The Economic Benefits of Water Rights Adjudication: Evidence from Agricultural Land Sales in Western States

Ngoc Ha Do, University of Wisconsin Madison, ntdo2@wisc.edu

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Ngoc Ha Do*

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Abstract

Water is an essential but increasingly scarce resource, especially in the Western U.S., where climate change and institutional fragmentation make efficient water regulation challenging. Adjudication, a legal process to formalize and clarify water rights, has emerged as part of efforts to establish clearer and enforceable rights. Despite its potential economic and environmental benefits, empirical evidence of the impacts of water rights adjudication remain limited. In this paper, I examine the effects of irrigation water rights adjudication on agricultural land and rural home values in Idaho. Using a repeated sales sample and a newly compiled water rights dataset, I employ a hedonic pricing model to estimate capitalization effects of adjudicated appurtenant irrigation rights. The main finding show that adjudicated rights significantly increase land value. The treatment effect evaluated at the sample mean implies an increase in a parcel's land value by $381 per acre. Moreover, adjudication effects are highly heterogeneous. Parcels with more senior or larger rights gain more from this process. In particular, downstream-senior water users experience the largest benefits from adjudication. These findings suggest adjudication can enhance the market value of water but also introduce distributional concerns that should be carefully considered in the design of future water policies.

*University of Wisconsin - Madison, Email: ntdo2@wisc.edu

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1 Introduction

Water is an essential resource which fuels agriculture, supports a wide range of industries, and is fundamental to human life. In recent decades, global groundwater and surface water levels have been experiencing a rapid and steady deline. Despite these alarming trends, effective water management remains a significant challenge. This is partly due to fragmented and inconsistent governance, which makes coordinated action difficult to implement. On top of that, climate change (e.g., rising temperatures) is adding even more stress to already strained water resources.

The question of how to manage water efficiently has been widely discussed in the literature. Demsetz's seminal work (Demsetz, 1974) on property rights suggests that as the value of a resource increases, societies tend to move from common property to private property systems. The idea is that private rights allow markets to form, which in turn allocate water more efficiently to the users who value it most. In the Western U.S., the prior appropriation system is an example of private property rights. However, in practice, water rights are often incomplete (Ayres et al., 2021, Edwards et al., 2024). Insecure and poorly defined water institutions make it hard to enforce exclusivity, transferability, and ownership of a water right (e.g., Grainger and Costello, 2014, Edwards et al., 2024). This in turn can lead to problems such as over-extraction, inefficient use, and water conflicts.

Adjudication emerges as part of efforts to better define and formalize private water rights. This process is common in most prior appropriation states, such as Washington, Oregon, and Idaho. The general process starts with claimants filing their claims to the water, the court will then investigate the claim. Based on the available information, the court makes a decision to change, deny, or approve the case. The main outcome of the process is the decree that clearly specifies the water rights components.

Based on the nature of the adjudication process, adjudication could potentially help "complete" water rights. First, it can enhance exclusivity by giving legal recognition and protection to rights holders, which makes it harder for others to steal one's water. Second, it could improve transferability by formalizing rights that reduce uncertainty and transaction costs. Finally, adjudication strengthens ownership guarantees by clarifying who holds which rights and enforcing the seniority system.

As water stress intensifies in the West, it becomes more necessary to have clearer and enforceable rights, which is evidenced by the fact that many western states have made progress on adjudicating their water rights. However, adjudication is very costly and slow, usually taking decades to complete. For example, the most recent adjudication process in Washington, which takes place in the Yakima River Basin, takes more than 40 years to complete. Despite the huge cost associated with the adjudication process and its potential economic and environmental benefits, empirical evidence remains scarce. One of the most related papers is Browne and Ji (2023), which finds that adjudication increases the likelihood of water transfers in Idaho. In another paper by Ayres et al. (2021), it is found that agricultural land experiences higher values in an adjudication area that forms a market for groundwater. More empirical evidence on adjudication effects is thus needed to provide a better understanding of the benefits of clarifying water rights.

