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An Econometric Test of Water Market Structure in the Western United States

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ABSTRACT

Water markets form differently across the western United States, depending on the relative importance of water supply uncertainty and impediments to water transfers. In many locations, trades take the form of short-term leases of water, allowing the underlying property rights to remain unaffected. In other regions, water right transfers predominate. We quantify the relative effects of economic, hydrologic, and state-level institutional variables on a water agency's decision whether to lease or purchase water rights. Econometric analysis of 3,806 transactions reported in the Water Strategist over 1990 supports the conclusion that market structure varies across states in accordance with local hydrologic and economic conditions. These conditions call for alternative forms of economic organization to achieve efficiency.

I. INTRODUCTION

Over the past several decades, western U.S. states have implemented institutions and regulations to facilitate water transfers from low-value rights holders to higher-value purchasers. Since the earliest demonstrations of theoretical gains from water markets,[1] much work has been done to quantify the efficiency gains realized in practice.[2] However,

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1. *See* L. M. Hartman & D. A. Seastone, Water Transfers: Economic Efficiency and Alternative Institutions (1970).

2. H. J. Vaux, Jr. & Richard E. Howitt, *Managing Water Scarcity: An Evaluation of Interregional Transfers*, 20 Water Resources Res. 785 (1984); *see also* Robert R. Hearne & K. William Easter, *The Economic and Financial Gains from Water Markets in Chile*, 15 Agric. Econ. 187, 187–99 (1997).

the emphasis on aggregate efficiency gains leaves the exact means of achieving the transfers uninvestigated. A monthly trade journal called the *Water Strategist*[3] records details of water transfers that take place across the western United States, making it possible to examine the influence of economic and hydrologic variables on the style of trading. This data source also allows for analysis of the effects of institutional characteristics on trading patterns. In describing transaction cost economics, Williamson notes that the differences in the attributes of transactions account for the variety of economic institutions we observe.[4] Furthermore, location-specific economic and hydrologic characteristics also play a significant role in how trading patterns develop.

Water transfers fall into two broad categories. First, the transfer of a water right may grant the purchaser the flow of water every year in perpetuity. Second, a water transfer may be in the form of a lease, granting the purchaser a pre-specified volume of water for the term of the lease. Leases may be "short-term" (one year or shorter) or "long-term" (longer than one year). Leases may be similar to spot market transactions, with negotiations occurring close in time to the physical transfer of water. They may also be negotiated in advance of need as forward contracts.[5] Leases of twenty years or longer, with provisions for renewal, more closely resemble water rights transfers than short-term leases. Lastly, leases may also be dry-year options, allowing for water transfers only in dry years when economic value is particularly high.

The aforementioned water transfer schemes raise the following questions: what factors do water agencies consider when deciding whether to purchase or lease a water right; do different conditions in different states affect the probability of opting for one type of transaction over the other; and how do various institutional, economic, and hydrologic factors affect the probability of opting for a sale or a lease?

Literature on a firm's choice of short-term loans or long-term bonds as a source of funding resonates in the situation studied here.[6] The problem also shares key features with the make-or-buy literature of transaction-cost economics, such as when a medical equipment firm manufactures a key valve itself rather than ordering it from an indepen-

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3. *The Water Strategist,* Stratecon, Inc., (Jan. 1990–Dec. 2010).

4. OLIVER E. WILLIAMSON, THE ECONOMIC INSTITUTIONS OF CAPITALISM 4 (1985).

5. A forward contract is an arrangement where buyer and seller agree to transfer an asset at a specified future time and price. By contrast, a spot contract is one in which buyer and seller transfer the asset immediately. John C. Hull, Options, Futures, and Other Derivatives 3–4 (7th ed. 2009).

6. D. J. Aigner & C. M. Sprenkle, *On Optimal Financing of Cyclical Cash Needs*, 28 J. FIN. 1249 (1973); *see also* Gary W. Emery, *Cyclical Demand and the Choice of Debt Maturity*, 74 J. BUS. 557 (2001).

dent machine-tool shop.[7] However, quantitative analysis of the make-or-buy decision is rare. It is also difficult to make comparisons across firms and industries when other parties' actions are uncertain, investment is transaction-specific, and transaction frequency varies. Water markets mitigate some of the difficulties for quantitative analysis by providing buyers and sellers with a discrete choice between leases and sales. This discrete choice makes observation of their choices cleaner and generalization possible.

This article investigates the style of water transfers within western water markets with reference to 3,806 transactions from 1990 to 2010 compiled from a monthly trade journal called the *Water Strategist*. The *Water Strategist* reported rights transfers and leases (including price, quantity, buyer and seller identification, buyer and seller use, and some additional contract terms) in sixteen western states on a monthly basis through 2010. We have examined the effects of some economic and hydrologic variables on water market activity and price by using the data collected from the *Water Strategist*.[8] Previously, no study has attempted to quantify the effects of these variables on the interaction between the rights and lease markets. With the details of transactions contained in the *Water Strategist* and the incorporation of additional economic, hydrologic, and institutional variables, this article explores the reasons why leases prevail in some states and sales prevail in others.

II. WESTERN WATER MARKETS

Two primary sources of heterogeneity among water users in the western United States contribute to the value differentials that induce trading. First, precipitation in the western United States is characterized

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7. Howard A. Shelanski & Peter G. Klein, *Empirical Research in Transaction Cost Economics: A Review and Assessment*, 11 J.L. ECON. & ORG. 335, 341 (1995); *see also* Peter G. Klein, *The Make-or-Buy Decision: Lessons from Empirical Studies*, *in* HANDBOOK OF NEW INSTITUTIONAL ECONOMICS 435–36 (C. Ménard & M. Shirley eds., 2005).

8. *See* John B. Loomis et al., *Expanding Institutional Arrangements for Acquiring Water for Environmental Purposes: Transactions Evidence for the Western United States*, 19 J. Water Resources Dev. 21, 24 (2003); *see also* David S. Brookshire et al., *Market Prices for Water in the Semiarid West of the United States*, 40 Water Resources Res. W09S04, 5 (2004); Richard E. Howitt & Kristiana M. Hansen, *The Evolving Western Water Markets*, 20 Choices 59, 61 (2005); Thomas C. Brown, *Trends in Water Market Activity and Price in the Western United States*, 42 Water Resources Res. W09402, 2 (2006); Jedidiah Brewer et al., *2006 Presidential Address Water Markets in the West: Prices, Trading, and Contractual Forms*, 46 Econ. Inquiry 91 (2008); Kristiana M. Hansen, Richard E. Howitt & Jeffrey Williams, *Water Trades in the Western United States: Risk, Speculation, and Property Rights*, *in* Water Trading and Global Water Scarcity: International Perspectives 55, 66–67 (J. Maestu ed., 2013).

by great spatial and temporal variation.[9] Second, many water rights holders utilize their water in relatively low-value agriculture, whereas many urban agencies and environmental users do not have enough water and are willing to pay high prices to acquire it.[10] Conversely, water has a number of characteristics that have complicated trading. First, conveyance costs constitute a large portion of delivered water price, as water can be cumbersome and expensive to transport.[11] Second, the high degree of interaction among water users often results in environmental and physical externalities.[12] Third, sellers of agricultural water often fallow their fields, causing negative economic impacts in the basin-of-origin.[13] Fourth, regulatory requirements are often imposed expressly to limit and prevent environmental externalities and to protect against negative economic impacts in the basin-of-origin.[14] Other state-imposed restrictions on transferring water exist simply due to inertia, carryover from a time when water was plentiful enough that its allocation rarely

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9. *See* Cary J. Mock, *Climatic Controls and Spatial Variations of Precipitation in the Western United States*, 9 Journal of Climate 1, 111 (1996); David P. Brown & Andrew C. Comrie, *A Winter Precipitation 'Dipole' in the Western United States Associated with Multidecadal ENSO Variability*, 31 Geophysical Research Letters L09203, 1–3 (2004).

