Rational, Lazy or Confused?

Evidence of misperception in consumer responsiveness to nonlinear electricity prices

Blake Shaffer

University of Calgary & Stanford University

Feb 4, 2019 @ University of California at Berkeley

Motivation

Policies are set based on an expectation of consumer behaviour.

… but what if our expectations are wrong?

What is the Research Question?

How do consumers respond to nonlinear tariffs?

Do consumers ...

- ... respond to **marginal cost**?
- ... respond to **average cost**?

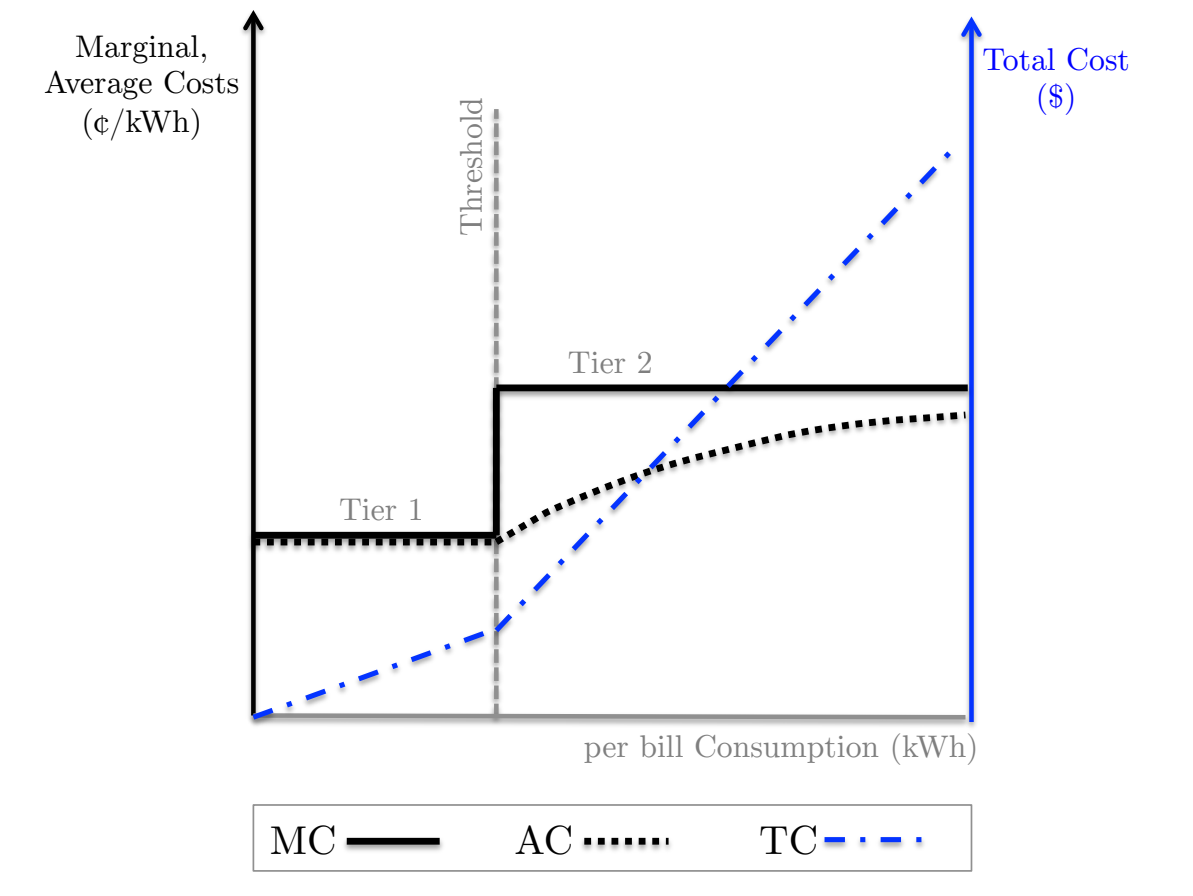
} Ito (2014, AER)

- ... something else?

⇒ My paper uncovers the presence of "misperception"

What do I mean by nonlinear pricing?

