Enduring effects of changes in billing frequency: Evidence from urban water use

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Resources for the Future

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Motivation

For environmental policy, how robust is information provision as a regulatory instrument?

- Increasing reliance on non-pecuniary mechanisms for conservation
- Varying degrees of persistence

Previous work:

- One-time social norm treatments can have lasting implications (Bernedo, Ferraro, & Price, 2014)
- The impact of sustained treatments decline (slowly) over time (Allcott and Rogers, 2014)
- Moral suasion and economic incentives have diverging long-run implications (Ito et al., 2015)
- More frequent billing (pre-paid metering) may relax credit constraints (Jack and Smith, 2015)

This talk

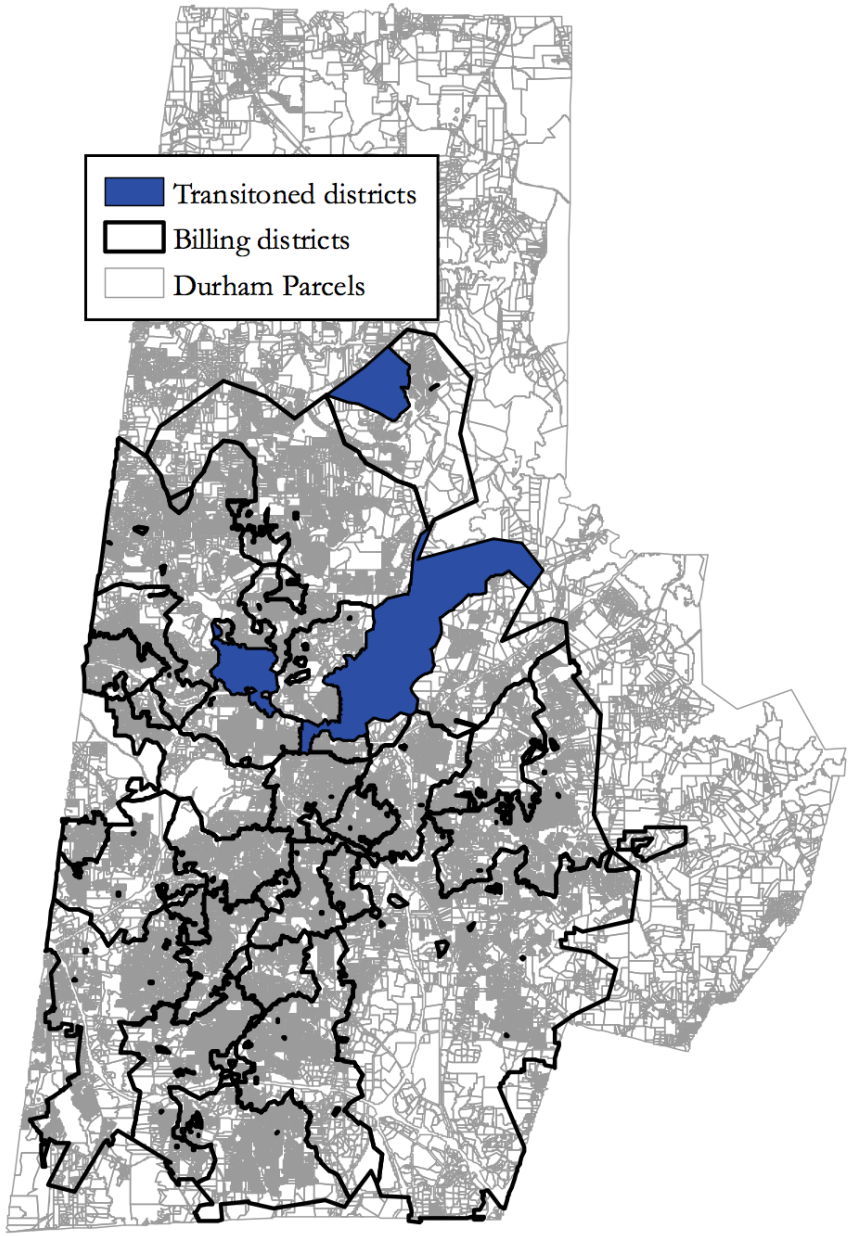
I exploit a natural experiment in water demand in which residential customers were transitioned from bi-monthly to monthly billing

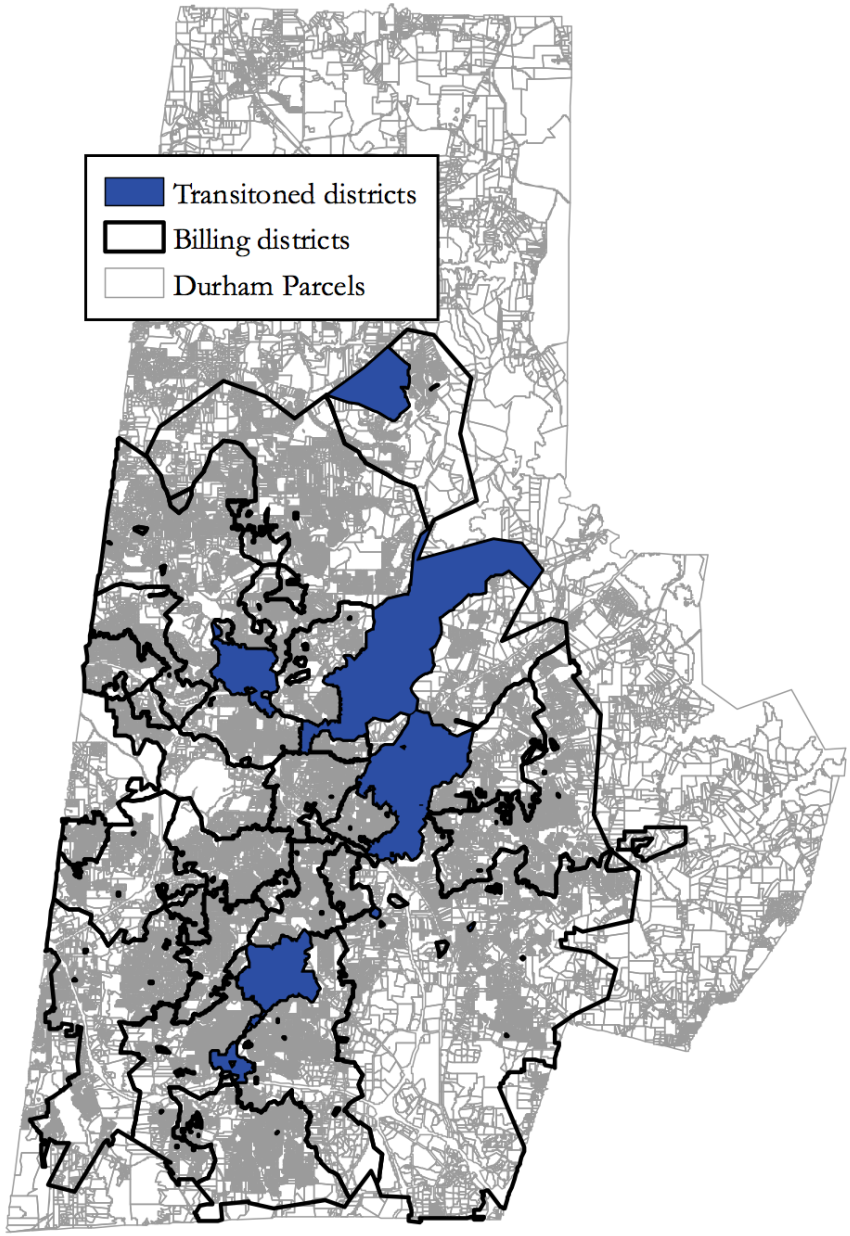
- Water customers *increase* consumption 3-5% in response to more frequent billing
- Can be reconciled in model of misperceived consumption costs, where more frequent information allows consumers to optimize "better"
- Dynamic treatment effects suggest that responses persist, but decline slowly over time
- Lowest users increase by the largest percentage
- No evidence of heterogeneous responses by income class

Data & empirical setting

Experimental setting in Durham, NC:

- Starting in Dec. 2011, water billing districts were individually transitioned from bi-monthly to monthly billing
  - Primary motivation: Delinquent payments, leak detection
  - Meter replacement
- By Sep. 2014, all of Durham's 17 billing districts were transitioned to monthly billing.


