Do consumers respond to billing frequency? Implications for urban water conservation

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Research questions

Generally, what's the role of information provision in environmental policy?

- Do consumers respond to increased billing frequency?
- Do these effects remain over time?

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- Do these effects remain over time? **Yes.**

Main research findings:

- Water consumers *increase* consumption by ~5% in response to more frequent billing.
- Treatment effects persist over time.
- Customer inattention to water bills negates these effects.

Road map

- Situate research in current literature
- Outline of data and billing transition
- Empirical strategy and results
- Conclusions, policy implications, and additional work

Context

- Information as environmental regulation
  - "Social norming" in water/electricity demand
    (Alcott, JPubE 2011; Ferraro and Price, REStat 2013)
  - Quantity reminders/bill shock in electricity demand
    (Gans et al., Energy Econ 2013; Jessoe and Rapson, AER 2014; Gilbert and Graff Zivin, JEBO 2014)
- Salience/attention
  - Consumer awareness of taxes
    (Finkelstein, AER 2009)
  - Automatic bill pay for electricity consumption
    (Sexton, REStat 2014)

Data & empirical strategy

Residential water billing data:

- ~4.5 years of billing data in Durham, North Carolina
  - Feb 2009 - June 2014
  - ~57,000 households
- Matched with tax assessor data at parcel level
- 2010 Census block group demographics

