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ALSO IN THIS ISSUE

From Drought to Deluge: Designing Groundwater Pricing Policies to Cope With California's Water Woes

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Groundwater pricing presents a promising tool for managing groundwater demand under California's Sustainable Groundwater Management Act. We use data from an agricultural region on the Central Coast to examine how farmers respond to an increase in price over a five-year period. We find that farmers are increasingly responsive to price over time.

Groundwater is an essential component of the water supply in California, supporting crop production and livestock in the largest agricultural state in the United States. Use of this resource can double from 40% in an average year to 80% in a drought year, as farmers turn to groundwater to make up for shortfalls in surface water deliveries.

As a result, groundwater levels fluctuate between wet and dry years in California. But the Central Valley loses groundwater much faster in a dry year than it can recover it in a wet one. A recent report by Donald Argus and co-authors in *Geophysical Research Letters* found that only a third of Central Valley groundwater lost during the recent, severe drought was recharged during subsequent years of heavy precipitation. So, despite the deluge California is receiving this year, it's unlikely that groundwater levels will recover from the damage done during the last drought.

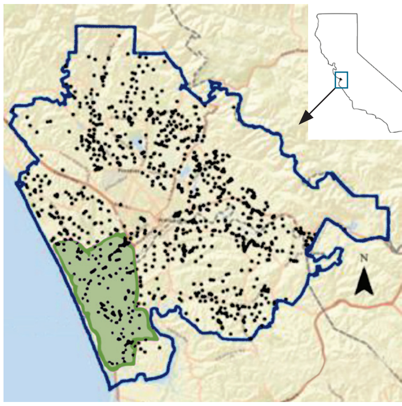
Part of why excessive depletion is occurring is because this resource is largely unmanaged. Groundwater is essentially free and unmetered. But this is changing with the Sustainable Groundwater Management Act (SGMA), which requires local agencies throughout the state to monitor and manage groundwater. The legislation covers more than 95% of the agricultural groundwater use in the state. Groundwater agencies throughout the state are actively revising and implementing plans to achieve sustainable groundwater use by 2040.

Pricing Groundwater

Economists have long suggested that pricing can be used to manage resources at the lowest cost. Pricing groundwater incentivizes users to be more efficient without prescribing how to change their behavior. This kind of flexible, incentive-based policy enables a regulator to achieve sustainable groundwater use with little to no knowledge of the capacity of each individual user to reduce groundwater consumption.

While agricultural groundwater pricing is popular among economists, this policy is rarely enacted in practice. Part of this can be explained by Proposition 218 and the ease with which landowners can vote down a proposed tax. California Proposition 218, the "Right to Vote on Taxes Act" which was passed in November of 1996, requires local governments to get taxpayer approval for property-related fees, and states that taxes charged to different parcels must reflect the proportionate service that those land parcels receive in return. Further, Prop 218 requires that water rates adhere to cost-of-service requirements, and pegging prices in this way could prevent agencies from using groundwater pricing as a means of directly incentivizing conservation.

Figure 1. Metered Wells Within the Boundary of the Pajaro Valley Water Management Agency



Source: Author's calculations based on Pajaro Valley Water Management Agency data.

Note: Green-shaded area indicates the Delivered Water Zone (DWZ). This area faced higher water prices after October 2010.

In groundwater sustainability plans written under SGMA, agencies often impose taxes to generate revenue to fund other basin-management activities. In fact, 60% of management plans state either a plan to implement, or consider the introduction of, a tax or fee. Sometimes these fees are based on acres of farmland or irrigated cropland and other times on groundwater pumping itself. Even if the groundwater agency is imposing a tax on pumping to fund a management plan, and not with the explicit goal of reducing extraction, it can still have a similar effect on water conservation.

Adaptations Over Time

How do farmers adapt to changing water prices? Since groundwater is rarely priced in practice, it's hard to predict what will happen when groundwater prices are imposed. Further, the ways that farmers respond will vary over time. Many agricultural decisions are longer run, with planting choices occurring on intervals that range from months to decades. In the short run, farmers may respond with deficit irrigation, that is, applying less water per acre of irrigated cropland. Over time, farmers may adjust the crops they grow, the acreage they farm, or their irrigation technology. These dynamic responses are critical to understanding the effect of a tax and for informing optimal policy design.

Pajaro Valley, CA

In joint work with Katrina Jessoe and Michael Hanemann, we were able to study this question about the dynamic impacts of a groundwater tax using data from the Pajaro Valley, a productive agricultural region on California's Central Coast. The region provides a rare opportunity because it is one of the few areas in the state with active groundwater metering and pricing. Importantly, a legal ruling created a natural experiment that is perfect for examining this very question. In 2010, the settlement of a lawsuit caused a shift from a single price for all farmers in the region to two geographically distinct volumetric prices. This presented a "control" and "treatment" group that we could use to examine the impacts of a pricing policy by comparing water use before and after the "treatment."

Figure 1 illustrates our study region within the boundaries of the Pajaro Valley Water Management Agency (PV Water). Each black dot represents a metered groundwater well. The green-shaded zone denotes the zone that began receiving a higher price after the legal ruling created a price split.