Transitoned districts
Billing districts
Durham Parcels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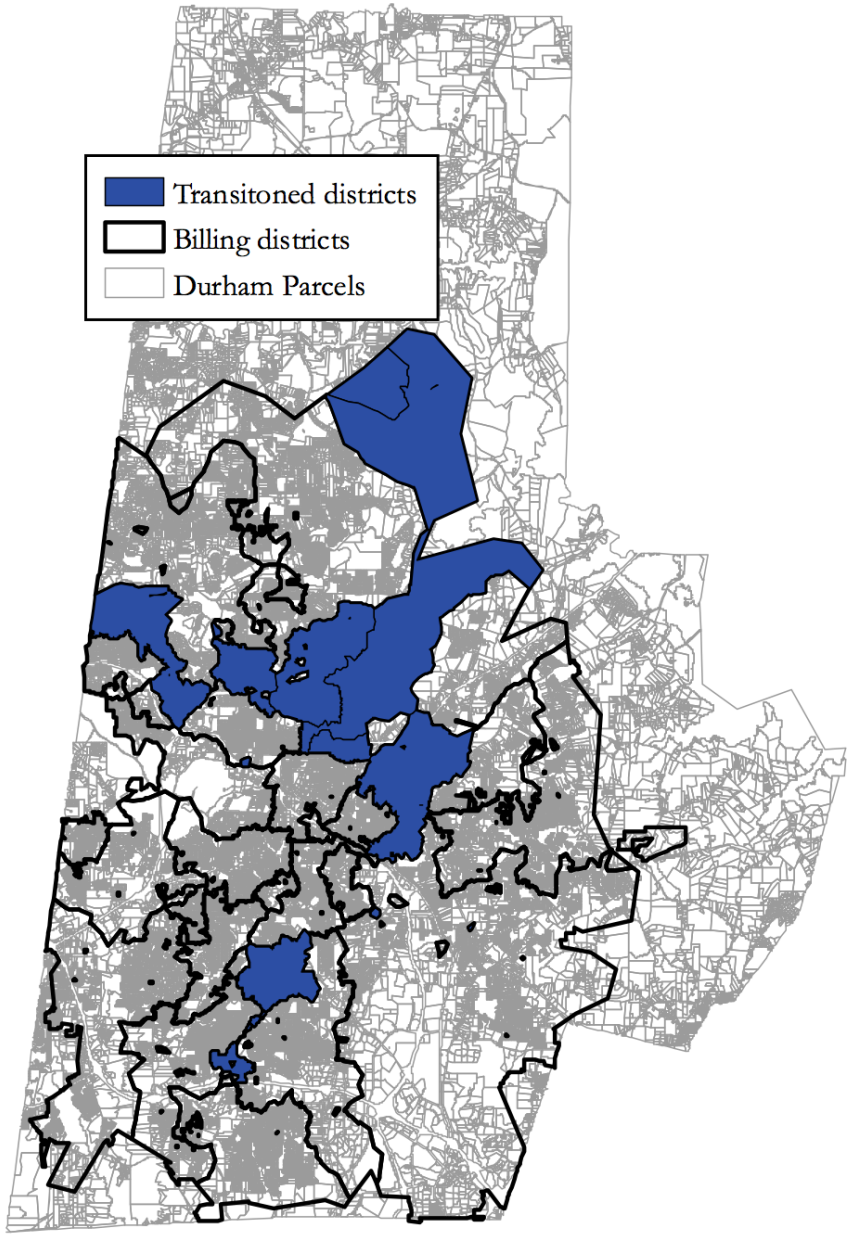
Billing districts
Durham Parcels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Billing districts
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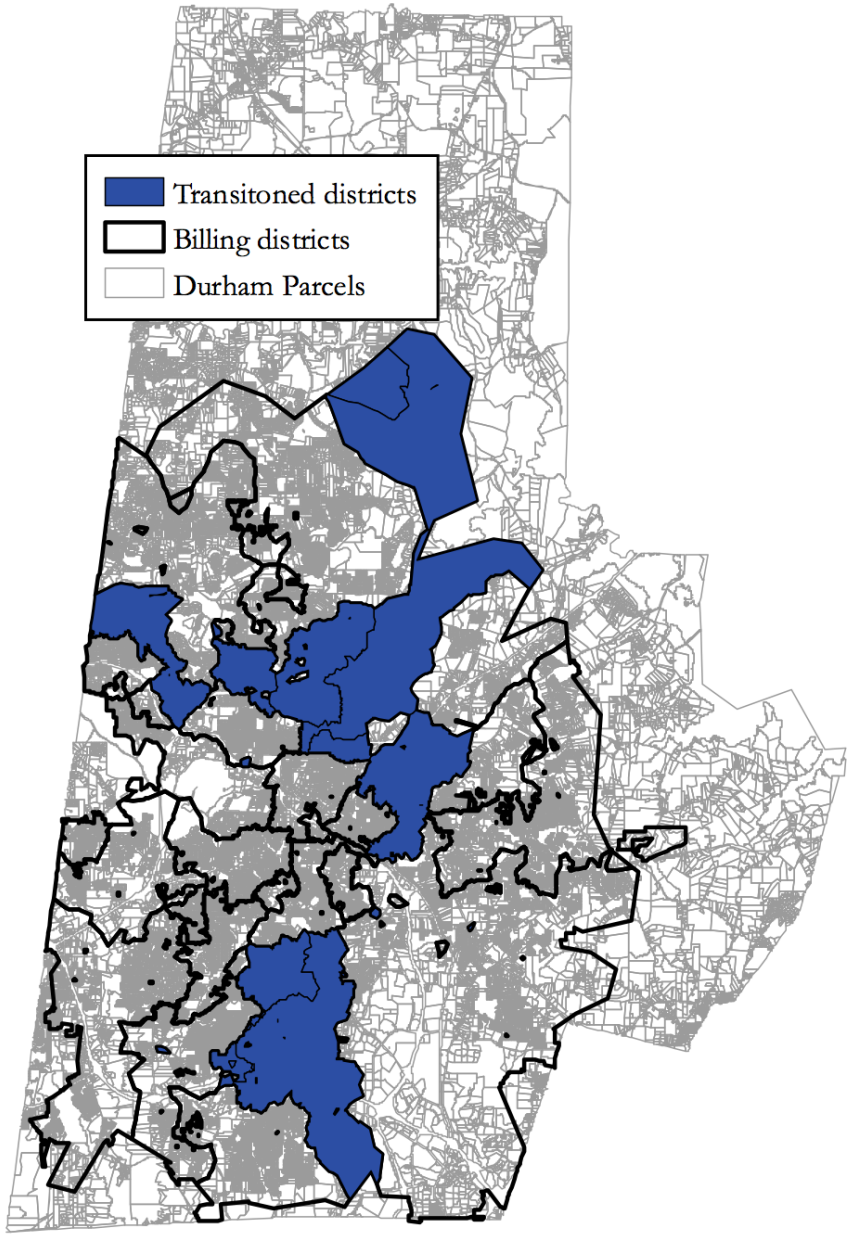
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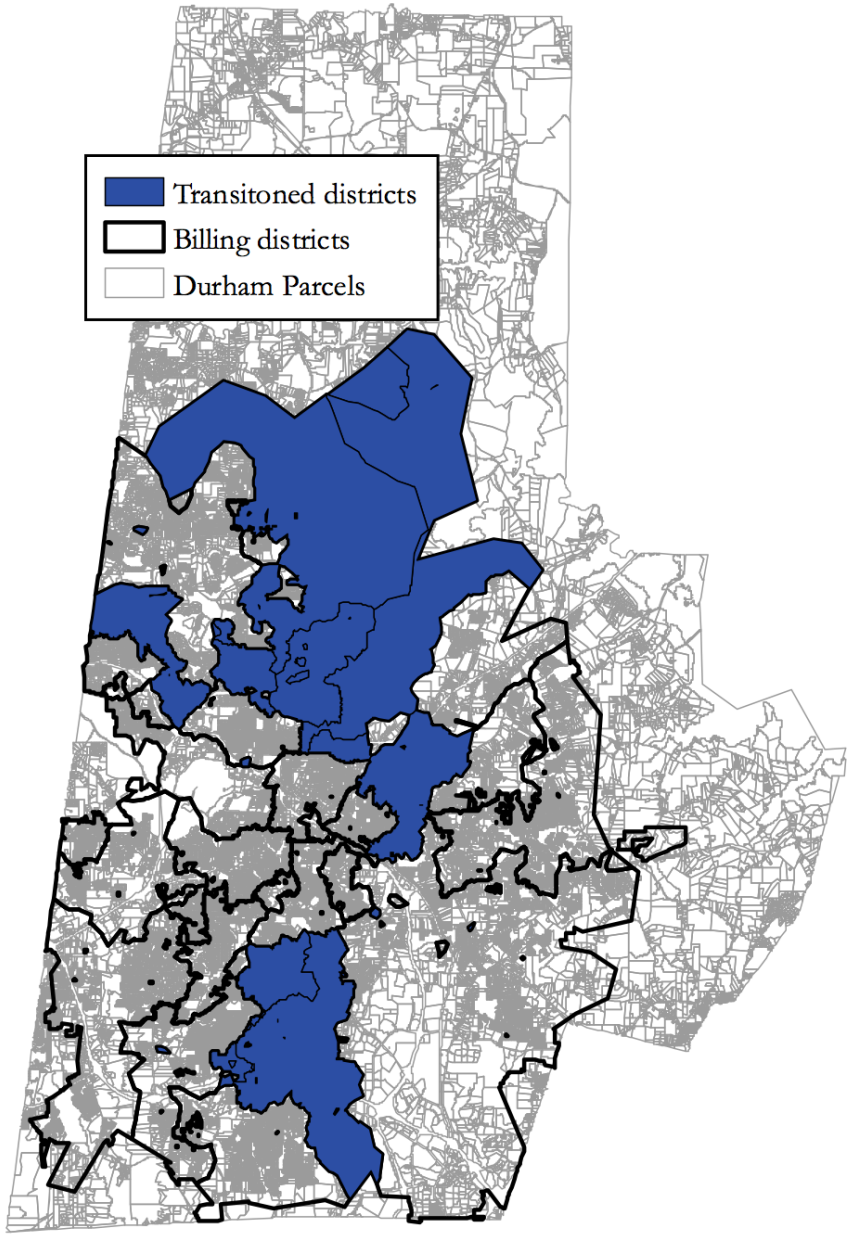
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Billing districts
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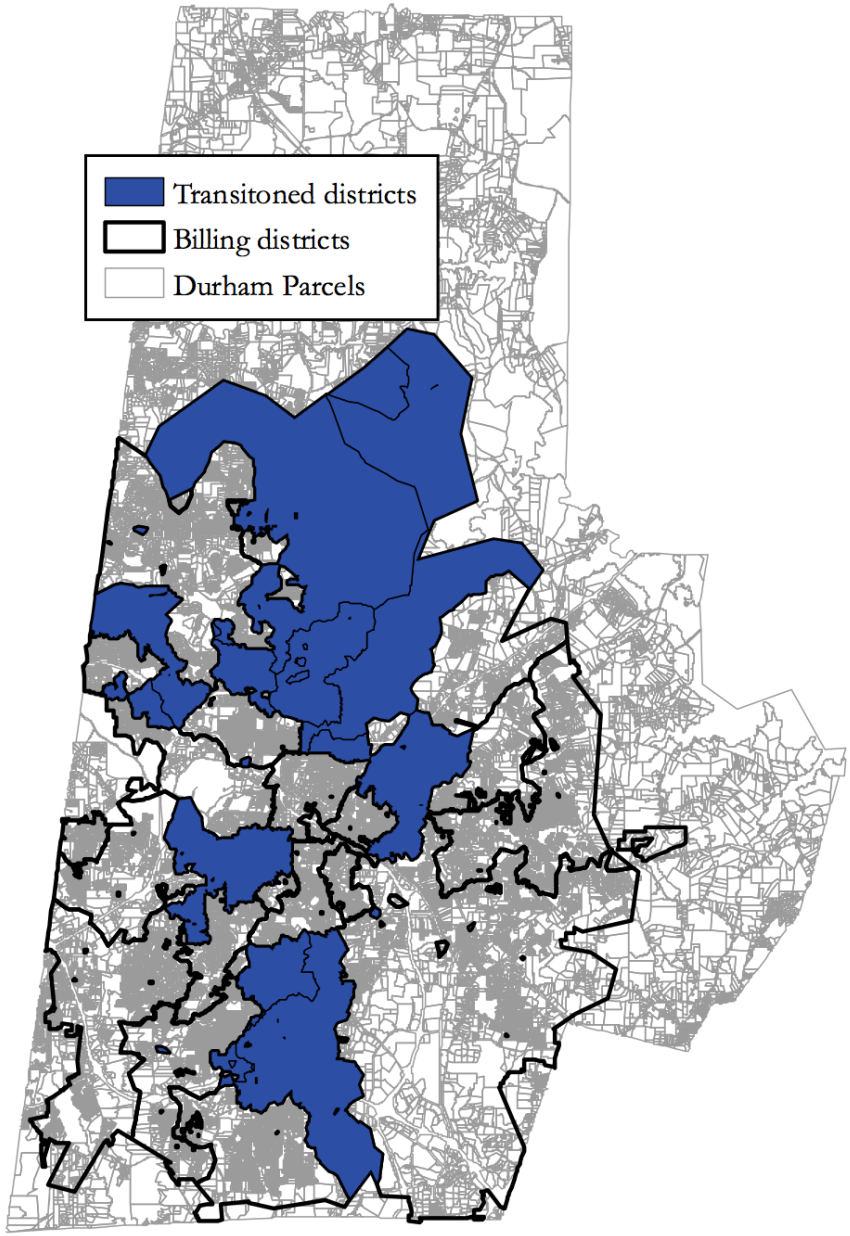
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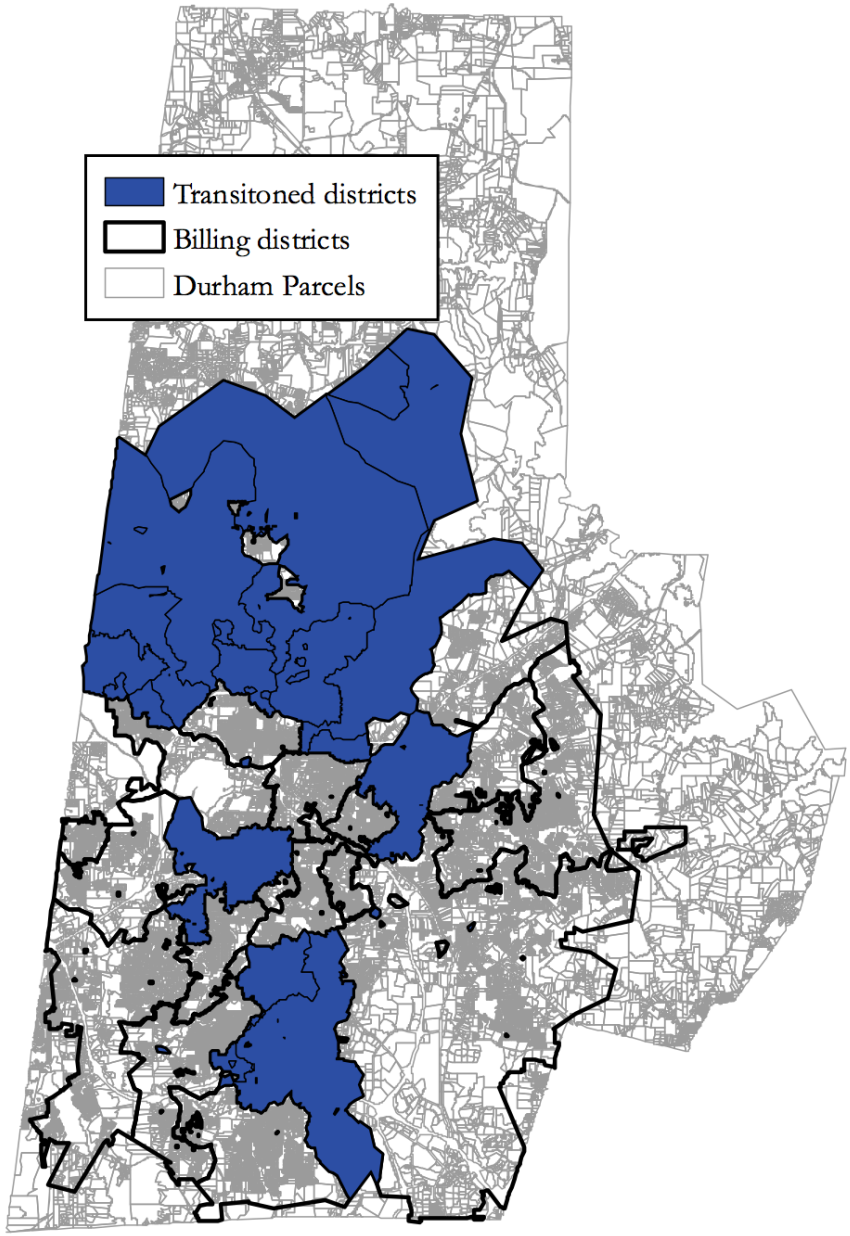