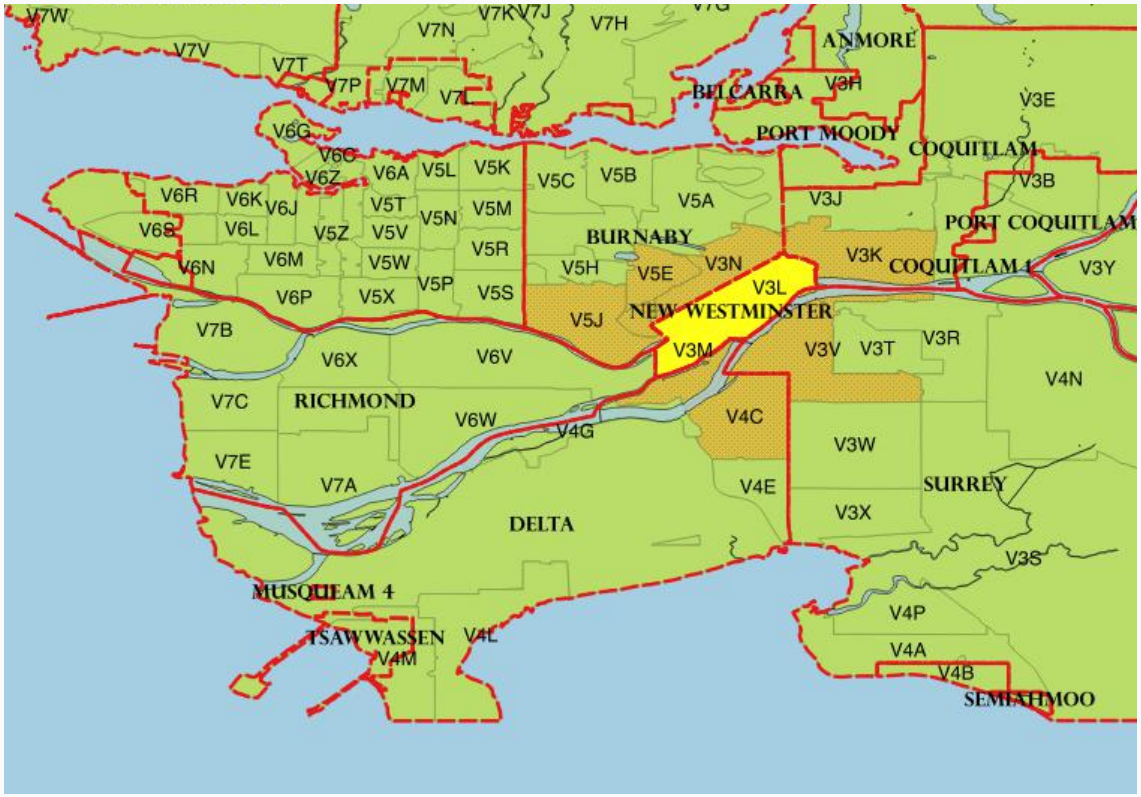
Figure 1: Costs under a RIB Tariff



RIB = Residential Increasing Block tariff

The Setting

- BC Hydro changed to a RIB in October 2008
- City of New Westminster did not.



▸ Large map

Outline of the Paper

This paper combines reduced form with structural methods to infer the presence of misperception.

Part 1 Top-down empirical analysis

- Bunching, Panel IV, Conditional DD

Part 2 Bottom-up simulation

- Heterogeneous ”types” of households
- Simulate consumption data for each type

Part 3 Indirect inference

- Find mix of types that best rationalizes the data

Part 1: Estimating consumer response to nonlinear pricing

Method 1 - Bunching

We want to estimate the price elasticity of demand in the following equation:

$$\frac{dz^*}{z^*} = e\frac{dp}{p} \tag{1}$$

Method 1 - Bunching

We want to estimate the price elasticity of demand in the following equation:

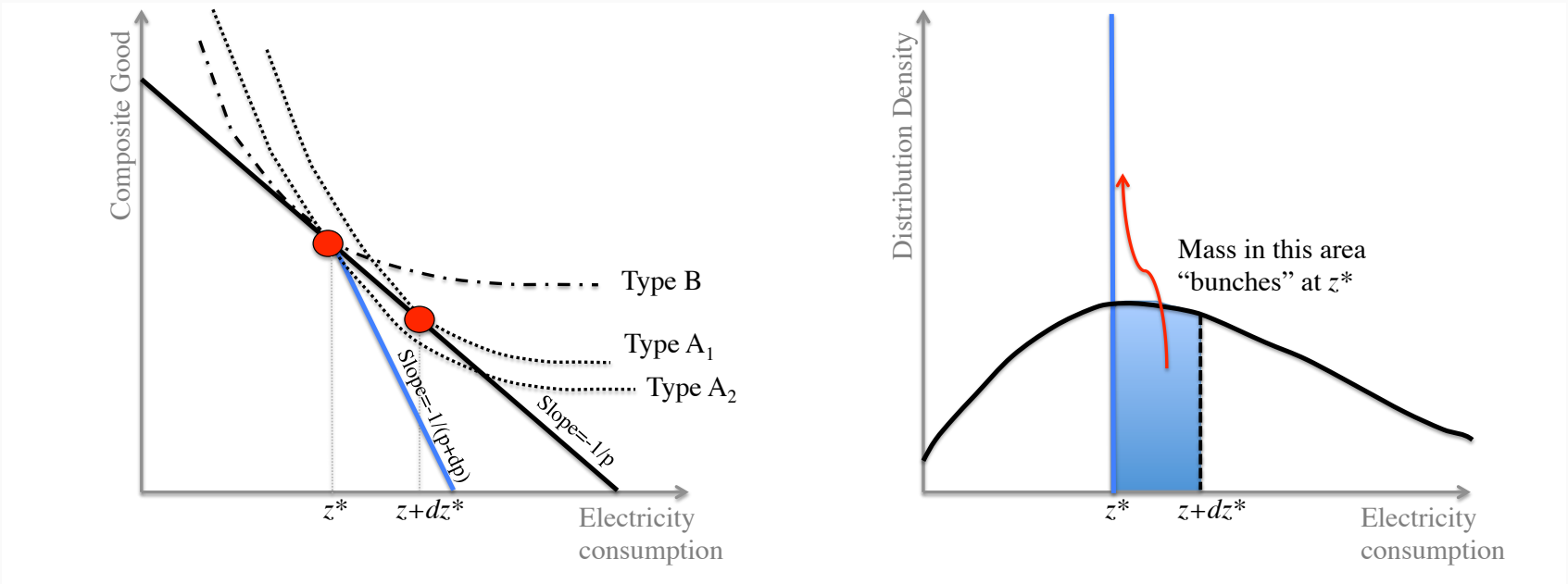
$$\frac{dz^*}{\boldsymbol{z^*}} = e\frac{\boldsymbol{dp}}{\boldsymbol{p}} \tag{2}$$

We know $\boldsymbol{dp}$, $\boldsymbol{p}$ and $\boldsymbol{z^*}$.
We need dz^*.

Bunching analysis gives us a way to do this!

Method 1 - Bunching

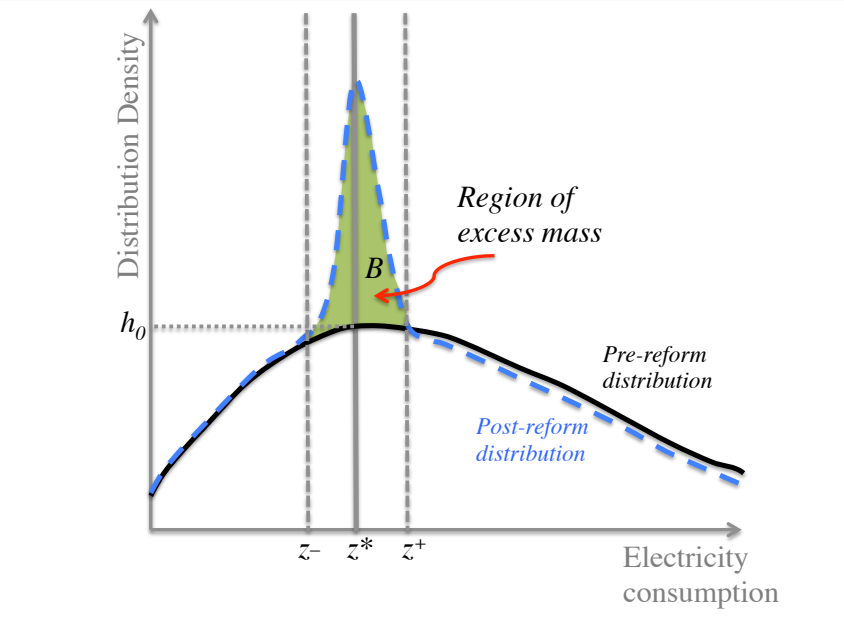
Figure 2: Bunching Theory



Adapted from Saez (2010)

