The Effects of Water Right Reforms in the Arid Western United States: Case Studies from Texas and New Mexico

University of Nevada, Reno

Gi-Eu Lee Kimberly Rollins Loretta Singletary

University of Nevada, Reno

Introduction and Objectives

Annual precipitation below 20 inches is typical west of 100th meridian in the U.S, where climate change is expected to reduce water supply and exacerbate variability. **Prior appropriation** (**PA**) doctrine, the primary institution governing water allocation in this region, includes *ex ante* rules for allocation based on priority ordering when total supply cannot meet the demand of all water right holders.

Critics of PA advocate for reform or replacement because of: 1) restrictive water transfer regulations; and 2) priority ordering placing unequal risk on water right holders using the same supply. Support for these criticisms are based largely on theoretical analyses and simulations, with scant empirical evidence to support or guide any significant reform.

Our study empirically assesses PA replacement or reform effects on agricultural revenue and income. We examine the effects of replacing PA with **Correlative Shares doctrine** (**CS**), and also investigate PA reforms necessary to allow for **water banking** (**WB**) programs.

Institutional Replacement or Reform

In 1971, CS replaced PA in Texas' lower Rio Grande Basin (**RGB**) and in the middle RGB in 1984. This change eliminated PA water right priority ordering and allocated water by shares among landowners. The CS system relies on the Falcon-Amistad reservoir system, which allows for water transfers that satisfy Texas' rule that no other users be harmed by the change in rights. Thus, in these circumstances, replacement of PA with CS : 1) changes the risk structure so that all shares have equal risk; 2) facilitates water reallocation; and 3) relaxes the timeframe for water use timing through storage.

Texas Water Banking: Texas legislation reformed PA in 1993 to encourage water right holder participation in water banking by: 1) omitting forfeiture of stored water rights; and 2) disseminating market information to facilitate leasing and sales of water rights.

Water Banking in the Lower Pecos River (LP), New Mexico: New Mexico legislation reformed PA in 2003 to: 1) omit forfeiture of stored water rights; and 2) eliminate State Engineer approval for temporary transfers. While water banks must be established by organizations such as irrigation districts, the few that have been created are limited to small areas, or are primarily for municipal use. The only water bank in the region with a large irrigation district (~566,000 acres) is located in the Lower Pecos (LP) River basin.

No-externality criteria: Texas and New Mexico adhere to the rule that no other users may be harmed by water transfers.

Table 1. Water Right Reforms Locations and Dates

Strategy Panel	Policy Year	Treatment Counties & DID Coefficients	Control Counties
1.Texas CS	1971 1984	Lower RGB (**LRBG**): Cameron, Hidalgo, Starr, Willacy Middle RGB (**MRGB**): Kinney, Maverick, Webb, Zapata	Brooks, Kenedy Duval, La Salle, Uvalde, Zavala
2A. New Mexico WB	2003	Lower Pecos (**NMWB1**): De Baca, Eddy, Lincoln, Chaves	Guadalupe, Otero, Curry, Torrance, Quay, Roosevelt, Lea
2B. NM WB with Irrigation District	2003	Lower Pecos with primary irrigation district (**NMWB2**): Eddy, Chaves	Guadalupe, Otero, Torrance, Roosevelt, Curry, Quay, Lea
3A. Texas WB: upper RGB	1991	Upper RGB in Texas (**TXWB1**): El Paso, Hudspeth, Culberson, Reeves, Loving, Winkler, Ward, Crane, Jeff Davis, Pecos, Upton, Presidio, Brewster, Terrell, Crockett, Sutton	RGB in New Mexico without WB: Sierra, Cibola, Los Alamos, Rio Arriba, Taos
3B. Texas WB: Non-RGB	1991	Texas Non-RGB counties along north-south TX-NM border (**TXWB2**)	New Mexico Non-RGB counties along north-south TX-NM border

