt}(y_i)$

Identification and estimation

Estimate dynamic model (Rust, 1987): investment decisions pin down Δ per-period payoff

$$\{-\kappa(x_j) + \epsilon_{jt}\}\, a_{jt} + \lambda(x_j) \sum_{i \in \mathcal{I}_{jt}} \pi(y_i, x_{jt}) \mathbb{E}\left[u(q_{jt}, r_{jt}, y_i) | a_{jt}, x_{jt}\right]$$

Challenge: Disentangle residents' preferences (u) and policymakers' preferences (λ, κ)

- Turnout function $\pi(y, x)$ from voting data to weight residents

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- **Estimate residents' net value for investment offline** Model Design Alt. Results Robustness
  - Housing demand model (Bayer, Ferreira & McMillan, 2007) comparing houses at boundary
  - Impact of investment on water quality and rate: event study (Cengiz et al, 2019)

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  - Variation from exogenous factors for pollution and rate (precipitation, subsidy eligibility)

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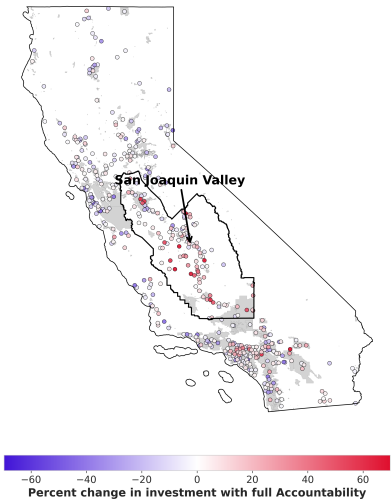
Finding: Policymakers respond to welfare—more under high accountability Results Fit Direct

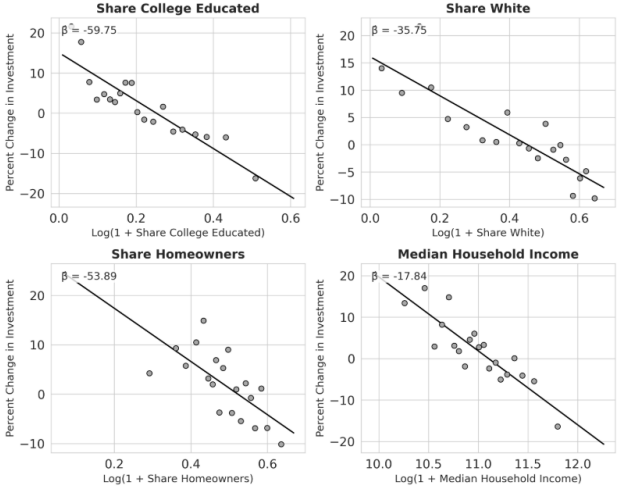
Counterfactuals

Quantifying misallocation from lack of accountability



- What if all elections were contested?
- Changes in investment vary across space
- Improvements concentrated in San Joaquin Valley (agricultural region, polluted water)
  - Includes East Orosi

