Supporting Tables

used in

"Climate Change, Water Rights and Water Supplies: the Case of Irrigated Agriculture in Idaho"

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Table B.1 Abbreviations Used in this Article

Abbreviation	Description
	Hydrological Basins/Sub-basins
BEA	Bear River Basin, measured at the Bear River at the Stewart Dam
BLA	Blackfoot River Basin, measured at the Snake River at Heise
BLR	Big Lost River area, measured at the Big Lost River Below Mackay Reservoir
BOI	Boise River basin, measured at Boise River near Boise
BRU	Bruneau River Basin, measured at the Bruneau River near Hot Spring
BWR	Big Wood River area, measured at the Big Wood River below Magic Reservoir
CAM	Medicine Lodge-Camas Basin (Mud Lake) area, measured at the Snake River at Heise
CRB	Clearwater River area, measured at the Clearwater River at Spalding
HEI	Snake River near Heise and measure here
HFB	Henry's Fork River basin, measured at Henry's Fork near Ashton
LLR	Little Lost River area, measured at the Little Lost River near Howe
LWR	Little Wood River area, measured at the Little Wood River near Carey
NPR	Northern Panhandle Region, measured at the Moyie River at Eastport
OAK	Oakley River area, measure at the Oakley Reservoir inflow
OWY	Owyhee River area, measured at the Owyhee River below Owyhee Dam
PAY	Payette River basin, measured at the Payette River near Horseshoe Bend
POR	Portneuf River Basin, measured at the Snake River at Heise
SAL	Salmon River Basin, measured at Salmon River at Whitebird
SFC	Salmon Falls Creek area, measured at the Salmon Falls Creek near San Jacinto, Nevada
SPO	Spokane River area, measured at the Spokane River near Post Falls
SR1	Heise-Idaho Falls area, measured at the Snake River at Heise
SR2	Idaho Falls-American Falls area, measured at the Snake River at Heise
SR3	American Falls-Boise area, measured at the Snake River at Heise
SR4	Snake River from Boise to Weiser, ,measured at the Snake River at Heise
SR5	Snake River in the canyon area, measured at the Snake River at Heise
WEI	Weiser River basin, measured at the Weiser River near Weiser
WIL	Willow River area, measured at the Snake River at Heise
	Others
CDL	Cropland Data Layer
CBWTP	Columbia Basin Water Transactions Program
GCM	Global Circulation Model
ICCDCD	Irrigated Land Capability Classification - Dominant Condition
IDWR	Idaho Department of Water Resources
IPCC	Intergovernmental Panel on Climate Change
KAF	Thousand Acre Feet
KAs	Thousand Acres
LSD	Land-Surface Datum
MAF	Million Acre Feet
MAs	Million Acres
NASS	National Agricultural Statistics Service
NRCS	Natural Resources Conservation Service
PRISM	Parameter-Elevation Regressions on Independent Slopes Model
SWE	Snow Water Equivalence
USDA	U.S. Department of Agriculture
USDC	U.S Department of Commerce
USGS	U.S. Geological Survey
WSO	Water Supply Outlook

Table B.2 Pearson Correlation Coefficients Between Farm Level April Minimum Temperature and Long-term Water Supply Conditions (N=6509)

	April Precipitation - Average	April Minimum Temperature - Average	April Maximum Temperature - Average	April Adjusted Streamflow - Average
April Precipitation - Average	1			
April Minimum Temperature - Average	-0.18379 (<.0001)	1		
April Maximum Temperature - Average	-0.42657 (<.0001)	0.92587 (<.0001)	1	
April – September Total Available Water - Average	-0.11422 (<.0001)	0.10156 (<.0001)	0.09400 (<.0001)	1

Note: p-values in parentheses.

Table B.3 Pearson Correlation Coefficients Between the Farm Level Measures of Minimum Temperatures from April to August (N=6509)

	April Minimum Temperature - Average	May Minimum Temperature - Average	June Minimum Temperature - Average	July Minimum Temperature - Average	August Minimum Temperature - Average
April Minimum Temperature - Average	1				
May Minimum Temperature - Average	0.991 (<.0001)	1			
June Minimum Temperature - Average	0.98041 (<.0001)	0.98991 (<.0001)	1		
July Minimum Temperature - Average	0.96456 (<.0001)	0.97305 (<.0001)	0.98677 (<.0001)	1	
August Minimum Temperature - Average	0.95273 (<.0001)	0.95566 (<.0001)	0.96497 (<.0001)	0.98975 (<.0001)	1

Note: p-values in parentheses.