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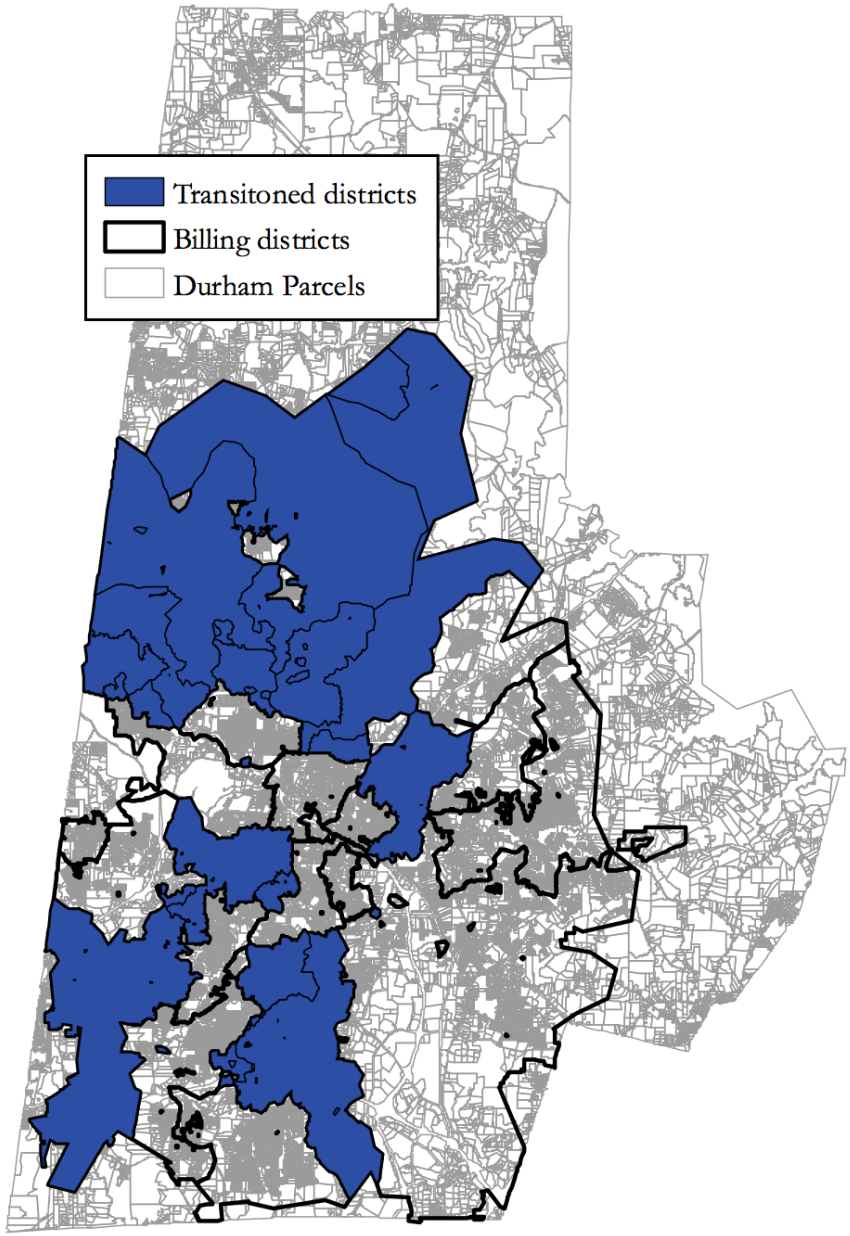
Durham Parcels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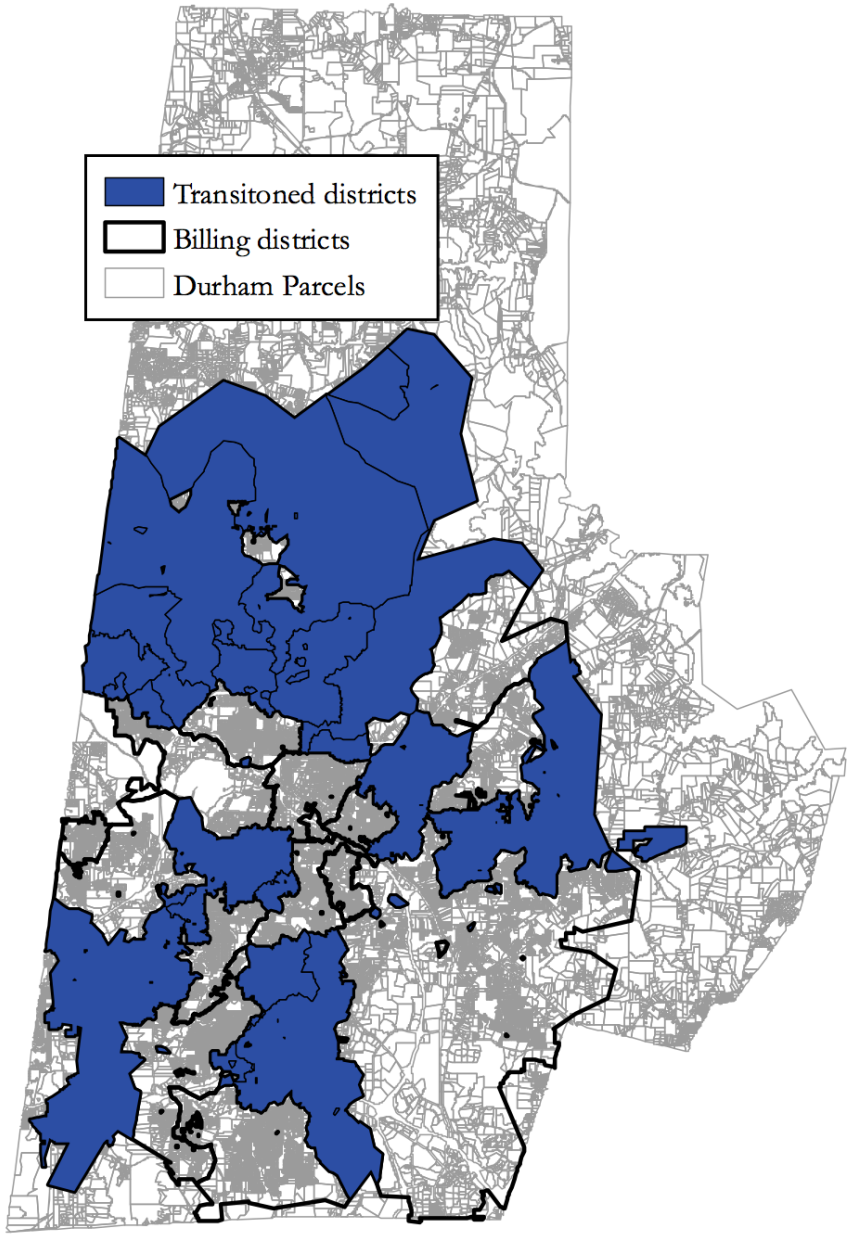
Billing districts
Durham Parcels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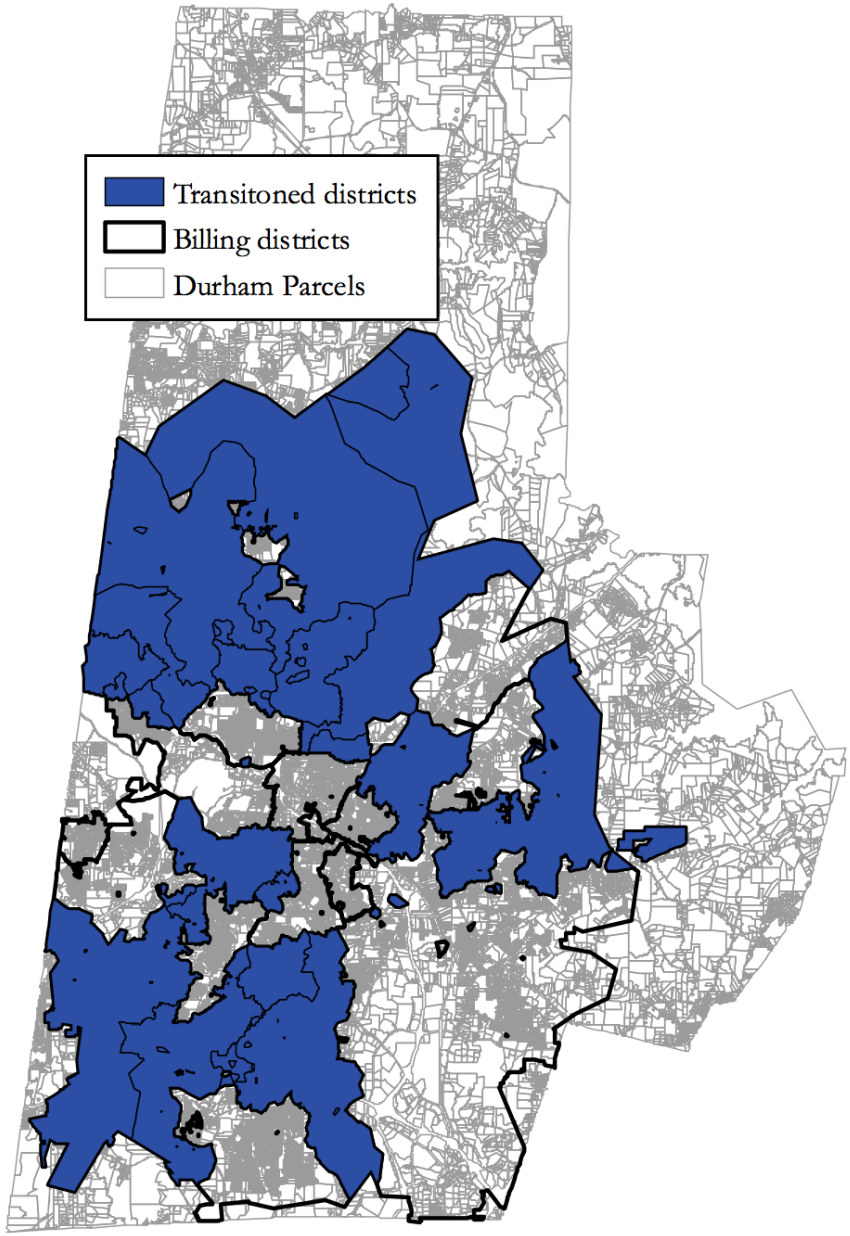
Billing districts
Durham Parcels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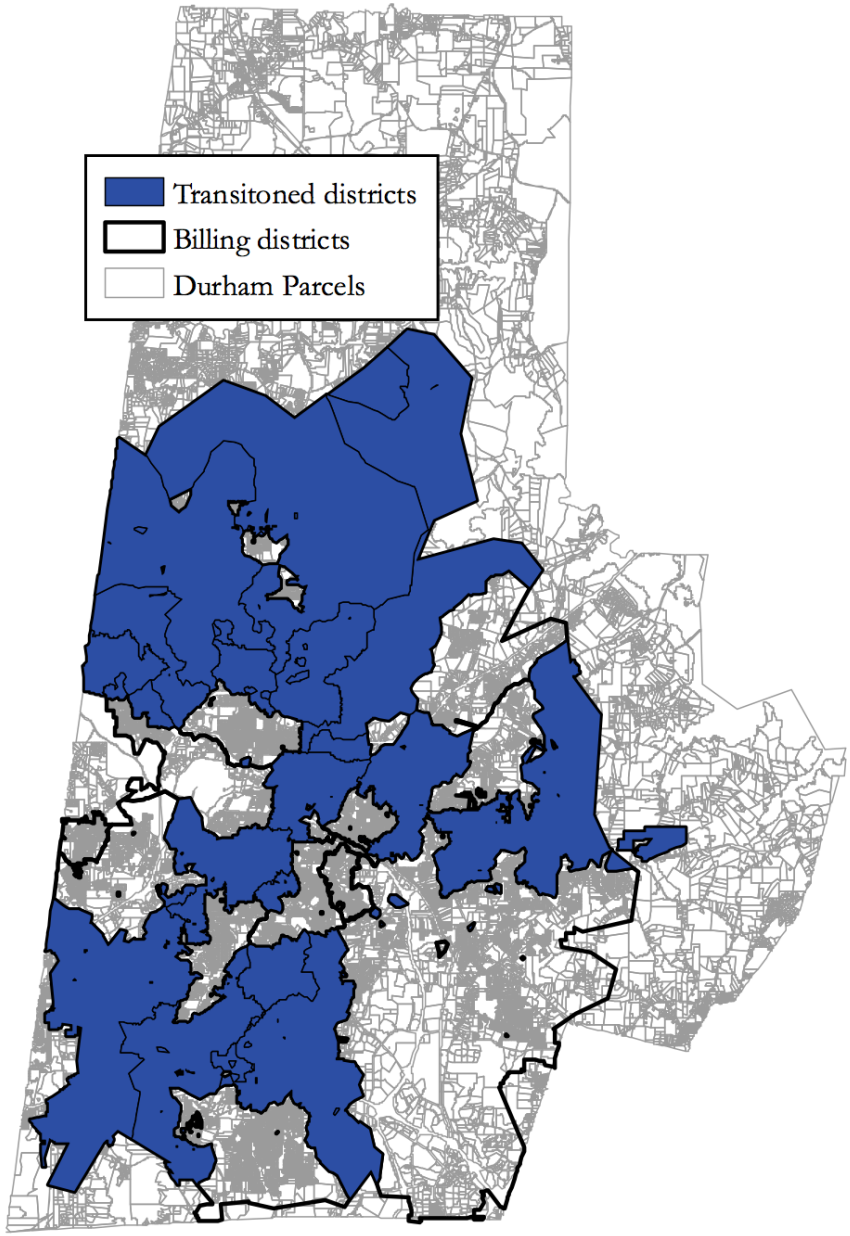
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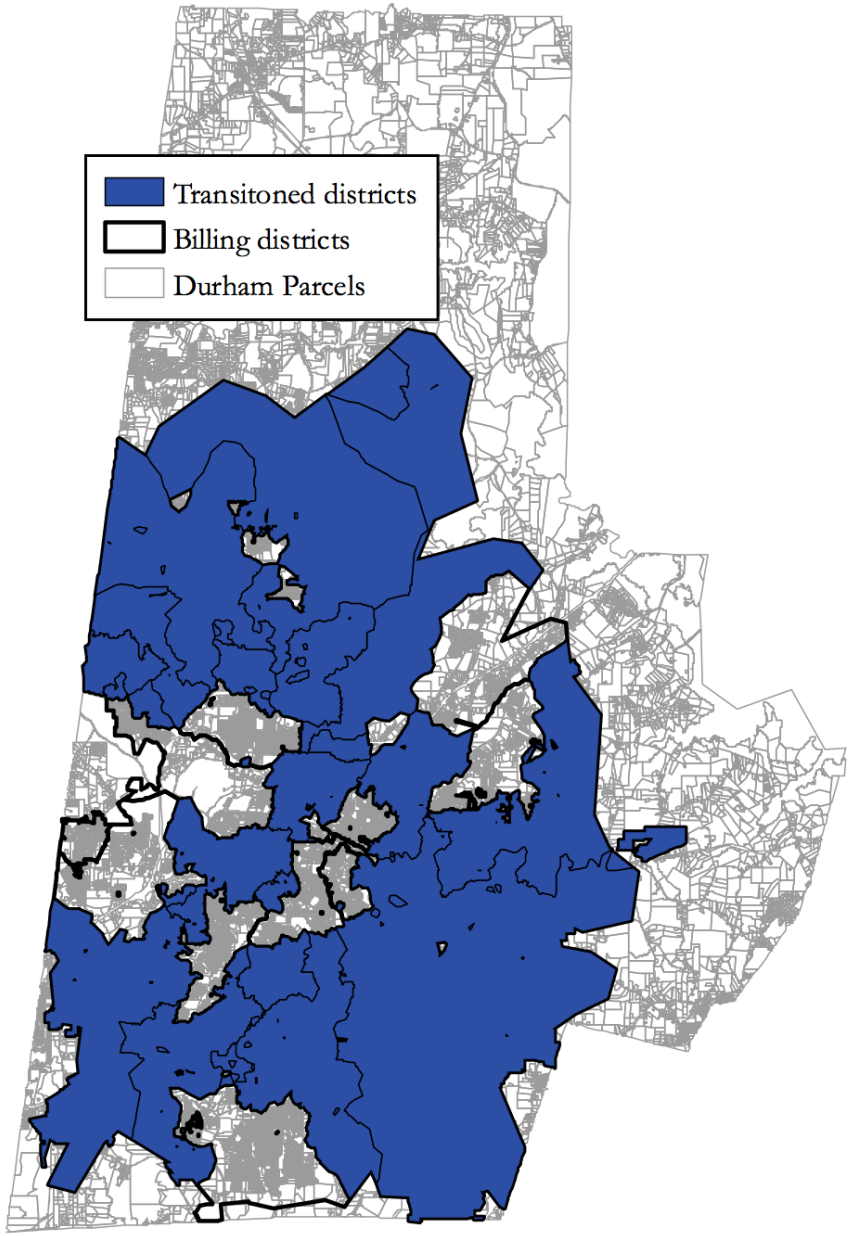
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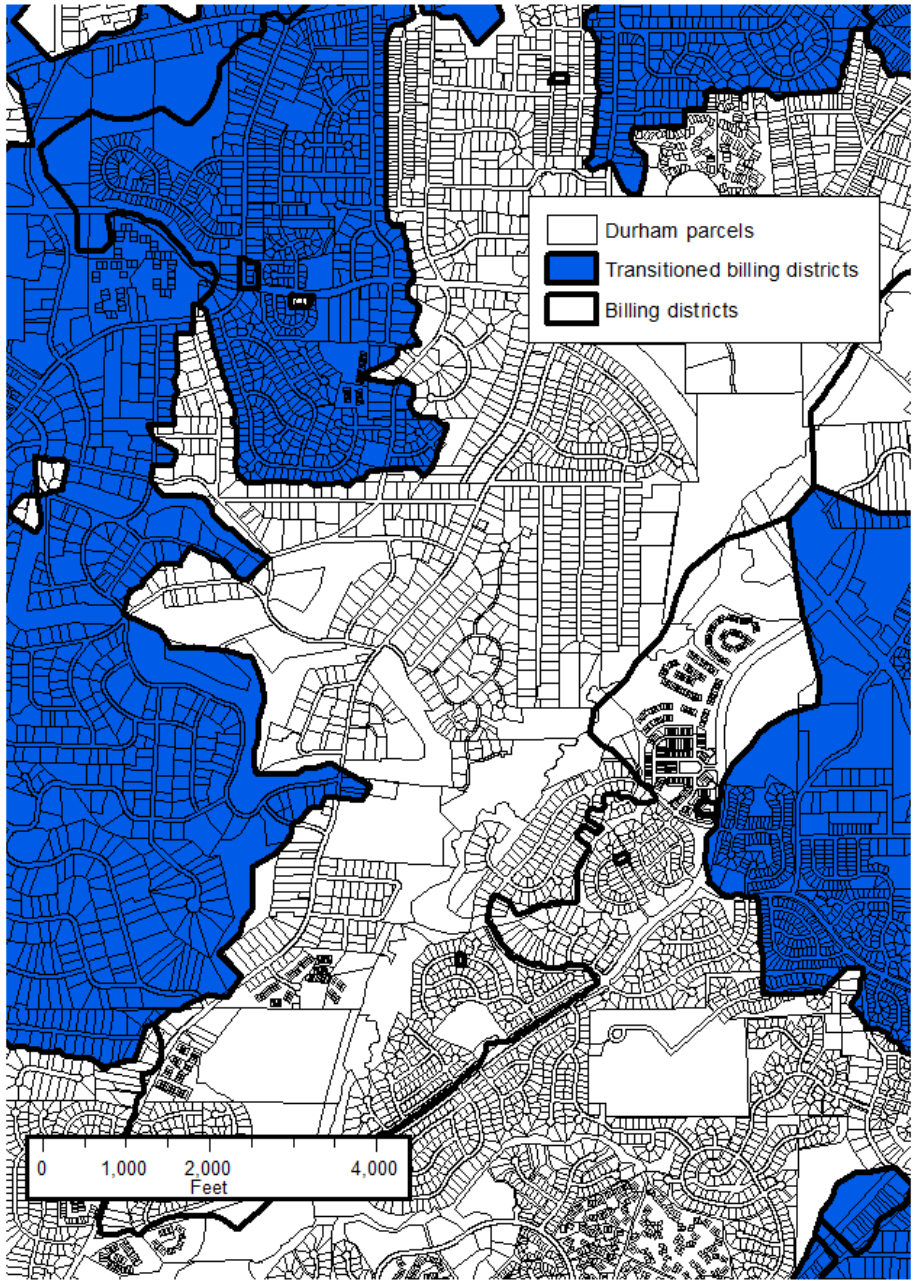

