Extended Abstract

Paper/Poster Title	Optimal and Sustainable Groundwater Use: Evidence from Nebraska

Abstract prepared for presentation at the 98th Annual Conference of The Agricultural Economics Society will be held at The University of Edinburgh, UK, 18th - 20th March 2024.

Abstract	***200 words max***

The agricultural sector is the primary water consumer in the US, and groundwater is one of its main sources. Groundwater use presents a common pool problem: if a farmer pumps groundwater, she decreases the aquifer's water table and thus increases the cost of pumping for farmers in the same aquifer. I leverage detailed farmer-level data on (ground)water use and crop yields to study the equilibrium implications of the current groundwater costs in Nebraska. To estimate the effect of water costs on water use and crop choices, I combine a crop-growth model with an economic model. I use the crop-growth model to recover the precise relation between water use and crop yields. I use the economic model to estimate the marginal cost of water for farmers. I then quantify how farmers respond to water costs by switching crops or changing the water use per planted crop. I find that farmers are inelastic to water costs: a 10% increase in the water cost would decrease water use by 3%. Moreover, farmers adapt to higher water costs by both reducing the water use per planted crop and fallowing the land. Lastly, I utilize my estimates to compute the optimal tax on groundwater use.

Keywords	Agricultural Production; Irrigation; Water Conservation
JEL Code	Q1, Q2, Q5

Introduction	***100 – 250 words***

The agricultural sector is the largest water consumer in the US. It accounts for 80% of the nation's consumptive water use, a figure that escalates to 90% in Western US. Groundwater is one of its main sources, with 65% of irrigated farmland relying on groundwater for their water supply. Groundwater use is largely unrestricted in the country, which has led to a systematic depletion of most of its aquifers. Policymakers are thus concerned about the sustainability of the current groundwater utilization, actively seeking the necessary policies to address this issue.

In this paper, I leverage detailed farmer-level data on water use, crop choices, and crop yields to study farmers' groundwater use decisions and their implications for optimal groundwater management policies. I focus on the Ogallala Aquifer in Nebraska. I develop a structural model where farmers endogenously decide which crop to plant and how much water to use in their planted crops, given the cost of groundwater. I combine this model with a crop-growth model to recover the precise (agronomic) relation between water use and crop yields. I then estimate how farmers would respond to changes in the cost of water and how much of such a response would be done through crop choices and water use per planted crop.

Methodology	100 – 250 words

I develop a two-stage model on crop choices and water use. In the first stage of the model, farmers decide which crop to plant. In the second stage of the model, the weather is realized, and farmers decide how much water and fertilizers to use to maximize profits.

I combine my economic model with a crop-growth model. The crop-growth model gives me a precise relation between inputs, especially water use, and yields. I thus use it to approximate a production function per crop-county, the smallest unit in which I observe the farmer. Then, I assume that the farmer's production function is the product of her individual-level productivity and the crop-growth-model production function. Since I observe water use, I can jointly recover the individual-level productivity and the fertilizer application by the optimality conditions of my model. More precisely, I recover these two unknowns from two model-implied equations. With the individual-level productivity, fertilizer application, and water use, I can flexibly recover the marginal cost of water per farmer from the first-order condition for water use in my model.

With the individual estimates for productivity and the marginal cost of water, I compute the expected profitability per crop and farmer. More specifically, I compute the optimal water-fertilizer input decision and thus profitability, given the weather. I then take the expected profits of each crop as the average profits over the potential weather. Lastly, I use the estimated profits to recover the preference parameters over crops using a discrete-choice model.

Results	100 – 250 words

My main findings are the following. First, I find that the marginal cost of water is rather heterogeneous within the region: the average marginal cost per acre-feet of water is 137 USD, whereas the standard deviation is 148 USD. The variation can be partially explained by observables in the data, such as the aquifer's water table beneath the farmer's land. I then quantify the relation between the marginal cost of water and the aquifer's water table. I find that the water table has a significant and relevant effect on the marginal cost of obtaining groundwater: a decrease of 1 foot on the water table increases the water cost per acre-feet by 5.4 USD. Third, I estimate the preference parameters to analyse how farmers respond to changes in water costs. More specifically, I quantify when farmers opt to switch crops and when they decide to change the water intensity per planted crop. I find that farmers are inelastic to water costs and that the two main margins of adaptation to an increase in water costs are decreasing water use per planting crop and fallowing the land. Lastly, I use my estimates to compute the optimal tax on groundwater use. I find it that an increase in 10% on the marginal cost of using water would be optimal.

Discussion and Conclusion	100 – 250 words

I leverage detailed farmer-level data on water use, crop choices, and crop yields to study the equilibrium implications of the current groundwater costs in the Ogallala Aquifer in Nebraska. In my analysis, I combine a crop-growth model with an economic model. I use the crop-growth model to recover the precise (agronomic) relation between water use and yields. I use the economic model to quantify the main margins of adaptations for farmers when they experience a change in their water cost. My model allows me to separately identify the individual-level productivity, marginal cost of water, and crop preferences for farmers.

My main findings are the following. First, farmers are rather heterogeneous in their marginal cost of groundwater in the region. For example, the average marginal cost of obtaining groundwater is 137 USD dollars in 2018 prices, while the standard deviation is 148 USD. Second, the water table has a relevant effect on the cost of obtaining groundwater. Third, farmers are inelastic to water costs, and they adapt to higher water costs by reducing the water use per planted crop and fallowing the land. Lastly, I utilize the estimates of my model to compute the optimal and sustainable tax on water use.