A Proposed Drought Index Insurance for California

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Background

- California's Central Valley is one of the most productive agricultural regions in the world. Yet it receives only limited rainfall. Almost all agricultural production in the Valley is irrigated.
- Surface water is brought from northern California to the more arid central and southern parts of the state through extensive networks of reservoirs, rivers, pipes, and canals.
- One surface water supply system known as the Central Valley Project (CVP) is managed by the federal government. Another surface water supply system known as the State Water Project (SWP) is managed by the State of California.

Background

- These water projects also provide water for municipal water systems in central and southern California.
- Environmental regulations require minimum water flow levels through rivers that are part of these delivery systems.
- When northern California receives unusually low amounts of precipitation (primarily snowfall in the mountains), surface water allotments for irrigation are reduced.
- In recent years California has experienced a severe drought. A recent paleoclimatic study found that the period 2012-2014 was the most severe drought in the past 1,200 years.

Background

- In normal years, groundwater constitutes only about one-third of water usage in California.
  - Groundwater pumping is a much more expensive source of water than surface water supplied by the CVP or SWP.
- Crop insurance does not cover the risk of shortfalls in water deliveries.
  - Farmers can only insure under an irrigated practice, acreage that, at the beginning of the crop season, is expected to receive a full irrigation water allocation.
  - Does not cover crop losses caused by reduced water allocations due to environmental regulations.

Focus of this Study

- This study examines the potential for landowners and farmers (much of the farmland is rented) who receive irrigation water from the CVP to use an index insurance product to protect themselves from the financial implications of reduced surface-water irrigation allotments.
- Two scenarios are considered. Reduced water allocations either:
  - Force landowners to leave some land fallow; or,
  - Force farmers to pump groundwater to replace the lost surface water allocation.
- Paper available in *Applied Economic Perspectives and Policy,* September 2016.

Sacramento Index

- Used by the CVP to forecast annual available surface water supplies. Also used by environmental regulators.
- Hydrologic year *t* begins in October. Most irrigation water use is in June, July, and August. Sacramento Index is measured on 1 May.

Sacramento Index

- $SI_t = (0.4 \times AprJul_t) + (0.3 \times OctMar_t) + \left(0.3 \times min(10, SI_{t-1})\right)$
- $AprJul_t$ is the May forecast of water runoff for April-July at measurement sites in northern California.
- $OctMar_t$ is the actual runoff for October-March at measurement sites.
- SI_{t-1} is the Sacramento Index for the previous hydrologic year.
- All variables are measured in millions of acre-feet.

Sacramento Index

Hydrologic Year Classification	Sacramento Index Value
Wet	$SI_t \geq 9.2$
Above Nomal	$9.2 > SI_t > 7.8$
Below Normal	$7.8 \geq SI_t > 6.5$
Dry	$6.5 \geq SI_t > 5.4$
Critical	$5.4 \geq SI_t$

Sacramento Index Insurance

- Insurance indemnity function:
  - $Indemnity_t = \begin{cases} 0 & if \;\; SI_t \geq U \\ D \times (U - SI_t) & if \;\; SI_t < U \end{cases}$
  - where *U* is the upper limit of the contract and *D* is the tick size. Both *U* and *D* are chosen by the insured.
  - Maximum possible indemnity = *D*×*U*.
- Consider actuarially fair premiums as well as premiums with loads of 10%, 20%, and 30%.

Sacramento Index Insurance

- Since the Sacramento Index has an autoregressive component, using it as the index for insurance could create the potential for intertemporal adverse selection.
- Potential solutions:
  - "Early Bird" Insurance: Must purchase insurance for hydrologic year *t* prior to October of year *t*-1.
  - Variable Premium Insurance: Premium rate for insurance in hydrologic year *t* is conditioned on the value of SI_{t-1} (buyer is concerned about protecting against shortfalls relative to an absolute level of SI_t).
  - Variable Deductible Insurance: Deductible for insurance in hydrologic year *t* is conditioned on the value of SI_{t-1} (buyer is concerned about protecting against shortfalls relative to the conditional $E(SI_t)$).

Challenge in Testing Sacramento Index Insurance

- Historical CVP water delivery data are only available since 1993.
- Environmental regulations have changed many times through the years (most recently in 2009). So stochastic historical CVP water deliveries are not drawn from a stationary distribution.
- Cal-lite Simulation Model.
  - Hydrologic simulation model developed by federal and state water agencies to estimate CVP water deliveries for the period 1922-2003 under different environmental regulatory regimes.
- Actual CVP water deliveries are highly correlated to Cal-lite Simulated water deliveries for 1993-2003 (especially when actual water deliveries are unusually low).

Testing Sacramento Index Insurance

- We use Cal-lite simulated CVP water deliveries (under the current regulatory regime) to test the performance of index insurance based on the Sacramento Index.
- Still must convert shortfalls in simulated CVP water deliveries into losses incurred by a landowners or farmers.
- Focus on Westlands Water District (WWD), a surface water management authority located in Fresno and Kings counties that receives most of its water from the CVP.

Estimating Landowner and Farmer Losses

- Landowners:
  - Annual fallowed land data were obtained from WWD (2000-2013). Fallowed acres are negatively correlated with the Sacramento Index.
  - Fallowed land is assumed to generate no rental income.
  - California annual cash rent per acre data obtained from USDA.
- Farmers:
  - When CVP delivers less water, many WWD farmers pump groundwater.
  - Annual data obtained on depth of groundwater table and amount of groundwater pumped in the WWD (1974-2013).
  - Energy intensity equation for groundwater pumping was used with California energy cost data to generate annual groundwater pumping costs.

Actuarially-fair Sacramento Index Insurance Results (U=7.8) with Losses Based on Fallowed Land (2000-2013)

Net Losses $ Millions	No Insurance	"Early Bird"	Variable Premium	Variable Deductible
Standard Dev.	10.9	7.8	9.3	10.2
Maximum Loss	56.3	48.2	52.7	55.3
Tick Size		7.9	6.2	6.8

Actuarially-fair Sacramento Index Insurance Results (U=7.8) with Losses Based on Groundwater Pumping Costs (1974-2013)

Net Losses $ Millions	No Insurance	"Early Bird"	Variable Premium	Variable Deductible
Standard Dev.	30.5	20.7	23.6	26.1
Maximum Loss	114.7	96.8	100.0	110.9
Tick Size		16.8	15.2	20.6

Conclusions

- Index insurance tick size was optimized in-sample. So results likely reflect “best-case” scenarios.
- Results suggest that the index insurance could benefit landowners and farmers in the Central Valley.
- Results for loaded premiums were similar with slightly higher standard deviation of net losses and maximum losses.
- Data on revenue streams and initial wealth would be needed to conduct an expected utility analysis.
- Future research could examine potential benefits for other users of CVP water (e.g., metropolitan water systems) or examine complementarity with water markets.

Thank You

- Maestro, T., B.J. Barnett, K.H. Coble, A. Garrido, and M. Bielza, 2016, "Drought Index Insurance for the Central Valley Project in California," *Applied Economic Perspectives and Policy* 38(3):521-545.