10. Loomis et al., *supra* note 8, at 26–27; Hansen et al., *supra* note 8, at 60, Table 4.3.

11. *See, e.g.*, Hansen et al., *supra* note 8, at 59; CAL. DEP'T OF WATER RES. (CDWR), MANAGEMENT OF THE CALIFORNIA STATE WATER PROJECT, II BULLETIN 132-02 (Sacramento, Cal. 2004).

12. *See* Susan M. Burke et al., *Water Banks and Environmental Water Demands: Case of the Klamath Project*, 40 WATER RESOURCES RES. W09S02 9 (2004). An externality occurs when a decision maker's actions affect another individual or firm but these actions are not compensated or paid for in an amount equal in value to the resulting benefits or costs. *See also* William J. Baumol & Wallace E. Oates, The Theory of Environmental Policy (2nd ed., 1988) The difficulties of measuring and monitoring water and the significant degree of interaction among water users contribute to the large number of externalities within water markets. *Id.* The interaction of groundwater users on an aquifer is a classic case of physical externality. One water user's groundwater pumping lowers the aquifer and affects the ability of a neighboring rights holder to access the water. *See* Bill Provencher & Oscar Burt, *The Externalities Associated with the Common Property Exploitation of Groundwater*, 24 J. Envtl. Econ. & Mgmt. 139, 139–40 (1993).

13. These negative impacts are generally measured in terms of reduced employment and secondary processing and packing of harvested crops. *See* Bonnie G. Colby, *Transaction Costs and Efficiency in Western Water Allocation*, 72 Am. J. Agric. Econ. 1184, 1185 (1990); *see* Richard E. Howitt, *Empirical Analysis of Water Market Institutions: The 1991 California Water Market*, 16 Res. and Energy Econ. 357, 362 (1994); Charles W. Howe & Christopher Goemans, *Water Transfers and Their Impacts: Lessons from Three Colorado Water Markets*, 39 J. Am. Water Res. Ass'n. 1055, 1062–63 (2003) (providing examples in Arkansas, California, and Colorado).

14. Ellen Hanak, *Stopping the Drain: Third Party Responses to California's Water Market*, 23 Contemp. Econ. Pol'y. 59, 59–60 (2005).

involved a trade-off between existing low value and potential higher-value uses.[15]

In spite of these hindrances, water's increasing relative scarcity has intensified efforts to move water from low-value to high-value uses through some type of trade. In many western states, leases are common. Leases face less stringent legal restrictions than rights transfers due to their less hazardous environmental and third-party impacts. This is because water transferred temporarily causes less disruption in the exporting basin and community than water transferred permanently.[16] The prevalence of short-term leases in many states may be a response to artificial impediments to rights transfers. Alternatively, leases may be the preferred type of transaction for purchasers responding to changing economic and hydrologic conditions in the short-term.

Water law in the western United States follows the doctrine of prior appropriation, so that water claimed earlier in time has greater seniority on a waterway than water claimed later; in the event of a drought, rights with seniority receive water before more junior rights, making them more valuable.[17] For example, in 2001 the Metropolitan Water District of Southern California (MWD) acquired 100,000 acre-feet of water under long-term lease from the Palo Verde Irrigation District, which has very senior rights to Colorado River water. The seniority of the water rights was an important aspect of the transaction because supply reliability is of primary importance to urban water agency managers.[18] Seniority is less an issue for short-term leases because short-term leases generally occur when the water is already physically present and available, regardless of the seniority of the underlying right.

Recent studies of water market transaction data report common themes in western U.S. water markets. More volume is transferred under lease than under sale,[19] though market studies tend to inflate the importance of leases by counting long-term leases and sales only once in the transaction year.[20] Irrigators are the largest sellers of rights and leases,

15. R. Maria Saleth & Ariel Dinar, The Institutional Economics of Water, A Cross-Country Analysis of Institutions and Performance 8–10 (2004).

16. Richard E. Howitt, *Spot Prices, Option Prices and Water Markets*, Markets for Water: Potential and Performance 119, 137 (K. W. Easter, M. W. Rosegrant & A. Dinar eds., 1998).

17. *See* A. Dan Tarlock, James N. Corbridge, Jr., David H. Getches & Reed D. Benson, Water Resource Management, A Casebook in Law and Public Policy 159 (6th ed. 2009).

18. Interview with Margot Selig, Water Resources Economist, Bureau of Reclamation Lower Colorado Region (2008); *see also* Denise Lach, Helen Ingram & Steve Rayner, *Maintaining the Status Quo: How Institutional Norms and Practices Create Conservative Water Organizations*, 83 TEX. L. REV. 2027, 2032, 2036–37 (2005); Hansen et al., *supra* note 8.

19. Howitt & Hansen, *supra* note 8, at 61; Brown, *supra* note 8, at 4–5; Brewer et al., *supra* note 8, at 104; Hansen et al., *supra* note 8, at 56, Table 4.1.

20. Brewer et al., *supra* note 8, at 99; Hansen et al., *supra* note 8, at 58.

while municipalities are the largest buyers of rights.[21] Public agencies and non-profit organizations increasingly purchase water to augment environmental in-stream flows for fisheries and recreation.[22]

Prices paid for municipal water are higher than prices paid for irrigation or environmental purposes.[23] Urban water agencies generally have the financial resources to pay higher prices for water, and their constituents demand a high level of water supply reliability.[24] One would expect that as market volume increases, competition would equalize prices paid across sectors.

The ratio of lease price to sale price within a market provides insight into the ease of implementing transfers within a market. If water markets had no transaction costs, risk, or uncertainty, a water user would be indifferent to borrowing money to purchase a water right or leasing water every year from the short-term lease market.[25] Studies find the overall lease-to-sale price ratio to be well below the market cost of borrowing money.[26] Several factors explain the low lease-to-sale price ratio. Leases within the agricultural sector tend to occur at administratively set prices. Municipal buyers are also willing to pay (and agricultural sellers demand) a premium on water rights to gain a reliable supply source rather than rely on the uncertainty of future lease markets.[27] The absence of equilibrium between lease and sale prices across states is also consistent with the hypothesis that water market institutions tend to emphasize either lease or sale markets, but rarely both. This is not surprising since lease and sale markets for water have different types and levels of externalities.