Durham parcels
Transitioned billing districts
Billing districts
0
1,000
2,000
Feet
4,000

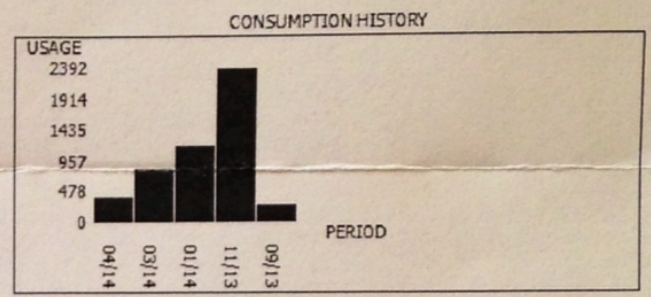
DURHAM
1 8 6 9
CITY OF MEDICINE

City of Durham
101 City Hall Plaza
Durham, NC 27701
919-560-1200
www.durhamnc.gov

City of Durham Utility Bill

Account	Customer Name	Service Location	Apt/Unit	Bill Date
				04/14/2014

PREVIOUS BILL AMOUNT	$80.91
PAYMENTS 04/09/2014	$80.91CR
ADJUSTMENTS	$0.00
BALANCE BROUGHT FORWARD	$0.00
WATER USAGE INSIDE CITY	$9.31
WATER SERVICE FEE 5/8" MTR	$6.15
SEWER USAGE INSIDE CITY	$15.79
SEWER SERVICE FEE 5/8	$7.02
MTHLY SOLID WASTE COLL FEE	$1.80



The City's Year-Round Odd-Even Irrigation Schedule remains in effect. Please visit www.DurhamSavesWater.org or call Durham OneCall at 919-560-1200 for more information, helpful tips, and for details on the City's WaterSense High Efficiency Toilet (HET) Rebate Program.

