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# VARIABLE IRRIGATION DISTRICT ACTION IN WATER TRADING[1]

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ABSTRACT: Irrigation districts (IDs) in the American west are highly diverse in their economic attributes and local water scarcity circumstances. This diversity may affect reallocative action via water transactions as scarcity rises. The institutional background defining and constraining IDs is described here. For a Texas study region the progress of permanent water right transfers involving IDs is documented and examined. An econometric analysis of multiple decades of ID water transfer activities in the Lower Rio Grande Valley finds that IDs with larger initial water right holdings and higher populations in nearby cities are more likely to participate in agricultural-to-municipal water transfer activities. The findings suggest that consolidation of smaller water right holding IDs may be an avenue for quickening the pace of reallocation, especially in more populated areas.

(KEY TERMS: water marketing; irrigation districts; water rights; Rio Grande Valley.)

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## INTRODUCTION

Literature addressing the water transfer responses of irrigation districts (IDs) and nondistricts in the western United States (U.S.) claims there are significant differences between the reallocative activities of the two groups. IDs are said to be less inclined to transfer water (Bretsen and Hill, 2009; Ghimire and Griffin, 2014). This impedes a potentially important strategy for addressing scarcity via water markets, especially in regions dominated by ID-held water. There may be considerable variations in water transfer responses among IDs as well, due to factors such as path dependency (effects of history and traditions), water right endowments, and water right reliability (Calatrava and Garrido, 2006). Political structures such as the voting arrangements within IDs may also contribute to reallocative variability (McDowell and Ugone, 1982; McCann and Zilberman, 2000).

The objective here is to investigate economic and demographic heterogeneities affecting permanent reallocation via water transfers in IDs. Empirical studies regarding how economic conditions and local factors affect water transfer responses in IDs are very limited, in part because of the dearth of data. We develop a dataset for IDs in the Rio Grande Valley (the "Valley") of Texas where IDs are diverse in terms of their water right endowments, acreages served, magnitude of local urbanization, and age of organizations (Casbeer and Trock, 1969), thus offering a unique opportunity to study this issue. The article contributes to existing literature in two prime ways. First, the process and general progress of water right transfers for IDs is documented for the study region. Second, we analyze whether the heterogeneity of IDs stemming from unequal water right endowments and uneven urbanization/population patterns has any relation to water transfer responses. To the best of our knowledge, this is the first study to

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examine the association between economic/demographic factors and water reallocation (agricultural to urban water transfer) for water owned by IDs. This portion of the analysis finds that initial agricultural water right holdings and population in nearby cities have significantly positive and possibly nonlinear impacts on water right transfers in the Valley.

The article is organized as follows. In the initial sections, IDs are introduced and their formation procedures are described, followed by a Texas-focused examination of administrative settings, water right development, and regulatory procedures. After reviewing relevant literature, an econometric model and estimation techniques are proposed. Original data are described for estimating the models. Regression results are presented and examined for their more policy-relevant implications.

## IDS AND FORMATION PROCEDURE

The organizing purpose of American IDs is to develop and deliver irrigation water to farmers (Hutchins, 1931; Leshy, 1982; McCann and Zilberman, 2000; Bretsen and Hill, 2006). Some IDs also produce and distribute hydroelectric power and municipal water, but these purposes are normally secondary. Elected boards of directors govern districts, and the district has legal ownership of the water to be used for the benefits of individual water users in the districts. This differentiates IDs from the less common "mutual" form of irrigation organization where ownership of shares by member irrigators may establish explicit water ownership by members (Griffin, 2012). IDs serve as local natural monopolists due to lowered average costs as deliveries increase. IDs can issue bonds, assess taxes, and exercise the power of eminent domain. These privileges helped IDs to secure financial support to construct irrigation infrastructure, primarily in the early 1900s (Hutchins, 1931). Federal subsidies were important cogs in this process.

Irrigation districts were formed at a time when agriculture was a mainstay of the economy, and abundant water was available for all sectors. However, irrigation infrastructure to capture and move water to dry farmlands was lacking in much of the American west. It was realized that a consolidated approach might help to reap economies of scale in water delivery (Hutchins, 1931). Individual efforts to construct irrigation infrastructures were financially prohibitive because of high capital cost requirements (Hutchins, 1931; Bretsen and Hill, 2006). Collective action such as the formation of cooperative irrigation organizations could acquire sufficient capital for infrastructure and reduce the financial costs in delivering irrigation water to off-channel lands. In certain cases, such as in the Rio Grande Valley of Texas, some IDs replaced private irrigation companies when the latter faced financial crises (Stubbs *et al.*, 2003).

The powers of taxation and condemnation created a favorable environment for district establishment by overcoming the twin problems of "free riding and holdout" in the western U.S. (Bretsen and Hill, 2006). The power of condemnation allowed IDs to acquire lands, easements, or any other property in districts to construct irrigation infrastructure without being blocked by landholder objections, thereby removing the problem of holdout. The power of taxation enabled IDs to recover costs within their service area thereby eliminating the problem of free riding. The nonprofit status of the districts activated a tax exemption benefit, generating further inducements to form districts. The trend was encouraged further in 1902 when the U.S. Congress created the U.S. Bureau of Reclamation to advise and financially assist irrigation infrastructure development. In most cases the water rights created by new dams were dedicated to the district itself or to the Bureau, and individuals only received use rights (Griffin, 2006, 2012; Bretsen and Hill, 2009). However, each member holds voting rights in selecting a board to govern district affairs, this ownership and political structure became a bottleneck in reallocating water to higher valued uses.

IDs were established as public entities for serving private individuals as early as 1887 when the Wright Act was passed in California, laying a unique foundation for ID formation and serving as a model for other states (Hutchins, 1931; Leshy, 1982; Bretsen and Hill, 2006). Originally the Act required 50 or a majority of land owners subject to irrigation from a common water supply source to petition county commissioners if they wanted to establish an ID (Hutchins, 1931). Some California landowners opposed the formation of IDs, claiming that the sale of lands for district taxes violated the Federal Constitution as it was tantamount to taking property without a due legal process. A California circuit court held that the Wright Act was unconstitutional on these grounds. In 1886 the Act was confirmed to be constitutional by the U.S. Supreme Court (Hutchins, 1931). Subsequently, district numbers grew rapidly in other western states.

There are variations and revisions in the petition and review procedures for ID formation in different states. For instance, Montana required 60% of landholders in a proposed district. California came to require either a majority or 500 landowners with at least 20% of the value of lands. Kansas required at least 75% of the resident landowners, whereas Utah required petitions to be signed by the governor upon recommendation by the state engineer (Hutchins, 1931; Bretsen and Hill, 2006).

Depending on state law, the petition was reviewed by county commissioners with or without a state engineer's preliminary feasibility and adequacy report. Hearings by county authorities were required to determine the fulfillment of statutory conditions such as the inclusion of land with only the common water supply source and the exclusion of land not benefitted by the process. Finally, the petition is granted and the formation election held if all the conditions are met (Hutchins, 1931; Bretsen and Hill, 2006).

The number of formed and operational IDs is shown using the left axis of Figure 1 and irrigated acres in IDs on the right axis. ID formation peaked after Congress passed the 1922 legislation authorizing the Bureau to contract directly with IDs. In 1926 the Omnibus Adjustment Act required the Bureau to contract only with IDs thereby further supporting ID formation (Leshy, 1982; Wahl, 1989).

