Behavioral Economics and the Demand for Water

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• Economics

• Implications for water managers
Origins of new thinking in economics

- Economic models of demand for differentiated commodities (Lancaster model).
- Behavioral economics
- Field experiments

Differentiated commodities change the framing of demand modeling in economics.

- Standard view:
  - A global optimization of everything at one point in time. Everything chosen afresh in one choice.

- New view:
  - Tens of thousands of differentiated commodities characterized by their attributes as well as their price.
  - Choices among subsets of items dispersed through time.
For modeling/theorizing

• Given the numerosity of goods, not credible that all goods are chosen in one swoop.
• Given the numerosity of potential attributes, not credible that all potential attributes are considered at the same time.
• Perception of attributes matters as opposed to “objective” measure of attributes.
• What is an attribute? These, too, are attributes:
  — Not overpaying
  — Not buying a sneaker made in sweatshop in Asia
  — Being ethical in my purchases
• Relative not absolute preferences.
  — Based on norms, expectations
• Hence, behavior (choice) is context-dependent.

Framing a choice

• What is this choice about?
  — Choice of levels or of differences
    • Should I keep doing the same thing or make a change?
• What are the alternatives I should consider?
  — Consideration set
    • What items I am familiar with?
• What are their relevant attributes?
  — Which attributes are relevant to this choice? Which are salient to me?
• How much do they cost?
• What constraints do I have?
What leads to changes in behavior?

• Inducing a person to reconsider status quo and consider making a change.
• Modifying the set of alternatives considered.
  • Highlighting choice alternative
  • Ruling out choice alternatives (efficiency standards)
• Modifying the set of attributes considered.
  • Invoking norms, social comparisons
  • Salience switches attributes (including price) on or off.
  • Highlighting attributes (attempting to raise their salience/visibility)
• Modifying the perception of attributes.
  • You thought this was risky. I convinced you it is not risky.
• Changing the price paid.
  • Fixed cost vs operating costs. PACE financing of solar energy.
  • Efficiency Vermont as a role model for water? One-stop shop makes it easy for users to change.

Not your father’s demand function

• This leads to a different – and richer – view of what managers can do to influence water use.
• Your father’s demand curve
  • \( x = f(p_w, p_o, y) \)
• Things wrong with this:
  – Not plausible that income per se influences demand except on secular time scales. Characteristics of the housing stock are the relevant variables.
  – Salience/visibility of price change has no role.
  – Implies a continuous response to price change. Perhaps the response is discontinuous; requires a different model.
  – Price is a blunt instrument. The fact is that almost no water user has any idea of how much water he is using.
    • Econometric evidence that marginal price has no influence.
  – We have little idea of what exactly water users do when they reduce (or increase) their water use. No end use data. Can’t track changes in end uses/housing stock characteristics (discrete-choices).
Housing stock

- Residential water use is mediated by the housing stock (as with electricity).
  - Low-flow toilets, showers.
  - But bath tubs 25% larger. & more indoor fixtures.
- Home renovation
  - Need to model water use in new construction versus existing homes separately.
- Outdoor water use (the last frontier)
  - New development in interior, hotter areas
  - Larger new homes
  - Yards become larger or smaller?
  - Landscaping style greatly affects water use

Heterogeneity

- If you look at micro-data on water use (residential or otherwise), the striking feature is tremendous heterogeneity among users who otherwise appear to be identical in terms of observed characteristics.
- What might cause the heterogeneity?
  - Salience
  - Inattention
Irrigation water use (Kern County CA)

95% Probability Intervals for Water Application Rates for Various Crop-Irrigation Technology Combinations

<table>
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<tr>
<th>Crop</th>
<th>Flood</th>
<th>Sprinkler</th>
<th>Almonds</th>
<th>Alfalfa</th>
<th>Vegetables</th>
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<tr>
<td>Cotton</td>
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<td>2.7</td>
<td>2.3</td>
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<td>2.3</td>
</tr>
<tr>
<td></td>
<td>5.5</td>
<td>5.8</td>
<td>4.0</td>
<td>4.1</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Acrefeet per Acre

2.0 | 3.0 | 4.0 | 5.0 | 6.0

Average = 5.14 flushes/cap/day
Std. Deviation = 2.51 flushes/cap/day
Median = 4.79 flushes/cap/day

Figure 3.11 Baseline toilet flush frequency distribution, pre-retrofit study group
Significance of heterogeneity

• For statistical analysis.
  – Estimating the mean demand is unhelpful.
  – Need to model the shape of the distribution – especially the right tail (quantile regression, regression where semi-variance is a function of regressors).

• For water managers.
  – Goal of conservation program is to change the shape of the distribution (reduce the right tail)
  – This has implications for
    • Rate design
    • Revenue design
Rate design

• What is the objective
  – Raise revenue
  – Influence behavior

• Alternative principles for rate design
  – Group similar users in same rate block
  – Use rates to influence water use

In each case, these call for very different rate designs

LADWP’s block rate

• Keep blocks simple. Just two blocks, but the switch point is different for different homes based on (i) lot size and (ii) climate.
• Switch point chosen to satisfy criteria of (i) fairness and (ii) not being too divergent from your peers. Two criteria employed:
  • 125% of median use of all homes in that category
  • Estimate of indoor use plus reasonable outdoor use
• Expect that most households would be in lower block most months of the year.
  • Not intended to raise a large amount of revenue
• Block rates set aiming at revenue neutrality.
  • Upper block set at estimate of long run marginal cost with replacement water. Summer rate includes peak capacity charge.
  • Lower block set at a bit below average cost, to ensure revenue neutrality.
Results in LADWP

• Water use fell, especially in upper block
  – Specific comparison complicated by fact that rates were adopted in the midst of a drought that ended soon after they were adopted.
  – Similar, and cleaner, effect in Broadview Irrigation District
• Rate structure proved politically popular and has endured for almost 20 years.
• Note: rates included explicit provision for adjustment in drought years.
With block rates, there are two price elasticities of demand. Which is the more important?

\[ E(x_1) = E\left(\left| x_1 \right| \text{consumption falls in 1st block} \right) \cdot Pr\left(\text{consumption falls in 1st block}\right) + E\left(\left| x_2 \right| \text{consumption falls in 2nd block} \right) \cdot Pr\left(\text{consumption falls in 2nd block}\right) \]

What happens with a price increase in \( P_1 \)?
- It reduces the level of consumption by those in block 2
- It reduces the probability of being in block 2

In other words, a price change affects:
- Consumption within the given block (the continuous choice)
- Switching between blocks (the discrete choice)

Therefore there are price elasticities for both components of consumer response. There is some empirical evidence that suggests that the second elasticity is often numerically more important than the first.

**Implication**

- We need to think differently about modeling demand.
- Instead of a demand function, we need to think of a series of conditional demand functions.
- Discrete choices – switching between one conditional demand and another – may turn out to be more important than continuous choices (variation of use governed by the same conditional demand function).
- Kerry Smith’s work has identified the differences among conditional demands. What we don’t understand – and need to know – is how to model the switching between conditional demands.
Revenue design

• The distinctive feature of water is that cost structure is dominated by fixed costs (much more so than any other public utility).
• This needs to be reflected in rate design.
• Historically water was financed by fixed charges (connection fee, service fee based on building characteristics or as % of property tax).
• The rationale for volumetric charge is to provide incentive to reduce water use. That is still a valid consideration.
• But the fixed charge component could be increased, and made dependent on fixed features that affect water use (swimming pool, landscaping, irrigation system).