

# Evaluation of Peak Pricing on Single-Family Residential Water Consumption in Seattle

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# Motivation

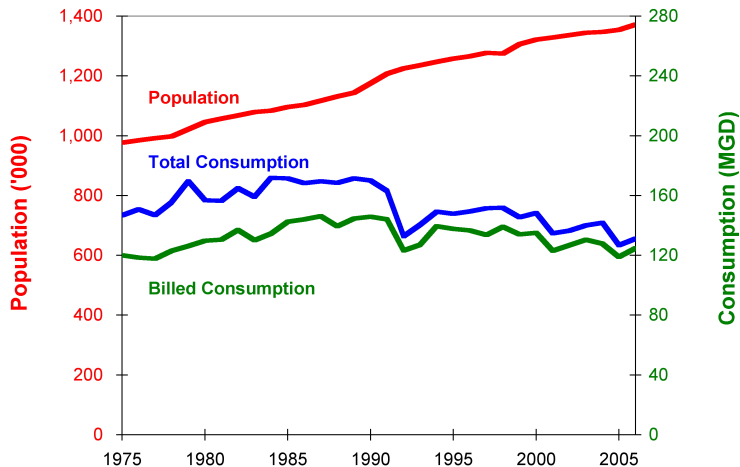
Urban water supply is of growing concern worldwide:

- climate change
- urbanization
- economic development

Reasons to manage urban supply, demand, and infrastructure:

- fixed supplies from protected watersheds
- no substitutes
- competing uses for water

# Surprise!? Water Consumption in Seattle is Down



On a per capita basis, total consumption -35%, billed consumption -25%. This trend is also occurring in other major cities: Boston, NY, LA. *Why?*

# Hypotheses

Various disciplines have focused on different policy options:

|               |   |                                     |
|---------------|---|-------------------------------------|
| engineers     | ⇒ | technical conservation              |
| planners      | ⇒ | urban form, density, building codes |
| psychologists | ⇒ | behavior and attitudes              |
| economists    | ⇒ | pricing policies                    |

I focus on price for the following reasons:

- cheap to deliver
- can target specific users
- can signal the environmental cost of supply
- good rate design is fundamental for other policies as well

# Research Question

*What was the impact of new price structure in Seattle in 2001?*

- previous two-tier inclined-block price structure
- third tier ('shock rate') applied only to summer peak
- only above 18 ccf, or 13,500 gallons per month
- a nonlinear price structure

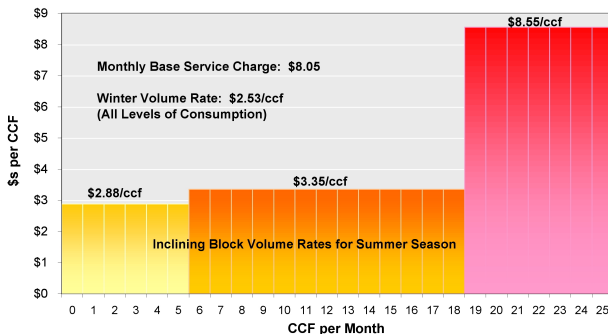
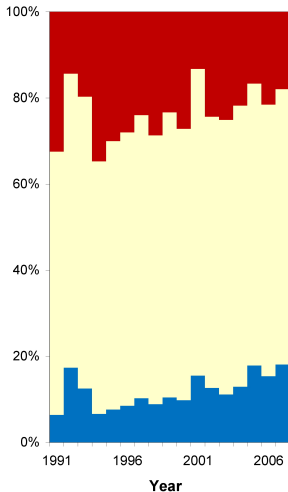
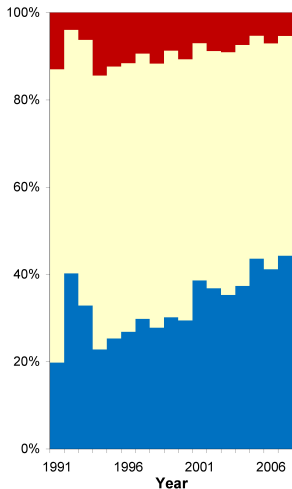


Figure: Seattle Public Utilities

# Distribution of Consumption in Tiers



(L) number of customers by tier; (R) quantities consumed by tier.

# Modeling Approach

A discrete-continuous choice model was used to model nonlinear prices, and control for weather and physical characteristics. Steps:

- ① discrete choice
  - ▶ calculate the probability of landing in each tier
  - ▶ allows estimation of effect of different prices on tier choice
- ② continuous choice
  - ▶ linear regressions within each tier
  - ▶ calculate the effect of appropriate marginal price in each tier
- ③ use model to simulate results statistically
  - ▶ calculate effect of changing prices and other variables

# Data

Seattle Public Utilities billing databases:

- panel data structure
- single-family residential household only
- bimonthly billing
- random sample from this database for eight census tracts

