DEVELOPING AN ECONOMIC TOOL TO PREDICT THE VALUE OF WATER RIGHTS

by

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ABSTRACT

Evidence suggests that advances in technology may be hastening the physical exhaustion of the Ogallala aquifer. This situation places the State of Kansas in a difficult situation. In administering water policy, State agencies are required to achieve an absolute reduction in water consumption, while maintaining the economic viability of irrigated agriculture in western Kansas. In order to maintain the profitability of irrigated agriculture, technological innovations need to continually be developed through research and adopted by the agricultural community. The question is how to allow this process to continue while at the same time reducing water consumption from the Ogallala aquifer.

Two potential policy alternatives are the Voluntary Water Rights Transition Program (VWRTP) and the Conservation Reserve Enhancement Program (CREP) currently under consideration by the State of Kansas. In order to implement these programs, the State of Kansas, policy makers, and stakeholders need input from the economic community on both program structure as well as the market value of water rights.

This research suggests that the value of water for agricultural purposes depends upon the spatially fixed, site-specific characteristics of the land on which the water is used. These factors include water source, soil type, crop type, depth to water, saturated thickness of the aquifer, the seniority level of the water right, average annual water usage, and local precipitation. Additionally, evidence suggests that the markets for irrigated and nonirrigated cropland are separate and distinct and as such should be modeled separately.

Conventional as well as spatial econometric hedonic models were developed to estimate the value of water rights in the five groundwater management districts in central and western Kansas. The spatially unadjusted OLS hedonic models for irrigated and nonirrigated land are considered the superior models from a predictive standpoint. Results indicate there is significant variation in the value of water rights within a given county. The results of this research will be beneficial to the State in the administration of future water rights retirement programs. This information can be used to set maximum acceptable bids and/or assess the reasonableness of a particular bid. The data also will be useful in program budgeting and/or predicting program success.

I. INTRODUCTION

Problem Description

Over the past 30 years there has been a significant increase in the number of irrigated acres in western Kansas. Additionally, an increase in the acres of water intensive crops, such as corn, has been observed. Each of these factors escalates the rate at which water is extracted from the Ogallala aquifer. The steady decline of the aquifer's saturated thickness raises concerns about the long-term viability of the irrigation-based economy of western Kansas. On the other hand, a steady reduction in the per acre water use for all irrigated crops has been observed. This efficiency gain likely has been the result of a combination of factors, including government regulation, intensive management, advances in technology, public awareness of the situation, and to an extent the lack of water availability. From a production economic perspective, these trends likely are revealing that the market is efficiently allocating scarce resources. However, from society's perspective, this economic efficiency may be less important than sustainability.

The public policy debate over the sustainability of the aquifer is significant. Several policy alternatives have been suggested, including water taxes, mandatory reductions in current water allocations, voluntary water retirement programs, incentive programs aimed at reducing the planted acreage of water intensive crops, incentive programs aimed at increasing irrigation efficiency (center pivot end gun removal, installation of water meters, low energy precision application (LEPA), sub-surface drip irrigation (SDI), etc.), and incentive programs aimed at temporarily converting irrigated land to dryland production. In order to make informed decisions, policy makers need accurate information from the economic community as to the economic impacts of these various policies.

Since the 1982 High Plains Study, both research and policy have focused on improving irrigation efficiency as the primary means of extending the economic life of the Ogallala aquifer. In Kansas, past trends in water consumption and crop mix, as well as recent economic research, suggests that efficiency gains might actually be accelerating water use and increasing the pace at which the aquifer is depleted (Golden, 2005). Government policy and economic research gradually are shifting toward a focus on sustainability issues and policy alternatives that achieve an absolute reduction in consumptive use. Two such policy instruments are the Voluntary Water Rights Transition Program (VWRTP) and the Conservation Reserve Enhancement Program (CREP). Through these policies an absolute reduction in consumptive use will be achieved by effectively purchasing and permanently retiring irrigation water rights in western Kansas.

Research Objective

In order to implement either the VWRTP or the CREP, the state of Kansas, policy makers, and stakeholders need input from the economic community on both program structure as well as the market value of water rights. The purpose of this research is to develop an in-depth understanding of the factors that impact the market value of water rights and provide the tools necessary to estimate the fair market value of water rights in western Kansas.

In this study, hedonic modeling procedures, along with spatial econometric techniques, are used to develop appraisal models to predict the value of water rights in the Ogallala region. The value of water rights are estimated as a function of parcel-specific hydrological characteristics such as well capacity, depth to water level, saturated thickness, and historical water usage. These models incorporate observed market data and adjust for objective differences in land quality, spatial location, and hydrological characteristics and yield an expected market value of water rights.

II. CONCEPTUAL MODELS

A Generalized Model of Land Value

As the demand for water has increased and supplies have decreased, the need to ensure efficient use and/or efficient reallocation of water resources has increased. As a result, a body of literature has developed for estimating the value of water. Unfortunately there is no well-defined market for water. Additionally, water rights are fuzzy, and as a result, the reallocation of these rights is difficult due to technical, legal, and political constraints. The absence of a well functioning market for water creates two problems. First, efficiency gains are lost due to the difficulty of reallocation, and second, price signals necessary for reallocation are often absent.

Two principal approaches have been used for examining land and water values: asset pricing models and hedonic models. This research will apply the hedonic technique. Hedonic theory was formalized in the 1920s; Rosen (1974) and Freeman (1979) provided the basis for modern hedonic modeling of heterogeneous consumer goods. Hedonic techniques use observed market data to estimate the value of water. Typically, hedonic modeling techniques are used to quantify the impact that various hydrological factors have on the observed price of irrigated land.

The purpose of this research is to assess the equilibrium market value of both agricultural land and water rights. The basic foundation of modern-day economics is the concept that, in a competitive market framework, equilibrium prices are determined by the interaction between supply and demand. With this in mind, the economics profession has generated a proliferation of supply and demand models that seems endless to the uninitiated. While these models are based on sound economic theory and derived with mathematical and statistical precision, as a general rule they all have one fault in common. That is, they are based on the assumption of a homogeneous good. By its very nature, agricultural land is a heterogeneous good. Individual parcels of land are differentiated by their location, use-type, soil type, recreational potential, road access, and a host of other factors. As such, many econometric modeling techniques are not suitable for evaluating the equilibrium price of land. One technique that is suitable and widely accepted in the economic community is the hedonic method as outlined by Rosen (1974).

Standard economic theory predicts that if there is a competitive market for water rights, separate from the associated land market, the allocation of water will be optimal and the market will be efficient. A portion of Weld County, Colorado was used to test the hypothesis that a separate and competitive market for water rights exists. In this area, water rights, defined as share ownership in ditch companies, could be traded without transferring the title of the associated land. Crouter (1987) hypothesized that where laws and institutions permit separate water transfers, the hedonic price function would be separable and linear in water. The resulting Box-Cox hedonic model, as a function of land quantity, water quantity, and distance to the nearest town, suggested that the land/water markets were neither separable nor competitive. The author suggested that this counterintuitive result was due to high transaction costs. The implicit value of water rights was estimated as $79.11 per acre per year. The author did not provide data on the acre-feet allocation per year.

As aquifer levels decline and irrigated cropland reverts to dryland production, one important economic impact for landowners will be a reduction in their land values. In 1965 the Fifth Circuit Court of Appeals, in the United States v. Marvin Shurbet et ux., held that groundwater in the Ogallala Aquifer in the southern high plains of Texas and New Mexico was a depletable mineral and natural deposit (McEowen and Harl, 2004). To qualify for this depletion allowance, aquifer drawdown had to be measured by state representatives. Torell, Libbin, and Miller (1990) used hedonic methods to place a dollar value on this drawdown. The research used data obtained from the Farm Credit Service and included farm sales from Colorado, Kansas, Nebraska, New Mexico, and Oklahoma for the 1979-1986 time period. Independent variables included a measure of income generating potential of the land, annual precipitation, depth to water, annual aquifer recharge, and a volumetric measure of water in storage. Coefficient estimates on measures of water depth and water in storage proved statistically significant in explaining land price. The authors point out that this is contrary to findings of Hartman and Taylor (1989) and Sunderland, Libbin, and Torell (1987). Two models were estimated, one for irrigated land and one for nonirrigated land. The value of water per acre-foot was the difference between the two estimates divided by the total water in storage. Water values varied across regions between $1.52 and $8.35 per foot of saturated thickness. A consistent finding across all regions was that the per-acre difference between irrigated and nonirrigated land was declining over time, indicating that the value of the water resource must have declined over time. The causes of these declines in value were declining water level and increased cost of pumping. Additionally, it was noted that higher water values tended to occur in areas where dryland production was severely limited due to the lack of natural rainfall.

There is an active market for water rights trading in the South Platte River Basin of Colorado. The demand for water generated by population growth in metropolitan areas has enticed producers of agricultural commodities to sell their shares in ditch companies. Goodman and Howe (1997) used hedonic techniques to value these water rights. The authors considered only those transactions where land was not transferred with the water right. Evidence suggests that the share price of a ditch company could be explained by the size of the share (appropriated quantity), the reliability of the share (seniority), and the transportation losses to the new diversion point. Surprisingly, the value of a share was not dependent upon the price of agricultural commodities and was statistically different between competing purchasers. While not discussed by the authors, these two points might imply that the market for water rights is not necessarily competitive.

Faux and Perry (1999) recognized that the observed sale price of irrigated land represents a bundled good which includes the value of land and the value of water. Incorporating this hypothesis, they used hedonic methods to estimate the implicit value of water. Their study focused on the value of surface water rights from several ditch irrigation districts in Malheur County Oregon, for the period 1991-1995. The authors assumed that the price difference between irrigated land and nonirrigated land, divided by the average annual water use of 3.5 acre-feet per year, represented the true value of water. Statistical analysis showed that the value of this water depended on the Natural Resource and Conservation Service (NRCS) land classification. Annual water values ranged from $9 per acre-foot to $44 per acre-foot. The present value of water rights, on a per acre basis, ranged from $514 to $2,551. Land with a higher productive classification had higher values of water.

The literature indicates that the value of water for agricultural purposes depends upon the spatially fixed, site-specific characteristics of the land on which the water is used. These factors include water source, soil type, crop type, depth to water, saturated thickness of the aquifer, seniority level of the water right, and local precipitation.

Formally, a model of agricultural land values and the associated hedonic regression is one in which the price of land is statistically regressed on the land attributes or characteristics. The resulting parameter estimates reflect the implicit prices of the attributes. Implicitly, the model assumes that the market is competitive and in equilibrium.