Balance Forward Due Per Previous Bill	**$.00**
Total Current Charges Due By 05/05/2014	**$40.07**
Total Amount Due	**$40.07**

Parcel ID	Account Type	IA Amount/ERU's "see back"
	RESIDENTIAL	

Meter Number	Previous Read Date	Present Read Date	Number of Days	Previous Reading	Present Reading	Usage in cubic feet	Usage equivalent in gallons
	03/12/2014	04/10/2014	29	6105	6526	421	3149

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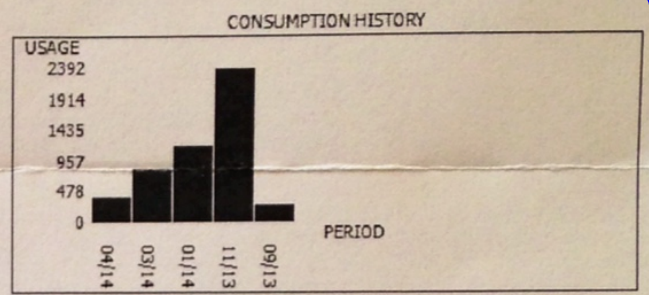

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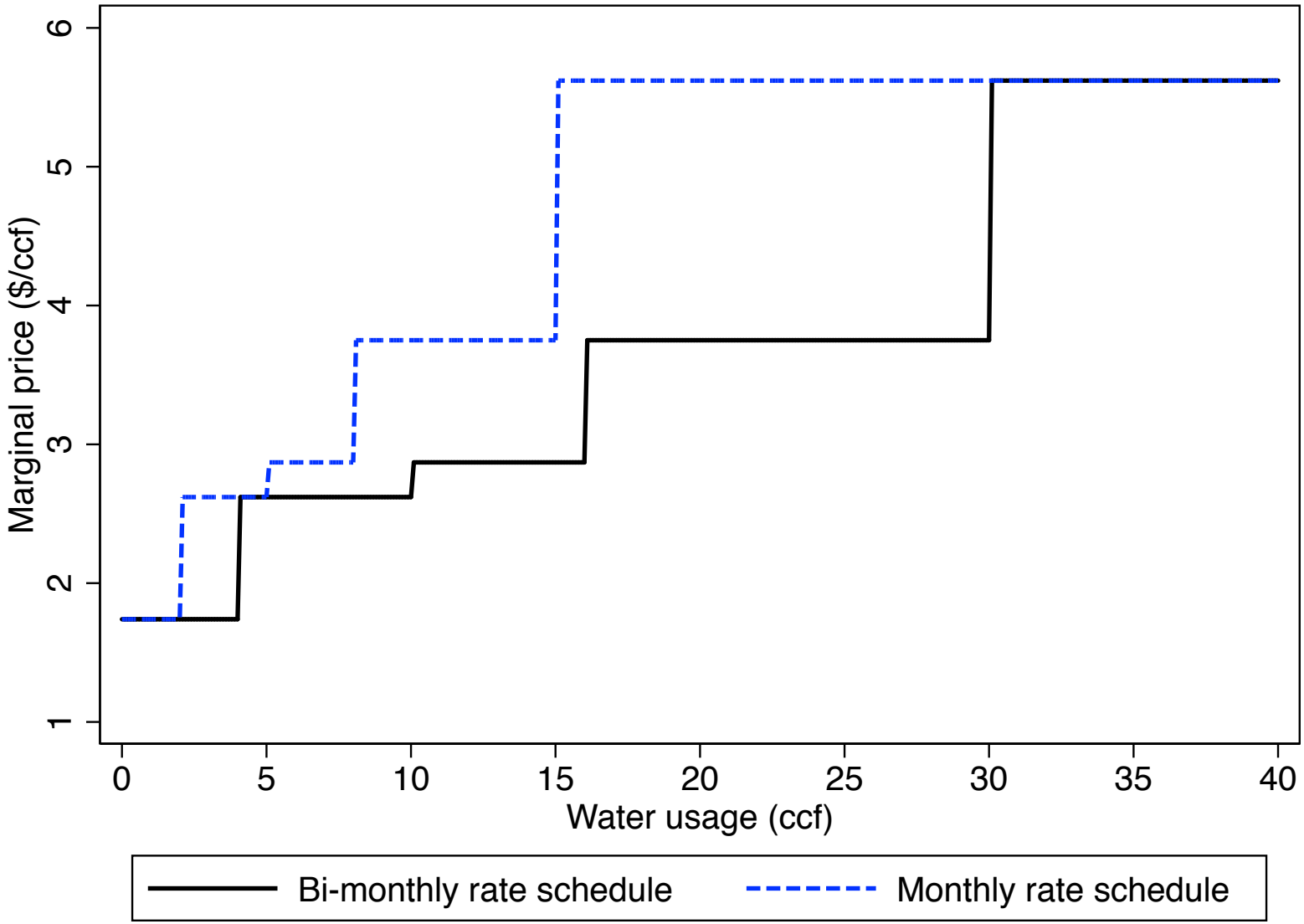
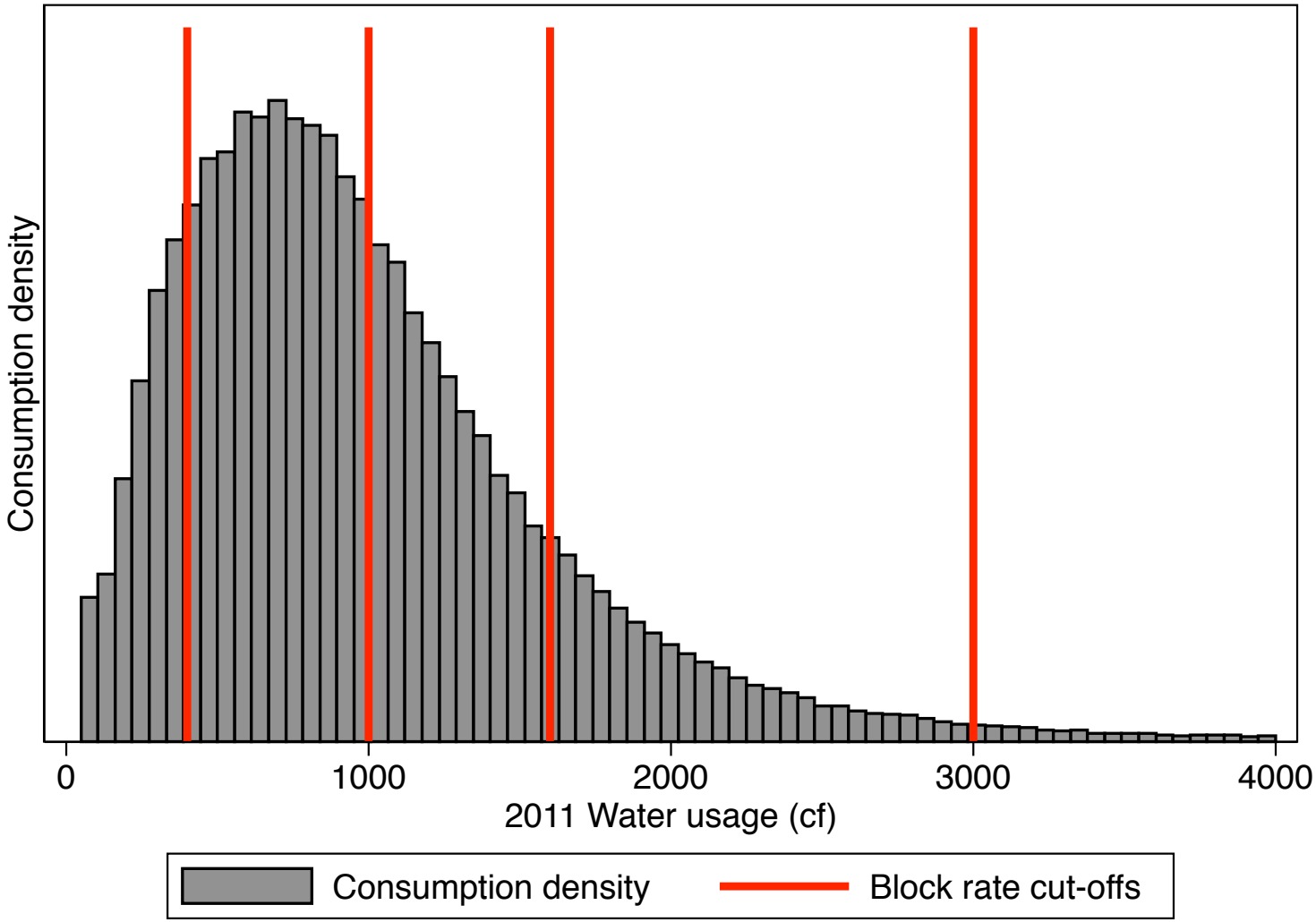
Tiered rate schedule under (bi-)monthly billing



Bunching at kink points?

