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Water Marketing as a Reallocative Institution in Texas

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Policy selection for guiding the allocation of water resources has long been debated among economists and policymakers. Economists have been prone to recommend water marketing on theoretical grounds, but the appraisal of realistic opportunities for employing market institutions requires analysis of actual markets. Twenty years of market activity in the Lower Rio Grande Valley of Texas are reviewed along with the historical development of water law in Texas and procedural requirements for transferring water rights. Developed data indicate active water marketing practices with significant volumes of agricultural water having been sold to municipalities. For transactions involving representative cities, estimated municipal benefits from water marketing are determined to far exceed the agricultural costs of the transfer. Attention to the unique circumstances of this region is required prior to extending results to other areas.

Water scarcity management continues to be a major policy issue at all government levels. For the first time in our history, noneconomists and decision makers have begun supporting market-oriented policies for allocating water supplies. The past few years have seen regulatory policy being supplanted by market operations in the western states.

Texas has been quietly using surface water markets for at least 20 years with the major activity concentrated in the Lower Rio Grande Valley (hereinafter called "the valley"). Although legal impediments to water marketing were eliminated several decades ago, the practice did not begin earnestly until the 1967 Water Rights Adjudication Act provided the water right specificity needed to convey value to permits.

This paper summarizes the statutory background for the conduct of water marketing in Texas. Texas Water Commission (hereinafter referred to as TWC or "commission") rules for obtaining approval of proposed transfers are discussed. Data concerning market transactions occurring since 1971 are developed from records of a watermaster's office and from the TWC. These data are examined to identify characteristics of diversions from the Rio Grande and to determine water marketing trends during the past two decades. As a starting point of a broader cost-benefit analysis of water marketing, a sample of representative transactions is chosen to identify possible methods for evaluating agricultural costs and municipal benefits. The paper's conclusion includes remarks concerning the future of water marketing in the valley and the implications of our findings for the West.

TYPES OF TEXAS WATER MARKETING

While the existence of Texas water marketing appears to have gone almost unnoticed in the literature, the practice is not new. Texas water marketing occurs in at least three forms: groundwater ranching, internal transfers, and permit exchanges. Groundwater ranching is typically conducted in northwest and west Texas. Cities purchase land (often irrigated) which is underlain by developable groundwater resources. Under Texas's absolute ownership doctrine (used for groundwater) this groundwater can be withdrawn and pumped to cities [*Kaiser*, 1987]. The overlying land is sometimes leased to dryland producers.

The second form, internal transfers, is endogenous to Texas's water districts and river authorities. River authorities are broadly empowered water districts which usually have a service area covering most or all of a river basin. These organizations provide water to multiple sectors, and because they receive no state or local appropriations, they are revenue conscious and are interested in effecting transfers as higher-paying customers appear [*Harper and Griffin*, 1988]. The opportunity to achieve water reallocation through internal transfers is significant in Texas. Texas's 13 largest river authorities supply about 25% of the consumptively used surface water in the state [*Harper and Griffin*, 1988].

The third form of Texas water transfer, permit exchange, involves the exchange of surface water rights. Under the Texas version of the appropriation doctrine (used for surface water) these transfers have been theoretically possible for several decades but did not begin until the first river basin was fully adjudicated over 20 years ago. Because this third form most resembles water marketing proposals for other states, it is the focus of this study.

A HISTORY OF TEXAS WATER LAW

There are two major surface water right doctrines which are recognized in the United States. Under riparian doctrine, the property owner adjacent to a watercourse has the right to use its water. Neither the amount of water nor purpose of use is specifically limited so long as it is reasonable [*Caroom and Elliott*, 1981]. The arid west found the riparian system to be ill suited to its conditions and adopted the prior appropriation system for regulating surface water use. Under the prior appropriation system, an appropriator must obtain a license to divert a specified quantity of water to be applied to a specific beneficial use. The "first in time, first in right" rule applies to the system with senior rights being satisfied to the exclusion of junior rights in time of shortage [*Jarvis*, 1991].

Texas, one of several dual-doctrine states, first adopted the riparian doctrine and later superimposed on it the Texas version of a prior appropriation system [*Templer*, 1981] under which state ownership is recognized and use of water is controlled by state license. This resulted in a complex system which is seldom found in other western states. The

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TABLE 1. Evolution of Texas Water Rights System

Sovereignty	Event	Date	Water Right System
Spanish Settlers		1600s	Spanish land grants
Republic of Mexico		1821	
Republic of Texas		1836	
	adoption of English common law	1840	riparian
State of Texas		1845	
	Irrigation Act	1889	prior appropriation (claims)
	Irrigation Act	1895	
	Irrigation Act	1913	prior appropriation (certified filing and permit)
	valley water suit	1956–1971	
	Water Rights Adjudication Act	1967	prior appropriation (certificate of adjudication and permit)

evolution of Texas water law is sketched in Table 1. The pertinent history of Texas water administration goes back to the 1600s during Spanish settlement. Spanish explorers and missionaries brought their legal principles relating to water. In this system, land was apportioned by governmental grant with or without specific rights for water access [*Kaiser*, 1987]. Spanish land grants law had aspects of both prior appropriation and riparian doctrines [*Dobkins*, 1959]. It was similar to the prior appropriation system insofar as the right to divert water had to be explicitly obtained from the government; riparians did not possess putative rights. It was similar to the riparian system in that only riparians can have rights, and rights were not expressly limited to fixed water quantities. The practice of Spanish land grants law continued through the mid-1800s under the successive republics of Mexico and Texas.

Starting in the early 1800s Anglo-American influence increased, and in 1840 the Republic of Texas adopted English common law with its riparian doctrine. Unlike the Spanish system, the English riparian doctrine gave all landowners adjacent to streams the right to use water for irrigation and other consumptive use as long as their diversions were reasonable. While the riparian doctrine was appropriate in the areas with sufficient amounts of rainfall, its suitability was questionable for arid portions of the state.

The drought in the late 1880s and early 1890s fanned the need for a new system. The Texas Legislature looked to other western states for a model law and adopted the prior appropriation doctrine. A series of statutes, specifically the Irrigation Acts of 1889 and 1895, progressively required individuals to obtain water rights from the state instead of exercising riparian claims. The Irrigation Act of 1889 was designed primarily to help the building of irrigation systems in the arid regions of the state. The unappropriated waters in the arid regions were all declared state property. Claims of a diversion were authorized simply by filing a sworn statement and map with the county clerk. The Irrigation Act of 1895 expanded and clarified the earlier act so that riparian rights would no longer be recognized. These statutes, however, did not abolish preexisting riparian rights but rather permitted new appropriation so long as it could not harm preexisting riparian rights [*Skillern*, 1988].

As a part of continuing efforts to solve problems within the water rights system, a 1913 statute introduced a more modern and more strictly administered appropriation doctrine, whereby persons had to apply to a state agency for a permit to appropriate water from Texas streams. This permit system was the first statewide water program in Texas. Pre-1913 claims of diversions were recorded as certified filings, and permits were required for appropriations commencing after 1913. The Board of Water Engineers was created to administer the operation of the statewide water rights system. With no intention of making matters worse, however, the 1913 Irrigation Act actually brought more problems. A mixture of riparian and appropriation doctrines was still found in the system, leading to many conflicts in practical application. While certified filings of the 1913 Irrigation Act were honored in a prior appropriation system, riparian rights were still protected in administration.

