WORKING PAPER

The Influence of the Real Estate Market on Water Right Values in New Mexico's Middle Rio Grande Basin

by
Matthew T. Payne & Mark Griffin Smith

Colorado College Working Paper 2011-09
September, 2011

Department of Economics and Business
Colorado College
Colorado Springs, Colorado 80903-3298
www.coloradocollege.edu/dept/EC

The Influence of the Real Estate Market on Water Right Values in New Mexico's Middle Rio Grande Basin

Matthew T. Payne and Mark Griffin Smith*

Abstract
Water markets in the western United States have expanded over the last 40 years driven by two forces – population growth in the West and Southwest and limited development of new storage projects. Until 2008 house prices, home construction and population growth appeared to be locked in an ever-increasing upward trend. With little historical experience to the contrary, water market prices similarly appeared to be driven by real estate development. The collapse of the housing market in the last three years provides an opportunity to examine the connection between the real estate and water markets.

Introduction

Water supplies are limited and inconsistent throughout the western United States as a result of the region's arid climate. In addition, supply variability intensifies over time as the climate changes.[1] Despite these water scarcity challenges, populations and their associated water demands continue to grow throughout the region. Markets for water rights evolved to satisfy these rising demands. Permanent and temporary water right transfers help new water users obtain supplies in fully appropriated basins, allow cities to accommodate population growth, and assist environmental protection interests in improving habitats for aquatic species.[2] As environmental regulations and a lack of suitable reservoir sites reduce the feasibility of infrastructure solutions to water shortage, water markets serve as an increasingly important mechanism for facilitating economic growth under water scarcity conditions.

* Matthew T. Payne is a Research Associate with WestWater Research, LLC in Vancouver, WA. Mark Griffin Smith is Professor of Economics at Colorado College in Colorado Springs, CO.
The authors are grateful to Charles W. Howe for helpful comments.
[1] NATIONAL ASSESSMENT SYNTHESIS TEAM, CLIMATE CHANGE IMPACTS ON THE UNITED STATES (2000).
[2] John B. Loomis et al., *Expanding Institutional Arrangements for Acquiring Water for Environmental Purposes: Transactions Evidence for the Western United States*, 19 WATER RESOURCES DEVELOPMENT 21-28 (2003)

In western water markets, water right trading activity is rising as urban populations grow, environmental protection interests enter the market, and investors recognize potential returns from water scarcity. However, water right values and price trends remain misunderstood as a result of the private nature of sale prices, and heterogeneity in water rights as well as regional markets. The incomplete price information available to market participants, along with price-setting by a few market participants, imperfect competition, and hydrological and institutional uncertainty, causes inefficiencies and forgone gains. While a body of existing scholarly literature addresses this problem, significant demand exists for current studies using complete water right transactions data to estimate water right values in new geographic regions.

To assist water market participants in understanding the factors that contribute to price variation among water rights, this article develops an econometric model that quantifies the influence of supply and demand conditions, along with individual water right attributes, on observed sale prices. This study is conducted in New Mexico's Middle Rio Grande basin using a proprietary dataset[3] that the authors consider the most current and complete compilation of water right transaction information available. Our results confirm the findings of previous water markets studies by demonstrating that economies of scale exist among water transfers[4], and that the location of a water right's point of diversion affects its value[5]. Following recent econometric analyses, we examine the influence of drought conditions on water right prices.[6]

---

[3] WestWater Research, LLC provided the water right transactions data used in this analysis. WestWater Research is an economic consulting firm in the water resources industry specializing in transaction advisory services, water right appraisals, and water investments.

[4] Bonnie G. Colby et al., *Water Right Transactions: Market Values and Price Dispersion*, 29 WATER RESOURCES RESEARCH 1565 (1993); Thomas C. Brown, *Trends in water market activity and price in the western United States*, 42 WATER RESOURCES RESEARCH (2006)

[5] Colby et al., *Id.* At 4; Clay J. Landry, *Giving Color to Oregon's Gray Water Market: An Analysis of Price Determinants for Water Rights*, Oregon State University MS Thesis (1995);

In addition, this article extends existing knowledge of water markets by analyzing the impact of real estate market trends on water right prices. While economists have postulated that a positive relationship exists between real estate development activity and water right values[7], little empirical work confirms or quantifies this association. Because our data are sufficiently current to include water right prices observed during the recent real estate market slowdown, this article is uniquely positioned to examine the proposed link between housing prices and water right values. Further, we show that wealthier areas are willing to pay higher prices for water rights than those that are less affluent. This difference in willingness-to-pay is attributed to the increased water demand that accompanies rising per capita incomes[8], and higher marginal values derived from water used as an input to production in economically vigorous areas.

Literature Review

Previous studies offer a variety of approaches to valuing water rights. The scope of this research ranges from asset-specific analyses, including examinations of prices for the trans-mountain water supplies provided to South Platte basin water users by the Colorado-Big Thompson Project[9], to meta-analyses of water right prices observed throughout the western United States[10].

Matthew T. Payne et al., *Price Determination and Efficiency in the Market for South Platte Basin Ditch Company Shares*, forthcoming.

[6] Brown *supra* note 4; Jennifer L. Pullen and Bonnie G. Colby, *Influence of Climate Variability on the Market Price of Water in the Gila-San Francisco Basin*, 33 JOURNAL OF AGRICULTURAL AND RESOURCE ECONOMICS 473-487 (2008); Lana Jones and Bonnie Colby, *Weather, Climate and Environmental Water Transactions*, 2 WEATHER, CLIMATE AND SOCIETY (2010)

[7] PATRICK PERSON AND ARI MICHELSEN, DETERMINANTS AND TRENDS IN WATER RIGHT PRICES: AN ECONOMETRIC ANALYSIS (1994)

[8] C. Vaughan Jones and John R. Morris, *Instrumental Price Estimates and Residential Water Demand*, 20 WATER RESOURCES RESEARCH 197-202 (1984)

[9] PATRICK PERSON AND ARI MICHELSEN *supra* note 7

[10] Brown *supra* note 4

In addition, research regarding international water markets such as Australia's Murray-Darling basin and the Chilean experience has recently emerged.[11]

Prior studies of water right prices can be grouped into three distinct categories based on the methods they employ. First, researchers examined real estate transactions in which the land sale includes water rights historically used on the transferred property. The implicit value that these land buyers placed on water rights was used to calculate the value that water contributes to land prices.[12] Second, descriptive studies of Water Strategist data examine trends in water right prices and trading activity throughout the West.[13] Third, researchers applied econometric analysis techniques to datasets of water right transfers separate from land to identify and quantify the price determinants of water rights.[14] Our analysis follows this third approach; thus we here summarize the previous work on econometric analysis of water transfer data.

---

[11] Henning Bjornlund and Peter Rossini, *Fundamentals in determining prices and activities in the market for temporary water*, 21 INTERNATIONAL JOURNAL OF WATER RESOURCES DEVELOPMENT 355-69 (2005); R. Quentin Grafton et al., *An Integrated Assessment of Water Markets: Australia, Chile, China, South Africa and the USA*, NATIONAL BUREAU OF ECONOMIC RESEARCH WORKING PAPER SERIES 16203 (2010)

[12] Jan P. Crouter, *Hedonic Estimation Applied to a Water Rights market*, 63 LAND ECONOMICS (1987); John Faux, *Hedonic Price Analysis to Reveal Value of Water in Irrigation: An application to Northern Malheur County, Oregon*, Oregon State University MS Thesis (1996); Heath A. Byrd, *Estimating the Value of Groundwater Rights to Irrigated Agriculture: An Application of the Hedonic Price Model in the Northern High Plains*, Colorado State University MS Thesis (2004).

[13] Loomis et al *supra* note 2; Jedidiah Brewer et al., *Water Markets in the West: Prices, Trading, and Contractual Forms*, 46 ECONOMIC INQUIRY (2008); Elizabeth Basta and Bonnie G. Colby, *Water Market Trends: Transactions, Quantities, and Prices*. APPRAISAL JOURNAL (2010); R. Quentin Grafton et al., *Markets – Water Markets: Australia's Murray-Darling Basin and the U.S. Southwest*. INTERNATIONAL CENTRE FOR ECONOMIC RESEARCH WORKING PAPER SERIES (2009).

[14] Colby et al. *supra* note 4; Person and Michelsen *supra* note 7; Landry *supra* note 5; D. Jay Goodman and Charles W. Howe, *Determinants of Ditch Company Share Prices in the South Platte River Basin*, 79 AMERICAN JOURNAL OF AGRICULTURAL ECONOMICS 946-951 (1997); David S. Brookshire et al., *Market prices for water in the semi-arid west*, 40 WATER RESOURCES RESEARCH (2004); Bjornlund and Rossini *supra* note 11; Brown *supra* note 4; Pullen and Colby *supra* note 6; Jones and Colby *supra* note 6

In their econometric analysis, Colby, Crandall, and Bush (1993) demonstrated that a positive relationship exists between a water right's value and its reliability. A dummy variable separated water rights with senior priority dates from junior rights, and senior rights were found to attract higher prices. The authors further showed that water rights appreciate over time, economies of scale exist in water acquisitions, and water right prices vary based upon the point of diversion location.