Because a parcel of agricultural land is sold as a bundle with a variety of characteristics and because the sale price reflects the value of the bundle, hedonic regression provides a means for estimating the implicit price of the individual characteristics of agricultural land and their impacts in determining land value. In many ways the hedonic approach is similar to the process followed by land appraisers when attempting to place a market value on a parcel of land. The main difference between the appraiser and the hedonic approach is that the latter provides more precision in the estimation of implicit prices and is less distorted by subjective bias. On the negative side, researchers using the hedonic approach might not have parcel-specific knowledge that is otherwise available to the appraiser (i.e., missing variables in the model).

A generalized statistical regression model of land values can be specified as

(1) $$SPA = \sum_{i=1}^{n} P_{C_i} C_i + \varepsilon ,$$

where *SPA* is the sales price per acre of land, C_i are *i* components or characteristic of the land with implicit prices P_{Ci}, and ε is a random disturbance term.

The literature reveals that the price of land can be conceptualized as having four major components or characteristics. These include a productivity component, a consumptive component, a speculative component, and a transactional component. The productive component is affected by factors related to the income-generating capacity of the land, including crop productivity, land use-type (irrigated production, nonirrigated production, or pasture land), topography, expected government payments, credit policies, and technological change. The productive component is generally considered the primary component of agricultural land values. Featherstone et al. (1993) and Roka and Palmquist (1997) have included land quality and use-type measures as indicators of the productive capacity of land.

The consumptive component recognizes the intrinsic value of land to the owner. Pope and Goodwin (1984) hypothesized that buyers purchase land so that they can touch, feel, and enjoy the rural experience. Factors impacting this component include income levels, population levels, levels and location of urbanization, and site characteristics. Featherstone et al. (1993) used road access and quality as a measure of the consumptive component, while Roka and Palmquist (1997) incorporated a population density variable. Crouter (1987) incorporated the distance to the nearest town as an explanatory variable to capture the impact of consumptive value.

The speculative component arises from the buyer's expectation that the price of land will follow some trend, either positive or negative, over time. Featherstone and Baker (1987) suggest the existence of speculative bubbles which cause markets to both overshoot and undershoot values based solely on the discounted stream of returns. Factors affecting the speculative component include trends in farmland prices, expected capital gains, expectations of government payments, cash rent trends, interest rates, inflation, international currency rates, and export policies. Featherstone et al. (1993) included yearly dummy variables to capture this impact.

While the productive, consumptive, and speculative components generally are viewed as determining land value, transactional components are critical in determining the price level of land. Since price is observed, and not value, it is important to consider transactional components. Transactional components can include special considerations given to the buyer and/or seller. These components also include the nature of the sale, such as owner or special financing, forced sales, and sales to relatives. Featherstone et al. (1993); Perry and Robinson (2001); and Lewicki, Saunders, and Minton (1999) explicitly modeled the impact of transaction-specific components on the price of land. Many others have implicitly modeled this impact by identifying and eliminating any observations that cannot be viewed as an "arms length transaction" from their datasets. Other transaction-specific components include the size of the parcel and value of improvements. Featherstone et al. (1993); Roka and Palmquist (1997); and Xu, Mittelhammer, and Barkley (1993) incorporated tract size variables to capture this impact.

Based on the definition of component parts, the generalized linear hedonic land model specified in equation (1) can be revised as

$$(2) \qquad SPA = \sum_{i=1}^{n} P_{PC_i} PC_i + \sum_{j=1}^{m} P_{CC_j} CC_j + \sum_{k=1}^{o} P_{SC_k} SC_k + \sum_{l=1}^{p} P_{TC_l} TC_l + \varepsilon ,$$

where SPA is the sales price per acre of land, PC_i are i productive components with prices P_{PCi}, CC_j are j consumptive components with prices P_{CCj}, SC_k are k speculative components with prices P_{SCk}, and TC_l are l transactional components with prices P_{TCl}. Given a set of market observations, including the observed sale price per acre of land as well as quantitative or qualitative measures for the various component parts, the objective of the hedonic model is to estimate the implicit prices associated with the individual component parts.

A Conceptual Model of the Value of Water Rights

The hedonic appraisal technique allows for the unbiased estimate of the value of water rights based both on the conventional site-specific characteristics as well as hydrological characteristics. The hedonic technique assumes that the value of a product, in this case a parcel of land, is equal to the sum of the value of the product's component parts as shown in equation (2). It is a relatively straightforward process that allows a water right to be conceptualized as simply a component part or characteristic of the land.

Investigation into the value of water rights and the role that various hydrological parameters have in determining that value requires the development and estimation of two basic hedonic models. By applying equation (2), the first model will estimate the value of nonirrigated land and the second model will be used to estimate the value of irrigated land. The difference between the irrigated parcels estimated sales price (SPA_I) and its estimated nonirrigated value (SPA_{NI}) represents the implicit value of the water right (VWR). Based on this conceptualization, a generalized statistical regression model of the value of water rights can be specified as

(3) $$VWR = SPA_I - SPA_{NI} + \varepsilon \, .$$

The hedonic or fair market value approach assumes that the value of water rights is represented by the price differential between irrigated cropland and nonirrigated cropland as observed in the marketplace. The hedonic approach to valuing water rights has been used by Crouter (1987); Sunderland, Libbin, and Torell (1987); Hartman and Taylor (1989); Torell, Libbin, and Miller (1990); Goodman and Howe (1997); and Faux and Perry (1999).

Crouter (1987) found that the annual quantity of water allocated was statistically significant in determining the implicit value. His research also suggested that the land/water markets were neither separable nor competitive. Torell, Libbin, and Miller (1990) used hedonic methods to determine that the distance to the static water level and the saturated thickness of the aquifer were statistically significant in explaining irrigated land prices. They also found that the per-acre value of water rights was declining over time. Goodman and Howe (1997) found that the appropriate quantity and seniority level of the water right helped determine the value of the water right.

In conclusion, the literature suggests that the value of water for agricultural purposes depends upon the spatially fixed, site-specific characteristics of the land on which the water is used and hydrological characteristics as well as other attributes of the water right. Factors that tend to influence land price include soil type, use-type, access, recreational value, urban influence, and location. Factors that tend to influence the value of water include water source, soil type, crop type, depth to water, saturated thickness of the aquifer, the seniority level of the water right, and local precipitation.

Given a dataset of market observations including the observed sale price per acre of irrigated and nonirrigated land, as well as quantitative or qualitative measures for the various factors that influence the price of land and water rights, the above conceptualized hedonic models can be used to discover the implicit value of each factor. Based on the value of individual characteristics, equation (2) can be used to estimate the value of a particular parcel when used as either irrigated or nonirrigated land. Equation (3) can then be applied to estimate the value of the water right.

III. DATA

Kansas Agricultural Statistics Service Data

The Kansas Agricultural Statistic Service (KASS) data set provides yearly aggregate estimates of land prices by crop reporting districts, for irrigated, nonirrigated, and pasture land. These data are obtained by the Agricultural Land Values Survey, which generally is conducted during the spring of each year. Survey respondents are asked to provide information on the value of the land they operate and the rental rates for any land they rent. Additional land value data are collected in the yearly Agricultural Survey.

The Census of Agriculture provides the official base for estimates of all farmland values. The Census occurs once every five years and estimates the value of all agricultural land and buildings. Using the Census as a basis, the Agricultural Land Values Survey and Agricultural Survey provide the data necessary to make annual estimates of market values for different categories of farmland. While the KASS data provide only an area-level point estimate of land values, and thus are not suitable for the evaluation of individual parcels, it is very useful for studying overall time trends in land values.

Kansas Society of Farm Managers and Rural Appraisers Data

The Kansas Society of Farm Managers and Rural Appraisers (KSFMRA) is an organization of professional people who are engaged in some phase of farm management or rural appraisal work. Membership is composed of professionals from farm management consulting companies, insurance companies who make agricultural loans, banks engaged in agricultural lending and farm management services, real estate agencies, the Farm Service Agency, Farm Credit Services, Kansas State University farm management and rural appraisal personnel, self-employed rural appraisers and farm managers, county appraisers, and others. The membership contributes farmland sales data to a database maintained by the Department of Agricultural Economics at Kansas State University. One of the unique features of this dataset is the subjective information pertaining to farmland sales provided by contributors, based on their local knowledge. This information includes qualitative opinions regarding the irrigation equipment, recreational value, value of improvements and buyer motivation. Additionally, the KSFMRA dataset includes objective measures of site specific characteristics not found in other sources. Contributors typically report the percent of mineral rights and associated royalty values transferred with the sale, acres of land enrolled in the Conservation Reserve Program (CRP), and the breakdown between flood and center pivot irrigated acres.

Water Information Management and Analysis System Data

In 1991, the U.S. Geological Survey, in cooperation with the Kansas Division of Water Resources, developed a Geographic Information Systems (GIS) application known as the Water Information Management and Analysis System (WIMAS). This application is used to assist in the analysis and management of the State's water resources. The WIMAS generated dataset provides time series data on each point of diversion (PDIV), typically a single water well, in the target area. For each PDIV the dataset includes well capacity, average annual acre-foot water usage, authorized water usage, seniority level, the technology used to irrigate the associated parcel, as well as a variety of other well-specific information.

Kansas Geological Survey Data

The Kansas Geological Survey High Plains Aquifer Section-Level Database consolidates information formerly maintained by several local, state, and federal agencies. The section-level data can be accessed through the WIZARD system maintained by the Kansas Geological Survey (KGS). The KGS dataset contains the necessary information on depth to water, saturated thickness, annual aquifer decline, sustainable yield, and other hydrological parameters.

Nonirrigated and Irrigated Datasets

The data used for the valuation of water rights in western Kansas consist of two datasets, a dataset comprised of observations on sales of nonirrigated land and a dataset comprised of observations on sales of irrigated land. The literature reveals that several applications of the hedonic method to water valuation have relied on single equation estimation of the hedonic price function where the data on irrigated and nonirrigated sales were pooled. One implicit assumption associated with single equation estimation is that there is one market encompassing both irrigated and nonirrigated cropland and the parameter estimates on explanatory variables are the same regardless of whether the land is irrigated or nonirrigated. Golden (2005) and post model testing from the current study suggests that the markets for irrigated and nonirrigated cropland are separate markets and thus require separate model estimation.

The assumption of separate markets and the estimation of separate models for irrigated and nonirrigated land requires formal definitions of what constitutes an observation of an irrigated sale and a nonirrigated sale. Within this context (irrigated versus nonirrigated) the definition for a nonirrigated sale is relatively apparent. The subset of observations classified as nonirrigated sales should include all sales where irrigation is not present. Sales observations classified as nonirrigated sales will consist of sales where only nonirrigated cropland acres and pasture acres are present. Categorizing sales as either irrigated or nonirrigated is consistent with Torell, Libbin, and Miller (1990). The nonirrigated dataset consists of 8,854 observations, for the years 1990 through 2004, obtained from the KSFMRA database. All sales were classified as "arms length transaction" by the KSFMRA contributor.