Calculating the amount of bunching

Figure 3: Bunching Theory

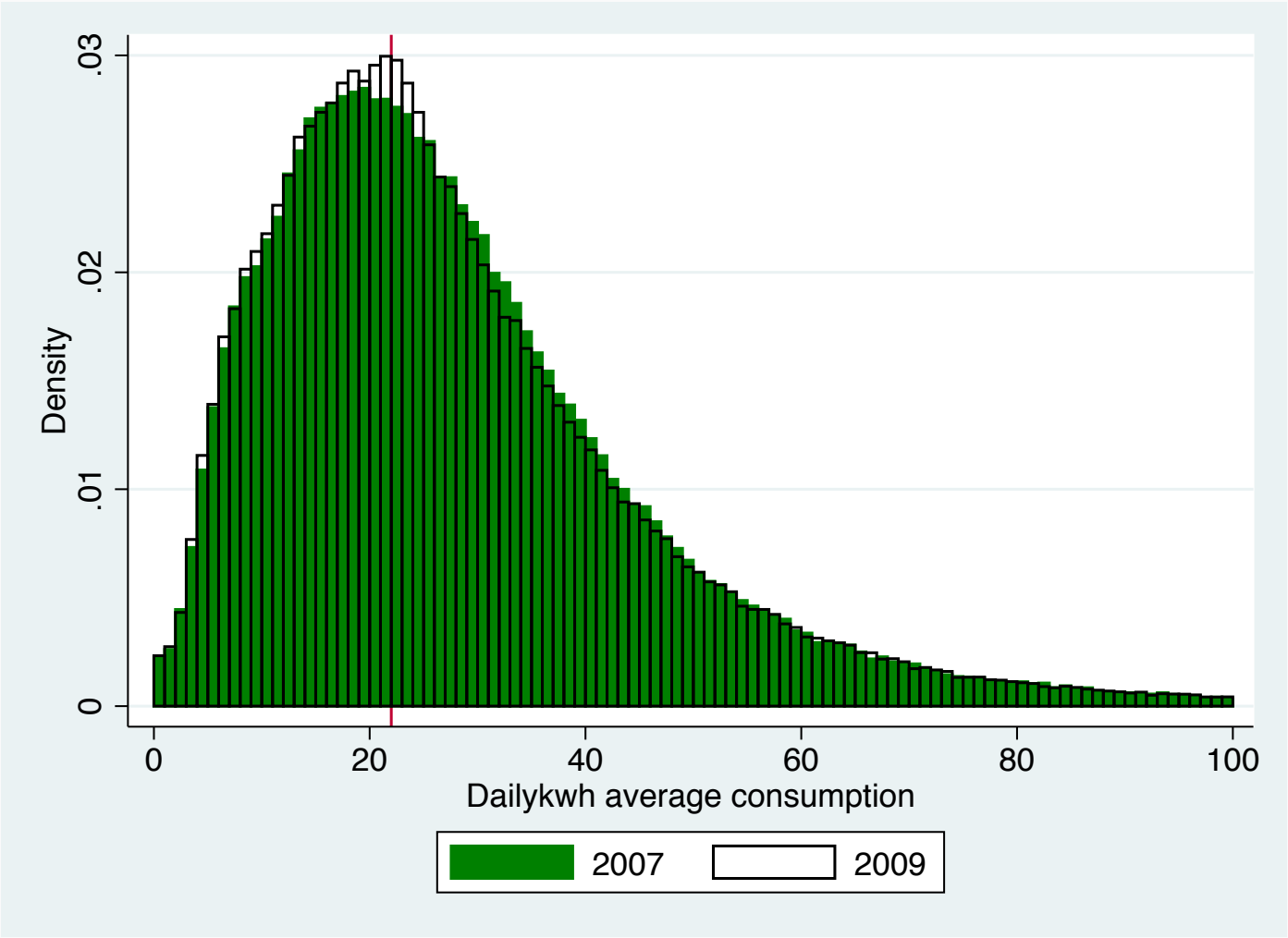


$$dz = \frac{B}{h_0} * binsize$$

Adapted from Saez (2010)

Evidence of bunching

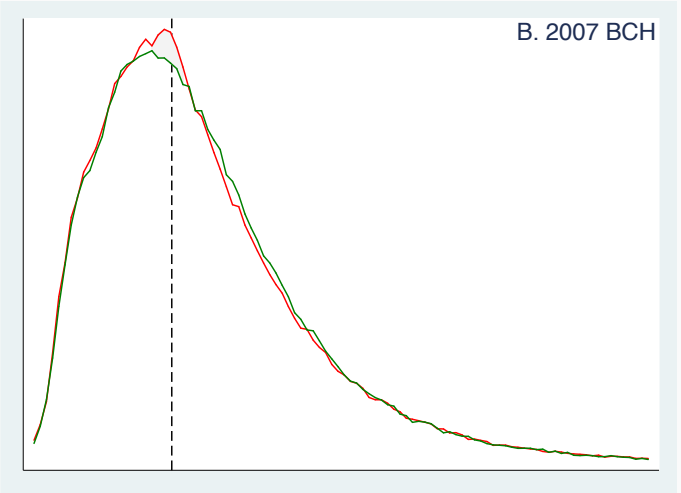
Figure 4: Distribution of BC Hydro consumption by household