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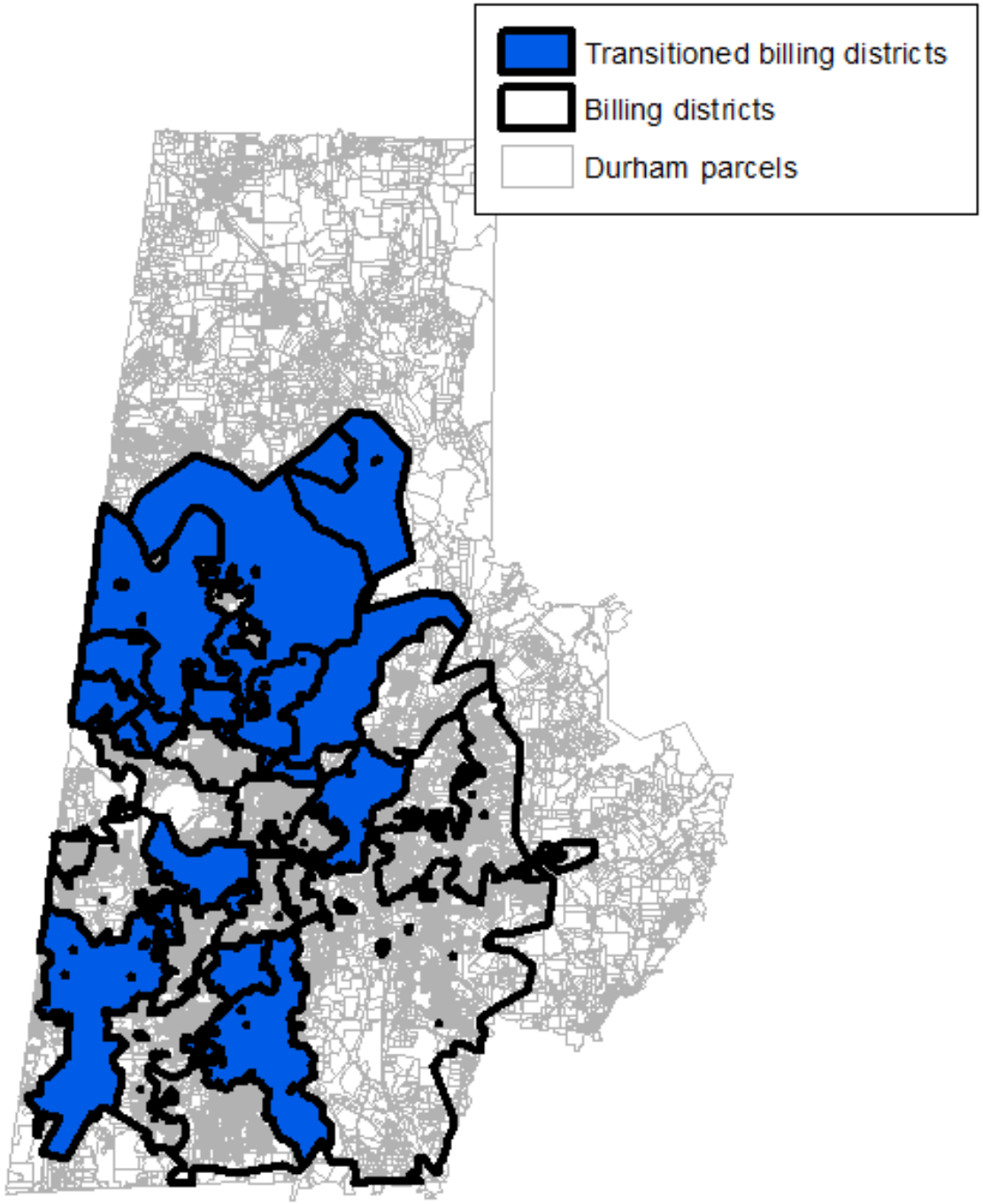
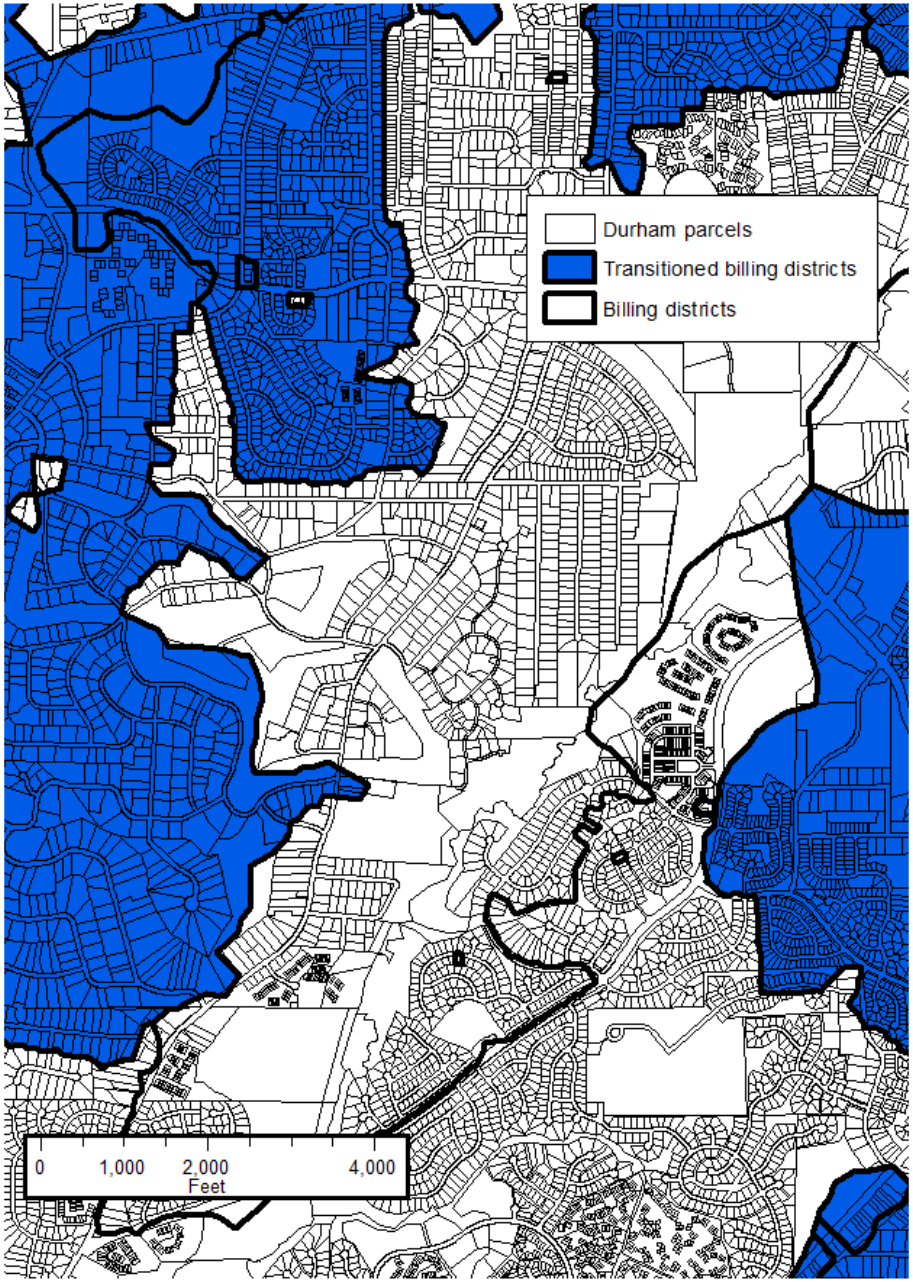
Experimental strategy:

- Starting in Dec. 2011, billing districts were individually transitioned from bi-monthly to monthly billing
- 12 out of 17 Durham's residential customers were transitioned by June 2014.
- Service fees and marginal prices for water consumption remained constant


Transitioned billing districts
Billing districts
Durham parcels


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

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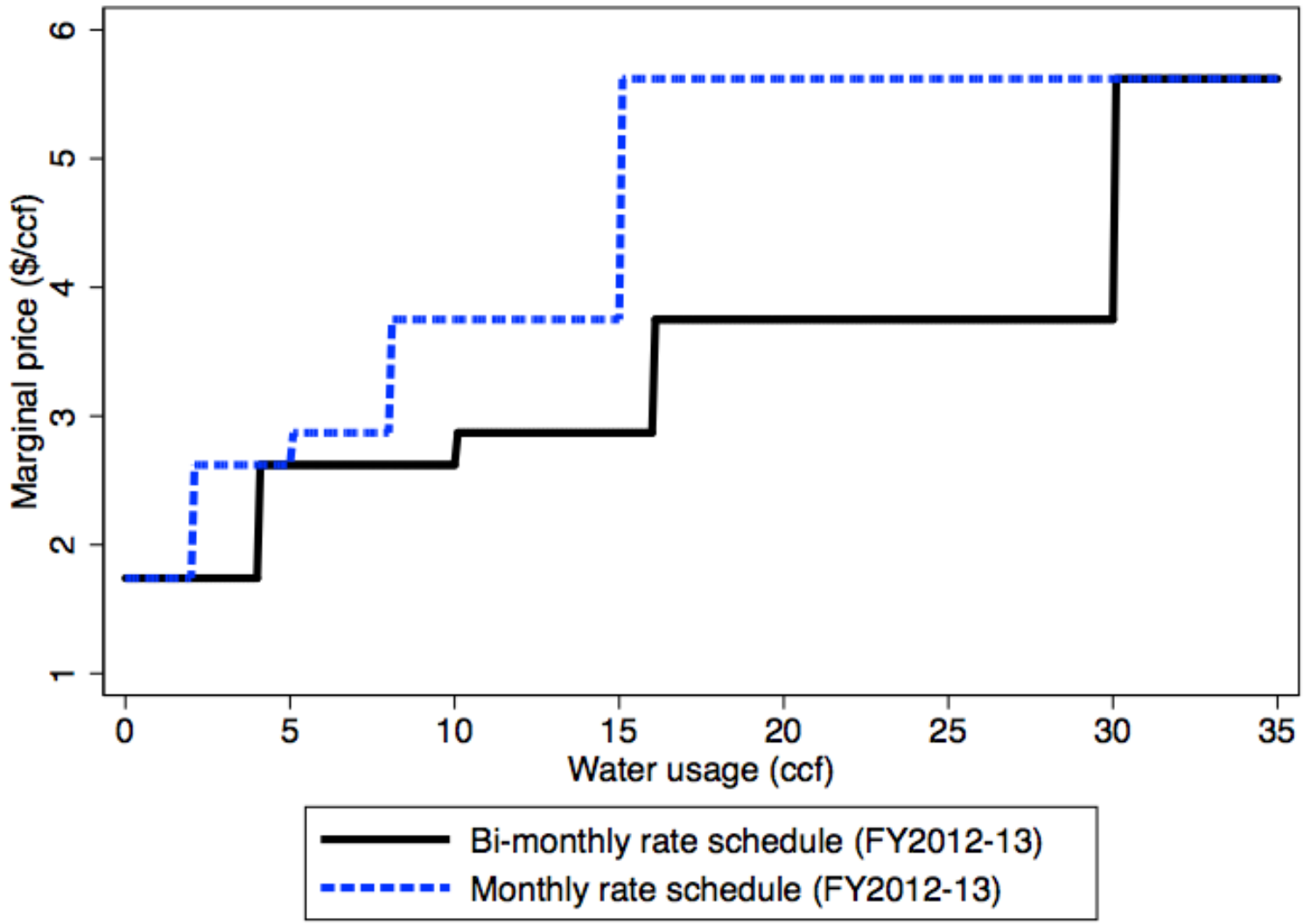
Tiered rate schedule under (bi-)monthly billing