Progressive consequences of increased accountability

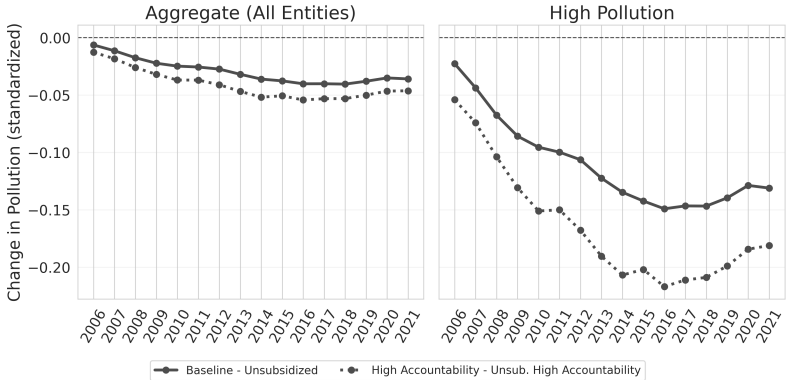


- Low-SES govs exhibit large increases in investment with greater accountability

Role of accountability in the returns to public funding

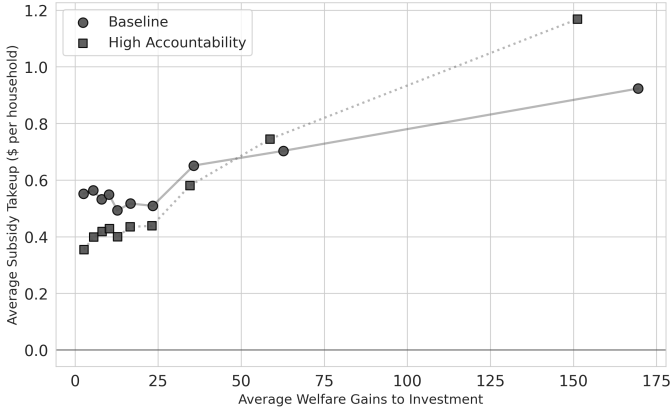
- Substantial public funding for drinking water investment
  - Federal: DWSRF (since 1997), expanded by ARRA (2009) and IIJA (2021)
  - California: general obligation bonds and SB 200 (2019)
  - targeted toward “disadvantaged communities”
- **Does limited electoral accountability reduce the effectiveness of subsidies?**
  - simulate investment under a no-subsidy counterfactual
  - contrast with baseline $\rightarrow$ effect of subsidies
  - evaluate how these effects change under higher accountability

Accountability improves the targeting of infrastructure policy



- Accountability boosts public funding's impact by 47% in **polluted** systems

Accountability directs subsidies to high-return projects



- Average subsidy take-up amount increases with the welfare gains from investment
- Steeper response under high accountability

Conclusion

- Suggestive evidence:
  - electoral accountability influences drinking water quality
- Empirical framework allows us to:
  - quantify distortions in how residents' preferences are translated into local investment
- Reducing local political distortions is key for effective infrastructure policy
  - accountability improves targeting and efficiency of public funding

Appendix

Roadmap

Measurement of voter preferences

Do voters care?

Impact of switching elections on-cycle

Identification of politicians' payoff parameters

Micro-foundation for the politician's payoff

Additional results

Measuring resident preferences for water quality

Back

1. Hedonic approach using housing transactions [our paper]
2. Avoidance behavior (e.g., water filters or bottled water purchases)
   - → Matching purchases to water service areas is imprecise
3. Voting behavior
   - Referenda on water infrastructure bonds
     * 133 relevant referenda (1995-2022); many bundle multiple purposes
   - Elections for office (city council, county supervisors, water district board)
     * Enables decomposition of λ
     * Candidate data not available + frequently uncontested for water district board elections

⇒ Hedonic approach is the best given data availability

Measuring resident preferences for water quality

Back

- **Interpreting WTP estimates**
  - may not capture all residents equally (e.g., homeowners vs. renters)
  - capture expectations about future water quality imperfectly (proxied by recent quality)
  - based on imperfect information about water quality

- **But they capture revealed preferences of voters**
  1. Investment responds positively to our measure of net value
  2. Housing market reacts to water quality shocks
     * Event study: house prices decline following Tier I EPA violations
  3. Boundary design: Balance test ✓ + robust to including school characteristics

⇒ WTP provides a meaningful proxy for politically relevant preferences

Robustness to mismeasurement of voter preferences

Back

Concern: Policymakers may observe WTP components we do not

1. **Classical error**: Error orthogonal to Δu
   - $\rightarrow$ attenuation bias in λ (conservative)
2. **Endogenous error** Error correlated with Δu
   - e.g. high-pollution areas have unobservably low demand
   - $\rightarrow$ endogeneity bias

Solution: Control function (work-in-progress)

- Use exogenous shocks to pollution and costs to isolate variation in Δu

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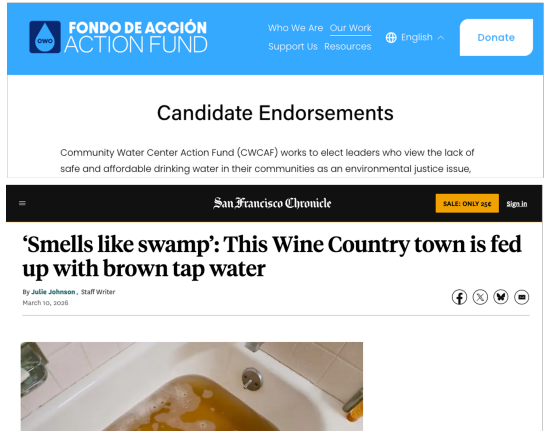
- Surveys indicate high public concern about drinking water pollution
- Advocacy organizations (e.g., Community Water Center Action Fund)
  - voter education, candidate endorsements, and grassroots campaigns
- Media coverage on water quality conditions and utility performance



