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

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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
- Wrt to 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)

Model

- 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 m^3)
- 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)

Model

10%	**340**	**100**	**70**	**40**	**40**	**90**
30%	710	200	170	80	70	190
60%	2170	700	500	200	170	600
	3220	May	June	July	August	September

- 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

Model

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

Set of potential bidders: $i = \{1,2,\ldots,I\}$

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:

$$W^*(s) \equiv \arg \max_{W_1(s),\ldots,W_I(s)} \left\{ \sum_{i=1}^{I} u_i(v_i(s), W_i(s), 0) \;\middle|\; \sum_{i=1}^{I} W_i(s) \leq W \right\}$$

Model

$Uniform - price:$ each bidder i assigned W_i pays the marke

clearing price $\overline{p}$ for each of the W_i units obtained;

i's total payment is $P_i = W_i \overline{p}$

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

$Pay - as - bid:$ each bidder i assigned W_i pays his

winning bids : $P_i = \int_0^{W_i} b_i(y, s_i) dy$

Model

Flat demand

Farmers are required to expresses constant marginal values for the "packaged" good, up to fix capacities (flat demand)

The total amout 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 $\bar{\lambda}_i = \lambda$
- 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)

Discussion

- 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

Conclusions

- 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