Do consumers respond to marginal price under increasing block tariffs when rate information is cheap? Evidence from residential water demand

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Motivation

- Electric and water utilities use increasing block tariffs (IBT) to promote conservation ▸ Graph
- Consumers do not respond to marginal price under IBT's (Ito 2014)
- Several possible mechanisms for this result
- Price salience as a possible mechanism
  - Educating consumers about IBT's decreases electricity demand (Kahn and Wolak 2013)
  - Informed consumers have higher price elasticities (Carter and Milon 2005; Meeks and McRae 2016)
  - Water utilities that provide price information on bills have higher price elasticities (Gaudin 2006)

Research Questions

Does providing better information about increasing block tariffs (IBT's) on monthly bills lead to higher marginal price elasticity of demand?

Approach

- Natural experiment with two water utilities in same metropolitan area that provide different levels of detail about IBT's on monthly bills
- Interaction of two empirical strategies
  1. Compare price elasticities for households who get **High Information** about prices on monthly bills to similar customers who get **Low Information** ▸ Bill examples
  2. Use a discontinuity introduced by a particular type of rate change to identify price elasticities separately for each utility ▸ Rate change graph

Findings

- Utility that provides price information on bills has more elastic demand
- Low Information: -0.06
- High Information: -0.32
- Quasi-experimental evidence linking price salience to price elasticity under IBT's
- Price salience a possible mechanism behind Ito's empirical puzzle

Empirical Setting

- Two water utilities in Reno metropolitan area in Northern Nevada
- Low vs. High information on monthly bills
- Utilities have different IBT's with several rate changes over time

  ▸ Rate Graphs
- Low information utility
  - Three rate changes over time
  - Several service (rate) areas
- High information utility
  - Two rate changes over time
  - One service (rate) area

  ▸ Map

Empirical Strategy Part 1

- Use households in the same city provided different detail about prices on water bills
- Estimate separate price elasticities for low and high information households

$$ln\, Q_{it} = \beta_1 ln\, MP_{it} + \beta_2 \mathbb{1}_{\text{HighInfo}} * ln\, MP_{it} + \varepsilon_{it}$$

- Two approaches
  1. Limit sample near utility border
  2. Use inverse propensity score weighting to balance sample

Empirical Strategy Part 2

- Estimate MP Elasticity under IBT's

$$ln\, Q_{it} = \beta ln\, MP_{it}(Q_{it}) + \varepsilon_{it}$$

- MP is endogenous
- Exploit tier threshold shifts over time ▸ Threshold shift
- Create an instrument from households affected by threshold shift
- Instrument

$$\text{Let } S_{it} = \begin{cases} 1, & \text{if } Q_{it-12} \in (k', k] \\ 0, & otherwise \end{cases}$$

Regression Model

Second Stage

$$\Delta ln\, Q_{it} = \beta_1 \Delta ln\, \hat{MP}_{it} + \beta_2 \mathbb{1}_{\text{HighInfo}} * \Delta ln\, \hat{MP}_{it} + \delta_{rt} + \alpha_{cy} + f(Q_{it-12}) + \Delta \varepsilon_{it}$$

First Stage

$$\Delta ln\, MP_{it} = \alpha_1 S_{it} + \gamma_{bt} + \alpha_{cy} + f(Q_{it-12}) + \Delta \eta_{it}$$

where

- $\Delta ln\, Q_{it} = ln\, Q_{it} - ln\, Q_{it-12}$
- $\Delta ln\, MP_{it} = ln\, MP_{it}(Q_{it}) - ln\, MP_{it-12}(Q_{it-12})$
- δ_{bt} meter reading route-by-period FE ▸ Fixed Effect Map
- α_{cy} city-by-year FE
- $f(Q_{it-12})$ polynomial of baseline water use (Mean Reversion)

Hypothesis

- $\beta_1, \beta_2 < 0$

Propensity Score Approach

- Estimate propensity scores (appraised value, year built, number of bedrooms, yard size, distance from border)
- Create inverse probability weights from propensity scores
  - Treatment: $\frac{1}{\hat{p}}$
  - Control: $\frac{1}{1-\hat{p}}$
- Run regressions with probability weights

Data

- Water Utility Billing Data 2003-2013
- Assessor Property Characteristics (appraised value, year built, yard size, number of bedrooms)
- NOAA weather station data
- Limit dataset to households that have at least 5 years of uninterrupted billing history with a good correspondence to assessor data
- Trim propensity scores outside (0.05,0.95)

Results

Table : First Stage Results High vs. Low Information Groups

	Near Border Summer	IPSW Summer
inst_2003_RMWS_t2	0.0849***	0.0784***
inst_2009_RMWS_t2	0.0834***	0.0866***
inst_2006_DWR_t3	0.1235***	0.1214***
inst_2006_DWR_t4	0.0673***	0.0613***
inst_2009_DWR_t2	-0.0228***	-0.0197***
inst_2009_DWR_t3	0.0639***	0.0629***
inst_2009_DWR_t5	0.0006	0.0065
inst_2006_DD_t3	0.0856***	0.0794***
inst_2009_DD_t3	0.0990***	0.0968***
inst_2009_DD_t4	0.1202***	0.1074***
inst_2007_STM_t1	0.2212***	0.2224***
inst_2007_STM_t2	0.0829***	0.0906***
inst_2008_STM_t1	0.2669***	0.2510***
inst_2008_STM_t2	0.1211***	0.1145***
inst_2009_STM_t1	0.1530***	0.1355***
inst_2009_STM_t2	0.1516***	0.1402***
inst_2009_STM_t3_1	0.1311***	0.1086***
Baseline Use	Yes	Yes
Change in temp/precip	Yes	Yes
R^2	0.2805	0.2869
Clusters	18,874	29,112
F-stat	897.1	685.3
Observations	146773	224310

SE Clustered at Household Level
Near Border is less than 2 miles from utility border
IPSW: Inverse propensity scores as probability weights
Includes route-by-period and city-by-year FE's
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results

Table : IV Results High vs. Low Information Groups

	Near Border Summer	IPSW Summer
Actual Change MP	-0.0554*	-0.0634*
	(0.0313)	(0.0369)
Difference High Info	-0.1899**	-0.2563**
	(0.0834)	(0.1003)
Baseline Use	Yes	Yes
Change in temp/precip	Yes	Yes
R^2	0.2201	0.2066
Clusters	18,874	29,112
Observations	146773	224310