The data indicates substantial variation in market volume and price, largely due to differences in institutional arrangements. Most importantly, trading activity is greatest where rights are homogeneous.[28] Under a homogeneous rights system, alternatively known as a proportional or correlative rights system, all shares within a watershed, ditch company, or water conservancy district receive the same amount of

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21. Brown, *supra* note 8, at 5; Brewer et al., *supra* note 8, at 105, Table 4; Hansen et al., *supra* note 8, at 60–61, Table 4.3.

22. Loomis et al., *supra* note 8, at 27; Hansen et al., *supra* note 8, at 60, Table 4.3.

23. Brown, *supra* note 8, at 9, Table 6; Hansen et al., *supra* note 8, at 60, Table 4.3.

24. Lach et al., *supra* note 18, at 2032–33; Hansen et al., *supra* note 8, at 61

25. Howitt & Hansen, *supra* note 8, at 62; Brown, *supra* note 8, at 8; Brewer et al., *supra* note 8, at 110; Hansen et al., *supra* note 8, at 59.

26. *See* Howitt & Hansen, *supra* note 8, at 62; Brown, *supra* note 8, at 8; Brewer et al., *supra* note 8, at 101–102; and Hansen et al., *supra* note 8, at 59.

27. *See* Howitt & Hansen, *supra* note 8, at 61.

28. *See, e.g.*, Janis M. Carey & David Sunding, *Emerging Markets in Water: A Comparative Institutional Analysis of the Central Valley and Colorado-Big Thompson Projects*, 41 NAT. RESOURCES J. 283, 302 (2001).

water. In a dry year when not all water rights can be fully satisfied, homogeneous shares are curtailed equally. This product homogeneity simplifies the priority relationship between shares, thereby facilitating transfers.[29] Brown and Brewer et al. observe that differences in transaction costs associated with legal impediments to trading and regulatory requirements seem to account for differences in trading patterns across states and recommend further analysis to quantify the effects.[30]

Generally, these findings suggest that water markets comprise three types of buyers and one type of seller. The first buyer type is a municipal water agency who primarily uses water markets to secure long-term supply to meet projected future growth, or to "firm up" existing water supplies.[31] It follows that urban water demand is price inelastic.[32] Even when the annualized purchase price is higher than the lease price, the urban agency buys rights as it considers the reliability of water supply to be of utmost importance.[33] These observations suggest that urban agencies prefer to avoid the uncertainty involved in acquiring sequential short-term leases.

The second buyer type is a high-value agricultural producer with a more elastic demand than an urban agency.[34] As long as substituting away from water-intensive crops on short notice remains an option, this buyer type is likely to be in the market only during dry periods when their own supplies are low.[35] Agricultural producers of perennial crops (for example fruit and nut trees) may also be in need of water during dry years to protect their capital investment, as failing to adequately irrigate a perennial crop during a dry year has implications for the crop's profitability in subsequent years. Due to the intermittent nature of their excess demand for water and also because the environmental and third-party costs associated with water rights purchases raise the annualized cost of a water rights purchase above the cost of a one-period lease, this type of buyer is more likely to lease than to buy.

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29. *See* Brown, *supra* note 8, at 1–2; Howe & Goemans, *supra* note 13, at 1059; *see* Carey & Sunding, *supra* note 28, at 302.

30. Brown, *supra* note 8, at 4–5; Brewer et al., *supra* note 8, at 110.

31. *See* Hansen et al., *supra* note 8, at 61–63.

32. *See* Jasper M. Dalhuisen et al., *Price and Income Elasticities of Residential Water Demand: A Meta-Analysis*, 79 Land Econ. 292 (2003) (conducting a meta-analysis of residential water demand study that finds an average price elasticity of -0.41, though estimates of residential elasticity of water demand vary greatly depending on season and location, time horizon, and retail pricing structure).

33. *See* Hansen et al., *supra* note 8, at 59.

34. *See* Karina Schoengold, David L. Sunding & Georgina Moreno, *Price Elasticity Reconsidered: Panel Estimation of an Agricultural Water Demand Function*, 42 Water Resources Res. W09411, 1–2 (2006) (estimating an agricultural demand elasticity of -0.79).

35. *See generally* Howitt, *supra* note 13, at 59–62.

The third buyer type is state and federal agencies that purchase water to augment instream flows for the support of fish and wildlife habitat. Environmental use purchases can happen through programs established specifically for environmental purposes or through markets more broadly.[36] This buyer shares some characteristics with the other two buyer types. Like an urban buyer, an environmental manager has a relatively inelastic demand and a relatively high penalty for being short of water. Likewise, similar to a high-value agricultural producer, its excess demand is relatively responsive to short-term fluctuations in precipitation. All three buyer types share a need for reliable water supplies—whether to meet municipal water supply obligations, protect agricultural capital investment, or maintain important fish and wildlife habitat—and are often able to pay relatively high water prices to ensure that they meet their objectives.

By contrast, sellers tend to be low-value agricultural producers. They can either transfer water rights and stop or reduce agricultural production or they can lease out water in dry periods, maintaining their ability to use the water as an agricultural input in wet and normal periods. Agricultural producers prefer to lease out water rather than sell their rights because they prefer to avoid reliance on the spot market to acquire water supplies in future years.[37] Further, the environmental and third-party costs of water transfers are greater for sales than for leases, since the latter is only a temporary disruption to the local environment and economy.[38] Both of these factors contribute to a price premium on rights transfers relative to leases. This hurdle price reflects the future uncertainty of water availability.

These broad characterizations of water market participants suggest some of the relationships we expect to observe among the economic, hydrologic, and institutional variables that persist in a particular market and inform a water agency's decision to buy or lease a water right.

36. In 2003 the United States Bureau of Reclamation (USBR) implemented a temporary water bank in the Klamath River Basin (southern Oregon and northern California) to protect three fish endangered fish species. The Bureau of Reclamation purchased the water from irrigators, who idled land and pumped groundwater to make the water available. Burke et al., *supra* note 12. The Environmental Water Account (EWA) in California is another example of a program established specifically for environmental benefit. The EWA is a fund established by the CALFED Bay-Delta Program through which state and federal fishery managers could purchase water in real time to help fisheries during critical periods. Hanak, *supra* note 14, at 15–17. Even before the EWA was established, the California Department of Water Resources (CDWR) purchased water for environmental purposes during the 1988–94 drought through a temporary bank sponsored by CDWR that also benefitted other water users. *Id*. at 17.

37. See generally Howitt, *supra* note 13, at 360.

38. *Id* at 359, 364.

First, we expect that the lease-to-sale volume ratio depends on realized precipitation because lower levels of precipitation would increase reliance on temporary water markets. We anticipate that leasing activity is a function of the size of the variance of inter-annual precipitation, as higher levels of chronic uncertainty may lead to greater reliance on leases, all else being equal. We also anticipate that leasing activity is a function of the value of agricultural production, as higher production value would increase water's value in the agricultural sector[39] and raise the likelihood that water would be retained for on-farm use rather than offered for sale in the temporary lease market.

Second, an increase in anticipated future growth is expected to increase water rights purchases, as municipal agencies would prefer to rely on water rights rather than leases to meet projected increased demand.[40] We might also expect to see an increased reliance on leases in areas where growth has already been significant, following the sale of easy-to-access water rights and the public opinion's opposition to additional rights transfers.[41]

Third, water rights purchase activity may also be a function of agricultural land value. Agricultural land in proximity to urban areas has higher value than more remote agricultural lands.[42] Higher land values due to increased agricultural productivity may also indicate higher opportunity cost of selling water,[43] thereby lowering the amount of water offered for sale by agriculture. In either case, high agricultural land value would likely lead to increased relative water-leasing activity.