Michelsen and Person (1994) estimated a two-equation model to explain price dispersion in the market for Colorado-Big Thompson (C-BT) units. Their results showed that a positive relationship between C-BT prices, inflation, and regional economic growth. The model further demonstrated an inverse association between interest rates and water right prices.

Landry (1995) used regression analysis to estimate the influence of duty, priority date, and market segmentation on water right prices in Oregon. Priority date, a measure of water supply reliability, significantly influenced the per-acre foot value of water rights, with senior water rights attracting higher prices than junior appropriations. In addition, location affected water right prices in the study, with water rights located east of the Cascade Mountains attracting a premium.

Goodman and Howe (1997) showed that, near Denver, a ditch company share's total price responds to the volume of water diverted per share. In addition, supply reliability and transportation losses significantly affect ditch share values. Other variables tested included crop prices, population, interest rate, and per-capita income.

Brookshire et al. (2004) analyzed water right price data from Arizona's Central Arizona Project (CAP) market, the C-BT market, and New Mexico's Middle Rio Grande Conservancy District (MRG). Their results indicated that characteristics of the market, such as buyer type and drought conditions, influence water right prices. Although common price determinants exist among these three markets, the authors conclude that the markets are heterogeneous, and the meta-analysis lacks the specificity required to provide meaningful insight into water right prices. Econometric analysis applied to water right transaction data within a single market region is needed to identify determinants of water right prices. The individual models developed for each regional market showed a strong time trend among water right prices.

Bjornlund and Rossini (2005) employed correlation analysis and regression techniques to explain water allocation trading activity and prices in the Goulburn Murray Irrigation District in Australia. Water allocation prices responded to commodity prices, climate variables such as evaporation and allocation, and macroeconomic indices including interest rates. The authors found that trading activity varies primarily based on month, with trades completed most frequently during the summer. Rainfall and evaporation also impact trading volume.

In his 2006 article, Brown developed separate price models for water leases and permanent water right sales. Brown showed that in lease agreements, annual prices respond to hydrologic conditions, population, and buyer type. Municipal water users pay higher prices in lease agreements than environmental or agricultural entities. Among permanent water right transactions, Brown found that prices rise over time, economies of scale exist among water transfers, buyer type affects sale prices, prices vary by water source, and water right values are higher in more populous regions. He found no statistically significant relationship between drought conditions and permanent water right sale prices.

Pullen and Colby (2008) analyzed price dispersion among water right transactions in New Mexico's Gila-San Francisco basin. Examining the connection between drought conditions and water rights prices represents the primary objective of this article. The authors contribute to the econometric analysis techniques applied to water transfer data by using an instrumental variable to correct for recognized endogeneity between sale price and transaction volume.

In their 2010 study, Jones and Colby extended the two-stage least squares method used in Pullen and Colby (2008) to datasets containing water lease prices for both environmental and non-environmental purposes. Statistically significant relationships exist between water lease prices and climate independent variables, including temperature and precipitation. The authors showed that lease rates increase in warm, dry years. The effects of climate and regional socio-economic characteristics on lease rates in environmental water markets differ from the influences of these variables on prices in non-environmental markets.

This study extends previous work on water markets by examining the most current water right transaction data available for a study area that received little attention in previous studies, the Middle Rio Grande River basin. In addition, we explore the relationship between the rise and recent fall of the housing market and water right prices.

New Mexico's Middle Rio Grande Basin

Central New Mexico's Middle Rio Grande basin extends south 175 miles from the Cochiti Reservoir to the Elephant Butte Dam, and includes areas of Socorro, Valencia, Bernalillo, Sandoval, and Santa Fe counties (See Figure 1). Highly urbanized areas near Santa Fe, Albuquerque, and Rio Rancho comprise the upper portion of the basin, while active agricultural production and small towns characterize the basin's southern regions. Several tribal communities are also situated throughout the basin, including the Cochiti, Santa Ana, and Santo Domingo pueblos.

Annual precipitation in the Middle Rio Grande basin averages only 10 inches. A *bosque*, or riparian forest of native tree species such as cottonwoods, lines the river. Return flows from irrigated agriculture support the *bosque.* Semi-arid desert comprises the portions of the basin situated further from the river. Native surface water flows in the Rio Grande River and its tributaries as well as transmountain diversions brought into the basin through the San Juan-Chama Project. Groundwater reserves in the region hold a close hydraulic connection with the Rio Grande River, and are administrated in conjunction with surface water. Consequently, groundwater production fails to provide an alternative supply source to surface diversions[15].

Annual flows in the Rio Grande River average 1,100,000 acre-feet[16]. However, under the Rio Grande Compact among New Mexico, Colorado and Texas, a significant quantity of Rio Grande surface water supplies must remain instream for use in the Lower Rio Grande basin in Texas. According to the Compact, a maximum of 405,000 acre-feet per year remain available for consumption by Middle Rio Grande basin water users. This obligation to deliver supplies to water users in the lower reaches of the Rio Grande contributes to the acute water scarcity conditions in the Middle Rio Grande basin.[17]

Water demand in the Middle Rio Grande basin is high for all uses - for agricultural, environmental, and urban. Farming is concentrated in the south of the basin, with irrigation primarily supporting alfalfa, pasture, corn, and vegetable cultivation. The Middle Rio Grande Conservancy District (MRGCD) is the predominate supplier of irrigation water in the region.

---

[15] RAMCHAND OAD AND J. PHILLIP KING, IRRIGATION FORBEARANCE FEASIBILITY STUDY IN THE MIDDLE RIO GRANDE CONSERVANCY DISTRICT (2005)
[16] *Id. 15*
[17] ACTION COMMITTEE OF THE MIDDLE RIO GRANDE WATER ASSEMBLY, MIDDLE RIO GRANDE WATER BUDGET (1999).

Although agriculture is also the largest consumptive water use in the study area, MRGCD diversions have declined since 2000.[18]

The river is home to the Rio Grande Silvery Minnow, a federally listed endangered specie. State and federal agencies have initiated several measures, including minimum instream flow requirements, for improving minnow habitat in the basin (USFWS 2003).

Santa Fe and Albuquerque, in the upper half of the basin, are the source of most municipal and industrial demand. M&I demand is rising rapidly in response to population growth, with basin-wide populations projected to increase by approximately 35% by 2025 (see Table 1). Land development stemming from population growth and economic development under fixed water supply conditions necessitates transferring water out of agriculture, thus driving water right trading in the basin.

Water Market Participants

By 1956 the number of diversions from the river required the New Mexico State Engineer to declare both surface water and groundwater fully appropriated and thus no new diversions or wells can be developed without acquisition of existing water rights.[19] As supplies are fixed, meeting new municipal and industrial water demand necessitates reallocation of existing water rights through the market. In water markets throughout the western United States, the difference in marginal value between water used as an input to crop production and water applied to urban purposes creates the potential for gains from water right trades to both urban buyers and agricultural sellers.[20]

---

[18] David Gensler et al., *Irrigation System Modernization: Case Study of the Middle Rio Grande Valley*, JOURNAL OF IRRIGATION AND DRAINAGE ENGINEERING (2009)

[19] MIDDLE RIO GRANDE WATER ASSEMBLY, MIDDLE RIO GRANDE REGIONAL WATER PLAN 2000-2005

[20] Grafton et al. *supra* note 13

Irrigated farms and ranches are the primary source of water rights in the Middle Rio Grande basin water market. Sellers derive higher returns from selling water rights than from using the water rights for agricultural production. Among the transactions examined here, over 80% of observed sales transferred water out of agricultural uses. The remaining, non-agricultural sellers, were water brokers and speculators.

As in much of the West, new water demand in the Middle Rio Grande basin arises from urban growth. Until the real estate market slowdown in 2008, property developers were the most active water right buyers in the basin. Developers acquire water rights to fulfill municipal water providers' raw water dedication requirements. The basin's municipal water authorities oblige developers to purchase water rights in sufficient quantity to accommodate the requirements of their projects, and then transfer these rights at no cost to the authority in exchange for permission to build. Since 2008 property developers have been less active in the market.

Municipal water authorities are themselves actively acquiring water rights to accommodate growing demands in their service areas. While cities often rely on groundwater production for water supplies, they must acquire surface water rights to offset increased groundwater withdrawals.[21] Santa Fe, Rio Rancho, Albuquerque, Los Lunas, and Bernalillo are all involved in the market.