The definition of an observed irrigated sale is more subjective and somewhat *ad hoc*. Approximately 85% of the observed sales that had irrigated land were irrigated with center pivot technology. Center pivot technology does not irrigate the corners of a square field. In general, a conventional center pivot system will irrigate approximately 78% of the acres in a square field. This percentage could vary depending on field shape irregularities. An irrigated sale is defined as a sale where at least 70% of the acreage was irrigated. Sales observations classified as irrigated sales will consist of sales where irrigated cropland acres, nonirrigated cropland acres, and pasture acres are present.

The irrigated dataset consists of 1,189 observations for the years 1990 through 2004 obtained from the KSFMRA database. All sales were classified as "arms length transaction" by the KSFMRA contributor. All data records contained the legal description of the property. Based on the legal description, the WIMAS, and KGS datasets were merged with the KSFMRA dataset. Observations with multiple or confusing points of diversion were manually reviewed and modified as deemed appropriate.

Adjusting Land Sales Price for Inflation

Without question, land prices have trended upward in the counties comprising the study area during the study period, 1990-2004. In order to obtain unbiased estimates of land value, this inflation needs to be taken into account. Land prices can be adjusted based on the assumption that per acre land price is inflating at a constant percentage per year or on the assumption that per acre land price is inflating at a constant dollar amount per year.

The KASS data provide a single point estimate of land values that is useful for studying overall time trends in land values. Trend analysis was conducted on the KASS data. The analysis suggests that the observed sales price of land should be de-trended based on the assumption of a linear time trend. This will be accomplished by inserting a linear trend variable into equation (2).

IV. FARMLAND AND WATER RIGHTS VALUE MODELS

Introduction

The hedonic appraisal technique allows for the unbiased estimation of the value of water rights based both on the conventional site-specific characteristics of the land as well as hydrological and related characteristics of the water right. From an empirical standpoint of water valuation, the hedonic model is based on market transactions as opposed to a researcher's estimate of crop yield, crop prices, fixed costs, and variable costs of production (Faux and Perry, 1999). The hedonic technique assumes that the value of a product, in this case a parcel of land, is equal to the sum of the value of the product's component parts. For explanatory purposes the characteristics of land are categorized as the productive, consumptive, speculative, and transactional components.

The productive components should include attributes that contribute to the income generating capability of the land, and thus are important to a producer. Productive components could include the proportion of irrigated cropland, the proportion of nonirrigated cropland, soil quality, annual rainfall, well capacity, depth to the water table, existing CRP and/or mineral royalty cash flows, parcel size, and the property's location relative to the buyer's existing business operation. The consumptive components should include attributes thought to influence a consumer's decision to purchase land. These factors typically increase the utility associated with property ownership. Scenic beauty, the quality of road access, recreational value, the distance to population centers, and population density normally are considered to be consumptive components of land. The speculative components should include characteristics of the land that would tend to influence investment. Expectations of interest rate, future land value inflation, and the future profit potential associated with a mineral interest in the land would be considered speculative components. The remaining saturated thickness of the underlying aquifer could be considered a speculative component in the case of irrigated land. Transactional components focus on issues specific to an individual sale, such as the number of acres included in the parcel, financing terms, and whether or not the sale is considered an arms length transaction.

Investigation into the value of water rights, and the role that various hydrological parameters have in determining that value, requires the development and estimation of two basic hedonic models. The first model will estimate the value of nonirrigated land and the second model will be used to estimate the value of irrigated land. The difference between the irrigated parcel's estimated sales price (SPA_I) and its estimated nonirrigated value (SPA_{NI}) represents the implicit value of the water right (*VWR*):

OLS Hedonic Model for Nonirrigated Cropland

The linear hedonic model for nonirrigated cropland can be specified as

$$(4)\quad \begin{aligned} SPA_{NI} = {} & \beta_0 + \beta_1 TREND + \beta_2 PNIRR + \beta_3 ADJ + \beta_4 TENANT + \sum_{i=5}^{n} \beta_i CTY + \\ & \beta_{n+1} CRP + \beta_{n+2} GQLT + \beta_{n+3} LQLT + \beta_{n+4} REC + \beta_{n+5} ID2 + \beta_{n+6} PRD + \\ & \beta_{n+7} DRD + \beta_{n+8} MIN + \beta_{n+9} ACRES + \beta_{n+10} ACRES^2 . \end{aligned}$$

In equation (4), SPA_{NI} is the per acre sale price of nonirrigated land. The productive components included in the model are the proportion of nonirrigated cropland (*PNIRR*), a binary variable that indicates whether the parcel sold was adjacent (*ADJ*) to the buyer's existing operation, a binary variable that indicates whether the parcel sold was sold to the current tenant (*TENANT*), binary variables for each of the counties (*CTY*) in the sample, a binary variable indicating whether a portion of the land was currently enrolled in the Conservation Reserve Program (*CRP*), and binary variables indicating whether the land quality was rated as good (*GQLT*) or low (*LQLT*).

Consumptive components include binary variables to identify whether or not the parcel had recreational potential (*REC*) and if the road access was by paved road (*PRD*) or dirt road (*DRD*). The impact of urban centers was incorporated by including the distance to the closest town with a population over 5,000. This distance was transformed to the inverse distance squared (*ID2*), to account for the diminishing impact of distance as distance increases. Additionally, the county binary variables will help capture the variation related to consumptive use.

The speculative aspect of land price is captured by inclusion of a trend variable (*TREND*) and the proportion of mineral rights (*MIN*) transferred with the sale. Because all sales are classified as arms length transactions there was no need to control for this transactional aspect of land prices. The total acres in the parcel (*ACRES*) and the associated quadratic term $ACRES^2$ were included to control for the size-specific aspect of sale price.

A positive sign on the parameter estimate for the proportion of nonirrigated cropland (*PNIRR*) is expected. To avoid perfect multicollinearity the proportion of pasture was not included in the model. As a result, the parameter estimate for *PNIRR* is measured relative to pasture land. Because the price of land is greater than zero and nonirrigated cropland is generally more valuable than pasture land it is reasonable to assume a positive influence.

It is generally believed that producers will pay a higher price for land that is adjacent to their existing operations, all else equal. The close location enhances operational efficiency and justifies the additional expense. As such, a positive sign is expected on *ADJ*. Social capital accruing to the tenant in a tenant-landlord relationship would suggest a negative sign on the parameter estimate for *TENANT*.

Annual rainfall should have a positive impact on the sale price per acre of land. An increase in rainfall should increase the income generating ability of nonirrigated cropland and pasture, and decrease the cost of irrigated production. This increased income stream should be at least partially capitalized in the price of land and raise the productive value of land. Additionally, county-level-population density is a measure of the number of potential buyers in the market. As the number of buyers increases, the demand for land should increase. This increase in consumptive value should be reflected as a positive impact on price. Many researchers have implicitly modeled both these impacts through the incorporation of regionalized binary variables. To capture these factors, binary variables for all counties but the reference county were included in the model. The reference county will vary by groundwater management district, with the county with the most sales being the default binary variable and all other county parameter estimates being relative to this default county. Post model tests, including likelihood ratio tests and out-of-sample analyses, verified that the use of county binary variables generated superior results as compared to alternative model specifications which included rainfall and population variables.

The presence of CRP payments (*CRP*) might add to the cash flow generated by the property. The income streams generated from this binary variable should be partially capitalized into the sales price of the land. The parameter estimate will quantify this impact and is expected to be positive.

Contributors to the Kansas Society of Farm Managers and Rural Appraisers (KSFMRA) database provide qualitative appraisals as to the overall quality of the land sold. The land is rated as good quality, average quality, or low quality. Using average quality land as the default, binary variable allows us to quantify the differential in land price between average quality land and good quality land and between average quality land and low quality land. As land quality increases the price of land is expected to increase. As a result, the parameter estimate on *GQLT* should be positive while the parameter estimate on *LQLT* should be negative.

The recreational aspect of land should increase the consumptive value of a property. *REC* is a binary variable that takes on the value of one if the property has recreational potential and zero otherwise. Based on data available in the KSFMRA data set, any property that was noted as having recreational or hunting potential, as well as any land that had large reservoirs or live water, was assigned a value of one. A positive sign is expected on the parameter estimate.

The distance to urban centers has been shown to have a negative value on land prices. That is, as the distance increases from the population center the sale price decreases. This impact is not linear and the negative impact generally diminishes less rapidly as distance increases. By specifying the impact as the inverse distance squared, the non-linear impact is accounted for and a positive sign is expected since the variable has larger values for shorter distances. The quality of road access has been shown to be a determinant of land price. Typically, as access quality improves, the value of the property increases. Road access was classified as paved roads, gravel roads, or dirt roads. The variables paved roads (*PRD*) and dirt roads (*DRD*) were specified as binary variables, with gravel roads acting as the default variable. Paved roads would be preferable to gravel roads so the expectation is that the parameter estimate on *PRD* will be positive. Similar logic would imply the parameter estimate on *DRD* would be negative.

The proportion of mineral rights (*MIN*) transferred with the property is generally transaction specific. As the proportion increases, expectations of future income from royalties increase, resulting in a positive impact on the sale price. A negative sign is expected on the parameter estimate for *ACRES*. This would be consistent with the findings of Featherstone et al. (1993); Roka and Palmquist (1997); and Xu, Mittelhammer, and Barkley (1993). As the size of a parcel increases, financial constraints limit the quantity of willing buyers, thus reducing the demand. The quadratic term $ACRES^2$ is included to capture the impact of diminishing marginal impact with the expectation of a positive sign.

OLS Hedonic Model for Irrigated Cropland

The OLS model for irrigated land can be specified as

$$\begin{aligned}SPA_I = {} & \beta_0 + \beta_1 TREND + \beta_2 PNIRR + \beta_3 ADJ + \beta_4 TENANT + \sum_{i=5}^{n} \beta_i CTY + \\ & \beta_{n+1} CRP + \beta_{n+2} GQLT + \beta_{n+3} LQLT + \beta_{n+4} REC + \beta_{n+5} ID2 + \beta_{n+6} PRD + \\ & \beta_{n+7} DRD + \beta_{n+8} MIN + \beta_{n+9} ACRES + \beta_{n+10} ACRES^2 + \beta_{n+11} PIRR + \\ & \beta_{n+12} FLOOD + \beta_{n+13} SPKINC + \beta_{n+14} SPKQLT + \beta_{n+15} AFU + \beta_{n+16} AFU^2 .\end{aligned} \tag{5}$$

The first portion of this model is identical to the nonirrigated model. Explanatory variables have been added to quantify the impact of several factors specific to irrigated land. The proportion of irrigated land (*PIRR*), the type of irrigation technology used on the property, either flood (*FLOOD*) or center pivot, whether or not the center pivot sprinkler system was included in the sale price (*SPKINC*), the quality of center pivot sprinkler system (*SPKQLT*) and the average annual acre-feet of water used on a per acre basis (*AFU*), as well as the quadratic specification (AFU^2), all add to the productive component of irrigated cropland.