Voters respond to drinking water quality

Back

	Incumbent staying		Incumbent vote share	
	OLS	2SLS	OLS	2SLS
High pollution reading	-0.031**	-0.115*	-0.033	-0.523***
	(0.013)	(0.061)	(0.021)	(0.127)
Year FE	Yes	Yes	Yes	Yes
Observations	4,870	4,870	4,560	4,560
R^2	0.018	-0.006	0.124	-0.350
F-statistics (1st stage)	-	111.90	-	103.65

- Based on election outcome data (not used in the estimation)
- Instruments for past period's pollution: precipitation

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Election timing and the political environment

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Election timing reshapes local political environments

1. Higher turnout in on-cycle elections (well-established)
2. On-cycle elections are more likely to be contested (our finding)
   - *Candidate-side:* lower entry costs from spillovers from concurrent campaigns
   - *Voter-side:* higher entry returns from more representative electorate
   - *Countervailing force:* stronger incumbency advantage (de Benedictis-Kessner, 2018)

   → Net effect is ambiguous a priori

Rather than taking a stand on the mechanism, we treat election timing as an **exogenous shift** in the political environment that affects **accountability**

Election timing and contested elections

Back

	Dependent var: Any contested elections			
	Full sample		Subsample	
	(1)	(2)	(3)	(4)
On-cycle election schedule	0.125***	0.117***	0.247***	0.235***
	(0.0326)	(0.0330)	(0.0474)	(0.0506)
Demographic attributes	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes
Jurisdiction FE	Yes	Yes	Yes	Yes
Observations	7,039	6,926	3,230	3,179
R^2	0.562	0.565	0.604	0.606

Notes. The unit of observation is jurisdiction $\times$ two-year period. SE clustered at the jurisdiction level. Columns (1)–(2) use the full sample, while Columns (3)–(4) restrict the data to the post-2014 period and excludes jurisdictions that already had on-cycle election schedules prior to 2018.

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Politicians respond to water investment needs

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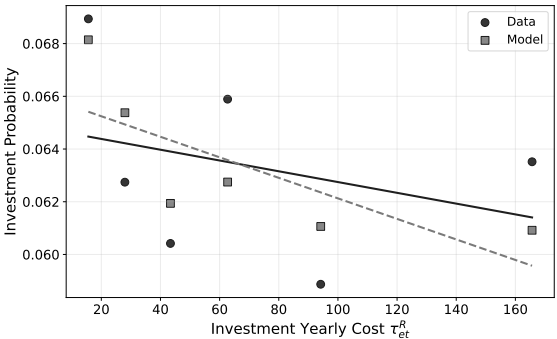

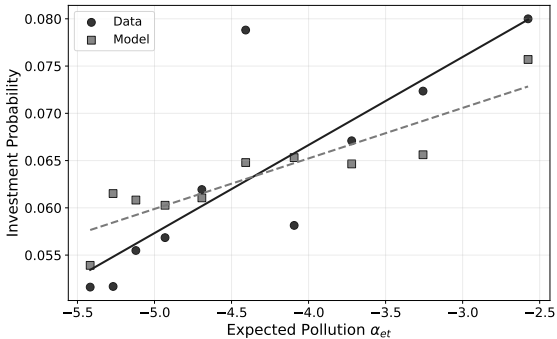

Responsiveness depends on political environment

Back

	Dependent var.: Any investment		
	(1)	(2)	(3)
Net Utility for Investment (Net WTP)	0.0002***	0.0001**	0.0008***
	(5.46e-5)	(5.18e-5)	(0.0002)
Net WTP × High Contested	0.0001*	0.0001*	0.0007**
	(7.29e-5)	(7.29e-5)	(0.0003)
Observations	8,986	8,986	8,986
R^2	0.0138	0.0190	0.0684
County FE	Yes	Yes	No
Year FE	No	Yes	Yes
Jurisdiction FE	No	No	Yes

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$. Standard errors clustered at the county level.

