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Willingness to pay for irrigation water when groundwater is scarce

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ABSTRACT

Conversion to surface water irrigation is one of the critical initiatives to address the decline in groundwater supply. A double-bounded dichotomous choice contingent valuation survey is used to estimate producers' willingness to pay (WTP) for surface water supplied by irrigation districts in Arkansas, United States. The estimated mean WTP for irrigation water is 2.7 ¢/m^3 ($33.21/acre-foot). Comparison indicates a significant share of producers are likely to have higher WTPs for surface water than the average pumping cost in the study area. Producers located in areas with less groundwater resources have higher WTPs. Producers that are more concerned with a water shortage occurring in the state in the next 10 years have higher WTPs. A somewhat unexpected result is that participation in the Conservation Reserve Program predicts lower WTPs. One possible explanation is that farmers see the transfer of land out of crop production as a more viable financial decision when groundwater supply decreases.

1. Introduction

Diminishing groundwater resources is threatening the security of nearly half of the world's drinking water supply and 43% of the world's irrigation water supply (Van der Gun, 2012). One main solution policy makers in many countries have relied on to reduce groundwater use is to improve irrigation efficiency. However, several recent empirical studies have shown that using more efficient irrigation technologies may actually increase total farm level water use (e.g., Pfeiffer and Lin, 2014). Groundwater trading can increase the allocative efficiency by moving water to higher value users, while market-based mechanisms may increase water use by activating previously unused (sleeper) or under-used (dozer) water entitlements (Palazzo and Brozović, 2014; Wheeler et al., 2014). Conversion to surface water irrigation where surface water resources are abundantly available has the most direct impact on reducing groundwater withdrawals. Although this approach has not been widely studied in academics, it has caught the attention of policy makers both in the US (e.g., MWH, 2008; North Harris County Regional Water Authority, 2014) and in other developed countries as well as developing countries such as Bangladesh (Krupnik et al., 2016).

In areas where infrastructure needs to be constructed to deliver surface water, estimates of the economic value of irrigation water to producers would be needed to conduct cost-benefit analysis of such projects as well as assess the financial viability of surface water irrigation systems. While several studies have examined the impact of water scarcity on the market value of water, few have analyzed non-market benefit of water to agricultural users. Mesa-Jurado et al. (2012) used the contingent valuation method (CVM) to show that the willingness to pay (WTP) of farmers in the Guadalquivir River Basin in southern Spain increased under conditions of water scarcity when farmers perceived the impact of guaranteed water supply to positively influence their own welfare. Toshisuke and Hiroshi (2008) evaluated the economic value of irrigation water to urban and non-urban users in Japan and found that rural users who rely on water resources for household use and to maintain agricultural income have a higher WTP for water than urban users. Storm et al. (2011) model demand for irrigation water in the Moroccan Drâa Valley using CVM and found that producer's true WTP exceeds current water prices in the region, but also note that only small increases in cost would be politically tenable, and because demand for irrigation water is relatively inelastic such price increases would do little to prevent aquifer drawdown.

This study uses a double-bounded contingent valuation method to estimate agricultural producers' WTP for off-farm surface water in an environment of decreased availability of groundwater resources in the Mississippi Delta region of the southern United States. Our WTP findings are useful to policy makers and agricultural producers around the world where irrigated agriculture is

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critical to the economy and adaptation to decreasing groundwater supply is a concern. In particular, the results are critical for evaluating the economic viability of infrastructure projects to bring surface water to farming communities. Our analysis also examines which factors have predictive power for influencing producers' WTP for off-farm shipments of irrigation water. Both our research design and research findings are useful for understanding the potential for conversion to surface water to alleviate the pressure on groundwater.

The rest of our paper is organized as follows. The next section describes the study region. The third section presents the survey data and variables used in the empirical analyses. The fourth section outlines econometric methodology. The fifth section reports results. The final section concludes.

2. Study area

The climate of the state of Arkansas in the United States is humid and subtropical, with an average high temperature of approximately 22.2 °C (72 °F) and an average low temperature of approximately 10 °C (50 °F) (ANRC 2017). During summer months, temperatures regularly reach 37.8° (100 °F), and in winter months, temperatures often fall below 0 °C (32 °F). The region experiences an average total annual rainfall of 127 cm (50 in.). However, months with the greatest quantities of rainfall (October through May) occur outside of the growing seasons of major crops such as rice and soybean. As such, there is usually insufficient rainfall within the study region during the growing season to sustain agricultural production, causing producers to rely heavily on groundwater to meet irrigation needs.

Agricultural production is of key importance to Arkansas's economy. The value of rice, soybean, corn and cotton production totaled $2.6 billion in 2013, about 2.4% of the state's gross domestic product (English et al., 2015). Arkansas ranks first among states in terms of rice production, accounting for 49.96% of total US production (USDA-ERS, 2016). It also exports large quantities of rice and is an important player in the global rice economy (ARF, 2015; English et al., 2013; Richardson and Outlaw, 2010).