This paper investigates the effects of irrigation water rights adjudication on agricultural land and rural agricultural homes in Idaho. Using a repeated sales sample and a newly compiled water rights dataset, I compare the sales values of a parcel before and after its associated water rights are adjudicated through a hedonic estimation. A key advantage of the repeated sales approach is that it controls for unobserved, time-invariant characteristics of each parcel. The main findings show that adjudicated irrigation rights are capitalized into land values. Specifically, a one unit increase in the diversion rate, as measured by cubic feet per second, increases a parcel's land value by 0.24%. This effect, evaluated at the sample mean, implies an increase of $381 per acre. However, the effects are not distributed evenly across water right holders. I find that adjudication effects are larger for agricultural parcels with more senior rights and/or greater allocation. Additionally, there is heterogeneity in the effects of adjudication based on the hydrologic location of a water user (e.g., downstream versus upstream). Specifically, adjudication effects are higher for downstream water users, and these effects become larger the more senior the users are.

I also contribute to the literature on the value of water. There is evidence of the land value premium of groundwater access (Hornbeck and Keskin, 2014), groundwater stock (Sampson et al., 2019) and evidence of irrigation premium in High Plains Aquifer (Brozovic and Islam, 2010, Sampson et al., 2019, Edwards et al., 2024, Perez-Quesada et al., 2024). Other studies examine the impact of water regulations on agricultural land values and found mixed results (Ifft et al., 2018, Bigelow et al., 2020, Chaudhry et al., 2024).

I organize this paper as follows. Section 2 provides background information on Idaho water rights and water statutes. Section 3 provides a conceptual model of the main channels leading to the effects of adjudication and the their heterogeneity. Section 4 describes the process of selecting a repeated sales sample for land and housing transactions in Idaho, as well as the procedure for linking parcels to their associated water rights. This section also introduces the formulation of the "downstreamness" score. Section 5 outlines the empirical framework. Section 6 presents the results, and Section 7 concludes the paper.

2 Background Information

2.1 Idaho Water Rights and Water Statues

Idaho follows the prior appropriation doctrine, which essentially means "first in time, first in right". This means that water rights are prioritized based on the date when water is first put into a beneficial use, with earlier claims receiving seniority in times of shortage. Water rights in Idaho are typically defined by several main components: beneficial use, allocation, place of use, and priority date. These rights apply to both surface and groundwater, although surface water rights generally hold senior priority over groundwater rights.

Under Idaho law, water is appurtenant to the land where it is used. As a result, water rights are automatically transferred with the sale of the associated land. However, if water rights are to be transferred independently from the land, such separate transfers must be approved by the Idaho Department of Water Resources (IDWR).

2.2 Adjudication in Idaho

Idaho began its formal water rights adjudication process in the late 1980s, starting with three test basins to establish procedures. Priority was given to adjudicating irrigation rights, which represent the majority of water use, while domestic and stockwater rights were allowed to defer adjudication. As of 2022, over 80% of irrigation water rights in Idaho have been decreed, making it one of the most comprehensive adjudication efforts in the western United States.

3 Word Model

3.1 How Adjudication Enhances Land Value in Idaho?

In Idaho, water is appurtenant to the land, meaning the value of a water right is directly tied to the land it irrigates. Adjudication enhances land value by securing and clarifying the terms of the water right (e.g., allocation, point of diversion, and priority date). This reduces uncertainty and increases the completeness of the right, which subsequently makes land assets less risky and more attractive for investment. In addition, adjudication stabilizes water supply and usage by ensuring reliable access, which supports long-term farm planning and productivity. Another important channel is through the enhancement of both the transferability and option value of water rights. By formalizing rights and reducing transaction costs, adjudication allows for greater flexibility in transferring water, even if the owner does not immediately intend to sell or lease the right. However, this value is only realized when the right is also secure. If the right is uncertain, the ability to transfer is less meaningful, thus the land value is also affected. Through simultaneous increases in the security and tradability of water rights, adjudication can improve the values of agricultural land.

3.2 Heterogeneous Treatment Effects

Adjudication does not affect all water rights holders uniformly. In practice, the impact varies depending on specific components of the water right and the hydrologic context in which it is exercised. Main characteristics such as the size of the allocation (e.g., diversion rate), seniority, and the type of beneficial use (e.g., irrigation vs. domestic) all shape the magnitude of adjudication's effects. For example, one might expect the effects of adjudication to be larger for irrigation rights holders than for domestic users, whose water use accounts for an significant share of overall consumption.