Water brokers and investors are also active in the Middle Rio Grande basin. Speculators profit by buying low-value, downstream, agricultural water rights, and re-selling to upstream, urban water users at a premium. Asymmetric price information, in conjunction with the high cost of finding and acquiring available water rights, enable speculative investment in this basin. In addition, records at the State Engineer's Office show that some agricultural water users

[21] THOMAS C. TURNEY, AGREEMENT BETWEEN INTERSTATE STREAM COMMISSION AND THE HOLDER OF OSE PERMIT RG-57125 (2010).

remain active buyers. These farmers produce such high-value goods as tree nuts and dairy products.

Water Rights in the Middle Rio Grande Basin

The majority of surface water rights in the Middle Rio Grande basin fall into the following two categories:

- The first are water appropriations created through diversion and beneficial use prior to 1907. The New Mexico water code, enacted in 1907, confirmed water rights perfected before 1907 such that all such rights hold the identical 1907 priority.[22] This common priority date results in all pre-1907 rights having the same diversion priority, thus the same level supply reliability.[23] Because pre-1907 water rights predate the establishment of the Office of the State Engineer and the Middle Rio Grande Conservancy District, they may be transferred to new purposes and places of use.
- The second are permitted water rights perfected after 1907. The MRGCD owns most Post-1907 water rights, and prohibits permanent transfers of the rights out of agriculture.

Our data set contains only pre-1907 surface water rights with their common priority date. Thus price dispersion must result from factors other than reliability, a major explainatory variable in other studies.[24] One might expect less price dispersion in the Middle Rio Grande basin than in regions where transfers of water rights with various priorities are observed. However, as shown by Figure 2, substantial price dispersion exists among pre-1907 water rights, and has increased over time. This price variation suggests that other factors are at play here. What could they be?

---

[22] Stephen N. Bretsen and Peter J. Hill, *Water Markets as a Tragedy of the Anticommons,* 33 WILLIAM AND MARY ENVIRONMENTAL LAW AND POLICY REVIEW (2009).
[23] David S. Brookshire *supra* note 14
[24] Goodman and Howe *supra* note 14; Colby et al. *supra* note 4; Brown *supra* note 4

First, the Middle Rio Grande basin remains unadjudicated - ownership status, title validity, and quantity of most water rights are unspecified.[25] This lack of legal defintion of the property right definition creates uncertainty in water right transactions.[26] In New Mexico, the State Engineer administers water resources, and holds the authority to approve or deny water right transfers. When a water right buyer applies for a change to a purchased water right's purpose and place of use, the State Engineer conducts a detailed analysis regarding the water right's beneficial use history. This analysis adjudicates the water right. The State Engineer quantifies the appropriated diversion, and assesses the consistency with which the water supplies have been used. Water rights that remain unused for a period of five consecutive years are ruled invalid and are forfeit.

Second, the State Engineer must consider objections from third party water right holders against impairment of their rights. Successful objections result in significant modifications or denial of the transfer. Objectors primarily protest an upstream change in the point of diversion. Objections have increased in recent years.[27] This uncertainty associated with unadjudicated water rights and the transfer approval process makes the market less efficient. However, water right buyers can negotiate purchase contracts contingent upon State Engineer approval of the proposed transfer, mitigating regulatory risk.

Price Determinants for Pre-1907 Water Rights

Once adjudicated, each water right permits use of a specific quantity of water annually. Previous studies show that an inverse relationship exists between a water right's price per acre-foot and

---

[25] Bretsen and Hill *supra* note 22
[26] Michael Pease, *Constraints to Water Transfers in Unadjudicated Basins: The Middle Rio Grande as a Case Study,* 144 JOURNAL OF CONTEMPORARY WATER RESEARCH AND EDUCATION 37-43 (2010)
[27] F. Lee Brown, *Surface Water Opportunities in New Mexico,* NEW MEXICO WATER RESOURCES RESEARCH INSTITUTE (2008)

the volume of water it yields.[28] These economies of scale in water transfers are attributable to consistent transaction costs among transfers regardless of quantity traded, and the lower level of demand for large volume transfers.

Point of diversion is a key attribute of any water right. Moving the point of diversion upstream may injure water rights between the historic and proposed point of diversion. As New Mexico's water law protects water rights from impairment caused by transfers, applications for change in point of diversion run the risk of State Engineer denial. Third party water users frequently object to upstream transfers, increasing the time and expenses required to complete the transfer process. The number of objectors rises with upstream transfers of longer distances, resulting in higher transactions costs. Third-party objections represent the primary obstacle to upstream transfers in the Middle Rio Grande basin, and the frequency of objections has increased over time.[29]

Physical water conveyance via pipeline serves as an alternative to the legal change process for conveying downstream water rights to upstream water users. However, physical conveyance incurs substantial costs: approximately $1,000 per mile for each acre-foot of capacity.[30] As a result of the transportation expenses, transaction costs, and risks associated with transferring a water right upstream, downstream water rights are expected to attract lower prices than upstream water rights.

---

[28] Charles W. Howe et al, *Transaction Costs as Determinants of Water Transfers*, 61 UNIVERSITY OF COLORADO LAW REVIEW (1990); Colby et al *supra* note 4; Brown *supra* note 4

[29] Brown *supra* note 27

[30] KENNETH WRIGHT AND PATRICIA FLOOD, WATER PRICES: THE ESSENTIALS

Supply reliability and source represent other water right attributes frequently tested for their influence on water right value.[31] However, because all observations included in our data transferred water rights holding identical priority dates and diverting from the same source, our analysis does not consider these qualities of water rights.

Supply and Demand Factors

Property developers and municipalities are the most active water right buyers in the Middle Rio Grande basin. These urban water users acquire water rights to accommodate increases in water demand associated with new development projects. Consequently, the demand for pre-1907 water rights in the basin is closely linked to land development activity. When real estate prices are high, developers build and substantial demand exists for water rights, driving high water right prices. However, with recent declines in real estate values, water right demand and prices have decreased (see Figure 3).

During periods of drought, water scarcity intensifies, increasing immediate demand for additional water supplies. Previous studies propose that rising water demand during drought causes higher water right prices.[32] This study uses similar methods to test for the impact of drought on water right prices. However, we predict that no statistically significant relationship exists between drought indices and the permanent water right sale prices for the Middle Rio Grande River basin. While demand for additional water supplies increases during drought periods, permanent water right acquisitions are not an effective means to adapt to short-term, drought-related scarcity. Because the administrative water right transfer process in New Mexico

[31] Goodman and Howe *supra* note 14; Colby et al . *supra* note 4; Brown *supra* note 4
[32] Brown *Id 31*; Pullen and Colby *supra* note 6; Jones and Colby *supra* note 6

takes between 6 months and 2 years to complete,[33] permanently purchased rights are not available to meet immediate needs. As a result, permanent water right acquisitions represent a long-term supply planning strategy rather than a method for offsetting short-term scarcity caused by temporary changes in hydrologic conditions. Water right lease agreements, including dry-year option contracts,[34] serve as a more effective technique for adapting to drought. Hydrologic conditions are more likely to influence prices in water right leases.[35]

Several previous studies test the affect of per-capita income on water right prices.[36] We similarly analyze the connection between per capita income and water right prices in the Middle Rio Grande basin. We predict that urban water right buyers in affluent communities offer higher prices for water rights than municipal water users in less wealthy areas. This trend results from heightened water demand caused by increased per capita incomes,[37] and the greater ability-to-pay in these wealthier communities. Water right buyers are willing to pay premium prices for water rights used as an input to production of high-valued goods. Valuable land development projects and production of industrial goods drive demand for water rights in the affluent upper portion of the Middle Rio Grande basin, where buyers pay high prices for water rights. Low per-capita income levels persist in the lower portion of the basin near Los Lunas and Belen, with agriculture serving as the primary economic activity. Water right buyers in this less wealthy area offer low prices for water rights consistent with their lower value uses.

---

[33] Interview with Carole Cristiano, Lee Wilson & Associates (Jan. 21 2009); Interview with Nancy Cunningham, Water Resources Supervisor, New Mexico Office of the State Engineer (Dec. 18 2009)

[34] Ari M. Michelsen and Robert A. Young, *Optioning Agricultural Water Rights for Urban Water Supplies During Drought*, 73 AMERICAN JOURNAL OF AGRICULTURAL ECONOMICS 1010 (1993)

[35] Brown *supra* note 4

[36] Goodman and Howe *supra* note 14; Brookshire et al. *supra* note 14

[37] Jones and Morris *supra* note 8

Analysis

This section describes the dataset compiled for this article, and the econometric model developed to explain water right prices in the Middle Rio Grande basin. A discussion of the results of our analysis follows.

