# (Mis)understanding prices: How consumers respond to nonlinear electricity tariffs

Presented by: Blake Shaffer, University of Calgary

June 6, 2017

# Motivation

Policies are set based on expectations of behaviour.

... but what if our expectations are wrong?

# What is the Research Question?

How do consumers respond to nonlinear tariffs?

# What is the Research Question?

**How do consumers respond to nonlinear tariffs?**

Do consumers ...

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

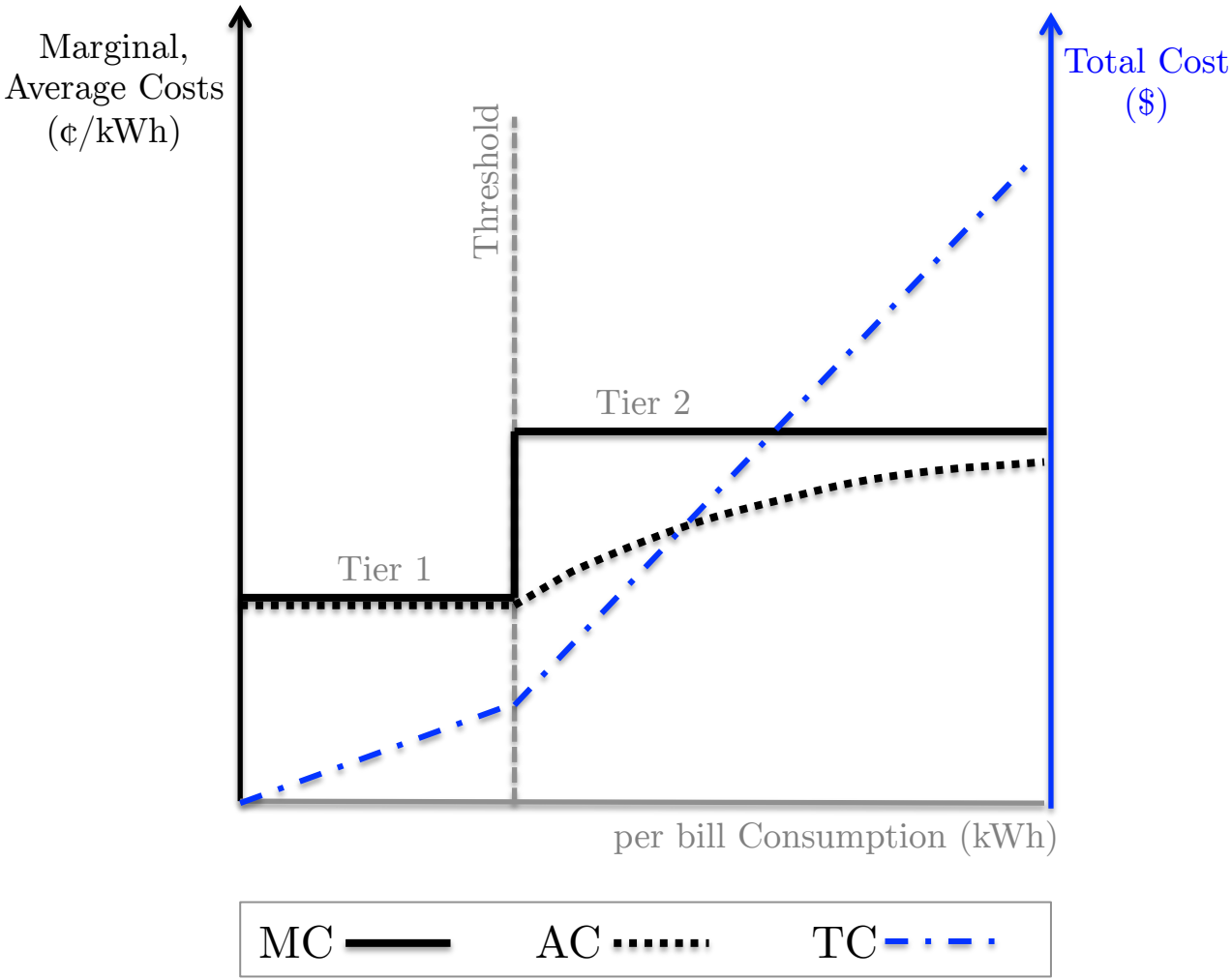
} Ito (2014, AER)

- ... misunderstand complex tariffs?