Table 1: Predicted Signs of Adjudication's Net Effects

Post Adjudication	**Upstream**	**Downstream**
Senior	• (−) Stricter enforcement • (+) Seniority order is respected → Net effects: *unclear*	• (+) More protection • (+) Seniority order is respected → Net effects: *positive (+)*
Junior	• (−) Stricter enforcement • (−) Seniority order is enforced → Net effects: *negative (−)*	• (≈) Stricter enforcement; more protection • (−) Seniority order is enforced → Net effects: *unclear (≈)*

≈ denotes an unclear sign.

Moreover, the physical location of the water user within the hydrological system, particularly whether they are upstream or downstream, can influence their ability to actually exercise their rights. In theory, under a fully enforced regime where each user is monitored and guaranteed their allocation, physical position should not determine water access. However, in practice, since enforcement and monitoring are often weak or limited, upstream users, who have the first access to water, may divert more than their share, which leaves downstream users with reduced access. In addition, during periods of water scarcity, when seniority is intended to determine the order of access, a user's physical position could interact with seniority in shaping the actual outcomes of adjudication. This interaction creates heterogeneous treatment effects of adjudication across different groups of users and make the net effects of adjudication unclear for certain group of users.

Table 1 presents the predicted signs of adjudication's net effects across four types of water users, categorized by their physical location (upstream vs. downstream) and their priority status (senior vs.

junior). The net effects appear to be most clearly identifiable for downstream-senior and upstream-junior users.

For instance, in the case of downstream-senior users, the pre-adjudication period, which is characterized by weak enforcement, often disadvantages them. Upstream users can divert water first, reducing downstream access. Furthermore, in times of scarcity, the lack of enforcement means that seniority is not reliably respected, leaving senior users with no guarantee of receiving their full allocation. After adjudication, however, these users benefit from stronger institutional protection and clearer enforcement of seniority rights. This results in the in positive net effects of adjudication.

In addition to estimating the main treatment effects, this paper also explores the heterogeneity in adjudication's impact across main components of water rights, including seniority, allocation amount, and the upstream or downstream location of a water user.

4 Data

4.1 Data Source

Data in this paper comes from many different sources.

Property and Land Sales Data I use two CoreLogic datasets: one on agricultural land sales transactions and another on property characteristics. The transactions dataset includes information on individual property sales, such as the buyer and seller, sale date, sale amount, and a unique property identifier. I use this identifier to link each transaction to CoreLogic's property characteristics dataset, which provides details such as parcel size (acres), number of bathrooms and bedrooms, number of buildings, year built, land use type, and property type. The dataset also includes latitude and longitude coordinates for each property, which I later use to link transactions to parcel boundaries and water rights data. To complement the CoreLogic property characteristics data, especially when I suspect that there is missing information, I scrape property details for these transactions using the Zillow Detail Scraper API from Apify. Zillow's data offers similar property attributes, allowing me to fill gaps and improve the completeness of the dataset. The final dataset includes transactions from 1985 to 2022.

Water Rights Data I use multiple sources to compile detailed information on water rights. First, I obtain publicly available shapefiles from the Idaho Department of Water Resources (IDWR) that include water rights Place of Use (POU) polygons and Point of Diversion (POD) point layers. Each POU and POD record contains key attributes such as the water right number, basin number, priority date, decreed (adjudicated) date, current owner, beneficial use, total irrigated acres, and water source (e.g., groundwater). The dataset includes a total of 177,762 water rights, where in many cases, a water right can be used for multiple purposes. There are 51,375 irrigation rights, which accounts for about 29% of the total number of rights. The remaining rights are rights for other uses such as domestic and stock water. Second, to complement this data, I use Python to scrape the Water Right Reports website from IDWR by water right number. The scraped data includes current and previous owners and allocation details. Specifically, allocation information provides diversion rate limits for each beneficial use (measured in cubic feet per second), and in some cases, volume limits (acre-feet per annum). I then link these two sources to create a comprehensive, novel dataset that captures a universal sample of water rights in Idaho.

Parcel Boundaries Data I use parcel boundaries data from Real Estate USA, which provides polygon shapefiles for all land parcels in Idaho. Similar to CoreLogic's property data, each parcel includes detailed information such as parcel ID, address, parcel owner, land cover, crop cover, and parcel size. This dataset allows me to spatially link property transactions and water rights to specific parcels for further analysis.

