

# **Impact of metering of electric tubewells on groundwater use and informal groundwater markets in West Bengal**

**Aditi Mukherji, International Water Management Institute, Colombo**  
**A. Banerji, Delhi School of Economics, Delhi**  
**J.V. Meenakshi, Delhi School of Economics, Delhi**

# Context

- West Bengal agriculture in general, and rice production in particular, is dependant on availability of water. Over time, boro rice, cultivated almost entirely on irrigation, the mainstay of the WB rice economy, accounting for 40% of total rice output. Much of water demand is in boro
- Changes in the economics of water use need to be viewed against the backdrop of a trend of decelerating growth in agricultural output
- Flat rate electricity pricing prevalent until recently, when switch to Time of Day (TOD) metering was effected in WB
  - Normal' hours: 6am-5pm, @Rs. 1.37/unit
  - 'Peak' hours: 5pm-11pm, @Rs. 4.75/unit
  - 'Off-peak' hours:11pm-6am @Rs 0.75/unit

# Context

- Criticisms of lumpsum payment for water are well known:
  - Encourages wasteful and inefficient groundwater use,
  - Can lead to overexploitation of groundwater and unsustainable cropping patterns
  - ‘Cheap’ electricity acts as disincentive to invest in electricity supply, leading to rationing and uncertain electricity (therefore water) supply
  - . “...introducing marginal cost for water and electricity not only promotes efficient use of water as manifested by higher farm-level water productivity, but also more sustainable use of water” Kumar, 2009 p.161

# Context

- Small but influential literature (Shah et al, 20) arguing in contrast that
  - Flat rate system encourages water sales, so that small and marginal farmers, who may not have been able to acquire pumps are not precluded from cultivating water-intensive crops such as paddy
  - Over time, small farmers are getting squeezed out of the market for water with ‘high’ flat rates that do not act as a subsidy
  - Switch to marginal cost pricing will cause water markets to contract, and may even result in an exit from agriculture altogether

# Objective: Assess impact of metering of electric tubewells on:

- Primary impact indicators:
  - Volume of water sales
  - Volume of water pumped
- Secondary impact indicators:
  - Cropping patterns
  - Efficiency of water use

## Data and estimation method

- Take advantage of prior surveys in 2004 and 2007 in 34 villages spread across seven districts of West Bengal, when a flat rate system prevailed. Sample size of 450 overall (250 owners, 200 buyers)
- Resurvey the same households in 2010 in a follow up survey to generate a panel
- Use a difference-in-difference estimator to identify impact, assuming that
  - metering progressed randomly,
  - metering is not complete, so that at least some of the villages in baseline, as yet unmetered, can serve as controls

# Was metering random?

	% of metered tubewells to total in		
	2009	2008	2007
N. 24 Paraganas	91.9	76.3	8.9
Hugli	87.4	38.3	7.4
Bardhaman	72.3	33.1	6.7
Birbhum	59.8	9.1	4.3
Bankura	86.2	33.9	17.4
Nadia	92.7	75.2	4.9
Murshidabad	33.1	34.3	12.9

Will we find enough number of control villages, given these coverage rates?

Answer obtained only when in field, so

- Plan A

- Enough number of villages are unmetered, or at least enough number of original respondents do not have meters (enough=adequately powered sample size) within each hydro-ecology
- Compare control and metered villages on observables to assess if treatment can be assumed to be random
- Use the roll out as a way to assess dose response—is adjustment done in one year, or does it take time to stabilize

- Plan B

- If not enough control villages/respondents are found, use recall of previous year's water use to assign control and treatment groups; given earlier table, more likely to find adequate sample size for previous year
- Recall biases likely to exist, but will be washed out in a double difference
- Similarly assess if control and treatment villages thus assigned are similar on observables

- Plan C

- Augment sample size to ensure sufficient number of control and treatment villages within similar hydro-ecologies. We plan to add 12 additional villages
- Use a first difference approach to assess impact