Data

In most commodity markets, observed purchase and sale prices provide accurate valuation information for the commodity. These markets operate efficiently with prices reflecting the value of the good's positive and negative qualities. However, market price information for water rights is largely unavailable as a result of the private nature of water right transactions. The lack of price signals prevents market participants from making pragmatic purchasing and selling decisions. In New Mexico, there is no central repository for water right price information. Moreover, local governments do not require market participants to report sale prices. In addition, water right buyers and sellers are protective of their confidential price information. Along with contributing to inefficiencies in water markets, the proprietary nature of water right price data poses a significant obstacle to conducting water valuation studies.

To compile the data used for this article, the authors reviewed water right transfer records maintained in State Engineer files. Further research was conducted regarding transfers characteristic of a water right purchase and sale. Buyers and sellers were contacted to obtain and confirm price information. In total, the authors compiled comprehensive data for 135 observations of water right sales to municipal and industrial water users completed between 2000 and 2009. These transactions transferred a total of approximately 3,758 acre-feet. Table 2 offers summary statistics for the data. The low average and median volumes traded per sale indicate highly fragmented ownership of pre-1907 water rights. In addition, the high standard deviation in relation to mean sale price reveals substantial price dispersion in the market.

Econometric Model

Our model expresses the per-unit price paid for water rights (dollars per acre-foot) as a function of individual water right attributes and supply and demand characteristics of the regional market, plus an error term.[38]

Unit price ($/AF) = f(water right attributes, market characteristics) + e

Volume and point of diversion location are the water right attributes tested for their influence on unit price. A negative relationship is predicted to exist between the quantity transferred in each sale and the unit price, indicating that economies of scale exist in the Middle Rio Grande basin water market. Water rights classified as diverting from downstream reaches of the river are hypothesized to attract lower prices than upstream water rights. Price variations by location result from physical and regulatory barriers to transferring downstream water rights to urban uses in the upper basin.

The supply and demand factors are: a time trend, real estate market indices, hydrologic conditions, and per-capita income. We project that the model will reveal price appreciation over time, a positive relationship between unit prices and real estate values, and higher water right prices in affluent regions. No statistically significant relationship is hypothesized to exist between drought conditions and permanent water right sale prices as such transactions are too slow to ameliorate temporary drought-related water shortages.

[38] ROBERT A. YOUNG, DETERMINING THE ECONOMIC VALUE OF WATER (2005)

- **Trading Volume:** The variable "*volume*" assumes the value of the volume of water transferred in each transaction. Volume is measured in acre-feet of consumptive use, defined as the amount of water permanently removed from its source. In New Mexico, only the consumptive use portion of a water right's diverted quantity is transferable to a new purpose and place of use.
- **Point of Diversion Location:** The dummy variable "*upstream*" separates water rights diverting above the Isleta Diversion Dam from appropriations receiving water at or below the Isleta Dam. The variable takes on a value of 1 for upstream water rights. The model includes this variable to estimate the premium that urban water right buyers place on water rights diverted high in the basin.[39] This premium results from the reduced transactions costs associated with acquiring upstream water rights. Fewer third-party water users file objections to changes in upstream water rights' purpose and place of use thus decreasing the time and expenses required to complete a transfer through the State Engineer. Further, the costs of physically conveying water to municipal and industrial entities situated high in the basin are lower for upstream appropriations.
- **Time Trend:** In preliminary estimations, the model included a variable assuming the value of the year in which the transaction took place. This variable tested for predicted water right price appreciation. However, we eliminated the variable as a result of its high correlation with real estate market indices.
- **Real Estate Market:** Water right transactions in the Middle Rio Grande basin occur primarily to accommodate new water demands associated with property development. As a result, water right prices hold a close correlation with land development activity and

[39] Brown *supra* note 27

real estate prices. Water right prices increased each year until 2007. In 2007 and 2008, following the peak in real estate values and subsequent decline, few new development projects were initiated, decreasing the demand for existing water rights. The lower levels of demand for water rights led to reductions in observed prices and trading activity. Figure 4 displays annual building permit issuances in the Middle Rio Grande basin. Building permit issuances reflect the “bubble” trend in the real estate market observed developing throughout the United States between 2000 and 2006.[40] During the real estate “bubble,” development activity increased most noticeably near the City of Rio Rancho in Sandoval County.

In preliminary estimations of the model, the authors tested the relationship between water right prices and building permit issuances by county, basin-wide building permit issuances, and the FHFA’s House Price Index for New Mexico (Federal Reserve Bank of St. Louis). The FHFA House Price Index for New Mexico holds a stronger correlation with water right prices than other tested proxies for real estate market activity. The variable “*hpi_yr_avg*” takes on the average value of this index during the year in which the sale took place. Figure 3 shows the relationship between the seasonally unadjusted FHFA House Price Index for New Mexico and water right trading trends in the Middle Rio Grande basin.

- **Buyer Type:** Our data include water right acquisitions by urban water users exclusively. These buyers include cities, water authorities, and land developers. Because they can expect to receive a return on their water investments, developers are predicted to offer higher prices for water rights than cities. Cities and water authorities set water rates to

[40] Edward L. Glaeser et al., *Did Credit market Policies Cause the Housing Bubble?,* RAPPAPORT INSTITUTE FOR GREAT BOSTON POLICY BRIEFS (2010).

cover costs, and rarely profit from water right purchases. The variable "*dev_buyer*" is a dummy variable separating land developer acquisitions from purchases by other buyers. The variable assumes a value of "1" for developer acquisitions.

- **Drought:** Following recent econometric analyses of water right transfer data[41], we examine the influence of drought conditions on permanent water right sale prices in New Mexico's Middle Rio Grande basin. These previous studies found that water right prices increase in dry years as a result of the heightened demand for additional water supplies during periods of hydrologic scarcity. Pullen and Colby (2008) found a statistically significant, inverse relationship between the Standardized Precipitation Index (SPI) with a 6-month lag and permanent water right sale prices in New Mexico's Gila-San Francisco basin. If Middle Rio Grande basin water right prices increase in dry years, an inverse relationship will exist between the SPI and prices because the SPI assumes negative values during drought.

  Eight measures of drought were tested: The 24-month SPI, the 24-Month SPI with a six-month lag, the 12-month SPI, the 12-Month SPI with a six-month lag, the Palmer Modified Drought Index, the Palmer Modified Drought Index with a six-month lag, the Palmer Hydrological Drought Index, and the Palmer Hydrological Drought Index with a six-month lag.[42] A statistically significant positive relationship was found between each drought index and water right prices. These unexpected results indicate that water right prices increase in wet years. The positive relationship is illogical, suggesting that water market participants base permanent purchasing decisions on factors other than current

[41] Brown *supra* note 4; Pullen and Colby *supra* note 6; Jones and Colby *supra* note 6
[42] NATIONAL CLIMATIC DATA CENTER, available online at http://lwf.ncdc.noaa.gov/oa/ncdc/html

hydrologic conditions. Consequently, we eliminated drought variables from the final model.

- **Per Capita Income:** The variable "*percapincome*" assumes the value of the per-capita income of the county in which the water right buyer is located.[43] Higher-valued water uses exist in more affluent areas, and water demand rises with increases in per-capita income levels.[44] As a result, we predict that this variable will hold a positive relationship with water right prices.

Results

Table 3 displays the results of our econometric analysis. The R-squared statistic of 0.8031 indicates that the model's independent variables explain approximately 80% of water right price dispersion in our dataset. All independent variables tested hold statistically significant relationships with unit price at the 99% confidence level. The estimated relationships are consistent with our hypotheses.

The Box-Cox transformation [45] serves as an effective method for testing for nonlinear relationships between dependent and independent variables. Box-Cox procedures transform the variable Z to $(Z^\lambda - 1)/\lambda$. When $\lambda = 0$, Z is transformed to the natural log of Z. If $\lambda = 1$, Z remains linear.[46] The dependent and independent variables were transformed separately using STATA's "lhsonly" and "rhsonly" options. The results of the dependent variable transformation indicate that a logarithmic specification is appropriate, while the independent variables' transformation results call for a linear specification. Consequently, we use a log-linear

---

[43] UNITED STATES CENSUS BUREAU, STATE AND COUNTY QUICKFACTS. Online at http://quickfacts.census.gov/qfd/states
[44] Jones and Morris *supra* note 8
[45] G.E.P Box and D.R. Cox, *An Analysis of Transformations,* 26 JOURNAL OF THE ROYAL STATISTICAL SOCIETY 211 (1964)
[46] PETER KENNEDY, A GUIDE TO ECONOMETRICS 2ND EDITION (1985)

specification to estimate the model presented in this section. The *upstream* and *dev_buyer* variables were not transformed because they are dummy variables. Other specifications tested include log-log, linear-log, and linear. The log-linear model generated the highest coefficient of determination (best fit), and was shown to be properly specified by the Box-Cox transformation.

