THE VALUE OF WATER RIGHTS IN AGRICULTURAL PROPERTIES IN THE PHOENIX ACTIVE MANAGEMENT AREA

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Abstract: This paper estimates the value of water rights in the Phoenix Active Management Area (AMA), Arizona. Within AMAs groundwater rights cannot be transferred separately from the agricultural land to which they apply. As a result there is no separate market for ground water rights. The lack of a market creates two problems: there is no direct signal of the scarcity of water and no mechanism for reallocating water from low-to-high value uses. Water can only be reallocated by changing land use. With the growth of metropolitan Phoenix the value of water committed to residential, commercial or industrial use has increased rapidly relative to the value of water committed to agriculture. This has led to the reallocation of land from agriculture to urban uses. To estimate the implied value of the water right we used the hedonic price method to explore the impact of water rights on property values using 391 agricultural land transactions that occurred between 2001 and 2010. We tested two main hypothesis that (1) the marginal willingness to pay (MWTP) for water rights is higher in more developed urban areas than it is in undeveloped rural areas, and that (2) that the MWTP for water rights in urban areas varies across cities. We found the MWTP for water rights to be highest among properties in urbanized or urbanizing areas where a large proportion of the land has already been developed. Additionally, we found that the MWTP for water rights varies significantly across cities within Maricopa County.

Keywords: Water rights, hedonic price method, urbanization, farmland prices, elasticity, marginal willingness to pay

1. Introduction

Among all the ‘ecosystem services’ supplied by arid or semi-arid landscapes, water supply is the most critical. Since water is a basic ingredient of life it is also an essential input in every sector of the economy. Rapid economic and demographic growth in the U.S. southwest means that is becoming increasingly scarce. Between 2000 and 2010, Arizona experienced the second highest rate of population growth in the U.S. after Nevada—24.6 per cent (Census of Bureau, 2010). Average annual rates of employment and output growth in the state, at 10.6% and 20.5% respectively, were not far behind. Most of this growth has been concentrated in the area of metropolitan Phoenix, and has been associated with the conversion of land from agriculture to a range of urban uses. Agriculture in the area has historically depended on two sources of water: surface water from the Colorado, Salt and Verde watersheds, and groundwater from the Phoenix aquifer. These two types of water are separately managed and regulated by the Arizona Department of Water Resources (ADWR).

Access to water in Arizona is regulated by a complex system of property rights. Many surface water-bodies are subject to open access rights for recreation. So the general public is free to boat or canoe in lakes or rivers. However, access to water itself is generally subject to defined rights. These are different in Arizona than in neighboring states. In Colorado, for example, a water right is considered as a separate private property because it can be bought or sold separately from lands (Jenkins *et al.*, 2007) without a state permit. In this situation, the value of a water right will reflect the market equilibrium between local water demand and supply for agriculture, creating an efficient water allocation (Petrie & Taylor, 2007). In Arizona, however, water rights for agricultural demands are appurtenant to the land (they are transferred with the land when it is bought or sold). The result is that a separate market for ground water rights has not yet established in Arizona. The lack of a well-functioning water-rights market creates two problems (Faux & Perry, 1999): one is the difficulty of reallocating water-rights, and the other is the absence of price signals of the scarcity of water-rights. The lack of a price signal for water rights makes it difficult to compare the value of water in different uses (e.g. agricultural versus municipal or industrial uses) (Brookshire *et al.*, 2004).

Transferring water-rights from low to high-valued uses in Arizona generally involves two parties: farmers and municipal water buyers. Farmers selling water rights gain more than they would by applying water to crop or livestock production, while municipal water buyers obtain water at a lower cost. With the growing population in the Phoenix metropolitan area and the associated urban sprawl, the difference in the value of water committed to agricultural versus municipal or industrial use is increasing. Understanding the marginal value of water in competing uses is critical to the efficiency of water allocation. It is also important to an assessment of the value of the externalities of changing land use and land cover in the watershed.

Within the active management areas (AMAs), the Assured Water Supply (AWS) rules apply when a new subdivision is being developed. Under these rules, developers of new subdivisions[8] must either obtain a Certificate of Assured Water from ADWR or must be served by a water provider with an ADWR-issued AWS designation (Eden & Megdal, 2010). In order to acquire a certificate, developers are required to demonstrate that they have access to a water supply, that is expected to be physically, legally, and continuously available for the next 100 years. One way that developers are able to obtain a Certificate of AWS is to give up a grandfathered or TYPE I water right, which is called, extinguishment of grandfathered/TYPE I rights. Once they extinguish a grandfathered right, water providers or developers are then able to utilize that amount of groundwater for their own purposes. For this reason groundwater rights (including TYPE 1 water rights) can be highly valuable to both farmers and residential/commercial developers. However, whether one sector values it more than another is an empirical question.

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[8] According to ADWR, a subdivision is six or more parcels with at least one parcel having an area less than 36 acres. This includes residential, commercial, stock operatives and condominiums. Short term leases (12 months or less) or subdivision in which all parcels have areas more than 36 acres do not fall into this category. In addition, small subdivisions with less than 5 parcels are exempt from AWS rules (Megdal, 2006).

The four active management areas authorized under the 1980 Groundwater Code in Arizona are the Phoenix, Pinal, Prescott, and Tucson AMAs (ADWR, 2010). In 1994, the Santa Cruz AMA, which had been southeast portion of the Tucson AMA, became a 5th AMA. Figure 1 shows the location of AMAs within the state of Arizona. These 5 AMAs include most urban areas in the state where groundwater has been pumped at rates greater than the natural recharge rate. According to the Groundwater Code, groundwater use within AMAs is subject to more strict and detailed regulation than outside the AMAs. Within the AMAs, the expansion of new irrigated lands is prohibited, and a management plan sets maximum annual groundwater allotment for a irrigation rights (ADWR, 2010). The annual groundwater allotment is calculated by multiplying irrigation water duty by the farm area. Irrigation water duty is the annual amount of water, in acre-feet, required to produce the crops historically grown during the period 1975 to 1980, divided by an assigned irrigation efficiency. Irrigation efficiency is a measure of the overall effectiveness of water application during a crop season. It is a function of evaporation loss, soil intake rate, water application rate, crop type, and irrigation water management practices (Source: Third Management Plan 2000-2010, ADWR 2010). In order to comply with the AMA management plans, irrigation efficiency must improve over time, and the development of new irrigated farms in AMAs is effectively prohibited. In other words, the volume of agricultural water demand should not increase over time. In practice there has been a decrease in agricultural demand for water over time. Each AMA has its own goal for the year 2025. In the Phoenix, Prescott, and Tucson AMAs, the primary management goal is to achieve safe-yield[9] by the year 2025. The goal of the Pinal AMA, where agriculture is dominant, is to maintain the agricultural economy as long as feasible, while considering the need to preserve groundwater for future non-irrigation use (ADWR, 2010). The target of the Santa Cruz AMA is to maintain safe-yield and prevent local water tables from experiencing long-term declines. In order to achieve their management goals, the AMAs have developed management plans that include progressively more rigorous management requirements for agricultural, industrial, and residential water users.