Table B.4 Pearson Correlation Coefficients Between the Long-term and Annual Measures of Farm Level April Minimum Temperatures (N=6509)

	April Minimum Temperature - Average	April Minimum Temperature - 2011	April Minimum Temperature - 2010	April Minimum Temperature - 2009	April Minimum Temperature - 2008	April Minimum Temperature - 2007
April Minimum Temperature - Average	1					
April Minimum Temperature - 2011	0.89746 (<.0001)	1				
April Minimum Temperature - 2010	0.92731 (<.0001)	0.94746 (<.0001)	1			
April Minimum Temperature - 2009	0.9341 (<.0001)	0.94395 (<.0001)	0.96163 (<.0001)	1		
April Minimum Temperature - 2008	0.94869 (<.0001)	0.89255 (<.0001)	0.95238 (<.0001)	0.94469 (<.0001)	1	
April Minimum Temperature - 2007	0.94759 (<.0001)	0.92323 (<.0001)	0.95968 (<.0001)	0.95871 (<.0001)	0.96594 (<.0001)	1

Note: p-values in parentheses.

Table B.5 Average Crop-Revenue per Acre During the Crop Years from 2007 to 2011, by Priority Groups

Priority group	All crop years	2007	2008	2009	2010	2011
Mean						
(1) Priority group (before 1870)	553.020	595.428	540.174	492.253	519.873	617.374
	(276.807)	(307.269)	(129.272)	(202.613)	(194.477)	(430.282)
(2) Priority group (1870-1890)	515.156	562.827	515.134	478.495	513.674	505.650
	(214.247)	(232.098)	(162.734)	(231.472)	(198.355)	(229.470)
(3) Priority group (1890-1910)	546.378	582.422	539.613	499.767	566.756	543.333
	(319.586)	(348.534)	(261.586)	(271.128)	(406.906)	(279.766)
(4) Priority group (1910-1930)	602.455	653.748	588.011	565.422	583.214	621.879
	(466.253)	(507.316)	(478.766)	(403.950)	(400.946)	(522.979)
(5) Priority group (1930-1950)	696.857	755.762	665.490	650.646	685.646	726.739
	(495.579)	(531.776)	(479.910)	(386.191)	(454.746)	(593.905)
(6) Priority group (1950-1970)	696.776	742.794	676.172	684.506	677.457	702.949
	(442.076)	(463.579)	(434.317)	(435.083)	(397.087)	(473.252)
(7) Priority group (after 1970)	736.036	774.162	715.913	702.615	714.939	772.550
	(571.742)	(562.331)	(611.498)	(501.301)	(522.539)	(645.140)
Kolmogorov-Smirnov Test (p-value)						
(1) vs. (2)	<.0001	0.142	0.022	0.274	0.017	0.001
(2) vs. (3)	<.0001	0.063	0.193	0.005	0.001	0.001
(3) vs. (4)	<.0001	0.000	0.068	0.001	0.083	0.006
(4) vs. (5)	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
(5) vs. (6)	0.066	0.407	0.722	0.057	0.244	0.610
(6) vs. (7)	<.0001	0.057	0.007	0.055	0.365	0.023

Note: Standard deviation in parentheses.

Table B.6 Empirical Regression Results of the Effects of Water Supply Information in Average Crop Revenue per Acre (Cont.)

