Journal of Environmental Economics and Management 91 (2018) 150–165

Contents lists available at ScienceDirect

Journal of Environmental Economics and Management

journal homepage: www.elsevier.com/locate/jeem

Adaptation to an irrigation water restriction imposed through local governance☆

Krystal M. Drysdale [a], Nathan P. Hendricks [b,*]

[a] City of Phoenix, United States
[b] Department of Agricultural Economics, Kansas State University, Manhattan, KS 66506, United States

ARTICLE INFO

Article history:
Received 3 July 2017
Revised 9 July 2018
Accepted 10 August 2018
Available online 16 August 2018

Jels:
Q15
Q25
Q30

ABSTRACT

We estimate how farmers adapted to a water restriction imposed through local governance. The restriction imposed a uniform quota on water use with a 5-year allocation and allowed trading of the quota within the restricted area. Our analysis exploits unique micro-level data on irrigated water use, irrigated acreage, and crops. We use a difference-in-differences econometric strategy that also includes farmer-time fixed effects to estimate the response to the restriction, where we exploit water rights between 2 and 5 miles of the policy boundary as a control group. Results indicate that farmers reduced water use by 26% due to the policy with most of the response due to reductions in water use intensity on the same crops rather than through reductions in irrigated acreage or changes in crops. The results imply that the short-run welfare impact of the policy was smaller than a policy that reduces irrigated acreage.

1. Introduction

Depleted aquifers due to irrigation extraction are a major concern globally. Using data from NASA's GRACE satellite, Famiglietti (2014) found that groundwater is being depleted in the largest global agricultural zones. Scanlon et al. (2012) show significant groundwater depletion in the southern portion of the High Plains Aquifer (e.g., Kansas, Oklahoma, Texas, and New Mexico) as well as the Central Valley in California. The open-access nature of aquifers is often cited as a reason for excessive depletion. Property rights to extract groundwater according to prior appropriations are currently in place in Kansas, yet these property rights have rarely been exercised to reduce the pumping of junior rights. Instead, one area in Kansas reduced groundwater extraction through a restriction starting in 2013 by forming a Local Enhanced Management Area (LEMA). In this paper, we estimate how farmers adapted to this water restriction.

There is a large literature in economics that studies the optimal extraction of groundwater. Gisser and Sanchez (1980) found that the gains from management of an aquifer may be small. However, other studies relax some restrictive assumptions in Gisser and Sanchez (1980) and found larger gains from management (Koundouri, 2004; Brozović et al., 2010; Guilfoos et al., 2013). Lin Lawell (2016) also documents several reasons why farmers may extract groundwater at a faster rate than is dynamically

☆ This material is based upon work supported by the National Science Foundation under Award No. EPS-0903806 and matching support from the State of Kansas through the Kansas Board of Regents, the USDA National Institute of Food and Agriculture, Agricultural and Food Research Initiative Competitive Program, Agriculture Economics and Rural Communities, grant # 2017-67023-26276, and the Arthur Capper Cooperative Center. We thank anonymous reviewers, Brian Briggeman, Bill Golden, Taro Mieno, Karina Schoengold, and participants at the Agricultural and Applied Economics Association annual meeting for helpful comments.

* Corresponding author. author.

E-mail address: nph@ksu.edu (N.P. Hendricks).

https://doi.org/10.1016/j.jeem.2018.08.002

optimal.

Recent articles indicate that there could be significant gains to management of the High Plains Aquifer in Kansas. Pfeiffer and Lin (2012) estimate that groundwater extraction is significantly larger due to spatial externalities. Guilfoos et al. (2016) use a simulation model of different policies that reduce water extraction and find larger gains to management in the LEMA area than other regions in northwest Kansas. Edwards (2016) estimate that land values increased more in counties with greater common pool externalities—due to varying hydrology—in response to the introduction of Groundwater Management Districts (GMDs) in Kansas. These GMDs implemented some rules to reduce common pool externalities—such as well-spacing requirements and closure to new drilling—but did not impose any restrictions on existing water rights. The GMDs were formed in 1972, but concerns about aquifer depletion persist. GMDs argued they did not have the authority required to impose restrictions needed to properly manage the aquifer leading to the passage of legislation in 2012 to authorize LEMAs.