Weather Data I utilize temperature and precipitation data from the Parameter-elevation Regressions on Independent Slopes Model (PRISM) Datasets, developed by Oregon State University's PRISM Climate Group. PRISM provides high-resolution raster datasets at a 4 km by 4 km scale across the United States. The most recent continuous PRISM data begins in 1981, and historical data are also available prior to that year. In my analyses, I primarily use data from 1980 onward.

National Hydrography Dataset (NHD) I use the National Hydrography Dataset from the U.S. Geological Survey, which provides detailed information on water bodies and drainage networks across the United States. Since Idaho is located within the Pacific Northwest (Region 17) and Great Basin (Region 16) hydrologic regions, I focus exclusively on data from these areas. The dataset's primary unit is the stream segment, with information on upstream and downstream connections for each segment. I use this information later in the paper to delineate hydrologic relationships among water users in Idaho.

Annual National Land Cover Database (NLCD), Collection 1.0. I use the Annual NLCD, Collection 1.0, which provides consistent land use and land cover data for the conterminous United States from 1985 to 2023. This dataset offers annual land cover classifications that I use to identify agricultural land within the full sample of property transactions. The sample selection process is described in more detail in Section 4.2.

4.2 Repeated Sales Sample Selection

In this paper, the construction of the repeated sales sample involves a number of filtering steps, which I summarize in Table 2. This table provides a brief description of each step, the number of observations removed, and the remaining sample size after each filter.

I begin with the full sample of property sales in Idaho. This broad starting point is motivated by the observation that many agricultural land transactions in the state involve significant improvements. In particular, it is common in rural Idaho for large parcels to combine agricultural uses (e.g., pasture for cattle grazing) with residential structures on the same property. Relying solely on CoreLogic's land use classification would limit the sample to bare or unimproved agricultural land, thereby excluding many properties that hold both agricultural value and associated water rights.

To address this, I use all available information to construct a more comprehensive sample of agricultural properties. This includes land use and property characteristics from CoreLogic, spatial boundaries from the parcel dataset, and land cover classifications from the Annual NLCD. By integrating these sources, I identify both pure agricultural land and rural agricultural properties with improvements, better capturing the full range of agricultural land transactions relevant to water rights in Idaho.

To account for the structure of the CoreLogic transactions data, I first group individual transactions into transaction groups. This is because in this dataset multi-parcel sales are often recorded as separate entries, each assigned the full transaction amount rather than a parcel-level price. Using information on the seller, sale date, and sale amount, I group transactions that likely belong to the same underlying sale event. I exclude transaction groups identified as foreclosures and restrict the sample to transactions occurring after 1985. To reduce the influence of within-year structural changes, such as major improvements or redevelopments that might inflate prices, I drop transaction groups in which the maximum parcel price within a given year is at least 1.5 times greater than the minimum price in the same group. This removes a total of 46,346 observations from the full set of sales.

Next, I restrict the dataset to a repeated sales sample, focusing on properties or parcels that were sold more than once during the study period. The initial sample contains 376,840 observations. Since repeated sales are more reliably tracked at the single-parcel level, I exclude multi-parcel sales, which reduces the sample by 2,183 observations. I further clean the data by removing transactions where the parcel address in the transactions dataset does not match the address in the property characteristics dataset, or where the address is missing altogether. This step removes an additional 58,633 observations. Finally, I drop duplicate entries where a property was sold for the same amount within the same year, eliminating 138 observations.

At this point, the repeated sales dataset consists of 310, 489 observations. However, not all of these represent agricultural land or agricultural properties. I link each property to the parcel boundaries dataset using geocoded latitude and longitude coordinates and then aggregate land cover information from the NLCD at the parcel level. I remove parcels where the land cover type is classified exclusively as "developed"[1]. To focus on properties with potential agricultural use, I further restrict the sample to parcels larger than one acre[2]. These filters reduce the repeated sales dataset to 25,120 observations.

Next, I refine the sample using the land use classification provided by counties, as recorded in the County Code column of the CoreLogic property characteristics dataset. I remove properties identified as industrial[3], commercial or common area[4], and exempt properties. This step removes 214 observations.

