THE RESPONSE OF AGRICULTURAL WATER USE TO CHANGES IN PUMPING COSTS

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Abstract. We estimate the response of agricultural water use to differences in pumping costs. Data come from *Agricultural Water: Potential Use and Management Program in Georgia*, supplemented by climatic and crop-specific information. The results show that pumping costs are a significant determinant of water use, although the magnitude of the effect is not huge. Some limited inferences can be made to how agricultural irrigators might react to different levels of volume-based water pricing.

INTRODUCTION

The state of Georgia is in the process of transition from having abundant water resources to not being able to supply water for all desired uses at all times. There are several reasons for this – increasing demands for instream flows to support environmental quality, increasing population, and increased use of water for agricultural and horticultural production being among the most significant.

Estimated water use in rural areas of Georgia grew 723% between 1960 and 1995 (USGS) as irrigated acreage went from almost nothing to 2.2 million permitted acres in 2000 (Georgia Board of Natural Resources). Irrigation is clearly important for the health of Georgia's agricultural industries. It is just as clearly important to include this sector in the state's overall plan to manage its water resources comprehensively and sustainably.

Under current practices, holders of agricultural water permits are allowed to pump up to the rated capacity of their equipment at all times. Understanding how to conserve water in agriculture requires information about how much it would cost agricultural producers to use less water in different places and on different crops.

This paper uses data on irrigation decisions to make inferences about how agricultural producers would respond to increases in the price they face for water use. Our method is based on using pumping costs as a proxy for water price.

THEORY

Farmers' decisions about irrigation depend not only on crop choice, soil characteristics, and rainfall conditions, but also on the profitability of using water as an input. This, in turn, depends on the economic cost of that water at the margin.

The price of water in Georgia currently reflects only the costs of pumping/ diversion, storage, treatment, and delivery. The fact that water is scarce does not affect farmer's decisions about whether to irrigate and how much water to use. This makes it difficult to predict how agricultural water use would change if there were a scarcity value in the price farmers pay for water.

The energy that farmers use to pump irrigation water represents a significant cost, and varies with the depth of the well and the characteristics of the pump and the fuel. We use this information to investigate how changes in the marginal cost of irrigation water affect irrigation volumes. The results suggest that farmers do use less water when it is more expensive, by significant but not overwhelmingly large amounts.

DATA

The data come from *Agricultural Water: Potential Use and Management Program in Georgia*, conducted by the university of Georgia's Nationally Environmentally Sound Production Agriculture Laboratory. Dr. Jim Hook and Dr. Dan Thomas have led an extensive data collection effort that has dramatically increased the state of knowledge about Georgia's irrigation practices by monitoring irrigation use of about 4% of Georgia's farmers. Data from this source include water use, crop type, area, and well depth. These data were augmented with meteorological information reported the National Oceanic and Atmospheric Administration. Due to limitations in information about surface water diversions, the sample we analyze has been restricted to groundwater users. We further restricted the data set because of incomplete records for some farmers, leaving us with 707 usable observations for this analysis.

METHODS

In order to estimate the marginal cost of pumping water from various depths, the engineering relationship between lift, pressure, and total dynamic head (TDH) was taken from Lamont et. al. (2001)

$$TDH = psi * 2.31 + LIFT$$

where psi is the pumping pressure and LIFT is the number of feet from the water table to the surface in feet. We then used estimated constants from the literature (Rogers and Alam 1999) to estimate fuel use from TDH and fuel type. Price data from the appropriate year was used to convert this information to dollars of pumping cost per acre-foot.

We used a Blaney-Criddle (USDA 1970) water demand index to measure water needs based on crop choice, growing season temperatures, and rainfall. The formula used was

$$BCI = [Temp * P * K_c]/100 + - PREC$$

where BCI is the estimated index of irrigation need, Temp is a composite temperature measure, P is mean daytime hours, K_c is a crop-specific water demand factor, and precipitation is a cumulative site-specific measure.

We then estimated water use per acre (IRR_acre) as a function of the marginal pumping cost (PC), the Blaney-Criddell water needs index (BCI), the growing year (1999 provides the base year, with dummy variables D00, D01, and D02 indicating growing seasons ending in 2000, 2001, or 2002), and the location of the field as either inside (64% of our observations) or outside (36%) the Flint River Basin (FRB):

$$IRR\_Acre = b_0 + b_1 PC + b_2 BCI + b_3 D00 + b_4 D01 + b_5 D02 + b_6 FRB + \varepsilon$$

RESULTS

Our regression equation performs reasonably well, with all variables except the Flint River Basin dummy and the dummy for the 2002 growing season showing statistical significance at the 95% level. The adjusted R^2 of 0.18 indicates that a substantial part of the variation in water is not explained by the variables in this regression. A $1 increase in the costs of pumping an acre-foot of water decreases water use by .007 acre-feet. This implies that an increase of $50 per acre foot in pumping costs is associated with a decrease in water use of .34 acre-feet (about 4 acre-inches). Fifty dollars is a useful reference price, and is what California's drought water bank paid for agricultural water in 1992 and 1994 (Howitt 1998). The mean water use in our sample is .42 acre-feet. Changes in pumping costs that are conservative in magnitude relative to water costs in other parts of the country therefore may change water use in Georgia by a significant percentage.