There were 363 U.S. IDs in 1930 which increased to about 830 in 1978 (Figure 1). Irrigated acreage served by IDs increased tremendously during this period (Figure 1). About 10.7 million acres are served by IDs which is more than 25% of the total irrigated acres in the 17 western states (Bretsen and Hill, 2009). According to 1978 statistics most IDs are in California and few are in Kansas, Oklahoma, and the Dakotas (Figure 2). As the national irrigation organization survey was discontinued after 1978, it is difficult to know the contemporary extent of ID control over water. Yet, because the termination of IDs is a rare event except when they are merged with other water districts, the control of western water by IDs remains substantial.

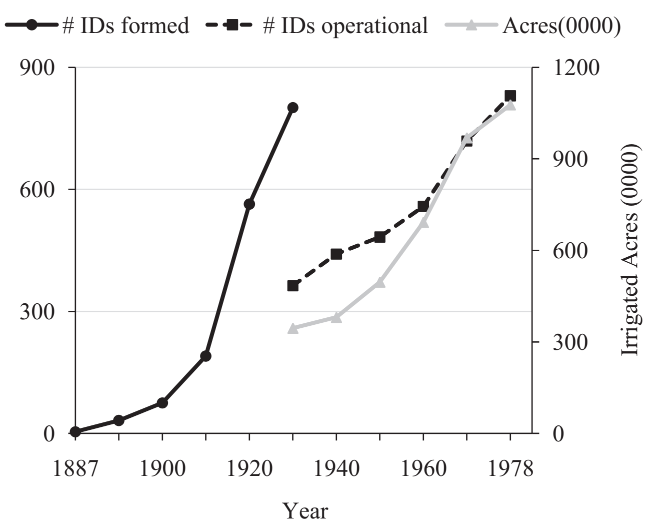


FIGURE 1. Numbers of Irrigation Districts (IDs) and Irrigated Acres. Sources: Hutchins (1931) and U.S. Department of Commerce, Bureau of the Census (1982). Note: #IDs formed indicates cumulative number of IDs formed as derived from Hutchins (1931). #IDs operational indicates number of IDs operating in respective years as derived from 1959 and 1978 censuses.

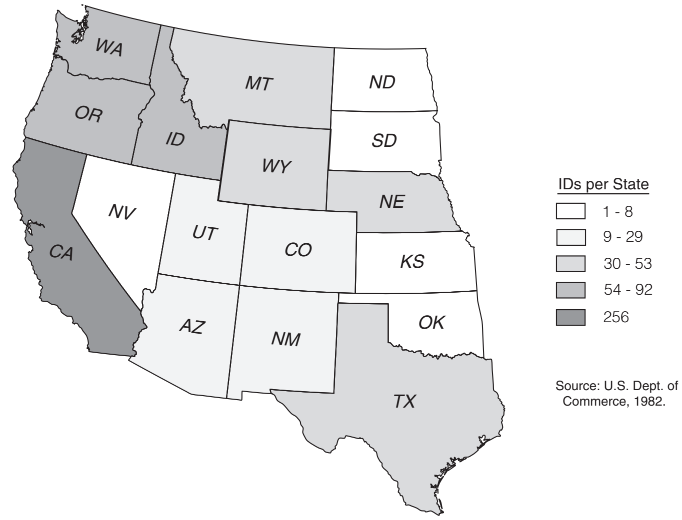


FIGURE 2. Irrigation District (ID) Intensity in the 17 Western States.

## IRRIGATION DISTRICTS IN TEXAS

Some Valley IDs commenced as irrigation and land companies over a century ago. Faced with financial crises such as the stock market crash of 1929, developers sold their land to farmers, and irrigation companies lost their incentives to maintain irrigation networks (Stubbs *et al.*, 2003). Subsequent bankruptcies led to the formation of several Valley IDs (Stubbs *et al.*, 2003). IDs were authorized by the Texas Legislature in 1905 after a 1904 constitutional amendment allowed public development of state's surface water resources for the first time (Stubbs *et al.*, 2003). IDs in the Valley are principally designed to deliver untreated water for irrigation purposes, yet they are also authorized to contract with other water suppliers or users for the delivery of the water (Tex. Water Code § 58.121).

An ID can be formed through petition to the local county clerk's office under Article III, Section 52 or Article XVI, Section 59 of the Texas Constitution. Fifty or more, or a majority of landowners with their land valuation of at least 50% of the proposed district land must petition to create an ID. An elected board of directors governs the district. Typically, there are five directors in a Texas district (Tex. Water Code § 58.071). A landowner having at least an acre of irrigable land in the district and entitled to receive the district's water is eligible to vote in district affairs. Tax assessors or collectors in a district can either be elected or appointed by the board. There is a considerable homogeneity in the voting schemes for the election of governing board of IDs in the Valley. IDs can sell surplus water for irrigation, domestic, or municipal purposes to any persons owning land in the vicinity of districts (Tex. Water Code § 58.184).

Many IDs in the Valley transformed themselves into Water Improvement Districts (WIDs) and Water Control and Improvement Districts (WCIDs). WIDs originally did not include any towns or cities and were required to get approval of the Board of Water Engineers (now defunct) in addition to a majority of votes in the service area if they wanted to include cities (Jasinski, 2011). On the other hand, IDs could include cities or towns, issue bonds, and they held the right of the eminent domain for constructing canals, pump sites, levees, and drainage ditches (Jasinski, 2011). IDs were allowed to be replaced by WIDs under the 1917 Conservation Amendment. WIDs can issue bonds with the consensus of a majority of eligible voters and can levy taxes on an *ad valorem* or a benefits basis but not on both bases (Smith, 2011). WIDs were further allowed to be converted to WCIDs in 1925. WCIDs may levy taxes on the local public through an *ad valorem* or benefit basis or both.

WCIDs may have broader powers such as irrigation, drainage, sanitation, fire protection, flood control, hydropower generation, and promotion of forest and water resources (Smith, 2011). WCIDs with a population of at least 30,000 in the district service boundary and having a real estate value of $50 million are eligible to be converted to municipal districts. Many WIDs and WCIDs converted themselves back to IDs in the 1980s to affirm their irrigation focus and minimize liabilities such as fire protection requirements (Smith, 2011). A few of them have been merged and consolidated into a single district. A list of Valley districts that have undergone some kind of structural change or conversion from WCIDs or WIDs to IDs or consolidation is provided in Table A1.

An ID can also change its name by following conditions set forth in the Texas Water Code and the Texas Administrative Code. Two or more districts can be consolidated into one district if the majority of electors in each district agrees to do so. The officers of a consolidated district assess and collect taxes on the property in the original district to pay its debt.

## SURFACE WATER RIGHTS AND REGULATORY PROCEDURE

Water rights are defined as a collectively recognized access to water resources under specific conditions (Saliba and Bush, 1987). The quantity of diversion, point, place, purpose of diversion, and priority dates are essential components of water rights. Water rights in the Valley, which are fully developed, are the outcome of the lengthy and costly so-called *Valley Water Suit*. The suit resulted in the judicial adoption of a weighted priority system of the rights administered by the area watermaster. The trial court set aside about 60,000 acre feet (AF) of water for municipal and domestic uses for the cities and urban areas, giving municipal and domestic water rights the highest priority (Smith, 1977). As per the weighted priority system, the trial court distinguished the five priority classes of irrigation water rights shown in Table A2. The trial court also determined the maximum allowable irrigation water per acre per year to be 2.5 AF.