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[9] Safe is defined as a long-term balance between the annual amount of groundwater withdrawn in the AMA and the annual amount of natural and artificial recharge (ADWR, 2012).

The primary goal of this study is to estimate the marginal willingness to pay (MWTP) and the price elasticity of demand for grandfathered irrigation rights (including type I water rights) in agricultural areas affected by urban expansion. Most of the existing studies (Crouter, 1987; Faux & Perry, 1999; Brookshire *et al.*, 2004; Butsic & Netusil, 2007; Jenkins *et al.*, 2007; Petrie & Taylor, 2007; Grimes & Aitken, 2008) explore the values of irrigation rights in general, but not the difference in the value of water rights between urban, urban-rural fringe, and rural areas. We contribute to the existing literature by testing two hypotheses:

a) that the MWTP for water rights is higher in more developed urban than in undeveloped rural areas, and

b) that the MWTP for water rights in urban areas varies across cities.

We found the MWTP for water rights to be highest among properties in urbanized or urbanizing areas where a large proportion of the land has already been developed. Additionally, we found that the MWTP for water rights varies significantly across cities within Maricopa County depending on the rate at which those cities were developing.

2 Agricultural water rights within the Phoenix AMA

Rapid urbanization within the AMAs has resulted in a decrease in land committed to agriculture. However, the agricultural sector is still the largest single source of water demand within the AMAs— approximately 2.2 million acre-feet of water or 58% of average annual water consumption in the state of Arizona between 2001-2005[10]. The Phoenix AMA had the largest annual average agricultural demand with 1.1 million acre-feet (47% of the total Phoenix AMA demand), and the Prescott AMA had the smallest with 5,300 acre-feet (22% of the total Prescott AMA demand). Agricultural water demand in the Phoenix AMA is met mostly from groundwater sources (41%). Surface water from the Salt, Verde and Colorado (via the Central Arizona Project (CAP) canals)

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[10] All water demand statistics presented here are based on the period of 2001 to 2005 reported in Arizona Water Atlas vol. 8.

is the second most important source (28%), followed by effluent (3%). It is interesting to compare these statistics with those from municipal sector, which has a comparable level of water demand. Between 2001-2005, the municipal demand comprised 46% of total water consumption, which is similar to agriculture demand (47%). However, the municipal sector relied more on surface (37%) and CAP water (31%), but less on groundwater (28%).

The Phoenix AMA planning area includes two counties: Maricopa and Pinal County, but Pinal County geographically comprises only 15% of the Phoenix AMA. Maricopa County is representative of the Phoenix AMA since it accounts for 85% of the Phoenix AMA in terms of geographical coverage. The geographical boundary of the dataset we collected is accordingly confined to Maricopa County. Maricopa has a population of 3,072,149, around 60% of the total population in Arizona (6,392,017) (Bureau, 2010). During the period of 2000 to 2010, population growth in Maricopa County was 24.2%, which is about the same as that in Arizona (24.6%).

As of 2007, there were 1,793 farms[11] in total with average size of farm of 271 acres and average market value of 8,498 dollars/acre (USDA, 2007). Figure 1 shows the share of the land by type in Maricopa County (USDA, 2007). It shows that 55.06% of farms were being used as cropland while 30.57% of farms were used as pasture (ranchlands). The information on the rest of 14.37% was not disclosed. The major crop items include forage (90,063 acres), cotton (26,234 acres), vegetables harvested for sale (17,472 acres), wheat for grain (16,386 acres), and barley for grain (14,374 acres). The most dominant livestock inventory item was cattle and calves (167,262 acres), followed by colonies of bees (17,552 acres), and horses and ponies (11,769 acres).

The two main sources of agricultural water—ground and surface water—are regulated separately. *Surface water refers to waters from all sources, flowing in streams, canyons, ravines or other natural channels, or in definite underground channels, whether perennial or intermittent, floodwaters, wastewaters, or surplus water, and lakes, ponds*

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[11] Total acreage of farms was 485,469 acres in 2007 (Census of Agriculture, 2007).

and springs on the surface (Arizona Revised Statues 45-101). The use of surface water is governed by the doctrine of prior appropriation: first in time, first in right. This means that the person who first put the water to a beneficial use[12] obtains a right that has priority over later appropriators of the water. Prior to June, 1919, surface water rights could be acquired simply by putting water to beneficial use and posting a notice of appropriation at the time of diversion. In June, 1919, the public water code, also known as the Arizona surface water code, was enacted. This law requires a person to apply for and acquire a permit in order to appropriate surface water. In general, surface water rights are appurtenant to the land. However, there are cases where a water right has been severed and transferred to a different location. In such cases, a person must obtain the approval of irrigation district or water user's association if water is used within their boundary.

There are three different types of surface water rights: (a) in-stream flow surface water rights, (b) stock-pond surface water rights, and (c) reservoir surface water rights. An in-stream flow right is a surface water right that remains in-situ or "in-stream". This water is not physically diverted for consumptive uses. The right aims to maintain the flow of water in-stream in order to preserve wild habitat for fisheries or recreation. Water rights for stock-ponds[13] are required of people who own stock-ponds constructed between June 12, 1919 and August 27, 1977. Landowners with stockponds constructed before June 12, 1919 are entitled to divert water from the pond without a stockpond right. The reservoir permit allows a person to construct a reservoir and divert public surface water in the state unless one of the following applies: (a) the water is from the mainstream of the Colorado river, (b) the person or the person's ancestor lawfully appropriated the surface water before June 12, 1919, or (c) the water is stored in a stockpond constructed between June 12, 1919 and August 27, 1977.

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[12] Beneficial use includes domestic use, stock-watering, mining, hydropower, municipal use, recreation, fish and wildlife, and irrigation, etc.