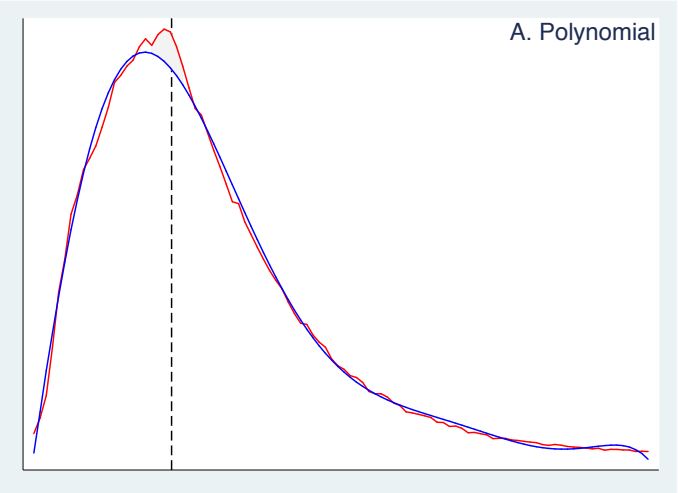


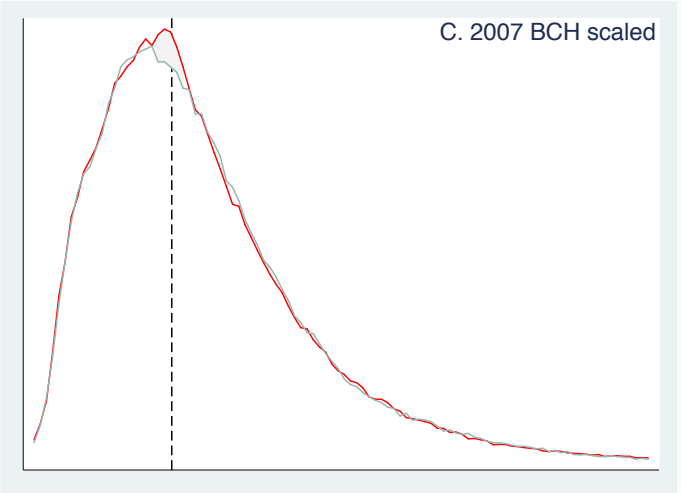
Counterfactuals

Three approaches:

- 2007 BCH
- 2007 Scaled by NW
- 2009 Polynomial







Bunching - Results

Table 1: Bunching estimates of price elasticity

(1) Polynomial	(2) 2007 BCH	(3) 2007 BCH scaled
-0.048	-0.041	-0.045
(0.010)	(0.012)	(0.017)

Bootstrapped standard errors in parentheses.

Key points:

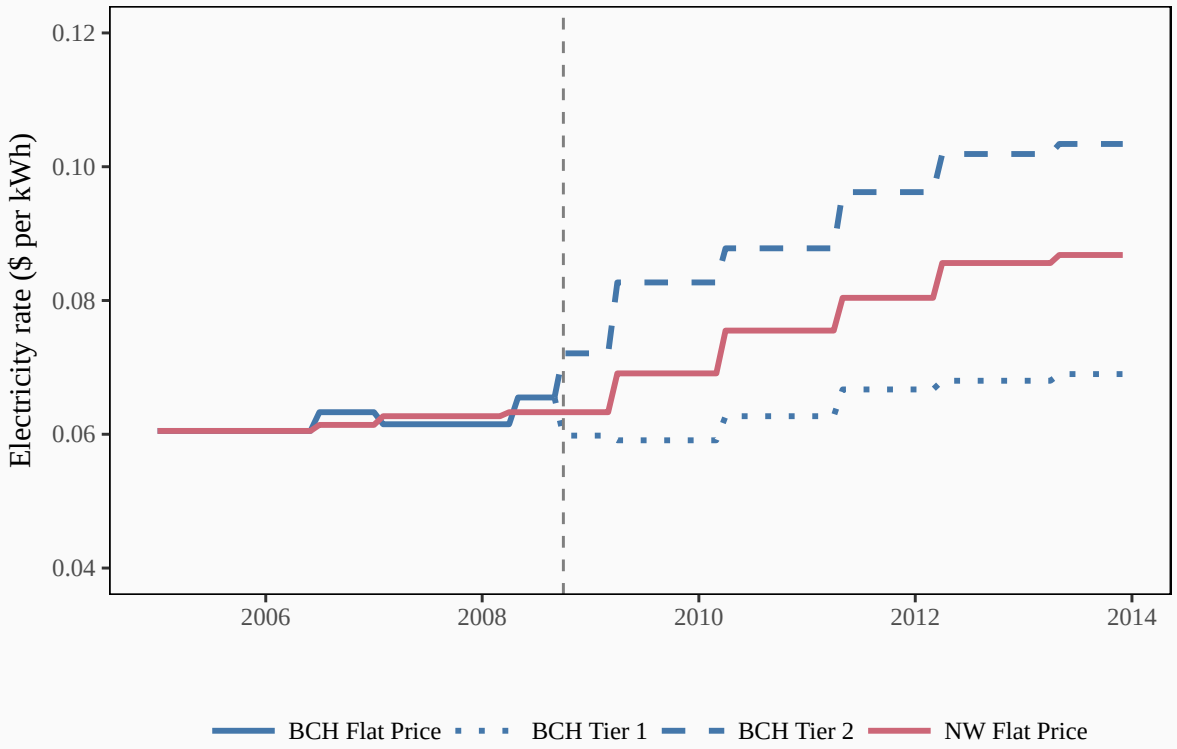
1. This is local to the area near the threshold
2. This is only **response to marginal cost**, not average cost
3. Ito (2014) found 0 elasticity by bunching

Scorecard!

Marginal cost response	✓
Average cost response	-

Method 2 - IV Panel Regression

Figure 5: BC Hydro and New Westminster electricity rates



IV Panel - Results

Table 2: Elasticity estimates using IV method

Dependent variable: $\Delta \ln dailykwh$

	(1)	(2)	(3)
$\Delta \ln MP$	-0.154	·	**-0.155**
	(0.008)	·	(0.011)
$\Delta \ln AP$	·	-0.157	**0.002**
	·	(0.010)	(0.014)

Key points:

1. **Response to average price rendered insignificant** once accounting for marginal price
2. Ito (2014) found the opposite

Scorecard!