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39. ROBERT A. YOUNG, DETERMINING THE ECONOMIC VALUE OF WATER (Steven Jent ed. 2005).

40. Lach et al., *supra* note 18, at 2032–33.

41. Hanak, *supra* note 14, at 61–62.

42. The theoretical competitive land market model of Dennis R. Capozza & Robert W. Helsley, *The Fundamentals of Land Prices and Urban Growth*, 26 J. Urb. Econ. 295, 304–305 (1989), demonstrates that proximity to urban areas increases agricultural land value above agricultural land rents (specifically, above the value of generated by using the land to agricultural purpose), primarily due to the expected future growth of land rents that is expected to occur when land is converted from agricultural to urban use. Numerous empirical studies have subsequently born out this finding. *See, e.g.*, Andrew J. Plantinga et al., *The Effects of Potential Land Development on Agricultural Land Prices*, 52 J. Urb. Econ. 561, 576 (2002); Tamer Isgin & D. Lynn Forster, *A Hedonic Price Analysis of Farmland Option Premiums Under Urban Influences*, 54 Can. J. Agric. Econ. 327, 339 (2006).

43. *See, e.g.*, James R. Wasson et al., *The Effects of Environmental Amenities on Agricultural Land Values*, 89 Land Econ., 466, 472–73, Table 6 (2013) (finding that the presence of irrigated pasture lands, reflecting increased rangeland productivity, increases land value).

Finally, transaction costs can dampen market activity.[44] Colby defines transaction costs as the costs necessary to acquire regulatory approval including attorneys' fees, engineering and hydrologic studies, court costs, and fees paid to state agencies.[45] The process of quantifying how much water can be transferred under a water right without harming other rights holders, for example, can be expensive and time-consuming. Such costs are necessary, as water rights holders must generally demonstrate to the appropriate state agency or court that other appropriators will not be harmed when they seek to transfer water.[46]

However, this "no harm" rule is relaxed in several western states to facilitate short-term transfers during dry seasons or years. More specifically, in some cases state laws have been modified so that requirements to prove no harm to other rights holders are relaxed or eliminated for short-term transfers.[47] Such changes tend to minimize the cost and time required to acquire approval for a lease relative to a permanent transfer.[48] In such jurisdictions, we would expect to observe greater reliance on leases, all else being equal.

Table 1 summarizes the causal relationships discussed thus far. Each row of the table indicates the name and description of a variable hypothesized to affect the likelihood of observing sales versus leases in a particular time or place along with a theoretical prediction of the relationship. For example, in locations and times with high agricultural production value ($\uparrow$), we predict relatively low leasing activity ($L \downarrow$), for the reasons discussed above whereas in locations with high agricultural land value ($\uparrow$), we predict relatively low buying activity ($B \downarrow$). The presence of transaction-specific information within the *Water Strategist* for both sales and leases allows us to examine the effects of both long-term variables (which affect rights transfer activity) and short-term variables (which affect leasing activity) on the decision whether to participate in a water market.

44. Robert A. Young, *Why Are There So Few Transactions Between Water Users*, 68 AM. J. AGRIC. ECON. 1143, 1145 (1986); *see also* Colby, *supra* note 13; Brookshire et al., *supra* note 8, at 2.

45. Bonnie G. Colby, *Economic Impacts of Water Law—State Law and Water Market Development in the Southwest*, 28 NAT. RESOURCES J. 721, 725 (1988).

46. David H. Getches, Water Law in a Nutshell (1997).

47. In some states, laws have been changed to explicitly protect water from abandonment when it is leased in the short term.

48. Lawrence J. MacDonnell & Teresa A. Rice, *Moving Agricultural Water to Cities: The Search for Smarter Approaches*, 14 Hastings W.-NW. J. Envtl. L. & Pol'y 105, 106–107 (2008).

III. DATA AND METHODS

The *Water Strategist* often records multiple transactions within a single entry. We have separated these entries into distinct observations when possible, so that our own database for the years 1990 to 2010 consists of 5,777 observations. However, not all of these observations are directly relevant to the decision whether to buy or lease a water right. We exclude exchange and storage contracts, retail transactions, options that are not known to have been exercised, transactions in which water price or volume transferred is not indicated, and transactions involving land and water where water is not priced separately. We also exclude states with minimal trading volume (Kansas, Montana, Nebraska, North Dakota, Oklahoma, Wyoming). We present the statistics on the remaining 3,806 observations in the following section.[49]

Table 2 summarizes transaction, volume, and price activity, by state.[50] Between 2004 and 2010 we observe a decline in sale prices and an associated increase in the implicit capitalization rate, likely due to declining economic conditions over the same period. The implicit capitalization rate (Table 2 column 10), which is the ratio of annual lease price to total sale price, varies significantly across states, indicating disequilibrium between the lease and sale markets in given states. The lease-to-sale ratio (Table 2 column 7), also indicates remarkable variation in trading patterns.

One might expect to see a systematic relationship between the implicit capitalization rate and the lease-to-sale ratio; jurisdictions in which it is difficult to lease might experience lower capitalization ratios, reflecting increased demand in the rights market. However, no such pattern exists. Unlike conventional commodities such as cars and real estate, the externalities and environmental impacts associated with water transfers tend to be different for water rights transfers versus leases. Furthermore, transfers and leases differ geographically, a fact reflected in states' different capitalization ratios. Brown suggests that further analysis on the factors influencing these ratios would be of value.[51] We perform that analysis by exploring the relative impact of various economic, hydrologic, and institutional variables on water market patterns.

To explore the reasons for the variation in this ratio, we assemble indicators for local economic, hydrologic, and regulatory conditions. Hydrologic conditions argue for a basin-level analysis, yet variables captur-

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49. *See* Hansen et al., *supra* note 8, at 57–58 for more details on database construction.

50. Brown, *supra* note 8, thoroughly analyzes the descriptive statistics for the period 1990–2003. We find qualitatively similar results for that period.

51. Brown, *supra* note 8, at 14–15.

ing economic and regulatory conditions primarily exist at the county and state levels. Table 1 (rightmost column) indicates names of variables used in the analysis. The descriptions presented here are for state-level variables; the county-level variables are constructed in a similar fashion.