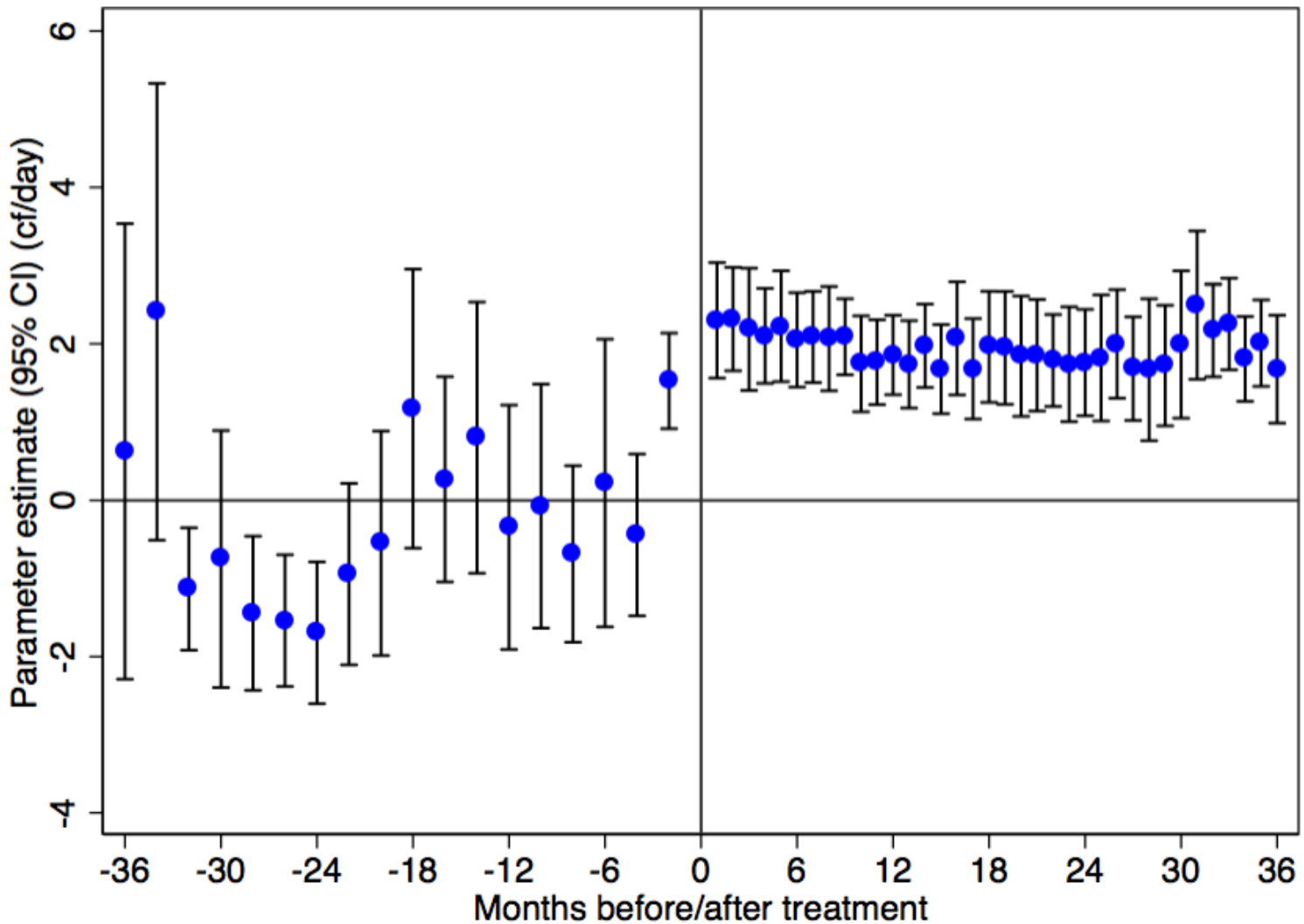


Data & empirical setting

Residential water billing data:

- ∼5.5 years of billing records in Durham, North Carolina
  - Feb 2009 - June 2015
  - ∼59,000 households
- Matched with tax assessor data at parcel level
  - Assessed value of home, lot size, age, square footage
- 2010 Census block group demographics
  - Percent renters, racial composition, household size
- Weather variables from the NC State Climate Office
  - Daily maximum temperature, total rainfall

Event study



(Conditional on weather, and time and route fixed effects)

Empirical framework

Spatial regression discontinuity, exploiting district boundaries, over time,

$$w_{ijt} = \alpha_i + \beta BF_{jt} + \gamma_D f(Dist_i) + \mathbf{X}'\gamma_1 + \mathbf{W}'\gamma_2 + \tau_t + \varepsilon_{ijt}$$

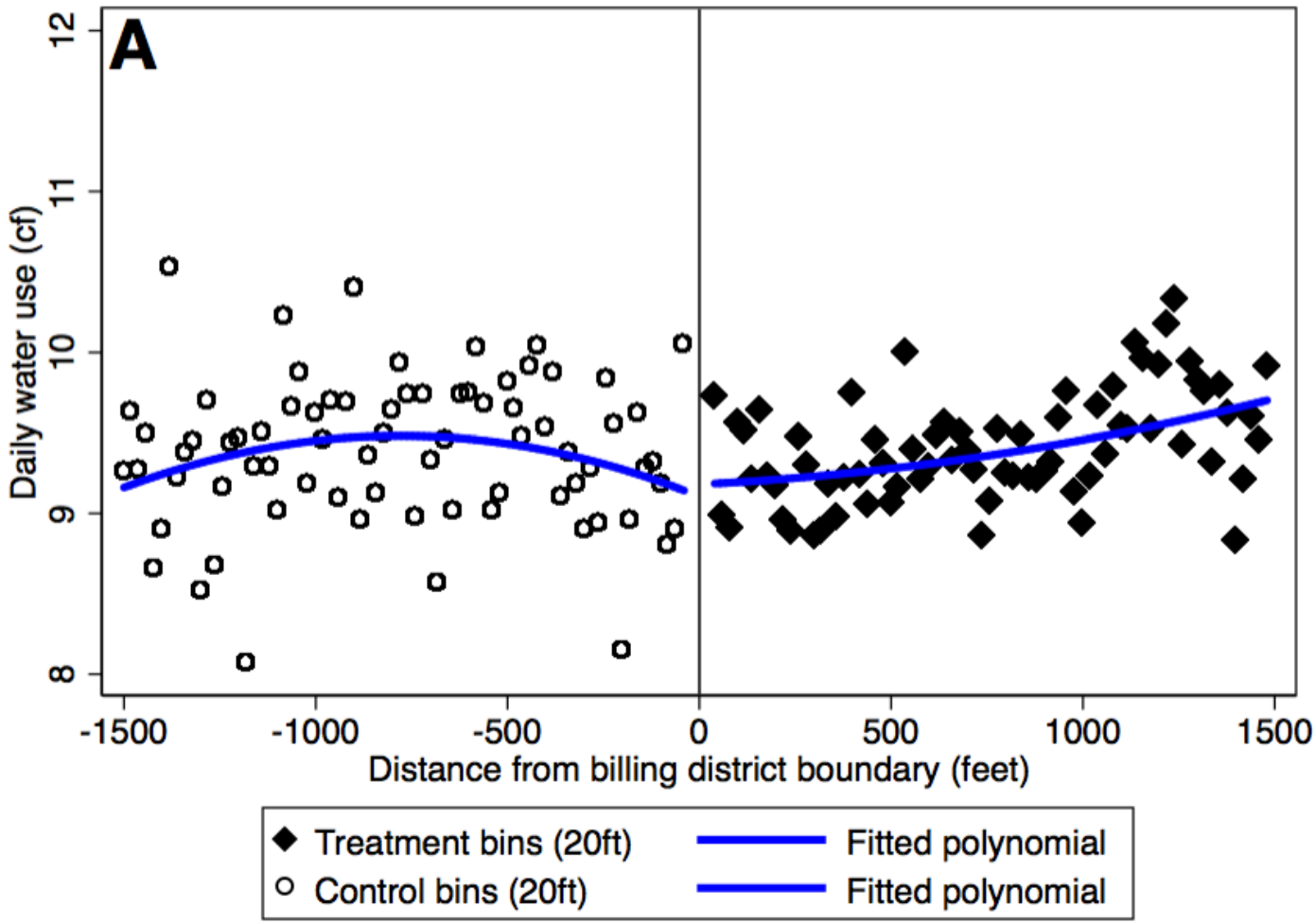
- w_{ijt} is daily water use at the household level

  $\implies$ β is a local average treatment effect (LATE) of increases in billing frequency on daily water consumption
- Avoids concerns of non-random selection into treatment
- Controls for unobserved changes in "neighborhood" characteristics over time
- Bandwidth of 500 feet from district boundary