Marginal cost response	✓✓
Average cost response	-

Method 3 - Conditional difference-in-differences

- Compare BCH vs NW, before and after the policy change (typical DD)
- But... compare **separately for each decile of usage** (conditional DD)

$$\ln x_{it} = \alpha[BCH_i] + \beta[Post2008_t] + \delta[Post2008_t] \times Decile_{id} + \gamma_d[BCH_i] \times [Post2008_t] \times Decile_{id} + \eta_i + \phi_t + \epsilon_{it}$$

Results

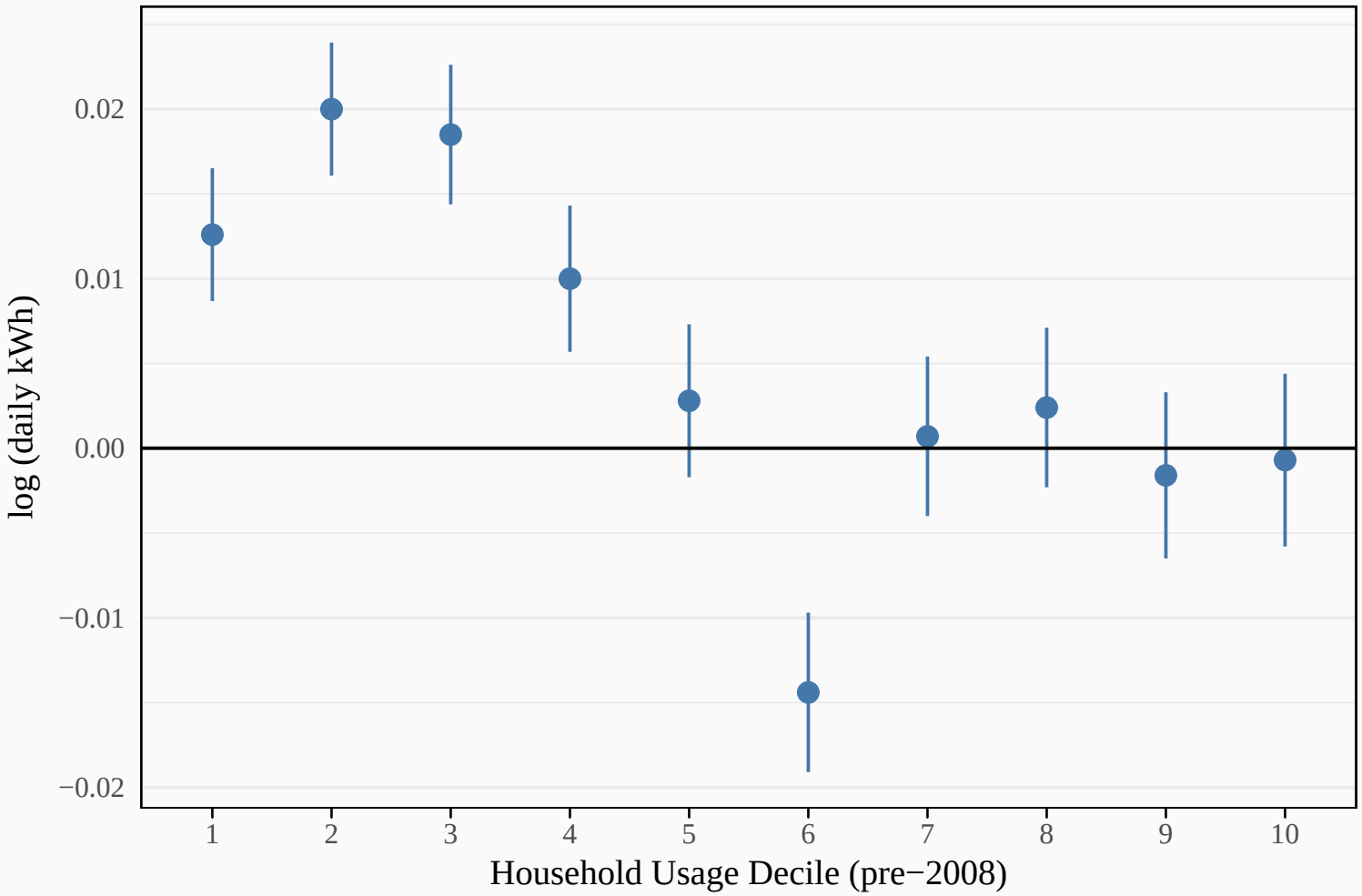


Figure 6: DD coefs

Comparing to price changes

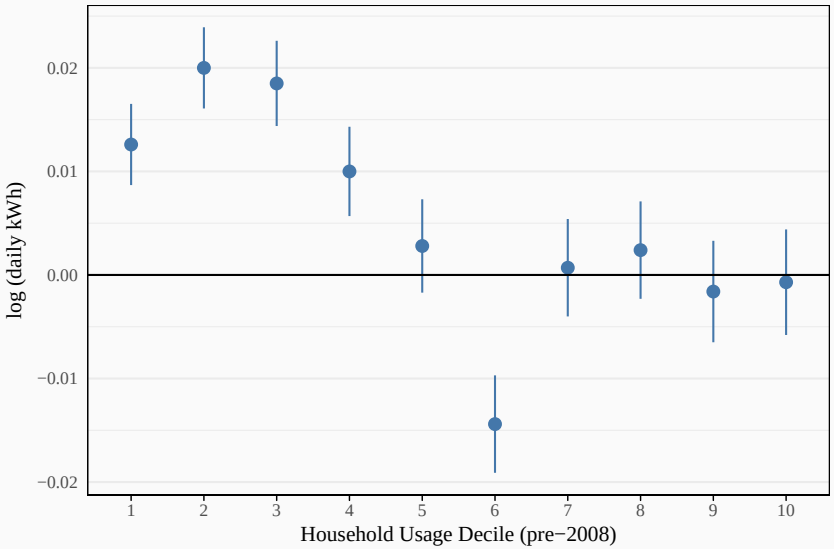


Figure 7: DD coefs

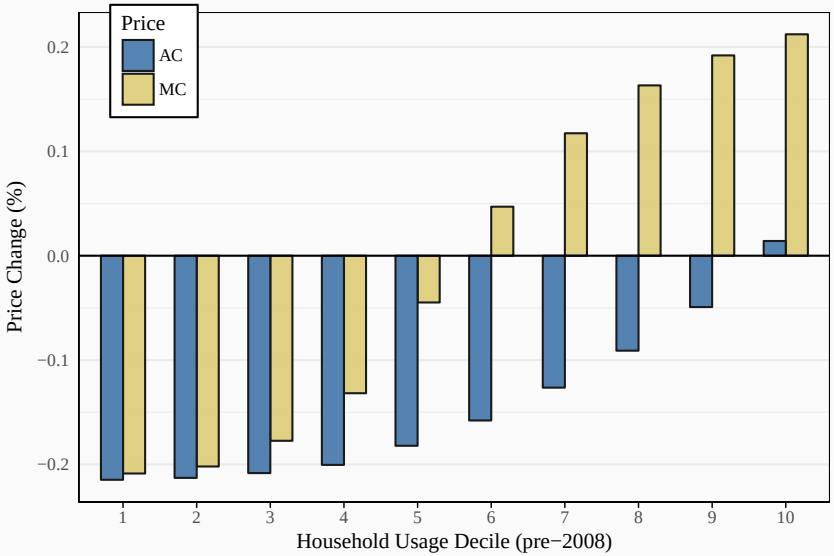


Figure 8: Δ Prices

▸ Elasticities

Scorecard!

Marginal cost response	✓✓
Average cost response	-
Something else??	✓

Conjecture

What if (at least some) consumers misperceive the tariff?

Part 2 - Simulating heterogeneous household types

Hypothesis

Three ”types” of households:

1. *Rational* — respond to MC
2. *Lazy* — respond to AC
3. *Confused* — respond to misperceived AC
    - *Misperception*: the price of electricity increases for *all* usage once the threshold is crossed, not just incremental units

