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An experimental analysis of water leasing markets focusing on the agricultural sector☆

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ABSTRACT

Climate variability, population growth and persistent droughts present water managers with challenges in allocating ever scarcer water resources. Water marketing intuitions that allow for the temporary transfer of water between water users can provide water managers and users with the ability to manage this challenge with minimal conflict. This paper develops a water market for temporary transfers for the Middle Rio Grande, NM as a test case to provide water managers and users with insight to a functioning market prior to implementation. Using the techniques of Experimental Economics the developed marketplace provides insights to two key questions: (1) does the value of water rights differ by the types of users engaging in the transaction, (2) how is economic welfare distributed amongst water users as a result of market transactions. The results of the experiments demonstrate that water values differ across trading partners and economic welfare gains as a result of market transactions are largest for capital crop farmers.

1. Introduction

Throughout the western U.S. water managers are faced with challenges in fulfilling existing water demands due to droughts, climate variability, population growth and shifting water demands. Over the last three decades market transfers of water rights have been one institution that has provided water managers with the ability to realign water rights as a measure of coping with potential water shortages. While the potential benefits of market based transfers have been widely published in the literature there are limited functioning water markets that can be found throughout the western U.S. (Washington Department of Ecology, 2004). One potential challenge that limits market activity is the lack of reliable information on how water markets could influence the value of water rights. Without this information potential sellers and buyers are unsure of the value of a water right and may be hesitant to enter the marketplace.

To date much of the published literature on water markets has had two focuses: (1) theoretical underpinnings of water markets and (2) empirical analysis of existing markets. The theoretical focus can be traced back to Johnson and Gisser (1981), Vaux and Howitt (1984), Saliba and Bush (1987), continuing to the present day in the U.S. by Liebcap (2010), Donohew (2009), Grafton et al. (2011), Janmaat (2011), and internationally by Calatrava and Garrido (2005), Garrido (2007), Garrick et al. (2009), Wheeler et al. (2010), and Tisdell (2011). This stream of literature has focused on the potential welfare gains of water markets for the markets users and possible limitations to market transactions such as third party effects, transaction costs and legal constraints.

Empirical efforts involve the analysis of existing market structures which are often challenged by transactional cost issues, price setting by an administrator and limited sectoral coverage for markets in the western U.S. (e.g. Czetwertynski, 2002; Yoskowitz, 2002; Loomis et al., 2003; Brookshire et al., 2004; Howitt and Hansen, 2005; Brown, 2006; Brewer et al., 2008; Basta and Colby, 2010; De Mouche et al., 2011). Many of these empirical studies have not formally addressed trading impacts and interactions with the natural,

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physical, hydrologic and engineering systems as the studies examine water markets throughout the entire western U.S. rather than for an individual basin.

In contrast, there are a series of articles that have investigated water markets in the Murray–Darling basin in southeastern Australia (e.g. Crase et al., 2000; Bjornlund, 2003; Bjornlund, 2004; Crase et al., 2004; Turral et al., 2005; Brennan, 2006; Brooks and Harris, 2008). Trading activity in this basin has been found to be more frequent as the market users have been able to successful enter the market for permanent and temporary water to manage highly fluctuating and decreasing water supplies. While a water market has proven successful in the Murray–Darling basin application to the western U.S. comes with a unique set of challenges due to the legal structure surrounding water rights, climatic variability and increased municipal demand.

We diverge from the majority of the empirical literature in that we are moving beyond learning by "listening to the radio play" (Smith, 1982) by designing and testing a water market framework for a singular basin in the western U.S. rather than analyzing an existing situation. Tisdell et al. (2004) argue that the use of laboratory experiments, as developed in this research, provide "a formalized, replicable approach to rapidly assess alternate policy directives, typically expressed as market outcomes, prior to catchment-wide implementation." The trading institution designed in this research focuses on the hydrologic dynamics of a singular basin (the Middle Rio Grande, NM) in order to generate data to test the robustness of a water market for temporary transfers to provide water managers and potential market users with information on how market activity could influence the value of water rights, prior to market implementation.

This institution involves a complex hydrological, engineering and trading platform tested through Experimental Economics procedures. The use of Experimental Economics procedures allows a researcher to investigate alternative market mechanisms to gain insight into how a marketplace might function prior to implementation. This technique has been helpful in designing successful markets for environmental policy in removing lead from gasoline (e.g. Kerr and Newell, 2005) and reducing acid rain producing sulfur dioxide from the atmosphere (e.g. Bellas and Lange, 2008).