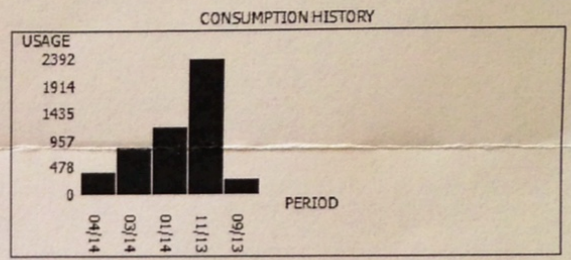
DURHAM 1869 CITY OF MEDICINE

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	$1.80
Balance Forward Due Per Previous Bill	**$.00**
Total Current Charges Due By 05/05/2014	**$40.07**
Total Amount Due	**$40.07**



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.

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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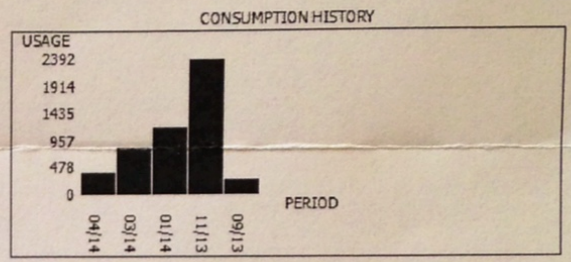

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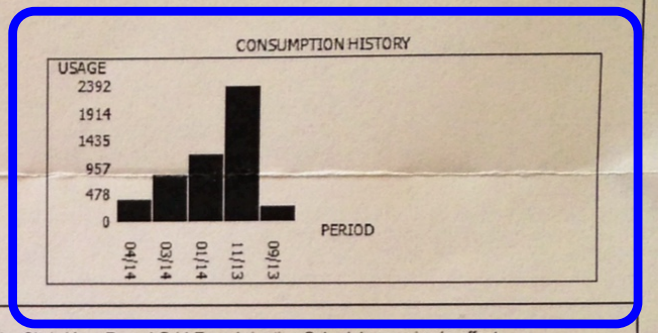

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Empirical strategy and results

