Impact of On-farm Water Conservation Practices on Groundwater Use in Arkansas

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INTRODUCTION

• Arkansas is the fourth largest user of groundwater in the nation. Its agriculture is heavily irrigated.
• The continuous and unsustainable pumping has put the aquifer in danger. An annual gap in groundwater as large as 7 million acre-feet is projected for 2050 (ANRC, 2015).
• Switching to more efficient irrigation technologies has often been proposed as a solution to water shortage problems. In particular, most existing studies have focused on the switch from traditional gravity irrigation to center pivot or to drip irrigation and analyzed their effects on water use (irrigation application rate or consumptive use).
• The focus on more efficient irrigation technologies, however, may miss important aspects in farmers’ behavior in dealing with water shortage problems. In addition to more efficient irrigation technology, a wide range of Water Management Practices (WMPs) could play a substantial role in water conservation in the US agriculture (Schaible and Allery, 2012).
• The data set used in this paper shows that almost half of farms under gravity irrigation also uses WMPs such as tailwater pits, laser land leveling, and alternate row irrigations.

RESEARCH QUESTIONS

• Does switch from gravity irrigation to pressure system affect irrigation water application rate in Arkansas?
• Does using WMPs within gravity irrigation generate a significant impact on water application rate?
• How do farm adjust water use under these different irrigation practices?

DATA

• Farm and Ranch Irrigation Survey (FRIS) collected by the US Department of Agriculture. It is arguably the most comprehensive data on irrigation. It contains information on irrigation water application rates, the use of irrigation technologies on a crop-specific basis as well as information on a range of WMPs.
• FRIS is a set of repeated cross-sectional data. Years 1998, 2003 and 2008 are used in the paper.
• County-level climate data such as daily precipitation and temperature are obtained from National Climatic Center (NCDC, 2014).
• Soil quality information is extracted from the Soil Survey Geographic database (SSURGO).

ESTIMATION

• Specifications to examine farm water use
  -- Dependent variables: Total farm level water use; water use per acre; % of irrigated area; % of acreage allocated to soybean, rice, corn, cotton (SUR)
  -- Key RHS variables: % of irrigated acreage allocated to gravity; % of irrigated acreage allocated to gravity * WMP dummy; % of irrigated acreage allocated to pressure system.
  -- Control variables: dummy that equals one if major occupation is farming; years of experience on farm; farm size; degree of crop diversity; an index that measures crop diversity on farm; % of irrigation water supply that comes from groundwater; price of water calculated as energy cost per acre-foot; average saturated hydraulic conductivity; total precipitation in growing season; total degree days.
• Specification to examine crop level water use adjustment. Dependent variable: crop specific water use per acre
• Instrumental variables for key RHS variables: Lagged county level % of irrigated acreage allocated to gravity; Lagged county level % of irrigated acreage allocated to pressure system; % of cultivated land that is rented; higher moments of the distribution of historic temperature and precipitation (previous 30 years, standard deviation and skewness).

RESULTS AND DISCUSSION

• For soybean, corn and cotton, the majority is still using gravity irrigation. In addition, most combined gravity irrigation with one or more WMPs. So at least in Arkansas, switching to more efficient irrigation technology is not the dominant behavior.
• Either switching to pressure system or staying with gravity irrigation but using WMPs reduce water application rate. When comparing farm water use without taking into account whether WMPs are used or not, the difference between gravity and pressure system is smaller or disappears. This says it is important to take into account WMPs as an important dimension of farmers’ irrigation behavior.
• When switching to pressure system or using WMPs, farmers adjust water use both at the intensive margin (water use per acre) and at the extensive margin (crop mix and irrigated acreage).