Contingent allocation of scarce irrigation water: a review of auction mechanisms

Michele Vollaro¹, Meri Raggi², Davide Viaggi¹

1 Department of Agricultural Sciences
2 Department of Statistics

University of Bologna

michele.vollaro@unibo.it

25-27 June 2014, Alghero (SS), Italy
Introduction

Droughts imply uncertain availability of water resources for irrigation

Farmers need to reduce the effects of weather risks

With common knowledge of water uses and values, allocation of scarce water would be efficient

Market-based (MB) act as information revelation mechanisms

Theoretically more effective to manage allocation of scarce water resources

Innovative mechanism in water crises management: right-to-choose (RTC) auction for irrigation rights

Contingent tool to respond to a temporary event

Get the scarce irrigation water to best valuable uses
Objectives

- To review the market-based mechanisms and auction application
- To explore the feasibility of an auction mechanisms for the allocation of forecasted scarce water

Method

- Framing a theoretical model
- Discussion about the operational and implementation issues
Policy rationale

- Alignment between water needs and economic values of water use (Blueprint - quantitative management)
- Centrally-managed systems (Italy): frequent unbalanced correspondence between farmers’ water demand and crops’ water needs
- Need: flexibility in water management in time and places of water scarcity
Economic rationale

- MB mechanisms able to reduce asymmetric information (AI) issues and to move water resources towards higher valued uses
- Adverse selection reduced if farmers find profitable to reveal their type
- Auctions can provide such opportunity and improve allocation efficiency
- Two conditions: heterogeneity among farmers in both water needs and willingness/ability to pay for marginal quantities of water
- Wrto a centrally-managed system, lower costs and flexibility in employment (use it only when needed and no institutional change - water ownership)
Auctions

- Promoting market-like competition for an otherwise regulated or non-marketable good
- Operate in a context of incomplete information
- Let agents to reveal, or at least signal, their own valuation of the auctioned good
- Rarely used: either because water already tradable or because publicly managed
- In case of scarcity, agents willing to pay more (risk-management)
- In Australia, used to allocate additional water or reallocate existing rights
- In USA, used by the government to buy-back water for environmental purposes (scarcity anyway)
Based on Ausubel and Cramton (2002) and Ausubel et al. (2013): shape of marginal utility (diminishing vs flat) affects multi-unit auction efficiency. If drought is forecasted, the authority employs the auction of irrigation rights (IR). IR correspond to water unit (i.e. 1000 m³). Water is uncertain and defined by a probability distribution. IR auctioned according to uncertainty levels. The winner chooses the amount needed (RTC) and pays-as-bid (flat marginal utility).
To confine the effectiveness of the instrument, only irrigators of the water authority can participate.

To guarantee fairness in the allocation, farmers need to report the prospective use (land and crops).

Authority sets cap per each bidder.

One auction per uncertainty level.

IR allocated to farmers up the cap.

<table>
<thead>
<tr>
<th></th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>340</td>
<td>100</td>
<td>70</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>30%</td>
<td>710</td>
<td>200</td>
<td>170</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td>60%</td>
<td>2170</td>
<td>700</td>
<td>500</td>
<td>200</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>3220</td>
<td>May</td>
<td>June</td>
<td>July</td>
<td>August</td>
</tr>
</tbody>
</table>

Model
Model

- IR superadditive values for bidders (water is a complement)
- Risk-neutrality

Set of potential bidders: \( i = \{1, 2, ..., I\} \)

Set of possible types (signal) of player \( i: s_i \in [0,1] \) of his value \( v_i; s \equiv \{s_i\}_{i=1}^I; s_{-i} \equiv \{s_j\}_{j \neq i}; \)

Joint distribution of types: \( F(\cdot) \) with support \([0,1]^I \); \( pdf: f(\cdot) \) strictly positive on \((0,1)^I\)

Ex-ante symmetry of bidders (farmers): the distribution function \( F \) is commonly known to bidders;

Independent private value model: the realization is known only to bidder \( i \);

An assignment of the good auctioned among bidders is said to be ex post efficient if each unit goes to the bidder who values it the most:

\[
W^*(s) \equiv \arg \max_{w_i(s),...,w_I(s)} \left\{ \sum_{i=1}^I u_i(v_i(s),w_i(s),0) \left| \sum_{i=1}^I w_i(s) \leq W \right. \right\}
\]
Model

Uniform – price: each bidder $i$ assigned $W_i$ pays the market clearing price $\bar{p}$ for each of the $W_i$ units obtained; $i$'s total payment is $P_i = W_i \bar{p}$

where $\bar{p} = \min \left\{ p \mid \sum_{i=1}^{I} b_i^{-1}(p) \leq W \right\}$ highest rejected bid

Pay – as – bid: each bidder $i$ assigned $W_i$ pays his winning bids: $P_i = \int_0^{W_i} b_i(y, s_i) dy$
Flat demand
Farmers are required to express constant marginal values for the "packaged" good, up to fixed capacities (flat demand).
The total amount $W$ can be normalized to 1.
Each participant eligible for $w_i \in \left[ \underline{\lambda}_i, \overline{\lambda}_i \right]$.
$\underline{\lambda}_i$ minimum quantity for which $v_i(s) > 0$.
$\overline{\lambda}_i = 1$ is the cap of each farmer.
Competition: $\sum_{j \neq i} \lambda_j > 1$ for each $i$.

$P_i = w_i b_i$
Efficiency

- Auction efficient only if demand is flat (as required), but
- Pay-as-bid efficient only if the capacities of each farmer are equal $\overline{\lambda}_i = \lambda$
- Implied by ex-ante symmetry and private values assumption
- If assumption relaxed, both pay-as-bid and uniform-price are inefficient: need to rank
- Ranking gives ambiguous outcomes
- *determining the better pricing rule is therefore an empirical question* (Ausubel et al., 2013)
Hardly accepted in publicly managed water communities

In Italy, “control room” (cabina di regia) for managing emergencies

No investigation about comparative evaluation

Many countries turning to MB: need to protect the value of the resource (experience)

Auctions: combined solution to initial allocation and outcome of trading – both at the same time (theory)
Theoretical and practical issues

- Uncertain good put on auction: no theoretical hints about bidding behavior (especially for risk-averse)
- Has water resource a common value features?
- If so, bidders affected by non-independent values
- The relationship between superadditivity levels and constant marginal values needs to be explored
- Cost-effectiveness of the instrument highly depending on such issues (for both design and implementation)
Expectations

- In theory, outcome similar to permanent tradable systems (both for temporality and allocation)
- Theoretical complexity mitigated by learning processes (experience)
- ...there must be sufficient room and opportunity to correct errors and to “fine-tune” the allocation of rights, as well as the trading rules (Kraemer and Banholzer, 1999)
- Opportunity in publicly-managed water systems
The proposed auction aims at mediating between the needs of:

- policy-makers to opt for a rapid and effective policy instruments
- of farmers to have the opportunity to secure irrigation supplies in case of emergency
- of both agents to avoid disputes regarding fairness and cost-effectiveness and to guarantee transparency and reliability of management in emergency interventions

Need to investigate comparative profitability of employing MB vs centrally-managed emergency tool.
Thanks