The difficulty of administering water rights called for some means to reconcile the incompatible doctrines. When claimed water rights greatly exceeded water available during the drought of the 1950s in the Rio Grande Valley, the multiple systems of water rights collided in *State of Texas versus Hidalgo County Water Control and Improvement District 18* [1969]. On June 27, 1956, the State of Texas filed a lawsuit against 40 water districts and some hundreds of corporations and individuals to have the state court adjudicate the water rights in the lower part of the Rio Grande [*Caroom and Elliott*, 1981; *Holbert*, 1984; *Jarvis*, 1991]. Fifteen years later, in 1971, adjudication of valley water rights was completed. This established a conducive environment for water marketing. The enormous effort and expense spent upon this litigation, however, indicated that another approach to administer Texas's water rights system was needed.

The Water Rights Adjudication Act was adopted by the Texas Legislature in 1967 to merge all surface water rights claims into the permit system, and this statute initiated the administrative adjudication of all surface water rights. Under the act, individuals claiming riparian water rights and unrecorded users of state water were requested to file claims with the TWC by September 1, 1969. Adjudication by the TWC of the water rights in the Middle Rio Grande Valley was completed in 1984. As of January 1991, all the river basins in Texas except the Pecos and Devils rivers are completely adjudicated.

Two categories of surface water rights are currently recognized in Texas: certificates of adjudication and post-1969 permits. Under the Water Rights Adjudication Act, all certified filings and permits existing prior to 1969 were reduced to certificates of adjudication. Also, all water users

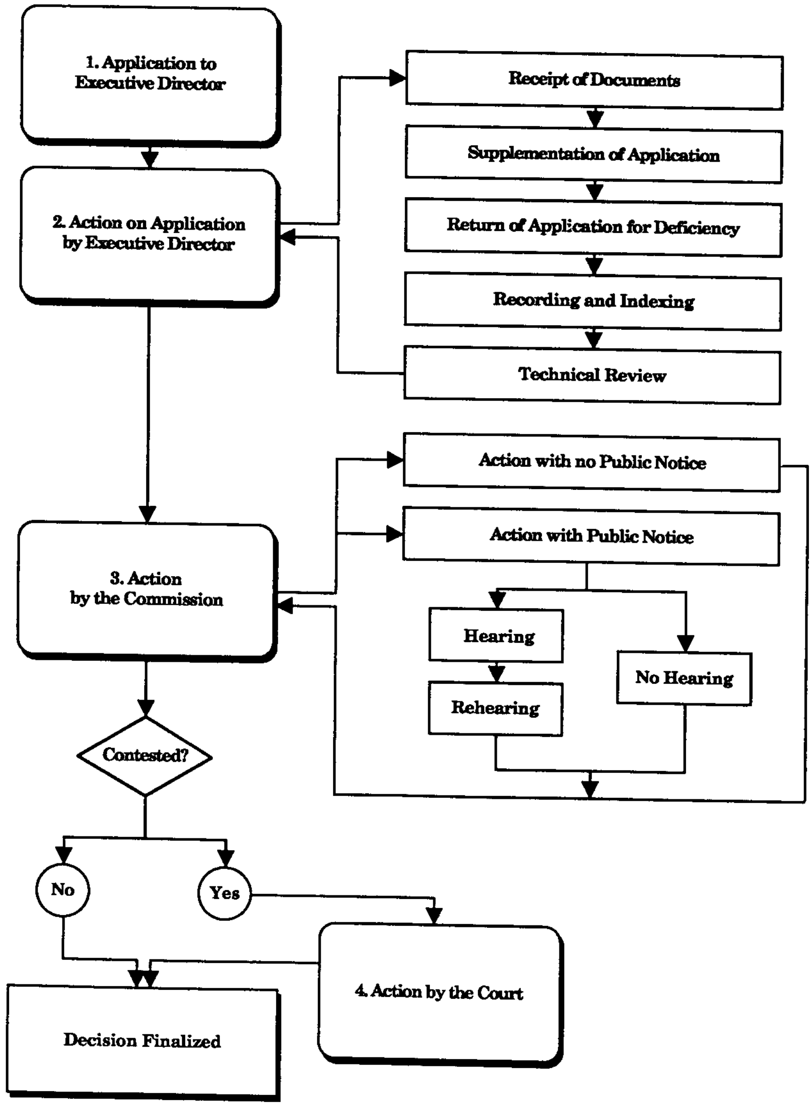

Fig. 1. Amendment procedure.

operating under grandfathered riparian or Spanish grant doctrines were required to obtain certificates of adjudication [*Skillern*, 1988]. Since 1969, anyone seeking to obtain a new right to divert surface water must apply to the TWC. A permit to appropriate water is granted only if unappropriated water is available, if there are no conflicts with preexisting rights, and if the appropriation is not detrimental to the public welfare [*Skillern*, 1988]. Upon a finding by the TWC that these conditions are satisfied, the permit stating the nature and extent of the water rights is granted [*Folk-Williams*, 1985]. Both certificates of adjudication and post-1969 permits are quantitatively limited, appropriative water rights with an assigned seniority.

TRANSFERRING SURFACE WATER RIGHTS IN TEXAS

Transferring water rights requires modification of either form of appropriative water rights. Because procedures are identical for both forms, both will simply be referred to as "water rights" hereinafter. Even though every transfer requires TWC approval, there are two cases with differing degrees of complexity. A transfer of a water right without amendment usually involves ownership changes which do not increase consumptive use or change the rate or time of diversion, and which do not need change in the place of diversion or purpose of use. The second kind of transfer requires amendment. An amendment is required when the transfer involves changes in the purpose of use, more consumptive use, different place of use, or different time of use.

The term "water marketing" typically implies changes in the purpose and/or place of use in addition to an ownership change. Therefore, water marketing necessitates amendments of water rights. Typically an amendment of a water right has four major steps as illustrated in Figure 1.

The first step is the filing of an application for amendment to the executive director of the TWC. Once an application is filed, it is reviewed for completeness with regard to informational requirements and for technical information before commission action commences. After satisfactory review by the executive director, action by the commission begins. Public notice is unnecessary if the amendment application does not contemplate an additional consumptive use or an increased rate or period of diversion and if, in the judgment of the commission, the amendment application has no potential for harming other water rights [*Texas Water Commission*, 1983]. However, certain types of amendments which may adversely affect other water rights (e.g., amendments for change of place, increase of an appropriation, and change of purpose) require that the commission give public notice by mail and publication. If, within the 30-day period following publication of the notice, no request for a public hearing has been submitted by the executive director, the applicant, or an affected person, then the commission may take action on an application without holding a public hearing. However, if a request for public hearing is made by the applicant, the executive director, or an affected person who objects to the application, a hearing will be held within 30 days after the notice of application has been published or mailed before the commission takes action. After the hearing proceedings, a final determination shall be made by the commission following the hearing examiner's proposal for decision. In the event that someone wants to appeal the final decision, a motion for rehearing can be filed. If the motion for rehearing is granted, the original decision is nullified. After the rehearing, the commission shall render a final decision of rehearing.