To further exclude non-agricultural properties, I remove parcels where the NLCD data show no cropland or pasture, and where CoreLogic's land use code is not agriculturally related. This results in the removal of 7,052 additional observations. Finally, I exclude parcels with less than 10% of their land area classified as cropland or pasture and that also lacks an agricultural land use code in CoreLogic. This final filter removes an additional 1,015 observations. Additionally, I remove transactions where the price per acre exceeds $2,000,000, as these likely reflect outliers or non-agricultural sales. I also exclude sales where there is potentially missing information on whether the sale involved multiple parcels. The final repeated sales dataset consists of 16,572 observations, all of which are arm's-length transactions that reflect market values.

4.3 Link Water Rights to Transactions

To link water rights to land transactions, I overlay Place of Use (POU) polygons with parcel boundary polygons. I begin by removing water rights whose POUs overlap with less than 50% of the parcel's area.

[1] This group includes "Developed Open Space", "Developed Low Intensity", "Developed Medium Intensity", and "Developed High Intensity" according to NLCD classification.

[2] Later in the paper, I show that the effects of adjudication vary by parcel size.

[3] This includes codes such as "IND", "INDUST", "INDUSTRIAL", "COMM/IND", "IMPR/INDUSTRIAL", "IMPROV.CAT 14/IND", and "INDUSTL".

[4] This includes "COMMON AREAS NO VALUE", "COMM", "COM", "COMMERCIAL", "IMPR/COMMERCIAL", "COMM/IND", "RURAL/COMM", and "COMMON AREA".

Table 2: Repeated Sales Sample Construction

Step	Description	Removed	Remaining
1	Exclude foreclosures, limit to post-1985 sales, and remove sales with major improvements	46,346	376,840
2	Remove multi-parcel sales	2,183	374,657
3	Drop transactions with missing or mismatched addresses	58,633	316,024
4	Remove duplicate sales (same amount, same year)	138	315,886
5	Keep repeated sales only (sold $>$ 1 time)	190974	124,912
6	Remove parcels with only developed land cover (NLCD) or $<$ 1 arce	99792	25120
7	Remove industrial, commercial, common area, and exempt properties	214	24,906
8	Remove parcels with no pasture/cropland and no ag-related land use code	7,052	17,854
9	Remove parcels with <10% pasture/cropland and no ag-related land use code	1,015	16,839
10	Remove extreme outliers ($>$ $2M/acre) and unclear multi-parcel indicators	267	**16,572**

Note: Removed and remaining units in the last 2 columns are observations, not properties.

For the remaining cases, I classify the relationship between a water right and a parcel into three tiers of match quality, based on the extent of overlap and the presence of a Point of Diversion (POD) within the parcel. The criteria used and the associated match classifications are summarized in Table 3.

In Table 3, a match level of 3 indicates a high-confidence relationship in which the parcel boundary and the water right closely align. Specifically, Condition 1 refers to cases where the parcel and water right boundaries are nearly identical. Condition 2 allows for more flexibility, which includes cases where the water right overlaps less than 85% but more than 50% of the parcel area. Condition 3 permits even smaller overlaps, where the right covers less than 50% of the parcel. In these three cases, there is a higher likelihood that the water right boundary is fully nested within the parcel boundary. Figure 1 provides an illustration of these cases. Water right boundaries are shown as blue lined polygons, while the underlying shaded polygons represent the parcels.

In some cases, water rights are defined at the Public Land Survey System (PLSS) quarter-quarter level, which may include multiple parcels. However, only one parcel is linked to the water right. To address this, I use the POD map to keep only the parcel within which the POD is located. These cases correspond to Conditions 4 and 5.

Table 3: Matching logic used to link water rights to parcels

Condition	Matching Description	Quality Level
1	The parcel and the water right both substantially overlap each other (each covers more than 85% of the other).	3
2	85% of the water right overlaps, and at least 50% of the parcel overlaps.	3
3	85% of the water right overlaps, less than 50% of the parcel overlaps.	2
4	85% of the parcel overlaps, and a POD is detected within the parcel.	1
5	At least 50% of the parcel overlaps, and a Point of Diversion is detected within the parcel.	1
6	All other cases (insufficient overlap or no POD detected).	0 (excluded)

To ensure the validity of these matches, I manually verified them by comparing the most recent owner of the parcel to the most recent owner of the associated water right [5].

Figure 1: Link Water Rights with Parcels

4.4 Downstream Score Formulation

To quantify the relative position of each water user within Idaho's hydrologic network, I construct a "downstreamness" score for every irrigation water right in the state. This measure captures the extent to which a given water right is downstream relative to others.