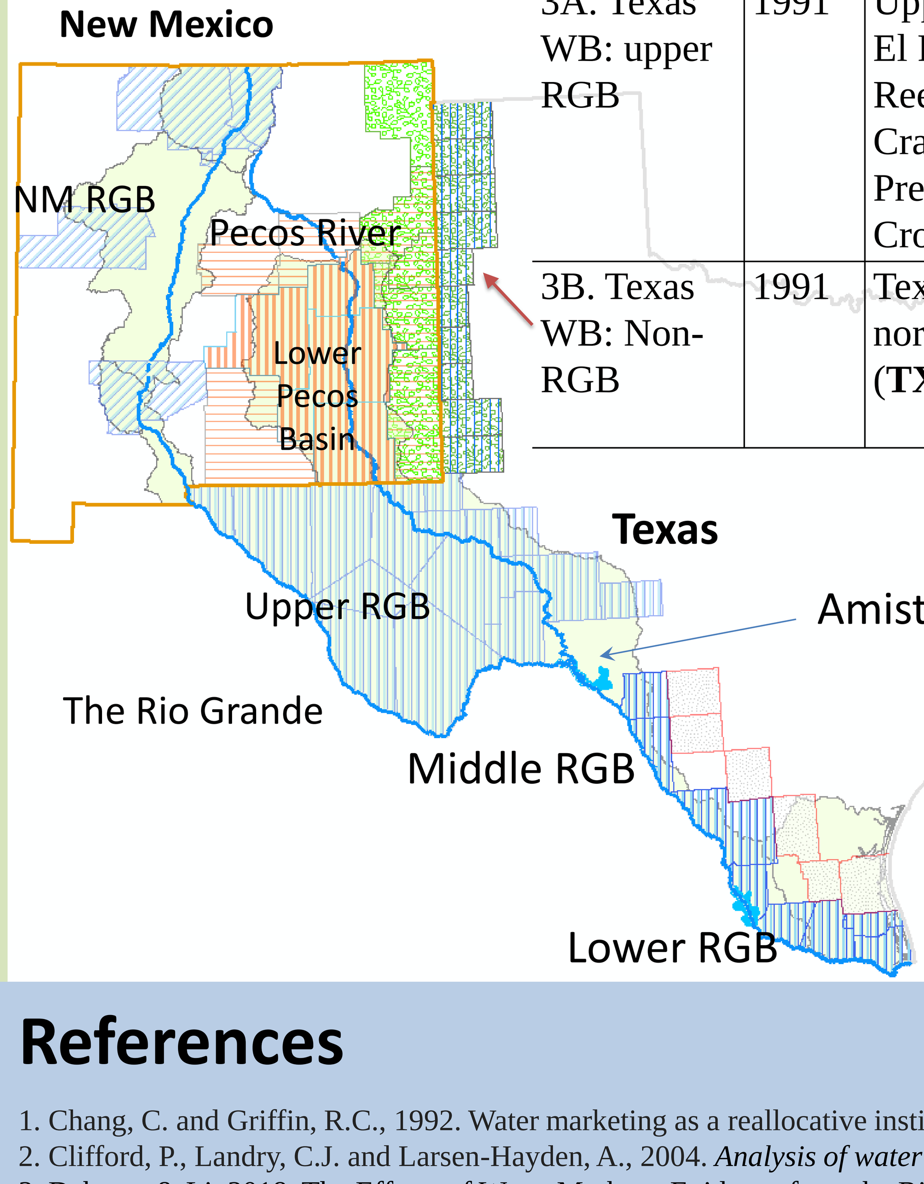

Figure 1. Study Areas: Rio Grande and Pecos River in New Mexico and Texas

Identification Strategy

We use a Difference-in-Difference (DID) approach to estimate the effects of institutional changes by comparing treatment counties in basins where changes are implemented with similar neighboring control counties that did not experience such changes. Table 1 lists treatment and control counties. We exclude the lower and middle RGB region of our Texas WB analysis to avoid a confounding effect from the implementation of CS. Panels 3A and 3B address potential heterogeneous effects of water banking in Texas given basin characteristics and hydrology.

Data and Empirical Model

Data: U.S. AG Census: 1950 - 2012; NOAA Climate Divisional Dataset (1895 – 2017). Dependent variables include: (1) Total value of agricultural products sold; (2) Total gross agricultural income (i.e. (1) – costs); and (3) Gross income per acre.

Model: Equation (1) describes the basic empirical model, in which y_{ct} denotes the outcome for county *c* in AG Census year *t*. Dummy variables *P* and *R* denote time and region of reform, and $\boldsymbol{w_{it}}$ is a vector of interaction terms indexing each of the reforms. The coefficient $\boldsymbol{\delta}$ represents reform effects. The vector $\boldsymbol{X_{ct}}$ controls for differences between treatment and control counties, such as precipitation and temperature, irrigated land size, distance to the U.S. border with Mexico, and population.