Simulated Distributions

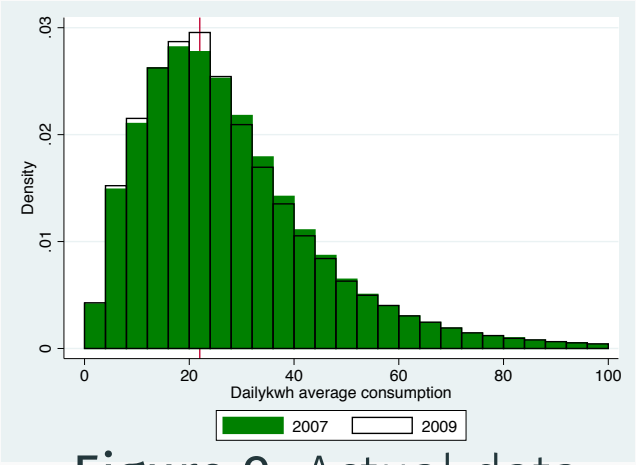


Figure 9: Actual data

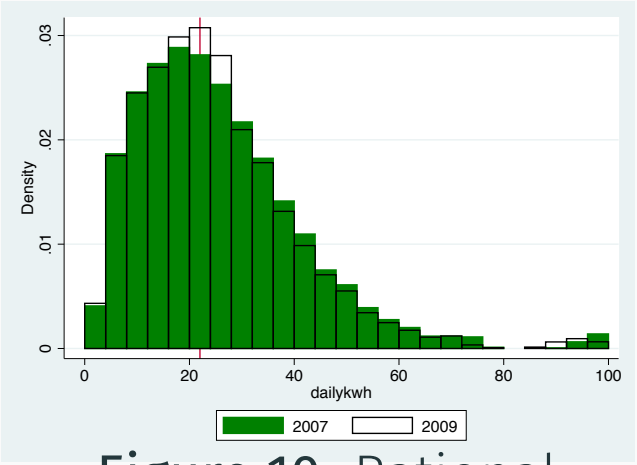


Figure 10: Rational

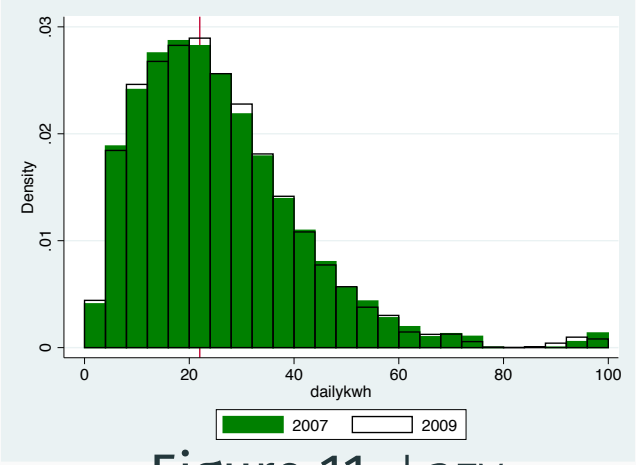


Figure 11: Lazy

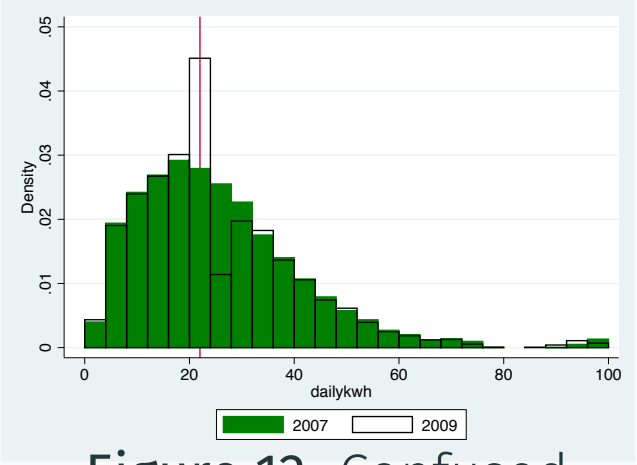


Figure 12: Confused

Simulated DD Results

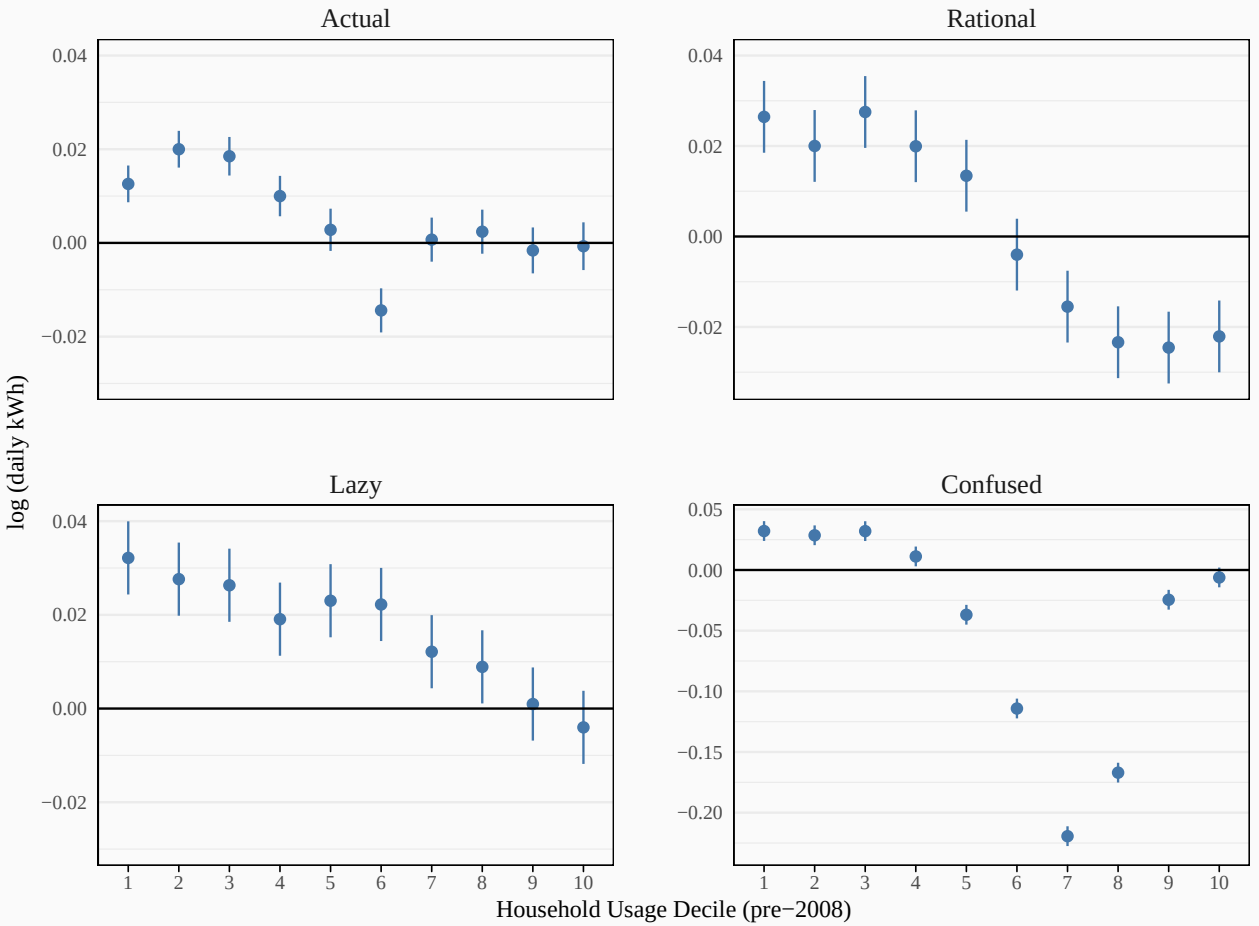


Figure 13: Simulated difference-in-difference coefficients

Part 3 - Use indirect inference to solve for mix of types

Simulated Mix

- Best fit: 85% *lazy*, 7% *rational* and 8% *confused*

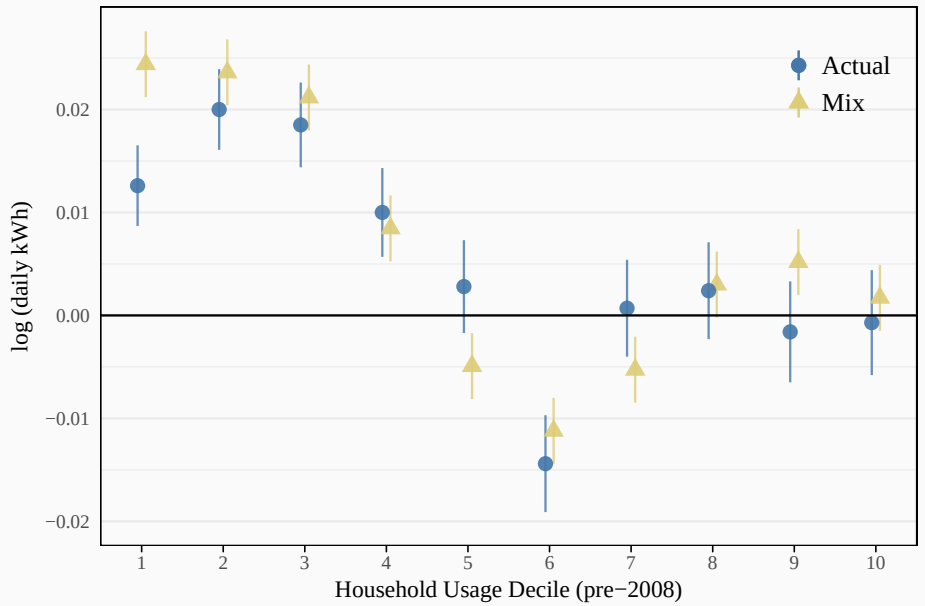


Figure 14: Simulated "mix" versus actual CATE coefficients

Conclusion

Summary of findings

- Households largely responding to **average cost**
- Small number of households likely **misperceiving** tariff
- The combination makes it *appear* there is **marginal cost** responsiveness to the nonlinear tariff

Implications

Policy implications

- In the short run, more conservation
- In the longer run, weak response
- Policy goal (conservation) better achieved by flat rate

Implications

Welfare implications

- Average DWL per household is roughly $5 per year, of ~1% of annual electricity expenditure
- For confused types, the average DWL is $58 per HH, or **~10% of expenditure**!