[13] Stockponds are artificially constructed ponds used for watering wildlife and livestock. In order to be eligible for a stockpond right, a stockpond within a property must meet the following criteria. First, it must be used exclusively for watering of livestock and/or wildlife. Second, it must not exceed a maximum capacity of 15 acre-feet. Finally, it must not be the subject of water rights litigation or protest before August 27, 1977(ADWR, 2010).

Groundwater rights are governed by the groundwater code within the AMAs, and by 'reasonable use' outside the AMAs. Groundwater water rights are conferred based on irrigation history. As with surface water rights, groundwater rights are appurtenant to the land in Arizona. There are three main types of groundwater rights within the AMAs: Irrigation Grandfathered Right (GFR), Type 1 non-irrigation Grandfathered right (TYPE I) and Type 2 non-irrigation Grandfathered right (TYPE II). A landowner may acquire an irrigation grandfathered right when he or she buys a property that has been irrigated[14] with groundwater between 1975 and 1980. This right is permanent, but is extinguished on change of land use (development). It specifies how much groundwater may be withdrawn for irrigation within a property in terms of volume (maximum annual acre-feet of water). Type I rights are associated with land permanently retired from farming and converted to a non-irrigation use such as building a new industrial plant, livestock feeding, and dairy. Like GFR, Type I water rights may be conveyed only with the property. Type II water rights are the most flexible water rights because they are sold separately from the land with ADWR approval. Like Type I water rights, they may serve non-irrigation purposes such as golf courses, livestock watering, mining, and industry. Type II water rights are not included in this study because they are not attached to the land, making it difficult to capture the impact of this water right on property prices.

3. Previous research

Hedonic pricing methods have been used to estimate the value of non-marketed environmental attributes in many circumstances. Attributes valued in this way include: open space (Weicher and Zerbst 1973; King et al 1991; Shultz and King 2001; Irwin and Bockstael 2001; Irwin 2002; Goeghegan 2002; Goeghegan et al 2003; Ready and Abdalla 2005; Sander and Polasky 2009), air quality (Zabel and Kiel 2000; Kim et al 2003; Kim et al 2010), landfill (Havlicek et al 1971; Lim and Missio 2003; Hite et al 2001; Ready 2010) and noise pollution (Nelson 2004; Jasper and Willemjin 2009). All of these studies use

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[14] Under the Groundwater code, "irrigate" means to apply water to 2 or more acres of land to produce crops for sale or human consumption or as feed for livestock.

residential property transactions. A limited number of studies have applied hedonic methods to investigate the value of water or water rights in agricultural land transactions (Jenkins et al 2007; Faux and Perry 1999; Butsic and Netusil 2007; Crouter 1987; Grimes and Aitken 2008; Petrie and Taylor 2007).

Most studies have found that water rights do affect land purchase decisions. Crouter (1987) examined the relationship between irrigation water and farmland prices using 57 farm sales in Colorado and found that no significant effect of irrigation water, although this may be due to the fact that he had only a small number of observations. All other studies have found a significant relation between water rights and land prices. Faux and Perry (1999), using 225 farmland sales in Malheur County, Oregon, explored the relationship between irrigation water and farmland prices, mainly focusing on the effect of different land productivity classes. They found values of irrigation water ranging from $9 to $44 per acre-foot per annum, depending on land class. Torell et al (1990) estimated separate hedonic functions for dry land and for irrigated land. They found that the price differential between those two types of land had diminished over time. In addition, they found that the water value component of irrigated farms comprises approximately 30%-60% of farmland sale prices. Butsic and Netusil (2007) estimated the value per acre-foot of irrigation water, using 113 farmland transactions for 2000 and 2001 in Douglas County, Oregon. They found that a property with an irrigation water right sold for 24% more than a property without a water right. They also estimated the value of leasing water using a range of discount rates and leasing periods and found that a farmer would be willing to accept $5.22 to $26.1 for a 1-year lease of an acre-foot of water depending on the discount rate used.

Findings outside the western states of the U.S.A have been similar. For example, Petrie and Taylor (2007) investigated the value of water rights in eastern United States focusing on the impact of a policy change called ‘agricultural irrigation permits moratorium’. Using 324 farmland sales in the state of Georgia, they investigated the impact of water right pre and post-moratorium and found the value of water rights to be capitalized into farmland prices post-moratorium. Grime and Aitken (2008) explored the impact of irrigation water right using 3,951 farmland sales in Mackenzie District in the South Island of New Zealand. They discovered that the flatter area and the area with poorly draining soil receives more benefit from irrigation water while drier area receives more benefit from irrigation than the area with high rainfall.

4. Methodology

We used the hedonic price method to explore the impact of water rights on property values. The hedonic pricing model, a revealed preference method for non-market valuation, has its foundations in Rosen's seminal work (Rosen, 1974). It is based on the assumption that market goods consist of different bundles of attributes or characteristics. A hedonic price function, $p(z)$, defines the equilibrium price schedule as a function of changes in the attributes of a property, z. This schedule is determined by the supply and demand of properties in the real estate market. Agricultural land is considered to have a set of n characteristics, z_1 ,z_2 , …….z_n, each of which potentially influences property prices (Palmquist, 1989). Some of these characteristics may be endogenous which means they may be under a farmer's control, such as farming techniques, farmer's skill, soil fertility and/or building structure. Others, such as land slope, precipitation condition, and soil type are exogenous, since they cannot be controlled by land owners.

Purchasers of agricultural property expect to be able to produce output, $Q(L,NL,\Omega)$, as a function of property inputs (L), non-property inputs (NL), and farmers' skill and experience (Ω). The farmer would maximize the discounted stream of expected variable profits subject to a production function. Expressing all terms as present values, this yields a problem of the form:

$$Max\Pi_V = P_m Q - \sum_i C_i NL_i \quad [1]$$

subject to

$$Q = Q(L, NL, \Omega) \qquad [2]$$

where P_m is a market price for output Q, and C_i and NL_i are variable cost and variable non-land inputs, respectively. This maximization problem can be solved for the non-land inputs demand function:

$$NL^* = NL(P_m, L, \Omega) \qquad [3]$$

Substituting [2] and [3] into [1] yields the variable profit function [4], which depends on the market price for inputs, property characteristics, and the farmer's skill and experience at farming.

$$\Pi^{V*} = P_m Q(L, NL, \Omega) - \sum_i C_i NL_i(P_m, L, \Omega) \qquad [4]$$

If the purchase price of the property is $P(Z)$, subtraction of that amount from variable profit gives the present value of expected actual profit:

$$\Pi^A = P_m Q(L, NL, \Omega) - \sum_i C_i NL_i(P_m, L, \Omega) - P(z_1, z_2, \dots \dots .., z_n) \qquad [5]$$