The final decision, in the form of written order, contains a statement of findings of fact and conclusions of law regarding the proposed amendment. If no one contests, the decision is final. A person affected by the final decision of the commission, however, may file a petition for judicial review. The contested case may be reviewed in District Court, Appeals Court, and the Texas Supreme Court. The decision by the court will be final.

A Special Case: The Rio Grande Valley

Special rules have been adopted for water resource administration in the Rio Grande Valley. In the "Rules of Procedure and Permanent Rule Changes" of the TWC, a special chapter (303) is devoted to the operation of the Rio Grande. Water rights in the Rio Grande Basin below Fort Quitman and water rights in that portion of the Nueces–Rio Grande Coastal Basin in Starr, Hidalgo, Willacy, and Cameron counties whose source of water is the Rio Grande are governed by these rules. In addition to its long-standing water marketing activity, the institutional makeup of the area is unique in the state. The following sections summarize some of the more noticeable differences.

Amendment Procedure

The general amendment procedure applies to the Valley with two exceptions. First of all, the rule prohibits a transfer of water rights from the Lower Rio Grande (from Gulf of Mexico to International Falcon Reservoir) and Middle Rio Grande (from International Falcon Reservoir to Amistad Reservoir) to points above Amistad Reservoir, although it does permit transfers between points on the Middle and Lower Rio Grande.

The other exception is with regard to the requirements for notice. Mailed and published notices are not required as long as transfers are made inside the Lower and Middle Rio Grande. The rationale for public notice is to inform any party whose rights may be adversely affected so that they may contest the application. Because of the special circumstances of the Lower and Middle Rio Grande, however, third party effects are uncommon. First, Amistad and Falcon reservoirs are the only source of water for the Lower and Middle Rio Grande, and all water diverted from the Rio Grande must be ordered through the watermaster's office as releases from these two, conjunctively managed reservoirs. From this perspective, the lowermost reservoir, Falcon, can be viewed as the effective diversion point of all downstream water rights. Water right transfers, therefore, do not have much potential for impacting third parties. Second, because of the aridity and drainage of the region, there is little possibility of return flow to the Rio Grande and, hence, diverted water is considered to be completely consumed. As long as the transfer is made inside the Amistad and Falcon system, it is not possible to adversely affect third parties; therefore, no public notice is necessary.

Water Contracts

Leasing of water rights is possible in the valley and is referred to as "water contracts." On the one hand, it is easy to satisfy the administrative requirements for leasing. The lessor need only call the watermaster's office to inform them of the temporarily changed ownership. On the other hand, the lessee must be a current water right holder, and no change in purpose is permitted for water contracts.

Absence of Seniority

Unlike the rest of the state, there are two categories of water rights for irrigation and mining purposes in the valley: class A and class B. At the time of adjudication for the valley, holders of different claims were given different weights in resolving conflicting claims over the limited water resource base. Holders of statutory water rights (e.g., certified filings under the 1913 Irrigation Act and water rights permits issued by the commission or its predecessors) received class A water rights. Class B water rights were given to other claims such as riparian rights and claims which were not filed with the Board of Water Engineers pursuant to the terms of the 1913 Irrigation Act. Class A right holders received 1.7 times as much water (on a per unit of irrigated land basis) as that allotted to class B right holders. All rights, A and B, are correlative, and there are no assigned seniorities. Shortages and surpluses are shared by all right holders. Because class A rights embody more water when considered on a per unit of land basis, they naturally trade at prices commensurate with the amount of water involved.

Watermaster Operations

Any water right holder who wants to exercise a water right must obtain written certification from the watermaster prior to diverting water and must post the certification at his/her diversion facility. The certification identifies the specific water right to be used and the number of the pump to be operated. Meters must be installed at the authorized point of diversion by each diverter. Deputies of the watermaster's office regularly check measuring devices to verify accurate measurement and accounting of the quantities of water diverted.

All right holders reimburse the watermaster for expenses involved in the administration of the watermaster program. An assessment account is established and maintained for each right. The total assessment is the sum of a uniform base

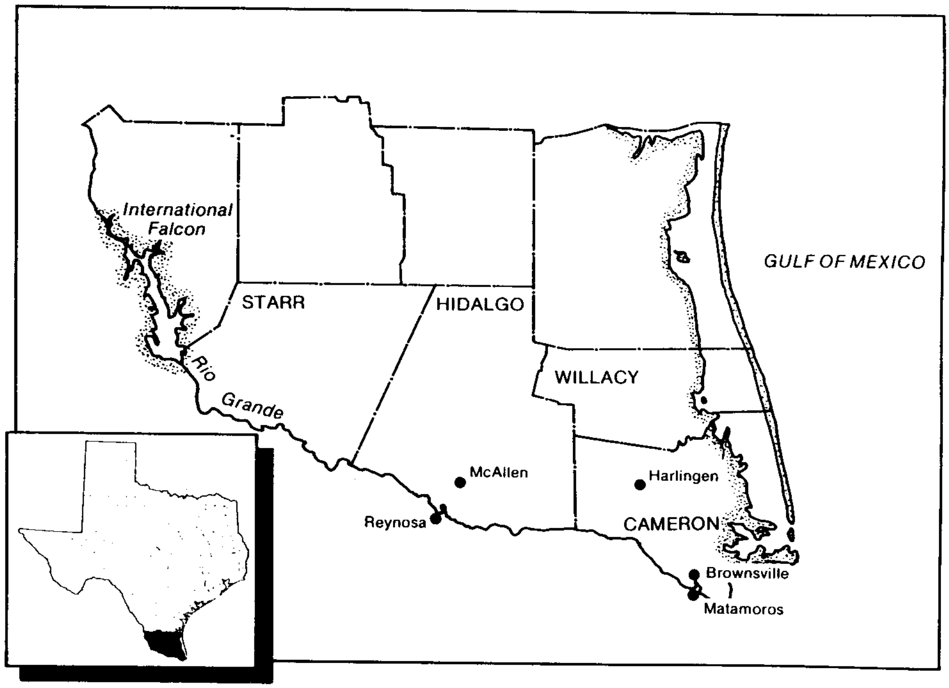

Fig. 2. Lower Rio Grande Valley.

charge, a use fee, and a storage fee. The annual flat base charge must be paid regardless of the size of the right or use of the right. A use fee is calculated as the multiple of the amount of water authorized for use and an assessment rate that varies according to purpose of use. The storage fee is similarly calculated based on storage authorization and a purpose-dependent fee [*Texas Water Commission*, 1986].

WATER ALLOCATION IN THE VALLEY

The early adjudication of water rights in the Lower Rio Grande Valley established the foundation of an active water market for the last 20 years. Even though the water rights in the Middle and Lower Rio Grande Valley are now administered by the same rule, our attention is focused upon the lower valley by virtue of its earlier adjudication.