Model:	OLS	2SLS (IV)	Censored (Tobit)
	(1)	(2)	(3)
Crops			
Alfalfa	-134.424 ***	-130.111 ***	-166.407 ***
	(8.992)	(8.962)	(5.298)
Barley	-53.406 ***	-48.500 ***	-54.162 ***
	(5.825)	(5.772)	(4.417)
Bean	8.818	12.503 *	-2.623
	(6.801)	(6.798)	(5.575)
Corn	18.334 ***	24.663 ***	14.215 ***
	(5.793)	(5.721)	(4.608)
Hay	-68.279 ***	-60.414 ***	-104.282 ***
	(5.233)	(5.096)	(3.877)
Lentil	-120.982 ***	-119.606 ***	-129.284 ***
	(26.251)	(26.353)	(18.747)
Oat	-52.434 ***	-45.034 ***	-49.172 ***
	(5.678)	(5.573)	(4.775)
Onion	380.023 ***	384.344 ***	440.451 ***
	(9.442)	(9.506)	(8.114)
Pea	-39.920 ***	-33.346 ***	-42.011 ***
	(7.077)	(7.040)	(6.182)
Potato	185.497 ***	192.342 ***	209.987 ***
	(5.465)	(5.360)	(4.610)
Wheat	-8.355	-3.381	-50.775 ***
	(6.341)	(6.264)	(4.379)
Basins & sub-basins			
SR1	95.109 ***	98.661 ***	88.232 ***
	(10.716)	(10.750)	(8.000)
SR2	31.078 ***	33.695 ***	40.063 ***
	(11.932)	(11.952)	(8.062)
SR3	-22.986 *	-15.734	9.093
	(12.544)	(12.497)	(8.942)
BOI	18.126	19.338	7.428
	(12.050)	(12.074)	(8.080)
BLA	21.701	25.213	44.987 **
	(27.012)	(27.274)	(19.058)
CAM	18.752	19.682	33.665 ***
	(16.324)	(16.344)	(12.930)
SAL	165.371 **	155.911 **	94.078 ***
	(65.891)	(65.864)	(34.399)
Farm size	-	-0.006 *	-
	-	(0.004)	-
Farm size dummy			
50 to 99 acre	16.652 **	-	5.979
	(8.038)	-	(5.433)
100 to 499 acre	23.969 ***	-	12.275 **
	(7.239)	-	(4.880)
500 to 999 acre	50.074 ***	-	40.462 ***
	(10.234)	-	(7.749)
1000 to 999 acre	70.350 ***	-	69.088 ***
	(12.739)	-	(10.327)
>= 2000 acre	55.774 ***	-	50.563 ***
	(13.838)	-	(11.246)
Growing Season (2007)	60.492 ***	60.143 ***	77.471 ***
	(5.890)	(5.904)	(4.606)
Distance to Urbanized Areas	23.337 ***	22.577 ***	12.088 **
	(6.593)	(6.595)	(4.712)
Distance to Major Waters	-2.247 ***	-2.101 ***	-0.677 **
	(0.444)	(0.444)	(0.316)
Soil quality - Dominant type	-21.083 **	-20.163 **	-20.433 ***
	(8.883)	(8.897)	(6.376)
Soil quality - Dominant type squared	2.310 **	2.277 **	2.611 ***
adjustment term	(1.001)	(1.002)	(0.701)
# Observations:	32,545	32,545	78,835
Adj R-square	0.186	0.185	-

Note: Robust standard errors in parentheses

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level.

Table B.7 Sensitivity Analysis Results (OLS) (Cont.)