Theoretically, the optimal hedonic price schedule is represented by the difference between variable and actual profit, which is known as the optimal bid function. The optimal bid function represents the amount of money that property buyers (farmers) will bid on a property with characteristics Z, and may be defined as:

$$\theta^*(z_1, z_1, \dots, z_n) = \Pi^{V*} - \Pi^A \qquad [6]$$

Equation [6] may also be written as:

$$\theta^*(z_1, z_2, \dots \dots ., z_n) = P_m Q(L, NL, \Omega) - \sum_i C_i NL_i(P_m, L, \Omega) - \Pi^A \qquad [7]$$

Differentiating eq. [7] with respect to a specific property characteristic, z_i yields

$$\theta_{zi} = \frac{\partial\theta}{\partial z_i} = P_m \frac{\partial Q(L,NL,\Omega)}{\partial z_i} - \sum_i C_i \frac{\partial NL_i(P_m,L,\Omega)}{\partial z_i} \qquad [8]$$

The marginal optimal bid for z_i (or marginal price associated with an increase in the level of characteristic z_i) can then be estimated by regressing property prices on the vector of farmland characteristics.

In this study, we take the water right to be the i^{th} of n land characteristics, z_i. The marginal impact of that right on output and the use made of non-land inputs respectively is $\frac{\partial Q(L,NL,\Omega)}{\partial z_i}$ or $\frac{\partial NL_i(P_m,L,\Omega)}{\partial z_i}$. We expect properties with water rights to be more productive. That is, $\frac{\partial Q(L,NL,\Omega)}{\partial z_i}$ was expected to be positive. However, increased productivity through water rights can either decrease or increase the use made of non-property inputs such as soil quality and precipitation. Although the sign on the second term is ambiguous, we generally expect that the net effect of water rights on property prices will be positive.

If a seller expects to gain profit by changing the characteristics of the land they will maximize an expected profit function that is the difference between farmland price and a joint cost function, yielding the problem of the form:

$$Max\Pi_s = P(z_1, z_2, \dots\dots., z_n) - C(z_1, z_2, \dots\dots, z_n, R, \psi) \qquad [9]$$

where $P(z_1, z_2, \dots\dots., z_n)$ is a farmland price schedule, and C is a joint cost function that depends on a the same vector of land characteristics, a vector of land input prices (R), and a vector of technical parameters (ψ) that may vary between land sellers. The components of ψ may include the ownership of other parcels in the immediate area or the availability of special credits opportunity (Palmquist 1989). Maximization of equation [9] with respect to land characteristic z_i requires that

$$\frac{\partial \Pi_s}{\partial z_i} = \frac{\partial P(z_1, z_2, \ldots\ldots, z_n)}{\partial z_i} - \frac{\partial C(z_1, z_2, \ldots.. z_n, R, \psi)}{\partial z_i} \qquad [10]$$

Equation [10] implies that the marginal cost of land characteristics must be equal to the marginal price of land characteristics in the equilibrium farmland market where $P(z_1, z_2, \ldots \ldots., z_n)$ is an offer function defining the prices at which the seller would make farmland available to the market (Palmquist 1989). The equilibrium price is determined where a marginal increase in farmland buyer's bid with respect to some characteristic is equal to a marginal increase in farmland seller's offer with respect to that characteristic. This is the 'marginal implicit price' of the characteristic. A marginal implicit price is estimated by regressing farmland prices on the associated characteristics of farmland.

The database was constructed from multiple sources. First, information on property prices, the size of farms (acres), and the year of sale, and property use code were collected from the Maricopa County Assessor. In order to match the period of the third groundwater management plan (2000 to 2010), we restricted our attention to sales between 2001 and 2010. This makes the situation simpler since the annual groundwater allotment for each groundwater right is constant within a management plan phase, but increases between management plans. The property use code (PUC) of Maricopa County Assessor allowed us to classify parcels by different types of land management. Originally, the database had 8 types of land management: crop field, mature crop field, mature citrus field, high density agriculture, jojoba, ranches, pasture, and fallow land. Of those, crop field (45%) and ranches (50%) were the dominant types of land management while other types accounted for a very small proportion of total number of observations (less than 1%). During our preliminary sub-sample analysis, we found that grandfathered irrigation rights (including type 1 rights) were important in crop farms but not in ranches. This is for three reasons. First, ranch properties do not require irrigation to serve their needs beyond type 1 rights[15]. Second, there are few ranches with irrigation and type 1 water rights for the period, which makes it hard to tease out the impact of such water rights. Third, according to (USDA, 2007), crop farms are the dominant type of agriculture in Maricopa County. Hence, we restrict our attention only to crop properties.

To simplify the land classification, we combined crop fields, mature citrus, high density agriculture, and jojoba and classified all of those as crop farms. This yielded 1,665 observations. We found, however, that some buyers bought a bundle of properties at the same price in the same year[16], and that those properties were contiguous to each other with homogeneous characteristics. Hence, treating those bundled properties as many single transactions would pose a serious problem because it would break the link between parcel's characteristics and its' transacted prices in the hedonic model. Hence, bundled transactions were aggregated by prices and sizes. After further excluding arm's length and erroneous transactions, we ended up with 391 croplands for analysis. Following (Ma & Swinton, 2010), the sale price was deflated to 2001 constant prices using the Prices Paid by Farmer Index (Service, 2008).

Second, two raster files were collected: average annual precipitation (1971-2000) and slope. The precipitation data was obtained from PRISM. Using zonal statistics, average annual precipitation for each property in millimeters was calculated. The USGS Digital Elevation Model for Maricopa County was used, from which we calculated slope in degrees for each property. These two variables were included to capture the impact of land characteristics and climate conditions that might potentially influence the price of agricultural lands. Locational characteristics were represented by log distance to the nearest freeway. Since farmers deliver final agricultural or livestock/dairy products to end users through road transport, the coefficient on freeway distance is expected to capture the effect on land prices of higher transport costs. Third, water rights information was acquired from ADWR GIS data center. The original shape file contains information both

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[15] In the case where ranchers have a mixed crop-livestock farming, access to groundwater for irrigation might play an important role, however, the information on mixed land management was not available.