Located at the southern tip of the state of Texas, the valley (Figure 2) is bounded on the east by the Gulf of Mexico and on the south by the Rio Grande [*Holbert*, 1984]. Amistad reservoir, mentioned previously, lies upstream of the illustrated region. The valley is made up of four counties: Cameron, Hidalgo, Starr, and Willacy. These four counties are major agricultural producers within the state, and the region has experienced a dramatic population increase over the last two decades. As shown in Table 2, total population has been increasing by more than 50% per decade, compared to a 29% increase per decade for the state as a whole. The average annualized rate of population growth in the Valley has been 4.32% for the last two decades [*Texas Department of Health*, 1984]. The area is considered to be one of the most rapidly developing regions in the state. More than 70% of the total Valley population is located in urban areas [*Kingston*, 1990].

Agriculture is the principal economic sector in the valley, and irrigation is important to agricultural productivity. Approximately 67% of total cropland acreage in the valley is irrigated [*Teague*, 1985]. Table 3 identifies the irrigated area of the valley for major crops. All Texas sugar cane is irrigated in the valley, and the irrigated area of valley citrus

TABLE 2. Population for Lower Rio Grande Valley Counties

	1970	1980	1990*	Percent Change 1970–1980	Percent Change 1980–1990
Cameron	140,368	209,680	317,211	49.4	51.3
Hidalgo	181,535	283,229	447,279	56.0	57.9
Starr	17,707	27,266	42,991	54.0	57.7
Willacy	15,570	17,495	20,464	12.4	17.0
Total	355,180	537,670	827,945	51.4	54.0

Source: *Texas Department of Health* [1984].
*Projection.

TABLE 3. Major Irrigated Crops in the Lower Rio Grande Valley, 1984

Irrigated Crop	Valley, ha	Texas, ha	Valley's Share, %
Sugar cane	14,366	14,366	100.00
Citrus	15,621	15,722	99.36
Vegetable (deep root)	26,790	41,985	63.81
Vegetable (shallow root)	25,495	44,549	57.23
Hay-pasture	20,295	82,000	24.75
Grain sorghum	71,022	432,321	16.43
Forage crops	16,187	101,833	15.90
Corn	44,111	314,464	14.03
Soybeans	4,023	39,127	10.28
Cotton	68,190	854,578	7.98
Orchard and vineyard	101	3,297	3.07
Alfalfa	835	62,316	1.34
Pecans	20	22,938	0.09
Total	315,354	2,794,583	11.28

Source: *Texas Water Development Board* [1986].

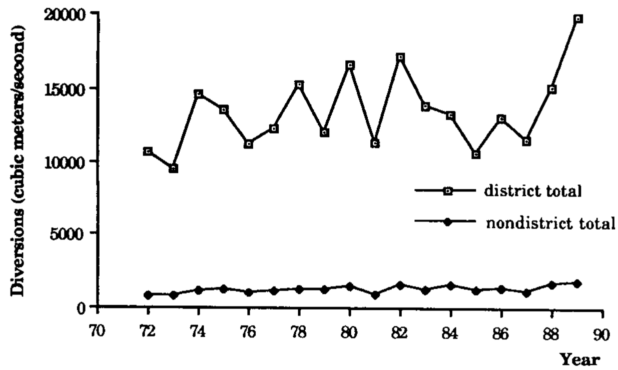

Fig. 3. Total diversions by year.

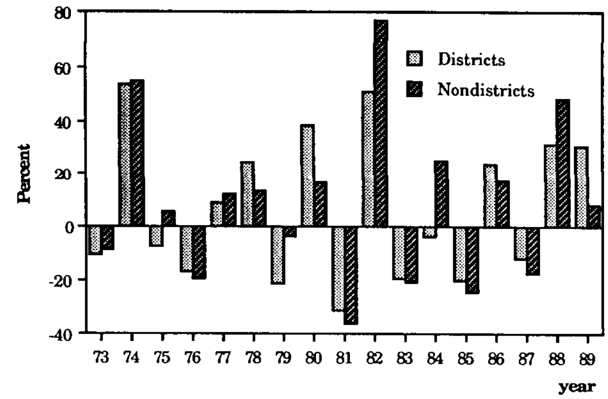

Fig. 4. Percent change of diversions from the previous year.

is more than 99% of state total. From 1969 to 1984, irrigated land declined by 31,442 hectares (76,704 acres) in the four valley counties [*Texas Water Development Board*, 1986].

Thirty-one irrigation districts in the valley furnish water for the irrigation of agricultural lands. An irrigation district is a public or quasi-municipal corporation organized under state laws for the expressed purpose of supplying water for the irrigation of lands within its boundaries [*Holbert*, 1984]. Irrigation districts in the valley also divert water from the river for water right holders with different purposes of use (e.g., municipal, industrial, and domestic). Most municipalities pay irrigation districts which operate along the river for pumping and delivering water. Irrigation districts in the valley deliver approximately 80–90% of all irrigation water while the other 10–20% is supplied by individual diverters. No river authorities operate in this region of the state. Diversions from the Rio Grande supply 97% of the total water used for irrigation. Groundwater accounts for only 3% [*Texas Water Development Board*, 1986].

Water Use Trends

Information obtained from the International Boundary and Water Commission (IBWC) shows how much water is actually diverted from the Rio Grande below Falcon Reservoir for both districts and "nondistricts." Nondistricts are hundreds of small, mostly agricultural, diverters. Few municipalities have their own pumping facilities along the river. Figure 3 shows total diversions for districts and nondistricts by year. Districts dominate total diversions from the Rio Grande while the percent of districts' diversion fluctuates slightly over the years (from a low of 89.19% in 1984 to a high of 92.58% in 1972). The amount of total diversions varies substantially over the years. Fluctuations between years can be attributed to climatic conditions affecting agricultural water demand. Figure 4 shows the yearly variation in diversions by districts and nondistricts. Because the highest water demand occurs from January through February and from April through July in the region, any changes in precipitation during these periods directly affect the need for irrigation. Precipitation has been below normal from the latter part of 1988 through the present, resulting in increased irrigation diversions as represented by two consecutive positive percent changes in Figure 4.

When water is diverted from the Rio Grande, it may be "charge" pumping or "no-charge" pumping. Diversions are charged using the schedules given in the Rio Grande section of TWC Rules of Procedures. When there is ample water available, however, the watermaster can designate a no-charge pumping period, and diversions during this period are not debited from water rights accounts. Nor are any diversion-dependent administrative fees assessed for no-charge pumping as long as the total amount of a diversion does not exceed 50 acre-feet (61,700 m^3) per year. For more than 50 acre-feet of no charge pumping, the fee will be levied during the subsequent fiscal year [*Texas Water Commission*, 1986].

A second data set is developed from account records maintained by the watermaster's office. Information for municipal, industrial, and domestic purposes from June 1971 to April 1990 was obtained and combined with the IBWC data to obtain total diversions for all purposes including agriculture. In Figure 5, the total diversions for municipal, industrial, and domestic purposes are indicated by year. Total diversions are increasing over time with few years of decline. The amounts of charge pumping and no-charge pumping show an expected inverse relationship (when charge pumping increases, no-charge pumping decreases, and vice versa). Agricultural diversions can be estimated by subtracting diversions for municipal, industrial, and domestic uses from total diversions. In Figure 6, total diversions for municipal, industrial, and domestic uses are graphed with total diversion for agricultural use. It is clear that the majority of water is diverted for irrigation. Though composing only 9–17% of total diversions, the total amount of water diverted for municipal, industrial, and domestic purposes has increased over the past 20 years.