Within this weighted priority system Class I rights receive 1.7 times as much water per acre as Class V rights, Class II receive 1.5 times as much as of Class V rights, Class III rights receive 1.3 times as much as of Class V, and Class IV receive 1.1 times as much as of Class V rights (Casbeer and Trock, 1969). The Court of Civil Appeals condensed these five classes into two on March 27, 1969 (Smith, 1977). Classes I and II were merged to form Class A (called legal rights) and the remainder into Class B (called equitable water rights). Among the lands receiving water rights, more than 89% were assigned Class A water rights (Table A2).

Class A water right holders get 1.7 times more water than Class B water right holders on per unit irrigated land basis (Smith, 1977; Schoolmaster, 1991; Chang and Griffin, 1992). Consequently, Class B right holders face more shortage than Class A right holders in times of scarcity. Currently, 27 active IDs deliver more than 80% of irrigation water in the Valley. The municipal water right holdings (Class M water rights) of the districts have increased almost fivefold since the resolution of rights (Table 1) due to the progressive, formal conversion of irrigation rights to municipal rights.

As a consequence of amendments repurposing water to other uses, the Class A agricultural water right holdings of districts have decreased by 111,574 AF (7.4%) since the initial allocation in 1971. The water right information of Table 1 indicates that Hidalgo and Cameron County ID#9, Delta Lake ID, Cameron County ID#2, Hidalgo County ID#2, and Harlingen ID are the top five IDs in terms of Class A

TABLE 1. Water Right Holdings (AF) of IDs by Class.

| | 2010 Water Rights | | | 1971 Water Rights | | |
|---|---|---|---|---|---|---|
| **Irrigation District** | **Class A** | **Class B** | **Class M** | **Class A** | **Class B** | **Class M** |
| Adams Gardens ID#19 | 18,737.7 | 0.0 | 0.0 | 19,000.0 | 0.0 | 0.0 |
| Bayview ID#11 | 16,978.0 | 0.0 | 183.1 | 17,561.0 | 0.0 | 300.0 |
| Brownsville ID | 33,949.5 | 1,431.2 | 4,884.0 | 49,949.5 | 926.6 | 0.0 |
| Cameron County ID#2 | 147,823.7 | 0.0 | 9,117.5 | 145,491.3 | 0.0 | 8,830.0 |
| Cameron County ID#6 | 52,141.9 | 0.0 | 20.0 | 54,781.9 | 0.0 | 0.0 |
| Cameron County WID#10 | 8,387.5 | 0.0 | 0.0 | 10,212.5 | 0.0 | 0.0 |
| Cameron County WID#16 | 3,712.5 | 0.0 | 0.0 | 4,462.5 | 0.0 | 240.0 |
| Delta Lake ID | 174,862.4 | 0.0 | 8,200.0 | 174,776.4 | 0.0 | 1,320.0 |
| Donna ID Hidalgo County #1 | 94,063.6 | 0.0 | 6,880.0 | 94,063.6 | 0.0 | 2,690.0 |
| Engelman ID | 18,869.4 | 0.0 | 598.5 | 23,095.0 | 0.0 | 80.0 |
| Harlingen ID Cameron County #1 | 98,232.5 | 0.0 | 19,312.0 | 100,332.5 | 0.0 | 4,780.0 |
| Hidalgo County ID#1 | 84,831.0 | 0.0 | 7,627.0 | 86,865.0 | 0.0 | 1,220.0 |
| Hidalgo County ID#16 | 30,948.9 | 0.0 | 1,600.0 | 20,000.0 | 0.0 | 100.0 |
| Hidalgo County ID#2 | 137,775.0 | 0.0 | 25,050.5 | 162,500.0 | 0.0 | 2,680.0 |
| Hidalgo County ID#6 | 34,913.0 | 0.0 | 5,816.0 | 53,945.0 | 0.0 | 750.0 |
| Hidalgo County MUD#1 | 50.3 | 1,171.4 | 384.0 | 0.0 | 2,545.3 | 0.0 |
| Hidalgo County WCID#18 | 0.0 | 3,560.6 | 0.0 | 0.0 | 5,505.2 | 0.0 |
| Hidalgo County WCID#13 | 4,856.9 | 0.0 | 0.0 | 4,856.9 | 0.0 | 0.0 |
| Hidalgo County WCID#19 | 9,047.6 | 0.0 | 0.0 | 11,776.7 | 0.0 | 0.0 |
| Hidalgo County WID#5 | 14,234.6 | 0.0 | 0.0 | 14,234.6 | 0.0 | 0.0 |
| Hidalgo County WID#3 | 9,852.6 | 0.0 | 13,980.0 | 19,852.9 | 0.0 | 0.0 |
| Hidalgo & Cameron County ID#9 | 177,151.6 | 0.0 | 17,163.0 | 180,151.6 | 0.0 | 4,230.0 |
| La Feria ID Cameron County#3 | 75,625.9 | 0.0 | 5,152.0 | 76,612.5 | 0.0 | 2,300.0 |
| Santa Cruz ID#15 | 75,080.0 | 3,577.5 | 120.0 | 77,180.0 | 0.0 | 120.0 |
| Santa Maria ID Cameron County #4 | 10,182.5 | 0.0 | 60.0 | 10,182.5 | 0.0 | 160.0 |
| United ID | 57,374.3 | 0.0 | 21,115.0 | 82,961.3 | 0.0 | 1,190.0 |
| Valley Acre ID | 16,124.3 | 0.0 | 200.0 | 22,500.0 | 0.0 | 0.0 |
| Total | 1,405,771.1 | 9,740.7 | 145,462.6 | 1,517,344.8 | 8,977.0 | 30,990.0 |

agricultural water right holdings. These five IDs control 52% of the Class A water rights in the Valley.

Discontent expressed by area cities over ID control of water rights, even as these IDs lost irrigated acreage to residential and commercial development, led to new legislation in 2007. The revised Texas Water Code establishes a petitioning procedure whereby land officially subdivided for nonagricultural purposes can force a conversion of ID water rights to the municipal purpose (Chapter 49, subchapter O). For this to occur, a municipal water supplier must petition the ID within a defined time schedule, and the ID must consider the petition expediently. Once the ID acts to amend water rights in response to a petition, the municipal supplier can either purchase the converted water rights or develop a contract with the ID for long-term water delivery (at least 40 years). Purchase price is established at 68% of market value as witnessed in the contemporary market, thereby requiring regular collection of price information for the first time. If the municipal supplier pursues the contract alternative, it is stipulated that contract prices are guided by the irrigation rates applied by the ID. These statutes are only applicable to the Valley region.

Texas water rights below the Fort Quitman boundary are overseen by the Rio Grande Watermaster located in Harlingen, Texas. The watermaster, who is appointed by the executive director of Texas Commission on Environmental Quality (TCEQ), regulates and monitors water diversions in the Valley (Wolfe *et al.*, 2007). All water right holders in the Valley are required to notify the watermaster about their water use intentions and record the quantity of water being diverted from the river. Each agricultural water right holder has an opportunity to store surplus water in Falcon Reservoir in any particular year and use the stored water subject to terms and conditions set forth by the watermaster. In releasing water from the two internationally managed reservoirs of the watershed, the watermaster works in close connection with the International Boundary of Water Commission (IBWC). The IBWC is responsible for measuring, recording, and managing the inflow of water in the reservoirs and tributaries, and resolving boundary disputes as they relate to the sharing of water and reservoirs by the U.S. and Mexico per Treaty stipulations (Wolfe *et al.*, 2007).