The variables *AgProdn* and *AgLand* capture the statewide opportunity cost to agricultural producers associated with participating in the market. The variable *AgProdn* is an index indicating percentage deviation from the state's average annual value of production per acre over the study period. The variable *AgLand* is the state-level, average per-acre value of farm real estate over the study period.[52]

The variable *Bld* is the number of building permits issued for each state in the sample, weighted by state population. Generally speaking, only urban areas require developers to acquire permits. The variable *BldStock* indicates long-term urban development pressure.[53]

We utilize the Palmer Drought Severity Index (PDSI) to capture the response of water markets to changing weather conditions.[54] The PDSI is a monthly hydrologic drought index measuring the severity of dry and wet spells. It takes into account precipitation, evapo-transpiration, and soil moisture conditions. PDSI values below zero indicate drought conditions and those above zero indicate relatively wet conditions. We create two drought variables from the PDSI. The variable *PDSI* reflects hydrologic conditions at the time of the transfer. It is the average of the PDSI values of the six months prior to a transaction. This variable registers the effect of short-term fluctuations in supply on the sale-to-lease ratio. The variable *PDSIcvar* is the coefficient of variation for each state's annual PDSI values. This variable registers the effect of expected variability in supply on market activity across different locations. Note that the PDSI is calculated for each National Oceanic and Atmospheric Administration (NOAA) climatic division, of which there are between four and ten per state in the study area. The variables *PDSI* and *PDSIcvar* are constructed from the mean PDSI value of all climatic divisions within a state.

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52. Agricultural Census Data, NATIONAL AGRICULTURAL STATISTICAL SERVICE, U.S. DEP'T OF AGRIC. (1992, 1997, 2002, and 2007), http://quickstats.nass.usda.gov/.

53. The United States Census Bureau estimates that less than two percent of all privately owned housing units constructed are built in areas that do not require permits. This variable thus adequately represents the increased pressure on municipal areas to meet the water needs of a growing urban population. Building Permits Survey, U.S. CENSUS BUREAU, U.S. DEP'T OF THE INTERIOR (2012), http://www.census.gov/construction/bps/.

54. Palmer Drought Severity & Crop Moisture Indices, NATIONAL OCEANIC AND AERONAUTICAL ADMINISTRATION, U.S. DEP'T OF COM. (2012), http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/cdus/palmer_drought/ (further data available at ftp://ftp.cpc.ncep.noaa.gov/htdocs/temp2/).

The variable *Expedite* is equal to 0 when state law requires that leases undergo the same procedures to demonstrate no harm to other rights holders for a water rights transfer; otherwise, the variable is equal to 1. Table 3 indicates which states have relaxed the no harm rule for short-term leases or otherwise expedited the short-term lease approval process.[55] For example, in 1999 the California Legislature required that the State Water Resources Control Board complete their review of short-term leases (one year or less) within one year, which was relatively short compared to the average long-term transfer approval time.[56] In 2002, the Colorado Legislature enacted legislation to allow the state engineer to approve changes to water rights without court approval, formal hearings, or other proceedings for transfers of five years or less.[57] Changes like these are incorporated into the variable *Expedite*, making it time-variant. We are not aware of significant changes in state law or regulations elsewhere in the study area.

The variable *Taf* is the transaction-specific quantity of water transferred, measured in thousand acre-feet. We also control for differences in population (*Popn*) and income (*Inc*) over time and between geographical locations. The variable *Time* controls for any time variant trends that may exist over the entire dataset.

State-level explanatory variables may be misleading because the realistic scope of a water market is smaller than a state's borders due to geography and high conveyance costs. To complement state-level analysis (in which state-level economic and hydrologic variables are denoted by the prefix *st*), we assign transactions to NOAA climatic divisions and counties based on the location of the purchasing agency. We cannot credibly assign many of the transactions to a specific county and climatic division due to lack of information in the *Water Strategist.* Restricting the county-level analysis to transactions (for which location can be identified) likely introduces bias. An alternative approach would be to assign transactions to the local NOAA climatic division, as these may better reflect meaningful hydrologic distinctions between markets. However, this would likely introduce additional bias in cases where an agency has access to reservoir or aquifer storage in a different climatic division. In

55. *See* MacDonnell & Rice, *supra* note 48, at 113; *see also* ADAM SCHEMPP, WESTERN WATER IN THE 21ST CENTURY: POLICIES AND PROGRAMS THAT STRETCH SUPPLIES IN A PRIOR APPROPRIATION WORLD, (2009), http://www.elistore.org/reports_detail.asp?ID=11349; TODD DOHERTY & RODNEY T. SMITH, WATER TRANSFERS IN THE WEST: PROJECTS, TRENDS, AND LEADING PRACTICES IN VOLUNTARY WATER TRADING, (2012), http://www.circleofblue.org/waternews/wp-content/uploads/2012/12/Western-Governors_Water-Transfers-in-the-West-2012.pdf.

56. Schempp, *supra* note 55; CAL. WATER CODE § 1726.

57. COLO. REV. STAT. § 37-92-308(4)(a).

short, the less precise state-level analysis with many transactions and the more targeted county-level analysis with fewer transactions together illuminate the decision to lease or buy a water right. County-level economic and NOAA climatic division-level hydrologic variables are denoted by the prefix *cn*.

We construct a binary discrete choice model to test the relative effects of the variables described above on the decision to lease or buy a water right.[58] We employ two specifications at each geographical resolution. In the first, the dependent variable is equal to 1 when the transaction is a rights transfer, and otherwise is equal to 0. In the second, the dependent variable is contract length rather than contract type, with the dependent variable equal to 1 for longer-term transactions and equal to 0 for short-term transactions lasting one year or less.

IV. RESULTS

Empirical results are largely consistent with theoretical expectations. We begin with a discussion of the contract type results. Because the dependent variable is a discrete variable that takes the value 1 for a sale and 0 for a lease, a positive sign on a coefficient indicates an increase in the probability of observing a sale, or a decrease in the probability of observing a lease. Tables 4 and 5 contain results for the state-level and county-level specifications, respectively. Model fit improves with county-level explanatory variables.[59] Model fit improves further with the addition of state-specific indicator variables (Table 5 columns (2) and (4)). The Arizona state indicator variable is equal to 1 when a transaction occurs within Arizona and 0 otherwise. These variables capture effects that cannot easily be quantified and included explicitly in the analysis. We focus discussion of specific explanatory variables on Table 5 because

58. Binary discrete choice models are a class of models in which the dependent variable takes on a value of 0 or 1. The independent variables included in the analysis explain the likelihood of observing either 0 or 1 in the dependent variable. The specific discrete choice model employed in this analysis is a maximum likelihood logit model. WILLIAM H. GREENE, ECONOMETRIC ANALYSIS 635–44 (2nd ed. 1993).

59. Goodness of fit measures provide an indication of how well the model explains variation in the dependent variable. We provide three goodness-of-fit measures for each specification in Tables 4 and 5. The log pseudo-likelihood is the maximized value of the log-likelihood function. The pseudo-R^2 value indicates the percentage of variation in the dependent variable that is explained by the model. The fraction of concordant pairs indicates the percentage of the time that the model predicts the dependent variable's value (0 or 1) correctly. Thus specifications with relatively high log pseudo-likelihood and pseudo-R^2 values and with concordant pair fractions closer to 1 have a better fit, and higher predictive value. All three measures are problematic for discrete choice analysis but taken together, they provide the best available indication of model fit. Greene, *supra* note 58, at 651–52.

inclusion of county-level explanatory variables improves the fit of the model.