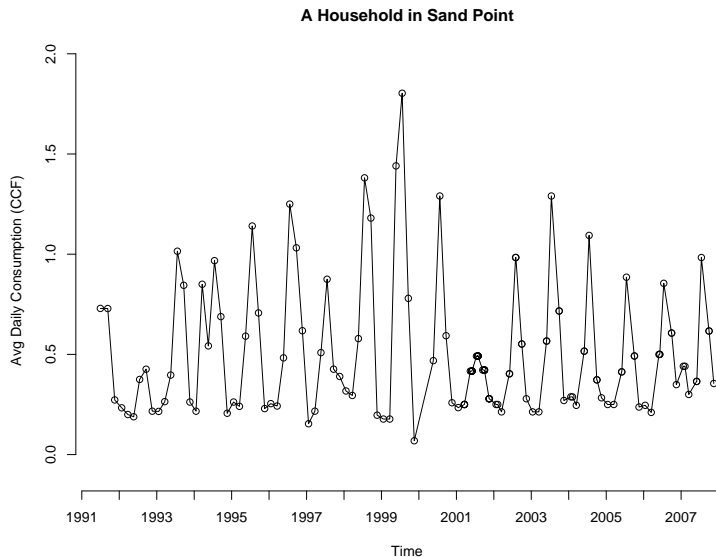
Outcome variable: household water consumption

Predictors used:

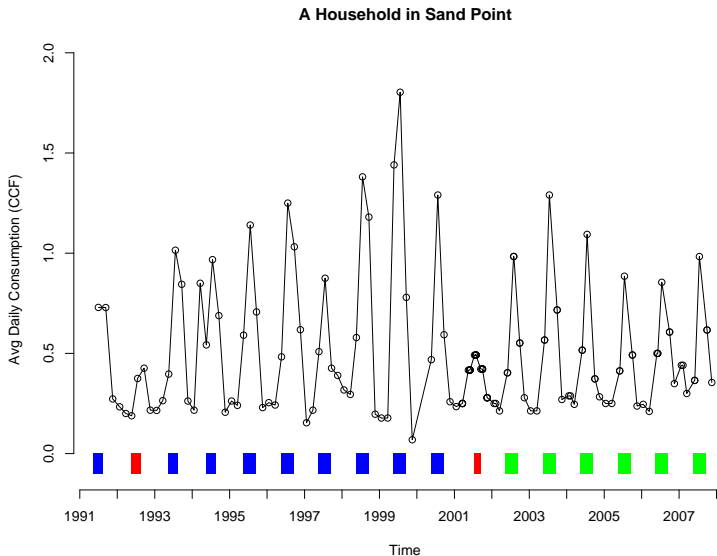
- average temperature, total precipitation (National Weather Service)
- marginal price history (Seattle Public Utilities)
- lot size and house value (King County tax assessor, 2007 only)

Removed 1992 and 2001 data, because of drought restrictions.