SE Clustered at Household Level in parentheses

Near Border is less than 2 miles from utility border

IPSW: Inverse propensity scores as probability weights

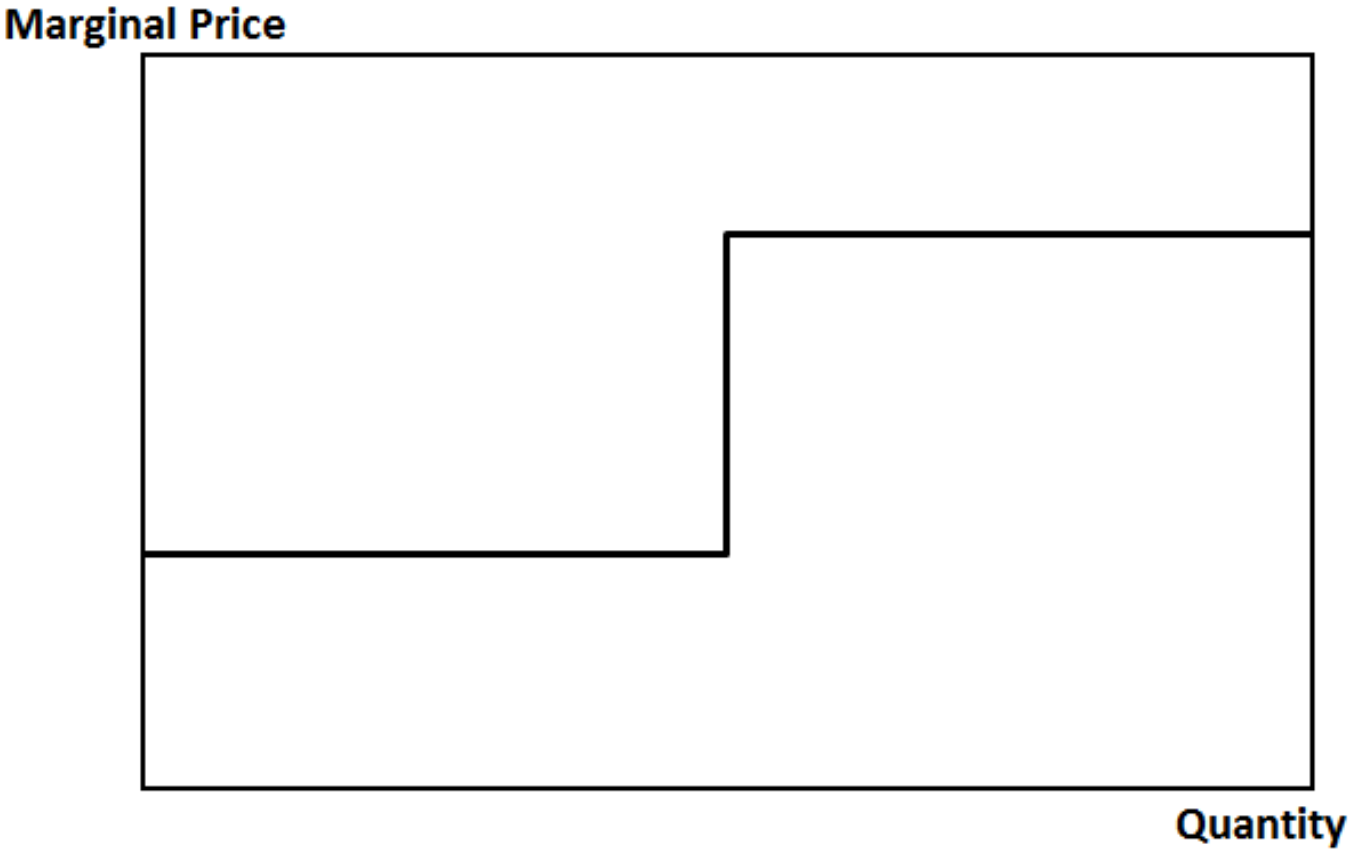
Includes route-by-period and city-by-year FE's

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Conclusions

- Quasi-experimental evidence that better information about prices on monthly bills leads to more elastic demand
- Contribute to understanding of price policy
- Improve conservation with existing rates
- Price information a cost effective policy compared to in-home displays

Two Tier Increasing Block Tariff



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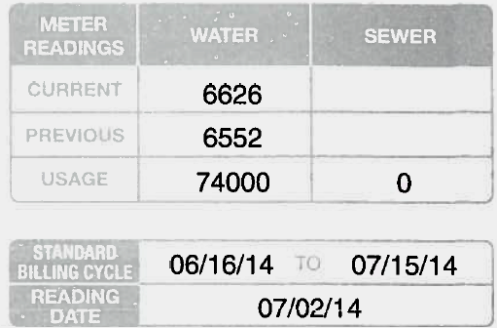
Use and Rate Information on Monthly Bills

Figure : Low Information Utility



METER READINGS	WATER	SEWER
CURRENT	6626	
PREVIOUS	6552	
USAGE	74000	0

STANDARD BILLING CYCLE	06/16/14	TO	07/15/14
READING DATE	07/02/14		

Figure : High Information Utility

Meter	Rate Code	No. of Days	From Date	To Date	Prior Reading	Current Reading	Reading Type	Factor	Billed Usage
03970534	RMWD1	30	07/06	08/05	6869	6913	Actual	1	44

Residential Customer Charge	3/4" Service	$17.43
Tier 1 Water Usage Charge	7 THOUSAND GALLONS X 2.62000	$18.34
Tier 2 Water Usage Charge	14 THOUSAND GALLONS X 3.27000	$45.78
Tier 3 Water Usage Charge	20 THOUSAND GALLONS X 3.93000	$78.60
Tier 4 Water Usage Charge	3 THOUSAND GALLONS X 5.25000	$15.75
TOTAL CURRENT CHARGES - Water Charges		**$175.90**

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Fee Summaries on Monthly Bills

Figure : Low Information Utility

TYPE OF SERVICE	AMOUNT	TYPE OF SERVICE	AMOUNT
WATER SERVICE	$333.65		
1.5 % SURCHARGE	$5.00		
STORMWATER	$7.34		
ARSENIC SURCHARGE	$2.38		
		TOTAL CURRENT CHARGES	$348.37

