Water, Cities and Sustainability

Christa Brelsford
Why Water?

- Why are water allocation institutions a useful case study for understanding how to develop more effective and sustainable institutions?
New York City

quality, robustness, and getting rid of .... stuff
STONE BRIDGE, BROADWAY AT CANAL STREET

NEW YORK CITY - BRIDGES - 1800
CSO’s at about ½ inch rainfall in 24 hours or 1/10th inch rainfall in an hour.
Irwin vs Phillips (1855)
intent
diversion
beneficial use
priority
Doctrine of Prior Appropriation
Whiskey is for Drinking;

Water is for Fighting Over

matching fixed supply with growing demand
Water Conservation in Las Vegas

Brelsford & De Bacco, *NETS.* 2018
Brelsford & Abbott, [in review]
Fixed amount of water per year
Fixed amount of water per year

Next year's allocation is based on this year's consumption
Fixed amount of water per year

Next years allocation is based on this years consumption

Boulder City got scared: Opened the fire hydrants at night in December 1990
Fixed amount of water per year

Next year’s allocation is based on this year’s consumption

Boulder City got scared:Opened the fire hydrants at night in December 1990

Feb 14th, 1991: Valentines Day Massacre
Fixed amount of water per year

Next years allocation is based on this years consumption

Boulder City got scared:Opened the fire hydrants at night in December 1990

Feb 14th, 1991: Valentines Day Massacre

June 27th, 1991: Southern Nevada Water Authority was created.
Fixed amount of water per year

Next year's allocation is based on this year's consumption.

Boulder City got scared: Opened the fire hydrants at night in December 1990.

Feb 14th, 1991: Valentines Day Massacre

June 27th, 1991: Southern Nevada Water Authority was created.

1993: Return Flow Credit Established
Las Vegas’ per capita water consumption fell dramatically in the 1990s and 2000s.
How can we identify the most important drivers of our observed decline in water consumption?

<table>
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<th>Semi Log Regressions</th>
<th>Gelbach’s Decomposition</th>
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<tr>
<td>with a rich set of fixed effects, temporal dummy variables and controls related to home characteristics, weather, and neighborhood</td>
<td>uses estimates of omitted variable bias to define the relative importance of various covariates</td>
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through scenario development
Building efficient infrastructure during new construction is the single biggest driver of reduced consumption.
How do we measure how effective the WSL program is?

Event Study

- Used to ensure that WSL driven water savings accrue at the time of the landscape change.
- This compares the seasonal water comparison for the new landscape, age $\tau$ to water consumption the year it was installed.

$$c_{it} = a + \sum_{k=-15}^{k=11} \beta_k [\tau_{it} = k]_it + \gamma_t + \zeta_i + \epsilon_{it}$$

Difference in Differences

- Used to estimate the gallons saved per meter converted.
- This compares CHANGES in consumption during the landscape change to CHANGES in consumption for households with static landscapes.

$$c_{it} = \zeta_i + \gamma_t + \beta_0 a_{it} + \beta_1 K_{it} + \epsilon_{it}$$

through quasi-experimental econometric methods.
What did we find?

Large and durable water savings across seasons.
How can we test for the existence of Peer Effects in WSL Participation?

1) WSL participants

\[
P(t_{iE} = t_i > 0 | \alpha, \mu, \{t_{kE}\}_{k \in \Theta_i}) = I_{x_i^0 = S} \prod_{t=1}^{t_i-1} (1 - \mu_i^t) \prod_{k \in \partial i | t_{kI} < t_i-1} (1 - \alpha)^{t_i - \tau_{kiI} - 1} \times [1 - (1 - \mu_i^t)(1 - \alpha)]
\]

2) Non-Participants

\[
P(t_{iE} = \infty | \alpha, \mu, \{t_{kE}\}_{k \in \Theta_i}) = I_{x_i^0 = S} \prod_{t=1}^{T} (1 - \mu_i^t) \prod_{k \in \partial i | t_{kI} < T} (1 - \alpha)^{T - \tau_{kiI}}
\]

3) Joint Probability for All Homes

\[
P(t | \alpha, \mu) = \prod_{i \in V | x_i^T = S} P(t_{iE} = \infty | \alpha, \mu, \{t_{kE}\}_{k \in \Theta_i}) \prod_{i \in V | x_i^T \neq S} P(t_{iE} = t_i > 0 | \alpha, \mu, \{t_{kE}\}_{k \in \Theta_i})
\]

We model participation like it’s an epidemic.
What did we find?

Transmission probability

Non-zero transmission probabilities across most neighborhoods
What did we find?

Models that allow peer effects fit the data better than models which don’t
• Landscape change is a small but measureable component of Las Vegas’ overall decline in residential water consumption.

• WSL landscape conversions save meaningful amounts of water.

• There is evidence of a peer influence in WSL participation.
Strategies for Analysis of Coupled Socio-Hydrological Systems
Thing 1

Thing 2

Thing 3
Thing 1

More Things

Thing 3

Thing 2

More Things
Water Scarcity
Water Excess
Adaptive Capacity
People Matter.

**POPULATION**

Urban areas house half of all the world’s people, and continue to grow in both rich and poor countries.

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<tr>
<th>Social Scale</th>
<th>Individuals</th>
<th>Cities</th>
<th>Nations</th>
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<tbody>
<tr>
<td>Nation</td>
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Probabilistic, Empirical or Agent Based Models

Brelsford & De Bacco. NETS (2018)
Individuals

Probabilistic, Empirical or Agent Based Models

Brelsford & De Bacco. NETS (2018)

Cities

Urban Scaling Theory


Nations

Predictable Cities

Data from 360 US metropolitan areas show that metrics such as wages and crime scale in the same way with population size.

METRIC:
- Crime
- GDP
- Income
- Patents

Social Scale
Urban Analysis and Stakeholder Engagement

Societal Goals: The urban future we want

Past & Present

Possible Futures

Urban Futures

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Brelsford & De Bacco. NETS (2018)

