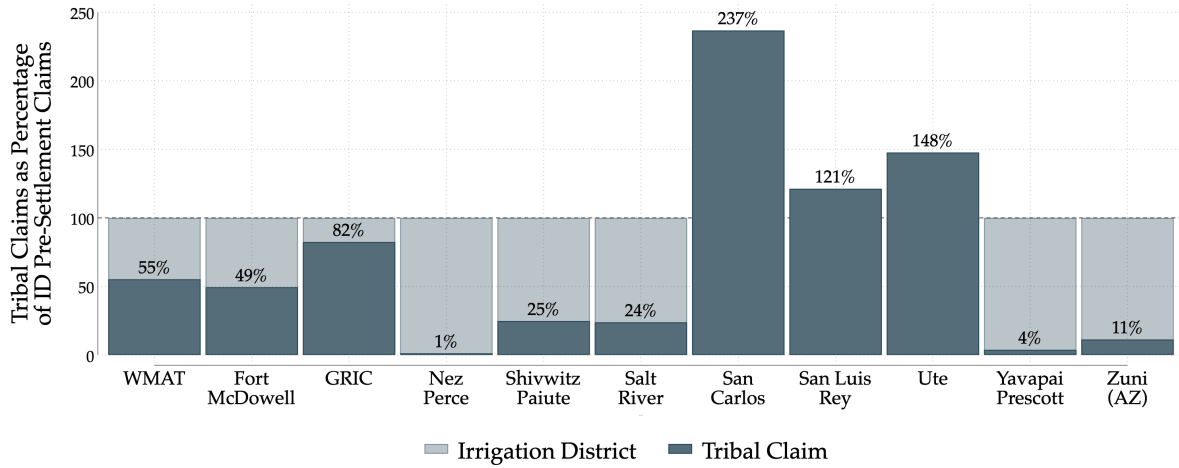


ONLINE APPENDIX

Bargaining in the Shadow of Prior Appropriation: Concessions and Trade-Offs in Native American Water Settlement Negotiations

May 16, 2024

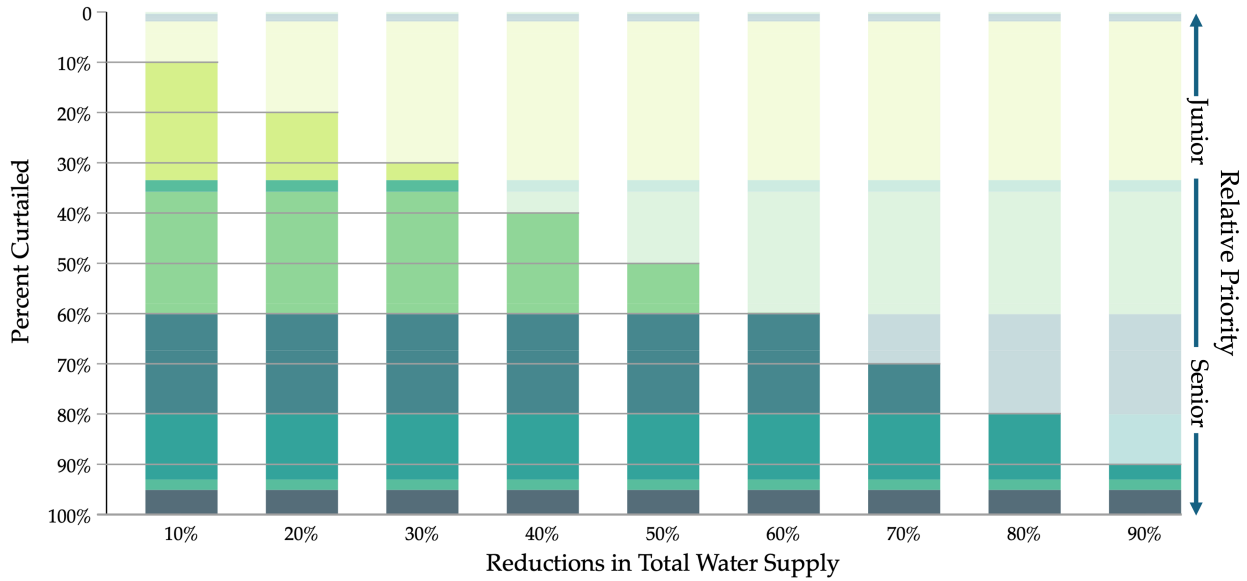
Figure A1: Projected Curtailments under Court Adjudication



Notes: Figure shows the percentage Winters right claims relative to IDs' collected pre-settlement water entitlements in each settlement. Data on Winters claims was collected from adjudication records and Statement of Claimants.