Difference-in-differences controlling for

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Dynamic models:
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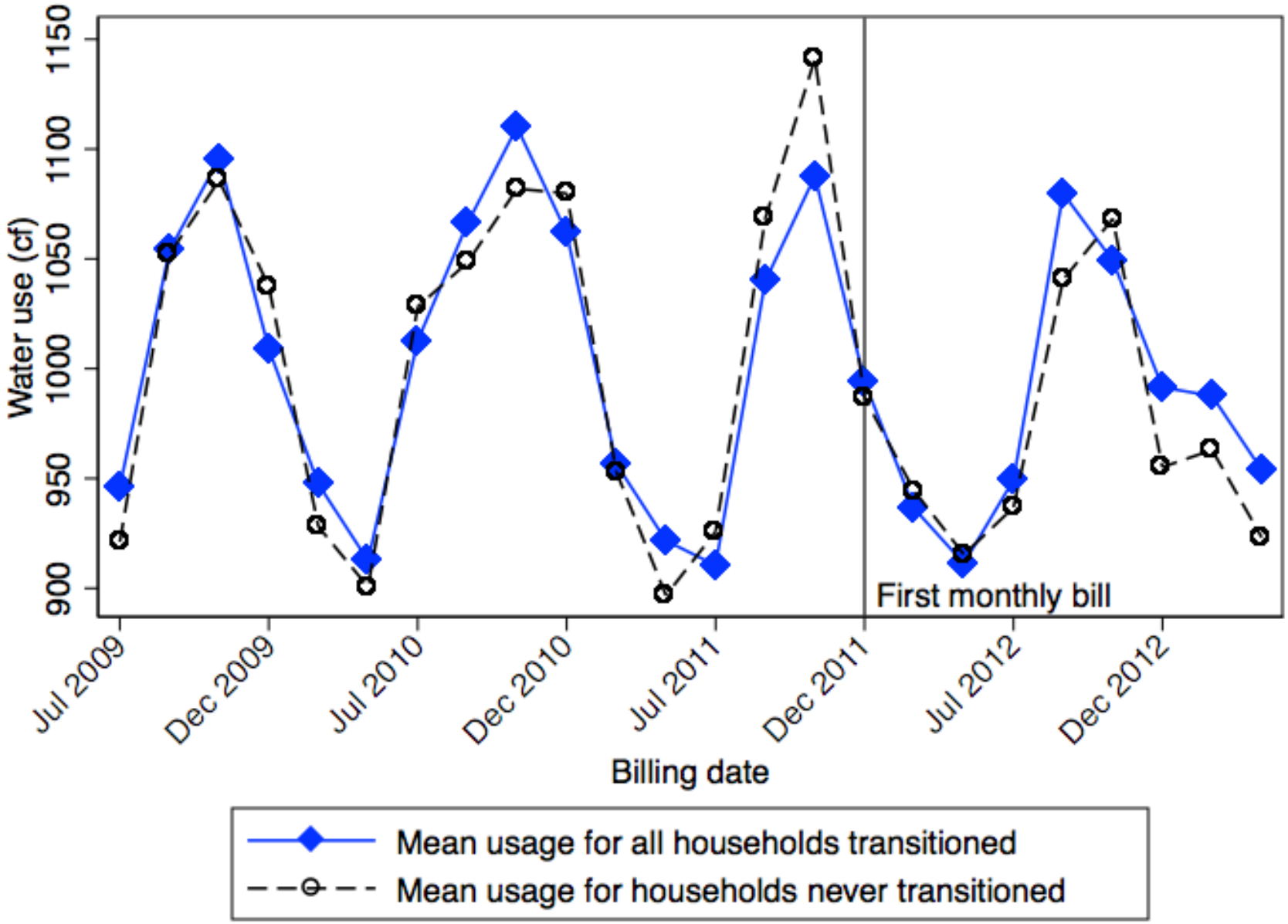
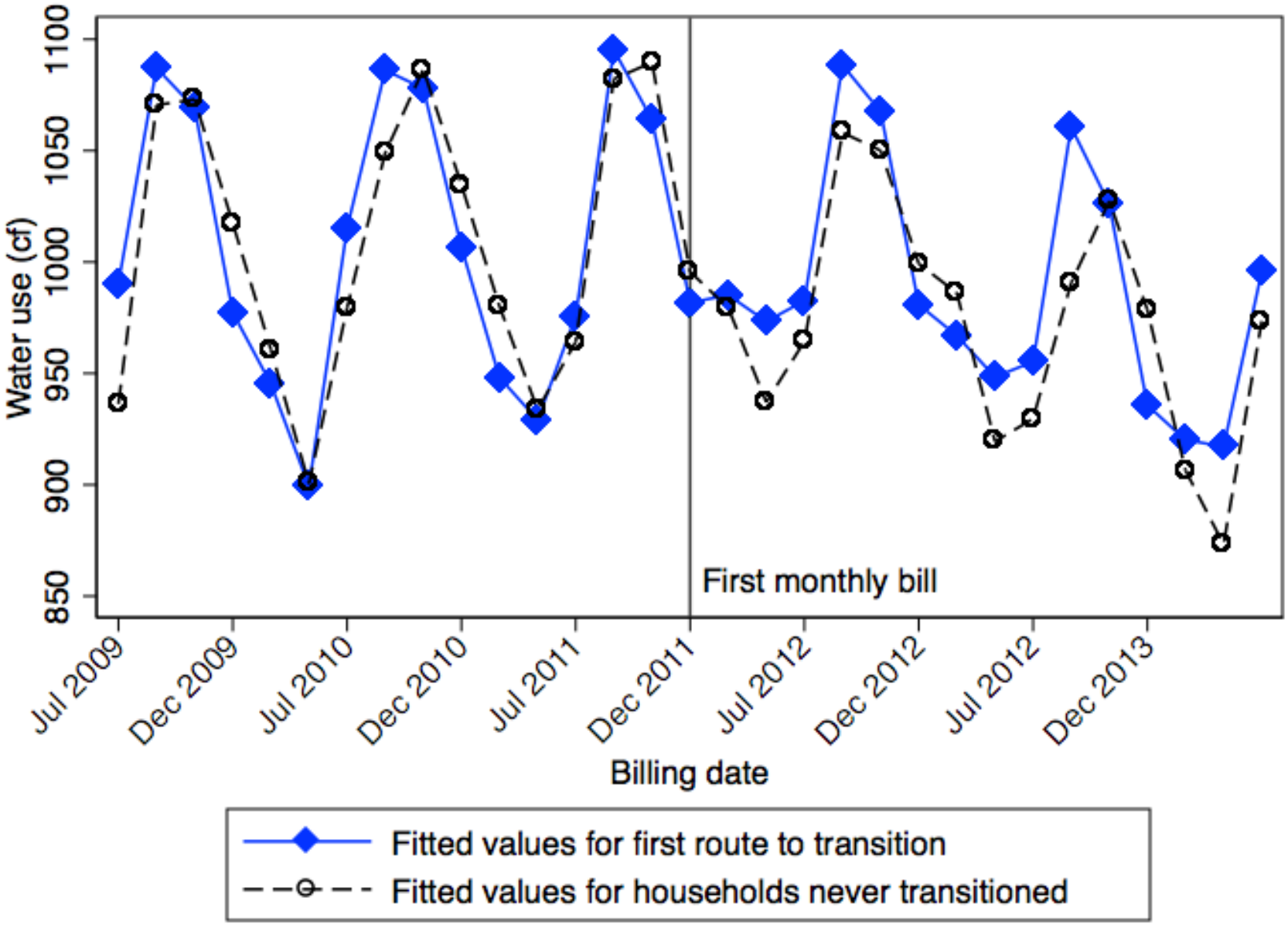
Heterogeneity:
→ No evidence of consumptive heterogeneity
→ Low "wealth" households display little response
→ Response in summer is 5× larger