This area is home to a large and diverse agricultural sector, with more than 30,000 acres in crop production and annual agricultural revenues totaling almost $1 billion. The region primarily produces high-valued commodities, including berries, apples, grapes, artichokes, lettuces, and other vegetable row crops. These crops comprise a mix of annuals and perennials and differ in fixed planting costs, lifespan, and the lag between when the crop is planted and harvested. These differences imply that the time step for water use decisions may range substantially, with farmers making cropping choices seasonally or annually for vegetables and longer for fruit trees.

Figure 2 plots changing groundwater prices during the study period. The yellow line denotes the prices in the "treatment" zone shown in green in Figure 1. Between 2005 and 2010, all users faced the same volumetric price. Starting in October of 2010, PV Water began charging different prices inside and outside of the special zone. After the price split, the percentage difference in price across zones remained constant for five years, with users inside the Delivered Water Zone (DWZ) facing a price that was 21% higher through June 30, 2015.

Quarterly water meter readings spanning 10 years from over 750 farms allow us to capture how farmers respond to prices over time. The persistence of the price split for several years enables the estimation of longer-run responses. We compare differences in the two zones in each of the five years following the price split relative to their differences before the price split, while controlling for other unobservable factors that might confound estimation.

Results

We find that in both the short and longer run, groundwater demand shrinks in response to the price increase, with the magnitude of the response increasing over time. Our results indicate that the 21% price increase led to a 22% reduction in average annual groundwater extraction. But short-run estimates meaningfully differ from those estimated in the longer-run. In fact, the reduction in annual water use doubled over a five-year period.

These results suggest that the avenues of response available to farmers in the short term may differ from the suite available to them in the longer run. In the short term, farmers may respond to a price increase by reducing the amount of water applied per acre of a given crop. However, land-use decisions such as fallowing, crop switching, or converting land out of agriculture may require a longer time horizon, and not manifest as a short-run response. Our findings underscore that the time step for water-use decisions is long, and estimates of water-use change that focus on the short run may fail to capture the full response to a policy.

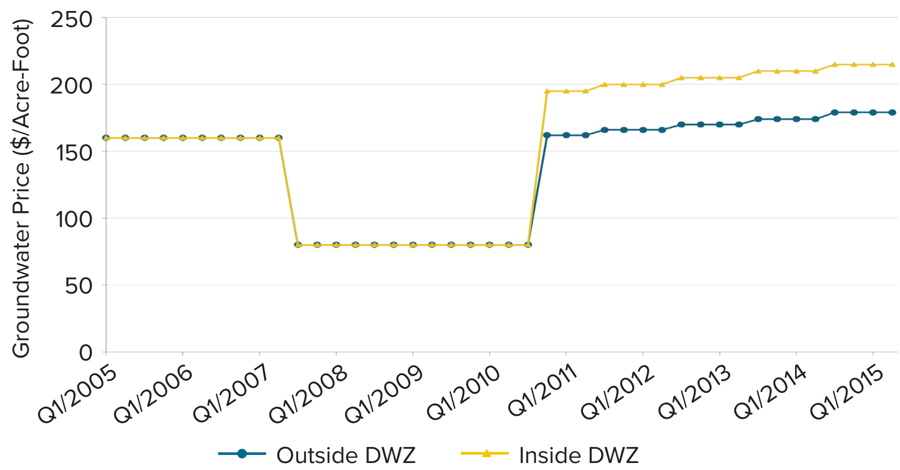
Policy Implications

These dynamics are important for the optimal design of groundwater taxes and are relevant for thinking about how groundwater management agencies will meet sustainability targets under SGMA. The Groundwater Sustainability Plan for Pajaro Valley seeks to reduce groundwater overdraft by 80% and achieve reductions of 5,000 acre-feet (AF) per year by 2023, which roughly represents a 10% cutback in aggregate groundwater extraction.

We estimate a price response in each of the five years following the price split and interpret year-one estimates as short run and year-five estimates as longer run. Using these estimates, we can compute the extent to which the price increase yields the groundwater conservation targets set forth under SGMA using our one-year and five-year estimates.

Our back-of-the-envelope calculation reveals that if we extrapolate into the longer run using year-one estimates, the imposed tax just meets the irrigation district's 10% groundwater conservation target proposed under SGMA. However, this tax would be far too high if we instead leaned on the five-year estimate, with the irrigation district exceeding the target three-fold. Thus, the choice of short-run versus longer-run estimates can yield fundamentally different policy conclusions.

Figure 2. Pajaro Valley Groundwater Fees Over Time



Source: Author's calculations based on Pajaro Valley Water Management Agency data.

Note: DWZ = Delivered Water Zone.

Concluding Thoughts

Groundwater management will be extremely important for the future of farming in California. As climate change causes more variable and extreme weather patterns in the state, groundwater reserves will become more important for buffering shocks and adapting to change. Pricing groundwater will not only help to incentivize conservation in the dry years but will also help to encourage recharge in wet years like this one. Attaching the proper value to this resource is critical for managing it.

While pricing groundwater presents one promising tool, its implementation is tricky and complicated by dynamics in farmers' responses. Figuring out how to achieve sustainable groundwater use is challenging, but case studies like this one provide opportunities to learn about the impacts of policies in practice and what that means for optimal policy design going forward.

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For additional information, the author recommends:

Bruno, Ellen M., Katrina K. Jessoe, and W. Michael Hanemann. 2023. "The Dynamic Impacts of Pricing Groundwater." Department of Agricultural and Resource Economics, UC Berkeley, Working Paper Series. Available at: https://bit.ly/41nk6Ym.

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