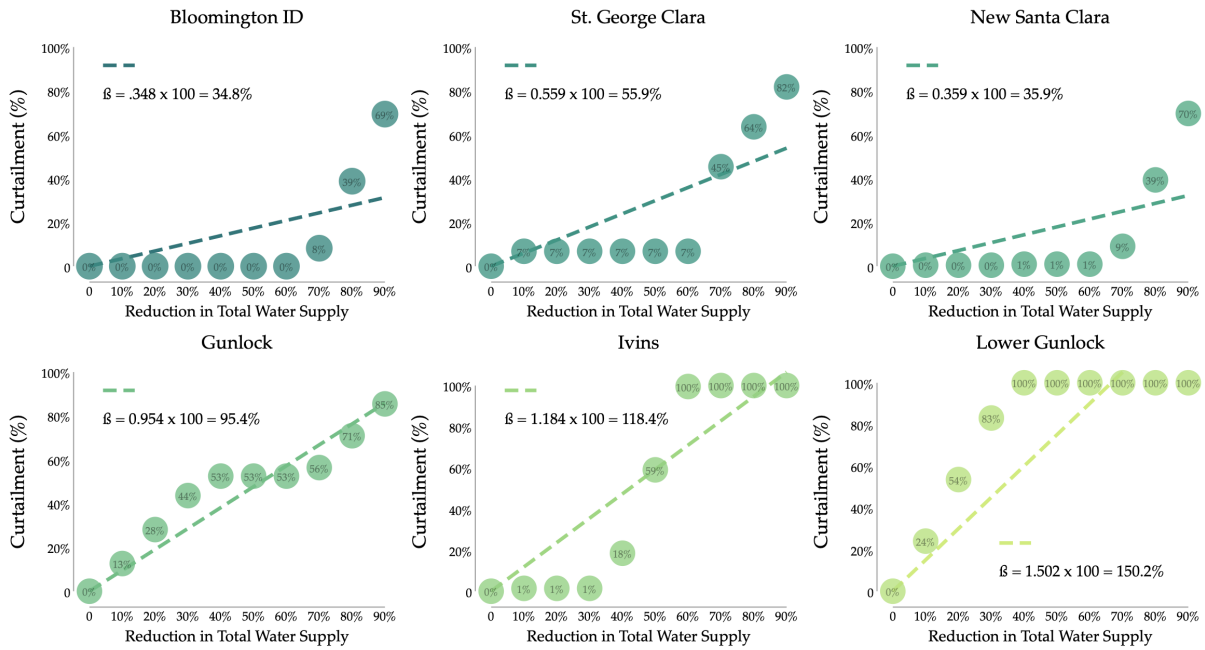
Estimating Relative Shortage Risk: The following figures provide an example of the step-by-step process to calculate IDs' water shortage risks relative to other IDs within a single tribal water right negotiation.

Figure A2: ID Pre-Settlement Water Right Claims, by Relative Priority



Legend: Bloomington (dark blue), St. George Clara (teal), New Santa Clara (green), Gunlock (light green), Ivins (yellow-green), Lower Gunlock (yellow).
Notes: Bar graph shows individual water rights claimed by six IDs in the Shivwitz Paiute Settlement, ranked in ascending priority order. From left to right along the x-axis, total water availability is reduced by ten percent increments. Relatively transparent bars above the grey, horizontal lines show corresponding curtailments to IDs water rights. As total water availability - measured as the volume of water held collectively by IDs participating in the negotiation - decreases in 10 percent increments, appropriate water law mandates that the most junior rights are cut first.

Figure A3: ID Pre-Settlement Water Right Claims, by Relative Priority



Notes: The percentage of each ID's water right claims that would be curtailed under prior appropriation rules is on the y-axis. The percentage reduction to total water supply is on the x-axis. $\beta_{i,s}^{risk}$ is the linear relationship between an ID's water curtailment as a function of diminishing water availability. A steeper line ($\beta_{i,s}^{risk}$) relative to other IDs indicates greater shortage risk.