[16] 159 buyers (mostly agricultural companies) purchased multiple properties, of those 13 buyers purchased more than 10 properties at the same prices in the same year.

on type 1 and grandfathered right with acres of property acres that are attached to each water right. However, information on the amount of water attached to each water right has not yet been digitized. Hence, information on the amount of water involved was manually collected from imaged records managed by ADWR. Data for Surface water right were collected from the same source. The geographical boundary for surface water rights was not defined in the shape files, but a point of diversion/use from reservoir or stockpond was provided. We used the existence of points of diversion/use to define dummy variables for surface water rights. Finally, year dummy variables for 9 years (2002-2010) were included to capture temporal variation in property prices.

In order to capture the impact of surrounding land cover, the percentage of cultivated crop and shrub within a 3000m buffer of the centroid of each parcel was calculated using the 2001 and 2006 NLCD land cover maps. Changes in land use that occur over time are recorded in five yearly revisions of the land cover maps. In order to reduce the inaccuracy caused by the non-availability of the 2011 map, properties that were sold between 2001 and 2005 were matched with 2001 land cover map, and those that were sold between 2006 and 2010 were matched with 2006 land cover map. Sensitivity analysis was conducted with different size buffers and revealed that the coefficients on these variables were robust in terms of magnitude and sign beyond 3000m.

Finally, a shape file showing the boundary of cities within Maricopa County was obtained from the Institute for Social Science Research at ASU. The file initially includes more than 20 cities within Maricopa County, however excluding cities with no observations left us with only 7 cities: Phoenix, Mesa, Chandler, Good Year, Glendale, Gilbert, and Buckeye. These cities rank two 10 in terms of population size in 2010 (Census of Bureau, 2010). Table 1 displays the statistics of population, average farmland price per acre, the amount of water attached to each farmland, average water amount per acre, and farmland size by city. From this table we notice three significant patterns. First, urban areas have less water associated with each water right (except Good Year) than rural areas, and this difference is large and statistically significant. Second, average water use per acre is largest for rural areas (rural areas engage in more water-intensive activities than urban areas). Third, there exists a noticeable difference in farmland price/acre across cities. Mesa appeared to have highest price ($722,990), followed by Gilbert ($590,975), Glendale ($361,772), Good Year ($329,196), Chandler ($319,175), Phoenix ($251,541), and Buckeye ($122,053). The average farmland price/acre in rural areas is lower than those in all cities except Buckeye. Higher farmland prices in cities reflects the potential value of development into commercial or residential properties in the future.

Table 2 reports the summary statistics of the selected variables. The price/acre varies between $771 and $16 million, indicating significant heterogeneity in property prices. In our dataset, 92.8% (363 sales) of croplands had a groundwater or type 1 water right at the time of sale. The annual amount of water attached to each water right varied widely across properties, ranging from 11.53 to 131,010 acre-feet. However, only 10 parcels (1.4%) had a surface water right when transacted.

5. Preliminary Results

The selection of the functional form for hedonic price function has been controversial issue. Palmquist (1991) and others suggest that economic theory generally does not provide any guidance for specifying the appropriate functional form for land (Faux and Perry 1999). We selected the semi-log functional form given the interpretability of its marginal effects, and given the evidence that simple functional forms tends to outperform more complex specifications in recovering the marginal implicit price in the presence of model misspecification (Cropper et al 1988; Abbott and Klaiber 2010). Given the spatial nature of housing sales data, it is desirable to investigate if there is any spatial auto-correlation in prices and unobserved error terms. Moran's I test (Moran, 1950) and LM tests for spatial autocorrelation in neighboring house prices and residuals were performed using a range[17] of distance-based row standardized spatial weights matrix and k-nearest spatial weights matrix. The null hypothesis of no spatial autocorrelation in prices could not be rejected consistently with p-value greater than 0.11 and the null hypothesis of no

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[17] 5-50 nearest neighbours were used as cut-off neighbours for constructing k-nearest spatial weights matrix, and 3000m-20,000m were used as cut-off distances for constructing the row-standardized spatial weights matrix.

spatial autocorrelation in unobserved errors could not be rejected consistently with p-value greater than 0.22, showing that it may not be appropriate to use spatial econometric models[18] to correct for spatial correlation of the data. In addition, as shown in Figure 2, agricultural parcels for our study area were very sparsely distributed across space, which also makes it hard to justify the use of spatial econometric methods. Hence, three different models were specified as the final hedonic models: a simple OLS model (MODEL 1), an OLS model with interaction between DEV3000 and water rights (MODEL 2), and an OLS model with interactions between specific cities and water rights (MODEL 3).

In MODEL2, we defined farmland to be ‘undeveloped’ if there was no developed area within a 3000m buffer of the centroid of the property, otherwise, we call it ‘developed’. Based on this criterior, 89 farmlands were classified as ‘undeveloped’. This way, we were able to recover MWTP for both ‘developed’ and undeveloped samples. Since the range of prices and land sizes was large, indicating the possibility of inconstant errors across observations, a Breusch–Pagan test (Breusch & Pagan, 1979) was performed to identify the presence of heteroskedastic errors. We found that the null hypothesis of constant errors was rejected (P-Value<0.001). One can still obtain the unbiased results in the presence of heteroskedasticity, but at the cost of biased standard errors. Biased standard errors make traditional hypothesis testing unreliable. In order to avoid this problem, robust standard errors were calculated for MODEL 1 and MOLDEL 2. For MODEL 3, a number of spatially fixed dummy variables were included and it was therefore expected that every observation within a city would be correlated with every other observation in the same city, but not across cities. In order to address this within-city correlation, cluster robust standard errors were calculated for MODEL 3.

Table 3 reports the estimated coefficients and standard errors for the three models. Most variables came out as expected, and the magnitudes and signs of coefficients turned out to be robust across three models. The coefficient on land size was negative because price

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[18] It was suggested that there might be little gain from using spatial models because parcels of our dataset are distributed very sparsely within the area of study (Luc Anselin personal information).

per acre decreases as total land size increases. Rainfall increases land price while steeper land slope decreases land price. The negative coefficient on slope is intuitive because steeper property is not desirable for growing vegetable and plants—consistent with previous studies (Grimes & Aitken, 2008). Being nearer to major highways also increases the value of land. A higher percentage of shrub surrounding agricultural property (3000m) decreases land price, potentially because it indicates inferior soil quality relative to the area with higher percentage of valuable crop. Six out of nine year dummy variables came out as significant. The coefficients on year dummies increase up to 2007, and decreasing thereafter, revealing the impact of the economic recession beginning in 2007.