A positive sign on the parameter estimate for the proportion of irrigated land (*PIRR*) is expected. To avoid multicollinearity, the proportion of pasture was not included in the model. As a result, the parameter estimate for *PIRR* is measured relative to pasture land. Since the price of land is greater than zero and irrigated cropland is generally more valuable than pasture land, it is reasonable to assume a positive influence.

The irrigation technology used on an irrigated parcel should impact the sale price of that parcel. It is generally believed that center pivot technology is superior to flood technology. Additionally, center pivot technology is more expensive. As a result, it would be expected that irrigated parcels with center pivot technology be valued at a higher price in the market. *FLOOD* is a binary variable that is equal to one if the parcel is flood irrigated and zero otherwise. A negative parameter estimate is expected on this variable.

Over the past two decades, farm size has increased and research indicates that much of this increase has occurred through the acquisition of land via rental agreements. An irrigated producer who expands his operation by renting property might well choose to lease irrigation equipment. In such a case the irrigation equipment may not be transferred to the new owner when the property sells. *SPKINC* is a binary variable which is equal to one if the sprinkler was included with the sale and zero otherwise. Including the center pivot irrigation equipment in the sale adds asset value to the property, thus raising the per acre sale price. Therefore, it would be expected to have a positive parameter estimate. The quality of center pivot equipment that accompanies the land sale will also impact sale price. *SPKQLT* is a binary variable that is equal to one if the irrigation equipment was rated as above average by the KFMRA appraiser and zero otherwise. A positive parameter estimate is expected on this variable.

The literature indicates that crop selection, to some extent, depends on well capacity. It has also been inferred that more water intensive crops tend to have a higher value. Since land values depend on the value of crop production, it can be inferred that land with higher well capacities will have a higher value. In some areas, the remaining saturated thickness of the aquifer limits the amount of time that a well can be pumped at full capacity. It is believed that the average annual acre-foot per acre (*AFU*) usage of irrigation water combines the positive impact associated with well capacity and a negative impact associated with diminishing saturated thickness. The average annual acre-foot per acre usage of irrigation water was the average obtained from the WIMAS dataset over the study period. A positive sign is expected on the parameter estimate for this explanatory variable. The quadratic form of this variable has been included to quantify the diminishing marginal impact. A negative parameter estimate is expected on AFU^2.

Model Estimation

The models described in equations (4) and (5) were estimated using ordinary least squares (OLS) in SAS 9.1. These equations were estimated for each of the five groundwater management districts. The summary statistics for the nonirrigated data used in model estimation are reported in Table 1 through Table 5. The summary statistics for the irrigated data used in model estimation are reported in Table 6 through Table 10. Parameter estimates and model fit statistics for both models are presented in Table 11 through Table 15. Measures of fit and the level of statistical significance for parameter estimates suggest the model will perform adequately in predicting the sales price of irrigated and nonirrigated farmland. In general, the parameter estimates verify prior expectations as to the direction of impact of the models' explanatory variables.

Model Verification

Out-of-sample testing is a loosely defined term relating, most generally, to testing the out-of-sample predictive accuracy of a model. There are no precisely defined methods or test statistics for out-of-sample testing. Individual researchers generally define their own procedures and methods of comparison. To test the out-of-sample predictive ability of the model, the data were randomly partitioned into four subsets. Using three fourths of the data, referred to as the in-sample data, parameter estimates were obtained for the model. These parameter estimates were then used to predict the remaining one fourth of the observations, referred to as out-of-sample data. This process was continued until all four subsets of out-of-sample data had been predicted.

Several statistical measures of prediction accuracy were used to evaluate the out-of-sample predictive ability of the model. The mean error (ME) is a measure of the overall bias in the predictions (did the predictions tend to be too high or too low on average?). The mean absolute error (MAE) is a measure of absolute deviation. The mean squared error (MSE) and the root mean squared error (RMSE) serve as measures of the degree of error. The Pearson correlation coefficient, reported here in its squared form to be comparable to the usual model fit measure (R^2), varies between zero and one, and measures the degree of linear co-movement between the observations and predictions.

This out-of-sample testing procedure was used to compare various model specifications to the models specified in equation (4) and equation (5). The results suggest that the specified OLS hedonic models do a superior job of predicting on an out-of-sample basis.

Economists long have been aware that the prices of neighboring parcels of agricultural land are highly correlated. Traditionally, this correlation has been quantified by the inclusion of independent variables that are believed to cause the correlation[1] and residual or unexplained correlation[2] generally has been ignored. As an example, in the above specified OLS hedonic model, county binary variables were included to capture the price correlation generated by spatial differences in rainfall, soil type, and population. However, residual analysis suggests that all spatial correlation associated with price has not been accounted for. Recent advancements in Geographic Information Systems (GIS), spatial econometric techniques, and computer algorithms allow the estimation of this residual spatial impact without specifying the actual cause of the spatial correlation.

Research into statistical and econometric methods to handle spatial effects was first initiated in the 1950s. In the early 1970s Jean Paelinck coined the phrase "spatial econometrics" to identify the field that focuses strictly on methods and procedures for handling spatial effects in economic models (Anselin and Florax, 1995). Anselin (1988) identified two types of spatial effects that potentially can lead to spatial correlation, spatial dependency and spatial heterogeneity. The presence of these spatial effects may cause conventional econometric techniques to be inappropriate.

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[1] This is typically referred to as "substantive" spatial correlation in the literature.
[2] This is typically referred to as "nuisance" spatial correlation in the literature.

Spatially adjusted models were estimated based on the first order spatial autoregressive moving average model (SARMA) as defined by Anselin (1988). The out-of-sample testing procedure was used to compare the OLS model specifications to the spatially adjusted models. The results suggest that the specified OLS hedonic models do a superior job of predicting on an out-of-sample basis. This finding is consistent with Golden (2005).

A maintained assumption when using OLS as an estimator is that the errors are homoskedastic. That is, the random disturbance term has a mean of zero and a constant variance. Heteroskedasticity exists when a model error does not have a constant variance over all observations. If the assumption of homoskedastic errors is violated, the resulting OLS parameter estimations are unbiased but potentially inefficient. As a result, inferences based on the calculated t-statistics may be inappropriate. The Breusch-Pagan test was used to test for heteroskedasticity. The Breusch-Pagan test is asymptotic and follows a χ^2 distribution. The null hypothesis assumes homoskedasticity and the alternative hypothesis is that each observation's error term has a different variance that depends on one or more explanatory variable. For the OLS hedonic model, the Breusch-Pagan test rejects the null hypothesis of homoskedasticity at the 99% confidence level. Figure 7.1 depicts the nature of the implied heteroskedasticity. Parcels of land with high sales price per acre generate large positive errors (i.e., predictions were lower than actual values). Parcels of land with low sales price per acre generate large negative errors (i.e., predictions were higher than actual values).

Heteroskedasticity can be corrected through model transformation and the application of generalized least squares estimation procedures, or data partitioning. However, these methods require assumptions as to the underling nature of the heteroskedasticity. In the presence of erroneous assumptions, which place artificial constraints on the model, both methods will yield biased and inefficient estimators. Additionally, it is hypothesized that heteroskedasticity often is the result of model misspecification, which generates omitted variable bias. In the presence of model misspecification no modeling technique results in unbiased estimators and the choice of estimator could depend on preference or some empirical method such as out-of-sample testing. As a general rule, most hedonic models suffer from heteroskedasticity and researchers apply OLS as an estimator anyway.

Generalized least squares estimation procedures were used to estimate models, theoretically correcting the heteroskedasticity. The out-of-sample testing procedure was used to compare the ordinary least squares model specifications to the adjusted models. The results suggest that the specified OLS hedonic models do a superior job of predicting on an out-of-sample basis.

Of special interest to stakeholders and policy makers associated with valuing water are potential determinants of the sale price of irrigated land that were not statistically significant, within our specification. Within the framework of the above specified OLS model for irrigated land, each of the variables discussed in the following paragraphs was individually tested for causality. This was accomplished by adding each variable, individually, to the model specified in equation (5) and evaluating the resulting parameter estimate. Based on a statistical confidence threshold of 90% for the associated parameter estimate, each potential causal factor was rejected as being important in determining the sale price of irrigated land.

Water rights that were adjudicated prior to April 12, 1984 are considered to be senior water rights. In the event of water rights curtailment, a senior water right would be preferable to a junior water right. *SEN* is defined as a binary variable that is equal to one if the associated water right is senior and zero otherwise. The literature suggests that the seniority level of the water right is a significant determinant of value. The lack of significance on this variable probably is due to the fact that rarely have junior water rights been restricted. If the market, based on past experience, does not see a difference between junior and senior rights, it is unlikely then that seniority will be a significant determinant of the market price. Awareness of the potential importance of seniority level, and its impact on market values, is increasing and producers currently are structuring their long-term leases so that the rental rate would be reduced if junior rights were ever restricted. If this trend continues, seniority, in all likelihood, will become a significant factor in determining the sale price of irrigated land.

During the adjudication process, an allowable quantity was assigned to each water right. *AQ* is a continuous variable that is equal to the adjudicated quantity associated with the water right. Since more water is preferred to less, a positive parameter estimate was expected on this variable. The lack of statistical significance associated with this variable probably is due to the high level of uniformity of adjudicated quantities within a geographical area.

Water used in the production of irrigated crops has a positive economic value. The saturated thickness of the aquifer underlying a specific parcel represents the stock value of future water use. Research has indicated that there is a positive correlation between this stock value and the price of land. *SAT* is a continuous variable that is equal to the saturated thickness of the aquifer underlying the specific parcel. Since more water is preferred to less, a positive parameter estimate was expected and obtained on this variable. The lack of statistical significance associated with this variable probably is due to the fact that the stock of water available is partially explained by *AFU*.

The distance to the static water level partially determines the cost of pumping. As the distance to the static water level increases, production costs increase while profits decrease.

Since these costs are expected to be capitalized into the price of land we would expect to observe parcels with greater distances to the static water level selling at a discount. It is possible that the lack of statistical significance is due to the high correlation between depth to the static water level, saturated thickness, and average annual usage. It is also possible that the small variation in pumping costs resulting from differing static water levels across localized parcels is insignificant in determining irrigated land prices.