An increase in volume traded leads to a decrease in the probability of sales relative to leases. This negative coefficient is expected, since the transferred volume is greatest in response to dry water years. This negative relationship may also reflect the fact that leases must be renewed each year to make up a long-term volume comparable to a sale, which is only recorded once in a database encompassing transactions rather than cumulative volume transferred. The coefficient on transaction-specific volume and its level of statistical significance tend to be greater in the contract type relative to the contract length specifications; ultimately, transaction size is more likely to influence contract type than contract length.[60]

We specify a possible interaction between the value of agricultural production variable *AgProdn*, and an indicator variable equal to 1, when water use before the transfer was agricultural, to capture the fact that agricultural production value is only likely to affect transfers from agriculture. (The variable *AgLand* is not interacted, since land value may affect transfers from of other water uses as well.) As predicted, an increase in the value of agricultural production decreases the probability of observing a lease; farmers are more likely to retain water for use on-farm when the expected value of agricultural production is relatively high. When the coefficient on *AgLand* is statistically significant, it indicates the long-term opportunity cost of selling water; farmers would be expected to sell water rights in response to a decrease in the value of agricultural land.

We also specify a potential interaction between the urban growth variables *Bld* and *Bldstock* with an indicator variable equal to 1 when water use after the transfer is municipal. Results are largely consistent with theoretical expectations. The coefficient on *Bld* is positive and statistically significant in most specifications, indicating that urban growth prompts agencies to secure more water rights relative to leases. This finding corresponds with anecdotal evidence gleaned from the *Water Strategist's* transaction descriptions, which indicates that municipal agencies prefer to purchase water rather than lease in response to projected growth. The fact that *Bld* is negative and statistically significant in the second state-level specification suggests that municipal agencies may

60. Statistical significance is a component of hypothesis testing that allows the analyst to determine, with a reasonable level of confidence, whether a relationship between an explanatory variable and the dependent variable really exists or whether it occurred by chance. If a variable is statistically significant at the 5 percent level, for example, there is only a 5 percent probability that the relationship occurred by chance alone.

have to meet growth in the short-run with short-term contracts, while they acquire longer-term supplies.[61] We had expected that high levels of cumulative water market activity would cause increased leasing activity, though in fact, the qualitative results on *BldStock* were mixed.

Short-term leases are more likely to occur in drought years than during wet and normal years (*PDSI* is positive and statistically significant in all specifications). The variable *PDSIcvar* suggests that higher variability increases the probability of observing short-term lease activity, though the coefficient on *PDSIcvar* tends to be smaller than that on *PDSI* and less likely to be significant. The less compelling results for *PDSIcvar* are not surprising, because one might easily predict a higher probability of sales in locations with greater variability in precipitation, as water users invest more in storage infrastructure in locations with greater variability in precipitation. A better measure of water availability would take into account existing storage and transportation infrastructure as well as reservoir levels.

The results for the variable *Popn* are somewhat ambiguous. In most specifications, the coefficient attached to *Popn* is negative. Once state-level fixed effects are included in the county analysis (Table 5 columns 2 and 4), this tendency is absorbed into the state-level fixed effects. The positive coefficients on *Popn* in those specifications is consistent with the observation that jurisdictions with large populations are often required to demonstrate long-term water supply before new construction can occur. The variable is more statistically significant in the contract length specification than the contract type specification; population is more important in explaining contract length than contract type. This is consistent with our hypothesis that water rights are more difficult to acquire than long-term contracts due to the transaction costs and externalities associated with rights transfers (discussed above).

The coefficient on the variable *Inc* indicates that markets with higher income levels tend to observe sales rather than leases. This is not surprising given that buyers in these markets would be better able to generate sufficient revenue to pay the purchase price, which tends to be higher, in annualized terms, than the lease price. Once county-level economic and hydrologic data has been accounted for in the analysis (Table 5), the sign on the variable *Time* is positive.

The transaction costs that make rights transfers more difficult to consummate than leasing arrangements likely explain the increased probability of observing long-term contracts—but not necessarily rights transfers—over time. There is insufficient variation in the data at the state level to isolate the effect of expedited lease procedures on the

61. *See* Doherty & Smith, *supra* note 55.

probability of observing leases. However, in all county-level specifications, the variable *Expedite* indicates an increased probability of short-term leases where states have streamlined the approval process for such transfers. The addition of county-level data appears to improve the predictive power of the model, in spite of the decreased number of observations available at that resolution.

State laws designed to expedite leases intend to minimize transaction costs associated with transferring water in instances where harm to the environment, other rights holders, and the exporting region is likely to be minimal or non-existent. It is beyond the scope of this analysis to determine whether the leases facilitated by such laws have in fact left other parties unharmed. However, the current findings indicate that such laws do have a significant impact on water trading patterns across the western United States.

State-specific indicator variables capture institutional differences between states that are not easily encapsulated in the explanatory variables for which we have quantitative measures. These variables dramatically improve the fit of the county-level specifications. State-level differences in water market institutions do affect the decision of water users to utilize the rights versus lease markets.

For example, the negative and positive signs on the California and Colorado coefficients, respectively, are consistent with differences between those two states' largest water projects. The Central Valley Project of California is comprised of many water districts whose water rights are priority rationed, all of which makes leases easier to implement than rights transfers. By contrast, the Colorado-Big Thompson project operates as a single water district within which rights are allocated proportionally, which facilitates rights transfers.[62] Another example is the negative coefficients for Oregon and Washington, which are likely driven in part by the tax benefits associated with transferring water rights at zero prices (resulting in relatively more leases than sales included in the regression analysis).

Water transfer price is noticeably absent from the economic specifications. We do not include prices in the empirical analysis because we only observe the price for the selected contract form and not the alternative. However, the variables that influence the choice of contractual form are available to us and are therefore included in the analysis. The variable capturing the seniority of a water right is also missing from our analysis. The *Water Strategist* did not report this information. However, the experience in one region for which data is available supports the conclusion that more senior water rights are more likely to be transferred than

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62. *See* Carey & Sunding, *supra* note 28, at 302.

less senior water rights. In the Rio Grande River Basin in Texas, an irrigation water right for one acre-foot can be either Class A, yielding 0.5 acre-feet for municipal use, or Class B yielding only 0.4 acre-feet for municipal use.[63] All transfers from this region in our database that are identified as Class A are rights transfers out of agriculture for municipal use. Half of the more junior Class B transactions are rights transfers or long-term leases from agriculture to municipal use, whereas the other half are short-term leases between agricultural users.

A more realistic characterization of a water agency's decision to acquire or sell water through a water market would be a nested logit specification. This specification would allow analysis of two related decisions: first whether to acquire or sell water through a water market at all, and second, for those who answer the first question yes, whether to enter the sale or lease market.[64] However, the only data on overall consumptive use available for the western United States are estimates made by the United Stated Geological Survey (USGS) once every five years.[65] This data source is not sufficiently detailed, either spatially or temporally, to generate meaningful results with the nested logit specification.[66]

These data shortcomings notwithstanding, the explanatory variables included here indicate that economic, hydrologic, and institutional variables have a strong, measurable impact on the decision whether to lease or buy a water right. Additionally, the state-level indicator variables demonstrate that differences in the level and importance of water market externalities between states also play a role in explaining the differences in the pattern of water markets across western states. Of the specifications presented in the analysis, those presented in Table 5 columns 2 and 4 exhibit the best goodness-of-fit.