# What is a nonlinear tariff?

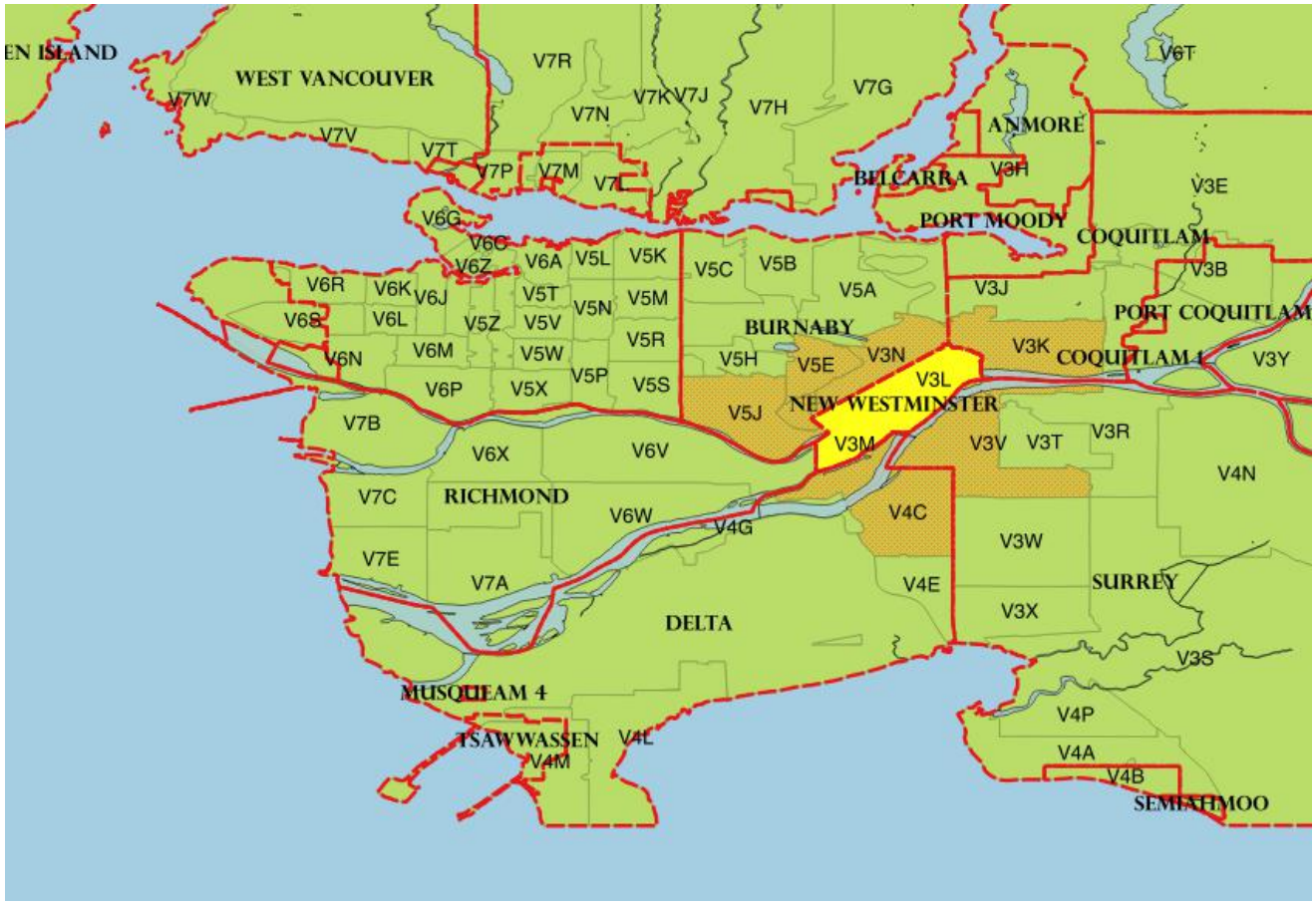
- Residential Increasing-Block Tariff

Figure: Costs under a RIB Tariff



# The Setting

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

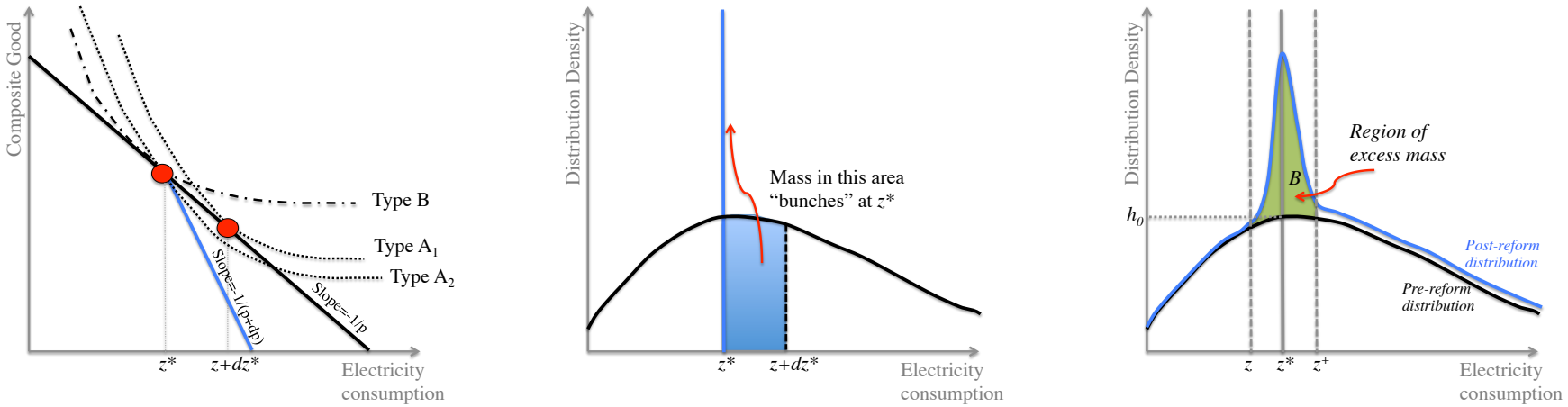


# Empirical Strategy

1. Reduced form analysis
   - Exploit natural experiment
   - 3 approaches (Bunching, IV, DD)
2. Simulation and method of indirect inference

