How Do Consumers Respond to Water and Electricity Pricing?
Evidence from Recent Empirical Studies in Economics

Koichiro Ito
SIEPR Postdoctoral Fellow
Stanford University
koichiro.ito@stanford.edu

Assistant Professor, Boston University (from July 2013)
Two Common Assumptions in Demand Estimation and Forecasting

1) Consumers **fully understand** their price schedule

2) Economic theory tells us that consumers respond to **marginal price**

Example: Nonlinear Residential Water Pricing in Irvine Ranch Water District in CA
Potential Problems about the Two Assumptions
Consumers Are Not Well Informed about their Water or Electricity Prices
Consumers Are **Not** Well Informed about their Water or Electricity Prices

**Easy** to see what gas price you are paying
Consumers Are **Not** Well Informed about their Water or Electricity Prices

**Easy** to see what gas price you are paying

**Hard** to see what water price you are paying
Typical Utility Bills: Difficult to Understand

Example: An Electricity Bill in California

<table>
<thead>
<tr>
<th>Charges Type</th>
<th>Quantity</th>
<th>Rate</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delivery Related Charges:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basic Charge</td>
<td>31 days</td>
<td>$0.02900</td>
<td>$0.90</td>
</tr>
<tr>
<td>Energy Charge:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline-Winter</td>
<td>313 kWh</td>
<td>$0.06825</td>
<td>21.36</td>
</tr>
<tr>
<td>Over Baseline 1%-30%</td>
<td>94 kWh</td>
<td>$0.06777</td>
<td>6.37</td>
</tr>
<tr>
<td>Over Baseline 31%-100%</td>
<td>93 kWh</td>
<td>$0.06777</td>
<td>6.30</td>
</tr>
<tr>
<td>DWR Bond Charge</td>
<td>500 kWh</td>
<td>$0.00469</td>
<td>2.35</td>
</tr>
<tr>
<td><strong>Delivery Subtotal</strong></td>
<td></td>
<td></td>
<td><strong>$37.28</strong></td>
</tr>
<tr>
<td>Generation Related Charges:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DWR Generation:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline-Winter</td>
<td>92 kWh</td>
<td>$0.09490</td>
<td>8.73</td>
</tr>
<tr>
<td>Over Baseline 1%-30%</td>
<td>23 kWh</td>
<td>$0.09490</td>
<td>2.66</td>
</tr>
<tr>
<td>Over baseline 31%-100%</td>
<td>27 kWh</td>
<td>$0.09490</td>
<td>2.56</td>
</tr>
<tr>
<td>SCE Generation:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline-Winter</td>
<td>221 kWh</td>
<td>$0.02650</td>
<td>5.86</td>
</tr>
<tr>
<td>Over Baseline 1%-30%</td>
<td>66 kWh</td>
<td>$0.05373</td>
<td>3.55</td>
</tr>
<tr>
<td>Over baseline 31%-100%</td>
<td>66 kWh</td>
<td>$0.17318</td>
<td>11.43</td>
</tr>
<tr>
<td><strong>Generation Subtotal</strong></td>
<td></td>
<td></td>
<td><strong>$34.79</strong></td>
</tr>
</tbody>
</table>

Total: $ 74.34
**Typical Utility Bills: Difficult to Understand**

Example: A Water Bill in California

<table>
<thead>
<tr>
<th>Category</th>
<th>Usage</th>
<th>Rate</th>
<th>Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Volume</td>
<td>6</td>
<td>0.91</td>
<td>$5.46</td>
</tr>
<tr>
<td>Conservation Base</td>
<td>10</td>
<td>1.24</td>
<td>$12.40</td>
</tr>
<tr>
<td>Inefficient</td>
<td>0</td>
<td>2.76</td>
<td>$0.00</td>
</tr>
<tr>
<td>Excessive</td>
<td>0</td>
<td>4.70</td>
<td>$0.00</td>
</tr>
<tr>
<td>Wasteful</td>
<td>0</td>
<td>9.84</td>
<td>$0.00</td>
</tr>
<tr>
<td><strong>Total Usage Charge</strong></td>
<td></td>
<td></td>
<td><strong>$17.86</strong></td>
</tr>
<tr>
<td>Water Service Charge</td>
<td></td>
<td></td>
<td><strong>$9.30</strong></td>
</tr>
<tr>
<td>Sewer Service Charge</td>
<td></td>
<td></td>
<td><strong>$17.20</strong></td>
</tr>
</tbody>
</table>
Given this environment,
Do Consumers Respond to Correct Marginal Price?
I Examine How Consumers Actually Respond to Water and Electricity Prices