Figure : High Information Utility

New Water Charges	Water Charges (see detail on back)	$175.90	
	Regional Water Mgmt Fee - 1.5%	$2.64	
	Total New Water Charges		**$178.54**
	New Balance		**$178.54**

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Water Use History on Bills

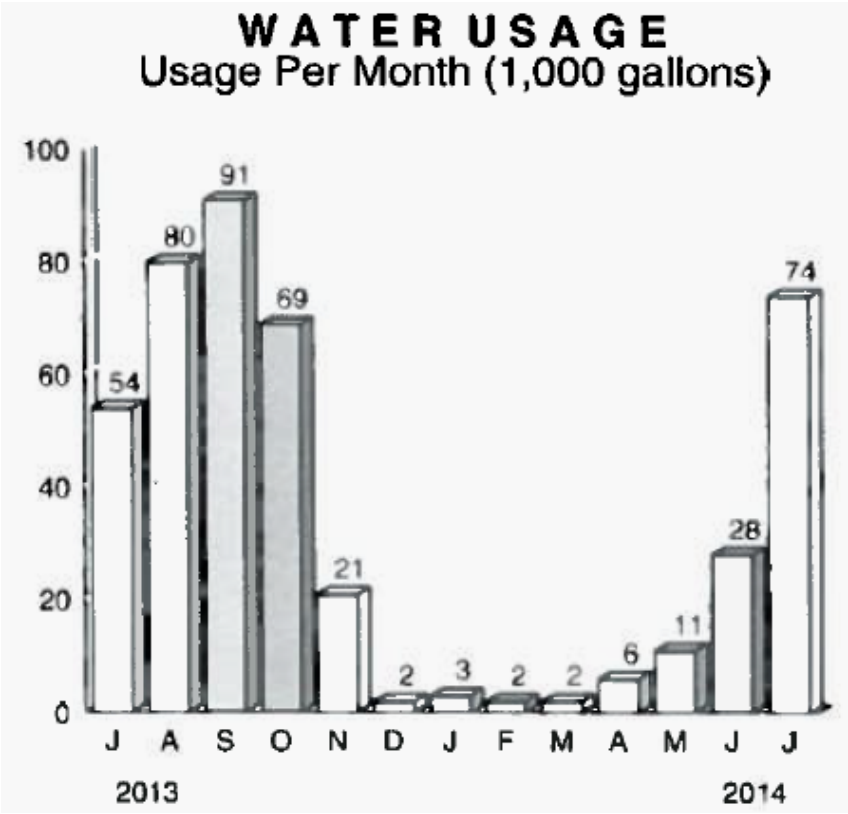

Figure : Low Information Utility