# Adequate sample size?

- Most studies struggle with this issue, largely because information on variances is often unavailable. In our case we use the baseline survey data
- Power calculations undertaken only for primary impact variables—number of hours of water pumped and sold
- Determining effect size is also difficult, here we assume an effect size of 250 hours, for both variables, representing a change of 12-17% of baseline mean values
- Rationale: farmers may avoid pumping during peak tariff hours – about 5 hours a day. Paddy needs 50 days of water.  $50 \times 5 = 250$  hours

# Sample size calculations

- With these magnitudes, a sample size of 60 households per treatment and control group is sufficient. Cannot detect a difference for lower effect sizes of say 100 hours
- Subject to earlier caveats, this is feasible, even with some attrition

# Attrition?

- Despite relatively long time span between baseline and follow up, reasons to be optimistic that attrition will be low.
  - Relatively low migration by land holding farmer households, given the importance of land to income generation in rural West Bengal.
  - Given the considerable capital costs involved in installing groundwater extraction equipment, this decision is taken on the basis of long term profitability. This lowers the probability of significant exit
  - Even if a previous respondent has indeed migrated, it is highly unlikely that the entire household would have moved out of the village.

# Impact heterogeneity

Season	Boro	Boro	Aman	Aman
Technology	Submersible	Centrifugal	Submersible	Centrifugal
Pump owners				
Water buyers				

- Seasonal differences in nature of water contracts—boro contracts are priced per season, aman are priced by hour
- Size of water markets and cropping patterns engendered by submersibles different from those by centrifugal pumps
- Use regression techniques to assess role of farm size etc.

## Secondary impact variables

- Cropping pattern changes—TOD metering may result in a switch to less water intensive crops, possible implications for paddy output growth in particular
- Water use may decline without changes in cropping pattern, with resultant impact on yields
- These impacts may vary for pump owner and buyers
- Water use efficiency may change, with additional investments in pipes, drips and so on
- Contract terms may change

# Program theory

## Pre-treatment

- Farmers pay a fixed cost for water
- Stylized fact: Water prices within a village and season are fairly uniform
- We take as given the terms of contract—price per acre or price per volume
- Also, each seller sells to multiple buyers
- Question: what institutional setting will yield the stylized fact above, and what are its efficiency implications?
  - Models of bargaining
  - Models of price competition
  - Models of sellers' monopoly

# Program theory

## Pre-treatment

- Efficiency defined as the marginal product of water being equal to its marginal value cost, for each farmer
- A range of models of bargaining and of price competition yield the observed styled fact of uniform water prices. Monopoly models do not
- For contracts on a per volume basis, models of competition and bargaining lead to efficient outcomes, monopoly does not, with buyers getting less water
- For contracts on a per acre basis, all three sets of models yield efficient allocations

# Program theory

## Post-treatment

- Instead of a fixed costs, farmers face a unit cost for water
- All models predict that total water volumes will decline as a consequence –both for water buyers and sellers
- For price charged on a per volume basis, bargaining can still lead to efficient allocations; under monopoly the inefficiency remains. But nothing suggests greater inefficiency post treatment
- However, for prices charged on a per acre basis, unit costs can lead to significant inefficiency under monopoly. Bargaining models can yield efficient allocations, but water prices can be high, with adverse consequences for buyers' profits with implications for equity

# Survey instrument

- Information on cropping patterns and water use by season in 2009-10 and 2008-9
- Technology use (pumpsets) and maintenance costs
- Information on production, input and output prices on the largest plots of the respondents
- With a panel, enables estimation of profit/production functions—and the price elasticity of water use by plot. Enables welfare analysis.
- Along with other production function parameter estimates, and estimates of costs of water extraction questions of efficiency of water allocation, and of equity can be addressed

# References

- Dinesh Kumar (2009) *Water management in India: What works what doesn't*, (Gyan publishing house)
- Tushaar Shah et al (2009), “Is irrigation water free? A reality check in the Indo-Gangetic basin” *World Development*, 37:2