Equation (2) considers the effects of water banking under drought, denoted by dummy variable D_{ct} when annual precipitation of county *c* at year *t* is less than -0.85 standard deviation from average. We use random effects to control for unobserved within-county correlation c_c, with cluster robust variance. To check robustness, we use fixed effects to estimate models with γ_R terms removed in equations (1) and (2) and find similar conclusions.

$$(1)\ y_{ct} = \alpha + \boldsymbol{P\gamma_P} + \boldsymbol{R\gamma_R} + \boldsymbol{w_{it}\delta} + \boldsymbol{X_{ct}\beta} + c_c + \varepsilon_{ct}$$

$$(2)\ y_{ct} = \alpha + \boldsymbol{P\gamma_P} + \boldsymbol{R\gamma_R} + \boldsymbol{w_{it}\delta} + \boldsymbol{X_{ct}\beta}\gamma_D + \gamma^D D_{ct} + D_{ct}\boldsymbol{P\gamma_P^D} + D_{ct}\boldsymbol{R\gamma_R^D} + D_{ct}\boldsymbol{w_{it}\delta^D} + c_c + \varepsilon_{ct}$$

Results

Our DID results (Table 2) for CS suggest that lower RGB counties benefit, and middle RGB counties see decreases in agricultural revenue and income. Drought conditions exacerbate these decreases.

We see no significant effects for PA reforms that allow for WB in New Mexico, with the exception of increased agricultural revenue under drought conditions for LP River counties with primary irrigation districts (Panel 2B). Panel 3A also shows no significant effects from Texas WB in upper RGB counties. However, WB improves revenue and per acre income in both normal and drought conditions for counties located along the north-south Texas-New Mexico border (panel 3B).

Table 2. Regression Results of DID Coefficients

Strategy Panel		Gross Income ($1K)	Gross Income ($/Acre)	Ag. Revenue ($1K)
	LRGB	13,255^{+}	35***	26,465*
Texas CS (1)	MRGB	-8,359^{+}	-15**	-23,004**
Texas CS (1)	LRGB	12,439^{+}	35***	25,124**
w/ Drought	LRGB_Drought	26,046***	84**	53,478**
	MRGB	-6,204	-10**	-19,597**
	MRGB_Drought	-31,405***	-36***	-53,021**
New Mexico	NMWB1	-2,102	-11	-3,413
WB (2A)	NMWB1_Drought	1,440	1	10,572
New Mexico	NMWB2	8,621	-5	24,263
WB (2B)	NMWB2_Drought	10,409	-1	150,066**
Texas	TXWB1	932	-11	3,012
WB (3A)	TXWB1_Drought	1,891	15	760
Texas	TXWB2	16,979	38**	183,240**
WB (3B)	TXWB2_Drought	15,476	30*	267,516**

$+\ p < 0.15$, $*\ p < 0.1$, $**\ p < 0.05$, $***\ p < 0.01$

Discussion

Our findings suggest that policies designed to replace or reform PA through water redistribution mechanisms alone are insufficient to improve allocative efficiency. Our empirical results indicate that replacing PA with CS, and partial reforms to PA required by WB, yield heterogeneous effects conditional on location and basin characteristics. Such heterogeneity may also explain ongoing challenges in reaching consensus on strategies for improving water allocation. Further empirical analyses are necessary to inform and ensure effective change.

References

1. Chang, C. and Griffin, R.C., 1992. Water marketing as a reallocative institution in Texas. *Water Resources Research*, *28*(3), pp.879-890.
2. Clifford, P., Landry, C.J. and Larsen-Hayden, A., 2004. *Analysis of water banks in the western states*. Washington State Department of Ecology.
3. Dabaere & Li, 2018. The Effects of Water Markets: Evidence from the Rio Grande. 2018 *American Economic Association Annual Meeting*, Philadelphia, Pennsylvania. January 5 – 7, 2018
4. Wooldridge, J, 2012. Difference in Difference Estimation. Unpublished Manuscript. *Programme Evaluation for Policy Analysis*, Institute for Fiscal Studies.

Contact

Gi-Eu Lee, Ph.D., NSF Post-Doctoral Research Fellow
Department of Economics, University of Nevada, Reno
Email: gieul@unr.edu