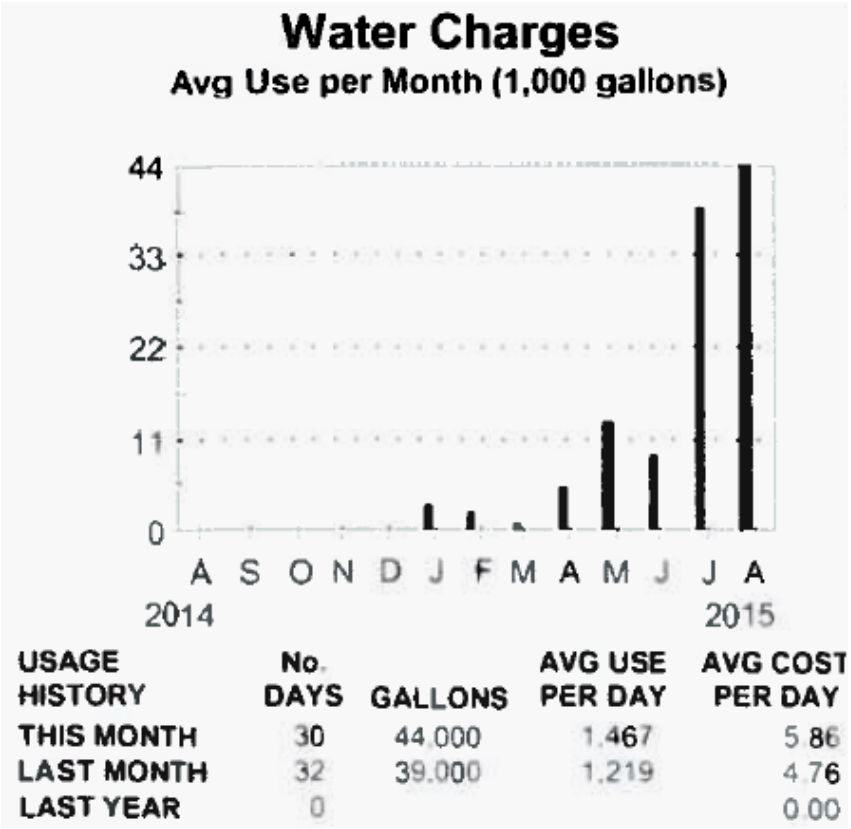

Figure : High Information Utility

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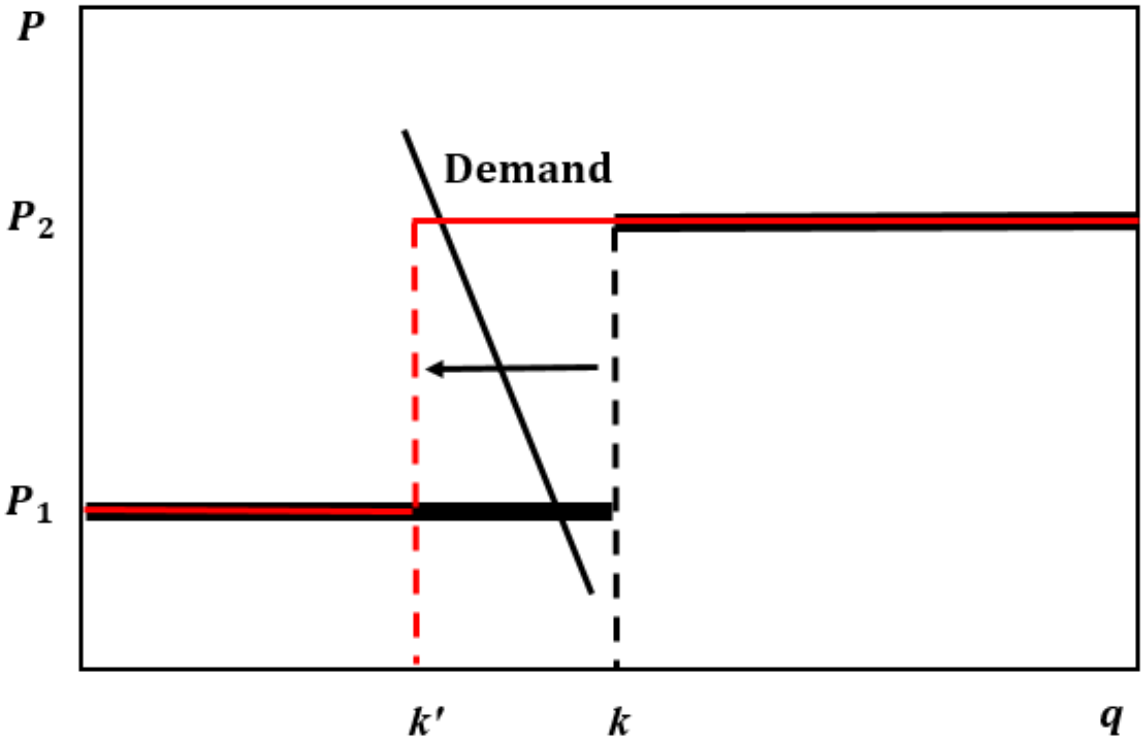
Shift in Tier Threshold



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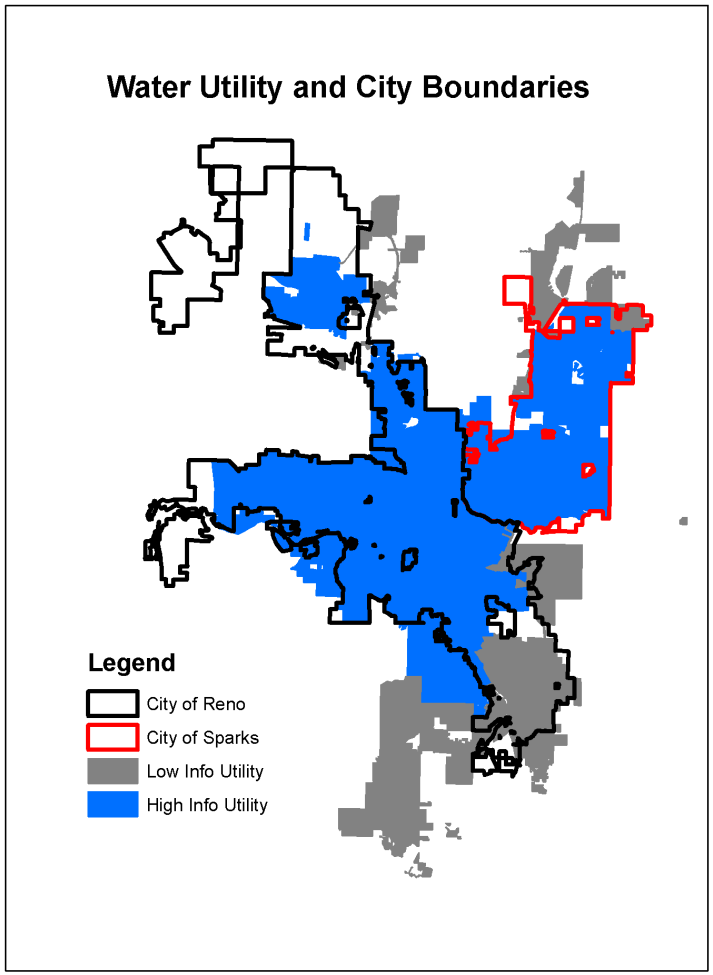
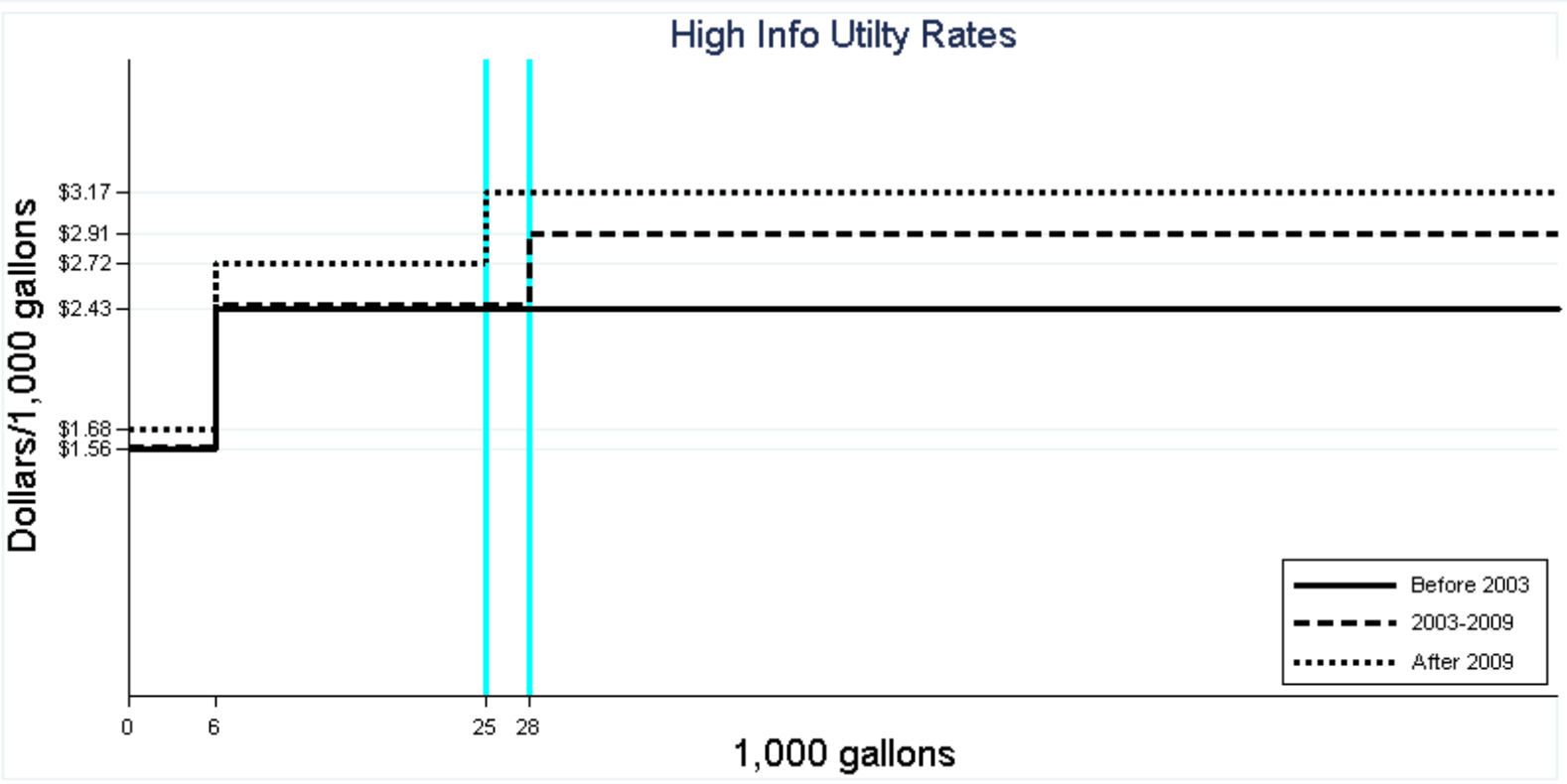
City and Water Utility Boundaries