It could be argued that differences in water market institutions between states exist because some states made poor choices in the past that, while seemingly inconsequential at the time, have resulted in present-day institutions that are inefficient. This path to dependency, or

63. Water Strategist, *supra* note 3, at 2–9 (JUL/AUG 1992).

64. By contrast, the logit specification used in this analysis ignores the first decision whether to participate, which is less ideal. *See* A. Colin Cameron & Pravin K. Trivedi, Microeconometrics: Methods and Applications 507 (2005) (noting that the logit and nested logit specifications are both examples of discrete choice modeling).

65. Estimated Use of Water in the United States, U.S. GEOLOGICAL SURVEY, U.S. DEP'T OF THE INTERIOR (2009), http://pubs.usgs.gov/circ/1344/pdf/c1344.pdf.

66. We also hypothesized that the annual percentage of water consumed within a state indicated likelihood of market participation, and that annual percentage would have an effect on the probability of observing sales versus leases within the logit specification. The consumptive use variable generated from the USGS data did not have a statistically significant effect; the variable was consequently removed from the analysis.

lock-in to a particular inefficient path, could perhaps have been avoided if measures had been taken at some point in the past to avoid the small, inconsequential steps that led to the inferior economic outcome.[67] If this were the case, then states whose water market institutions facilitate water rights transfers would be demonstrably more efficient than those whose institutions favored leasing. States who favored leasing would be merely exhibiting a path dependence that prevented them from realizing the full welfare gains that would derive from increased water rights transfer activity, which is a form of market failure.

However, before we could claim that states that favor leasing exhibit market failure, we would need to demonstrate that they could have implemented some alternative course of action, at reasonable cost, that would have increased efficiency.[68] Given the variety of economic and hydrologic conditions and the different water market institution features that exist across states (we have only isolated one that was sufficiently simple to include in quantitative analysis), it would be impossible to identify and advocate a single recipe for efficient water market development across the western United States. Recall how well our empirical model fits the data. The model's goodness of fit suggests that the institutional paths the different states took reflect the meaningful differences differentiating the states, rather than their failure to choose the more efficient path.

V. CONCLUSION

In this article, we employed a discrete choice model to test theoretical expectations about the influence of economic, hydrologic, and institutional variables on the style of water market activity, whether lease or sale. According to Oliver E. Williamson, whose research seeks to understand how agents choose among different contracting possibilities given the prevailing property rights regime, two tasks must be accomplished: first, the analyst must answer the question of why behavior among agents differs and determine the characteristics of the governance structures from which agents may choose; second, the analyst must generate ideas about what different types of agents will do, and corroborate these ideas with data. We addressed these two tasks in this article.

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67. Brian Arthur, *Competing Technologies, Increasing Returns, and Lock-In by Historical Events*, 99 Econ J. 116, 116–17 (1989); *see also* Stan J. Liebowitz & Stephen E. Margolis, PATH DEPENDENCE, Encyclopedia of Law and Economics, Volume I. The History and Methodology of Law and Economics 981–98 (B. Bouckaert & G. De Geest, 1999).

68. Oliver E. Williamson, *Transaction Cost Economics and Organization Theory*, 2 Indus. & Corp. Change 107, 140–41 (1993); Stan J. Liebowitz & Stephen E. Margolis, *Path Dependence, Lock-in and History*, 11 J. L. Econ. & Org. 205, 206–07 (1995).

In a study on the important role of institutions in shaping trading activity, we should note that our data source the *Water Strategist* is an institution that may itself have influenced water prices, quantity and contract terms, through increasing information available to market participants. Although one should remain concerned that the data may not be comprehensive of all trades that have occurred in the western states, the analysis here supports the idea that transactions reported by the *Water Strategist* are reasonably representative, since the estimation results match theoretical expectations.

A second caveat is that the analysis would be better performed at the basin level rather than at the state or county levels. This is especially true in light of Getches' argument that federal and local laws are more important than state laws in shaping water market activity.[69] However, even at the state and county levels, the influence of the factors we have identified is clear. Analysis at the basin level would likely corroborate our findings of the importance of economics, hydrology, and institutions on the type of trading that develops in water markets.

A measure of the seniority of rights underlying leases and sales is missing from the quantitative analysis. Although a water right with seniority would be expected to sell at a higher price and would also be more likely to be transferred than one with junior rights, it is not immediately clear what effect seniority would have on the ratio of sales to leases within a state. It might be the case that senior rights would tend to be sold and junior rights to be leased, and that such leasing could only occur in years when there is sufficient water to fulfill the junior rights. Unfortunately, it is not possible to study the effect of seniority on style of trading, as only a handful of the transaction descriptions in the *Water Strategist* include information on seniority. If it is true that junior rights are less likely than senior rights to be transferred in the first place, then an analysis of seniority based on observed trades would not be adequate to address the issue of seniority.

Although the data set used here lacks specificity in some regards, it does have the benefit of covering a large geographical area, which is necessary to provide an empirical estimate of the factors that influence the choice of water market institutions across the western United States. We have been able to parse out the effects of time-invariant economic and hydrologic conditions on lease and sale markets from those that vary from year to year through the use of short-term and long-term variables, in spite of data shortcomings. For example, agricultural production (*AoldXcnAgProdn*) influences whether farmers lease out water from

69. David H. Getches, *The Metamorphosis of Western Water Policy: Have Federal Laws and Local Decisions Eclipsed the States' Role?*, 20 Stan. Envtl. L.J. 3, 18–20 (2001).

year to year, whereas the underlying value of agricultural land (*cnAgLand*) affects whether farmers sell water rights. These variables combined influence the agricultural producer's decision to lease or sell. Similarly, the long-term index of average variability (*cnPDSIcvar*) captures agents' decisions to transfer water rights, whereas the index of realizations of precipitation (*cnPDSI*) captures agents' decisions to utilize the lease market in response to expected (and subsequently realized) annual variability in precipitation. State-level fixed effects in the county-level analysis quantify the influence of state regulations on the development of water market institutions.

These studies illustrated that water market structure varies across states because the local nature of externalities dictates alternative forms of economic organization to achieve efficiency. States that have implemented regulations to facilitate leasing activity do so in response to externalities that are more significant for rights transfers than they are for short-term leases. We would consequently not expect to see a confluence of institutions and implicit capitalization ratios across states. Each state is on a certain path dictated by its particular economic and hydrologic circumstances.

The institutional category "market" is too broad. It is far too simplistic to say that market transactions occur because they are permitted. The form of the transaction matters as well. The emergence of certain types of markets is dictated by the economic and hydrologic conditions prevailing in a particular location. This analysis measures the effect of state regulations and scarcity values on the type and extent of water markets, and provides an explanation of the paradox of sale or lease specialization by states and a foundation for additional measures of the development of institutions. This analysis supports the conclusion that market structure varies across states in accordance with the local nature of water market externalities. These externalities call for alternative forms of economic organization to achieve efficiency.