Table A1: Dirkson Center Congressional Power Index

Congressional sponsor is:

1. Is one of the majority party in the chamber:
If yes, rates a 3. If a member is of the minority party, rates a - 3. If Independent, score a 0.
2. Holds formally elected party membership post:
Speaker of the House or Majority Leader of the Senate: 5 points
Minority Leader or Assistant Majority Leader: 4 points
Majority or Minority Whip, Assistant Minority Leader: 3 points
Assistant Whips, Democratic or Republican Conference Chair: 2 points
Democratic or Republican Conference Secretary or Policy Chair: 1 point
3. Chairs (or is ranking member of) a “money” committee:
Committee chair rates 5 points; ranking member ranks 3 points
House “money” committees: Appropriations, Budget, Ways and Means
Senate “money” committees: Appropriations and Finance
4. Chairs (or is ranking member of) another committee:
Chairs rates 4 points; ranking member rates 2 points
5. Chairs (or is ranking member of) subcommittee:
Chairs rates 3 points; ranking member rates 1 point
6. Is a member of one of the following committees (rates 3 points for each):
House: Appropriations, Armed Services, Energy and Commerce, Rules, or Ways and Means
Senate: Appropriations, Armed Services, Budget, Finance, or Judiciary
7. Seniority:
Zero to 2 terms rates 0, then 1 point for each additional two terms
8. Margin of victory in last election (not percentage of vote):
60%: 3 points; 59-60%: 2 points; 56-58%: 1 point; 53-55%: 0 points; 50-52%: -1 point; ≤50%: -2 points
9. Campaign funding on hand:
\$100,000: -5 points; \$100,000-\$199,999: -4 points; \$200,000-\$299,999: -3 points; \$300,000-\$399,999: -2 points;
\$400,000-\$499,999: -1 point; \$500,000-\$599,999: 0 points; \$600,000-\$699,999: 1 point; \$700,000-\$799,999: 2
points; \$800,000-\$899,999: 3 points; \$900,000-\$999,999: 4 points; ≥\$1,000,000: 5 points
10. Exposure in National press (Use ONE of the following):
Washington Post online search for one week (1 point for every 4 hits with a maximum of 5 points), OR
New York Times online search for one month (1 point for every 4 hits with a maximum of 5 points), OR
CNN.com search (cnn.com only) (1 point for every 30 hits with a maximum of 5 points).

Table A2: Variable Definitions

Irrigation District-Level	Definition	Data Source
AFY/Acre	Total AFY volume of water claimed by an ID prior to settlement divided by ID service area acreage	State water right databases
Acres	ID service area acreage	State water agencies
Hay/Pasture (%)	Hay/pasture land cover (category 44) within ID boundaries in decade prior to settlement, as a percentage of ID acreage	Falcone (2015)
Agriculture (%)	Hay/pasture and cropped land cover (categories 43 and 44) within ID boundaries in decade prior to settlement, as a percentage of ID acreage	Falcone (2015)
USBR Contract (%)	Percentage of ID pre-settlement water right claims delivered via US Bureau of Reclamation contract	State water right databases
Urbanization Rate (%)	Percent change in developed land cover (Classes 21-27) within ID boundaries in decade prior to settlement	Falcone (2015)
Water Shortage	Water shortages, occurring when freshwater demand exceeds supply, are assessed as the million cubic meter per month (MCM/mo.) difference between demand and renewable freshwater supply between 1985-2015. Shortages are defined as a deficit that lasts at least 12 months and has a 50-year return period.	Heidari et al. (2021) and adapted from Sanchez et al. (2023) .
Settlement-Level	Definition	Data Source
Prime Reservation Acreage	Logged reservation acreage with a soil productivity index > 9	Schaetzl et al. (2012)
Reservation Population	Reservation population in decade prior to settlement	Sanchez et al. (2020)
Congressional Power Index	Index score calculated according to Dirksen Congressional Center definition	Various sources
Municipal Population Growth Rate (%)	Population growth rate within boundaries of municipal water providers represented in negotiation prior to settlement	U.S. Census
Negotiating IDs	Number of IDs participating in a negotiation	Sanchez et al. (2020)
Water Right-Level	Definition	Data Source
USBR Contract	Water right claimed by ID is assigned a value of 1 if it was delivered via Reclamation contract and a zero if it was not	State water right databases
Received Compensation	Water right relinquished by ID is assigned a value of 1 if ID received compensation for that water right, and a value of zero if it did not	Water settlement texts