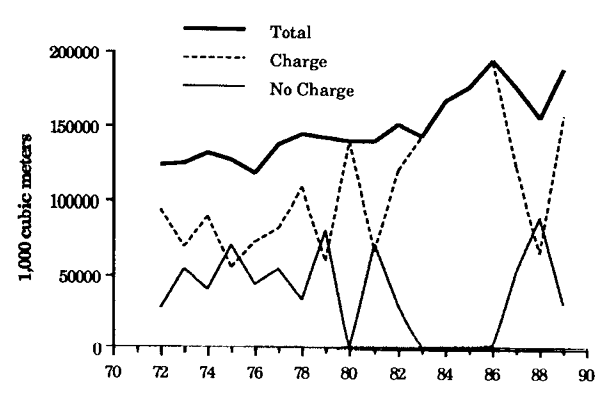

Fig. 5. Total diversions for municipal, industrial, and domestic purposes.

Water Marketing Trends

To get acquainted with the study area and to learn how water marketing is truly done, we visited with representative participants and administrators in the valley. These contacts revealed two additional pieces of information. First, relatively small transaction costs are involved in actual marketing activity. Agricultural water right holders are well aware that the major buyers are cities and can readily contact these potential buyers. Moreover, the watermaster's office maintains a current list of willing sellers. Potential buyers can obtain a copy of this list and contact the owners. Administrative procedures for transfer are relatively expeditious in the valley as discussed above. Unlike the rest of Texas, adjudication has long been complete in the valley, and water rights are well understood by diverters. All of the above facts contribute to lowered total transaction costs, making water markets more active and attractive. Also, diversions are very closely monitored by the watermaster's office, so the possibility of withdrawing more water than one is entitled to is very low. Groundwater opportunities are virtually nonexistent, so the impetus for market participation is strong.

The second observation of interest was that we could not identify any instances where an irrigation district had sold a water right. Sales of water rights, therefore, originate from private water right holders. Irrigation districts do lease water in the form of water supply contracts. The fact that districts are reluctant to sell rights seems to be partly responsible for some political tension in the region, for districts have been accused of denying water to cities. Reiterating an observation by *Harper and Griffin* [1988], districts are understandably reluctant to release water rights because these permit holdings are fundamental to the job security and remuneration of district employees. Furthermore, surface water delivery via canals is a clear case of increasing returns to scale so that the cost of delivering a unit of water is lowest when the total amount of delivered water is high.

Water right sales. After a thorough review of TWC files for individual water rights, 152 transactions involving a change in the purpose of use were identified. Each of the 152 transactions was coded by various categories of interest. These included permit number, purpose of use, amount of water authorized under the permit, amount of water transferred in acre-feet, date of approval for original permit or amendment, owner of permit, and type of permit. Contractual details such as the price of the purchased water are not available from these records.

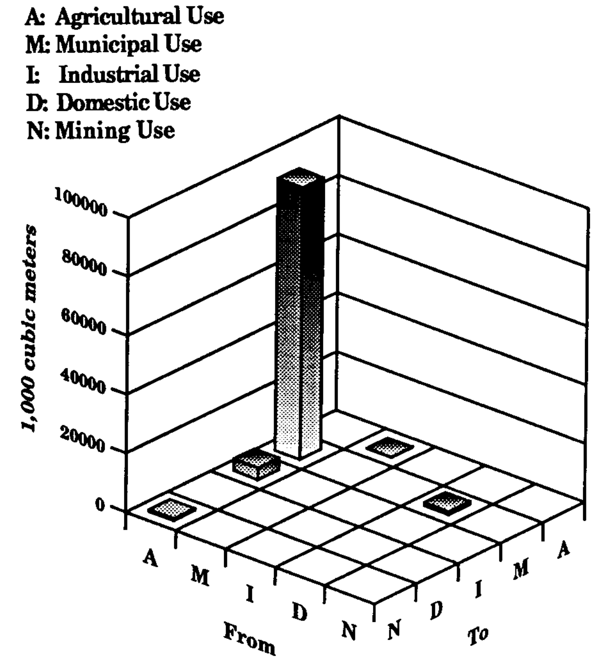

Fig. 7. Volume of water right transfers.

Figure 7 is a summary of water marketing with regard to purpose of use changes in the valley for the last 20 years. Transfers from agriculture to municipalities are most noticeable in the amount of actual water transferred. Transfers of 94,312,569 m^3 (74,966.2 acre-feet) from agricultural use to municipal use constitute nearly 94.12% of total transfers in terms of volume. More broadly, 99% of all water transferred was from agriculture to nonagriculture.

Two observations are noteworthy. First, as of October 1990, 45% of all valley municipal water rights were obtained by transfer during the last two decades. This clearly illustrates the importance of water marketing in the changing socioeconomic structure of the valley. In Table 4, the distribution of existing water rights in the valley is shown. Second, 657,450 m^3 (533 acre-feet) from five transactions were exported from agricultural use in the valley to mining use in the Middle Rio Grande Valley. Although it is permitted to transfer water rights between Lower and Middle Rio Grande Valley, there is not much activity between the two areas.

Water right rentals. Data concerning valley leasing patterns are only available since July 1986 (when the watermas-

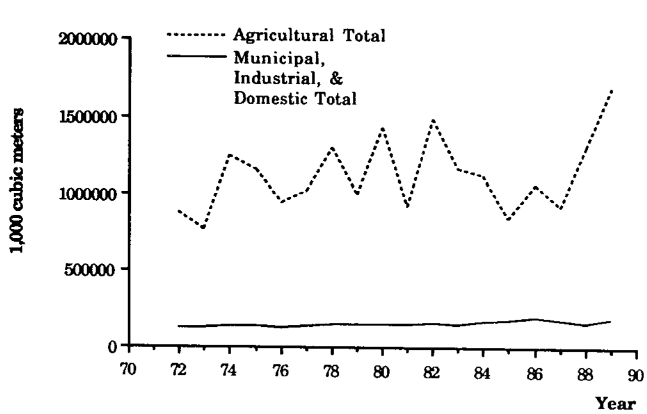

Fig. 6. Diversions for two major purposes.

TABLE 4. Water Rights in the Lower Rio Grande Valley

Use	Amount, 1000 m^3	Percentage
Agricultural	2,179,534.98	88.06
Municipal	206,584.20	8.35
Domestic	31,433.52	1.27
Industrial	57,612.26	2.33
Total	2,475,164.96	100.00

Source: records from watermaster's office, Weslaco, Texas, October 1990.

TABLE 5. Water Supply Contracts Summary

Use	Amount of Contracts, 1000 m^3	Number of Contracts	Average Contract Size, 1000 m^3	Average Price of Contracts, Dollars per 1000 m^3
Agricultural	36,647	144	254	7.34
Domestic	1,665	3	555	10.81
Municipal	30,671	43	713	10.56
Mining	68	5	14	35.79

Source: records from watermaster's office, Weslaco, Texas, October 1990.

ter's office adopted new procedures for maintaining these data). Beginning at this time, information regarding the amount of water leased, rental price of water, date of execution of lease, purpose of use, and appropriate certificates of adjudication numbers was recorded.