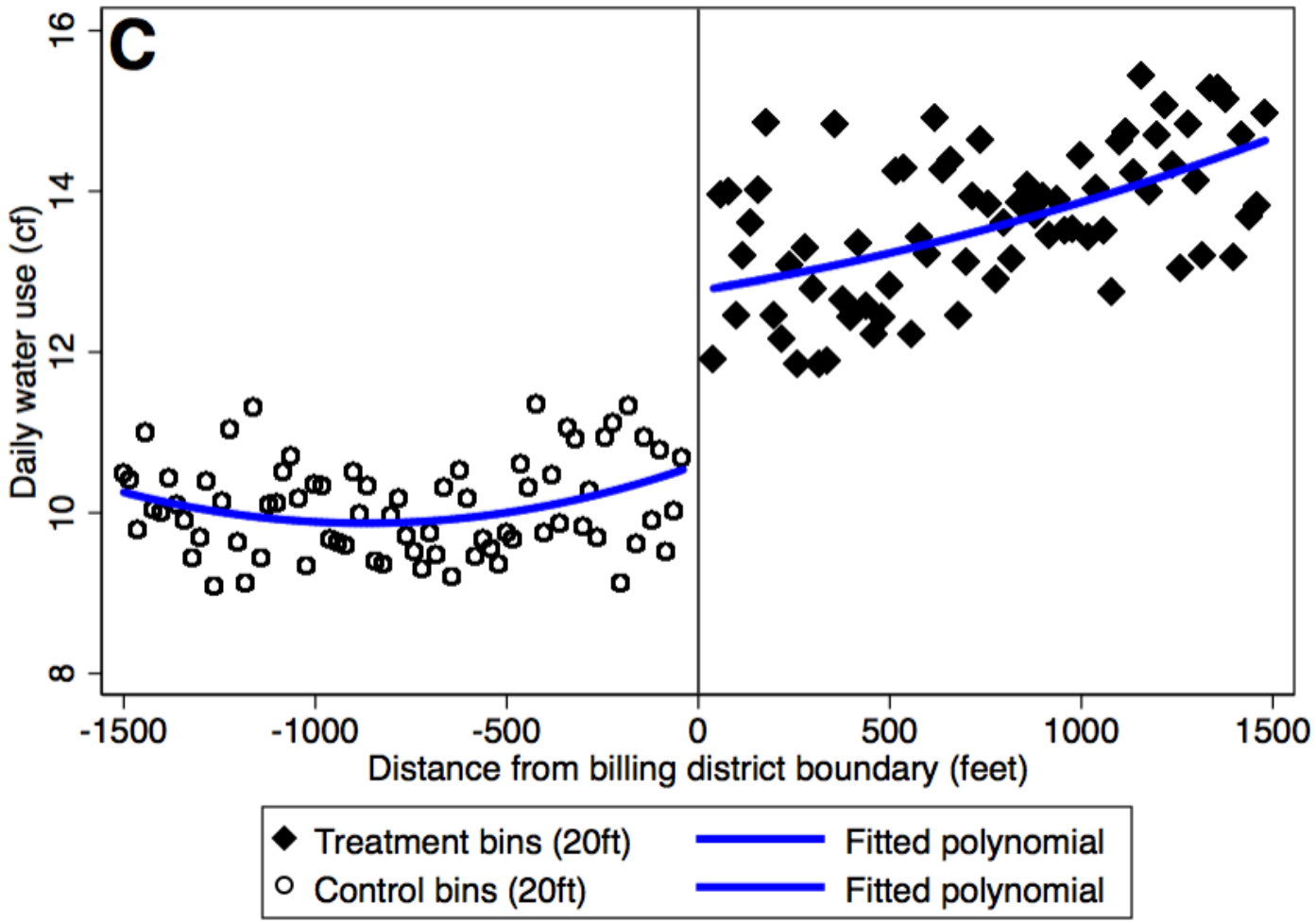
Re-estimate to obtain "dynamic" LATE,

$$\sum_{S=0}^{30} \beta_S \cdot \mathbb{1}(BF_{jt-S})$$

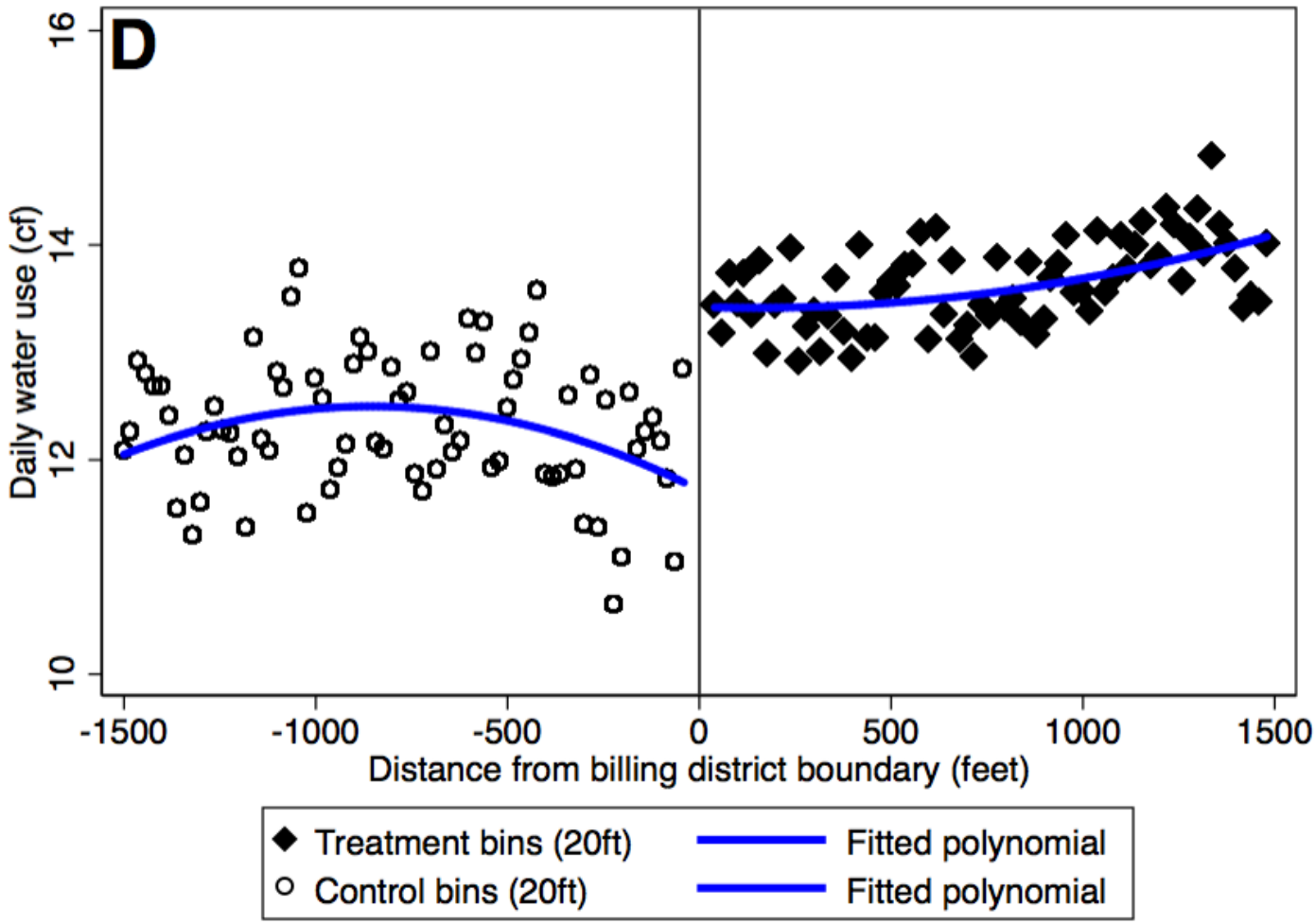
RD design (1 year before treatment)



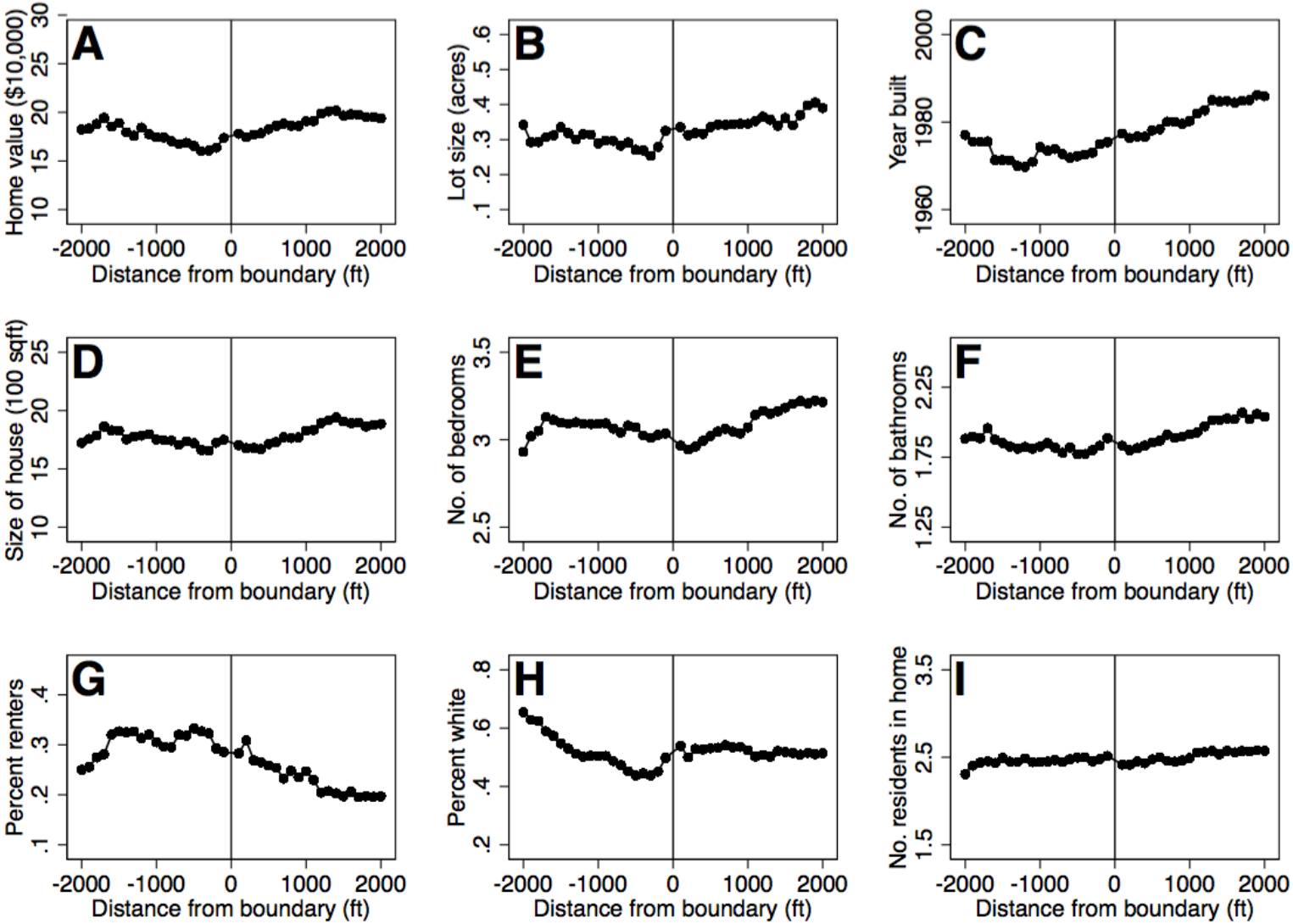
RD design (year after treatment)



RD design (2 & 3 years after treatment)



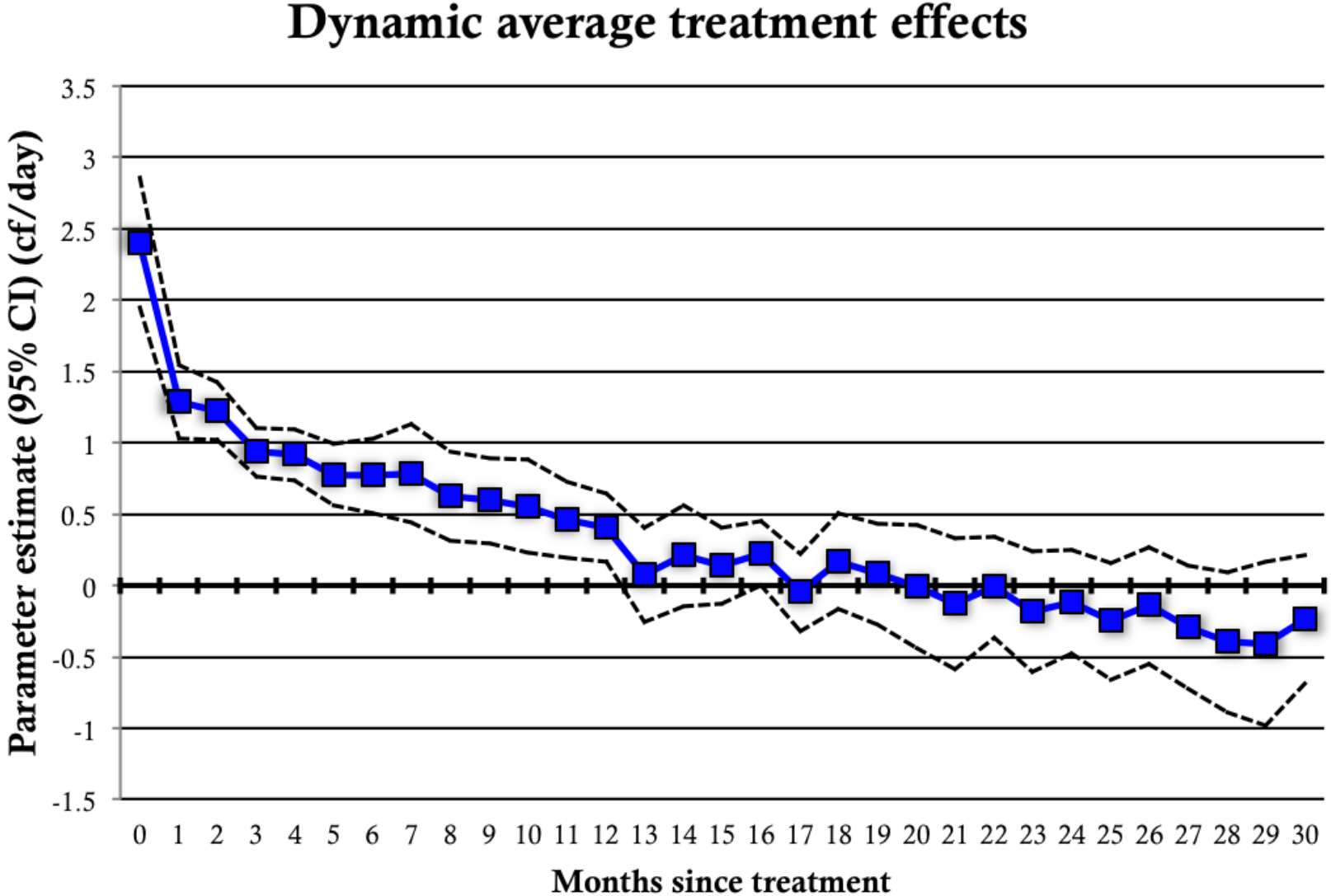
RD design (observables)