Each ID has its own rules and regulations for serving member-clients. Many of these rules and regulations strike a close resemblance across the Valley. Water users must purchase a water ticket from the district at least 5 days in advance of water use, and generally water should be used within 15 days of the authorized application date (HCID#6, 2002; CCID#2, 2011). The water ticket shall mention the plan and purpose of water use and terms of payment. In addition, each water user is required to furnish a plan depicting the acreage to be irrigated, types of crops to be grown, and pay the assessments or charges set forth by the district, usually at the beginning of the year or any time upon a written request by the district. Water should be used for beneficial purposes without any waste or face a penalty which might vary across districts. The canal riders or water superintendents oversee the delivery of water to individual users who are required to prepare their fields for irrigation prior to water diversion by the riders (HCID#6, 2002).

## PRIOR LITERATURE AND HYPOTHESES

Coase (1960) argued that when transaction costs are low and property rights are well-defined the efficient allocation of resources is achieved through trade regardless of the initial assignment of property rights. This doctrine highlights the importance of transaction costs and property establishment options in allocating resources efficiently. Ruml (2005) contends that larger institutions promote external water reallocations by helping to achieve Coase conditions. Political factors are also important in making water transfer decisions. McDowell and Ugone (1982) observe that political conditions such as voting rules are principal factors influencing water transfer differentials among Arizona IDs. McCann and Zilberman (2000) reinforce the finding that property-weighted voting districts are more responsive to external water transfers than popular voting districts because water sales in such districts directly benefit landowners.

Miller (1987) indicates that external water transfers are positively associated with increased internal water delivery costs and negatively associated with increased external transfer costs. She argued that larger IDs with broader service areas might be less willing to transfer water outside IDs, because IDs can internally utilize seepage or runoff water multiple times thereby decreasing the cost of internal water delivery. Stated another way, there can be positive externalities among the irrigators served by an ID. Casbeer and Trock (1969) note that larger IDs are financially and managerially capable of timely improvements in irrigation infrastructure and are better able to create a positive environment for water transfers. So they advocated for at least moderately sized master districts that could easily promote infrastructure rehabilitation and increased water use efficiency.

A myriad of political, legal, physical, financial, and behavioral factors affect water transfers for IDs. Among them are the water right holdings and financial strength of IDs. Larger IDs may have greater latitude to explore novel arrangements and are likely to be fuller participants in regional water planning because of their relatively important water right holdings. Larger IDs are perhaps more likely to possess financial resources useful in pursuing advanced water management strategies. They might be viewed as possessing specialized knowledge creating innovations to participate in broader water transfer decisions and planning.

Brewer *et al.* (2007, 2008) and many others advocate water marketing as a least cost alternative to incentivize farmers to conserve and thereby meet increasing, population-fueled urban water demands. Citing some examples of higher marginal value of water in municipal uses than in agricultural uses in Arizona and California, the authors argue that water trade can be fostered in these regions by lowering transaction costs. They note that agriculture-to-urban trade is on the rise in the American west, but most trade is agriculture-to-agriculture rather than agriculture-to-urban and most trade is short-term leases with substantial variation across states. Brookshire *et al.* (2004) observe that prices are significant determinants in water trading. They found substantial variation in water market activities and prices in Arizona, Colorado, and New Mexico. Chong and Sunding (2006) identify the importance of transaction costs and third party effects on water market transactions. Bjornlund *et al.* (2007) highlight the importance of heterogeneities among individual irrigators and IDs in designing economic instruments for enhancing water use efficiency in Alberta, Canada. Wheeler *et al.* (2009) investigated attributes of private irrigators that are influencing water transfers in the Goulburn-Murray ID in Australia and found that early water traders are more likely to be older farmers with intensive farming practices, higher education levels, low farm productivity, larger irrigated area, and greater farm assets or operating surpluses. However, none of these studies investigate how economic and local heterogeneities contribute to variable water transfer performances for IDs.

Higher wealth and resources in an enterprise help stimulate growth, build economies of scale, and provide market power for creating more wealth (Ireland *et al.*, 2003; Ketchen *et al.*, 2008). Wealthier firms with larger financial resources may better identify and exploit entrepreneurial opportunities. Financial resources can also be used to acquire better technical and human capital for improved management of financial capital (Dutta *et al.*, 2002). IDs with larger water right holdings generally possess greater financial resources as water rights are valuable property. IDs with better financial resources can better justify and afford improvements to infrastructure, and they can hire skilled managers and employees to oversee and manage the water delivery system. Better managerial and financial resources can identify and exploit entrepreneurial opportunities through innovative planning strategies, including external water transfers. Thus, higher water right holdings might support increased water transfers.

Studies show that risk perception toward water transfers crucially affects transfer responses even though such studies are limited to individual farmers. Because small farmers put higher weight on risk minimization, farmers with higher water right endowments transfer more water compared to farmers with lower water right endowments under duopolistic market scenarios (Ranjan and Shogren, 2006).

The association between water transfers and water right holdings should not be taken in isolation as there are other factors such as urbanization which can exert significant pressures favoring transfers. Urbanization should reduce agricultural water demand due to land use conversion thereby making the ID water surplus relative to IDs experiencing less urbanization. Also, urbanization can exert a direct influence on water transfers through higher demand for municipal water. Therefore, population and income growth in nearby cities can be expected to exert pressure favoring water transfers. ID attributes like district operation costs, water market prices, the number of ID members, and magnitude of conveyance losses may also impact water transfers, as may many other factors.

## ECONOMETRIC MODEL AND ESTIMATION TECHNIQUES

Unbalanced panel data econometric models employed for the forthcoming analysis are specified as follows.

$$y_{jt} = \Phi(\rho + x_{jt}\beta) + \alpha_j + u_{jt}\; j = 1,2,\ldots,N; t = 1,2,\ldots T_j \quad (1)$$

$$z_{jt} = \rho + x_{jt}\beta + \alpha_j + u_{jt}\;\; j = 1,2,\ldots,N; t = 1,2,\ldots T_j \quad (2)$$

where $y_{jt}$ is a 0-1 categorical variable (no transfers or transfers) for a full sample probit model in Equation (1), and $z_{jt}$ is the amount of water transferred by ID $j$ in year $t$ for partial sample model in Equation (2). $\Phi(\cdot)$ is the standard normal cumulative distribution function. $\rho$ is the intercept term. $x_{jt}$ is a $1 \times$ K vector of explanatory variables, and $\beta$ is a K $\times$ 1 vector of regression parameters to be estimated in both the models. $\alpha_j$ is the influence of district-specific, unobserved attributes presumed to be constant over time. $\alpha_j$ is assumed to be independently and identically distributed with zero mean and variance $\sigma^2_\alpha$. $u_{jt}$ is an idiosyncratic error term. The error terms ($\alpha_j$ and $u_{jt}$) are assumed to be heteroscedastic across panels because of their uneven nature.

In general, the above panel data econometric models can be estimated using a fixed effect (FE) or a random effect (RE) panel data estimation procedure, and a Hausman test can be applied to decide which model best fits the data (Wooldridge, 2001). A RE model assumes that $\alpha_j$ are uncorrelated with the explanatory variables: $E[\alpha_j \mid X_j] = 0$. Under this assumption the RE estimates are consistent and efficient. On the other hand, the FE model allows correlation between regressors and ID specific heterogeneity: $E[\alpha_j \mid X_j] \neq 0$. However, with the FE model any time invariant covariates are wiped out because of the demeaning process (Wooldridge, 2001).