Implications

Methodological implications

- Simulated mix of largely AC types *appears* as MC responsiveness!
- Bunching and panel IV methods should be used with caution in the presence of heterogenous behaviour

Thank you!

blake.shaffer@ucalgary.ca


Gulf of Alaska
NORTHWEST TERRITORIES
Hudson Bay
NEWFOUNDLAND AND LABRADOR
Canada
BRITISH COLUMBIA
ALBERTA
MANITOBA
SASKATCHEWAN
QUEBEC
ONTARIO
PE
NB
NOVA SCOTIA
MAINE
Ottawa
VT
NH
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
NEW YORK
CT
RI
WISCONSIN
MICHIGAN
OREGON
SOUTH DAKOTA
PENN
Philadelphia
IDAHO
Chicago
MD
DE
WYOMING
OHIO
IOWA
ILLINOIS
WEST VIRGINIA
NEBRASKA
NEVADA
San Francisco
United States
UTAH
COLORADO
KANSAS
MISSOURI
KENTUCKY
NORTH CAROLINA
CALIFORNIA
TENNESSEE
SOUTH

Return

Encompassing test

Tests whether the effect of one variable (eg. marginal price) is rendered insignificant with the inclusion of another (eg. average price)

- Davidson & MacKinnon, 1993

$$\Delta \ln x_{it} = \beta_1 \Delta \ln MP_{it} + \beta_2 \Delta \ln AP_{it} + \sum_{q=1}^{100} D_{qit} + \gamma_c + \epsilon_{it} \quad (3)$$

Monthly panel regression

$$\Delta \ln x_{it} = \beta_1 \Delta \ln MP_{it} + \beta_2 \Delta \ln AP_{it} + \sum_{q=1}^{100} D_{qit} + \gamma_c + \epsilon_{it} \quad (4)$$

- *Simulated instruments as IV* for MP_{it} and AP_{it}
- Dummies for consumption percentiles (D_{qit})
- Time-invariant region fixed effects (γ_c)

Simulated instrument

To resolve the endogeneity problem (higher Q $\Rightarrow$ higher P), I use an instrumental variable common to the public finance literature, a simulated instrument (Murray, 2005).

Specifically, **I take a prior period household consumption level and project it onto current tariffs as if their consumption level did not change**.

In doing so, the simulated instrument captures only the change in prices due to a change in tariff rates, not due to any change in behaviour.

◂ Return

Elasticities

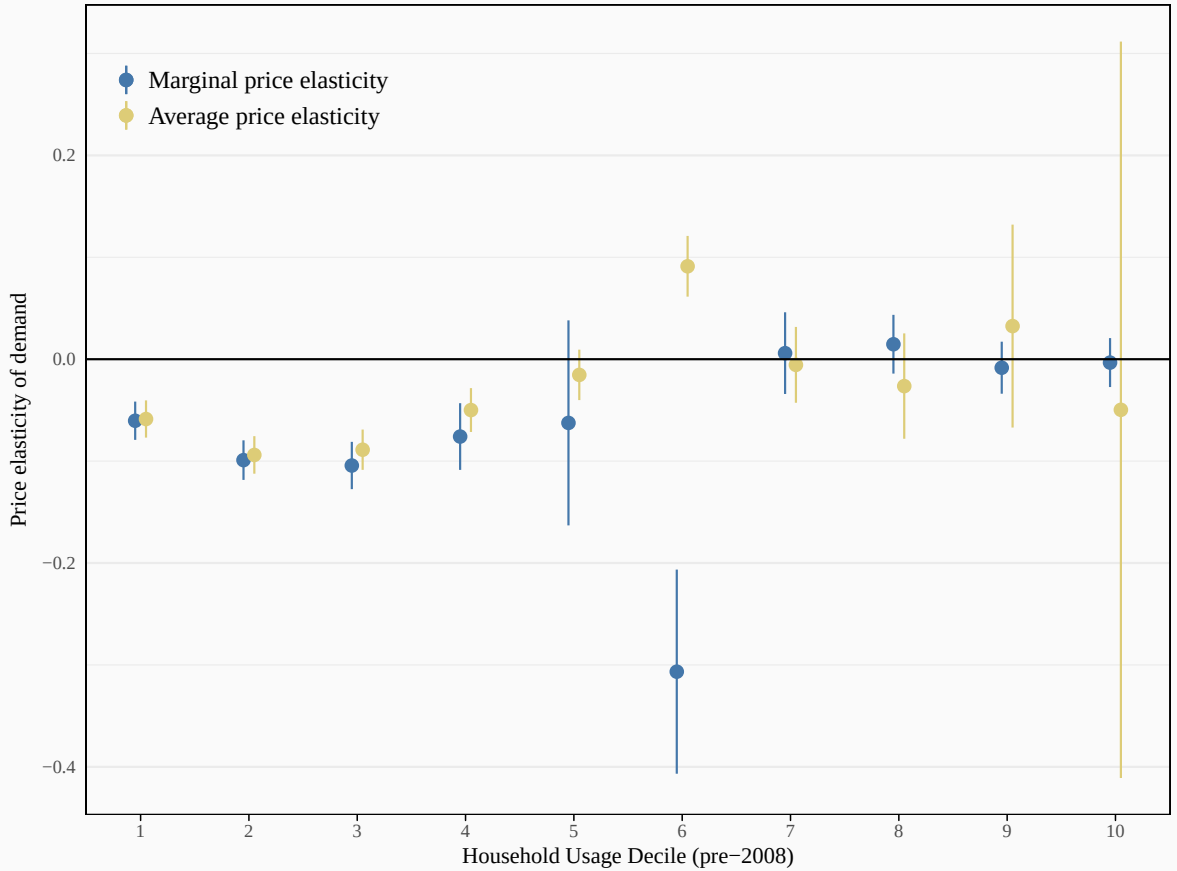


Figure 15: Price elasticity of demand

◂ Return

What is indirect inference?

Indirect inference is a variant of the generalized method of moments (GMM), useful when nonlinear models make estimation by more efficient methods, such as maximum likelihood, intractable.

- Gourieroux et al., 1993

Implementing indirect inference

Use indirect inference to find optimal mix of ”types” that best rationalizes the data:

$$\min_{\theta}[\gamma(\theta) - \gamma_R]' W [\gamma(\theta) - \gamma_R] \tag{5}$$

where:

θ	structural parameters of interest (types, elasticity)
$\gamma(\theta)$	10×1 vector of estimates from simulated data
γ_R	10×1 vector of estimates from actual data
W	weighting matrix

◂ Return

Misperception fading over time?

Table 3: Bunching estimates of price elasticity by year

2009	-0.048
2010	-0.035
2011	-0.033
2012	-0.032
2013	-0.020