# Method 1 - Bunching

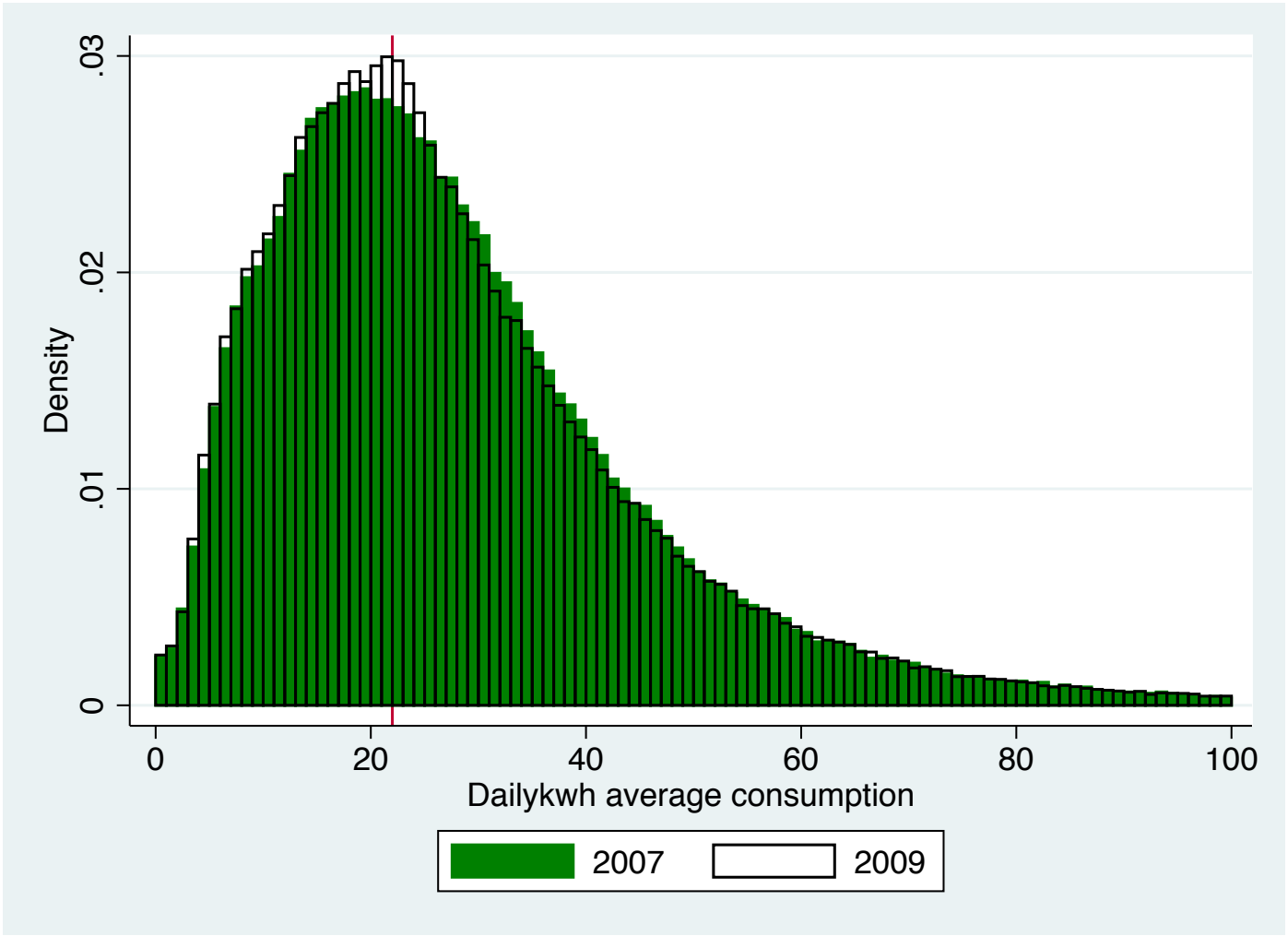
Figure: Bunching Theory




Adapted from Saez (2010)

# Bunching cont.

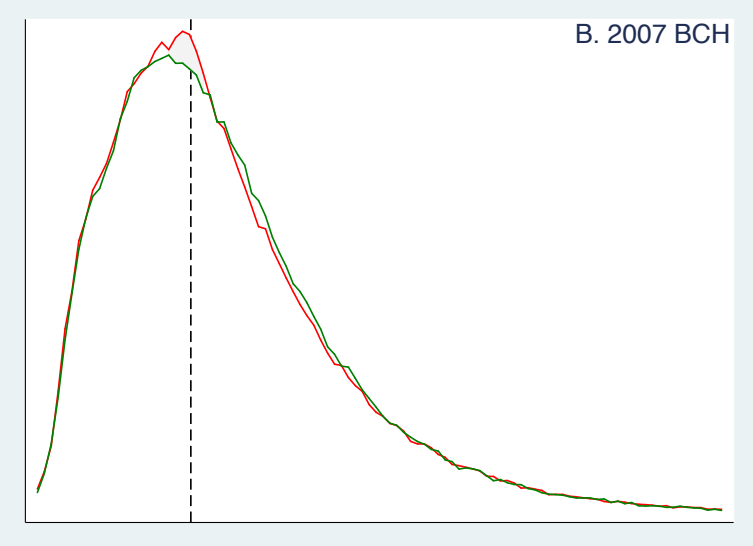
Figure: Distribution of BC Hydro consumption by household