[5] I was able to manually verify these matchings using ownership names for most cases, except a few. In Idaho, although water rights ownership changes are legally required, this process is often forgotten or delayed

I begin with compiling all irrigation rights and their associated PODs across Idaho into a single, interconnected system. Using the National Hydrography Dataset (NHD), I then calculate a downstreamness ratio for each POD, defined as the number of inflowing connections to the point divided by the total number of both inflowing and outflowing connections:

$$\text{Downstreamness Score} = \frac{\#\text{Inflow Nodes}}{\#\text{Inflow Nodes} + \#\text{Outflow Nodes}}$$

This score is normalized to lie between 0 and 1. A value of 0 indicates a point that is entirely upstream (i.e., it diverts water but has no upstream sources). A value of 1 indicates a point at the end of the system (i.e., water flows into it but does not flow out to other users).

Figure 2 provides an illustrative example. At the top of the system, the most upstream POD has only outflows and no inflows, so its score is 0. A midstream POD, which receives flow from one upstream node and supplying water to four others, receives a score of 0.2. The bottom most POD, with one inflow and no outflows, receives a score of 1.

As a water user's score increases, it indicates that they are situated further downstream in the irrigation network and are thus more reliant on upstream flows. This formulation allows me to assign a continuous measure of "downstreamness" to each water right in Idaho's system.

In some specifications, I also construct a distance-weighted downstreamness score to account for the spatial arrangement of water users along the stream network. Instead of simply counting the number of inflow and outflow nodes, this alternative measure weights each node by its distance from the point of diversion.

Specifically, I calculate the average distance of all inflowing nodes to a given point, and the average distance of all outflowing nodes from that point. The distance-weighted downstreamness score is then defined as the ratio of the average distance of inflow nodes to the sum of the average distances of inflow and outflow nodes. Like the unweighted version, this score is normalized to lie between 0 and 1, with higher values indicating a more downstream location.

4.5 Weather Data Aggregation

I aggregate annual temperature and precipitation data from PRISM to each parcel in the repeated sales sample. Furthermore, following the approach used in prior literature (e.g.,), I construct rolling 5-year averages of temperature and precipitation for each parcel. This captures medium run climate conditions that are likely to influence land and property values.

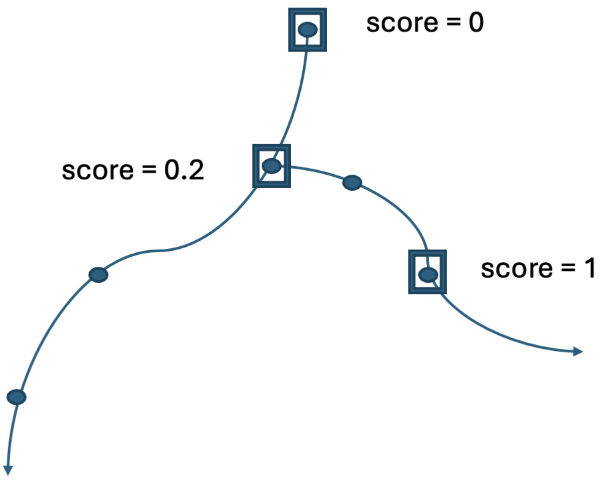

Figure 2: Example of a Water System and Downstreamness Score

5 Empirical Framework

5.1 Treatment Effects

I employ a DiD framework and a repeated sales sample to examine the causal effects of adjudication on land values. The regression equation is as follows:

$$log(\frac{price}{acre})_{it} = \alpha * post_{it} + \beta X'_{it} + \mu_i + \gamma_{county-year} + \epsilon_{it} \tag{1}$$

In Equation 1, the left-hand side variable is the log of price per acre of property i in year t. The main explanatory variable of interest, $post_{it}$, is a post-treatment indicator that equals 1 for observations after adjudication. In alternative specifications, I define the treatment as a continuous measure, which can be either the decreed allocation amount, seniority of the right, or the number of associated adjudicated rights. X'_{imt} is a vector of control variables, including weather controls (e.g., temperature and precipitation) and a dummy for structural improvements. I add property fixed effects μ_i to account for time-invariant unobserved characteristics of each property. I also include county-by-year fixed effects $\gamma_{county\text{-}year}$ to capture region-specific temporal trends that might confound the treatment effect.