Static water level decline rates are a major concern to stakeholders in the Ogallala aquifer. These decline rates are monitored closely by state agencies and market participants. Since water use density, recharge rates, and other hydrological parameters vary across parcels, decline rates also vary across parcels. Since the decline rate impacts both the current cost of production and long-term irrigation potential of a parcel, it is expected to impact the market price of irrigated cropland. *Change* is a continuous variable that is equal to the total change in feet, between 1991 and 2001, in the static water level of the aquifer underlying the specific parcel. If the static water level declined, the observation has a negative value. On the other hand, if the aquifer recharged and the static water level increased, the observation has a positive value. With this in mind, a positive parameter estimate was expected and obtained. The lack of statistical significance associated with this variable likely is due to the high level of uniformity in the area and the fact that decline rates in the sample period were minimal.

The Value of Water Rights

The OLS hedonic models for irrigated and nonirrigated land are considered to be the superior models. Measures of fit, levels of statistical significance, out-of-sample testing, and structural testing of the two models provide confidence in the model specifications.

Additionally, it is believed that the OLS model will receive greater acceptance, due to its simplicity and intuitive nature, from the stakeholders involved in the political process.

Table 16 through Table 20 provides estimates of the predicted average 2006 fair market value of irrigated and nonirrigated land for the counties in western Kansas. For comparison purposes, this table categorizes the value of irrigated land based on the average acre-foot per acre water usage. The difference, at a specified level of water use, between the estimated fair market value of irrigated land and the estimated fair market value of nonirrigated land would be the estimated fair market value of the water right.

The values for irrigated land assume a 160 acre parcel composed of 130 acres of irrigated land and 30 acres of nonirrigated land. Included in the dollar amount is the implicit value of a center pivot of above average quality. The value of the irrigation equipment was included because the literature suggests that the value of a water right normally is considered to be the difference between the observed price of irrigated land and comparable nonirrigated land, which would include the value of the irrigation equipment. Additionally, the inclusion of the irrigation equipment is consistent with the intent of the current Voluntary Water Rights Transition Program and the Conservation Reserve Enhancement Program. Table 16 through Table 20 also assumes average quality land and average road access.

In order to calculate the estimates listed in Table 16 through Table 20 all sales observations classified as irrigated farmland were estimated using equation (5) and the parameter estimates from the irrigated model shown in Table 11 through Table 15. This process yielded an estimated irrigated sales price per acre (SPA_I) for each irrigated parcel. Additionally, all sales observations classified as irrigated farmland were estimated using equation (4) and the parameter estimates from the nonirrigated model shown in Table 11 through Table 15. This process yielded an estimated nonirrigated sales price per acre (SPA_{NI}) for each irrigated parcel. Equation (3) was then applied to generate the expected value of the water right (*VWR*) for each parcel in the data set classified as irrigated farmland sales.

Table 21 through Table 25 provide data on the expected dispersion of market values for water rights. These data are based on an average annual water use of 1.0 acre-feet per acre. While water right values based on the numbers in Table 16 through Table 20 can be interpreted as average point estimates of the value of water rights, one interpretation of Table 21 through Table 25 is the confidence interval associated with the point estimates of the value of water rights. The numbers in Table 21 through Table 25 are based on the assumption of normality, each county's mean estimate of the value of water rights, and the standard deviation of the parcel-specific estimates within a county. At the 50th percentile, the values listed in Table 21 through Table 25 exactly match the county means listed in the same table. This table illustrates that there is significant variation in the value of water rights within a given county, even at a constant water usage.

The data in Table 21 through Table 25 also can be used in other manners. For example, in the administration of the program, this information could be used to set the maximum acceptable bids and/or assess the reasonableness of a particular bid. The data might also be useful in program budgeting and/or predicting program success.

V. CONCLUSION

In general, the pertinent results relative to the irrigated and nonirrigated models of farmland value, as well as those associated with the value of water rights have been discussed in their individual sections. This section focuses on results and observations made during the research process that are somewhat peripheral to the main objective of valuing water rights, and yet are important to discuss.

Two Markets – Two Models

The literature reveals that several applications of the hedonic method to water valuation have relied on single equation estimation of the hedonic price function where the data on irrigated and nonirrigated sales were pooled. One implicit assumption associated with single equation estimation is that the parameter estimates on explanatory variables are the same regardless of whether the land is irrigated or nonirrigated. As an example, a single equation conceptual model that includes both irrigated and nonirrigated land, as well as county binary variables, implicitly assumes that the spatial impacts associated with location have the same impact regardless of land use-type composition.

Initially, the single equation modeling technique was applied in this research. Within the framework of single equation estimation, low values on R^2, the parameter estimates on theoretically important variables such as *AFU* that lacked statistical significance, as well as poor out-of-sample prediction ability, suggested model misspecification. This led to the methods presented in this research, which model the markets for irrigated land and nonirrigated land as separate markets.

The regression analyses suggest that the markets for nonirrigated land and irrigated land are separate and distinct. The existence of two separate markets requires the estimation of separate parameter estimates for explanatory variables for irrigated and nonirrigated land, which can be accomplished with two separate models.[3] These results suggest the following

[3] It should be pointed out that a nested model with binary variable interaction terms would suffice. The choice of technique depends on the assumption of error structure. A nested model would assume that the mean and variance of the error distribution is the same for irrigated and nonirrigated cropland while the estimation of separate model

conclusions. Low quality land receives a substantial discount if it is used for nonirrigated production while there is little discount associated if it used for irrigated production. The distance to the nearest town is important for nonirrigated land but usually has a statistically insignificant impact on irrigated land value. Contrary to the accepted belief that sales price per acre decreases with farm size for nonirrigated land, these models suggest that it actually increases for irrigated land.

Competitive Markets and Market Efficiency

As previously discussed in the section outlining the development of the theoretical and conceptual hedonic models, an underlying assumption of hedonic theory is that the market for land is both competitive and efficient. The assumption of competitive markets implies that there are a large numbers of willing buyers and sellers, and that information is free and readily available. The efficient market hypothesis states that at any point in time the observed sales price of land reflects all available information. One implication of market efficiency is that economic agents cannot profit through arbitrage.[4]

In previous research on land markets, Golden and Tsoodle (2004) and Golden (2005) have illustrated that the market for irrigated land in western Kansas can be categorized as thin and thus potentially volatile. They estimated, based on data from the Property Valuation Division, that slightly more than 300 acres of irrigated land per county, classified as a fair market transaction, are sold each year in northwest Crop Reporting District number ten (NW-10). Based on the KSFMRA dataset for irrigated land, approximately 398 acres of irrigated land per county, classified as a fair market transaction, sold each year in counties comprising GMD#5. If it is

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assumes the error structure is different. The nested approach would yield identical parameter estimates with lower estimated standard errors due to increased number of observations.

[4] Arbitrage is the nearly simultaneous purchase and sale (pure exchange) of a good in order to profit from the price differential.

assumed that a typical quarter section farm has 130 acres of irrigated land, then approximately only three parcels of irrigated land are sold each year on a per-county basis. The observations of this research are consistent with those of Golden and Tsoodle (2004) and Golden (2005), and suggest that the number of willing sellers may be too limited for the market for irrigated land to be classified as competitive.

The possible existence of market arbitrage raises concerns relative to the underling economic assumptions associated with hedonic theory. The simultaneous existence of a competitive market in equilibrium and the presence of arbitrage has been debated in the economic literature. A discussion of this literature goes well beyond the scope of this research, other than to report that the literature suggests that the two concepts are not mutually exclusive.

Voluntary Water Rights Retirement Programs

The implementation of the Voluntary Water Rights Transition Program as well as the Conservation Reserve Enhancement Program will require the development of a fair and equitable means of appraising the value of water rights. In order to accomplish the program goals this appraisal method should incorporate information on the stock and flow characteristics of the existing water well. The hedonic appraisal methods developed in this research should prove useful to the State during the development and implementation stages of the program. Measures of statistical fit and out-of-sample testing procedures provide confidence in the estimated fair market value of water rights.

While it is suggested that the estimates of values associated with these models are reasonably accurate, caution should be used in the interpretation of specific model parameters. These parameter estimates represent the best unbiased point estimate of the true value. In some cases there is a rather large conference interval around these point estimates. As with any regression analysis, the individual parameter estimates are purely a function of the data and model specification. Different datasets and model specifications will undoubtedly suggest different parameter estimates.

Spatial econometric methods were applied in an effort to correct a perceived spatial autocorrelation problem. Out-of-sample testing suggested that the standard OLS hedonic models often provided as good as or even superior estimates of land values. The results suggest that spatial adjustment models in the presence of unavoidable model misspecification may not lead to unbiased parameter estimates. Even though the spatial econometric models were not used in the final estimation, they prove beneficial in identifying the source of spatial autocorrelation and incorporating the required explanatory variables into the OLS hedonic models.

Alternative Voluntary Programs to Reduce Water Consumption

While the voluntary water rights retirement programs are a viable means of achieving an absolute reduction in groundwater consumption they probably should not be viewed as the only policy option. Research strongly suggests that water consumption can be reduced at the farm level without significantly reducing farm level net profits. Golden (2005), Bernardo et al. (1987), Buller (1988), Buller (1996), and the Docking Institute of Public Affairs (2002) all support the finding that water use can be significantly reduced without adversely impacting net revenue. This statement should not be viewed as indicating that agricultural producers are using the State's water resources inefficiently. The current water usage is generating economic profits for producers. However, producers may not be considering the social value of the water applied.

Suggestions for Future Research

In 1980, Gisser and Sanchez suggested that "…the economic profession would benefit more from estimating economic and hydrological parameters than from further discussing optimal control schemes for groundwater management." (p. 641). In the year 2006, this advice needs to be repeated. While optimal temporal allocation studies provide interesting mathematical exercises, they have failed to justify the continued and intensifying regulation associated with groundwater use. As a profession, we do not need to focus on whether groundwater should be regulated, rather we need to focus on estimating economic parameters that will allow policymakers to adequately judge the economic impact of such regulations.

The data analyzed provide several counterintuitive results. As the saturated thickness of the Ogallala Aquifer decreases and the cost of extracting water increases over time, it would be expected that the value of water should decline. Surprisingly, contrary to conventional wisdom and published literature, the value of water appears to be increasing in both nominal and real terms. One possible explanation is that the rate of technological advancement in water use efficiency and crop production is increasing the value of the remaining stocks of water faster than the aquifer is being depleted. While these findings are consistent with Golden (2005) additional research is needed to verify the impact technological advancement has on the value of water rights.