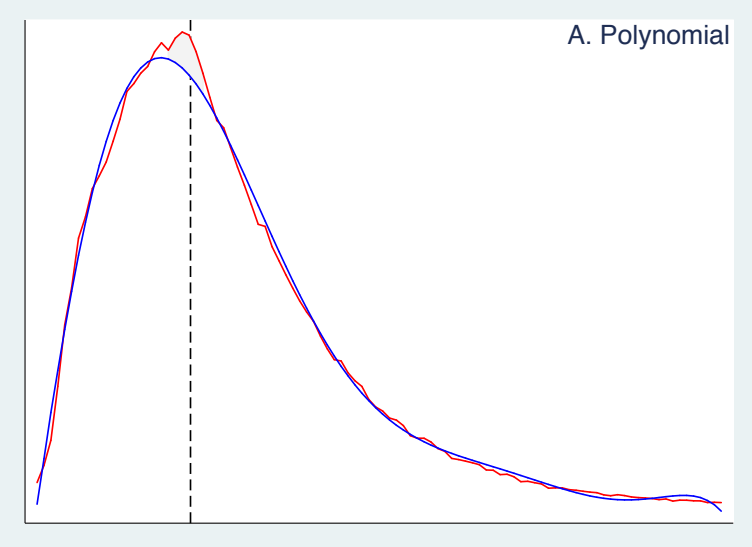


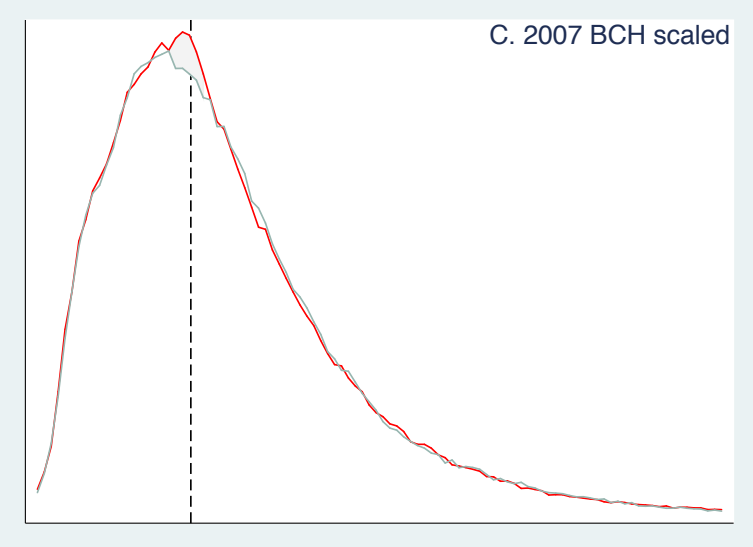
# Bunching cont.

Counterfactual methods:

- 2007 BCH
- 2007 Scaled by NW
- 2009 Polynomial



# Bunching - Results

Table: 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.

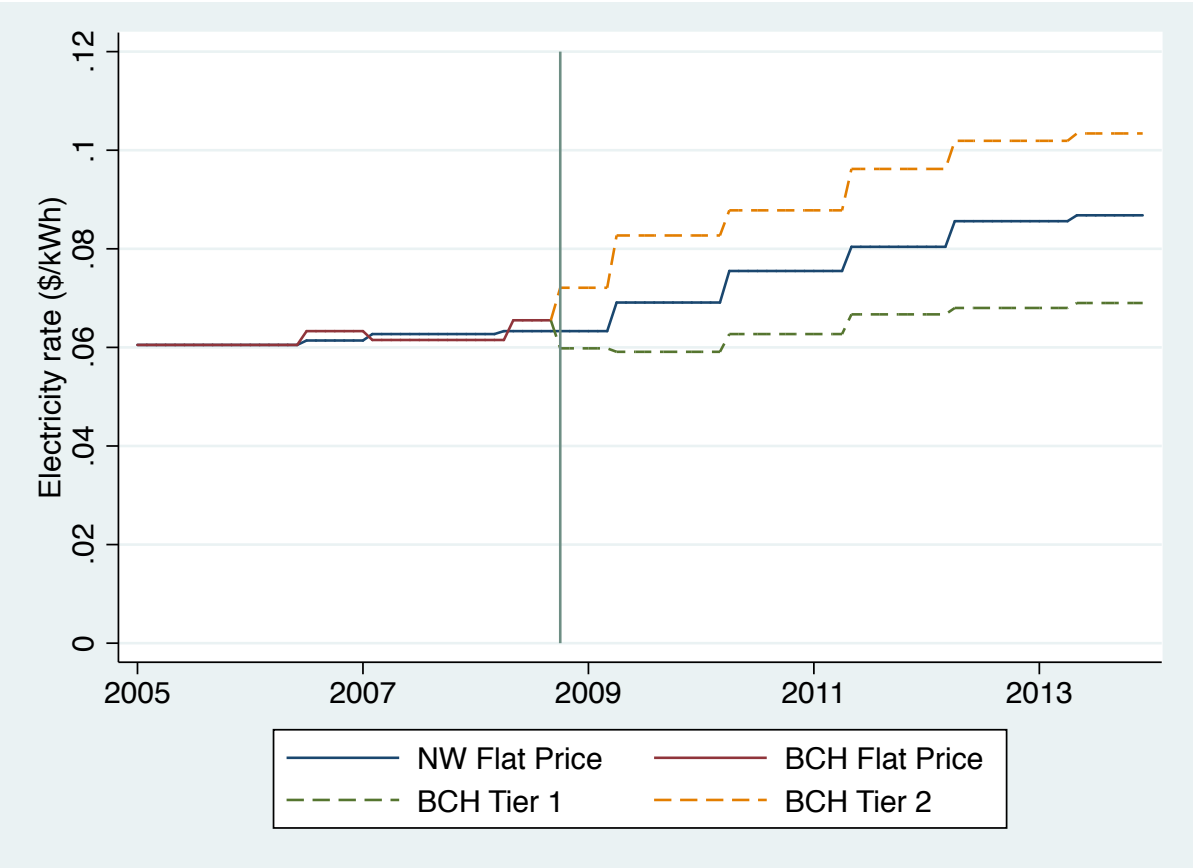
Key points:

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

# Method 2 - IV Panel Regression

- Monthly panel regression
- Exploits time and spatial variation in nonlinear tariffs
- Uses simulated instrument as IV

Figure: BC Hydro and New Westminster electricity rates



# IV Panel - Results

Table: Elasticity estimates using IV method

Dependent variable: $\Delta \ln dailykwh$

| | (1) | (2) | (3) ) |
|---|---|---|---|
| $\Delta \ln MP$ | -0.136 | · | -0.141 |
| | (0.007) | · | (0.010) |
| $\Delta \ln AP$ | · | -0.133 | 0.010 |
| | · | (0.009) | (0.013) |

Standard errors clustered at the household level are shown in parentheses.