Water use (cf)
900
950
1000
1050
1100
1150
Jul 2009
Dec 2009
Jul 2010
Dec 2010
Jul 2011
Dec 2011
Jul 2012
Dec 2012
Billing date
First monthly bill
Mean usage for all households transitioned
Mean usage for households never transitioned


Water use (cf)
850
900
950
1000
1050
1100
First monthly bill
Jul 2009
Dec 2009
Jul 2010
Dec 2010
Jul 2011
Dec 2011
Jul 2012
Dec 2012
Jul 2012
Dec 2013
Billing date
Fitted values for first route to transition
Fitted values for households never transitioned

Pooled cross-section difference-in-difference results

Dependent Variable: $\ln(W_{it})$	(1)	(2)	(3)	(4)	(5)
BF	0.047 (0.006)*** [0.033]	0.058 (0.006)*** [0.035]	0.072 (0.006)*** [0.022]***	0.047 (0.007)*** [0.021]**	0.038 (0.005)*** [0.022]*
Observations	1,670,476	1,670,476	1,661,315	1,661,315	1,661,315
R-squared	0.001	0.002	0.038	0.039	0.040
Additional controls:					
Time trend	Y	Y	Y	Y	Y
Weather covariates	–	Y	Y	Y	Y
HH characteristics	–	–	Y	Y	Y
Season FEs	–	Y	Y	Y	Y
Time FEs	–	–	–	Y	Y
Billing district FEs	–	–	–	–	Y

Note: Robust standard errors clustered at the household-level in parentheses. Robust standard errors clustered at the billing district in square brackets. *** p<0.01, ** p<0.05, * p<0.1.

Fixed effects difference-in-difference regression results

Dependent Variable: $\ln(W_{it})$	(1)	(2)
BF	0.079	0.045
	(0.005)***	(0.005)***
	[0.020]***	[0.020]**
Households	56,888	56,888
Observations	1,670,476	1,670,476
Within R-squared	0.004	0.006
Additional controls:		
Time trend	Y	Y
Weather covariates	Y	Y
Season fixed effects	Y	Y
Time fixed effects	–	Y
Household fixed effects	Y	Y

Note: Robust standard errors clustered at the household-level in parentheses. Robust standard errors clustered at the billing district in square brackets. *** p<0.01, ** p<0.05, * p<0.1.