5.2 Heterogeneous Treatment Effects

In this section, I investigate the heterogeneous treatment effects of adjudication by examining specific aspects of water rights. These include the decreed water rights' allocation, seniority, the number of decreed rights associated with a property, and the physical location of the water rights (e.g., downstreamness). To explore these dimensions, I interact the main treatment indicator, $post_{it}$, with each of these factors separately. The specification maintains the same vector of control variables and fixed effects as in Equation 1.

$$log(\frac{price}{acre})_{it} = \alpha * post_{it} + \beta * post_{it} * Z_{it} + \gamma * Z_{it} + \rho X'_{it} + \mu_i + \gamma_{county-year} + \epsilon_{it} \quad (2)$$

In Equation 2, Z_{it} can be either allocation, seniority, number of rights and downstreamness score.

6 Results

6.1 Treatment Effects

Table 4 presents the hedonic estimates for irrigation water rights based on Equation 1, using a sample of all parcels that are at least one acre in size. The results suggest a positive effect of the number of decreed irrigation rights on land value (column (2)), as well as an expected positive effect of seniority (column (3))[6]. However, these effects are statistically imprecise. The only consistently significant effect appears in column (1), where the decreed amount of water allocation, measured by the diversion rate (in cubic feet per second, CFS), is positively associated with land value. Specifically, each additional decreed CFS increases the price per acre by approximately 0.24%. The sample mean of the diversion rate of irrigation rights in this sample is 0.28, so the treatment effect evaluated at the mean implies an increase of approximately $381 per acre.

Table 4: Hedonic Estimates for Irrigation Rights

	Treatment Effects			
	(1)	(2)	(3)	(4)
post	-0.0015			
	(0.0362)			
post x #_IRR_rights		0.0208		
		(0.0378)		
post x seniority			0.0000	
			(0.0000)	
post x diversion				0.0024***
				(0.0008)
Adjusted R^2	0.847	0.847	0.847	0.847
Observations	14028	14028	14025	14028

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
All specifications (columns) include property fixed effects, county-year fixed effects, and control variables (weather and improvement dummy). The sample used includes all parcels that are at least one (1) acre in size.

[6]Seniority is measured by the age of the water right in years; thus, more senior rights are expected to be more valuable.

Table 5 reports estimates from Equation 1, similar to Table 4, but based on samples restricted by parcel size. The results from both the ≥ 2-acre and ≥ 5-acre samples indicate that most water right components have no statistically significant effect on land value [7]. However, the number of decreed irrigation rights has a significant positive effect in the ≥ 5-acre sample. Specifically, each additional adjudicated irrigation right increases price per acre by 13%.

Table 5: Hedonic Estimates for Irrigation Rights for Sample of Different Parcel Sizes

	≥ 2-acre Sample				≥ 5-acre Sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
post	-0.0303				0.1654			
	(0.0530)				(0.1295)			
post x #_IRR_rights		-0.0022				0.1320*		
		(0.0452)				(0.0760)		
post x seniority			0.0000				-0.0001	
			(0.0000)				(0.0001)	
post x diversion				-0.0007				-0.0005
				(0.0015)				(0.0025)
Adjusted R^2	0.782	0.782	0.782	0.782	0.746	0.746	0.746	0.746
Observations	6833	6833	6830	6833	2735	2735	2732	2735

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
All specifications (columns) include property fixed effects, county-year fixed effects, and control variables (weather and improvement dummy).

6.2 Heterogeneity

Table 5 illustrates the heterogeneous effects of different components of water rights including seniority, diversion rates, and the number of rights, on land value. The results show consistent and statistically significant heterogeneity in the effects of adjudication through both seniority and diversion, but not through the number of rights. Specifically, post-adjudication increases land values (as shown in columns (2) and (5)), and these effects are more pronounced when the rights are more senior and/or have larger allocations (higher diversion rates).

When I restrict the sample to parcels larger than 2 acres (Table 7) and more than 5 acres (Table 8), the results show that the heterogeneous effects of adjudication through seniority remain consistent and statistically significant only in the sample of parcels larger than 2 acres. In contrast, for parcels larger than 5 acres, there appears to be no significant heterogeneity in the effects of adjudication through diversion rates and the number of rights.

[7] The estimated effects of diversion and seniority are economically small, with magnitudes ranging from 0.0% to 0.07% increases in land value.