Users of a common pool resource take action to reduce extraction when the benefits exceed the costs (Coase, 1960; Demsetz, 1967). The costs include not only the short-run loss in returns from reduced withdrawals but also the transaction costs of taking action (Wiggins and Libecap, 1985; Ayres et al., 2018). Water rights in Kansas follow the prior appropriations doctrine, so a property right structure exists to reduce groundwater extraction—senior water rights can file a claim that junior water rights are impairing the use of their right. Burness and Quirk (1979) and Libecap (2011) note that applying prior appropriations may not be economically efficient due to large transaction costs of trading water rights. Another approach to reduce extraction is to impose a restriction through local governance or collective action (Ostrom, 1990).

Our paper does not address the important question of transaction costs of trading under prior appropriations, but our estimates of how producers adapted to the restriction sheds light on the loss in short-run returns. An upper bound estimate of the cost of applying prior appropriations is the loss due to a reduction in irrigated acreage by junior water right holders (i.e., assuming transaction costs prevent any trades). Farmers in the LEMA could reduce their water use by reducing irrigated acres or reducing water application on the same irrigated area. To the extent that farmers adapt to the restriction through means other than reduced irrigated acreage, the short-run loss in net returns from the restriction must have been smaller than this upper bound estimate of the cost of applying prior appropriations.

We use a variant of a difference-in-differences estimation strategy where our econometric strategy exploits changes in irrigation behavior inside the policy boundary compared to behavior of water rights between 2 and 5 miles from the policy boundary for those farmers that have water rights both inside the LEMA and in the control group. We decompose the total effect on irrigation water use into responses along the extensive margin (changes in irrigated acreage), direct intensive margin (changes in intensity holding cropping pattern constant), and an indirect intensive margin (changes in intensity due to changes in cropping patterns). We find that the water restriction reduced water use by 26% compared to a counterfactual scenario where no restriction had been put in place. Most of the response occurred along the direct intensive margin (21% reduction), with a smaller but significant response along the indirect intensive margin (4.5% reduction) and an insignificant response along the extensive margin.

Unfortunately, we cannot precisely estimate the short-run welfare impact of the water restriction because we do not have field-level yield or cost of production data to understand how the reduced water use impacted yields and costs. We are able to infer that the loss in welfare is less than $28.08 per irrigated acre because the welfare loss must be smaller than the loss of reducing irrigated acreage since farmers chose to adapt mostly through reduced intensity. It is also noteworthy that minutes from recent public meetings indicate that most producers supported a new LEMA proposal that would create a 5-year allocation for 2018–2022.[1] Farmers in the region would only support a renewal of the quota if they perceived any losses in the short run do not exceed the gains in the long run.

Our work is most closely related with Smith et al. (2017). They study the impact of a self-imposed water tax on irrigation in a district in Colorado. In their case, the district imposed the tax in an effort to avoid state regulations on pumping. Smith et al. (2017) also use a difference-in-differences methodology and find that a tax of $75/acre-foot of water reduced extraction by 33%. They also find that most of the response occurs due to reduced irrigation intensity along with limited changes in cropping patterns and irrigated acreage. A key difference between our methodology and Smith et al. (2017) is that we are able to also control for farmer-time fixed effects. We show that omitting these farmer-time fixed effects leads us to overstate the impact of the policy on water use. We also do not have the presence of surface water allocations in our context that complicate the analysis in Smith et al. (2017) and we estimate an event study to understand if the response changed over time.

In another related study, Hornbeck and Keskin (2014) estimate adaptation of agriculture to water availability. They exploit the introduction of new technologies after World War II that allowed farmers to extract groundwater from the High Plains Aquifer. Hornbeck and Keskin (2014) find that counties over the High Plains Aquifer initially adapted by expanding irrigated acreage with little changes in total farmland acreage and then in later periods also began expanding total farmland. They also find that farmers over the High Plains Aquifer adopted higher-valued crops that were more sensitive to droughts. The results in our study indicate that in the short run, farmers adjusted to a water restriction primarily by reducing the intensity of irrigation with relatively small changes in cropping patterns. Therefore, farmers have responded to the LEMA water restriction mostly by

[1] See the formal review and advisory committee reports available at http://agriculture.ks.gov/divisions-programs/dwr/managing-kansas-water-resources/local-enhanced-management-areas/lists/lemas/sheridan-county-6-lema.