Recent econometric analyses of water transfer data test for endogeneity between unit price and volume traded. Instrumental variables were used to correct for endogeneity[47]. We employed the Hausman-Wu test to determine if using two-stage least squares (2SLS) to correct for endogeneity is necessary. The first stage of the tested 2SLS model expressed volume traded in each sale as a function of per capita income in the seller's county, the predicted population growth rate in the buyer's county, an interaction term between agricultural sellers and the NASS All Farm Index Prices Received[48], and an error term. Volume values predicted by the first stage were included in the second stage as an instrumental variable. The Hausman-Wu test showed that the 2SLS model failed to estimate results significantly different from the OLS model (see Table 4), allowing us to accept the null hypothesis that unit price and volume are exogenous.

The question of the endogeneity of price and quantity arises when using equilibrium observations of market transactions to estimate the determinants of price. Where price and quantity are endogenously determined, parameter estimates should be made with two-stage least squares to address the identification problem of equilibria occurring at the intersection of various supply and demand curves. For a number of reasons, permanent water right transactions, as they work on the ground, may not exhibit strong endogeneity between unit price and the consumptive use volume traded in a particular transaction.

---

[47] Pullen and Colby *supra* note 6; Jones and Colby *supra* note 6
[48] NATIONAL AGRICULTURAL STATISTICS SERVICE, ALL FARM INDEX: PRICES RECEIVED AND PRICES PAID. ALL ITEMS, 1979-2010 U.S. ANNUAL, online at http://www.nass.usda.gov/Charts_and_Maps/graphics/data/allprpd.txt

First, farmers sell either surplus water or water coming out of low-value production. Sellers may also be quitting farming all together. Because water rights yield specific volumes of water and can be difficult to divide, water right transactions are "lumpy." They are not marginal transactions in which more water rights or partial water rights could be offered for a marginal increase in the price. The water rights judicial or administration process associated with a change of use further decrease the simultaneity with which price and volume are determined. The high transactions costs associated with the Office of the State Engineer adjudication and change process disincentivize purchasing partial water rights or marginally smaller water quantities.

Second, the Office of the State Engineer establishes the consumptive use volume provided by the water right, not the right's market price. During the change case, the State Engineer will examine evidence regarding historic use as well as objectors' filings to determine the quantity that is transferable to a new use without injuring other existing water rights. This determination of transferable volume is often uncertain due to the lack of water right adjudication in the basin, and is difficult to account for in price negotiations.

White's Test generated a p-value of 0.0992 and the Breusch-Pagan Test produced a p-value of 0.6995, allowing us to accept the null hypothesis of constant variance (homoskedasticity). We tested for collinearity using condition indices, a condition number, and a correlation matrix. A condition number of 21.34 indicates that some collinearity exists, but is not seriously influencing the estimation results. Condition numbers under 30 are generally regarded as showing an acceptable level of collinearity.[49] A correlation matrix revealed no

[49] Kennedy *supra* 46

associations above 0.27 among independent variables. These statistics show that collinearity does not significantly influence our estimation results.

As a result of its semilog specification, the model's dependent variable holds a porportionate relationship with its independent variables. The coefficient estimated for each independent variable is the ratio of the proportionate change in the dependent variable to the absolute change in the independent variable. For example, the coefficient of approximately 0.0114 estimated in our model for the variable *hpi_yr_avg* indicates that, if the average HPI for the year increases by 1, water right unit prices ($/AF CU) rise by 1.14%.

The inverse relationship between unit price and transaction size shows that economies of scale exist in water transfers in the Middle Rio Grande basin. These scale economies are attributable to stable transaction costs regardless of transaction size[50], the low levels of demand for large water rights.

The positive association between *upstream* and water right unit price indicates that, as a result of the legal and physical barriers to upstream water right transfers, water rights diverting from high in the basin attract premium prices. While this relationship is statistically significant at the 99% level, a stronger statistical association (increased t-statistic) is hypothesized to exist in other regions characterized by more stringent barriers to upstream trades. In the Middle Rio Grande basin, upstream transfers are frequently permitted by the State Engineer, but incur high transactions costs due to third-party protests. In other basins around the West, upstream transfers are even more risky. For example, Colorado Water Courts rarely approve any upstream transfers. The few approved upstream point of diversion changes rest contingent upon implementation of exchange plans, often resulting in dramatic reductions in transferable water

[50] Howe et al. *supra* note 28

quantity. In basins with more prohibitive restrictions on upstream transfers, water market participants place a greater premium on water rights diverted high in the stream system.

The strong positive relationship between housing prices in New Mexico and water right prices emphasizes the leading role that real estate market activity and property development play in determining water market activity and prices in the Middle Rio Grande basin. High housing prices lead to new development and rising water demand in urban areas. Water transfers must occur to accommodate heightened water demand, and increased demand for water rights results in high water right prices. Following real estate market slowdowns in 2008 and 2009, water right prices in the basin declined.

Socioeconomic conditions in the buyer's immediate vicinity, as well as the buyer's new use for purchased water rights, influence prices in this basin. The positive relationship between unit price and *percapincome* shows that buyers located in affluent areas are willing to pay higher prices for water rights than buyers in less wealthy regions, all else equal. Demand for water increases as per capita incomes rise, and water is often applied to higher-value uses in wealthy areas. The positive association between the variable *dev_buyer* and unit price indicates that developers pay higher prices than other urban buyers in this market, all else equal. Developers expect to receive a return on their investment, and therefore pay higher prices than cities and water authorities. Municipal water providers establish rates to cover costs.

Price differences across buyers and new uses create opportunities for arbitrage in the Middle Rio Grande basin water market. Recognizing these opportunities, speculative water rights buyers acquire agricultural appropriations diverted low in the basin, and market them to land developers in the upper basin's more affluent areas. In an efficient market, such arbitrage would incite rapid price convergence, resulting in consistent prices for the same water right regardless of new use. New use variables would not statistically account for variation in prices among water rights if the market operated efficiently. However, price convergence across new uses has not occurred in the Middle Rio Grande Basin, providing further evidence that this market is inefficient.

Conclusion

Market failures, including insufficient price signals, imperfect competition, high transaction costs, and hydrologic and institutional uncertainty, inhibit the ability of water markets to efficiently allocate water resources. These problems extend to New Mexico's Middle Rio Grande basin, where the high level of price dispersion observed for water rights indicates that the market operates inefficiently. Price variation among heterogeneous water rights may signal that the market is efficient if prices paid for the heterogeneous rights reflect their unique positive and negative attributes. However, transferable water rights in the Middle Rio Grande basin are more homogenous as a result of their common priority date. In an efficient market, prices for these more uniform assets would remain consistent, but observed prices for pre-1907 water rights vary significantly.

Assisting water market participants in making pragmatic purchasing and selling decisions improves water market efficiency. To enhance market participants' ability to complete informed transactions, this article identifies and quantifies the effects of water right attributes and supply and demand factors on water right prices. Although the specific statistical relationships between independent variables and water right prices estimated in our analysis are unique to the Middle Rio Grande basin, the trends we identify extend to water markets throughout the western United States.

Our model reveals that economies of scale exist in water transfers in the Middle Rio Grande basin. Previous studies show that this trend is common among western water markets[51]. Municipalities can account for scale economies in least-cost supply expansion strategies by choosing to enter into a few acquisitions of large water rights rather than purchasing many smaller rights.

Water right values in the Middle Rio Grande basin vary based on the location of their point of diversion, with downstream water rights attracting low prices. Water right location influences values in many regional markets[52], and represents an important consideration for water right buyers throughout the west.

Our analysis shows a strong positive correlation between water right values and housing prices in the Middle Rio Grande basin. This finding is attributable to the importance of water transfers in accommodating increases in water demand associated with new property development in the basin. A similar relationship between the real estate market and water right prices is expected to exist in other regions where property development drives water market activity, such as Nevada's Truckee River basin. The demonstrated influence of real estate market trends on water right prices offers a new consideration for municipalities' least-cost supply expansion plans, and for water right investors' purchasing decisions. Buyers may succeed in negotiating lower water right purchase prices during periods of declining housing values.