High Information Utility Rate Changes



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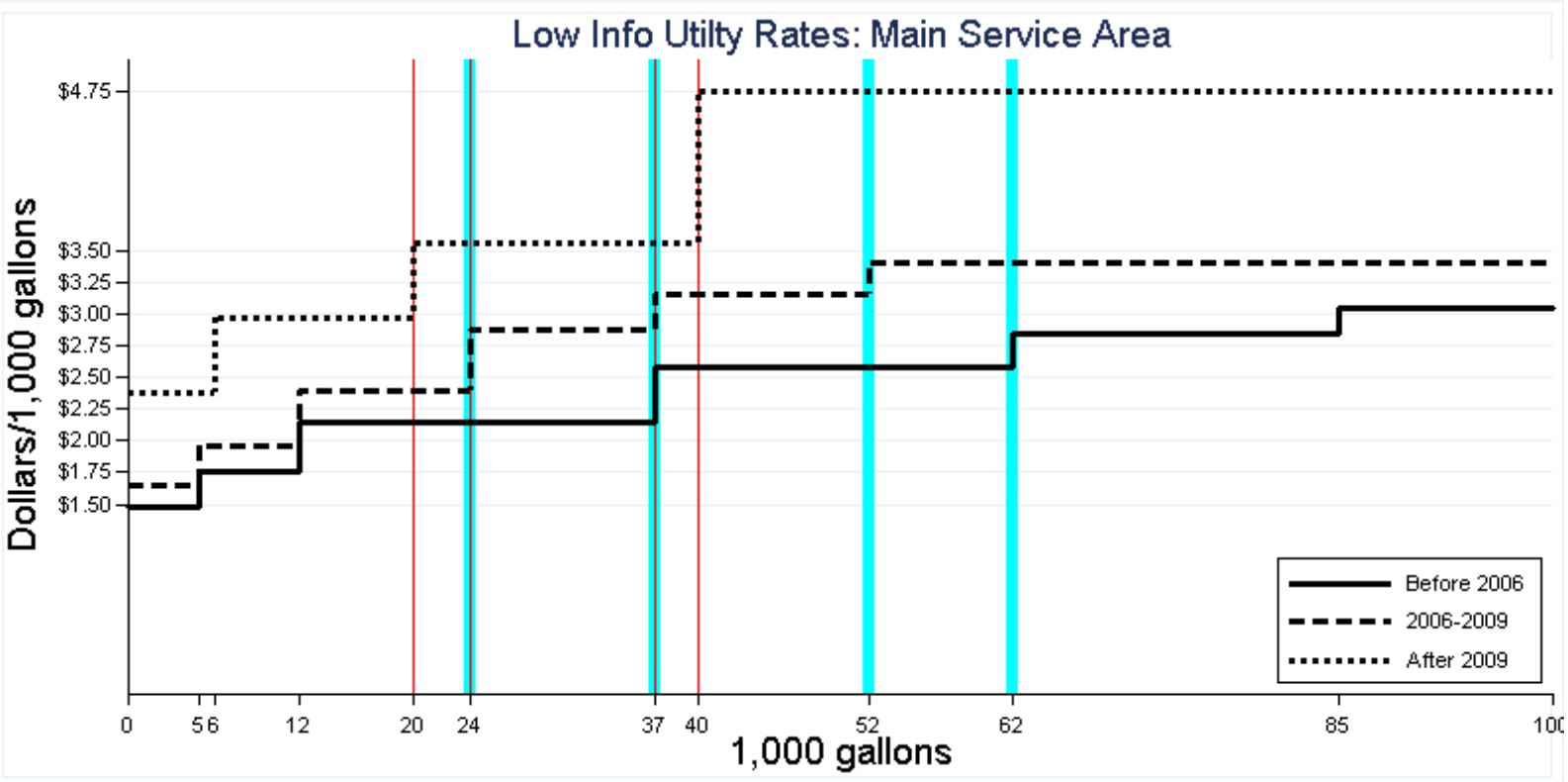
Low Information Utility Rate Changes