Given data availability constraints particular to the region and the long interval over which water has been traded there, selected explanatory variables are water right holdings, per capita income, population, and age of ID establishment. We expect a positive impact of water right holdings, population, and income on water transfers for reasons emergent in the above section. Age is expected to exert a positive impact on water transfer if older IDs have more managerial know-how to capture the market opportunities. Other variables like prices of water transfer may be important but are excluded here as they are not available (private information not disclosed in the past).

## DATA SOURCES AND ESTIMATION ISSUES

Water transfer data are obtained from the amendments to certificates of adjudication maintained by the TCEQ. The amendments include any alterations in the conditions of water rights including changes in purpose of water use, changes in place, point, rate of diversion and irrigated acreage, correction of previous amendments, acknowledgement of any agreement/ legal change, and severance/combinations of water rights. For this study, water transfer is defined as a change in the purpose of water uses from agriculture to municipal, industrial, or domestic uses (collectively called municipal uses) with or without ownership changes. Therefore, permanent intersectoral reallocations are examined rather than the intrasectoral lease markets of the Valley. A list of ID water rights in the Rio Grande basin was identified from the water rights database maintained by the TCEQ. Transfer data were extracted by the authors from the amendments stored in microfilms, microfiches, and paper files of the TCEQ.

The data for initial water right holdings are obtained from the watermaster office (Texas Water Rights Commission, 1971). The water rights data for 2010 are obtained from the water right database maintained by the TCEQ. The urbanization data for 2006 are obtained from Bonaiti and Fipps (2011). Bonaiti and Fipps define an urban area as "a continuous developed or developing area that is no longer in agricultural use." They use GIS and aerial photography to identify urban area in an ID thereby measuring the extent of urban area in IDs. Distance to nearest market could well be an important explanatory variable but omitted here because it is redundant as urban area in an ID is available. The latest urbanization data available are for 2006. The age of ID establishments is defined as 2012 minus the date of establishment as provided by Casbeer and Trock (1969). In the partial sample model, age is computed for each year of water transfer thereby making it time variant. The latest population and per capita income for the nearest cities of IDs are obtained from the U.S. Census Bureau (U.S. Census Bureau, State and County QuickFacts. http://quickfacts.census.gov/qfd/states/48/4822660.html, *accessed* October 2012). Although time series ID-specific income and population data may be preferred, only 2010 per capita income and population data are used in the absence of such data for the corresponding years of water transfer. Use of latest population and income data for modeling past water transfers may be reasonable as cities plan water supply enhancements in advance of population growth.

The water transfer data indicate that 16 of the 27 currently active IDs in the Valley have transferred water from irrigation to a municipal purpose. Table 2 contains a summary of the pooled cross section and time series data. Transfers occurring more recently than 2006 are ignored because the 2007 legislative changes modified the structure of the transfer environment. On average IDs have transferred 1,184 AF of municipal water during the 35-year period since 1971-2006 with minimum of 0 AF and maximum of 8,000 AF. The proportion of municipal water right holdings has increased over time while the proportion of agricultural water right holdings, especially Class A, has declined for the selected IDs. IDs have transferred about 6.9% of their initial water right holdings, and there is a great variation in the ratio of water transfers to water right endowments among IDs. In Figure 3, IDs' sorted water right holdings are shown on the primary vertical axis and water transfer ratios on the secondary vertical axis. Hidalgo County Municipal Utility District Number 1 with a current water right endowment of 878 AF has transferred the greatest proportion of its water (about 60% of 1971 water right holdings and 70% of 2010 holdings). In absolute terms, United ID (UID) with current water right holding of 49,802 AF of municipal equivalent water has transferred the highest quantity of water (14,625 AF) which is almost 34% of its 1971 endowment and 29% of 2010 endowment. In computing the water right endowment of UID, the endowments of Hidalgo County ID#14 and Hidalgo County WCID#7 are taken into account. Hidalgo and Cameron County ID#9, the highest water right holder in the Valley with 105,739 AF of water, has transferred about 1.4% of its 2010 water right endowments. All agricultural water rights are displayed as municipal water equivalents in Figure 3. An acre-foot of Class A water right is equivalent to 0.5 AF of municipal water and an acre-foot of Class B water is equivalent to 0.4 AF of municipal water in the Rio Grande Valley.

TABLE 2. Summary Statistics.

| Variable | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|
| Water transfer (AF) | 1,183.60 | 1,765.70 | 0.00 | 8,000.00 |
| Ag. water right holding (AF) 1971* | 31,377.87 | 28,072.79 | 1,018.10 | 90,075.81 |
| Urban area 2006 (acres) | 10,280.33 | 11,586.56 | 120.00 | 39,107.00 |
| Per capita income (2010 US$) | 14,811.89 | 3,526.94 | 4,719.00 | 19,490.00 |
| Age of ID establishment (years) | 83.24 | 10.72 | 61.00 | 107.00 |
| Population (#) 2010 | 56,206.02 | 40,848.48 | 2,873.00 | 175,023.00 |

Notes: Sample size is 45 with 27 IDs represented.
*Total agricultural (Class A and Class B) water right holding converted into municipal water equivalent.

On average, IDs in the Valley contain 13,492 acres of urban land with minimum of 120 acres and maximum of 39,107 acres as in 2006 (Table 2). The spread is suggestive of high variability in the degree of urbanization in IDs. The majority of younger IDs contain less urban areas. The average age of IDs is 83 years with a range of 46 years (Table 2).

Because of data limitations, most of the explanatory variables are time-invariant. For instance,


FIGURE 3. Proportions of Water Transfers and Water Right Holdings. Note: Water rights are expressed in municipal equivalents.

population and per capita income are not available for corresponding years of water transfer, so the latest years' available data are used for these variables. For water right holdings, only 1971 data are used. Consequently, estimation of a FE model is infeasible. Because of the unbalanced nature of panel data, heteroscedasticity may be a problem in need of redress. Data are converted into their logs to reduce skewness and smooth the data. A robust estimator is used to make standard errors robust with respect to model misspecification and to reduce heteroscedasticity for both probit and partial sample models. In the partial sample (Equation 2) model, the heteroscedasticity consistent pooled cross-section time series feasible generalized least square (FGLS) estimation technique is used to correct the problem of heteroscedasticity. Jackman (2004) suggested using FGLS estimation technique to overcome the problem of group-wise heteroscedasticity in unbalanced panel data estimation. Oaxaca and Geisler (2003) have shown that there is an equivalence in the coefficients of the two-stage GLS and pooled ordinary least square (OLS) estimates on the time invariant variables in an unbalanced FE panel. Wooldridge (2011) argues that under certain conditions the parameter estimates of FE, RE, and pooled OLS are equivalent for an unbalanced panel data model.

Before conducting regression analysis, the covariates are investigated to diagnose correlations. Most of the squares and interaction terms are severely correlated (correlation coefficient $\geq$0.80) with their untransformed levels. The urban area and interaction term of agricultural water rights and population are highly correlated with a coefficient of 0.87. Urban area has high correlation with other variables as well. Consequently, urban area is removed from the regression analysis as its higher correlation with variables makes its independent contribution difficult to assess reliably. Square terms and interaction terms with correlation coefficients exceeding 0.80 are also removed from the final analysis to reduce collinearity issues.

