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Towards a Market Solution to Water Shortage: The Case of Lower Rio Grande Valley

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Structural Vs. Market Approaches

• Traditional approaches to water allocation and conservation

• Far from effective in dealing with water shortage situations

• Non-structural approaches such as *market transfer* of water rights
  • Allocative Efficiency and Productive Efficiency

• Coase (1960) - Government intervention unnecessary if property rights are freely tradable
Lower Rio Grande Valley (LRGV) Region
Lower Rio Grande Valley (LRGV) Region

• Dependent on the waters of Rio Grande for domestic, municipal and agricultural uses

• 4 counties – Hidalgo, Cameron, Willacy, and Starr has been under some water stress periodically

• Low average precipitation along with occasional hurricanes in the summer and fall

• Water requirements of this region is fulfilled by the Amistad- Falcon Reservoir system- a resource shared by Mexico
The Water Treaty - 1944

• To fix and delimit the rights is US and Mexico with respect to the water of:

  • Colorado and Tijuana Rivers and

  • Rio Grande from Fort Quitman to the Gulf of Mexico

  • One-third of the flow to Rio Grande from the Conchos, San Diego, San Rodrigo, Escondido and Salado Rivers and the Las Vacas Arroyo…this one-third shall not be less, as an average amount in cycles of five consecutive years, than 350,000 acre-feet

  • In case of “extraordinary drought” or serious accident to the hydraulic systems on Mexican tributaries…the treaty allows for the deficiencies to be repaid in the following five-year cycle

  • If reservoir levels exceed 85 percent full then deficit if forgiven and a new five-year cycle starts
The Water Treaty - 1944
Mexico’s Water Debt (IBWC)
Municipal Availability vs. Requirement

ACRE-FEET / YEAR

2020 2030 2040 2050 2060 2070

Municipal supplies  Municipal Needs
Water Delivery and Rainfall

- Mexico’s water delivery closely follow the amount of rainfall along the Rio Bravo riverbed
Estimation and Forecasting

- Water Deliveries\(_t\) = f(Rainfall in the Rio Bravo Watershed\(_t\), Cumulative Deficit\(_t\), Delivery\(_{t-1}\), Irrigated Acreage\(_t\), Population\(_t\)) + \epsilon\(_t\)

- An OLS model will give deterministic forecasts
- Dependent variable – Annual Water Deliveries by Mexico
- Independent Variables – Rainfall in the Riverbed, Irrigated Acreage, Population

**Data Source**

Rainfall - CNA, Mexico (1990 – 2017), Monthly
CDF of Water Deliveries

Probability of water deliveries up to a certain thousand acre-feet for the years 2021 to 2025.
A Dry-Year Option Program

- Dry year option contracts, in exchange of an initial payment guarantees the purchaser the right to lease water at a future date at an agreed upon “exercise” price (Characklis et al., 2006)

- Certainty around water availability for the buyer at a mutually acceptable price

- Also allows for allocative efficiency

- The agricultural water users have a lower willingness to pay and present as a likely source (Brown and Carriquiry, 2007)
Provisions of an Option Contract

• **The Threshold** - As water level go below a threshold level, the framers who have enrolled their rights in the program will be notified to suspend irrigation by the concerned authority.

• **The Payment** - The program requires that the farmers be paid an enrollment fee per acre-foot of water and an additional suspension fee if the option is called.

• **Required Enrollment** – The amount of water to be enrolled in the option program by the sellers.
The Threshold in the Valley

• As water level goes below a threshold level, option will be called

• Water distribution channel is not the same across all irrigation districts – reservoirs vs. unlined canals of unknown shape

• The critical levels therefore, differ from one district to the other

• The trigger date is expected to be in the Fall-Winter season before the next crop year begins

• Evaluation of water availability status prior to the trigger date so farmers make necessary adjustments
The Payment

• The payment farmers will be willing to accept to suspend using their water rights must at least compensate them for revenue loss from irrigated agriculture.

• Deterministic and stochastic estimates of value of irrigation water is obtained to approximate the value of forgone benefits of water to the seller.

• The crop budgets developed by Texas AgriLife Extension; Historical yields and prices are available from USDA-NASS.