TABLES

Table 1. GMD#1: Nonirrigated Summary Statistics

Variable	N	MIN	MAX	MEAN	STD
PNIRR	357	0.19	1.00	0.93	0.17
ADJ	357	0.00	1.00	0.00	0.05
TENANT	357	0.00	1.00	0.00	0.05
GREELEY CO	357	0.00	1.00	0.20	0.40
LANE CO	357	0.00	1.00	0.23	0.42
SCOTT CO	357	0.00	1.00	0.27	0.44
WALLACE CO	357	0.00	1.00	0.14	0.34
WICHITA CO	357	0.00	1.00	0.17	0.37
CRP	357	0.00	1.00	0.10	0.30
GQLT	357	0.00	1.00	0.32	0.47
LQLT	357	0.00	1.00	0.05	0.22
REC	357	0.00	1.00	0.01	0.09
ID2	357	0.00	0.00	0.00	0.00
PRD	357	0.00	1.00	0.13	0.34
DRD	357	0.00	1.00	0.12	0.33
MIN	357	0.00	1.00	0.58	0.46
ACRES	357	58.00	1440.00	244.90	173.93

Table 2. GMD#2: Nonirrigated Summary Statistics

Variable	N	MIN	MAX	MEAN	STD
PNIRR	1173	0.12	1.00	0.84	0.20
ADJ	1173	0.00	1.00	0.02	0.14
TENANT	1173	0.00	1.00	0.01	0.07
HARVEY CO	1173	0.00	1.00	0.01	0.09
McPHERSON CO	1173	0.00	1.00	0.66	0.47
RENO CO	1173	0.00	1.00	0.31	0.46
SEDGWICK CO	1173	0.00	1.00	0.02	0.12
CRP	1173	0.00	1.00	0.11	0.32
GQLT	1173	0.00	1.00	0.16	0.37
LQLT	1173	0.00	1.00	0.09	0.28
REC	1173	0.00	1.00	0.02	0.13
ID2	1171	0.00	0.28	0.01	0.02
PRD	1173	0.00	1.00	0.23	0.42
DRD	1173	0.00	1.00	0.07	0.25
MIN	1173	0.00	1.00	0.93	0.25
ACRES	1173	20.00	720.00	112.46	64.67

Table 3. GMD#3: Nonirrigated Summary Statistics

Variable	N	MIN	MAX	MEAN	STD
PNIRR	899	0.10	1.00	0.93	0.17
ADJ	903	0.00	1.00	0.01	0.11
TENANT	903	0.00	1.00	0.02	0.14
FINNEY CO	903	0.00	1.00	0.08	0.28
FORD CO	903	0.00	1.00	0.12	0.33
GRANT CO	903	0.00	1.00	0.14	0.34
GREY CO	903	0.00	1.00	0.09	0.29
HAMILTON CO	903	0.00	1.00	0.07	0.25
HASKEL CO	903	0.00	1.00	0.05	0.21
KEARNEY CO	903	0.00	1.00	0.04	0.19
MEADE CO	903	0.00	1.00	0.09	0.29
MORTON CO	903	0.00	1.00	0.06	0.25
SEWARD CO	903	0.00	1.00	0.07	0.26
STANTON CO	903	0.00	1.00	0.09	0.28
STEVENS CO	903	0.00	1.00	0.09	0.29
CRP	903	0.00	1.00	0.13	0.34
GQLT	903	0.00	1.00	0.27	0.44
LQLT	903	0.00	1.00	0.04	0.19
REC	903	0.00	1.00	0.00	0.03
ID2	901	0.00	0.74	0.01	0.04
PRD	903	0.00	1.00	0.11	0.32
DRD	903	0.00	1.00	0.12	0.32
MIN	903	0.00	1.00	0.41	0.45
ACRES	903	32.00	1440.00	221.68	149.68

Table 4. GMD#4: Nonirrigated Summary Statistics

Variable	N	MIN	MAX	MEAN	STD
PNIRR	1677	0.10	1.00	0.82	0.25
ADJ	1681	0.00	1.00	0.01	0.09
TENANT	1681	0.00	1.00	0.02	0.13
CHEYENE CO	1681	0.00	1.00	0.13	0.34
DECATURE CO	1681	0.00	1.00	0.15	0.36
GOVE CO	1681	0.00	1.00	0.04	0.21
GRAHM CO	1681	0.00	1.00	0.11	0.31
LOGAN CO	1681	0.00	1.00	0.10	0.30
RAWLINS CO	1681	0.00	1.00	0.08	0.28
SHERIDAN CO	1681	0.00	1.00	0.09	0.29
SHERMAN CO	1681	0.00	1.00	0.11	0.32
THOMAS CO	1681	0.00	1.00	0.15	0.35
WALLACE CO	1681	0.00	1.00	0.03	0.17
CRP	1681	0.00	1.00	0.11	0.31
GQLT	1681	0.00	1.00	0.31	0.46
LQLT	1681	0.00	1.00	0.11	0.32
REC	1681	0.00	1.00	0.00	0.06
ID2	1680	0.00	0.22	0.00	0.01
PRD	1681	0.00	1.00	0.09	0.28
DRD	1681	0.00	1.00	0.31	0.46
MIN	1681	0.00	1.00	0.82	0.33
ACRES	1681	27.00	1440.00	256.96	180.72

Table 5. GMD#5: Nonirrigated Summary Statistics

Variable	N	MIN	MAX	MEAN	STD
PNIRR	1852	0.10	1.00	0.84	0.20
ADJ	1853	0.00	1.00	0.02	0.12
TENANT	1853	0.00	1.00	0.02	0.13
BARTON CO	1853	0.00	1.00	0.13	0.33
EDWARDS CO	1853	0.00	1.00	0.10	0.30
KIOWA CO	1853	0.00	1.00	0.08	0.26
PAWNEE CO	1853	0.00	1.00	0.10	0.30
PRATT CO	1853	0.00	1.00	0.11	0.32
RENO CO	1853	0.00	1.00	0.20	0.40
RICE CO	1853	0.00	1.00	0.17	0.38
STAFFORD CO	1853	0.00	1.00	0.11	0.32
CRP	1853	0.00	1.00	0.11	0.31
GQLT	1853	0.00	1.00	0.16	0.37
LQLT	1853	0.00	1.00	0.07	0.25
REC	1853	0.00	1.00	0.01	0.12
ID2	1848	0.00	0.48	0.01	0.02
PRD	1853	0.00	1.00	0.17	0.37
DRD	1853	0.00	1.00	0.07	0.26
MIN	1853	0.00	1.00	0.73	0.43
ACRES	1853	20.00	1040.00	160.63	107.59

Table 6. GMD#1: Irrigated Summary Statistics

Variable	N	MIN	MAX	MEAN	STD
PNIRR	74	0.00	0.89	0.20	0.25
ADJ	74	0.00	0.00	0.00	0.00
TENANT	74	0.00	1.00	0.05	0.23
GREELEY CO	74	0.00	1.00	0.07	0.25
LANE CO	74	0.00	1.00	0.05	0.23
SCOTT CO	74	0.00	1.00	0.18	0.38
WALLACE CO	74	0.00	1.00	0.39	0.49
WICHITA CO	74	0.00	1.00	0.31	0.47
CRP	74	0.00	1.00	0.08	0.27
GQLT	74	0.00	1.00	0.54	0.50
LQLT	74	0.00	1.00	0.04	0.20
REC	74	0.00	0.00	0.00	0.00
ID2	74	0.00	0.00	0.00	0.00
PRD	74	0.00	1.00	0.07	0.25
DRD	74	0.00	1.00	0.07	0.25
MIN	74	0.00	1.00	0.72	0.41
ACRES	74	126.00	1200.00	345.28	229.42
PIRR	74	0.08	1.00	0.74	0.27
FLOOD	74	0.00	1.00	0.26	0.44
SPKINC	74	0.00	1.00	0.76	0.43
SPKQLT	74	0.00	1.00	0.72	0.45
AFU	65	0.06	4.13	1.10	0.88

Table 7. GMD#2: Irrigated Summary Statistics

Variable	N	MIN	MAX	MEAN	STD
PNIRR	97	0.00	0.89	0.14	0.16
ADJ	97	0.00	1.00	0.01	0.10
TENANT	97	0.00	1.00	0.03	0.17
HARVEY CO	97	0.00	1.00	0.24	0.43
McPHERSON CO	97	0.00	1.00	0.41	0.49
RENO CO	97	0.00	1.00	0.26	0.44
SEDGWICK CO	97	0.00	1.00	0.09	0.29
CRP	97	0.00	1.00	0.02	0.14
GQLT	97	0.00	1.00	0.27	0.45
LQLT	97	0.00	1.00	0.08	0.28
REC	97	0.00	1.00	0.03	0.17
ID2	97	0.00	0.26	0.02	0.04
PRD	97	0.00	1.00	0.33	0.47
DRD	97	0.00	1.00	0.05	0.22
MIN	97	0.00	1.00	0.97	0.18
ACRES	97	40.00	629.00	168.96	90.06
PIRR	97	0.09	1.00	0.80	0.19
FLOOD	97	0.00	1.00	0.28	0.45
SPKINC	97	0.00	1.00	0.65	0.48
SPKQLT	97	0.00	1.00	0.59	0.49
AFU	97	0.14	2.76	0.98	0.48

Table 8. GMD#3: Irrigated Summary Statistics

Variable	N	MIN	MAX	MEAN	STD
PNIRR	413	0.00	0.87	0.11	0.16
ADJ	413	0.00	1.00	0.02	0.14
TENANT	413	0.00	1.00	0.02	0.15
FINNEY CO	413	0.00	1.00	0.03	0.17
FORD CO	413	0.00	1.00	0.07	0.25
GRANT CO	413	0.00	1.00	0.20	0.40
GREY CO	413	0.00	1.00	0.11	0.31
HAMILTON CO	413	0.00	1.00	0.01	0.11
HASKEL CO	413	0.00	1.00	0.13	0.33
KEARNEY CO	413	0.00	1.00	0.04	0.20
MEADE CO	413	0.00	1.00	0.10	0.30
MORTON CO	413	0.00	1.00	0.05	0.21
SEWARD CO	413	0.00	1.00	0.09	0.29
STANTON CO	413	0.00	1.00	0.08	0.27
STEVENS CO	413	0.00	1.00	0.10	0.31
CRP	413	0.00	1.00	0.03	0.16
GQLT	413	0.00	1.00	0.35	0.48
LQLT	413	0.00	1.00	0.04	0.19
REC	413	0.00	1.00	0.00	0.07
ID2	413	0.00	0.39	0.01	0.03
PRD	413	0.00	1.00	0.12	0.32
DRD	413	0.00	1.00	0.09	0.28
MIN	413	0.00	3.20	0.44	0.50
ACRES	413	71.00	1470.00	296.26	209.25
PIRR	413	0.06	1.00	0.85	0.19
FLOOD	413	0.00	1.00	0.15	0.36
SPKINC	413	0.00	1.00	0.80	0.40
SPKQLT	413	0.00	1.00	0.79	0.40
AFU	392	0.21	11.00	1.71	1.16

