ECONOMIC ORGANIZATION AND THE STRUCTURE OF WATER TRANSACTIONS

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ABSTRACT:
This paper analyzes the structure of water transactions using data on contract duration from California. Water rights in the western United States are transferred through short-term and long-term leases as well as permanent ownership contracts. We test predictions about the type of water contracts derived from the literature on economic organization by using ordered probit models to investigate the correlates of contract duration. We confirm that long-term and permanent contracts are more likely when investments in specific assets are required for conveyance. We also find that longer-term arrangements are common when buyers with uncertain water supplies are purchasing from sellers with more certain rights, suggesting that urban municipalities use long-term contracts to reduce risk. We do not find robust evidence supporting the hypothesis that short-term agreements are more likely when the costs of a transfer to third parties are potentially high.

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"The City Owns Its Water"
It is not the economic theory of municipal ownership and administration of public utilities which concerns us; we are confronted with a condition and not a theory. The city owns its water, and our experience should convince us of…the farsighted wisdom of our Spanish and Mexican predecessors in holding on to the rights of the waters of Los Angeles with a grip of iron.

Los Angeles Board of Water Commissioners (1902)[1]

I. INTRODUCTION

The emergence and expansion of markets for environmental and natural resources in the last several decades has been an important development influencing the use and conservation of these resources. Water in the western United States, in particular, has seen a dramatic increase in the use of markets (Libecap 2007, 2008), though many argue the potential for markets is vast (Anderson and Hill 1997). Despite their importance for reallocating assets from lower-valued to higher-valued uses, our understanding of the economic structure of these market transactions is still limited.

We make progress in filling this gap by examining the structure of water market transactions using lease and ownership data from California. In California and the western United States water rights are transferred through short-term and long-term leases as well as permanent ownership contracts. We employ the insights from transaction costs economics and the economics of organizations to develop and test predictions about what drives choices on the length of contracts. We combine data on water transactions with data on economic, demographic, hydrologic-climatic, and political data to estimate models of contract/transaction choice.

The study will focus on the choice among short-term leases, long-term leases, and permanent transfers (i.e., sales). An important implication from the literature is that when there are specific assets (Klein, Crawford, and Alchian 1978, Williamson 1979) involved in a transaction it is more likely to be a long-term deal or an outright sale. The paper will also examine the extent to which political forces (e.g., interest group pressure) can shape the structure of these transactions.

[1] See http://wsoweb.ladwp.com/Aqueduct/historyoflaa/cityownswater.htm visited June 17, 2014.

As the epigraph notes, the City of LA owns its water, it aqueducts, and the related land from the Owens Valley to the LA Basin. This outcome was the result of many transactions over three decades (Libecap 2008). The integrated ownership of water, land at the headwaters, the aqueduct, and the urban delivery system alleviates potential holdup problems that would arise if separate asset owners would contractually connected. This integration is rather unique but illustrates how complete integration can emerge in the organization of water.

A classic economic organization question is whether or not assets or activities should be undertaken or controlled by the firm or by another contracting party (Coase 1937, Williamson 1979). Economic organization decisions are influenced by asymmetric information, asset specificity and complexity, moral hazard, monitoring costs, and other economic and, even, political forces. Transaction cost economics predicts that the factors influencing contract choice will include much more than the simple economic variables affecting gains from trade under different types of contracts. Namely, contract choice is influenced by the potential for opportunistic behavior on the part of either buyers or sellers.

We take some of these predictions to the data by focusing on the lease-own decision for transfers of water. Water is most commonly transferred between users through three types of contracts (Hanak 2003, Bewer et al 2007). First, short-term leasing is a common method of temporarily reallocating water. A short-term lease is an agreement between an owner of the water right and a willing lessee where a negotiated quantity is transferred at a single point in time, typically for a season or a year. Second, longer term leasing is a contractual relationship where water is transferred annually until the expiration of the contract. Both short-term and long-term leases do not involve permanent transfer of the specific water right. That is, the right to the asset is maintained by the seller or lessor. Third, ownership (or sales) contracts are permanent agreements where a buyer purchases the legal right to divert a certain quantity each into the future. Unlike leases, ownership contracts do transfer the actual water right.

Our empirical evidence generally supports the prediction from the economic organization literature that long-term relationships and vertical integration are more likely to result when asset specificity is present.[2] Studies using cross-sectional data from different industries and explaining the emergence of vertical integration as a function of variables measuring specific assets generally find evidence in support of the economic organization hypothesis (Levy 1985, Caves and Bradford 1988, Lieberman 1991, Minkler 1994, Baker and Hubbard 2001, 2003). