Coping with Water Scarcity: recent developments in residential demand management

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Outline

1. California water supply update
2. What we know about residential demand management
3. A case study in conservation pricing
4. Recent legal developments
5. Looking ahead
CA water supply update

Water year 2014: third driest on record in terms of precipitation

Source: National Oceanic and Atmospheric Administration (NOAA)
CA water supply update

Water years 2011-2014: driest three-year period on record

Source: National Oceanic and Atmospheric Administration (NOAA)
CA water supply update

Calendar year 2014: **hottest on record** for California

**Hottest year on record for California**

2014 was the state’s warmest year since 1895, when modern records were first kept. Average state temperature per year:

- **2014 average temperature:** 61.5°F
- **Average:** 57.4°F

Source: NOAA

1895: 56.5°F

Source: San Jose Mercury News, January 8, 2015
CA water supply update

Central Valley groundwater resources have declined substantially

Source: National Geographic; Famiglietti lab at UCCHM at UCI
Current water year: dry to average so far

Source: Jeanine Jones, CA Department of Water Resources
Sierra snowpack is very dry

Source: Jeanine Jones, CA Department of Water Resources
Drought persists despite recent rains
CA water supply summary

- Drought emergency declaration and restrictions remain in effect
- Reservoirs remain below average and runoff forecasts are generally less than half of average
- MWD is anticipating 20% SWP allocation and ~70% CRA deliveries; reserves are down more than 50% since 2012
- USBR announced initial CVP allocations on Friday
  - 25% for municipal and industrial customers and 0% for agriculture
Residential demand management

• Supplies are low and **supply augmentation** tends to be costly, and problematic in the short-run
• But demand-side management offers short-run opportunities
• Six P’s of demand-side management
  1. **Pleading**: voluntary requests for conservation
  2. **Prohibiting**: mandatory restrictions and other requirements
  3. **Pressuring**: social norm messaging and peer group influence
  4. **Plastering**: education and information campaigns
  5. **Programming**: offer incentives for conservation practices
  6. **Pricing**: reduce demand by increasing the price of water
Pleading and Prohibiting

• **Voluntary requests** have relatively small effects
  • Atlanta case study (Ferraro et al. 2011; Bernardo et al. 2014)
    • Technical advice suggesting ways to reduce water use: **no reduction**
    • Technical advice with a request signed by the GM: **2.7% reduction**
  • EMWD study: uniform rates
    • Requests for short-term voluntary conservation have a **5% effect** in the month issued

• **Mandatory restrictions** can be very effective *if enforced!*
  • Enforcement is costly
  • Behavior is slippery
  • Restrictions are inefficient and thus costly to households
    • Estimated cost of 2-day-per-week irrigation restrictions relative to a price-based approach: ~25% of a household’s average water bill (Mansur and Olmstead 2007).
Pressuring and Plastering

• **Pressuring** (i.e. social norm messaging) is relatively new
  • Atlanta case study (Ferraro et al. 2011; Bernardo et al. 2014)
    • Technical advice, GM letter, social norm comparison: **4.8% reduction**
  • EBMUD case study (Mitchell and Chestnutt 2013)
    • WaterSmart Home Water Reports: **5.6% reduction**

• **Plastering** (i.e. information and education)
  • Billing frequency: no detectable effect (Olmstead and Stavins 2007)
  • Conservation messaging (Janmaat 2012, *working paper*)
    • **Message source variety** increases conservation effort
    • Knowledge of water issues *does not!*
Programming

• Three main conclusions:
  1. Conservation practices often do not live up to expectations.
  2. Efficiency gains vary significantly across cases.
  3. Conservation programs typically are not as cost-effective as pricing.

• However conservation programs can address equity issues associated with pricing strategies.
Programming: recent studies

Demand reduction attributable to WMWD sprinkler nozzle give-away (Schwabe et al. 2014)

<table>
<thead>
<tr>
<th></th>
<th>Pre (July-Sep 2010)</th>
<th>Post (July-Sep 2012)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Voucher</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>Voucher</td>
<td>30</td>
<td>26</td>
</tr>
</tbody>
</table>

Differences (2010-12)
- +1.66 CCF (8% increase)
- -0.22 CCF (0.8% decrease)
- -1.88 CCF (9% decrease)

Difference in Difference (Voucher minus No Voucher)

Estimated Water Savings from Various Turf Replacement Programs (Addink 2014)

<table>
<thead>
<tr>
<th>Location</th>
<th>Gallons per square foot</th>
<th>Cost/AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Marin Water District</td>
<td>33</td>
<td>$512</td>
</tr>
<tr>
<td>Albuquerque, NM since 1996</td>
<td>19</td>
<td>$718</td>
</tr>
<tr>
<td>Southern Nevada Water Authority</td>
<td>62</td>
<td>$532</td>
</tr>
<tr>
<td>El Paso, Texas 2004 (n=385)</td>
<td>18</td>
<td>$1834</td>
</tr>
</tbody>
</table>

Cost/AF: $512, $718, $532, $1834

Did not require irrigation improvements
Pricing

• There is **ample evidence** that customers respond to price changes and that pricing is a cost-effective means of achieving conservation goals.