In Table 5, characteristics of leasing activities in the valley for the period are shown. More agricultural water is leased than water for any other use. The average agricultural water contract is 254,000 m^3 (206 acre-feet) which is much lower than that of municipal water. According to personnel of the watermaster's office, many irrigation contracts were to replenish the accounts which had created a negative usable balance due to overuse of the authorized water. These contracts were for small amounts of irrigation water and have been popular among acquainted irrigators. Prices paid for these contracts are usually minimal, and some contracts even indicate that no financial terms are involved. Managers of urban utilities prefer water right purchases over leasing arrangements as a means of addressing periodic shortage. Nevertheless, a substantial amount of municipal water leasing does occur.

The yearly trend of contract water by two major uses is shown in Figure 8. The contract water market is sensitive to climate and water availability. Effects of no-charge pumping periods can be clearly seen in Figure 8, where 1987 and 1988 contracts for water are extremely low. According to watermaster's records, five months of 1987 and nine months of 1988 were listed as "no-charge pumping" periods.

AN ECONOMIC EVALUATION OF WATER MARKETING

The record of water marketing clearly indicates that the vast majority of transfers are from agriculture to municipalities. To obtain an initial perception of the agricultural costs and municipal benefits that may be associated with these transfers, a sample of representative transactions is selected for analysis. Because buyers of water rights other than cities (e.g., water supply corporations) may deliver water to more than one city, making economic assessment more complex, the evaluations presented here focus on purchases of a single city. Only transactions occurring in 1981–1985 are considered, because this is the time frame employed by our community water demand study [*Griffin and Chang*, 1989] which is extensively used for the estimation of municipal water values. After reviewing transfers occurring during this period as well as the data requirements for completing economic assessment, four purchases by the City of Edinburg and four purchases by the City of Brownsville were selected for examination. Detailed information on these eight transactions is shown in Table 6. Prices paid per unit of purchased water range from \$405 to \$486 per 1000 m^3. These prices compare to a range of \$339 to \$527 per 1000 m^3 based upon valley sales reported in the *Water Market Update* and *Water Intelligence Monthly* over the past several years.

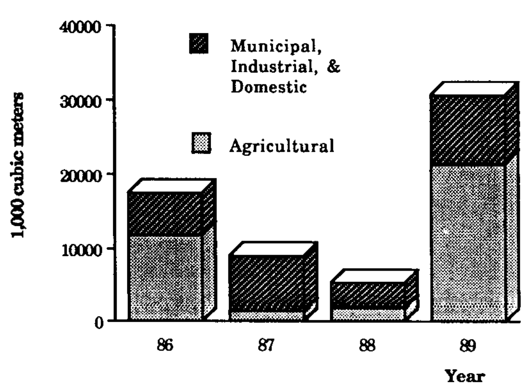

Fig. 8. Total amount of contract water.

Agricultural Costs

Telephone interviews with the sellers of these water rights revealed some interesting details. Two sellers in Edinburg transactions were faced with the cancellation of their water rights because they no longer employed the water. According to the Texas Water Code (11.171–11.186), a water right is subject to cancellation after 10 years of nonuse. The third seller to Edinburg had surplus water as a result of owning several water rights. Even after this water was sold, irrigated production continued unabated. When agricultural water rights were used for irrigation, cotton was the most common crop produced in the area. None of these sellers had been irrigating the region's higher-valued crops, such as vegetables, sugar cane, or citrus. The last seller involved in Edinburg transactions could not be contacted.

In the case of Brownsville, a single seller (a private company) owned all four water rights. Two of these water rights had been conveyed to the company by an individual without change in the purpose of use just before the sale of

TABLE 6. Representative Transactions

Transaction	Amount Bought, 1000 m^3	Amount Sold,* 1000 m^3	Price, Dollars per 1000 m^3	Date of Sale
		City of Edinburg		
1	9.87	24.67	405.35	Feb. 1, 1983
2	135.96	339.89	486.43	Jan. 17, 1984
3	14.8	37	405.35	March 14, 1984
4	308.37	770.93	445.89	April 25, 1984
		City of Brownsville		
1	80.18	200.44	···†	May 26, 1982
2	45.64	114.1	···†	May 26, 1982
3	228.2	570.5	···†	May 26, 1982
4	43.17	107.93	···†	May 26, 1982

*The TWC uses a conversion rule when purpose is changed from agriculture to municipality: 1 acre-foot of class A(B) irrigation water right equals 0.5(0.4) acre-feet of municipal water right (1 acre-foot is equal to 1,233.49 m^3).

†No explicit water price terms were involved in City of Brownsville transactions because the city purchased these water rights through the total acquisition of a private company that was the previous owner. Also see text.

the water rights. Most of the information was obtained from this individual who was knowledgeable about the old use of his and the company's water rights. There were no price terms involved with these four transactions because the City of Brownsville acquired the water rights through the total acquisition of the private company due to bankruptcy. Land and water rights associated with the company's land were acquired by the city, and payments were made to bond holders resulting in no separable price for water rights. It was revealed, however, that cotton had been grown with the old water rights.

After considering these facts, we adopted the following assumptions for evaluating the agricultural value of sold water: the selling party had fully employed the water right in the production of cotton, and after the sale, an appropriate amount of arable land was converted to dryland production. These assumptions imply that the evaluation is best interpreted as identifying an upper bound for true agricultural costs. The budgeting methodology and the data employed in the assessment of agricultural costs are described in the appendix.

The value of irrigation water applied to cotton in the valley in 1983 dollars is shown in Table 7. Also shown in Table 7 are values of irrigation water computed without considering deficiency payments. Deficiency payments are excluded in this set of findings because it is improper to consider transfer payments as a part of the social value of irrigation water. The agricultural value of water ranges widely in response to output price and dryland yields. Producer water values (with deficiency payments) range from \$14.83 to \$113 per 1000 m^3 (\$18.29 to \$139.38 per acre-foot) per year in 1983. When deficiency payments are omitted so as to obtain social water values, these values may even become negative in low price–high dryland yield scenarios. Social water values range from −\$3.5 to \$77.41 per thousand m^3 (−\$4.32 to \$95.49 per acre-foot) per year. For ease of comparison with the municipal benefits computed in the forthcoming section, a 6% discount rate and a 50-year planning horizon are used to place all of these values on a present value basis in Table 8.