Fixed effects difference-in-discontinuity results

Dependent Variable: $\ln(W_{it})$	(1) Within 2000ft	(2) Within 1000ft	(3) Within 500ft
BF	0.049 (0.006)*** [0.021]**	0.047 (0.008)*** [0.020]**	0.044 (0.011)*** [0.024]*
Number of households	45,398	27,810	14,903
Observations	1,327,468	807,481	431,532
Within R-squared	0.006	0.006	0.006
Additional controls:			
Time trend	Y	Y	Y
Weather covariates	Y	Y	Y
Season fixed effects	Y	Y	Y
Time fixed effects	Y	Y	Y
Household fixed effects	Y	Y	Y

Note: Robust standard errors clustered at the household-level in parentheses. Robust standard errors clustered at the billing district in square brackets. Results are from local linear panel data estimators with log consumption as the dependent variable. *** p<0.01, ** p<0.05, * p<0.1.

Dynamic models and partial adjustment estimates

	(1)	(2)
Estimator:	OLS	Fixed Effects
Dependent variable:	$\ln(w_{it})$	$\ln(w_{it})$
$\ln(w_{it-1})$	0.812***	0.618***
	(0.006)	(0.003)
BF	0.023*	0.029***
	(0.013)	(0.002)
Long-run treatment effect:	0.123*	0.076***
	(0.065)	(0.006)
Number of households	—	56,868
Observations	1,529,937	1,538,201
R-squared	0.649	—
Within R-squared	—	0.367

Note: Robust standard errors clustered at the household-level in parentheses. All models control for weather, demographic covariates, time trend, and season, time and billing district fixed effects. *** p<0.01, ** p<0.05, * p<0.1.

Heterogeneous responses to billing frequency

Dependent Variable: $\ln(W_{it})$	(1)	(2)	(3)	(4)
		Consumptive heterogeneity		
Panel A:	< 25%ile	$25 - 50$%ile	$50 - 75$%ile	> 75%ile
BF	0.029**	0.044***	0.052***	0.047***
	(0.014)	(0.009)	(0.008)	(0.008)
Number of households	14,455	14,114	14,124	14,195
Observations	417,753	417,511	417,617	417,595
Within R-squared	0.031	0.005	0.012	0.044
		Wealth heterogeneity		
Panel B:	< 25%ile	$25 - 50$%ile	$50 - 75$%ile	> 75%ile
BF	0.018	0.042***	0.076***	0.052***
	(0.012)	(0.010)	(0.009)	(0.010)
Number of households	15,041	14,134	13,903	13,810
Observations	417,637	417,620	417,607	417,612
Within R-squared	0.005	0.005	0.006	0.018

Note: Robust standard errors clustered at the household-level in parentheses. All models control for weather, time trend, seasonality, time and households fixed effects. *** p<0.01, ** p<0.05, * p<0.1.

Seasonal heterogeneity and automatic bill payment

Dependent Variable: $\ln(W_{it})$	(1)	(2)	(3)
BF	0.021***	0.049***	0.083***
	(0.006)	(0.005)	(0.005)
BF×spring	-0.007		
	(0.005)		
BF×summer	0.133***		
	(0.008)		
BF×fall	0.033***		
	(0.005)		
BF×abp		-0.079***	-0.077***
		(0.014)	(0.014)
Number of households	56,888	56,888	56,888
Observations	1,670,476	1,670,476	1,670,476
Within R-squared	0.006	0.006	0.004
Additional controls:			
Time fixed effects	Y	Y	N

Note: Robust standard errors clustered at the household-level in parentheses. All models control for weather, time trend, seasonality, and household fixed effects. *** p<0.01, ** p<0.05, * p<0.1.

Summary

Consumers increase consumption (3-8%) in response to more frequent billing.

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Why?

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Why?

- Price and/or quantity misperception
- Increased billing frequency reduces bias in consumers' perceptions of price and/or use
- Welfare gains to consumers from increases in information

Summary and implications

Summary of results:

- Consumers increase consumption (3-8%) in response to more frequent billing
- Effects are persistent and heterogenous across wealth and seasonality
- Inattention (auto bill pay) negates these effects

Policy relevance:

- Results run contrary to findings in electricity literature
  - $\Longrightarrow$ unintended result from increased information provision
- Increased billing frequency might not aid in conservation
- Refines understanding of decision making under limited information

Questions?

Thank you.

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