Models	(4)	(5)	(6)	(7)	(8)
Crops					
Alfalfa	-131.499 ***	-134.314 ***	-135.720 ***	-149.358 ***	-125.911 ***
	(8.986)	(8.995)	(8.989)	(10.678)	(8.897)
Barley	-52.439 ***	-52.570 ***	-53.276 ***	-61.885 ***	-53.653 ***
	(5.801)	(5.812)	(5.819)	(6.916)	(5.747)
Bean	8.214	7.765	9.331	12.223	6.114
	(6.788)	(6.790)	(6.801)	(8.075)	(6.725)
Corn	-41.003 ***	18.854 ***	18.382 ***	27.851 ***	20.768 ***
	(7.069)	(5.792)	(5.793)	(6.879)	(5.725)
Hay	-69.339 ***	-68.026 ***	-69.745 ***	-81.749 ***	-69.382 ***
	(5.227)	(5.238)	(5.222)	(6.214)	(5.189)
Lentil	19.788 ***	-136.294 ***	-122.121 ***	-139.021 ***	-119.295 ***
	(5.781)	(25.563)	(26.251)	(31.171)	(25.923)
Oat	-138.877 ***	-52.563 ***	-53.765 ***	-61.787 ***	-52.523 ***
	(25.100)	(5.678)	(5.671)	(6.743)	(5.627)
Onion	-51.841 ***	381.619 ***	380.064 ***	407.881 ***	381.288 ***
	(5.674)	(9.438)	(9.437)	(11.212)	(9.273)
Pea	380.448 ***	-40.409 ***	-39.688 ***	-48.604 ***	-37.318 ***
	(9.424)	(7.079)	(7.077)	(8.404)	(7.049)
Potato	184.915 ***	187.021 ***	185.919 ***	208.080 ***	185.414 ***
	(5.448)	(5.429)	(5.465)	(6.489)	(5.377)
Wheat	-9.857	-8.292	-8.633	-9.668	-7.732
	(6.344)	(6.343)	(6.340)	(7.529)	(6.249)
Basins & sub-basins					
SR1	85.386 ***	91.400 ***	96.552 ***	114.139 ***	90.561 ***
	(9.225)	(10.643)	(10.707)	(12.725)	(10.622)
SR2	-17.704	19.540 *	30.319 **	39.336 ***	28.824 **
	(11.975)	(11.106)	(11.951)	(14.168)	(11.809)
SR3	-39.323 ***	-21.802 *	-21.308 *	-11.871	-26.881 **
	(12.215)	(12.540)	(12.552)	(14.896)	(12.333)
BOI	4.858	11.010	16.534	11.949	15.133
	(11.064)	(11.583)	(12.078)	(14.309)	(11.909)
BLA	13.072	16.995	21.855	25.787	25.582
	(26.381)	(26.959)	(26.999)	(32.075)	(26.109)
CAM	8.818	11.771	21.760	24.798	10.413
	(15.025)	(16.155)	(16.298)	(19.384)	(16.254)
SAL	-48.457 ***	165.768 **	151.432 **	172.470 **	174.736 ***
	(18.555)	(65.895)	(65.560)	(78.242)	(64.544)
Farm size					
50 to 99 acre	17.030 **	16.296 **	16.302 **	21.023 **	13.232 *
	(8.030)	(8.039)	(8.039)	(9.545)	(7.899)
100 to 499 acre	24.966 ***	22.893 ***	22.837 ***	30.980 ***	18.435 ***
	(7.215)	(7.243)	(7.230)	(8.596)	(7.077)
500 to 999 acre	51.647 ***	49.431 ***	47.557 ***	61.251 ***	42.828 ***
	(10.218)	(10.261)	(10.218)	(12.152)	(10.095)
1000 to 999 acre	72.484 ***	70.628 ***	67.641 ***	87.429 ***	60.398 ***
	(12.730)	(12.797)	(12.723)	(15.127)	(12.623)
>= 2000 acre	56.279 ***	56.527 ***	52.460 ***	74.441 ***	37.199 ***
	(13.817)	(13.860)	(13.818)	(16.432)	(13.719)
Growing Season (2007)	60.619 ***	61.793 ***	53.918 ***	-58.712 ***	62.479 ***
	(5.887)	(5.848)	(5.611)	(6.994)	(5.820)
Distance to Urbanized Areas	55.489 ***	31.017 ***	23.199 ***	24.508 ***	20.461 ***
	(7.289)	(5.837)	(6.603)	(7.829)	(6.473)
Distance to Major Waters	-2.482 ***	-2.359 ***	-2.223 ***	-2.580 ***	-2.187 ***
	(0.440)	(0.443)	(0.444)	(0.527)	(0.441)
Soil quality - Dominant type	-25.064 ***	-22.624 **	-20.175 **	-8.938	-24.433 ***
	(8.841)	(8.862)	(8.880)	(10.548)	(8.770)
Soil quality squared adjustment term	2.780 ***	2.486 **	2.194 **	0.852	2.700 ***
	(0.998)	(0.999)	(1.000)	(1.188)	(0.990)
# Observations:	32,545	32,545	32,545	32,545	32,545
Adj R-square	0.187	0.186	0.186	0.173	0.183

Note: Robust standard errors in parentheses

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Table B.8 Projected Losses In Crop Revenues Along the Snake River: Average Crop Revenue per Acre

Temperature		Surface water supply		Crop revenue
Mean	Volatility	Mean	Volatility	Gain/Loss
		Using estimates from model (1)		
+ 1 °C	- 0.5 °C	- 19.8%	+ 5%	-0.56
	- 0.5 °C	- 29.6%	+ 5%	-24.66
	+ 1.0 °C	- 29.6%	+ 5%	-195.51
	+ 1.0 °C	-44.2%	+ 5%	-231.40
+ 2 °C	- 0.5 °C	- 19.8%	+ 5%	3.24
	- 0.5 °C	- 29.6%	+ 5%	-20.86
	+ 1.0 °C	- 29.6%	+ 5%	-191.71
	+ 1.0 °C	-44.2%	+ 5%	-227.60
+ 3 °C	- 0.5 °C	- 19.8%	+ 5%	7.04
	- 0.5 °C	- 29.6%	+ 5%	-17.06
	+ 1.0 °C	- 29.6%	+ 5%	-187.91
	+ 1.0 °C	-44.2%	+ 5%	-223.80
		Using estimates from model (3)		
+ 1 °C	- 0.5 °C	- 19.8%	+ 5%	36.58
	- 0.5 °C	- 29.6%	+ 5%	28.36
	+ 1.0 °C	- 29.6%	+ 5%	-145.64
	+ 1.0 °C	-44.2%	+ 5%	-157.87
+ 2 °C	- 0.5 °C	- 19.8%	+ 5%	36.98
	- 0.5 °C	- 29.6%	+ 5%	28.76
	+ 1.0 °C	- 29.6%	+ 5%	-145.24
	+ 1.0 °C	-44.2%	+ 5%	-157.47
+ 3 °C	- 0.5 °C	- 19.8%	+ 5%	37.38
	- 0.5 °C	- 29.6%	+ 5%	29.16
	+ 1.0 °C	- 29.6%	+ 5%	-144.84
	+ 1.0 °C	-44.2%	+ 5%	-157.07