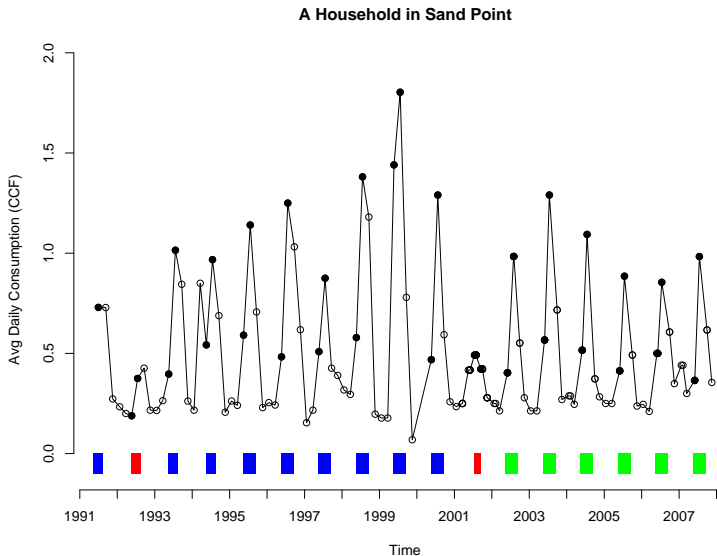
# Individual Household Data



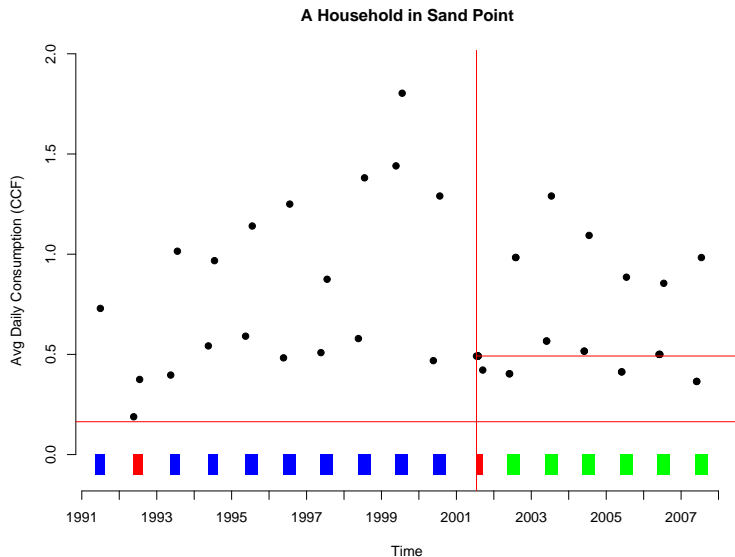
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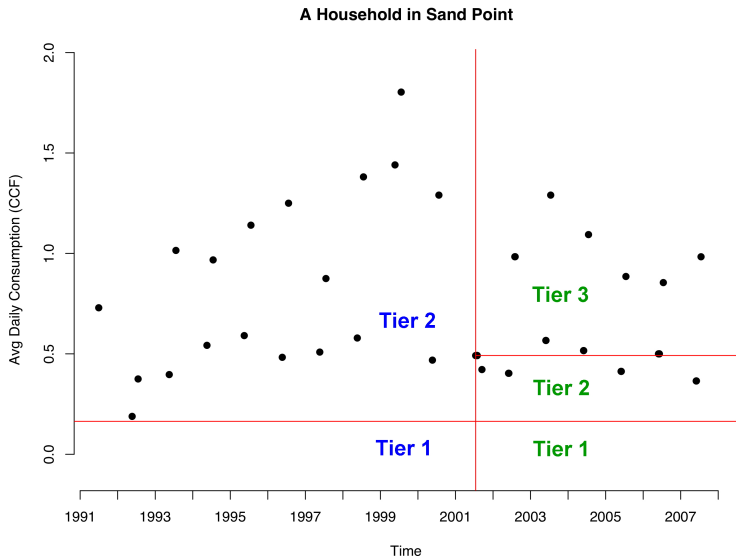
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## Discrete Choice

Estimated coefficients for ordered categorical fit to center-normalized data:

| Variable         | Estimate | Std Error | z value | Pr     |     |
|------------------|----------|-----------|---------|--------|-----|
| (Intercept)      | -1.2198  | 0.0332    | -36.79  | <2e-16 | *** |
| temperature      | 0.4206   | 0.0367    | 11.47   | <2e-16 | *** |
| price in tier 3  | -0.3366  | 0.0344    | -9.79   | <2e-16 | *** |
| log(house value) | 0.2946   | 0.0227    | 12.98   | <2e-16 | *** |
| log(lot size)    | 0.2783   | 0.0373    | 7.47    | 8e-14  | *** |
| precipitation    | -0.0975  | 0.0376    | -2.59   | 0.0095 | **  |

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*The choice probability of tier 3 is influenced first by temperature; then price; then physical characteristics. Precipitation seems relatively unimportant.*

## Continuous Choice within Tier 3

Estimated coefficients for log-linear fit to center-normalized data:

| Covariate        | Estimate | Std Error | z value | Pr      |     |
|------------------|----------|-----------|---------|---------|-----|
| (Intercept)      | -0.13980 | 0.00859   | -16.27  | < 2e-16 | *** |
| log(lot size)    | 0.15925  | 0.01135   | 14.04   | < 2e-16 | *** |
| log(house value) | 0.06135  | 0.00641   | 9.58    | < 2e-16 | *** |
| price in tier 3  | -0.03779 | 0.00925   | -4.08   | 4.7e-05 | *** |
| temperature      | 0.03302  | 0.00942   | 3.51    | 0.00047 | *** |
| precipitation    | -0.02178 | 0.00999   | -2.18   | 0.02945 | *   |

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*Once you're in tier 3, housing best explains quantity of water used.*

# Elasticity of Water Demand

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$$\varepsilon_d = \frac{\Delta Q/Q}{\Delta P/P} = \frac{\Delta Q}{\Delta P} \frac{P}{Q}$$

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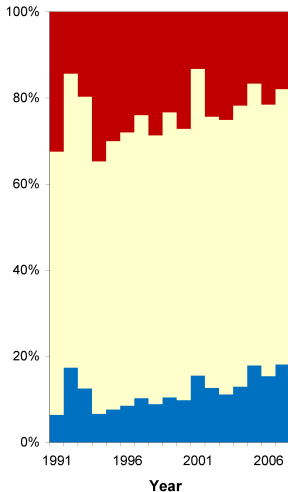
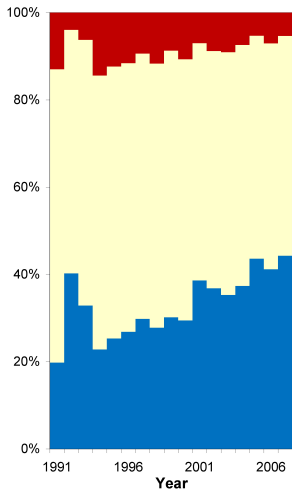
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- 1 change in probability of tier 3:  $-8\%$ .
- 2 change in quantity in tier 3:  $-5.4\%$

A2: If we change our third tier price by 250%:

- 1 change in probability of tier 3:  $-26\%$ .
- 2 change in quantity in tier 3:  $-14\%$

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# Conclusions

Preliminary conclusions:

- ① applied discrete-continuous choice model to water demand
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## Ongoing research:

- ① establish causal inference
- ② investigate seasonal and geographic variation
- ③ identify effects of other conservation policies

Thank you

Questions?

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