Table A3: Summary Statistics

ID-Level	Mean	SD	Min	Max	n
% Δ AFY	-11.505	22.009	-99.97	0	61
Risk (%)	99.230	42.049	0	158.9	61
\$/Acre-Foot	1,163.78	523.56	329.30	2,182.65	11
Pre-Settlement AFY/acre	7.837	6.556	1	28	61
Post-Settlement AFY/acre	7.062	6.054	0.626	25	60
Hay/Pasture (%)	9.849	11.847	0	44	60
Urbanization Rate (%)	18.662	28.136	0	113	60
Water Shortage (MCM/mo)	0.675	1.012	0	5	61
ID Acreage	48,727	63,198.808	410	337,684	61
USBR Contracts (%)	38.067	41.749	0	100	61
Settlement-Level	Mean	SD	Min	Max	n
Congressional Power Index	12.636	10.259	-2	24	11
ln(Prime Res Acres)	10.357	4.086	0	14	11
Reservation Pop.	4,959	4,339	176	12,429	11
Municipal Pop. Growth (%)	42.089	25.505	2	75	11
Settlement IDs (n)	6	6.788	1	24	11
Water Right-Level	Mean	SD	Min	Max	n
USBR Contract = 1	0.231	0.422	0	1	851
Received Compensation = 1	0.203	0.406	0	1	64
Priority Rank if Ceded (%)	44.278	34.881	0	100	64

Table A4: MLR Estimates of Shortage Risk and ID Water Entitlement Changes – Tribal Claims

	Y = % Δ AFY					
	(1)	(2)	(3)	(4)	(5)	(6)
Shortage Risk (%)	-0.179** (0.071)	-0.179** (0.070)	-0.252*** (0.083)	-0.227** (0.097)	-0.214** (0.101)	-0.156 (0.102)
Shortage Risk ² (%)	-0.123* (0.070)	-0.120* (0.069)	-0.190** (0.078)	-0.173* (0.089)	-0.164* (0.093)	-0.124 (0.077)
Urbanization Rate (%)		0.081 (0.065)	0.067 (0.080)	0.056 (0.083)	0.078 (0.097)	0.050 (0.108)
ID Acreage			0.000 (0.000)	0.000* (0.000)	0.000* (0.000)	0.000* (0.000)
Hay/Pasture (%)			-0.442 (0.276)	-0.323 (0.284)	-0.373 (0.302)	-0.376 (0.273)
Pre-Settlement AF/acre				0.544 (0.734)	0.539 (0.745)	0.495 (0.714)
Water Shortage (MCM/mo)					-10.634 (14.928)	-7.302 (16.049)
USBR Contracts (%)						-0.119 (0.178)
Constant	6.472 (5.913)	4.871 (6.046)	12.640* (6.949)	4.725 (13.378)	9.899 (14.936)	7.623 (13.428)
Observations	61	60	60	60	60	60
R ²	0.300	0.317	0.366	0.378	0.384	0.404
Settlement FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Risk is assessed as a quadratic function of curtailed water availability. All specifications include settlement-level fixed effects. ID urbanization rate prior to settlement is a measure of an ID's water demand; AFY/acre reflects an ID's pre-settlement capacity to support irrigated agriculture; and hay/pasture land cover represents the marginal value of an ID's water use. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A5: MLR Estimates of Shortage Risk and ID Water Entitlement Changes – Tribal Claims

	Y = % Δ AFY					
	(1)	(2)	(3)	(4)	(5)	(6)
Risk (%)	-0.182*** (0.065)	-0.182*** (0.065)	-0.182*** (0.066)	-0.190*** (0.066)	-0.188*** (0.067)	-0.108 (0.131)
ln(Prime Res Acres)	0.957 (0.888)	0.943 (1.177)	0.816 (1.271)	-1.778** (0.712)	-1.018 (0.854)	0.164 (1.840)
Reservation Pop.		0.000 (0.001)	0.000 (0.001)	0.004*** (0.001)	0.003** (0.001)	0.002 (0.002)
Municipal Pop. Growth (%)			0.076 (0.148)	0.376** (0.162)	0.225 (0.166)	0.104 (0.267)
Settlement IDs (n)				-2.830** (1.089)	-2.350** (0.968)	-1.410 (1.588)
Water Shortage (MCM/mo)					-3.179 (3.268)	-4.979 (3.997)
USBR Contracts (%)						-0.136 (0.146)
Constant	-4.938 (11.489)	-4.869 (12.155)	-7.377 (13.216)	27.698** (12.779)	25.519** (12.095)	9.764 (22.997)
Observations	61	61	61	61	61	61
R ²	0.272	0.272	0.273	0.294	0.299	0.329
State FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: All specifications include state-level fixed effects. Settlement-level variables include prime reservation acreage as a measure of the potential magnitude of a tribe's PIA-based water right claim; reservation population prior to settlement as a measure of reservation water needs; the population growth rate within service area boundaries of municipal water interests participating in the negotiation; and the number of IDs participating in the settlement. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A6: MLR Estimates of Shortage Risk and ID Water Entitlement Changes – Tribal Claims