Irrigation is the most important input in Arkansas' crop production. For example, despite a widespread drought throughout much of Arkansas in 2012, Arkansas soybean farmers harvested record yields (Hightower, 2012). In 2013, Arkansas accounted for 8.9% of all cropland under irrigation in the US, and the state is the third largest user of irrigation water in the country (USDA-NASS, 2014). Irrigated hectares in Arkansas have also increased steadily over years. In 2013, Arkansas farmers irrigated about 93% of rice, soybean, corn and cotton, compared to 81% in 2003 and 87% in 2008 (USDA-NASS, 2004, 2009, 2014). Most crop production is in the Arkansas Delta located in eastern Arkansas. The area is underlain by the Mississippi River alluvial aquifer (MRVAA), which extends approximately 402 km (250 miles) from north to south and 121 km to 241 km (75–150 miles) from west to east (Czarnecki et al., 2002). The Arkansas Natural Resources Commission (ANRC, 2012) estimates that agricultural irrigation is responsible for 96% of all withdrawals from the MRVAA.

However, the continuous and unsustainable pumping has put the MRVAA in danger by withdrawing at rates greater than the natural rate of recharge. Many counties in east Arkansas have been designated as critical groundwater areas due to continued decline in groundwater levels (Arkansas Soil and Water Conservation Commission, 2003). Continued drawdown of the MRVAA, largely the result of increased irrigation to insure against drought induced losses, as in 2012, poses a threat to the continued success of water intensive crops in Arkansas (Kovacs et al., 2015). An annual gap in groundwater as large as 8.6 billion cubic meters (7.26 million acre-feet) is projected for 2050 and most of the expected shortfall is attributed to agriculture (ANRC, 2015). In focus groups conducted by the authors in November 2014 with stakeholders from east Arkansas, the decline in groundwater supply was ranked among the top concerns by producers.

To combat growing projected scarcity, the state of Arkansas and the ANRC have identified two critical initiatives in the 2014 Arkansas Water Plan Update highlight adopting conservation measures that can improve on-farm irrigation efficiency as well as infrastructure-based solutions that convert more irrigated hectares currently supplied by groundwater to surface water in eastern Arkansas (ANRC, 2015). Surface water in Arkansas is relatively abundant and is allocated to farmers based on riparian water rights.[1] The ANRC (2015) estimates that average annual excess surface water available for inter-basin transfer and non-riparian use is 9.4 billion cubic meters (7,605,800 acre-feet). Currently, the purchase of off-farm surface water is relatively rare in Arkansas. In the Farm and Ranch Irrigation survey conducted by the National Agricultural Statistics Service (NASS) of the USDA, only 245 farms (4.82%) reported utilization of off-farm surface water in Arkansas in 2012 (NASS, 2014). The per cubic meter price these produces paid ranged from less than 0.08¢ to more than 4.9¢ ($1 to $60 per acre-foot).

The Grand Prairie Area Demonstration Project and the Bayou Metro Project[2] are both important features of the Arkansas Water Plan, which are designed to supplement agricultural groundwater irrigation with surface water in the hopes of reducing groundwater withdrawals in the Grand Prairie Critical Groundwater Area and preventing decline of the deeper Sparta Aquifer, which is a critical source of drinking water for the region (ANRC, 2015). In total, ANRC (2015) estimates that the construction of needed infrastructure to shift groundwater irrigation to surface water irrigation in the nine major river basins of eastern Arkansas will cost between $3.4 and $7.7 billion. Financing these projects has grown increasingly difficult because of decreases in the availability of federal grants, cost-share and loans (ANRC, 2015). As such, understanding the nature of water use and quantifying the full value of irrigation water to agricultural producers in the Delta will be critical for continued funding and long-run success of irrigation district projects, as well as the long-run viability of agricultural production in Arkansas.

3. Data and variable definitions

The data set comes from the Arkansas Irrigation Use Survey conducted by the authors with collaborators from Mississippi State University. The survey was completed in October 2016. Survey data were collected via telephone interviews administered by the Mississippi State University Social Science Research Center. Potential survey respondents come from the water user database managed by the ANRC and all commercial crop growers identified by Dun & Bradstreet records for the state of Arkansas. Of 3712 attempted contacts, 842 resulted in calls to disabled numbers, resulting in a net sample size of 2870. Of the remaining contacts, 1321 led to no answer, busy signal or voicemail. Another 925 contacts were ineligible due to illness or language barrier or identified as non-farmer. In total, 624 contacts reached were eligible to complete the survey.

[1] In Arkansas, when land toucfhes a surface water resource (a lake, stream, river or other waterway), land owners have the right to divert water without permit if doing so does not unreasonably harm another use. Arkansas law also provides a mechanism for non-riparian owners to divert surface water with approval from the ANRC as long as the use is reasonable, beneficial and will not adversely impact the environment (ANRC 2015).

[2] These projects are expected to supply irrigation water to 15% of regions with expected groundwater gaps (ANRC 2015).