For estimation purpose two types of models are specified: one for all IDs (full sample) and another for IDs with positive water transfers (partial sample). We use a binary choice regression approach to identify which IDs are most likely to transfer water. With a binary choice model we can make fullest use of information even for those IDs that have not transferred water in the past. For a binary choice model, OLS produces regression errors that are heteroscedastic; consequently parameter estimates will be inefficient and test statistics unreliable. Hence, binary choice probit model is used for full sample estimation purpose. The specification does not account for the number of transfers occurring in a year by IDs and it is done purposefully. Here our objective is not to investigate number of water transfers but to identify which IDs are more likely to transfer water thereby making some other probit methods such as an ordered probit unnecessary.

However, the binary choice probit approach disregards the magnitude of water transfer as IDs with higher magnitude of water transfer are treated the same as those with smaller magnitude of transfer. Therefore, model (3) uses the partial sample in which only IDs transferring water transfer are used. Also if there are unmeasured barriers that prevent certain IDs from participating in water transfer, it would be sensible to exclude those IDs in the analysis. The full sample estimation probit model is

$$y_{jt} = \beta_0 + \beta_1 \ln(\text{Endowment}_j) + \beta_2 \ln(\text{Income}_j) + \beta_3 \ln(\text{Population}_j) + \beta_4 \ln(\text{Age}_j) + \beta_5 \ln(\text{Endowment}_j) * \ln(\text{Population}_j) + \varepsilon_{jt} \,. \quad (3)$$

In Equation (3) the dependent variable $y_{jt}$ is a categorical variable with a value of 1 if an ID has transferred water and 0 otherwise. Subscripts $j$ (=1, 2, …, 27) indicate IDs and $t$ indicates time period (=1973, …, 2006) with gaps as the data are available only for few years. There are 27 IDs with an average of 1.7 years of water transfer and total sample size of 45. It might be better to use weighted endowment (weighted by irrigated area) instead of absolute value of endowment as one of the explanatory variables of interest, but the lack of data on ID-level irrigated area precludes this path.

The partial sample analysis estimation model is identical to that of Equation (3) except that the dependent variable is the log of water transfers. Sixteen IDs are represented in the partial sample. On average they have 2.1 years in which water transfers occurred, providing a sample size of 34 for the analysis. Also the population and income data for IDs are unavailable for corresponding year of water transfer thereby relying only on 2010 data. The county level income data provided almost identical results in terms of marginal effect (ME) in the FGLS model. Use of 2010 data for explaining past water transfer may potentially produce endogeneity concern. However, a test of endogeneity of 2010 income data instead of the data for each corresponding year of water transfer rejected such concern at 99% or better confidence level. In this model, ID age varies across districts and years because it is possible to compute the age for corresponding year of transfer for all partial sample IDs.

If IDs self-select whether to transfer water, using IDs only with positive water transfer might introduce sample selection bias. To avoid this bias, Heckman type sample selection models can be used if we have proper selection variables or instruments (Heckman, 1979; Miranda and Rabe-Hesketh, 2006). So we used Heckman two-step regression approach to determine whether there is a selection problem. In the selection equation urban area is used as additional selection variable (instrument) in addition to regressors used in the outcome regression (i.e., log of water transfer, population, income, age, and interaction between log of water transfer and log of population). The resulting inverse Mills ratio is highly insignificant implying selectivity is not a problem in making water transfer decisions in IDs. Tabulated results for the Heckman-based analysis are omitted for brevity.

## RESULTS AND DISCUSSION

The regression results of full sample probit estimates are presented in Table 3. The fit of model is good as indicated by Wald chi-square and associated lower $p$-value at the bottom of the table. The coefficient estimates are not directly interpretable as they are probit estimates. Presence of interaction terms further complicates the interpretation. So MEs are computed as derivatives of the estimated model and presented in Table 4; these nonlinear MEs are evaluated at both sample means and medians.

Similarly, RE and FGLS estimation results for the partial sample are presented in Table 5. Both the models are significant according to Wald chi-square statistics and associated probability values. The magnitudes and significance levels of coefficient estimates vary between the two models/techniques. A majority of the FGLS coefficient estimates are significant at 1% significance level or lower. The RE coefficient esti-

TABLE 3. Full Sample Probit Regression Results.

| | Probit Estimates | |
|---|---|---|
| **Covariates** | **Coefficient** | **SE** |
| Log of ag. water right holdings (1971) | −8.599 | 5.368 |
| Log of per capita income (2010) | 17.835*** | 5.747 |
| Log population (2010) | −10.572** | 4.754 |
| Log of age | −3.988 | 6.736 |
| Log water right × Log population | 1.194** | 0.501 |
| Intercept | −77.105 | 90.907 |
| Wald $\chi^2$ (5) | 37.550 | |
| Prob > $\chi^2$ | 0.000 | |

Notes: Dependent variable is a dummy variable with value of 1 if an ID has transferred water and 0 otherwise. Total sample size is 45 with number of IDs 27 and average number of years 1.7.
ag., agricultural; SE, standard error.
**Significant at ≤5%.
***Significant at ≤1%.

TABLE 4. Full Sample (Probit) Marginal Effects.

| | At Means | | At Medians | |
|---|---|---|---|---|
| **Covariates** | **ME** | **SE** | **ME** | **SE** |
| Log of ag. water right holdings (1971) | 3.912*** | 0.868 | 4.836*** | 0.930 |
| Log of per capita income (2010) | 17.835*** | 5.747 | 17.835*** | 5.747 |
| Log population (2010) | 1.031 | 0.654 | 1.611** | 0.749 |
| Log of age | –3.988 | 6.736 | –3.988 | 6.736 |

Notes: ME, marginal effect; SE, standard errors computed by the delta method; ag., agricultural.
**Significant at ≤5%.
***Significant at ≤1%.

TABLE 5. Partial Sample Regression Results.

| | FGLS Estimates | | RE Estimates | |
|---|---|---|---|---|
| **Covariates** | **Coefficient** | **SE** | **Coefficient** | **SE** |
| Log of ag. water right holdings (1971) | −5.963*** | 1.014 | −5.713** | 2.813 |
| Log of per capita income (2010) | −2.711*** | 0.469 | −3.381*** | 1.186 |
| Log population (2010) | −4.604*** | 0.908 | −4.333* | 2.420 |
| Log of age | 1.204* | 0.728 | 0.484 | 1.112 |
| Log water right × Log population | 0.576*** | 0.094 | 0.555** | 0.256 |
| Intercept | 75.137*** | 14.437 | 81.45** | 35.390 |
| Wald $\chi^2$ (5) | 222.000 | | 53.390 | |
| Prob > $\chi^2$ | 0.000 | | 0.000 | |

Notes: Dependent variable is log of water transfer. Total sample size is 34 with number of IDs 16 and average number of years 2.1. FGLS, feasible generalized least square; RE, random effect; SE, standard error; ag., agricultural.
*Significant at ≤10%.
**Significant at ≤5%.
***Significant at ≤1%.

TABLE 6. Partial Sample Marginal Effects (evaluated at means).

| | FGLS Estimates | | RE Estimates | |
|---|---|---|---|---|
| **Covariates** | **ME** | **SE** | **ME** | **SE** |
| Log of ag. water right holdings (1971) | 0.244*** | 0.061 | 0.263* | 0.159 |
| Log of per capita income (2010) | −2.711*** | 0.469 | −3.381*** | 1.186 |
| Log population (2010) | 1.079*** | 0.092 | 1.14*** | 0.246 |
| Log of age | 1.204* | 0.728 | 0.484 | 1.112 |

Notes: FGLS, feasible generalized least square; RE, random effect; ME, marginal effect; SE, standard error computed by the delta method; ag., agricultural.
*Significant at ≤10%.
***Significant at ≤1%.

mates vary in significance level with most coefficients significant at 1-5% or lower significance level. A similarity of the two models is that coefficient signs are the same. Thus, the two models provide similar results albeit with differing significances and magnitudes. Because of the presence of interaction terms, the coefficient estimates in the table are not directly interpretable, and MEs are again computed and tabulated (Tables 6 and 7).