Key points:

1. Estimated effect of AC insignificant once MC accounted for
2. Ito (2014) found the opposite

# Method 3 - Conditional Difference-in-differences

- Compare BCH vs NW, before and after the policy change
- But... common trend violation!
- Solution: Compare **separately for each decile of usage**

# Conditional Difference-in-differences Results

$$\ln x_{it} = \alpha I[BCH_i] + \beta I[Post2008_t] + \delta I[Post2008_t] \times Decile_{id} + \gamma_d I[BCH_i] \times I[Post2008_t] \times Decile_{id} + \eta_i + \phi_t + \epsilon_{it} \quad (1)$$

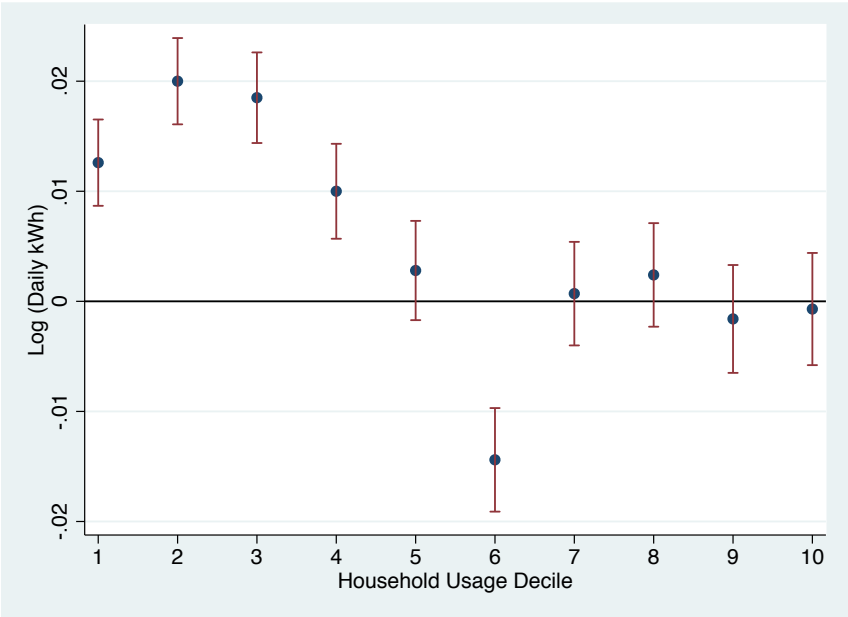



Figure: Demand

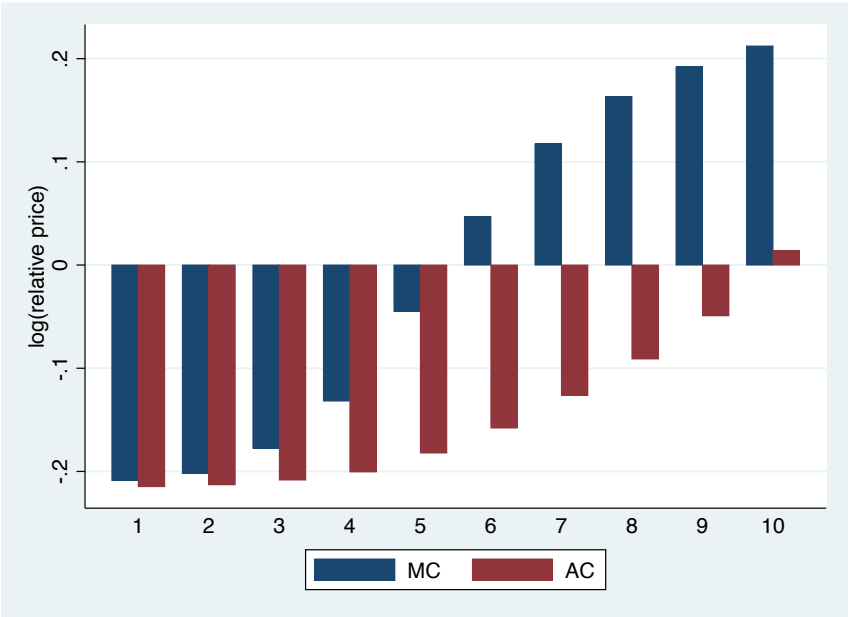



Figure: Prices

Key points:

1. DD coefficients not consistent with *either* MC nor AC

# Conjecture

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

# 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

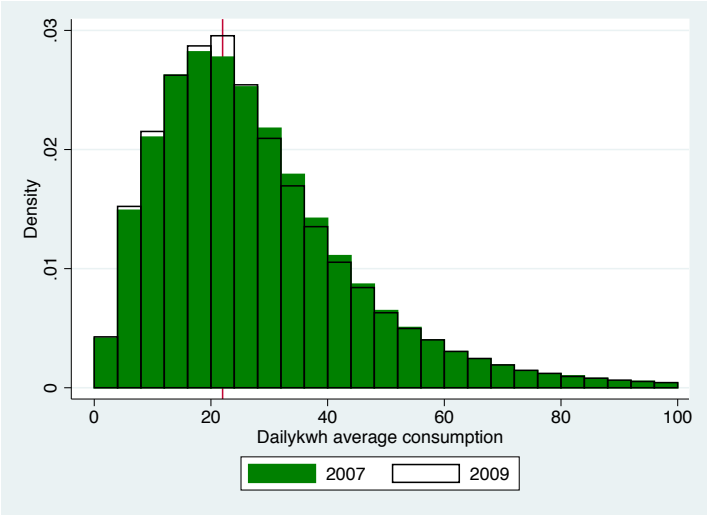



Figure: Actual data

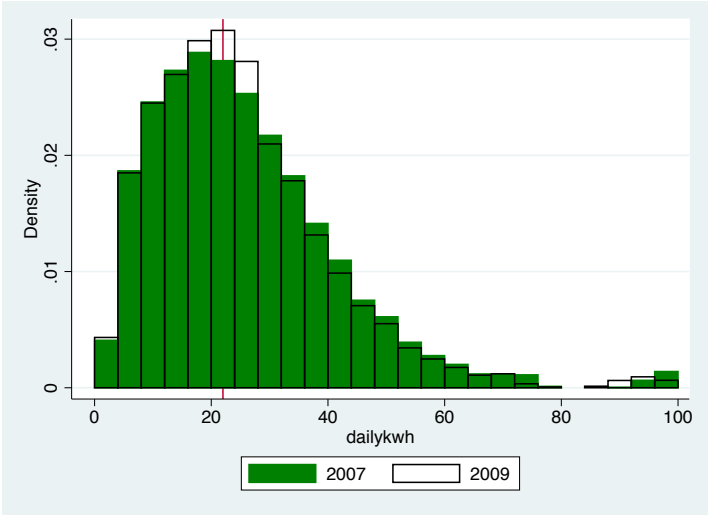



Figure: Rational

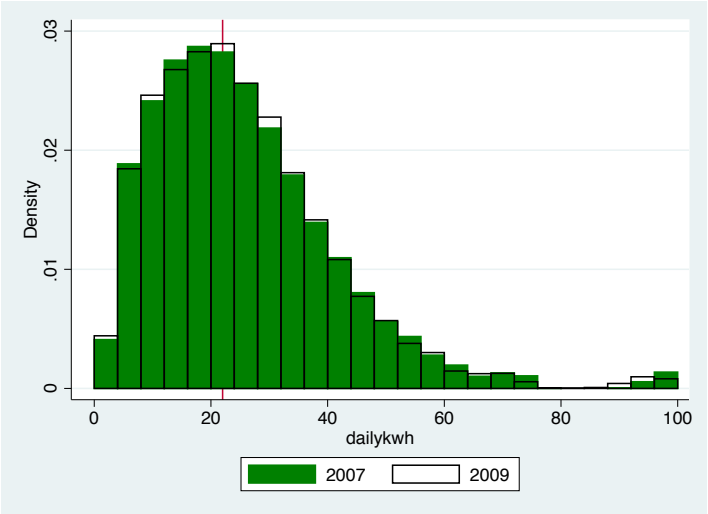



Figure: Lazy

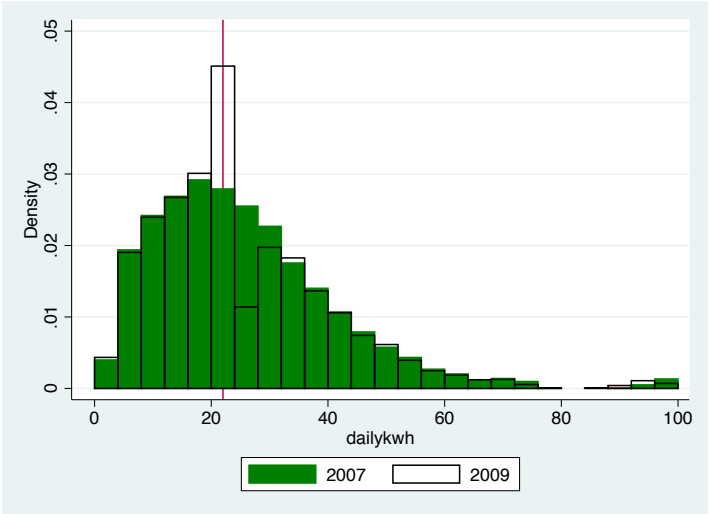



Figure: Confused