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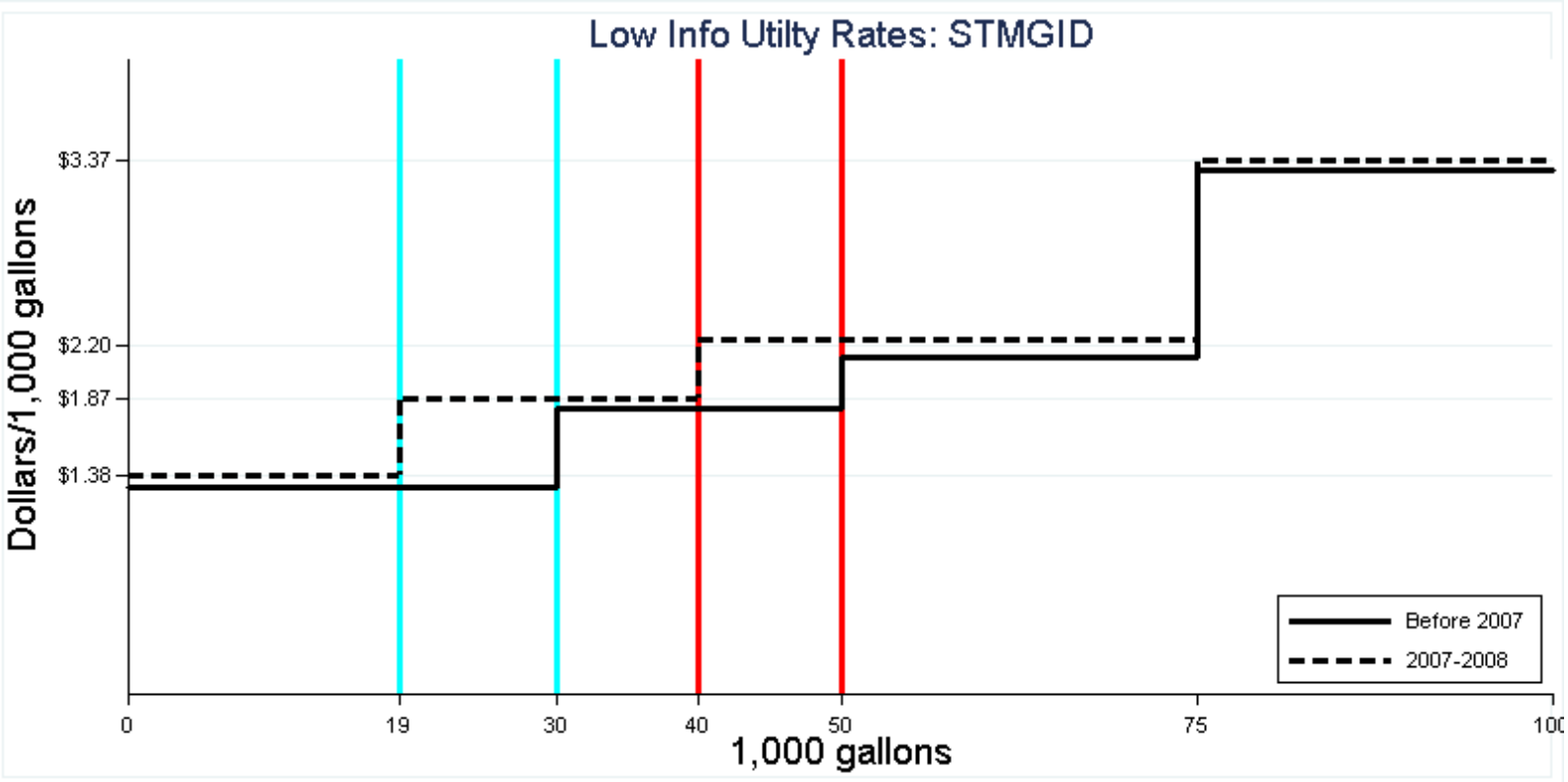

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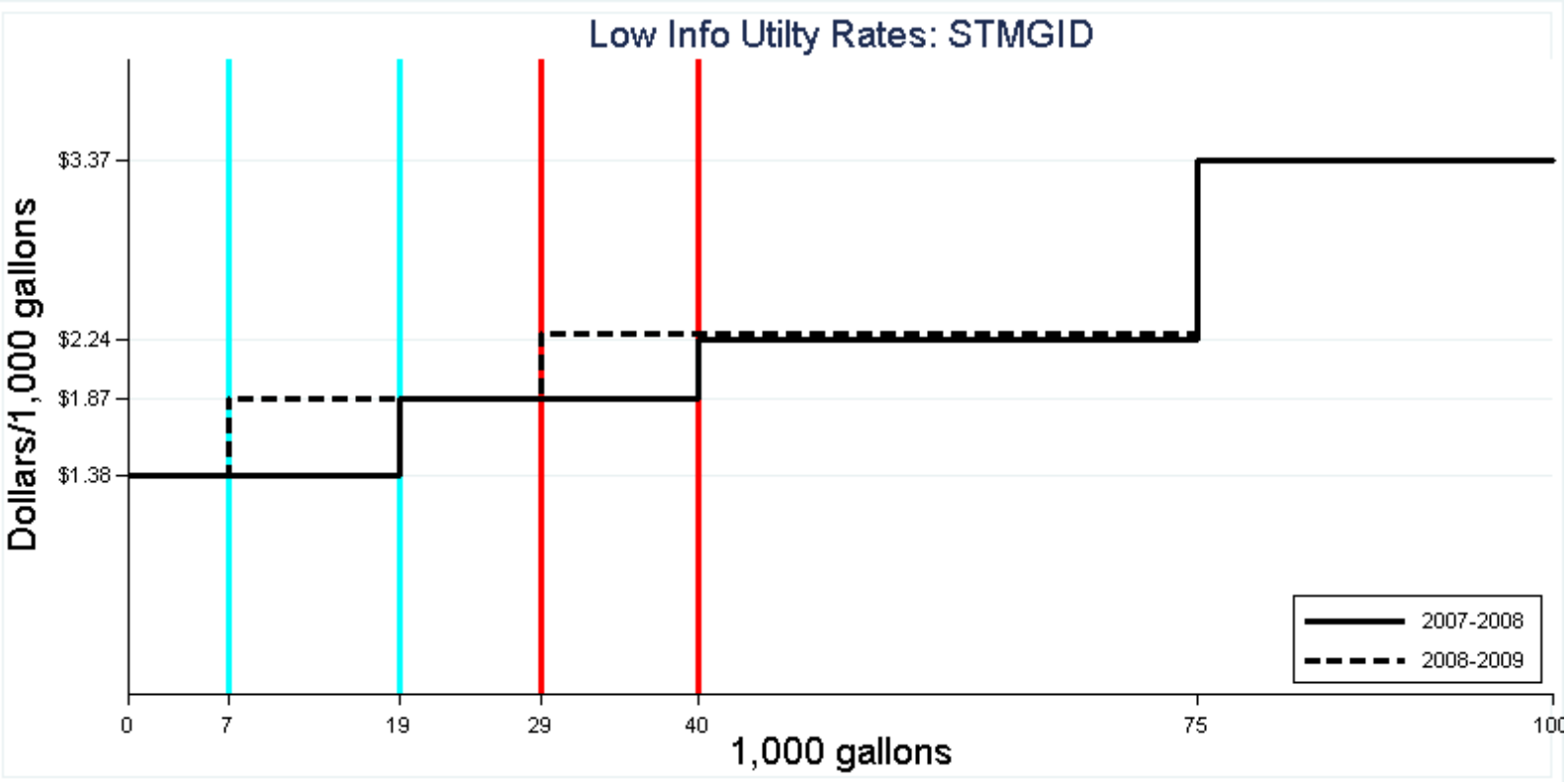