TABLE 1. Theoretical Predictions of Relationships Between Variables

Variable Description	Prediction	Variable Name
Economic		
Value of agricultural production (short-term opportunity cost) ↑	*L* ↓	*AgProdn*
Value of agricultural land (long-term opportunity cost) ↑	*B* ↓	*AgLand*
Current urban growth ↑	*B* ↑	*Bld*
Cumulative urban growth ↑	*L* ↑	*BldStock*
Hydrologic		
Annual precipitation (short-term drought indicator) ↑	*L* ↓	*PDSI*
Expected volatility in precipitation (long-term drought indicator) ↑	*L* ↑	*PDSIcvar*
Regulatory		
Expedited approval process for leases ↑	*L* ↑	*Expedite*

TABLE 2. Transacted Volume and Volume-Weighted Prices for Reported Water Transactions, 1990-2010

	Total		Lease		Sale			Prices		
State	No. of Obsvns	Quantity (taf)	No. of Obsvns	Quantity (taf)	No. of Obsvns	Quantity (taf)	Lease/Sale Ratio	Lease	Sale/ Share	Implicit Rate of Return (%)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
AZ	179	7,967	64	7621	115	347	22	70	720	9.68
CA	846	10,200	752	9730	94	470	21	129	1,123	11.51
CO	1573	700	132	577	1,441	122	5	61	4,222	1.45
ID	152	5,979	132	5850	20	128	46	10	292	3.27
NM	176	635	116	598	60	37	16	688	2,029	33.89
NV	305	157	5	32	300	125	0.26	16	6,904	0.23
OR	127	1,008	107	984	20	24	40	208	551	37.76
TX	338	1,876	270	1612	68	263	6	60	1,912	3.16
UT	71	184	24	128	47	56	2	99	1,826	5.43
WA	52	217	41	131	11	86	2	78	265	29.23
Total Quantity	3819	28,923	1643	27264	2,176	1,659	16	96	1,610	5.96

Notes: Data from the *Water Strategist*. Sales of 48,794 acre-feet in shares from the Colorado-Big Thompson Project in Colorado is omitted from the price calculation. CBT shares are relatively valuable because the water available through them is inversely proportional to current water conditions. (In a dry year, the amount of water awarded for one share is larger than that awarded in a normal year.) If CBT shares are included, Colorado sale price increases to $6,001/acre-feet, the overall total sale price increases to $1,885/af, and the overall implicit rate of return is 5.09%.

TABLE 3. Expedited Lease Approval Process Variable

State	Expedited lease approval process
AZ	0
CA	0
CO	0
ID	0
NM	1
NV	1
OR	0
TX	0
UT	0
WA	0

Notes: California and Colorado implemented expedited lease approval proceedings in 1999 and 2002, respectively. The expedited lease variable takes on a value of 1 in these states after those dates.

TABLE 4. Determinants of Trading Patterns in Western Water Markets, State-Level Analysis (1990-2010)

Explanatory Variables		Contract Type (Sale=1) (1)		Contract Length (Long-Term=1) (2)	
Taf	Transaction volume (thousand acre-feet)	-0.0095***	(0.0000)	-0.0045***	(0.0000)
AgOld x stAgProdn	Ag seller x value of agricultural production (% of state average)	0.0805***	(0.0000)	0.0421***	(0.0000)
stAgLand	Value of agricultural land (in $ thousands)	-0.0123	(0.1660)	-0.0414***	(0.0000)
MINew x stBld	MI seller x building permits issued annually (in millions)	0.6319**	(0.0130)	-0.4018*	(0.0950)
MINew x stBldStock	MI seller x total building permits issued since 1990 (in millions)	0.0690***	(0.0020)	0.1083***	(0.0000)
]stPDSI	Short-term PDSI drought index	0.0058*	(0.0540)	0.0118***	(0.0000)
stPDSIcvar	Long-term PDSI drought index	-0.0076***	(0.0000)	-0.0065***	(0.0000)
Expedite	Expedited approval process for leases	0.0009	(0.9440)	-0.0172	(0.1750)
stPopn	State population (in millions)	-0.0013***	(0.0000)	-0.0010***	(0.0000)
stInc	State per capita income (in $ thousands)	0.0296***	(0.0000)	0.0316***	(0.0000)
Time	Annual time trend	-0.0433***	(0.0000)	-0.0394***	(0.0000)
Log pseudolikelihood		-1300.71		-1329.75	
Pseudo R2		0.50		0.47	
Fraction of Concordant Pairs		0.87		0.86	
Observations		3806		3806	

Notes: Estimation method is maximum likelihood logit. Marginal effects are reported at the median values of the independent variables. Marginal effects for dummy variables give change in predicted probability associated with changing the variable from 0 to 1. The fraction of concordant pairs is the fraction of observations for which the model correctly predicts probabilities and responses. Standard errors in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

TABLE 5. Determinants of Trading Patterns in Western Water Markets, County-Level Analysis (1990-2010)

	Contract Type (Sale = 1)				Contract Length (Long-Term = 1)			
Explanatory Variables	(1)		(2)		(3)		(4)	
Taf	-0.0103**	(0.0430)	-0.0031*	(0.0950)	-0.0033	(0.0470)	-0.0007*	(0.0890)
Aold x cnAgProdn	0.1036***	(0.0000)	0.0637***	(0.0000)	0.1029	(0.0000)	0.0543***	(0.0000)
cnAgLand	-0.0371***	(0.0000)	-0.0017	(0.2650)	-0.0332***	(0.0000)	-0.0024**	(0.0410)
MInew x cnBld	10.0817***	(0.0000)	4.3069***	(0.0050)	5.8723	(0.0160)	3.9137**	(0.0350)
MInew x cnBldStock	0.2922	(0.3530)	-0.3648**	(0.0210)	0.3313**	(0.2200)	-0.1048	(0.5700)
cnPDSI	0.0082***	(0.0030)	0.0052**	(0.0560)	0.0117***	(0.0000)	0.0062***	(0.0140)
cnPDSIcvar	-0.0001	(0.6890)	0.0002	(0.2730)	-0.0002*	(0.4800)	0.0001	(0.6000)
Expedite	-0.0734***	(0.0000)	-0.0962***	(0.0000)	-0.1606***	(0.0000)	-0.1099***	(0.0000)
cnPopn	-0.1419***	(0.0000)	0.0053	(0.2540)	-0.0450	(0.2350)	0.0085***	(0.0090)
cnInc	0.0109***	(0.0000)	0.0023***	(0.0000)	0.0095***	(0.0000)	0.0026***	(0.0000)
Time	0.0017	(0.2260)	0.0016	(0.1160)	0.0058***	(0.0000)	0.0043**	(0.0000)
California			-0.3038***	(0.0000)			-0.2979***	(0.0000)
Colorado			0.2729**	(0.0000)			0.2533***	(0.0000)
Idaho			-0.0107	(0.9110)			-0.0136	(0.8840)
New Mexico			0.3272**	(0.0000)			0.2904***	(0.0000)
Nevada			0.3821***	(0.0000)			0.3219***	(0.0000)
Oregon			-0.3484***	(0.0040)			-0.2834***	(0.0030)
Texas			-0.2251***	(0.0020)			0.0410	(0.5290)
Utah			0.0724	(0.3950)			0.1860**	(0.0280)
Washington			-0.3470***	(0.0060)			-0.2529***	(0.0220)
Log pseudolikelihood	-770.09		-529.23		-812.37		-515.11	
Pseudo R2	0.48		0.65		0.41		0.62	
% of Concordant Pairs	0.89		0.91		0.88		0.92	
Observations	2434		2434		2434		2434	