Finally, coefficients on water rights, the variable of the most interest, were found to be positive and significant across all three models. This shows that the presence of legal access to irrigation or non-irrigation water is an important factor in the price of agricultural lands. The coefficient on interaction between land size and water right turned out to be negative across all models, indicating that irrigation becomes less valuable on a per-acre basis as land size increases (Butsic and Netusil 2007). This also implies that a farmer with a water right may be able to allocate water more efficiently over the smaller area. The coefficient on interaction between water right and the percentage of developed area turned out to be positive and significant in both MODEL2 and MODEL3, indicating that an increase in the proportion of developed land within a 3000m buffer increases the impact of water right on farmland price. In early versions of the model a dummy variable for surface water right was found to be insignificant. This does not necessarily mean that surface water rights are not important to farmlands. Instead, it reflects two issues. First, in our dataset, only 10 parcels out of 391 had surface water rights, meaning that there was little scope for teasing out the impact of surface water rights. Second, surface water rights are not required for landowners with stockponds constructed before 1919, or for landowners whose precedent appropriated surface water before 1919. What this means is that there may be a number of properties that retain the right to appropriate surface water without a water right. The surface water shape file we obtained from ADWR only contained surface water rights established between 1919 and 1977, so the impact of missing surface water rights might not have been fully captured in our model. Thus, a dummy variable for surface water rights was excluded from the final model.

The partial F-test was conducted to test the null hypothesis of all interaction terms in MODEL2 and MODEL3 being statistically equal to zero against MODEL1. The result shows that the null hypothesis is rejected with p-value less than 0.01 for MODEL2 and p-value less than 0.05 for MODEL3, supporting MODEL2 and MODEL3 over MODEL1. Hence, only the parameters from MODEL2 and MODEL3 were used to derive the MWTP and price elasticity of water rights.

Given estimated baseline parameters for water rights and interaction parameters between a water right and DEV3000 or each of the cities, the MWTP for an additional acre-foot of water rights for rural, developed area, undeveloped areas and each of city lands was calculated by using the following equations.

$$MWTP_{no\_dev} = P_{no\_dev} * (\overline{Land_{no\_dev}} * \beta_{Land2} + \beta_{baseWR_2}) \tag*{[11]}$$

$$MWTP_{dev} = P_{dev} * (\overline{Land_{dev}} * \beta_{Land2} + \beta_{baseWR_2} + \beta_{int_{WR_{dev}}} * \overline{DEV3000}) \tag*{[12]}$$

Where

P_{no_dev} : mean farmland price/acre for undeveloped area

P_{dev} : mean farmland price/acre for developed area

$\overline{Land_{no\_dev}}$: mean farmland size for undeveloped area

$\overline{Land_{dev}}$: mean farmland size for developed area

β_{Land2} : coefficient on interaction between land size and water right (MODEL2)

β_{baseWR_2} : baseline coefficient on water right(MODEL2)

$\beta_{int\_WR\_dev}$: coefficient on interaction between water right and DEV3000 (MODEL 2)

$\overline{DEV3000}$: mean value of % of developed area with 3000 m buffer

$$MWTP_{rural} = P_{rural} * \left(\overline{Land_{Rural}} * \beta_{Land3} + \beta_{baseWR3}\right) \quad [13]$$

$$MWTP_{city} = P_{city} * (\overline{Land_{city}} * \beta_{Land3} + \beta_{baseWR3} + \beta_{int\_WR\_city}) \quad [14]$$

Where

P_{rural} : mean farmland price/acre for rural area
P_{city} : mean farmland price/acre for each of city
$\overline{Land_{Rural}}$: mean farmland size for rural area
$\overline{Land_{city}}$: mean farmland size for each of city
β_{Land3} : coefficient on interaction between land size and water right (MODEL3)
$\beta_{baseWR3}$:baseline coefficient on water right (MODEL3)
$\beta_{int\_WR\_city}$:coefficient on interaction between water right and each of city dummy(MODEL3)

In the same way, the price elasticity of water rights (% change in property price/acre with respect to 1% increase in acre-feet of water attached to water right) was calculated by:

$$\varepsilon_{rural} = WR_{rural} * (\overline{Land_{Rural}} * \beta_{Land3} + \beta_{baseWR3}) \quad [15]$$

$$\varepsilon_{urban} = WR_{city} * (\overline{Land_{city}} * \beta_{Land} + \beta_{baseWR3} + \beta_{int\_WR\_city3}) \quad [16]$$

where WR_{rural} and WR_{city} represents the mean acre-feet of water (attached to water rights) for rural and urban properties respectively.

Using the above equations, the estimated mean and sampling error (95% confidence interval) for elasticity and MWTP for undeveloped, developed, rural and city samples was calculated. The 95% confidence intervals for both MWTP and elasticity estimates were generated using the Monte-Carlo simulation method proposed by (Krinsky & Robb, 1986). The procedure generates 10,000 random variables from the distribution of the estimated parameters and calculates 10,000 MWTP estimates and elasticities for both samples. Then the 95% confidence interval bounds were obtained by dropping 2.5% of right and left tail of the distributions. The means and sampling errors of elasticity and MWTP for developed and undeveloped sample were summarized in Table 4. From it, the null hypothesis of equality of MWTP and elasticities between developed and undeveloped samples was tested via 2-sample T-statistics. These showed that MWTP was significantly higher for developed land (\$39.5, p-value<0.0001) than for undeveloped land (\$8.3, p-value<0.0001). In the same way, Table 5 reports the estimated means and sampling distributions of elasticities and MWTPs across cities. Those values were calculated based on parameters obtained from MODEL3. From it, the null hypothesis of the equality of elasticities and MWTPs across cities was also tested. In general, MWTP was significantly higher for all cities (p-value<0.0001) than for rural properties. The estimated mean MWTP was highest for Glendale (\$345.63), followed by Gilbert (\$287.17), Mesa (\$204.79), Chandler (\$132.99), Phoenix (\$94.6), and Good Year (\$55.48). The opposite is true for the price elasticity of water rights. Elasticities were found to be higher for undeveloped land (29.37%) than for developed land (8.1%), and elasticities in rural areas were found to be higher than urban areas for all cities except Glendale. Two factors might explain this. First, Table 1 shows that farmland prices/acre were higher for developed than undeveloped land in most of cities, and both were higher than in rural areas, while the amount of water attached to each water right was highest in undeveloped and rural areas. It follows that agricultural water rights might be expected to explain a larger portion of farmland prices in rural/undeveloped area relative to urban/developed area. At the same time the potential for future development may contribute more to farmland prices/acre in developed/urban areas.