Municipal Benefits

Many economic studies of agricultural water values have been conducted for different regions and periods as well as different crops. For the benefit side of water rights transfers, however, there is little published evidence concerning municipal value. The net present value of an urban supply

TABLE 7. Annual Value of Irrigation Water (Dollars per 1000 m^3)

Dryland Yield, kg/ha	Cotton Price, dollars/kg				
	1.04	1.17	1.30	1.43	1.56
	With Deficiency Payment				
359	73.00	83.00	93.00	102.99	113.00
448	43.79	51.36	58.93	66.51	74.08
538	14.83	19.98	20.38	30.28	35.43
	Without Deficiency Payment				
359	37.42	47.42	57.41	67.41	77.41
448	16.83	24.40	31.97	39.55	47.13
538	−3.50	1.65	6.79	11.95	17.10

TABLE 8. Argicultural Water Value (Dollars per 1000 m^3)

Dryland Yield, kg/ha	Cotton Price, dollars/kg				
	1.04	1.17	1.30	1.43	1.56
	With Deficiency Payment				
359	1,223.70	1,391.25	1,558.81	1,726.36	1,894.05
448	733.95	860.87	987.79	1,114.85	1,241.77
538	248.55	334.84	341.63	507.55	593.84
	Without Deficiency Payment				
359	627.27	794.83	962.38	1,129.93	1,297.62
448	282.11	409.04	535.95	663.01	789.94
538	−58.70	27.59	113.88	200.30	286.59

Values are calculated from Table 7 values using a 50-year planning horizon and a 6% discount rate.

increment (which includes purchase of water rights) can be calculated as a consumer surplus measure. *Griffin*'s [1990] procedure employs alternative scenarios relating to population growth, rate growth, and the temporal distribution of the increased supply to accomplish this. Since the present study is an attempt to evaluate economic benefits from transferring agricultural water rights to a city in the valley, Griffin's method is easily adapted.

Knowledge of a point on a water demand function and an estimated elasticity at the point permits local approximation of the function. When demand is specified, population growth shifts this demand function outward over time. If supply is increased, the value of the increment in each time period is obtained as consumer surplus. With water rates increasing over time, the per capita demand for water is curtailed, and consumer surplus per capita is reduced. Working in the opposite direction, population growth expands total surplus.

City of Edinburg. An intensive community water demand study involving 221 Texas communities [*Griffin and Chang*, 1989] and telephone interviews with the City of Edinburg utility personnel provide data for the estimation of municipal benefits from water right acquisitions. Table 9 contains average water consumption and average real prices for Edinburg and Brownsville during 1981–1985 as well as the elasticity estimates reported by *Griffin and Chang* [1991].

A 50-year planning horizon is assumed, and a real monthly discount rate of 0.49% (6.0% annual) is assumed. All prices, elasticities, and the discount factor are real, not nominal, and prices have been deflated by the monthly consumer price index (CPI) [*U.S. Department of Commerce*, 1986]. While *Griffin*'s [1990] study used hypothesized scenarios for different temporal distribution of the acquisition and alternative rates for population growth and growth in water rates, the present analysis is customized for Edinburg.

To determine how Edinburg distributes annual water supplies across the 12 months of the year, 1987–1990 distribution practices were obtained and used. The degree of excess supply capacity is important to value because it delays the need for purchasing water rights. For every month during 1981–1985, this excess capacity ratio to actual monthly use is computed. An average of the annual excess capacity ratio, beginning in 1981 up to the year the transaction occurred, was used in our assessment. Edinburg's average annual population growth rate during 1981–1985 was determined to be 3.48% from *Griffin and Chang*'s [1989]

TABLE 9. Initial Conditions (1981)

	Edinburg		Brownsville		
Month	Consumption, m^3/person/day	Price, dollars/m^3	Consumption, m^3/person/day	Price, dollars/m^3	Elasticity
Jan.	0.39	0.41	0.68	0.39	−0.31
Feb.	0.39	0.43	0.78	0.39	−0.30
March	0.42	0.41	0.75	0.38	−0.35
April	0.53	0.39	1.01	0.38	−0.37
May	0.48	0.40	0.84	0.38	−0.38
June	0.55	0.39	0.82	0.39	−0.39
July	0.56	0.39	0.90	0.38	−0.41
Aug.	0.58	0.38	1.00	0.38	−0.41
Sept.	0.48	0.42	0.79	0.39	−0.39
Oct.	0.42	0.43	0.75	0.39	−0.36
Nov.	0.43	0.43	0.76	0.39	−0.33
Dec.	0.42	0.46	0.75	0.39	−0.31

data. This value is much higher than the high case (1.7%) employed in the statewide water plan which projects water requirement through 2030 [*Texas Department of Water Resources*, 1984].

Griffin [1990] determined that the value of a supply increment is very sensitive to the price growth rate. Two different rates were used in this report. Edinburg data for 1981–1985 indicate that nominal water rate growth averaged 7% per year. Deflating this value by the CPI, real water rates increased at an average of 2.9% per year. The statewide average real water price growth rate of 8% annually from 1981 to 1985 [*Griffin and Chang*, 1989] was also employed to examine how a high price increase rate might affect the value of supply increments.

A computer program employed in Griffin's hypothetical study was utilized with the above data to calculate the value of each acquisition in every month over a 50-year planning horizon. Results are summarized in Table 10. The net present value column identifies aggregated monthly net present value over all 600 months. The right-hand column of Table 10 shows net present value per 1000 m^3 of water. The net present values are sensitive not to the amount of water transacted or to dates of acquisitions but are sensitive to the assumed price growth rate. A low growth in water rates combined with high population growth rate produces large net present value and net present value per 1000 m^3. As expected, the larger the amount of water purchased, the smaller the net present value per 1000 m^3, although the differences are small. For the actual rate of water rate growth observed for Edinburg, the net present values of $15,861 to $17,138 per 1000 m^3 of water extremely exceed what the city actually paid. Only in the case of high price growth rate (8%) do net present values converge upon price paid. Obviously, these municipal values also exceed the agricultural costs reported in Table 8.

In a hypothetical setting emphasizing average urban conditions across Texas, *Griffin* [1990] found values of municipal water acquisitions to range from $0 to $3,241 per 1000 m^3 ($0–4,000 per acre-foot). The highest value involves scenarios with high population growth and no price-induced water conservation. When compared with high net present values obtained for Edinburg purchases, it is clear that a high population growth rate can make purchased water rights extremely valuable.

City of Brownsville. The same procedures used above are also employed to evaluate Brownsville's water purchases. Brownsville's average water consumption and average real prices are given in Table 9. Brownsville, which is larger than Edinburg, had a smaller average annual population growth rate (2.26%) during 1981–1985. This rate, however, is still higher than the high case of the statewide water plan. Brownsville consumers experienced no water rate increases during the 1981–1985 period, indicating a decrease in real water prices at an average of 4.1% per year. Given

TABLE 10. Municipal Water Value

City	Transaction	Amount, 1000 m^3	Excess Capacity, %	Population	Water Rate Growth, %	Net Present Value, dollars	Not Present Value per 1000 m^3, dollars
Edinburg	1	9.87	9.1	29,354	2.9	167,716	16,975
					8.0	6,589	667
Edinburg	2	135.96	8.8	30,818	2.9	2,255,773	16,592
					8.0	77,166	568
Edinburg	3	14.8	8.8	30,818	2.9	253,681	17,138
					8.0	10,554	713
Edinburg	4	308.37	8.8	30,818	2.9	4,891,585	15,861
					8.0	128,081	415
Brownsville	1–4	397.18	4.2	91,440	−4.1	3,057,000	7,697
					0.6	2,065,798	5,202
					2.9	1,090,111	2,744
					8.0	0	0

that some rate changes occurred after 1985, the 10-year (1981–1990) average price growth rate of 0.6% per year is also employed in the analysis. To explore possible explanatory factors for discrepancies between Brownsville and Edinburg water values, price growth rates used in the Edinburg analysis are also employed in the Brownsville consumer surplus calculations.