• Thereafter, the residual imputation method is used.
Residual Imputation Method and Empirical Distribution

<table>
<thead>
<tr>
<th>Per-acre</th>
<th>Corn</th>
<th>Cotton</th>
<th>Sorghum</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Stochastic) Yield</td>
<td>100.0</td>
<td>1388.6</td>
<td>76.0</td>
</tr>
<tr>
<td>Price</td>
<td>3.8</td>
<td>0.6</td>
<td>7.5</td>
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<tr>
<td>Variable Cost</td>
<td>282.3</td>
<td>712.6</td>
<td>244.5</td>
</tr>
<tr>
<td>Water Use (ft)</td>
<td>1.5</td>
<td>2.1</td>
<td>1.3</td>
</tr>
<tr>
<td>Irrigation labor</td>
<td>26.4</td>
<td>13.2</td>
<td>13.2</td>
</tr>
<tr>
<td>Total Water Cost</td>
<td>56.4</td>
<td>55.2</td>
<td>39.2</td>
</tr>
<tr>
<td>Net Returns</td>
<td>158.6</td>
<td>174.6</td>
<td>362.8</td>
</tr>
<tr>
<td>Irrigated Acreage</td>
<td>31.10%</td>
<td>25.80%</td>
<td>43.10%</td>
</tr>
<tr>
<td>Composite Returns</td>
<td></td>
<td>250.7</td>
<td></td>
</tr>
<tr>
<td>Composite Water Use</td>
<td></td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>Net returns /ac-foot</td>
<td></td>
<td>159.8</td>
<td></td>
</tr>
</tbody>
</table>

\[
F(x) = \begin{cases} 
0 & \text{if } x < X_{(1)} \\
\frac{i - 1}{n - 1} + \frac{x - X_{(i)}}{(n - 1)(X_{(i+1)} - X_{(i)})} & \text{if } X_{(i)} \leq x < X_{(i+1)} \text{ for } i = 1, 2, \ldots, n - 1 \\
1 & \text{if } X_{(n)} \leq x 
\end{cases}
\]
PDF of Composite NRTW per acre-foot
The Required Enrollment

• Irrigation districts are responsible for distribution of water to the municipalities and agricultural farms

• Small amount of municipal water in comparison to agriculture

• The distribution canals are recharged using irrigation water

• Absence of irrigation water, which cannot be ruled out under critical drought situations makes it impossible to convey municipal water
Push Water

- Push water - water required in the canals for carrying urban water

- Municipal Water Supply Network defined as parts of the irrigation water distribution network that also convey municipal water

- The MSN water assessment was done under normal operational conditions accounting for evaporation and seepage losses

- The sum of individual enrollments in each district should at least be as large as their static volume
## Push Water Volumes

<table>
<thead>
<tr>
<th>District</th>
<th>Min</th>
<th>Max</th>
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</thead>
<tbody>
<tr>
<td>Delta Lake</td>
<td>1884.4</td>
<td>2916.2</td>
</tr>
<tr>
<td>Donna</td>
<td>1714.8</td>
<td>1832.3</td>
</tr>
<tr>
<td>Edinburg</td>
<td>688.2</td>
<td>1038</td>
</tr>
<tr>
<td>Harlingen</td>
<td>375.7</td>
<td>550.1</td>
</tr>
<tr>
<td>HCID 3</td>
<td>75</td>
<td>110.5</td>
</tr>
<tr>
<td>HCID 16</td>
<td>2008</td>
<td>2011.1</td>
</tr>
<tr>
<td>La Feria</td>
<td>1525.3</td>
<td>1525.3</td>
</tr>
<tr>
<td>Los Fresnos</td>
<td>186.6</td>
<td>279.9</td>
</tr>
<tr>
<td>Mercedes</td>
<td>1453.8</td>
<td>1710.6</td>
</tr>
<tr>
<td>mission 6</td>
<td>404.5</td>
<td>431.6</td>
</tr>
<tr>
<td>San Benito</td>
<td>2059.1</td>
<td>2243.3</td>
</tr>
<tr>
<td>San Juan</td>
<td>2344.9</td>
<td>2344.9</td>
</tr>
<tr>
<td>Santa Cruz</td>
<td>661.9</td>
<td>676.2</td>
</tr>
<tr>
<td>United</td>
<td>447.7</td>
<td>449.9</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>15829.9</strong></td>
<td><strong>18119.9</strong></td>
</tr>
</tbody>
</table>
Potential Welfare Implications

- Direct impacts of the program is on (i) the farmers enrolling their water rights into the program (ii) the municipal and industrial water users (iii) and the irrigation district

- Farmers in the program will benefit if payments received from enrollment and suspension compensates for loss from change in crop-mix to dry-land cropping

- DMI users ought to benefit from the program in terms of water security every year. “insurance” against any shortages that might occur in exchange for a premium

- In order to keep the irrigation districts’ welfare unchanged, they will need to be compensated for the loss from withdrawal suspension
• Thank you!