6. Summary and Policy Implications

Water rights are capitalized into the value of both urban and rural land. However, the estimated value of urban rights is significantly greater than the estimated value of rural rights. Water rights attaching to urban land are 3-10 times as much water rights attaching to rural land. The difference is significantly greater than that found in previous studies. Two studies of more than 2000 water transfers between 1987 and 2005, found that water transfers from agricultural-to-urban uses were, on average, 2 to 4 times more valuable than transfers from agriculture-to-agriculture (Brewer *et al.*, 2007; Eden *et al.*, 2008) . While our results are consistent with this, we found conversion of land from rural to urban uses to be significantly more valuable than did these earlier studies.

Second, Arizona requires developers within the AMAs to demonstrate sufficient water to support a growing population for the next 100 years. Once they buy a property with irrigation water rights, they can extinguish those rights in order to obtain a groundwater credit, which defines the amount of groundwater the credit holder is allowed to abstract. This credit can then be severed from the land and be traded in the market to convert water use from irrigation to commercial, industrial or residential use. The capitalized value of this conversion right is reflected in properties that are located in urban-rural fringe areas with higher population growth/development pressure.

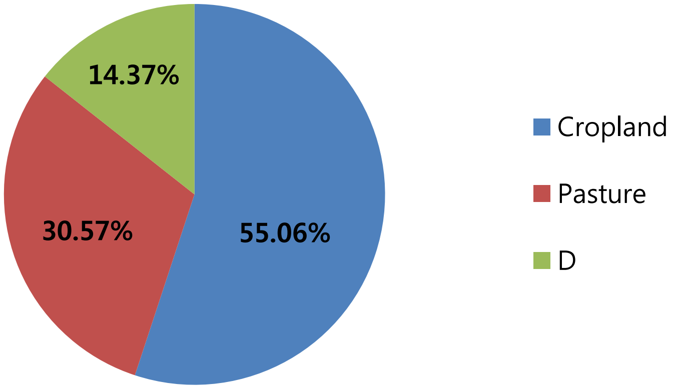
Third, we found that the value of irrigation water rights varied significantly between developed and undeveloped land across cities. The main gains in the capitalized value of water occur on the change in land use. Thereafter, they tend to diminish. We found that the land price elasticity of water (% change in land price with respect to a 1% change in the amount of water attached to a water right) was higher for rural/undeveloped areas than for urban/developed areas.

Our results have implications for a number of bodies concerned with the management of water resources: ADWR, urban/city planners and residential or commercial developers. Currently the amount of irrigation water available through permits is historically determined by ADWR with the aim of conserving future groundwater supplies and promoting the economic development of Arizona. Our results show that while the absolute value of the premium per acre-foot of water rights was lower in rural than in urban areas, the land price elasticity of water was higher in rural areas. Understanding the difference in land price responses (elasticities) between urban and rural areas may help ADWR set the quantity of water rights so as to better to approximate an efficient allocation.

There is also scope for urban/city planners and residential or commercial developers to use this information on the capitalized value of water rights in urban-rural fringe areas, as well as across different cities, to set property taxes. Furthermore, since groundwater rights may be converted into groundwater credits at the time of land development, and since these can be separately traded in a water rights market, the information on marginal willingness to pay for water rights should help policy makers who are considering the development of an efficient water rights market in Arizona.

In future research we will relate these findings to changes in water availability due to changes in land use and land cover in the upper watersheds, especially in Yavapai and Coconino Counties. Since groundwater use in the Phoenix AMA is sensitive to the availability of surface water from the Salt and Verde watersheds, this will make it possible to estimate the value of water externalities associated with land use and land cover change in those watershed. To be more specific, developing hedonic price methods that incorporates the interaction between NDVI (represented by land use change) and water-related service such as water infiltration and siltation delivery might provide richer information on the value of water-related externalities. It will be also desirable to look at robustness of our results using more accurate land cover maps in the future. The percentage of developed and shrub land cover calculated in this study is based on 2001 and 2006 land cover map, which could potentially bias our results. Although it is known that land cover did not change much over the period of our study, it is recommended, in the future, to match every property sale with a land cover map for the corresponding year, created by remote sensing technique. Finally, since we were not able to identify what is driving the difference in the value of water rights across different cities in this study, this should be further investigated.

Figure 1: Percentage of type of land in farms.



Source: Census of Agriculture, 2007

Figure 2: Detail location of agricultural farms within the Phoenix AMA (Source: Created in GIS by author)

Table 1: Population, average farmland price, land size, water amount, and average water amount by city

City	Population (2010)	Farmland price/acre	Average water amount per water right	Average farmland size	Average water amount/acre
Phoenix	1445632	251,541	1,257AF/year	48 acres	35.48AF/acre
Mesa	439,041	722,880	886AF/year	32 acres	80.03AF/acre
Chandler	236,123	319,175	592AF/year	27 acres	67.60AF/acre
Glendale	226,721	361,772	342AF/year	20 acres	15.81AF/acre
Gilbert	208,453	590,975	853AF/year	49 acres	42.72AF/acre
Good Year	65,275	329,196	4,128AF/year	133 acres	55.63AF/acre
Buckeye	50,876	122,053	3,562AF/year	114 acres	65.20AF/acre
Rural	20,576	163,183	3,900AF/year	78 acres	2733AF/acre