# Simulated DD Results

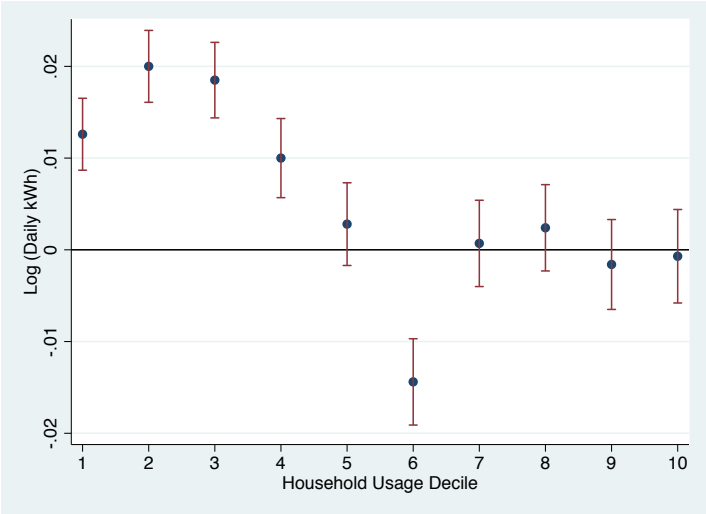



Figure: Actual data

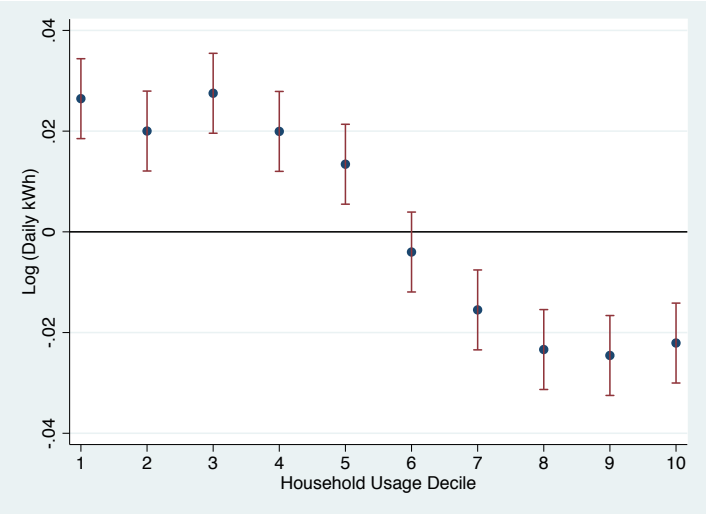



Figure: Rational

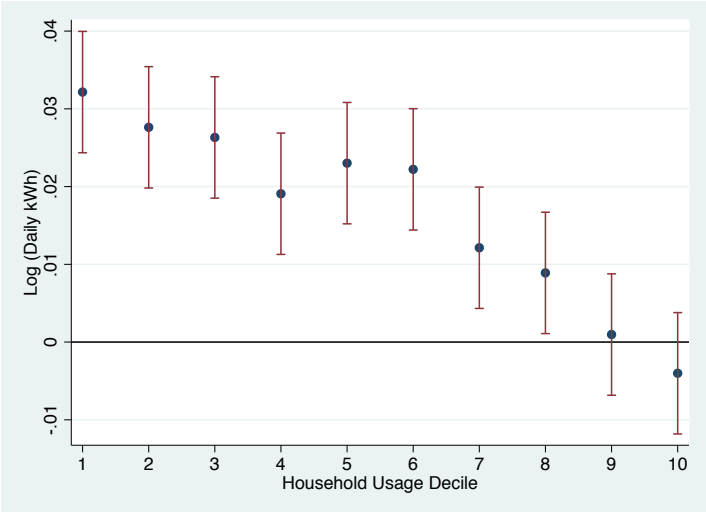



Figure: Lazy

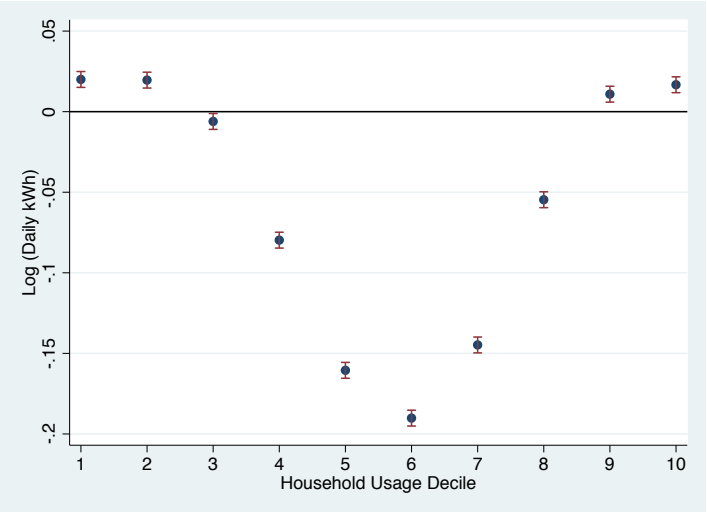



Figure: Confused

# Simulated Mix

- Use *indirect inference* to find optimal mix of "types" that best rationalizes the data
- Best fit: 85% *lazy*, 7% *rational*, 8% *confused*