In this research we seek to gain insights as to how a water market that allows for the reallocation of water rights on a temporary basis could impact the distribution of economic welfare to users in a basin and potential differences in the value of water depending on the parties that engage in a transaction. For instance, Brewer et al. (2008) find dramatic differences in the value of water for urban uses versus agricultural uses. The techniques of Experimental Economics allow us to examine if these differences exist and observe the impact market transfers could have upon the distribution of economic welfare.

The research reported in this paper builds upon the coupled hydrologic and economic model presented in Broadbent et al. (2009) where austere farming choices were used to test a proof of concept model. In this paper the model is extended to include more realistic farming choices by adding a capital crop (pecans) and two cash crops (alfalfa and chili) with multiple months of trading within a growing season. The results of the experiments allow us to investigate two questions: (1) does the value of water differ by user type, (2) how does the distribution of economic welfare change due to market transfers?

The remainder of this paper is as follows. Section 2 provides background on the legal structure of the Middle Rio Grande, our study site. Section 3 discusses the structure of the underlying utility and demand functions for the experimental participants who are assigned the roles of irrigated agricultural, urban municipalities, and how the environmental constraint is imposed for the marketplace along with the computerized double-auction trading platform to facilitate transactions. Section 4 reports the experimental results. Section 5 reflects on the experimental results to provide insights to water managers and users, while Section 6 presents some limitations of the research.

2. Water rights, Middle Rio Grande and climatic scenarios

Throughout the western U.S. the prevailing water law is known as the Doctrine of Prior Appropriation (DPA). In 1848 the discovery of gold in California brought miners in search of gold that quickly led to laws for divvying up the minerals and water needed to harvest gold (Wilkinson, 1992). This principle became known as "first in time, first in right" (Getches, 1997). Later in 1859 major gold strikes were made in Nevada and Colorado. As miners flocked to discover gold in these new states they brought with them California's new water law which became known as the DPA (Wilkinson, 1992). The DPA swept across the western U.S. and was adopted extensively in most states. In a United States Supreme Court ruling of 1911 the Court held that the DPA would be applied between the states as well as within states.[1]

Generally the DPA, as adopted in the western U.S. is that the first person to use a quantity of water from a water source for a beneficial use has the right to the continual use of that quantity of water. Subsequent users are allowed to use water for their own beneficial purposes provided that they do not impinge on the rights of earlier users. This creates a system of water rights that have yearly appropriations and priority dates, older priorities are said to be "senior" to the more recent or "junior" priorities.

2.1. The Middle Rio Grande basin

Utilizing the physical and behavioral characteristics of the Middle Rio Grande (MRG) basin as a test case we design a water market for temporary transfers. The MRG, located in central New Mexico, is characterized by basin and range topography with mountains on the eastern flank and arid valleys and mesas on the central and western flank. In 1907 the DPA was adopted through the New Mexico Water Code (Franks, 2007). In 1931 the New Mexico Underground Water Law was passed extending the 1907 Water Code to groundwater (Jones, 2002). In New Mexico, the DPA establishes a senior right for agricultural water with a priority date of 1907 for the MRG. As such, our work does not focus on differing priority dates as is common in many western U.S. basins as all water rights are a 1907 priority date (see Phillips et al., 2011).

Demands for water resources in the MRG include one urban sector, Albuquerque, with multiple smaller communities (Belen, Bernalillo, Los Lunas, Rio Rancho and Socorro). Agricultural users are present controlling the largest share of available water (see Grafton et al., 2010), with Native American water use represented in the form of irrigated agriculture. Lastly, environmental issues are present through the existence of an endangered fish, the Silvery Minnow, causing minimum flow requirements to be put in place throughout the MRG (U.S. Fish and Wildlife Service, 2003). These environmental issues are common in many basins in the western U.S. For example, the Santa Ana Sucker in California, the Greenback Cutthroat Trout in Colorado and the Virgin River Chub in Arizona and Nevada are all listed as federally endangered species. Using the hydrologic model detailed in Broadbent et al. (2009), we are able to capture the complexities of this basin by extending the model to have six months within a growing season (18 total trading rounds over three growing seasons) in order to model the choices that

[1] See Wyoming v. Colorado, 259 U.S. 419 (1922).