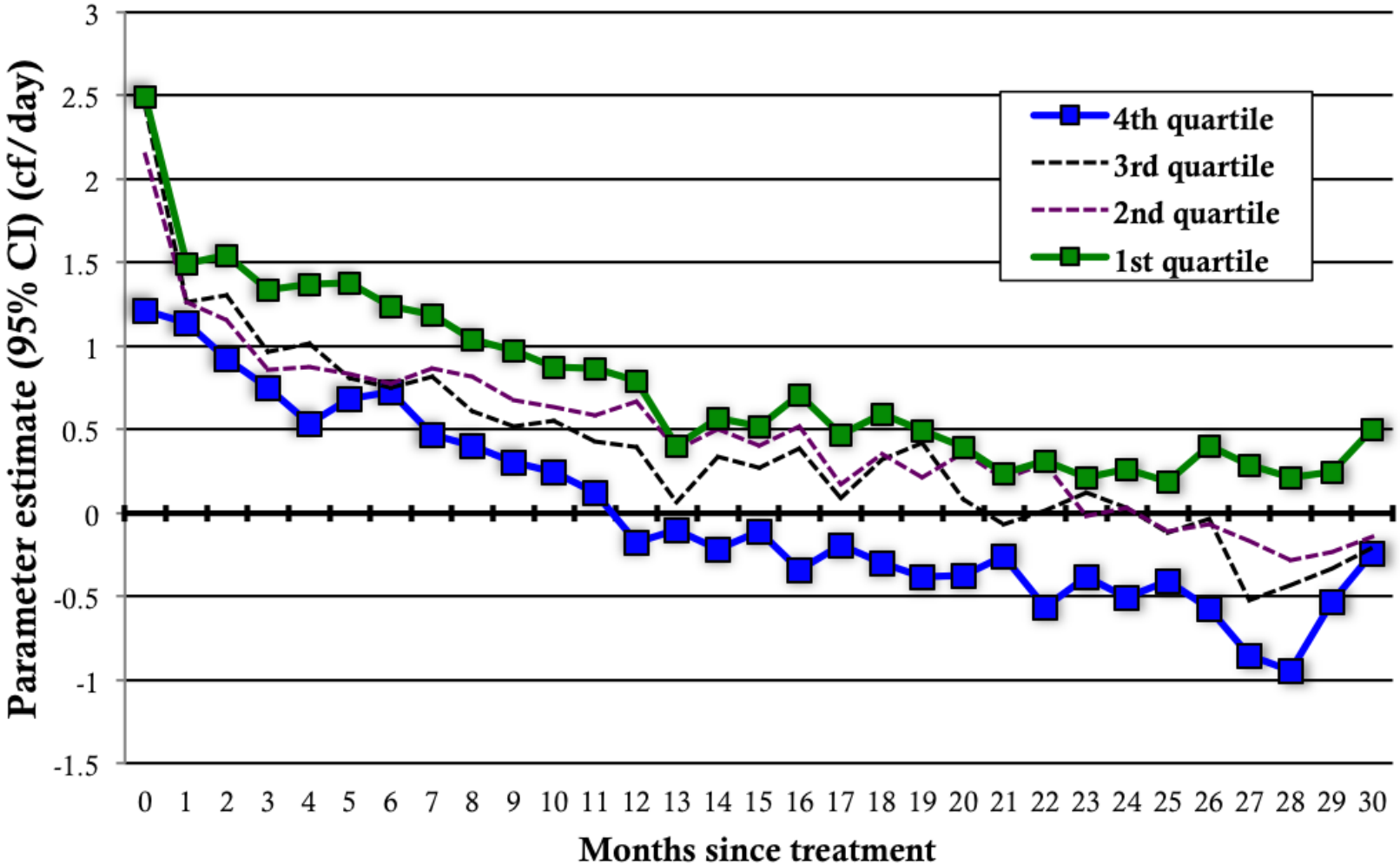
Main regression results

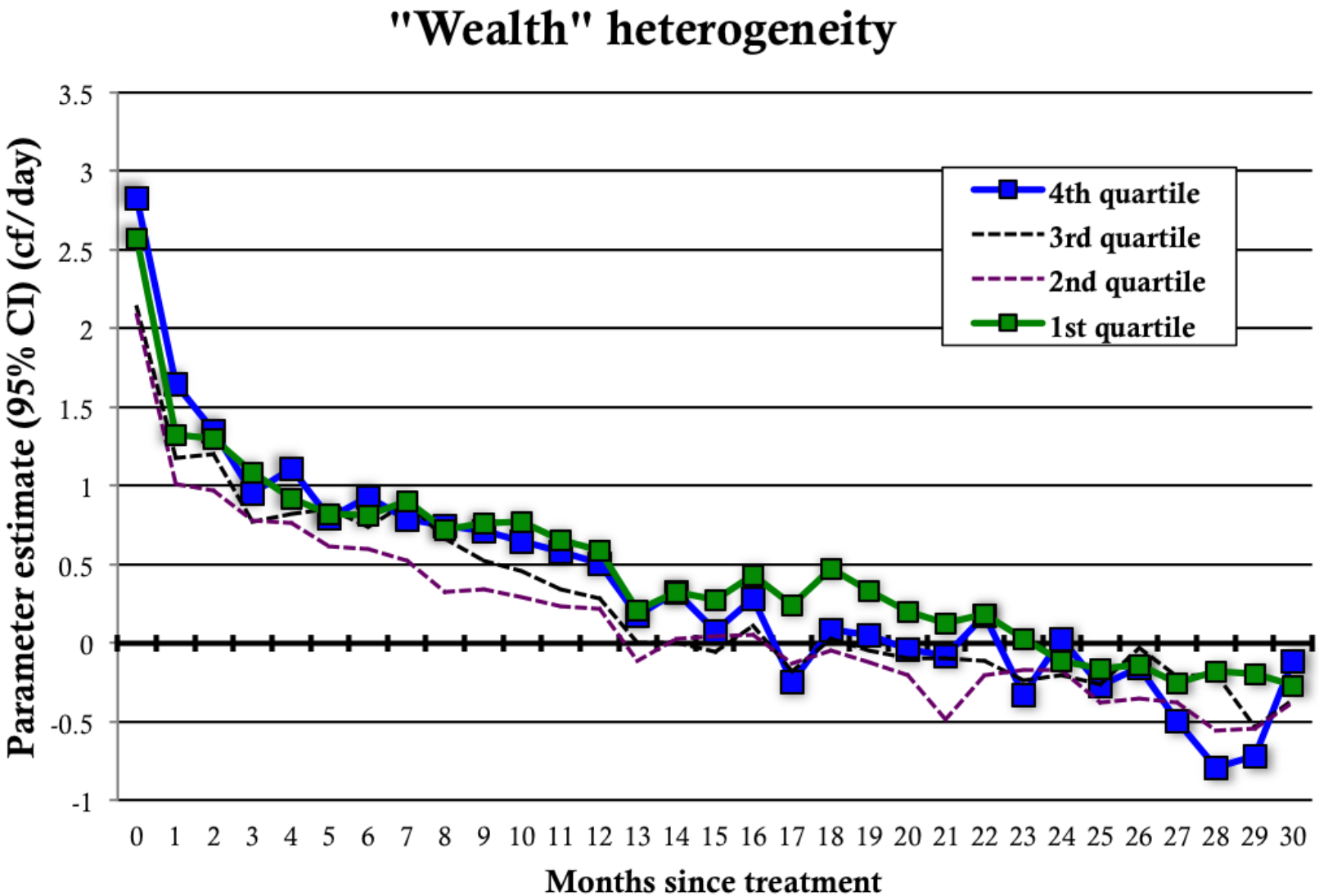
		Spatial RD		
	Full sample	<2000 ft	<1000 ft	<500 ft
BF_{ijt}	0.685**	0.581**	0.555**	0.541**
	(0.239)	(0.237)	(0.223)	(0.213)
Household fixed effects?	Y	Y	Y	Y
Time fixed effects?	Y	Y	Y	Y
Weather covariates?	Y	Y	Y	Y
Observations	2,086,488	1,642,061	1,003,800	539,601
R-squared	0.030	0.030	0.029	0.028
Number of households	58,780	46,496	28,535	15,412

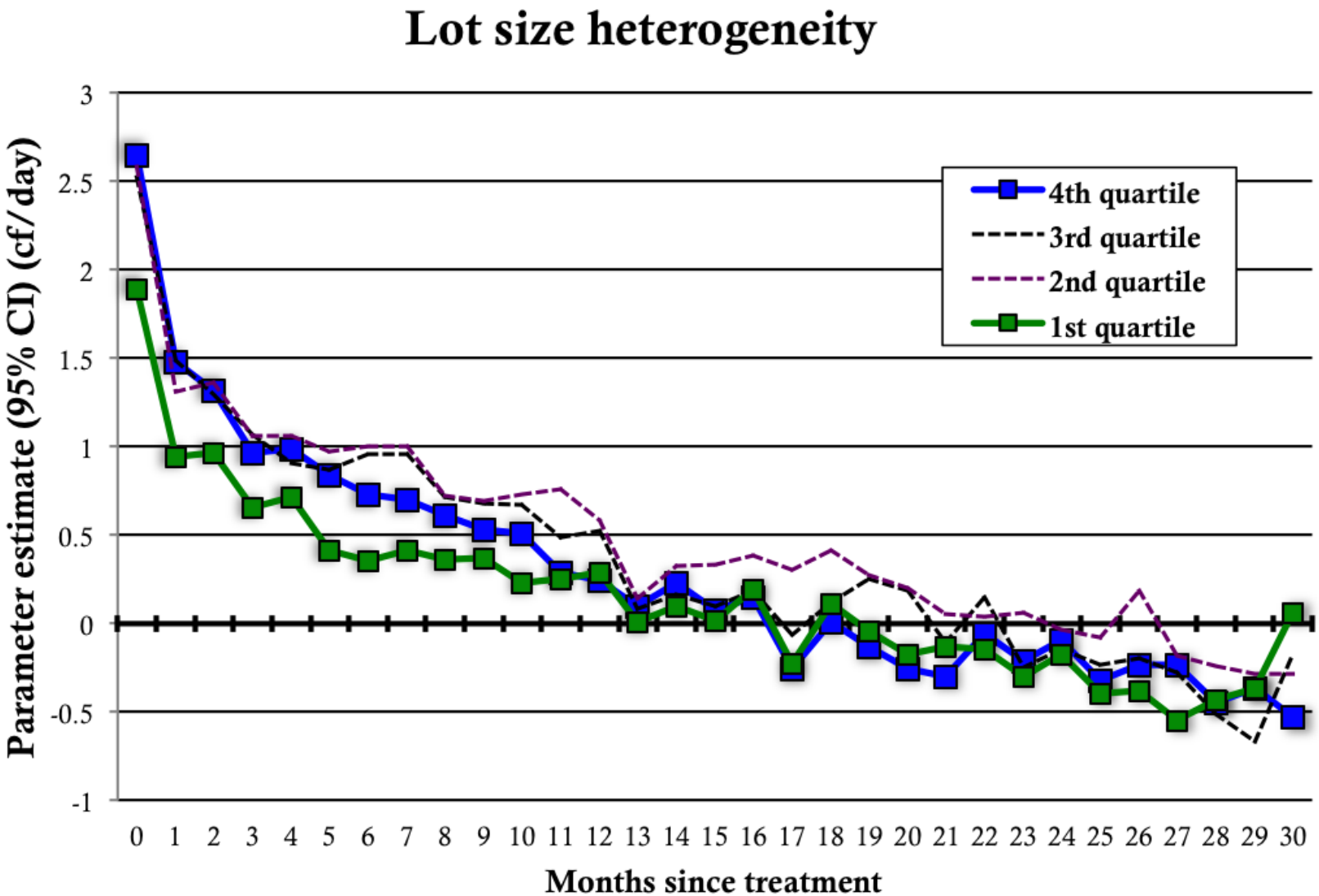
Dependent variable is daily water consumption in cubic feet. Robust standard errors in parentheses clustered at billing district level. *** p<0.01, ** p<0.05, * p<0.1.


Dynamic average treatment effects
Parameter estimate (95% CI) (cf/day)
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Months since treatment

Consumption heterogeneity




"Wealth" heterogeneity
Parameter estimate (95% CI) (cf/day)
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Months since treatment
4th quartile
3rd quartile
2nd quartile
1st quartile


Lot size heterogeneity
Parameter estimate (95% CI) (cf/day)
3
2.5
2
1.5
1
0.5
0
-0.5
-1
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Months since treatment
4th quartile
3rd quartile
2nd quartile
1st quartile

Summary and implications

Main results:

- The average treatment effect masks important dynamic behavior.
- Dynamic treatment effects decrease over $\sim$2 years
- Consumers in the lowest quartile of consumption increase usage by the highest percentage.

  $\Longrightarrow$ consumers responding to something other than price?
- No evidence of heterogeneity among proxies for wealth.
  - Little support that more frequent billing helps smooth consumption month to month.

Questions?

Thank you

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