The illogical statistical relationships identified between drought indices and water right prices led us to discount temporary changes in hydrologic conditions as a determinant of water right values in the Middle Rio Grande basin. The lengthy regulatory approval process for

---

[51] Colby et al. *supra* note 4; Brown *supra* note 4
[52] Colby et al. *id* 51; Landry *supra* note 5; Pullen and Colby *supra* note 6

permanent water right transfers impedes the ability of permanent acquisitions to immediately increase supplies during short-term droughts. As a result, water market participants do not base their buying and selling decisions on current hydrologic conditions. Water right lease agreements represent more effective mechanisms for expanding water supplies during periods of immediate scarcity. Consequently, prices in lease agreements are more responsive to drought that permanent purchase prices[53]. As observed in California's Central Valley, water users use single-year lease agreements and dry-year option contracts to adapt to droughts (Hanak 2002; Michelsen and Young 1993).[54]

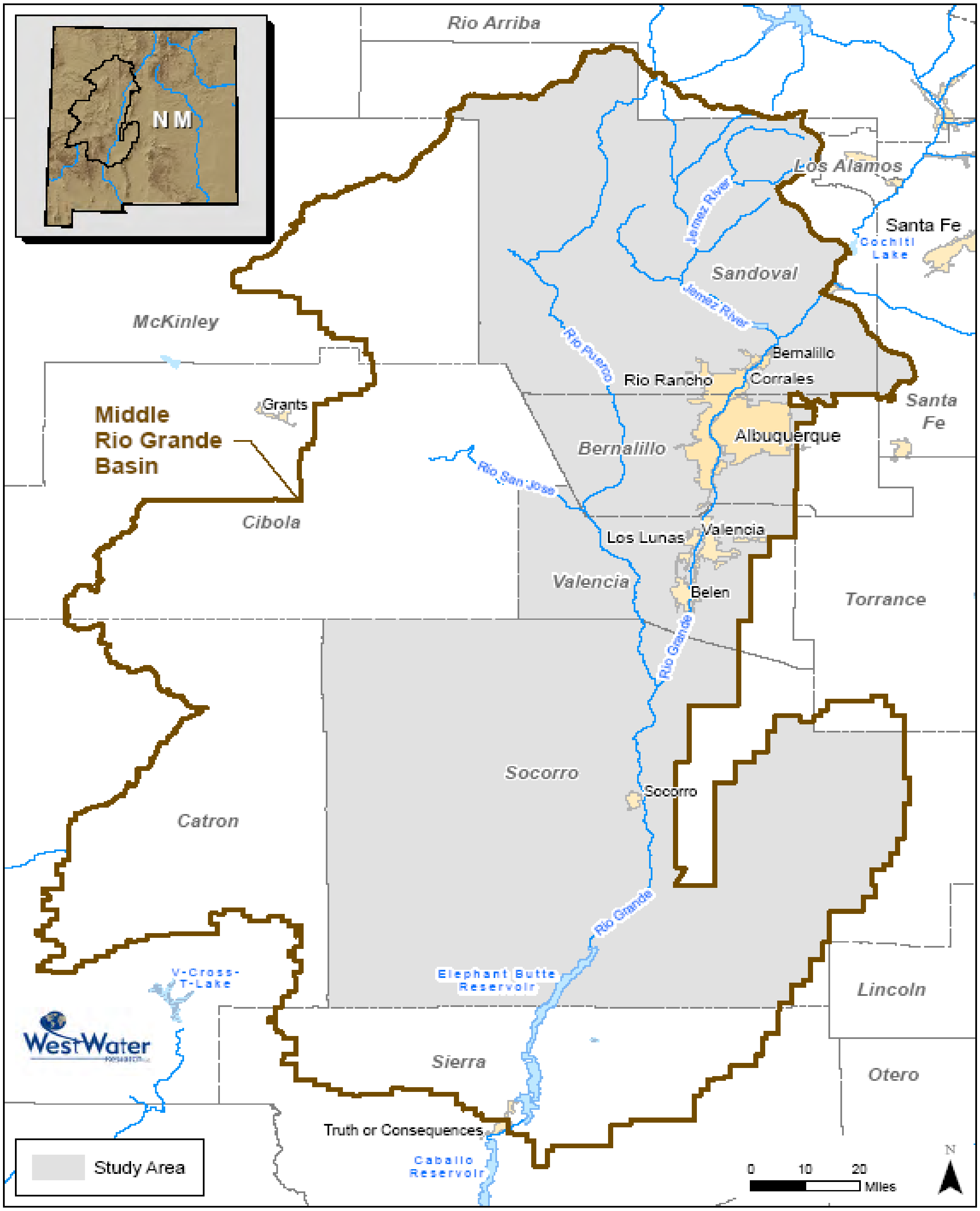
Further research regarding the influence of real estate market conditions on water right values in other regional water markets is needed to enhance understanding of water right values and price trends. Additional studies using complete, accurate transaction data will help to improve water market efficiency throughout the west.

---

[53] Brown *supra* note 6

[54] Ellen Hanak, *California's Water Market, By the Numbers*. Public Policy Institute of California Occasional Papers (2002); Michelsen and Young *supra* note 34

Figure 1: Middle Rio Grande Basin Study Area



Source: WestWater Research, LLC. Used with Permission

Figure 2: Water Right Trading Trends in New Mexico's Middle Rio Grande Basin, 2000 – 2009

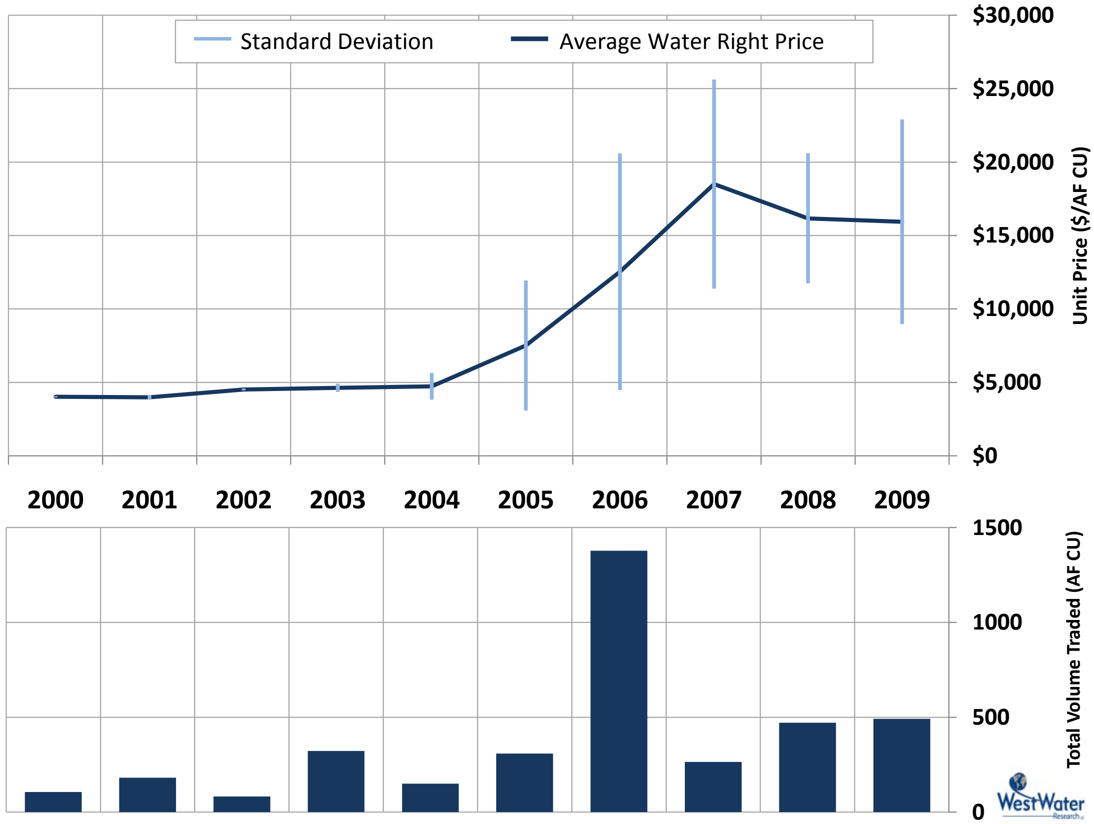


Figure 3: The Relationship between Housing Prices and Water Right Values in the Middle Rio Grande Basin, 2000 – 2009