### *Water Right Endowments and Water Reallocation*

Water right holdings exert significant positive effect on likelihood of water transfer at 99% or better confidence level in full sample probit approach

TABLE 7. Partial Sample Marginal Effects (evaluated at medians).

| | FGLS Estimates | | RE Estimates | |
|---|---|---|---|---|
| **Covariates** | **ME** | **SE** | **ME** | **SE** |
| Log of ag. water right holdings (1971) | 0.517*** | 0.078 | 0.527*** | 0.171 |
| Log of per capita income (2010) | −2.711*** | 0.469 | −3.381*** | 1.186 |
| Log population (2010) | 1.276*** | 0.106 | 1.33*** | 0.299 |
| Log of age | 1.204* | 0.728 | 0.484 | 1.112 |

Notes: FGLS, feasible generalized least square; RE, random effect; ME is marginal effect; SE is standard error computed by the delta method; ag., agricultural.
*Significant at ≤10%.
***Significant at ≤1%.

(Table 4). The MEs in partial sample analysis (Tables 6 and 7) also have significant positive impact on water transfers at a 99% or better confidence when evaluated at medians. The magnitude of the ME appears to be higher when evaluated at medians than at means while the direction remains the same. Magnitudes of MEs are similar in both the models. The point estimates, however, are not sufficient to explain the entire underlying association between water right holding and water transfers.

In Figure 4 estimated MEs of initial water right endowments are plotted against the observed population ranges for both RE and FGLS estimates. Based on RE estimates (the upper panel of Figure 4) the ME of water right holdings on transfers becomes significantly positive for IDs with nearby city populations of around 49,000 or more. Based on the data, about 59% of IDs that have participated in water transfers have cities with qualifying populations in the vicinity. However, based on the FGLS estimates (in the lower panel of Figure 4), the ME of water right holdings on transfer becomes significant for IDs at lower and higher population ranges. As per the model, the ME does not turn out to be significant for about 6% of IDs with population in nearby cities ranging from 26,900 to 32,860. Even though there are disagreements in the two models about the ME at the lower population level, they do agree at the higher level of population (>49,000). This indicates that water right entitlements become more influential for water transfers when population is bigger.

Overall, the analysis does not reject the hypothesis that IDs with higher initial agricultural water right holdings are more likely to transfer water (and also more water) depending on the level of population in the surrounding areas. It is possible that larger IDs are more pressured, proactive, or innovative in capturing the opportunity costs of water through transfer as argued by Casbeer and Trock (1969). Or larger IDs might be willing to bear more risks for higher

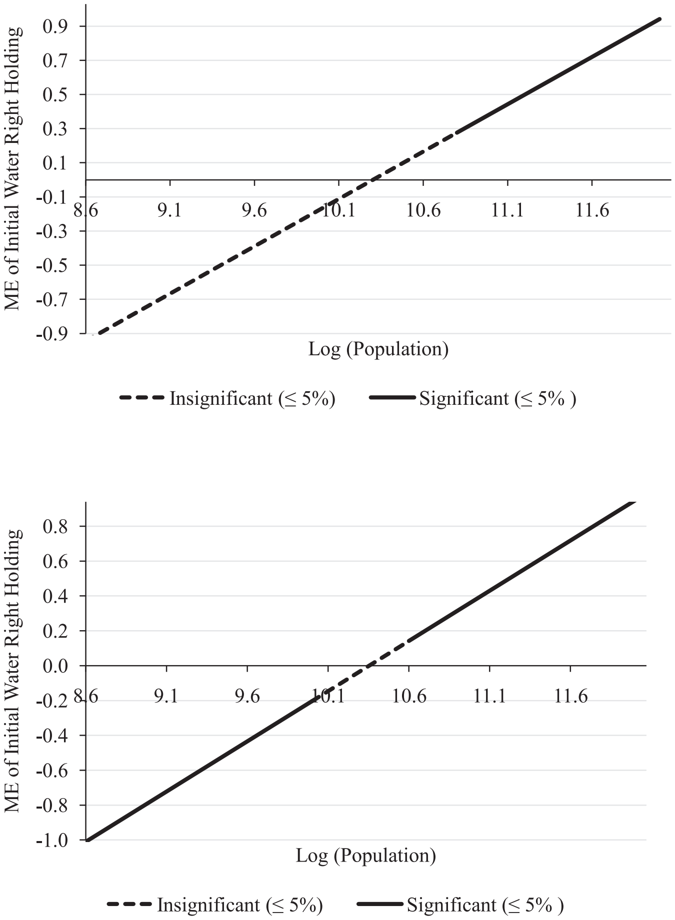


FIGURE 4. Marginal Effect of 1971 Water Right Holdings on Transfers. Note: The upper panel shows random effect estimates and the lower one the feasible generalized least square estimates.

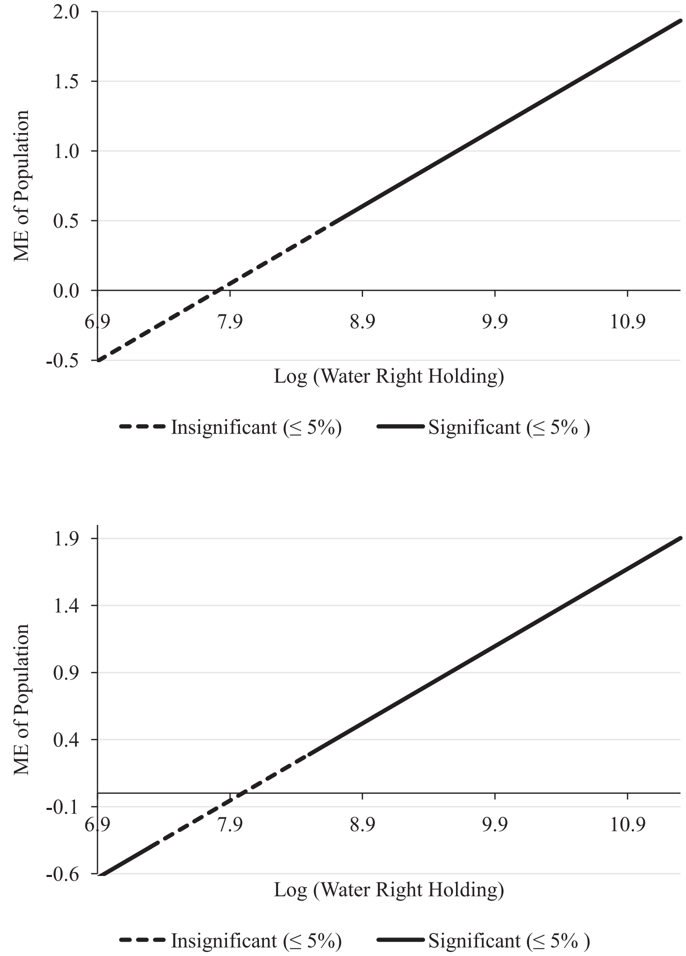


FIGURE 5. Marginal Effect of Population on Water Transfer. Note: The upper panel shows random effect estimates and the lower one the feasible generalized least square estimates.

transfer rewards. The larger districts are financially and technically in a better position to improve their water supply infrastructures thereby reducing conveyance losses and releasing more water for transfers. However, water right holdings significantly interact with population thereby exerting nonlinear effects on transfers.