Table 9. GMD#4: Irrigated Summary Statistics

Variable	N	MIN	MAX	MEAN	STD
PNIRR	271	0.00	0.75	0.19	0.15
ADJ	271	0.00	1.00	0.00	0.06
TENANT	271	0.00	1.00	0.01	0.09
CHEYENE CO	271	0.00	1.00	0.13	0.34
DECATURE CO	271	0.00	1.00	0.03	0.18
GOVE CO	271	0.00	1.00	0.03	0.17
GRAHM CO	271	0.00	1.00	0.01	0.10
LOGAN CO	271	0.00	1.00	0.02	0.13
RAWLINS CO	271	0.00	1.00	0.05	0.22
SHERIDAN CO	271	0.00	1.00	0.07	0.26
SHERMAN CO	271	0.00	1.00	0.23	0.42
THOMAS CO	271	0.00	1.00	0.31	0.46
WALLACE CO	271	0.00	1.00	0.11	0.31
CRP	271	0.00	1.00	0.04	0.20
GQLT	271	0.00	1.00	0.49	0.50
LQLT	271	0.00	1.00	0.05	0.21
REC	271	0.00	1.00	0.01	0.09
ID2	269	0.00	0.07	0.01	0.01
PRD	271	0.00	1.00	0.16	0.37
DRD	271	0.00	1.00	0.21	0.41
MIN	271	0.00	1.00	0.82	0.34
ACRES	271	53.00	1200.00	290.19	190.53
PIRR	271	0.07	1.00	0.73	0.22
FLOOD	271	0.00	1.00	0.17	0.38
SPKINC	271	0.00	1.00	0.80	0.40
SPKQLT	271	0.00	1.00	0.76	0.43
AFU	259	0.13	3.62	1.03	0.58

Table 10. GMD#5: Irrigated Summary Statistics

Variable	N	MIN	MAX	MEAN	STD
PNIRR	297	0.00	0.70	0.16	0.13
ADJ	297	0.00	1.00	0.01	0.10
TENANT	297	0.00	1.00	0.01	0.12
BARTON CO	297	0.00	1.00	0.10	0.30
EDWARDS CO	297	0.00	1.00	0.20	0.40
KIOWA CO	297	0.00	1.00	0.14	0.35
PAWNEE CO	297	0.00	1.00	0.16	0.37
PRATT CO	297	0.00	1.00	0.14	0.35
RENO CO	297	0.00	1.00	0.07	0.26
RICE CO	297	0.00	1.00	0.07	0.26
STAFFORD CO	297	0.00	1.00	0.11	0.32
CRP	297	0.00	1.00	0.05	0.21
GQLT	297	0.00	1.00	0.21	0.41
LQLT	297	0.00	1.00	0.02	0.15
REC	297	0.00	1.00	0.01	0.12
ID2	297	0.00	0.24	0.01	0.02
PRD	297	0.00	1.00	0.20	0.40
DRD	297	0.00	1.00	0.06	0.24
MIN	297	0.00	1.00	0.09	0.27
ACRES	297	50.00	1038.00	200.49	117.50
PIRR	297	0.05	1.00	0.77	0.15
FLOOD	297	0.00	1.00	0.14	0.35
SPKINC	297	0.00	3.00	0.70	0.48
SPKQLT	297	0.00	1.00	0.86	0.35
AFU	297	0.00	3.68	0.86	0.47

Table 11. GMD#1: Irrigated and Nonirrigated OLS Model Estimates

Variable	Irrigated Model	Nonirrigated Model
INTERCEPT	-106.217	152.677 ***
TREND	49.308 ***	13.122 ***
PNIRR	34.787	236.935 ***
ADJ	NI	23.005
TENANT	-220.237 ***	-50.792
GREELEY CO	-73.448	-39.164 **
LANE CO	-132.973 *	-56.796 ***
SCOTT CO	-105.121	NI
WALLACE CO	NI	-61.602 ***
WICHITA CO	-105.838 **	2.626
CRP	-82.452	7.291
GQLT	147.673 ***	62.033 ***
LQLT	-42.249	-76.683 ***
REC	NI	-47.714
ID2	82198.225	-22383.392
PRD	104.090	27.302 *
DRD	-104.206	-10.728
MIN	106.657 **	-6.890
ACRES	0.165	-0.111 *
$ACRES^2$	0.000	0.000
PIRR	246.694	NI
FLOOD	-150.370	NI
SPKINC	-119.080	NI
SPKQLT	99.768	NI
AFU	252.092 ***	NI
AFU^2	-47.572 **	NI
N	65	357
RSQ	0.847	0.515
RMSE	123.764	83.162

The dependent variable is the nominal sales price per acre
*significant at the 90% confidence level; ** significant at the 95% confidence level; *** significant at the 99% confidence level
NI: not included

Table 12. GMD#2: Irrigated and Nonirrigated OLS Model Estimates

Variable	Irrigated Model	Nonirrigated Model
INTERCEPT	-409.443	269.240 ***
TREND	48.467 ***	24.804 ***
PNIRR	236.144	277.968 ***
ADJ	NI	-58.109 **
TENANT	-386.711 ***	6.683
HARVEY CO	205.249 ***	-3.410
McPHERSON CO	NI	NI
RENO CO	-173.474 ***	-57.702 ***
SEDGWICK CO	256.138 ***	56.122 *
CRP	-113.192	-60.919 ***
GQLT	166.417 ***	121.535 ***
LQLT	-130.883 *	-102.573 ***
REC	-49.635	81.287 **
ID2	914.099 *	588.704 ***
PRD	-4.592	4.048
DRD	52.593	-45.172 **
MIN	-83.425	12.355
ACRES	-0.256	-0.720 ***
$ACRES^2$	0.002	0.001 ***
PIRR	795.329 ***	NI
FLOOD	-33.603	NI
SPKINC	56.823	NI
SPKQLT	168.227 **	NI
AFU	516.511 ***	NI
AFU^2	-139.531 **	NI
N	97	1171
RSQ	0.827	0.499
RMSE	175.590	137.330

The dependent variable is the nominal sales price per acre
*significant at the 90% confidence level; ** significant at the 95% confidence level; *** significant at the 99% confidence level
NI: not included

Table 13. GMD#3: Irrigated and Nonirrigated OLS Model Estimates

Variable	Irrigated Model	Nonirrigated Model
INTERCEPT	-230.475	126.185 ***
TREND	27.613 ***	9.183 ***
PNIRR	276.108 *	196.650 ***
ADJ	164.830 **	45.644 *
TENANT	-11.509	-23.007
FINNEY CO	276.352 ***	63.559 ***
FORD CO	271.981 ***	96.120 ***
GRANT CO	NI	NI
GREY CO	227.998 ***	67.870 ***
HAMILTON CO	-47.001	-21.856
HASKEL CO	250.441 ***	113.852 ***
KEARNEY CO	145.233 **	47.975 ***
MEADE CO	255.566 ***	56.509 ***
MORTON CO	12.736	8.582
SEWARD CO	239.792 ***	14.461
STANTON CO	96.358 *	2.585
STEVENS CO	87.510 *	38.710 ***
CRP	-60.481	-41.456 ***
GQLT	42.858	29.966 ***
LQLT	-183.993 **	-101.088 ***
REC	15.837	38.190
ID2	-219.742	67.788
PRD	-85.931 **	-1.396
DRD	25.634	-20.180 **
MIN	-5.366	-11.802
ACRES	-0.031	-0.064
$ACRES^2$	0.000	0.000
PIRR	600.019 ***	NI
FLOOD	-122.150 **	NI
SPKINC	-76.711	NI
SPKQLT	57.282	NI
AFU	79.746 ***	NI
AFU^2	-6.863 **	NI
N	392	897
RSQ	0.460	0.446
RMSE	223.092	85.551

The dependent variable is the nominal sales price per acre
*significant at the 90% confidence level; ** significant at the 95% confidence level; *** significant at the 99% confidence level
NI: not included

Table 14. GMD#4: Irrigated and Nonirrigated OLS Model Estimates

Variable	Irrigated Model	Nonirrigated Model
INTERCEPT	-384.511 **	154.764 ***
TREND	41.454 ***	13.5736 ***
PNIRR	384.515 ***	270.506 ***
ADJ	53.273	28.7263
TENANT	-172.174	-27.569 *
CHEYENE CO	-122.517 **	-61.52 ***
DECATURE CO	-95.771	NI
GOVE CO	-99.892	-68.546 ***
GRAHM CO	-562.573 ***	-98.106 ***
LOGAN CO	-121.800	-95.844 ***
RAWLINS CO	-185.356 ***	-14.497 *
SHERIDAN CO	9.943	6.00562
SHERMAN CO	-148.149 ***	-76.522 ***
THOMAS CO	NI	-13.657 *
WALLACE CO	-131.402 ***	-105.88 ***
CRP	10.249	-28.881 ***
GQLT	38.493 *	85.5856 ***
LQLT	-157.185 ***	-71.038 ***
REC	-28.809	40.5718
ID2	932.996	534.938 **
PRD	36.673	-3.3124
DRD	47.319 *	-11.673 ***
MIN	25.639	-4.6889
ACRES	0.132	-0.0713 **
$ACRES^2$	0.000	5.8E-05 **
PIRR	826.835 ***	NI
FLOOD	-42.544	NI
SPKINC	73.508	NI
SPKQLT	50.507	NI
AFU	258.194 ***	NI
AFU^2	-61.063 ***	NI
		NI
N	259	1676
RSQ	0.764	0.728
RMSE	159.839	76.900

The dependent variable is the nominal sales price per acre
*significant at the 90% confidence level; ** significant at the 95% confidence level; *** significant at the 99% confidence level
NI: not included

Table 15. GMD#5: Irrigated and Nonirrigated OLS Model Estimates

Variable	Irrigated Model	Nonirrigated Model
INTERCEPT	-925.424 ***	51.951 **
TREND	53.184 ***	17.422 ***
PNIRR	476.680 ***	248.676 ***
ADJ	38.219	22.729
TENANT	NI	-15.594
BARTON CO	177.655 ***	116.680 ***
EDWARDS CO	NI	50.376 ***
KIOWA CO	-5.833	NI
PAWNEE CO	81.125 *	7.369
PRATT CO	27.959	42.231 ***
RENO CO	25.226	184.410 ***
RICE CO	21.883	140.728 ***
STAFFORD CO	206.804 ***	79.435 ***
CRP	3.276	-36.875 ***
GQLT	117.110 ***	60.675 ***
LQLT	32.770	-80.317 ***
REC	30.350	55.754 **
ID2	4.206	684.184 ***
PRD	0.917	4.660
DRD	-56.935	-34.300 ***
MIN	-22.651	20.800 ***
ACRES	1.005 ***	-0.150 **
$ACRES^2$	-0.001 **	0.000 *
PIRR	1217.902 ***	NI
FLOOD	-194.910 ***	NI
SPKINC	67.708 **	NI
SPKQLT	130.339 ***	NI
AFU	158.559 **	NI
AFU^2	-35.647 *	NI
N	297	1847
RSQ	0.705	0.503
RMSE	208.433	119.894

The dependent variable is the nominal sales price per acre
*significant at the 90% confidence level; ** significant at the 95% confidence level; *** significant at the 99% confidence level
NI: not included

Table 16. GMD#1: Irrigated and Nonirrigated Estimated 2006 Land Values ($/acre)

County	0.5 Ac-Ft	Irrigated 1.0 Ac-Ft	1.5 Ac-Ft	Nonirrigated
GREELEY CO	$1,066	$1,156	$1,223	$535
LANE CO	$1,006	$1,097	$1,163	$518
SCOTT CO	$1,034	$1,125	$1,191	$575
WALLACE CO	$1,139	$1,230	$1,296	$513
WICHITA CO	$1,033	$1,124	$1,190	$577

The irrigated predictions are based on a 160 acres parcel composed of 130 acres of irrigated land and 30 acres of nonirrigated land. Included in the dollar amount is the implicit value of a center pivot and associated equipment of above average quality.