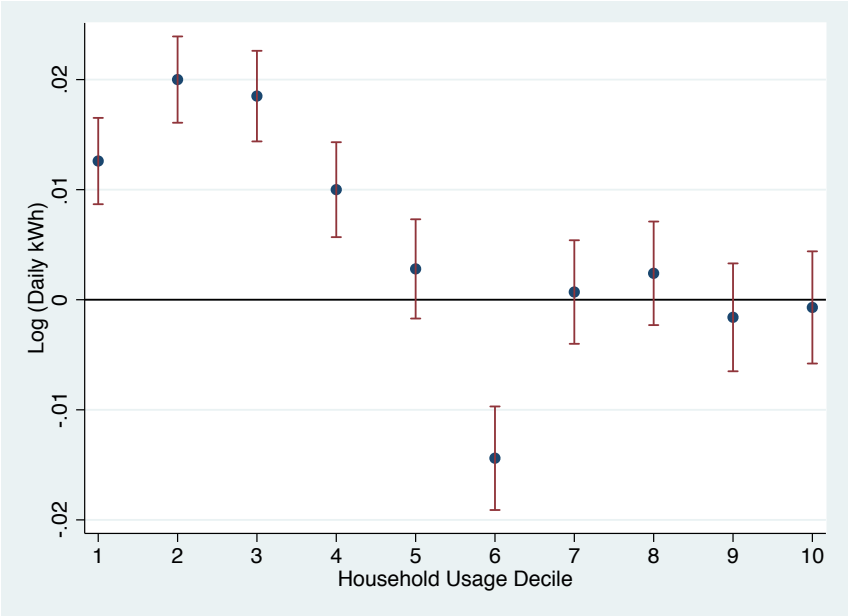



Figure: Actual data

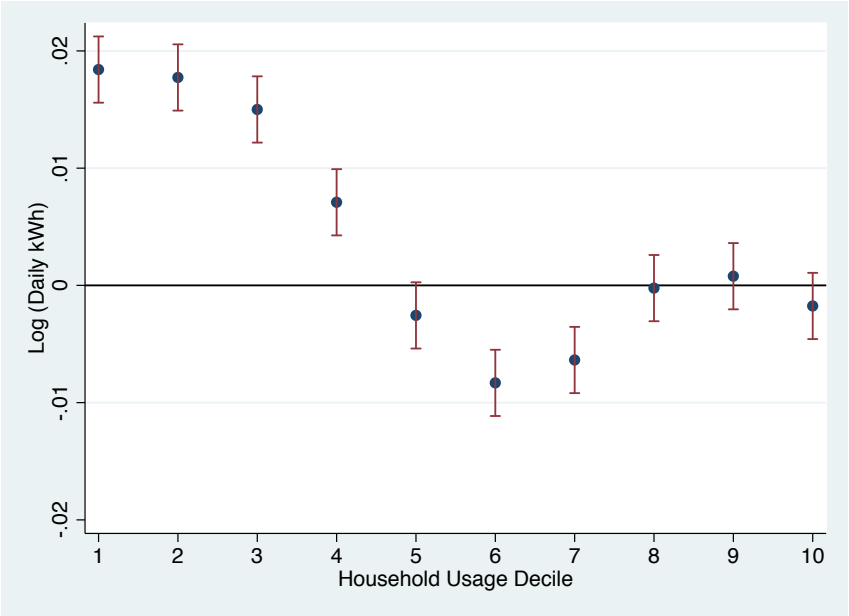
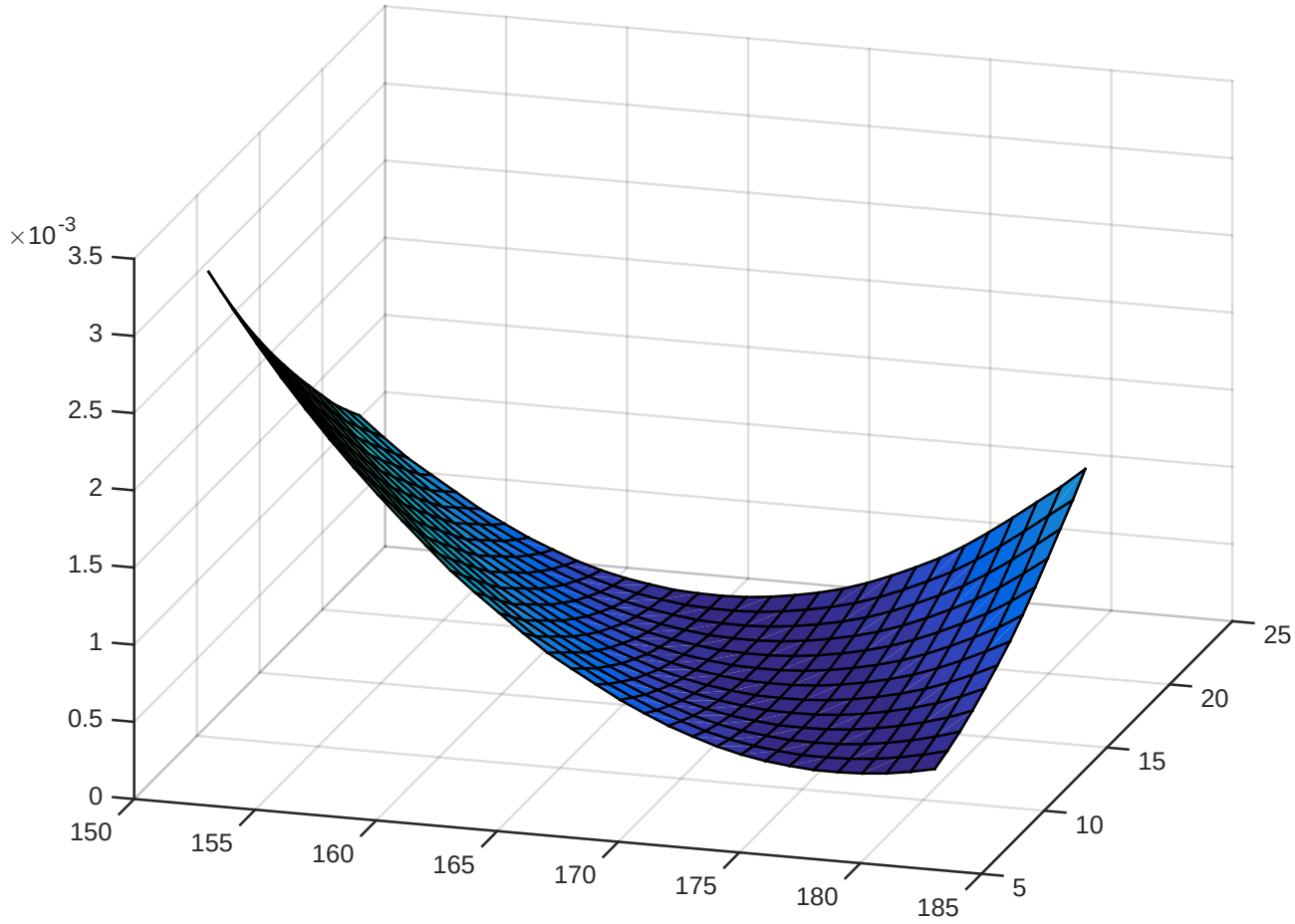



Figure: Simulated Mix

# Numerical simulation stability

- Minimum is identified; more precision around amount of *confused*



# Simulated Mix (Elasticity Estimates)

Bunching Estimates

| Counterfactual | Actual | Simulated Mix |
|---|---|---|
| Polynomial | -0.048 | -0.098 |
| | (0.007) | (0.032) |
| 2007 | -0.041 | -0.078 |
| | (0.007) | (0.020) |
| 2007 Scaled | -0.045 | -0.083 |
| | (0.007) | (0.021) |

Standard errors in parentheses, using bootstrap method.

IV Estimates

| | Actual | | | Simulated Mix | | |
|---|---|---|---|---|---|---|
| $\Delta \ln MP$ | -0.136 | · | -0.141 | -0.133 | · | -0.137 |
| | (0.007) | · | (0.010) | (0.008) | · | (0.011) |
| $\Delta \ln AP$ | · | -0.133 | 0.010 | · | -0.130 | 0.006 |
| | · | (0.009) | (0.013) | · | (0.010) | (0.014) |

Standard errors in parentheses, clustered at premise level.

# Conclusion

- 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

$\Rightarrow$ Misperception masking an otherwise weak response

# Contributions

1. Methodological:
   - Develop a **strategy to uncover misperception**
   - Highlight risk of **spurious conclusions** from standard empirical techniques

2. Policy:
   - **Quantify** the role of misperception in affecting outcomes
     - ★ In the short run, more conservation (due to misperception)
     - ★ In the longer run, weak average cost response
   - Suggest **alternative policy**
     - ★ Policy goals (conservation) better achieved by flat rate

Thank you! (Questions?)