*Demographics and Water Reallocation*

The MEs of population (Tables 6 and 7) are positive and significant on water transfers in both RE and FGLS models, and at both means and medians. The ME of population is positive when evaluated at medians but not stronger in the probit model (Table 4). To visualize the ME of population on water transfers, a graph with estimated slope of water transfer on vertical axis and water right holding on horizontal axis is shown in Figure 5. The marginal plots are drawn only for the partial sample. The ME of population on water transfer is significantly positive (at 95% confidence level or better) for IDs with water right holdings of 6,000 AF (municipal equivalent) or more for RE estimates in the upper panel of the figure. The results are similar for FGLS estimates in the lower panel of the figure except that the MEs become significant for lowest water right holders as well in the FGLS model. About 70% of IDs in the Valley have initial agricultural water right holdings equal or greater than 6,000 AF (municipal equivalent). The findings reinforce the literature in water economics where population growth has been described as one of the influential factors in agriculture to municipal water transfers in the American west (Smith, 1989; Watson and Davies, 2011; Libecap, 2011). Higher population and consequent industrialization and urbanization create pressure for water demand and opportunities for win-win water transfers.

The ME of income is positive and significant in full sample probit estimates as expected. Surprisingly, the MEs of per capita income in RE and FGLS models are found to be significantly negative on water transfers. The discrepancy in the direction of ME of income in full sample and partial sample analysis cannot be well-explained using knowledge or data at hand.

The ME of age on water transfers is statistically insignificant and negative in full sample probit. The MEs are positive and statistically significant at 10% significance level in partial sample analysis. Consequently, the direction of age effect varies for two models, and its effect on water transfers is inconclusive.

### *Limitations*

The study does not have the market-generated water right prices which are likely to be an important factor for motivating transfers. The cost of conducting water transfers, conveyance losses, and managerial ability might play a role in water transfers but are excluded from the analysis because of data unavailability. It might also be better to weight water right endowment by irrigated area, yet court-authorized irrigated areas are highly correlated (correlation coefficient 0.99) with water right holdings, thereby making such data unsuitable. Also, the sample size is naturally small. Unless additional IDs transfer water more frequently in future or we are able to include IDs from other western states, there are limited opportunities to enhance the sample size. Because of a high correlation among variables of interest, higher order polynomial terms have not been included in the analysis. Even though panel type analysis is performed here, limited data on water transfer has precluded a FE panel analysis.

## CONCLUSIONS AND POLICY IMPLICATIONS

IDs established in the Rio Grande Valley about a century ago control a significant portion of surface water rights. Although the IDs resemble each other in political structure and regulatory procedures, they are heterogeneous in their water right holdings, local urbanization, population, income, and age. The study finds that 27 IDs of the lower Rio Grande Valley exhibit a high degree of skewness in water right holdings and transfer activities. Less than half a dozen IDs control more than 50% of the total Class A agricultural water right holdings in the Valley. About a dozen IDs have never participated in agricultural to municipal water transfers. Among the IDs with some positive water transfers, larger and more population centric IDs tend to be transferring more water compared to smaller and less populated IDs. Larger IDs with higher initial water right holdings might have better infrastructure, better technical and financial resources, and innovative capabilities allowing them to be more responsive to water transfer opportunities. Consistent with theoretical expectations, empirical results indicate that IDs with higher population in nearby cities are more likely to transfer water with increasing water right holdings potentially, presumably due to higher residential and industrial water demand.

The negative ME of per capita personal income on water transfers in FE and RE estimates is an unexpected result. The effect of ID ages on water transfer is inconclusive. A high correlation between urbanization and other covariates such as water right holdings and population precluded testing the hypothesis of positive association between ID level urbanization and water transfer.

Taken at face value, the findings suggest that smaller IDs be consolidated to improve their transfer participation in areas with higher population. Yet, idiosyncratic infrastructural conditions, such that occur when neighboring IDs share no common facilities, may limit the potential of this observation. As the population and economic activity continue to grow in the region, even small policy inducements for external transfers may have impact where conditions are favorable.

## APPENDIX A

TABLE A1. IDs Experiencing Structural Change or Consolidation.

| # | Previous Name | Current Name | Date of Change |
|---|---|---|---|
| 1 | Hidalgo County WID#2 | Hidalgo County ID#2 | 1980 |
| 2 | Hidalgo & Willacy Counties WCID#1 | Delta Lake ID | 1986 |
| 3 | Hidalgo & Cameron Counties WCID#9 | Hidalgo & Cameron Counties ID#9 | Unknown |
| 4 | Cameron County WID#11 | Bayview ID#11 | 1982 |
| 5 | Cameron County WCID#5 | Brownsville ID | 2000 |

(continued)

TABLE A1. Continued.

| # | Previous Name | Current Name | Date of Change |
|---|---|---|---|
| 6 | Hidalgo County WCID#14 | Hidalgo County ID#14 | 1982 |
| 7 | Hidalgo County ID#14 + Hidalgo County WCID#7 | United ID | 8/14/1987 |
| 8 | Cameron County WCID#19 | Adams Garden ID#19 | 1/7/1981 |
| 9 | Cameron County WID#2 | Cameron County ID#2 | 2/1/1981 |
| 10 | Hidalgo County WID#3 | Hidalgo County ID#3 | Unknown |
| 11 | Hidalgo County WCID#16 | Hidalgo County ID#16 | Unknown |
| 12 | Hidalgo County WCID#6 | Hidalgo County ID#6 | Unknown |
| 13 | Cameron County WCID#6 | Cameron County ID#6 | Unknown |
| 14 | Cameron County WCID#1 | Harlingen ID Cameron County #1 | 4/9/1987 |
| 15 | Hidalgo County WCID#1 | Hidalgo County ID#1 | Unknown |
| 16 | Hidalgo County WID#1 | Donna ID Hidalgo County #1 | Unknown |
| 17 | Hidalgo County WID#5 | Hidalgo County ID#5 | Unknown |
| 18 | Hidalgo County WCID#13 | Hidalgo County ID#13 | Unknown |
| 19 | Hidalgo County WCID#15 | Santa Cruz ID#15 | Unknown |
| 20 | Cameron County WCID#3 | La Feria ID Cameron County #3 | Unknown |
| 21 | Cameron County WCID#4 | Santa Maria ID Cameron County #4 | Unknown |
| 22 | Hidalgo County WID#6 | Engelman ID | Unknown |
| 23 | Hidalgo County WCID#17 | Hidalgo County MUD#1 | Unknown |

TABLE A2. Classes of Irrigation Water Rights Rendered by Trial Court.

| Priority Classes | Who | Counties | Land (acres) |
|---|---|---|---|
| Class I | Landowners with Certified Filings granted under Irrigation Acts of 1895 and 1913 | Cameron and Hidalgo | 465,631 |
| Class II | Landowners with permits granted between 1913 and 1945 | Cameron, Hidalgo and Starr | 137,317 |
| Class III | Landowners not meeting the Class I and II criteria but irrigating before Nov. 8, 1945 | Entire Valley | 28,008 |
| Class IV | Landowners with permits from the state after Nov. 8, 1945 | Hidalgo | 12,641 |
| Class V | Landowners not qualifying for the above four classes but irrigating before Falcon Reservoir construction | Cameron and Hidalgo | 29,018 |

Source: Based on Smith (1977) and Casbeer and Trock (1969).

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