The Blaney-Criddell index was also of the expected sign and highly significant – this is unsurprising, and indicates only that this variable captures some part of the influence of crop choice, rain, and temperature on irrigation decisions.

Growing seasons ending in the years 2000 and 2001 had significantly higher water use than 1999, holding other factors constant. In 2000 water use was three acre-inches greater than in 1999, and in 2001 it was 2 acre-inches greater. This may have been a response to heightened concern about the effect of drought on yields, or may reflect some other unexplained set of concerns or behavior.

The fact that location in the Flint River Basin does not seem to indicate any markedly different behaviors supports the view that crop producers in Georgia operate in a fairly similar manner throughout the state.

DISCUSSION

We believe these results support the position that farmers consider the cost of water in making irrigation decisions. This implies that management strategies that include a pricing component may be effective. It is not only tax or fee policies that can include price as one of the factors in farmers' decisions. Quantified water use rights with the possibility of exchange would offer similar incentives to conserve.

We caution against putting too much weight on the specific estimates presented here. Pumping cost is likely an imperfect proxy for price, in that farmers' knowledge of pumping costs in likely to be inexact, and farmers may respond differently to a direct incentive like price than to a less obvious incentive like fuel costs.

We also urge caution because of the relatively small sample and the number of discarded observations in our data set, and because of the strong assumptions needed to estimate pumping costs.

However, we think it highly likely that farmers' response to a change in the actual price they pay for water might be significantly greater than response to changes in pumping costs. This is because institutional change that brought about explicit water pricing would be accompanied by increased awareness of water use and a very clear price signal. Estimating marginal energy costs is likely to be inexact and not as transparent to farmers making irrigation decisions.

FURTHER RESEARCH

Farmers can respond to changes in water costs by using less water, by investing in more efficient irrigation technology, or by choosing to grow a different crop (or no crop at all). We believe it would be valuable to investigate the effects of water price on these latter two avenues for water conservation. Doing so will require more and better data.

We would like to be able to say something about how changes in water cost affect farm profitability. Investigation of this question requires that existing data be augmented with information about crop yields.

CONCLUSION

Using pumping cost as a proxy for water price, we find that farmers use less water for irrigation when it is more expensive. These effects were similar inside and outside the Flint River Basin. Overall, the results support the view that moderate increases in water prices will decrease the quantity of water used by agriculture by a significant amount.

LITERATURE CITED

Board of Natural Resources Presentation to Joint Comprehensive Water Plan Study Committee (SR 142). Water Issues White Paper. May 31 2001.

Howitt, Richard, "Spot Prices, Option Prices, and Water Markets," in Markets for Water: Potential and Performance, Easter, Rosengrant, and Dinar (eds), Kluwer Academic Publishers, 1998.

Lamont Jr., William J., Jayson K. Harper, Albert R. Jarrett, Michael D. Orzolek, Robert M. Crassweller, Kathleen Demchak, and Georget L. Greaser. Irrigation for Fruit and Vegetable Production. *Agricultural Alternatives*. The Pennsylvania State University. College of Agricultural Sciences. Agricultural Research Extension and Cooperative Extension Service. 2001.

National Environmentally Sound Production Agriculture Laboratory (NESPAL). *Agricultural Water Pumping Study Data*. 1999-2002.

Rogers, Danny H and Mahbub Alam. Comparing Irrigation Energy Costs. Irrigation Management Series. MF-2360. Kansas State University. Agricultural Experiment Station and Cooperative Extension Service. January 1999.

USDA Soil Conservation Service Engineering Division, Technical Release #21, September, 1970.

Regression Statistics	
Multiple R	0.433
R Square	0.187489
Adjusted R Square	0.180524
Standard Error	0.386283
Observations	707

	Coefficients	*t Stat*
Intercept	0.454142	8.086867
BCI	0.026448	6.387436
PC	-0.0067	-3.72326
D00	0.250394	5.42537
D01	0.184009	4.030542
D02	-0.21293	-1.41483
FRB	-0.06263	-1.11223