	Y = % Δ AFY					
	(1)	(2)	(3)	(4)	(5)	(6)
Risk (%)	-0.174** (0.067)	-0.173** (0.068)	-0.172** (0.070)	-0.178** (0.070)	-0.175** (0.071)	-0.098 (0.087)
Risk ² (%)	-0.120* (0.066)	-0.120* (0.067)	-0.119* (0.069)	-0.122* (0.069)	-0.119* (0.070)	-0.065 (0.061)
ln(Prime Res Acres)	0.972 (0.915)	0.940 (1.188)	0.807 (1.280)	-1.794** (0.743)	-1.024 (0.882)	0.156 (1.896)
Reservation Pop.		0.000 (0.001)	0.000 (0.001)	0.004*** (0.001)	0.003** (0.001)	0.002 (0.002)
Municipal Pop. Growth (%)			0.079 (0.150)	0.380** (0.169)	0.227 (0.170)	0.106 (0.277)
Settlement IDs (n)				-2.837** (1.120)	-2.350** (0.988)	-1.413 (1.631)
Water Shortage (MCM/mo)					-3.232 (3.374)	-5.016 (3.988)
USBR Contracts (%)						-0.136 (0.149)
Constant	-5.816 (12.546)	-5.681 (13.166)	-8.432 (14.302)	26.576** (12.449)	24.185** (11.837)	8.777 (18.831)
Observations	61	61	61	61	61	61
R ²	0.272	0.272	0.274	0.294	0.300	0.330
State FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: All specifications include state-level fixed effects. Settlement-level variables include prime reservation acreage as a measure of the potential magnitude of a tribe's PIA-based water right claim; reservation population prior to settlement as a measure of reservation water needs; the population growth rate within service area boundaries of municipal water interests participating in the negotiation; and the number of IDs participating in the settlement. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A7: Estimates of Relative Priority of Ceded Water Rights – Robustness Check

	Y = Percentile Rank (%)				
	(1)	(2)	(3)	(4)	(5)
Risk (%)	0.029 (0.474)	0.316 (0.491)	0.272 (0.535)	-0.339 (0.280)	-0.448 (0.337)
Risk ² (%)	-0.016 (0.412)	0.225 (0.421)	0.189 (0.458)	-0.325 (0.252)	-0.415 (0.296)
USBR Contract _{WR=1}	-12.752 (11.468)	-13.680 (10.247)	-13.420 (10.085)	-9.973 (8.735)	-10.373 (8.622)
ln(Prime Res Acres)		-8.577 (5.358)	-8.935 (6.273)	-7.210 (9.368)	-12.490 (13.208)
Reservation Pop.			0.002 (0.002)	0.002 (0.003)	0.004 (0.004)
Hay/Pasture (%)				-1.782*** (0.611)	-1.747** (0.630)
Water Shortage (MCM/mo)				-12.872* (6.506)	-22.843 (17.035)
Municipal Pop. Growth (%)					-0.678 (1.172)
Constant	48.139 (48.297)	130.212* (63.448)	129.324* (68.387)	190.137* (97.722)	292.983 (206.526)
Observations	64	64	64	63	63
R ²	0.057	0.098	0.105	0.235	0.241

Notes: Table presents estimates of the relationship between measures of ID bargaining power and the relative seniority of water rights that were relinquished/diminished in a negotiation. The dependent variable is the percentile rank of water right, $WRis$, claimed by ID, i , prior to settlement. The percentile rank is increasing with a water right's seniority. A negative coefficient on $\hat{\beta}_n$ indicates correlation with the cession of a relatively junior right. Standard errors clustered at the ID-level are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A8: Probability of an ID Securing Settlement Funding