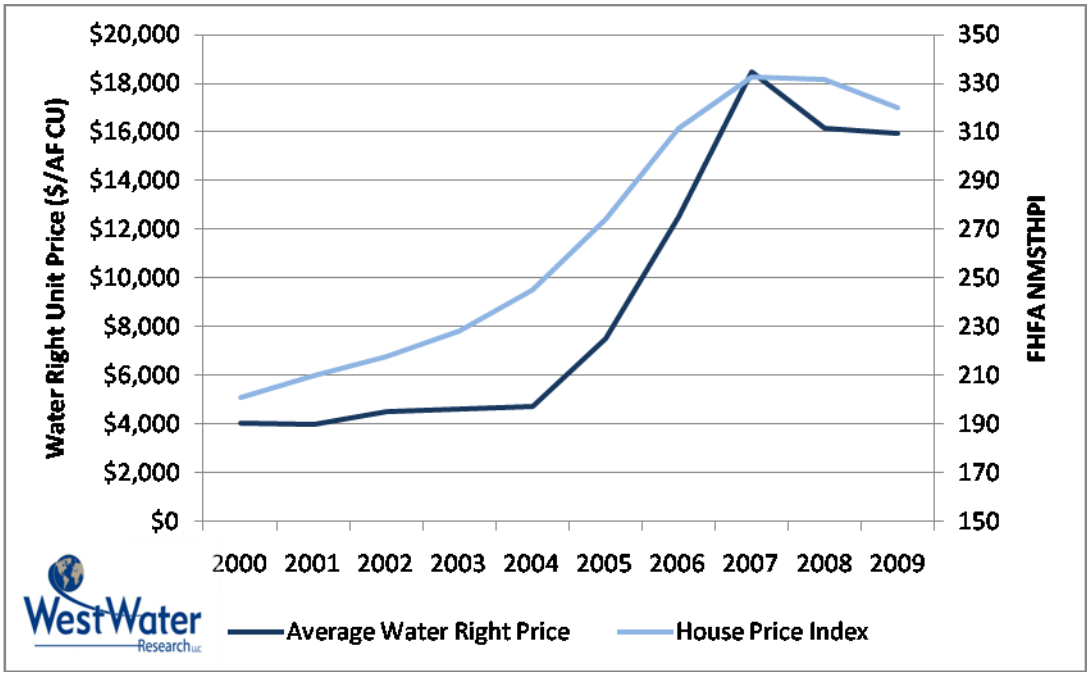


Figure 4: Annual Building Permit Issuances and Water Right Trading Activity in the Middle Rio Grande Basin, 2000 – 2009

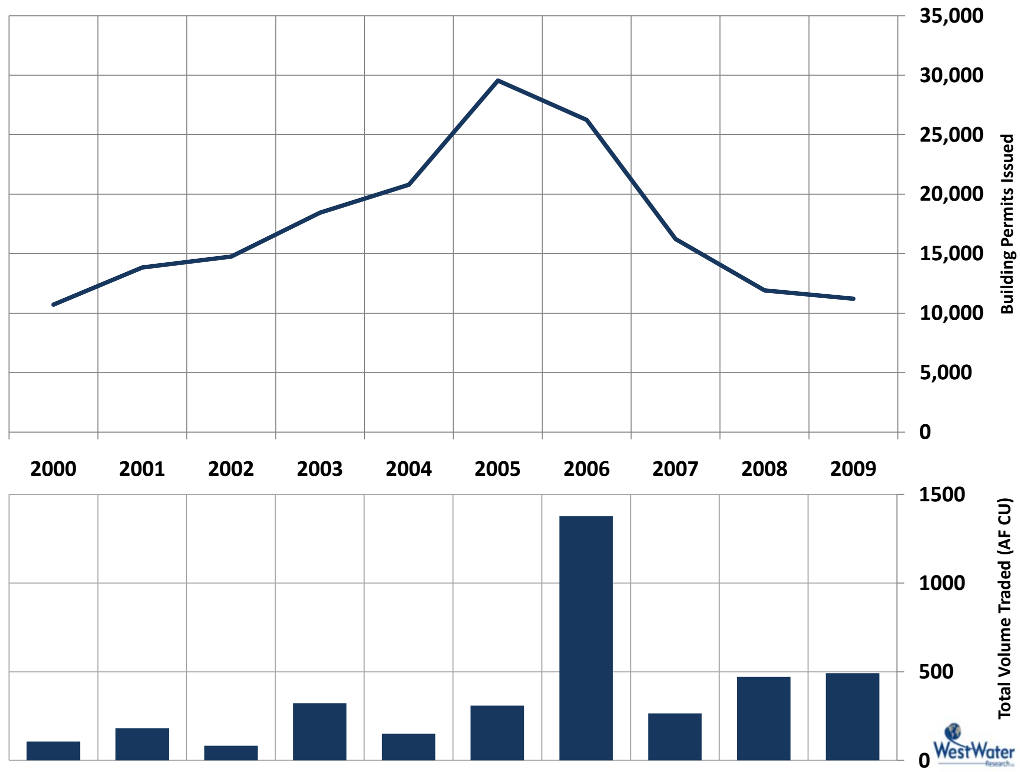


Figure 5: Observed Average Water Right Prices Compared to Prices Estimated by Econometric Model

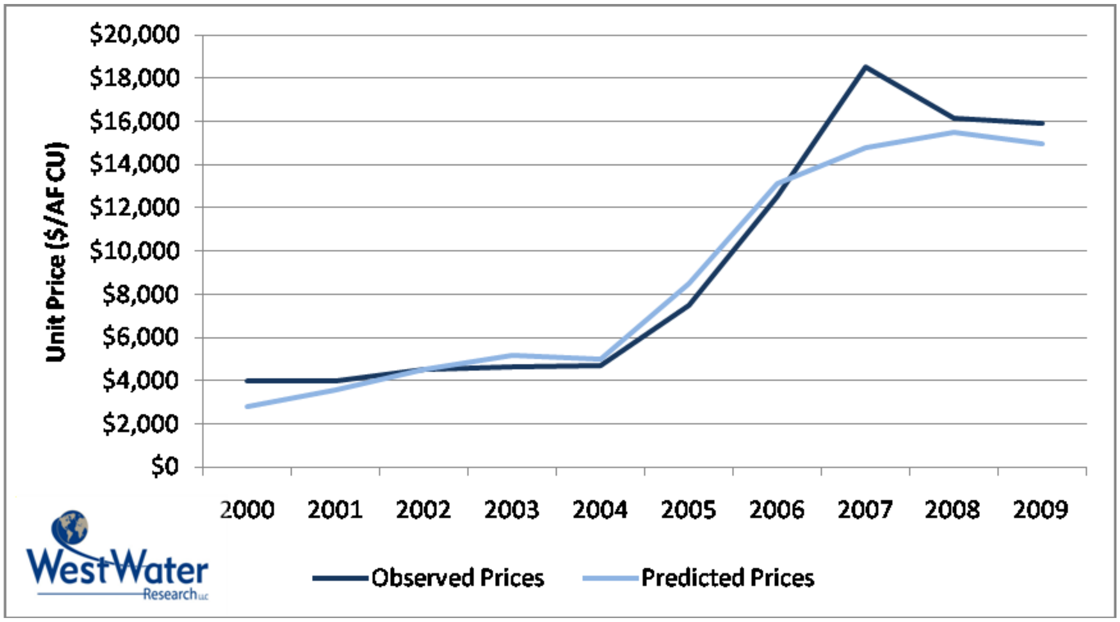


Table 1: Projected Population Growth in New Mexico's Middle Rio Grande Basin, 2010 - 2025

	Projected Population				
County	**2010**	**2015**	**2020**	**2025**	**Growth**
Bernalillo	713,020	811,861	905,393	993,650	39.36%
Sandoval	125,675	144,087	163,315	182,592	45.29%
Santa Fe	151,510	159,056	165,719	170,730	12.69%
Socorro	19,250	20,012	20,678	21,167	9.96%
Valencia	79,894	89,045	98,459	107,294	34.30%
Basin Total	1,089,348	1,224,061	1,353,564	1,475,433	**35.44%**

Source: New Mexico County Population Projections July 1, 2005 to July 1, 2035, Bureau of Business and Economic Research, University of New Mexico. Released August 2008.

Table 2: Summary Statistics for Water Right Transactions in the Middle Rio Grande Basin, 2000 – 2009

	Volume Traded (AF CU)	Unit Price ($/AF CU)
Mean	27.84	$12,776.56
Median	9.68	$12,483.32
Min	0.5	$3,332.20
Max	1,188	$33,288.85
St. Dev.	104.67	$7,522.79
Count	135	135

*All quantities listed are consumptive use (CU) volumes. Only the CU portion of pre-1907 water rights is transferable to a new purpose and place of use.

*Reported prices adjusted to 2009 dollars using the consumer price index

Table 3: Results of Econometric Model Estimation

Dependent Variable: Natural Logarithm of Water Right Unit Price ($/AF CU)						
Independent Variable	**Coefficient**	**Std. Err.**	**t**	**P-value**	**95% Conf. Interval**	
*volume***	-0.0015011	0.0002592	-5.79	0.000	-0.0020139	-0.0009883
*hpi_yr_avg***	0.0113793	0.0006021	18.90	0.000	0.0101881	0.0125705
*upstream***	0.1691434	0.0627675	2.69	0.008	0.0449565	0.2933304
*percapincome***	0.0000754	0.0000088	8.56	0.000	0.0000579	0.0000928
*dev_buyer***	0.2820771	0.0762777	3.70	0.000	0.1311598	0.4329944
Constant	4.399062	.2377424	18.50	0.000	3.928683	4.869442

R^2 = 0.8031 Adj. R^2 = 0.7955 F = 105.24 n = 135

**Statistically significant at the 99% confidence level

Table 4: Exogeneity Test Results

Hausman – Wu Test	
Null Hypothesis: *volume* is exogeneous	
P-value	0.2295
Result	Fail to reject H0

References

Action Committee of the Middle Rio Grande Water Assembly. *Middle Rio Grande Water Budget (Where water comes from, & goes, & how much), Averages for 1972 – 1997.* October 1999.