Note: We assume that carbon emissions, land uses, crop prices, water governance structures, and ground water levels are held constant, and the standard deviations of the temperature and water supply under actual 2002-2010 realizations. We also assume that the pattern of the standard deviation of water supply is based on observations from the past 100 years.

Table B.9 Long-Term Changes in the Depth to Ground Water at Irrigation Wells Across Idaho: Water Level Below Land-Surface Datum (LSD) (Unit: Feet) [1]

Well groups	Total # of wells	Percentage	5-year average water level		
			Beginning level	Ending level	% Change
By the ending level groups					
All Groups	865	100%	169.95	182.84	7.60%
(1) Depth to water (<= 0)	36	4.20%	-50.40	-35.80	29.00%
(2) Depth to water (0 ~ 25)	158	18.30%	10.70	12.30	15.00%
(3) Depth to water (25 ~ 50)	87	10.10%	33.34	37.46	12.40%
(4) Depth to water (50 ~ 100)	138	16.00%	65.36	71.38	9.20%
(5) Depth to water (100 ~ 200)	134	15.50%	133.93	147.90	10.40%
(6) Depth to water (200 ~ 300)	111	12.80%	226.28	246.70	9.00%
(7) Depth to water (> 300)	201	23.20%	458.42	483.55	5.50%
By the nature and magnitude of change					
Increase in water depth					
(1) Depth to water increase (0~1%)	29	3.40%	379.98	382.14	0.60%
(2) Depth to water increase (1~5%)	190	22.00%	346.46	355.72	2.70%
(3) Depth to water increase (5~10%)	138	16.00%	194.82	208.82	7.20%
(4) Depth to water increase (10~50%)	231	26.70%	112.23	134.75	20.10%
(5) Depth to water increase (> 50%)	93	10.80%	32.12	67.05	108.70%
Decrease in water depth					
(6) Depth to water decrease (0~1%)	12	1.40%	226.94	226.00	-0.40%
(7) Depth to water decrease (1~5%)	39	4.50%	174.30	170.08	-2.40%
(8) Depth to water decrease (5~10%)	22	2.50%	81.08	75.44	-7.00%
(9) Depth to water decrease (10~50%)	82	9.50%	29.82	24.09	-19.20%
(10) Depth to water decrease (> 50%)	29	3.40%	20.95	11.34	-45.90%
By the range of the years for the observation of each well					
(1) Observation period (20 ~ 30)	324	37.50%	144.54	153.86	6.40%
(2) Observation period (30 ~ 40)	177	20.50%	145.16	159.28	9.70%
(3) Observation period (40 ~ 50)	196	22.70%	181.52	194.96	7.40%
(4) Observation period (50 ~ 60)	112	12.90%	224.32	240.85	7.40%
(5) Observation period (> 60)	56	6.50%	246.02	266.60	8.40%

Note: The summary statistics are calculated by using irrigation wells with at least 20 years of observations. The beginning and ending levels of ground water depth are calculated as the average values of the first and the last five observations for these wells respectively.

[1] We have summarized the ground water levels at the individual irrigation wells from three perspectives: (1) By the ending level of the depth to water; (2) by the nature and magnitude of the change from the beginning level to the ending level; and (3) by the range of the duration for the observation for each well. Note that, the increase in depth to ground water indicates the decrease in ground water level. Irrigation wells in this data sample possess at least 20 years of measurements, which, however, may not have been taken continuously. We find that, in general, irrigation wells with relatively shallow water levels tend to have more change in depth over time. Irrigation well water levels have declined over time.