	LASSO (1)	Y = Pr(Funding) Logit			
		(2)	(3)	(4)	(5)
Congressional Power Index	0.023 (0.097)	0.219** (0.102)			
Urbanization Rate (%)	-0.082 (0.063)		-0.043 (0.036)		
Water Shortage (MCM/mo)	1.860 (1.141)			1.500*** (0.570)	
AFY/acre	-0.231 (0.202)				-0.212** (0.104)
Constant	-0.572 (1.627)	-4.745** (2.039)	-0.529 (0.467)	-2.056*** (0.492)	0.428 (0.657)
Observations	36	37	36	37	37

Notes: Table presents estimated probability of an ID having secured funding in a settlement. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A9: Probability of an ID Securing Settlement Funding - Simple Logistic Model

	Y = Pr(Funding)					
	(1)	(2)	(3)	(4)	(5)	(6)
Risk (%)	-0.001 (0.011)					
ln(Prime Res Acres)		-0.214 (0.320)				
USBR Contracts (%)			-0.002 (0.010)			
Urbanization Rate (%)				-0.043 (0.036)		
Hay/Pasture (%)					-0.030 (0.047)	
Municipal Pop. Growth (%)						-0.004 (0.032)
Constant	-0.707 (1.173)	1.733 (4.051)	-0.761 (0.572)	-0.529 (0.467)	-0.666 (0.553)	-0.707 (1.177)
Observations	37	37	37	36	36	37

Notes: Table presents estimated probability of an ID having secured funding in a settlement. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A10: Probability of an ID Securing Settlement Funding - Logistic Model

	Y = Pr(Funding)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Congressional Power Index	0.185** (0.090)	0.232* (0.136)	0.189 (0.120)	0.057 (0.072)			
AFY/acre	-0.204* (0.110)		-0.164* (0.088)	-0.390 (0.244)		-0.422* (0.245)	-0.231* (0.134)
Urbanization Rate (%)		-0.062 (0.059)	-0.050 (0.053)		-0.116 (0.074)		-0.085 (0.061)
Water Shortage (MCM/mo)				1.269* (0.694)	2.517** (1.106)	1.547** (0.692)	2.040* (1.064)
Constant	-2.870 (1.996)	-4.453* (2.432)	-2.695 (2.325)	-1.004 (1.386)	-1.538*** (0.575)	-0.136 (0.819)	-0.280 (0.773)
Observations	37	36	36	37	36	37	36

Notes: Table presents estimated probability of an ID having secured funding in a settlement. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A11: SLR Estimated effects of bargaining power on \$/AFY funding

	Y = \$/AF (adj. 2020)			
	(1)	(2)	(3)	(4)
Congressional Power Index	71.108*** (21.193)			
Water Shortage (MCM/mo)		215.428** (91.886)		
AFY/acre			25.059 (28.565)	
Urbanization Rate (%)				-15.081 (15.752)
Constant	-303.619 (450.307)	796.660*** (201.561)	1,057.883*** (155.953)	1,161.079*** (177.551)
Observations	11	11	11	10
R^2	0.551	0.408	0.021	0.104

Notes: Table presents SLR estimates of the relationship between LASSO-identified independent variables and per AF funding outcomes to 11 IDs that received funding in exchange for water in a negotiation. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A12: SLR Estimated effects of bargaining power on \$/AFY funding – Robustness Check

	Y = \$/AF (adj. 2020)				
	(1)	(2)	(3)	(4)	(5)
Risk (%)	-1.170 (2.332)				
ln(Prime Res Acres)		-27.970 (104.364)			
USBR Contracts (%)			-0.019 (3.111)		
Hay/Pasture (%)				3.091 (9.227)	
Municipal Pop. Growth (%)					-16.068** (6.939)
Constant	1,285.605*** (219.659)	1,479.619 (1165.200)	1,164.670*** (290.942)	1,036.313*** (164.794)	1,729.220*** (279.642)
Observations	11	11	11	10	11
R^2	0.016	0.006	0.000	0.008	0.348

Notes: Table presents SLR estimates of the relationship between alternative measures of bargaining power and per AF funding outcomes to 11 IDs that received funding in exchange for water in a negotiation. Robust standard errors are in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

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