- Partnered with Water Utility (Irvine Ranch Water District) in CA
- Partnered with Electricity Utilities in CA
- Household-level monthly billing data for about 10 years
  - Electricity consumers: 40,749 households
  - Water consumers: 64,601 households
- Quasi-experimental research design
  - Use *policy changes* as natural experiments
  - Exploit *spatial discontinuities* to create “treatment” and “control” groups
In Orange County CA, Households in the Same City Have Different Power Companies

Edison (Southern California Edison) provides electricity for the north side

San Diego (San Diego Gas & Electric) provides electricity for the south side
They Experience Very Different Pricing

Households experience substantially different nonlinear pricing:

- **Edison** and **San Diego**: Cents per kWh in 2002

![Graph showing monthly consumption vs. average price for Edison and San Diego, with the formula: Average Price = Total Bill Payment / Total Usage.](image-url)
Similarly, Exploit Policy Changes in Irvine Ranch Water District (IRWD)

Figure 2: Service Areas of Irvine Ranch Water District (IRWD)

Notes: This figure shows service areas in Irvine Ranch Water District (IRWD). The District serves the City of Irvine and portions of the Cities of Costa Mesa, Lake Forest, Newport Beach, Tustin, Santa Ana, Orange and unincorporated Orange County. Santa Ana Heights service area was consolidated in 1997 and Lake Forest service area was consolidated in 2001. The original map is provided by IRWD.
Residential Water Pricing Changed from Flat Pricing to Nonlinear Pricing

Figure 3: Five-Tier Increasing Block Price Schedule in IRWD in August 2002

Notes: This figure shows the five-tier increasing block price schedule in IRWD in August 2002. IRWD allocates a "baseline allocation" to a customer, and the customer's marginal price depends on consumption relative to the baseline allocation. The marginal price equals the first tier rate up to 40% of the baseline, the second tier rate up to 100%, the third tier rate up to 150%, the fourth tier rate up to 200%, and the fifth tier rate over 200% of the baseline.

(1) Before Policy Change (Flat)

(2) After Policy Change (Nonlinear)
What Do I Find?
Findings: Both Water and Electricity Consumers Respond to Average Price (not Marginal Price)

Introduction

Research Design

Estimation

Welfare

Conclusion

Research question: How do consumers respond to nonlinear price schedules?

Standard economic theory predicts:
Consumers respond to Marginal Price

Laboratory experiments find:
Many individuals respond to Average Price

\[ \text{Average Price} = \frac{\text{Total payment}}{\text{Quantity}} \]

Demand Curve

Marginal Price (cents per kWh)

Monthly Consumption

Standard theory and laboratory evidence provide different predictions
Why Do We Care about the Findings?

1) Responding average price weaken the incentive for conservation

2) Forecasts based on marginal price might be biased
So, What Can We Do?
The Key is:
Providing Better Price Information
In My Other Research, I Provide “In-home display” for Electricity Consumers

Figure 2: Information on In-Home Display

Notes: This figure shows an example screenshot of the in-home display that are installed for both control and treatment consumers in the experiment.
Using the “In-home display”, Consumers Can See Real-Time Information about Price and Usage

Note: This figure shows the price schedule of the variable critical peak pricing in the experiment. The marginal price of electricity is 15 yen for every hour in non-event days. When a CPP event day is announced, consumers are informed about their critical peak price one-day ahead, which is either 50, 75, 100, or 150 yen.
Randomized Field Experiment

Households

Random Assignment

Treatment Group

Control Group
When Consumers Have Clear Price Information, They DO Respond to their Price Incentives Correctly

Dynamic Pricing Group (Orange) and Control Group (Green)
Similar Findings from Other Studies: Providing Better Information is the Key

- Teaching Income Tax Code:
  - Chetty and Saez (2013)

- Other Evidence from Electricity Pricing
Summary: What Can We Learn from Recent Economic Studies?

1) Not-clear price information --> Consumers don’t get right price signals
   - Evidence: both water and electricity consumers respond to average price
   - Wrong price signals --> weaken incentives for conservation

2) Providing better price information is the key
   - Evidence from electricity pricing and income taxation
   - Consumers respond to price signals correctly when they receive clear info

3) Discussion
   - How can we improve the clarity of water price information for consumers?
Thank you for your attention

Koichiro Ito
SIEPR Postdoctoral Fellow
Stanford University
koichiro.ito@stanford.edu