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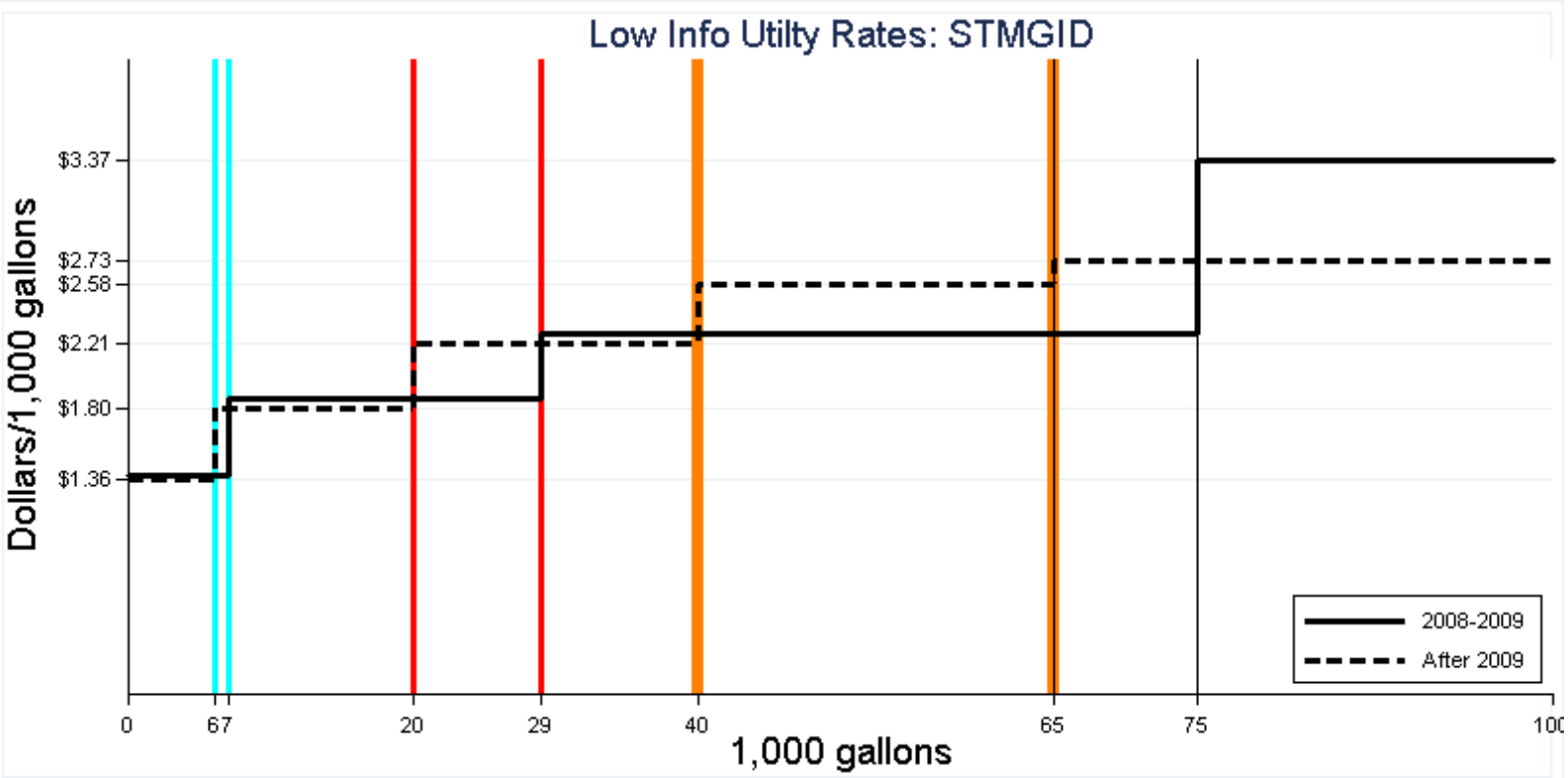

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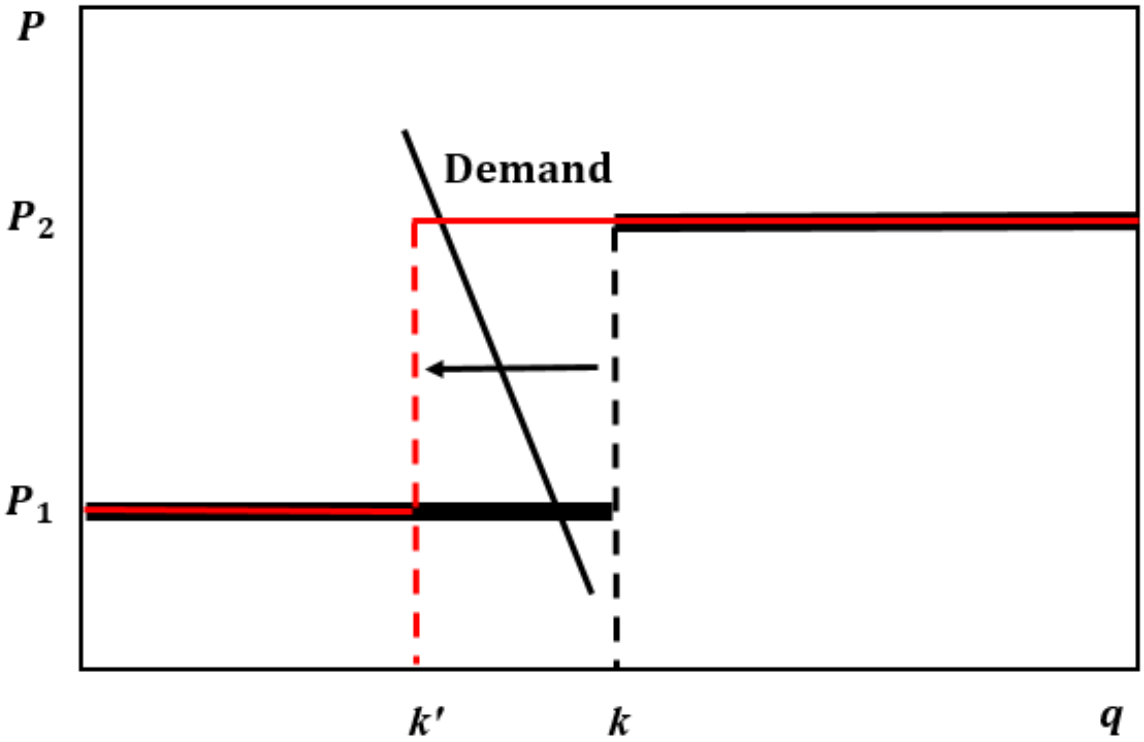
RD Tier Approach



