Do Increasing Block Rate Water Budgets Reduce Residential Water Demand?

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Background: EMWD rate change

Eastern switched from uniform rates to increasing block budget-based rates in April 2009:

- *Indoor water use*: \( w_1 = (HHS \times PPA) \times DF + IV \)
- *Outdoor water use*: \( w_2 = (ET \times CF \times IA + OV) \times DF \)
- *Excessive water use*: \( w_3 = \frac{1}{2} (w_1 + w_2) \)
- *Wasteful water use*: in excess of \( w_3 \)

Goal was to promote conservation while maintaining fiscal neutrality

➔ *How much did this rate change affect consumption?*
Data: sources and types

• 12,065 residential accounts (~9% of total) with good spatial coverage
• Continuous records from January 2003 – April 2014
• From EMWD:
  • Pricing, usage, household size, irrigated area, conservation requests, microclimate zone, latitude/longitude
• From other sources:
  • ET: EMWD/Hydropoint, CIMIS
Data: spatial distribution of sample households

Sample accounts
All water service connections

Image credit: Kristian Barrett, EMWD
## Data: Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
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</thead>
<tbody>
<tr>
<td>ET (in/month)</td>
<td>4.67</td>
<td>4.87</td>
<td>4.59</td>
<td>4.73</td>
<td>4.87</td>
<td>4.81</td>
<td>4.70</td>
<td>4.55</td>
<td>4.85</td>
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<tr>
<td>Nominal price ($/CCF)</td>
<td>1.43</td>
<td>1.46</td>
<td>1.53</td>
<td>1.62</td>
<td>1.69</td>
<td>1.85</td>
<td>1.93</td>
<td>2.10</td>
<td>2.05</td>
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<tr>
<td></td>
<td>1.27</td>
<td>2.33</td>
<td>4.17</td>
<td>7.63</td>
<td>2.10</td>
<td>1.43</td>
<td>2.61</td>
<td>4.68</td>
<td>8.56</td>
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<tr>
<td>Real price (2010$/CCF)</td>
<td>1.66</td>
<td>1.66</td>
<td>1.68</td>
<td>1.72</td>
<td>1.77</td>
<td>1.86</td>
<td>1.98</td>
<td>2.10</td>
<td>1.98</td>
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<tr>
<td></td>
<td>1.30</td>
<td>2.37</td>
<td>4.25</td>
<td>7.78</td>
<td>2.10</td>
<td>1.43</td>
<td>2.61</td>
<td>4.68</td>
<td>8.56</td>
</tr>
<tr>
<td>Real Income (2010$/month)</td>
<td>316.26</td>
<td>317.45</td>
<td>318.05</td>
<td>319.20</td>
<td>320.78</td>
<td>316.70</td>
<td>311.07</td>
<td>309.96</td>
<td>309.44</td>
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</table>
Estimation strategy

• Estimate a uniform rate demand model using data from January 2003 – December 2008

\[ \ln(w_{it}) = \delta z_{it} + \alpha f(p_{it}) + \gamma g(y_{it}) + \varepsilon_{it} \]

• Use the model to predict demand from April 2009 – April 2014 under equivalent uniform prices

• Difference between actual and predicted demand is the water budget-induced demand effect
Estimation results

- Good model fitness
- $R^2$ values: 0.3 to 0.4
- Intuitive and highly significant coefficients
- Price elasticity: -0.7 to -0.8
Demand effect emerges about 1 year after the rate change.

Observed vs. Predicted Demand
12-month moving average

Household CCF/month

Dec-03 Aug-04 Apr-05 Dec-05 Aug-06 Apr-07 Dec-07 Aug-08 Apr-09 Dec-09 Aug-10 Apr-11 Dec-11 Aug-12 Apr-13 Dec-13

- Observed
- Predicted under uniform rates
Some evidence the demand effect has stabilized around 10-15%

Demand reduction attributable to the rate change:
12-month moving average

- Full sample
The rate change has had a bigger effect on inefficient households

Full Sample: 2.2 → 1.9

Efficient Households: 1.7 → 1.6

Average Households: 2.2 → 1.9

Inefficient Households: 2.9 → 2.2
Efficiency improvements by inefficient households also have been the most resilient
Conclusions

• How much did the EMWD rate change affect consumption?
  • *Between July 2011 and April 2014 household usage was 10-15% lower than it would have been under equivalent uniform rates.*

• Real average prices rose ~3% under water budgets, but would have had to rise ~30% under uniform pricing to achieve the same demand effect.
  • *Significant conservation potential while also addressing equity concerns.*

• Conservation gains generally appear resilient to changing conditions that would otherwise tend to increase demand.
  • *Evidence of a price-induced “ratcheting effect”: higher prices create new habits that become permanent.*
Ongoing/Future Work

• Could the effect be partitioned into a price effect and a quantity effect?
  • *Price effect due to higher marginal rates*
  • *Quantity effect due to viewing the budget as a “soft restriction”?

• Welfare effects
  • *Theoretically consistent welfare estimation under nonlinear pricing is problematic*
  • *Structural estimation of the utility function under block rates complete; prediction and welfare estimation under alternative price structures in progress.*

• Optimal pricing
  • *Welfare maximization subject to revenue and quantity constraints*