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Probabilistic voting model Back

Agents:

- Governing body facing reelection on a staggered cycle $\equiv$ policymaker
- Residents that differ in how they evaluate drinking water cost/quality trade-off

Actions:

- Policymakers make investments with lasting effects on water rates and quality
- Residents vote to retain/replace members based on current outcomes

Timeline:

- Investment decision $\rightarrow$ quality and rate are realized $\rightarrow$ election takes place

Voting and incumbent's expected payoff from elections

Back

- Resident i votes in favor of the policymaker iff

$$u(q_t, r_t, y_i) \;\geq\; v_{it}$$

where $v_{it} \sim U[-\frac{1}{2\sigma_v}, \frac{1}{2\sigma_v}]$ independent from water outcomes

- With uncertainty in translating vote share to victory, $\eta_t \sim U[-\frac{1}{2\sigma_\eta}; \frac{1}{2\sigma_\eta}]$,

$$\text{winning prob.} \;=\; \frac{1}{2} \;+\; \sigma_\eta\, \sigma_v \int \tilde{\pi}_t(y)\, u(q_t, r_t, y)\, dF_{yt}(y)$$

- Incumbent values getting reelected at ν + elections are contested with prob ρ:

$$\mathbb{E}(\text{payoff from election}) = \underbrace{\rho\nu\sigma_\eta\, \sigma_v}_{\lambda} \quad \underbrace{\int \tilde{\pi}_t(y)\, u(q_t, r_t, y)\, dF_{yt}(y)}_{\text{turnout-weighted welfare average}}$$

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Share of water below health standards, 2009-19

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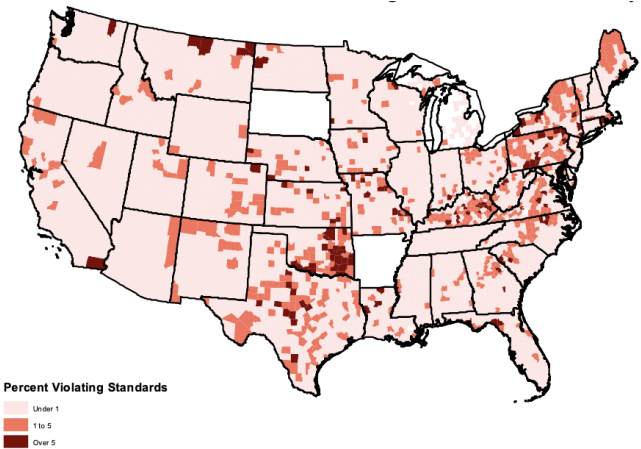


Source: Kaiser et al (2023), Figure 1-C

Investment frequency and finances

Back

	Cities	Special districts
Annual investment frequency	0.069	0.049
Conditional on any investment		
Amount debt-financed or externally funded		
Mean (in $ millions)	131.68	48.01
Median (in $ millions)	13.53	6.96
Per household, Mean (in $)	3,481	7,971
Per household, Median (in $)	1,755	2,031
% financed via debts (vs. grants)	66.21	57.92
Number of governments	273	551

Drinking water quality measurement

Back

- Water pollution measured at each treatment facility
- Measured as the sum of
  (a) an indicator for EPA Tier I and II violations
  (b) an indicator for each pollutant reading $>$ MCL, excluding disinfection byproducts

  divided by (the total number of pollutants + 1)

	Cities	Special Districts
Pollution measure $>$ 0	0.260	0.199
EPA - Tier I	0.005	0.008
EPA - Tier II	0.065	0.084

Accountability increases response to subsidy opportunities

Back

	Dependent var.: Any investment			
	All		Low Accountability	High Accountability
	(1)	(2)	(3)	(4)
E(grant intensity)	0.3909***	0.4668***	0.0773	0.4644***
	(0.1415)	(0.1632)	(0.1626)	(0.1637)
E(grant intensity)× Higher accountability		-0.4876**		
		(0.2106)		
Jurisdiction FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	14,320	14,320	1,460	12,860
R^2	0.0602	0.0603	0.0589	0.0609