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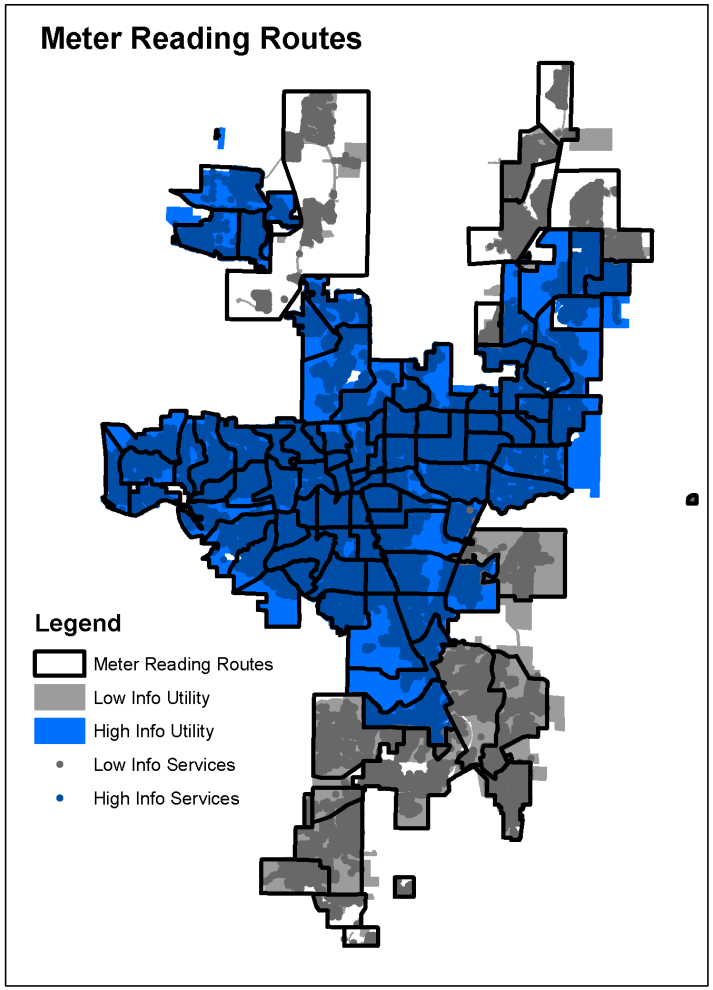
Meter Reading Routes



Results

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inst_2003_RMWS_t2	0.1051***	0.0849***	0.0974***	0.0784***
inst_2009_RMWS_t2	0.0977***	0.0834***	0.0998***	0.0866***
inst_2006_DWR_t3	0.1362***	0.1235***	0.1341***	0.1214***
inst_2006_DWR_t4	0.0791***	0.0673***	0.0719***	0.0613***
inst_2009_DWR_t2	-0.0743***	-0.0228***	-0.0729***	-0.0197***
inst_2009_DWR_t3	0.0694***	0.0639***	0.0664***	0.0629***
inst_2009_DWR_t5	0.0157***	0.0006	0.0169***	0.0065
inst_2006_DD_t3	0.1079***	0.0856***	0.0990***	0.0794***
inst_2009_DD_t3	0.1121***	0.0990***	0.1084***	0.0968***
inst_2009_DD_t4	0.1417***	0.1202***	0.1244***	0.1074***
inst_2007_STM_t1	0.2095***	0.2212***	0.2163***	0.2224***
inst_2007_STM_t2	0.0867***	0.0829***	0.0938***	0.0906***
inst_2008_STM_t1	0.2158***	0.2669***	0.2139***	0.2510***
inst_2008_STM_t2	0.1210***	0.1211***	0.1175***	0.1145***
inst_2009_STM_t1	0.1619***	0.1530***	0.1542***	0.1355***
inst_2009_STM_t2	0.1560***	0.1516***	0.1504***	0.1402***
inst_2009_STM_t3_1	0.1334***	0.1311***	0.1137***	0.1086***
Baseline Use	Yes	Yes	Yes	Yes
Change in temp/precip	Yes	Yes	Yes	Yes
R^2	0.2782	0.2805	0.2908	0.2869
Clusters	18,878	18,874	29,117	29,112
F-stat	1211.3	897.1	1026.9	685.3
Observations	336070	146773	508429	224310

SE Clustered at Household Level
Near Border is less than 2 miles from utility border
IPSW: Inverse propensity scores as probability weights
Includes route-by-period and city-by-year FE's
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Results

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	Near Border All Months	Near Border Summer	IPSW All Months	IPSW Summer
Actual Change MP	-0.0911***	-0.0554*	-0.0558	-0.0634*
	(0.0326)	(0.0313)	(0.0362)	(0.0369)
Difference High Info	0.0334	-0.1899**	-0.0320	-0.2563**
	(0.0851)	(0.0834)	(0.0974)	(0.1003)
Baseline Use	Yes	Yes	Yes	Yes
Change in temp/precip	Yes	Yes	Yes	Yes
R^2	0.2047	0.2201	0.2100	0.2066
Clusters	18,878	18,874	29,117	29,112
Observations	336070	146773	508429	224310

SE Clustered at Household Level in parentheses

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Overlap Propensity Scores