Table 17. GMD#2: Irrigated and Nonirrigated Estimated 2006 Land Values ($/acre)

County	0.5 Ac-Ft	Irrigated 1.0 Ac-Ft	1.5 Ac-Ft	Nonirrigated
HARVEY CO	$1,764	$1,918	$2,002	$877
McPHERSON CO	$1,559	$1,712	$1,796	$880
RENO CO	$1,385	$1,539	$1,623	$823
SEDGWICK CO	$1,815	$1,969	$2,052	$937

The irrigated predictions are based on a 160 acres parcel composed of 130 acres of irrigated land and 30 acres of nonirrigated land. Included in the dollar amount is the implicit value of a center pivot and associated equipment of above average quality.

Table 18. GMD#3: Irrigated and Nonirrigated Estimated 2006 Land Values ($/acre)

County	0.5 Ac-Ft	Irrigated 1.0 Ac-Ft	1.5 Ac-Ft	Nonirrigated
FINNEY CO	$1,069	$1,104	$1,135	$534
FORD CO	$1,065	$1,100	$1,131	$566
GRANT CO	$793	$828	$859	$470
GREY CO	$1,021	$1,056	$1,087	$538
HAMILTON CO	$746	$781	$812	$449
HASKEL CO	$1,043	$1,078	$1,109	$584
KEARNEY CO	$938	$973	$1,004	$518
MEADE CO	$1,048	$1,083	$1,114	$527
MORTON CO	$806	$840	$872	$479
SEWARD CO	$889	$924	$955	$473
STANTON CO	$880	$915	$946	$509
STEVENS CO	$1,033	$1,067	$1,099	$485

The irrigated predictions are based on a 160 acres parcel composed of 130 acres of irrigated land and 30 acres of nonirrigated land. Included in the dollar amount is the implicit value of a center pivot and associated equipment of above average quality.

Table 19. GMD#4: Irrigated and Nonirrigated Estimated 2006 Land Values ($/acre)

County	0.5 Ac-Ft	Irrigated 1.0 Ac-Ft	1.5 Ac-Ft	Nonirrigated
CHEYENE CO	$1,199	$1,283	$1,336	$585
DECATURE CO	$1,226	$1,309	$1,362	$647
GOVE CO	$759	$843	$895	$549
GRAHM CO	$1,222	$1,305	$1,358	$578
LOGAN CO	$1,200	$1,283	$1,336	$551
RAWLINS CO	$1,137	$1,220	$1,273	$632
SHERIDAN CO	$1,332	$1,415	$1,468	$653
SHERMAN CO	$1,174	$1,257	$1,310	$570
THOMAS CO	$1,322	$1,405	$1,458	$633
WALLACE CO	$1,191	$1,274	$1,327	$541

The irrigated predictions are based on a 160 acres parcel composed of 130 acres of irrigated land and 30 acres of nonirrigated land. Included in the dollar amount is the implicit value of a center pivot and associated equipment of above average quality.

Table 20. GMD#5: Irrigated and Nonirrigated Estimated 2006 Land Values ($/acre)

County	0.5 Ac-Ft	Irrigated 1.0 Ac-Ft	1.5 Ac-Ft	Nonirrigated
BARTON CO	$1,643	$1,695	$1,730	$694
EDWARDS CO	$1,465	$1,517	$1,552	$627
KIOWA CO	$1,459	$1,512	$1,546	$577
PAWNEE CO	$1,546	$1,599	$1,633	$584
PRATT CO	$1,493	$1,545	$1,580	$619
RENO CO	$1,487	$1,539	$1,574	$718
RICE CO	$1,490	$1,543	$1,577	$761
STAFFORD CO	$1,672	$1,724	$1,759	$656

The irrigated predictions are based on a 160 acres parcel composed of 130 acres of irrigated land and 30 acres of nonirrigated land. Included in the dollar amount is the implicit value of a center pivot and associated equipment of above average quality.

Table 21. GMD#1: Percentile Table for the Estimated 2006 Fair Market Value of Water Rights ($/acre).

County	Mean	Implied Std. Dev	10%	20%	30%	40%	Percentile 50%	60%	70%	80%	90%
GREELEY CO	$621	$173	$400	$476	$530	$577	$621	$665	$712	$766	$842
LANE CO	$579	$75	$483	$516	$540	$560	$579	$598	$618	$642	$675
SCOTT CO	$550	$162	$343	$414	$465	$509	$550	$591	$635	$686	$757
WALLACE CO	$717	$211	$446	$539	$606	$663	$717	$770	$828	$894	$987
WICHITA CO	$547	$106	$411	$458	$491	$520	$547	$573	$602	$636	$682

The predictions are based on an average county irrigated parcel with 1.0 acre-feet of average annual water usage, less the parcel's implied value as nonirrigated land.

Table 22. GMD#2: Percentile Table for the Estimated 2006 Fair Market Value of Water Rights ($/acre).

County	Mean	Implied Std. Dev	Percentile 10%	20%	30%	40%	50%	60%	70%	80%	90%
HARVEY CO	$1,041	$225	$752	$851	$922	$984	$1,041	$1,098	$1,159	$1,230	$1,329
McPHERSON CO	$832	$207	$567	$658	$723	$780	$832	$884	$941	$1,006	$1,097
RENO CO	$716	$184	$481	$562	$620	$670	$716	$763	$813	$871	$952
SEDGWICK CO	$1,032	$147	$844	$909	$955	$995	$1,032	$1,069	$1,109	$1,155	$1,220

The predictions are based on an average county irrigated parcel with 1.0 acre-feet of average annual water usage, less the parcel's implied value as nonirrigated land.

Table 23. GMD#3: Percentile Table for the Estimated 2006 Fair Market Value of Water Rights ($/acre).

County	Mean	Implied Std. Dev	Percentile 10%	20%	30%	40%	50%	60%	70%	80%	90%
FINNEY CO	$570	$44	$514	$533	$547	$559	$570	$581	$593	$607	$626
FORD CO	$533	$124	$374	$429	$468	$502	$533	$565	$598	$637	$692
GRANT CO	$357	$112	$214	$264	$299	$329	$357	$385	$416	$451	$500
GREY CO	$517	$157	$317	$386	$435	$478	$517	$557	$600	$649	$718
HAMILTON CO	$332	$283	-$31	$94	$183	$260	$332	$404	$481	$570	$695
HASKEL CO	$494	$141	$313	$375	$420	$458	$494	$530	$568	$612	$674
KEARNEY CO	$455	$103	$322	$368	$400	$428	$455	$481	$509	$541	$587
MEADE CO	$556	$154	$359	$427	$475	$517	$556	$595	$637	$686	$754
MORTON CO	$361	$96	$238	$281	$311	$337	$361	$386	$412	$442	$484
SEWARD CO	$451	$106	$316	$362	$395	$424	$451	$478	$507	$540	$586
STANTON CO	$406	$121	$251	$304	$342	$375	$406	$437	$470	$508	$561
STEVENS CO	$583	$98	$458	$501	$531	$558	$583	$607	$634	$665	$707

The predictions are based on an average county irrigated parcel with 1.0 acre-feet of average annual water usage, less the parcel's implied value as nonirrigated land.

Table 24. GMD#4: Percentile Table for the Fair Market Value of Water Rights ($/acre).

		Implied	Percentile								
County	Mean	Std. Dev	10%	20%	30%	40%	50%	60%	70%	80%	90%
CHEYENE CO	$698	$227	$407	$507	$579	$640	$698	$755	$817	$888	$988
DECATURE CO	$663	$115	$516	$566	$603	$634	$663	$692	$723	$759	$810
GOVE CO	$294	$160	$90	$160	$210	$254	$294	$335	$378	$428	$499
GRAHM CO	$727	$200	$471	$559	$622	$677	$727	$778	$832	$896	$984
LOGAN CO	$733	$110	$592	$641	$675	$705	$733	$760	$790	$825	$873
RAWLINS CO	$588	$245	$274	$382	$459	$526	$588	$650	$716	$794	$902
SHERIDAN CO	$763	$236	$461	$564	$639	$703	$763	$822	$886	$961	$1,064
SHERMAN CO	$687	$184	$451	$532	$590	$640	$687	$734	$784	$842	$923
THOMAS CO	$772	$164	$562	$634	$686	$731	$772	$814	$858	$910	$982
WALLACE CO	$733	$209	$465	$557	$623	$680	$733	$786	$843	$909	$1,001

The predictions are based on an average county irrigated parcel with 1.0 acre-feet of average annual water usage, less the parcel's implied value as nonirrigated land.

Table 25. GMD#5: Percentile Table for the Fair Market Value of Water Rights ($/acre).

		Implied	Percentile								
County	Mean	Std. Dev	10%	20%	30%	40%	50%	60%	70%	80%	90%
BARTON CO	$1,001	$295	$624	$754	$847	$927	$1,001	$1,076	$1,156	$1,249	$1,378
EDWARDS CO	$890	$177	$664	$741	$797	$845	$890	$935	$983	$1,039	$1,116
KIOWA CO	$935	$211	$665	$758	$824	$881	$935	$988	$1,045	$1,111	$1,204
PAWNEE CO	$1,014	$289	$645	$772	$863	$941	$1,014	$1,087	$1,166	$1,257	$1,384
PRATT CO	$926	$253	$603	$714	$794	$862	$926	$990	$1,059	$1,138	$1,249
RENO CO	$822	$173	$600	$676	$731	$778	$822	$865	$912	$967	$1,043
RICE CO	$781	$267	$439	$557	$641	$714	$781	$849	$921	$1,006	$1,123
STAFFORD CO	$1,068	$173	$847	$923	$977	$1,024	$1,068	$1,111	$1,158	$1,213	$1,289

The predictions are based on an average county irrigated parcel with 1.0 acre-feet of average annual water usage, less the parcel's implied value as nonirrigated land.

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