- Use quasi-exogenous variation in funding: expected grant intensity

Residents' demand for water quality

Back

- Individual i's indirect utility from a house h in period t:

$$U_{iht} = \boldsymbol{\theta}_x \boldsymbol{x}_{ht} + \theta_q(y_{it}) q_{j(h)t} - \theta_p(y_{it})(p_{ht} + r_{j(h)t}) + \theta_d d_{iht} + \psi_{b(h)t} + \xi_{ht} + \varepsilon_{iht}$$

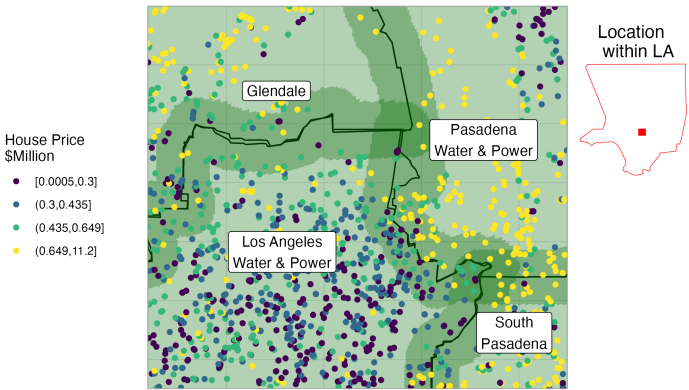
  - $q_{j(h)t}$: water quality provided by h's jurisdiction, $j(h)$
  - $r_{j(h)t}$: annual water rate specific to house h
  - p_{ht}: annual user cost of housing except for r_{ht}
  - d_{iht}: distance to i's work to house h

- Resident i's marginal WTP for quality $\omega()$ is given by:

$$\omega(y_{it}) = \frac{\theta_q(y_{it})}{\theta_p(y_{it})}.$$

Illustration of boundary design

Back



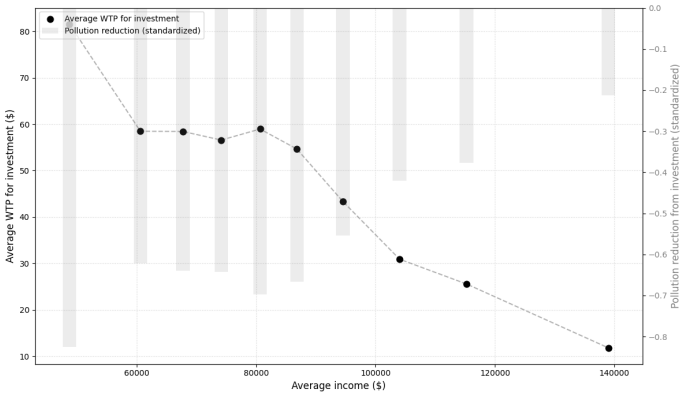
Residents care about water quality, *heterogeneously*

Back

	Without Neigh. Pref. (1)	With Neigh. Pref. (2)
First Stage		
Income (log) × Water pollution	0.008 (0.550)	0.025 (0.115)
Income (log) × House price	36.241 (0.044)	32.116 (0.118)
Distance to workplace	-6.792 (0.040)	-6.799 (0.273)
Income (log) × Block-group income		0.480 (0.236)
Second Stage (IV) - Dep. Var: $\hat{\delta}$		
House user cost (price + rate)	-66.187 (1.257)	-59.742 (1.116)
Water pollution	-0.020 (0.007)	-0.023 (0.009)
Fraction of college educated	0.968 (0.047)	0.933 (0.046)
# Bedrooms (log)	0.037 (0.007)	0.038 (0.006)
Other house attributes	Yes	Yes
Border × Year FE, Market FE	Yes	Yes
Observations	870,637	870,637

Willingness to pay for 1 SD increase in water quality

Back



- Mean WTP ≈$60 per year/household
- Reasonable?
  - family of 4 spend $250-$2,700 annually on bottled water
  - average water bill $1,128

Estimates of policymakers' preferences

Back

	Coefficient	Std. Error
κ: **Capacity**		
Constant	3.276	(0.371)
Number of skilled employees (log)	-0.157	(0.028)
Small-sized	0.454	(0.039)
λ: **Weight for constituent welfare**		
Constant	-15.874	(3.160)
Electoral accountability index	9.613	(3.349)
County FE	Yes	
Observations	8,986	
Avg. Neg. log-likelihood	0.230	

Capacity more limited if:

- smaller systems
- fewer skilled employees

Welfare weight increases with electoral accountability