Basta, E. and B.G. Colby. "Water Market Trends: Transactions, Quantities, and Prices." *The Appraisal Journal.* Winter 2010.

Bjornlund, H. and P. Rossini. "Fundamentals Determining Prices and Activities in the Market for Water Allocations." *The International Journal of Water Resources Development* 21(2) (2005): 355-369.

Box, G.E.P, and D.R. Cox. "An Analysis of Transformations." *Journal of the Royal Statistical Society*. Series B (Methodological), Vol. 26, No. 2. (1964), pp. 211-252.

Bretsen, S. and P.J. Hill. "Water Marketing as a Tragedy of the Anticommons." *William and Mary Environmental Law and Policy Review* 33 (3), Spring 2009.

Brewer, J., R. Glennon, A. Ker, and G. Libecap. 2008. "Water Markets in the West: Prices,Trading, and Contractual Forms." *Economic Inquiry* 46, no. 2.

Brookshire, D.S., B. Colby, M. Ewers, P. Ganderton. 2004. "Market Prices for Water in the Semi-Arid West." *Water Resources Research* 40, no. 9.

Brown, F.L. "Surface Water Opportunities in New Mexico." New Mexico Water Resources Research Institute, October 2008.

Brown, T.C. 2006. "Trends in Water Market Activity and Price in the Western United States." *Water Resources Research* 42 (2006).

Byrd, H.A. 2004. "Estimating the Value of Groundwater Rights to Irrigated Agriculture: An Application of the Hedonic Price Model in the Northern High Plains." MS Thesis, Colorado State University.

Cristiano, C. Lee Wilson & Associates, Santa Fe, NM. Interview by author, 21 January 2010.

Colby, B.G., K. Crandall, and D.B. Bush. 1993. "Water Right Transactions: Market Values and Price Dispersion." *Water Resources Research* 29, no. 6: 1565.

Crouter, J.P. 1987. "Hedonic Estimation Applied to a Water Rights Market." *Land Economics* 63, no. 3.

Cunningham, N. Water Resources Supervisor, New Mexico Office of the State Engineer, Albuquerque. Interview by author, 18 December 2009.

Faux, J. 1997. Hedonic Price Analysis to Reveal Value of Water in Irrigation: An Application to Northern Malheur County, Oregon. MS Thesis, Oregon State University.

Federal Reserve Bank of St. Louis. Economic Data – FRED. House Price Index for New Mexico. Website. Online at http://research.stlouisfed.org/fred2/series/NMSTHPI.

Gensler, D., Oad. R., and Kinzli, K.D. 2009. "Irrigation System Modernization: Case Study of the Middle Rio Grande Valley." *Journal of Irrigation and Drainage Engineering*. ASCE, March/April 2009.

Glaeser, E.L., Gottlieb, and J. Gyourko. "Did Credit Market Policies Cause the Housing Bubble?" *Policy Briefs*, Rappaport Institute for Greater Boston, Taubman Center for State and Local Government. May 2010.

Gleick, P.H. "Water: The Potential Consequences of Climate Variability and Change for the Water Resources of the United States." The Report of the Water Sector Assessment Team of the National assessment of the Potential Consequences of Climate Variability and Change, U.S. Global Change Research Program, September 2000.

Goodman, D.J., and C.W. Howe. 1997. "Determinants of Ditch Company Share Prices in the South Platte River Basin." *American Journal of Agricultural Economics*, 79, no. 3.

R.Q. Grafton, C.J. Landry, G.D. Libecap and R.J. O'Brien. "Markets – Water Markets: Australia's Murray-Darling Basin and the U.S. Southwest." (July 22, 2009). ICER Working Paper No. 15/2009. Available at SSRN: http://ssrn.com/abstract=1437510

Grafton, R.Q., C.J. Landry, G.D. Libecap, S. McGlennon, and R. O'Brien. 2010. "An Integrated Assessment of Water Markets: Australia, Chile, China, South Africa, and the USA." *National Bureau of Economic Research*, Cambridge, MA. Working Paper 16203.

Hanak, E. 2002. "California's Water Market, By the Numbers." Public Policy Institute of California Occasional Papers. Prepared for Presentation to the Department of Water Resources.

Howe, C.W., C.S. Boggs, and P. Butler. 1990. "Transaction Costs as Determinants of Water Transfers." *University of Colorado Law Review*, 61, 393.

Jones, C.V. and J.R. Morris. "Instrumental Price Estimates and Residential Water Demand." *Water Resources Research* 20, no. 2 (1984): 197-202.

Jones, L. and B.G. Colby. "Weather, Climate and Environmental Water Transactions." *Weather, Climate, and Society.* Early online release 6/7/2010. Doi: 10.1175/2010/WCAS1028.1

Kennedy, P. 1985. *A Guide to Econometrics*. 2nd edition. The MIT Press, Cambridge, Massachusetts.

Landry, C.J. 1995. "Giving Color to Oregon's Gray Water Market: An Analysis of Price Determinants for Water Rights." MS Thesis, Oregon State University.

Loomis, J.B., K. Quattlebaum, T.C. Brown, and S.J. Alexander. "Expanding Institutional Arrangements for Acquiring Water for Environmental Purposes: Transactions Evidence for the Western United States." *Water Resources Development* 19, No. 1 (2003): 21-28

Michelsen, A.M., and R.A. Young. "Optioning Agricultural Water Rights for Urban Water Supplies During Drought." *American Journal of Agricultural Economics* 73 (November 1993): 1010-1020.

Middle Rio Grande Water Assembly. "Middle Rio Grande Regional Water Plan 2000 – 2005." Accepted 2004.

National Agricultural Statistics Service. "*All Farm Index: Prices Received and Prices Paid. All Items, 1979 – 2010 U.S., Annual*" Website. Online at http://www.nass.usda.gov/Charts_and_Maps/graphics/data/allprpd.txt

National Assessment Synthesis Team 2000. "Climate Change Impacts on the United States." Washington, D.C.: U.S. Global Change Research Program

National Climatic Data Center. Website. Online at http://lwf.ncdc.noaa.gov/oa/ncdc.html.

Oad, R. and J.P. King. "Final Report: Irrigation Forbearance Feasibility Study in the Middle Rio Grande Conservancy District." Prepared for MRGCD July 28, 2005.

Payne, M.T., M.G. Smith, and C.J. Landry. "Price Determination and Efficiency in the Market for South Platte Basin Ditch Company Shares." Forthcoming.

Pease, M. 2010. "Constraints to Water Transfers in Unadjudicated Basins: The Middle Rio Grande as a Case Study." *Journal of Contemporary Water Research & Education*. Issue 144, 37-43.

Person, P. and A. M. Michelsen. 1994. "Determinants and Trends in Water Right Prices: An Econometric Analysis." Laramie. U. S. DOI Geological Survey and Wyoming Water Resources Center, University of Wyoming. WWRC-94-06.

Pullen, J.L. and Colby, B.G. "Influence of Climate Variability on the Market Price of Water in the Gila-San Francisco Basin." *Journal of Agricultural and Resource Economics* 33(3) (2008): 473-487.

Smith, M.G. 1990. "The Water Market in the Southern Front Range of Colorado." *Proceedings of the Symposium on International and Transboundary Water Resource Issues.* March 1990.

Turney, T.C. 2010. "Agreement Between Interstate Stream Commission and the Holder of OSE Permit RG-57125." Presentation to the Middle Rio Grande Conservancy District, 12 July 2010.

United States Fish and Wildlife Service (USFWS). *Federal Register 50 CFR Part 17. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Rio Grande Silvery Minnow,* Final Rule. Vol. 68, No. 33 (2003). U.S. Department of the Interior.

University of New Mexico, Bureau of Business and Economic Research. "New Mexico County Population Projections July 1, 2005 to July 1, 2035." Released August 2008.

U.S. Census Bureau. *State and County QuickFacts*. Website. Online at http://quickfacts.census.gov/qfd/states/

Wright, K. and Flood, P. 2009. "Water Prices: The Essentials." Wright Water Engineers, Inc. CLE Presentation. Denver, CO.

Young, R. A. 2005. *Determining the Economic Value of Water.* Washington, DC: Resources for the Future.