Table 6: Hedonic Estimates for Irrigation Rights for $\geq$ 1-acre Sample

	Diversion or Seniority			Diversion and Seniority	
	(1)	(2)	(3)	(4)	(5)
post	-0.2460	11.1249**	-0.0551		10.9418**
	(0.2193)	(5.2854)	(0.0427)		(4.9716)
post x #_IRR_rights	0.2118				
	(0.1945)				
post x seniority		0.0057**		0.0000	0.0056**
		(0.0027)		(0.0000)	(0.0025)
post x diversion			0.0031***	0.0032***	0.0031***
			(0.0009)	(0.0009)	(0.0007)
Adjusted R^2	0.847	0.847	0.847	0.847	0.847
Observations	14028	14025	14028	14025	14025

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
All specifications (columns) include property fixed effects, county-year fixed effects, and control variables (weather and improvement dummy). The sample used includes all parcels that are at least one (1) acre in size.

Table 9 presents the heterogeneous treatment effect estimates based on the physical location of water right holders, specifically their downstreamness. As shown in Columns (2) and (4), water users located further downstream experience greater benefits from adjudication. Moreover, the positive effects are larger when the water right holder is also more senior. This finding aligns with the hypothesis proposed in Section 3.2, which suggests that senior water users located downstream are more likely to benefit from adjudication.

7 Conclusion

This paper examines the impact of irrigation water rights adjudication on agricultural land values in Idaho. The findings indicate that adjudication positively affects land value, with one additional CFS increasing price per acre by 0.24%, which is equivalent to approximately $381 at the sample mean. However, these gains are not evenly distributed. Heterogeneous effects suggest that more senior and higher-volume rights gain greater value increases, particularly for smaller parcels (less than 5 acres). Furthermore, senior rights holders located downstream benefit the most. These results highlight that, while adjudication enhances the market value of water, it also raises distributional concerns that should be carefully considered in the design of future water policies.

Table 7: Heterogeneity for ≥ 2-acre Sample

	Diversion or Seniority			Diversion and Seniority	
	(1)	(2)	(3)	(4)	(5)
post	-0.2481	7.9925*	-0.0256		7.9884*
	(0.2411)	(4.6647)	(0.0779)		(4.6845)
post x #_IRR_rights	0.1856				
	(0.1996)				
post x seniority		0.0041*		0.0000	0.0041*
		(0.0024)		(0.0000)	(0.0024)
post x diversion			-0.0003	-0.0003	-0.0002
			(0.0025)	(0.0025)	(0.0025)
Adjusted R^2	0.782	0.782	0.782	0.782	0.782
Observations	6833	6830	6833	6830	6830

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
All specifications (columns) include property fixed effects, county-year fixed effects, and control variables (weather and improvement dummy). The sample used includes all parcels that are at least two (2) acre in size.

Table 8: Heterogeneity for ≥ 5-acre Sample

	Diversion or Seniority			Diversion and Seniority	
	(1)	(2)	(3)	(4)	(5)
post	0.0032	7.0889	0.2558		5.7196
	(0.5705)	(5.5539)	(0.2101)		(7.0404)
post x #_IRR_rights	0.1298				
	(0.4067)				
post x seniority		0.0036		-0.0001	0.0028
		(0.0029)		(0.0001)	(0.0037)
post x diversion			-0.0042	-0.0042	-0.0037
			(0.0035)	(0.0036)	(0.0040)
Adjusted R^2	0.746	0.746	0.746	0.746	0.746
Observations	2735	2732	2735	2732	2732

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
All specifications (columns) include property fixed effects, county-year fixed effects, and control variables (weather and improvement dummy). The sample used includes all parcels that are at least five (5) acre in size.

Table 9: Heterogeneity through Downstream Location

	≥1-acre Sample			≥5-acre Sample
	(1)	(2)	(3)	(4)
post x downstream	-0.1726	57.2312*	-0.2243	208.7465***
	(0.1369)	(29.1019)	(1.0523)	(57.0740)
post x seniority x downstream		0.0293*		0.1072***
		(0.0148)		(0.0292)
Adjusted R^2	0.846	0.846	0.742	0.742
Observations	14009	14006	2721	2718

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
All specifications (columns) include property fixed effects, county-year fixed effects, and control variables (weather and improvement dummy).

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