Because all four Brownsville transactions occurred at the same time, it is appropriate to combine the four transfers in estimating municipal value. Results are summarized in Table 10. Once again, low price growth rate generates large net present value and net present value per 1000 m^3. Compared to Edinburg, Brownsville has a lower water rate growth rate and smaller excess capacity which both work to increase net present value per 1000 m^3 for Brownsville. However, it is clear that Brownsville's lower population growth counters these influences and forces the municipal water value per 1000 m^3 to be less than that obtained for Edinburg. If Brownsville's water rates are expected to increase as much as water rates for Edinburg, net present value per 1000 m^3 of purchased water in Brownsville would be one-sixth the value of Edinburg's purchases. Also, if water rates increase by the statewide average for the same period of time, no economic value would accrue to the purchases of water by Brownsville. It is clear that one of the driving forces of large municipal water values for valley cities is the population growth rate.

Conclusions

Texas water law has steadily evolved in a direction which supports the market exchange of water rights. Now that appropriative water rights are firmly defined and transfer procedures are stated clearly, the stage is set for a more extensive use of water marketing as the means to adjust to the changing conditions of the state. Texas's Lower Rio Grande Valley contains the most active water market in the state. This region's steady increases in urban population and economic development motivate greater allocation of scarce water for these purposes. It was expected, and the data clearly indicate, that significant volumes of agricultural water have been sold for municipal and industrial purposes in the valley.

Analyses of representative water market exchanges indicate that benefits accruing to the municipal buyer clearly exceed agricultural opportunity costs. When we examine the private costs (with deficiency payments) incurred by irrigators in trading fully employed water rights, it appears that lost water values may range from \$249 to \$1,894 per 1000 m^3 under optimistic agricultural circumstances. Assumptions used in obtaining these values imply that this range presents an upper limit of true values. If it is generally true that about half of the farmers sell their water rights because these rights are unemployed, the current agricultural costs associated with water right transfers are truly overestimated. On the other hand, municipal benefits are sizeable (about \$5,000 to \$17,000 per 1000 m^3) assuming that regional population growth remains strong and cities continue to keep water rates low. It is worth noting that these two provisions are linked in that population growth has allowed valley communities such as Edinburg and Brownsville to reap economies of scale in water treatment and delivery.

Use of market institutions for the reallocation of scarce water resources has been strongly recommended by many economists. The 20-year history of water marketing, both sales and leases, in the valley demonstrates that this can be an important policy instrument: nearly half of current municipal water rights were purchased from agricultural interests. Before one can extend the positive experiences of the valley and our findings of market-related costs and benefits to other regions, however, one must observe the particularized circumstances of this area. The valley is somewhat unique in several ways: (1) there is virtually no groundwater option; (2) all rights are correlative (no seniority); (3) surface water diversions are closely monitored; (4) there are many players (no monopolistic power); (5) urban growth has been substantial; and (6) there are no return flow complexities. These features, especially the latter one, limit one's ability to apply valley findings in projecting marketing results elsewhere in the state or, more broadly, the West. To identify realistic opportunities for employing market institutions in more general settings, it is essential to attend to third party effects, transaction costs, and the public good character of streamflows.

With respect to the future of valley marketing, growth-generated pressures remain, so privately held agricultural water rights will continue to gravitate to cities. However, the several irrigation districts will not enter the market as sellers (except in leasing) unless they are subjected to very strong political forces. Districts will probably take the road traveled by some of the state's large river authorities. They will diversify into the municipal water supply business by obtaining change-of-purpose amendments for their own water rights and entering into long-term contracts for delivering water to urban utilities.

Appendix

The available methods for estimating irrigation water values are market analysis, production function analysis, linear programming (LP), and budgeting. Market analysis requires an active market between irrigators for the statistical analysis of market observed data. Such is not the case for the valley. Production function analysis derives irrigation water demand from statistically fitted production functions emphasizing irrigation water as a production input, but data are unavailable for pursuing this method. Linear programming is the technique which is most extensively used in the literature for obtaining agricultural water value. Satisfactory use of this procedure requires that LP activities be constructed so as to completely capture the full range of water use, input substitution, and water conservation alternatives. Again, data availability constrains the use of this method in the study region. Budgeting is essentially a simplistic form of linear programming where representative farm crop budgets are used to estimate the maximum revenue share of water input [*Gibbons*, 1986]. From this share, a maximum average value (willingness to pay) for water for that crop can be determined. From the perspective of data availability, this is an attractive method for our research, and it is also conservative in the sense that it overestimates the true value of water at the margin.

The value of irrigation water in the valley is estimated under alternative yield levels and cotton prices using two data sources: (1) Texas crop enterprise budgets data which were developed by the area economists of the *Texas Agri-*

cultural Extension Service [1983] and (2) yield and price data from Texas field crop statistics (TFCS) by *Texas Department of Agriculture* [1985]. The procedure to determine returns to irrigation water involves accounting for all cost items of the budget with any residual considered as returns to irrigation water (see *Lacewell et al.* [1974] for similar work).

Total returns per hectare are obtained by combining cotton lint yield times price, cottonseed yield times cottonseed price, and deficiency payments associated with cotton price. In comparing Texas crop budgets data and TFCS data, irrigated cotton yield and price show little or no variation. The only significant discrepancy between the two budgets was for dryland cotton yield which is greatly dependent upon received rainfall. While the price of cotton in farm crop budgets data shows little deviation from TFCS price, historical data indicate that cotton prices do fluctuate over time. To accommodate the possibility of different water values depending on dryland cotton yield levels and prices, alternative dryland yields and prices are used to assess the sensitivity of irrigation water value to changing economic and production conditions. A fixed irrigated yield of 729 kg per hectare (650 pounds per acre) and alternative dryland cotton yield levels and prices were employed. Dryland yields were varied by 20% from the farm budgets data, and price variation was considered at 10% and 20% from the 1983 average season price in TFCS data, making 15 different scenarios.

A management charge of 5% of total returns is included as a cost. Variable costs are divided into preharvest costs such as applications of pesticide and water, and harvest costs for ginning, bagging, and harvest-specific labor. Because some harvesting costs are based on yield level, different yield levels of dryland cotton alter these costs. Depreciation and interest costs for capital items are included in the fixed costs. Land charges are excluded from costs.

Returns to land only are calculated by subtracting all the cost items from total net returns on dryland cotton budgets. The same computation is performed for irrigated cotton budgets to obtain net returns to both land and water. Returns to irrigation water, then, are found when net returns to land are subtracted from net returns to land and water. Returns to water are converted to a cubic meter basis by dividing by the quantity of water applied. In the case of cotton, three applications totaling 1,851 m^3 (1.5 acre-feet) are required [*Texas Agricultural Extension Service*, 1983].

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