• Price elasticity of water demand (a measure of **price responsiveness**) in the residential sector tends to be around -0.4 to -0.6 but it depends on local conditions.

• Pricing provides **revenue** needed to cover operating costs and utilizes an existing **monitoring system** (water meters).

• However there is also evidence that pricing tends to be **regressive**: it has a disproportionate impact on lower-income households.
How should water be priced?

• Three common goals of a water price structure:
  • Financial stability: maintain a balanced budget
  • Equity: ensure affordability for essential uses
  • Efficiency: send an appropriate marginal cost signal

• Challenges to finding an appropriate price structure:
  • Efficiency typically requires a higher price
  • Equity typically requires a lower price
  • Neither is likely to achieve a balanced budget
Alternative water rate structures

- **Flat rate**: a fixed charge per billing period
- **Uniform rate**: a constant price per unit consumed
- **Block rate**: price per unit depends on amount consumed
- **Allocation- (or budget-) based rate**: blocks depend on household and environmental characteristics
Water pricing in California

- As of 2005: about half of all utilities (400+) were using block rates
- As of 2008: fewer than 14 utilities were using allocation-based rates
- From 2009-2011: 9 more utilities adopted allocation-based rates
  - All in southern California
  - Major driver: Governor’s 20x2020 Water Conservation Plan
- Why the apparent reluctance to adopt allocation-based rates?
  - Fixed cost
  - Financial risk
  - Legal questions
  - *Uncertain effect on demand*: is it worth the cost/risk?
EMWD rate change study

Eastern Municipal Water District (EMWD) switched from uniform rates to increasing block allocation-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 balance

→ *How much conservation did they achieve?*
Data: sources and types

• 12,065 residential accounts (~10% of total) with good spatial coverage
• Continuous records from Jan. 2003 – Apr. 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>
</tr>
</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>
</tr>
<tr>
<td>Nominal price ($/CCF)</td>
<td>1.43</td>
<td>1.46</td>
<td>1.53</td>
<td>1.62</td>
<td>1.69</td>
<td>1.85</td>
<td>1.93</td>
<td>1.27</td>
<td>4.17</td>
</tr>
<tr>
<td>Real price (2010$/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>1.30</td>
<td>2.37</td>
</tr>
<tr>
<td>Budget (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>
</tr>
</tbody>
</table>
Estimation strategy

• Estimate a uniform rate demand model using data from January 2003 – December 2008
  • Estimated with household-level fixed effects
• 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

Average Monthly Demand: 2003-08

- Good model fitness
- $R^2$ values: 0.3 to 0.4
- Intuitive and highly significant coefficients
- Price elasticity: -0.7 to -0.8
observed vs. predicted demand

after the rate change

Demand effect emerges about 2 year
Some evidence the demand effect has stabilized around 10-15%
The rate change has had a bigger effect on inefficient households.
Efficiency improvements by inefficient households also have been the most resilient

Demand reduction attributable to the rate change:
12-month moving average
Potential legal challenges to block rates

Proposition 218: the “Right to Vote on Taxes Act”

- Passed in 1996, amended the California constitution
  - Generally limits local government ability to assess taxes and fees on landowners
- Local government fees must not exceed:
  - The \textit{reasonable} cost of providing the service
  - The \textit{proportional} cost of providing the service to each parcel served
- In 2006, California supreme court ruled that it applies to water rates
  - Agencies may not charge more for water than it costs
  - Agencies may not cross-subsidize water costs
Recent legal cases

2011: City of Palmdale v. Palmdale Water District
• Plaintiffs argued that block rates were not “proportional” to cost of service
• Trial court ruled for PWD; **appellate court ruled for plaintiffs**
  • PWD failed to demonstrate proportionality
  • But budget-based rates *do not necessarily* violate Prop 218

2013: Capistrano Taxpayers Assn. v. City of San Juan Capistrano
• Plaintiffs made a similar “proportionality” argument
• **Trial court ruled for plaintiffs**; appellate court decision is pending
  • Inefficient and efficient users both consume the same “marginal water”
  • Fees for services not “actually used by or immediately available to” all parcels cannot be assessed on all parcels
An economist’s view

• Courts appear to be invalidating **opportunity costs**
  • The true cost of using water is the budgetary cost to deliver it plus the **foregone benefit** it may have generated in another, possibly future, use.
  • Omitting opportunity costs encourages inefficiently high levels of use.

• Courts appear to be undermining potential **gains from trade**
  • Markets tend to promote cost-effective, mutually beneficial solutions
  • City of SJC was attempting to facilitate a **market-like transaction**
  • Current interpretations of Prop 218 ironically may increase costs
Looking ahead

- **Proposition 218**: new legislation needed?
- **Proposition 1** (the Water Bond): some short-term relief in hard-hit areas; otherwise long-term supply augmentation

**Local agencies:**
- Increased reliance on **local supplies**: recycling, stormwater
- Increased investment in **local storage**
- Focus on robust **rate structures** with built-in drought-triggers
- More **prohibitions**, especially for outdoor use
- More conservation **programs**, again focusing on outdoor use
- More **information** campaigns, designed to change cultural norms