Source: 2010 Census of Bureau and author's calculation

Table 2: Summary Statistics of DATA

Variable	**Description**	**391 observations**		
		Mean	**Min**	**Max**
Sale price/acre	Deflated property price in acre (2001)	$276,470	$771	$15,712,730
Land size	The size of land in acres	76	0.14	1,294
Precipitation	Average annual precipitation in millimeter (1971-2000)	214.26	187.64	257.12
Slope	Average slope in degrees	0.34	0.04	5.66
Ln_Free	Natural log distance to nearest freeway	7.79	3.05	10.18
Shrub3000	The % of shrub cover within a 3000m buffer of a centeroid of farmland	0.2000	0.0011	0.9078
Dev3000	The % of developed cover within a 3000m buffer of a centeroid of farmland	0.0102	0	0.1333
Water Right	Total acre-feet of water in water right (grandfathered right or type I water right)	2878.74AF	0	131,010AF
Year Dummy				
YR2001	1 if farm transacted in 2001, else 0	0.056(22 obs)	0	1
YR2002	1 if farm transacted in 2002, else 0	0.049(19 obs)	0	1
YR2003	1 if farm transacted in 2003, else 0	0.049(19 obs)	0	1
YR2004	1 if farm transacted in 2004, else 0	0.082(32 obs)	0	1
YR2005	1 if farm transacted in 2005, else 0	0.212(83 obs)	0	1
YR2006	1 if farm transacted in 2006, else 0	0.202(79 obs)	0	1
YR2007	1 if farm transacted in 2007, else 0	0.109(43 obs)	0	1
YR2008	1 if farm transacted in 2008, else 0	0.064(25 obs)	0	1
YR2009	1 if farm transacted in 2009, else 0	0.082(32 obs)	0	1
YR2010	1 if farm transacted in 2010, else 0	0.095(37 obs)	0	1
City Dummy				
Urban	1 if farm transacted in urban areas, else 0	0.598(234 obs)	0	1
Phoenix	1 if farm transacted in Phoenix, else 0	0.087(34 obs)	0	1
Mesa	1 if farm transacted in Mesa else 0	0.102(40 obs)	0	1
Chandler	1 if farm transacted in Chandler, else 0	0.072(28 obs)	0	1
Glendale	1 if farm transacted in Glendale, else 0	0.026(10 obs)	0	1
Gilbert	1 if farm transacted in Gilbert, else 0	0.043(17 obs)	0	1
Good Year	1 if farm transacted in Good Year, else 0	0.120(47 obs)	0	1
Buckeye	1 if farm transacted in Buckeye, else 0	0.148(58 obs)	0	1

Table 3: OLS, OLS+interaction hedonic models (Dependent variable: log price/acre)

Variable	MODEL1: OLS	MODEL2: OLS with interactions (WR and DEV3000)	MODEL3: OLS with interactions(WR and city dummy)
Constant	8.0700(1.0142)***	7.84005(1.0159)***	8.26101(0.70285)[b]***
Land Size	-0.00645(0.00144)***	-0.0066(0.0001)***	-0.00799(0.00089)***
Land Size^2	9.98e-06(2.89e-06)***	0.00001(3.03e-06)***	0.00001(1.83e-06)***
Precipitation	0.0222(0.00451)***	0.02342(0.00452)***	0.01698(0.00349)***
Slope	-0.45745(0.08398)***	-0.45872(0.08457)***	-0.33299(0.06797)***
Ln_free	-0.24571(0.05717)***	-0.24511(0.05684)***	-0.19195(0.07709)**
DEV3000	6.31219(3.90976)	1.55499(4.31578)	8.29445(3.62045)*
SHRUB3000	-1.26647(0.37344)***	-1.29984(0.37310)***	-0.80297(0.37326)**
WR(Water Right)	**0.00011(0.00002)*** **	**0.00009(0.00002)*** **	**0.00013(0.00001)*** **
Int_WR_LAND	**-1.23-e07(2.89e-08)*** **	**-1.33e-07(3.03e-08)*** **	**-1.58e-07(1.82e-08)*** **
Int_WR_DEV3000		**0.00391(0.00167)** **	
Phoenix			-0.10705(0.16381)
Mesa			0.46967(0.15799)**
Chandler			0.84097(0.07736)***
Glendale			0.66658(0.09049)***
Gilbert			0.72977(0.08219)***
Good Year			0.74140(0.06204)***
Buckeye			0.10141(0.08193)
Phoenix_WR			**0.00025(0.00002)*** **
Mesa_WR			**0.00016(0.00002)*** **
Chandler_WR			**0.00029(0.00008)*** **
Glendale_WR			**000083(0.00014)*** **
Gilbert_WR			**0.00036(0.00006)*** **
Good_Year_WR			**-0.00006(6.79e-06)*** **
Buckeye_WR			9.28e-06(6.61e-06)
YR2002	0.06977(0.39571)	0.0907(0.39496)	0.16428(0.23873)
YR2003	0.62320(0.31639)**	0.69852(0.31173)**	0.71207(0.28533)**
YR2004	0.97614(0.26512)***	0.95056(0.26626)***	1.11705(0.21448)***
YR2005	1.30611(0.21043)***	1.31398(0.20909)***	1.39054(0.16696)***
YR2006	1.30020(0.20613)***	1.28965(0.20589)***	1.36147(0.21336)***
YR2007	1.08612(0.25009)***	1.09074(0.24776)***	1.09278(0.37419)**
YR2008	0.56894(0.30462)*	0.61481(0.30583)**	0.56350(0.19157)**
YR2009	0.30491(0.31440)	0.34700(0.31284)	0.36926(0.39202)
YR2010	0.16595(0.27401)	0.17645(0.27191)	0.387186(0.22038)
R^2	0.4256	0.4335	0.4839
SSE	534.022	526.658	479.791
MSE	1.435	1.419	1.340
DF	18	19	32
Partial F-test		4.51(0.01[c])***	2.99(0.05)**

b: The cluster robust standard errors were reported for OLS with city dummy model.

c: The number represents the F-statistics derived from partial F-test. The number inside the bracket shows the p-value.

*	Significance at 10% level
**	Significance at 5% level
***	Significance at 1% level

Table 4: The comparison of Elasticity and MWTP between developed and undeveloped areas

	Elasticity (% increase in price/acre with respect to 1% increase in water right	MWTP/additional 1 acre feet of annual water attached to a water right
Developed	8.1% (0.6%-17.9%)[a]	\$39.55 (\$20.72-\$59.06)
Undeveloped	29.37% (11.49%-47.3%)	\$8.27 (\$3.23-\$13.31)

a: 95% confidence interval generated from Monte Carlo simulation (Krinsky and Robb, 1987)

Table 5: Comparison of elasticity MWTP across cities

City	Elasticity (% increase in price/acre with respect to 1% increase in water right	MWTP/additional 1 acre feet of annual water attached to a water right
Phoenix	47.29% (40.92% - 53.55%)[a]	\$94.6 (\$81.91 - \$107.19)
Mesa	25.09% (20.19% - 29.97%)	\$204.79 (\$164.78 - \$244.59)
Chandler	24.66% (13.54% - 35.79%)	\$132.99 (\$72.99 - \$193.02)
Glendale	32.66% (31.19% - 34.11%)	\$345.63 (\$227.59 - \$463.46)
Gilbert	41.45% (29.78% - 53.11%)	\$287.17 (\$206.33 - \$367.95)
Good Year	69.57% (56.78% - 82.60%)	\$55.48 (\$65.87 - \$45.28)
Buckeye	-[b] -	- -
Rural	48.6% (34.87% - 58.16%)	\$19.08 (\$14.59 - \$23.50

a: 95% confidence interval generated from Monte-Carlo simulation (Krinsky and Robb, 1987)
b: Not reported because coefficient on interaction term was insignificant

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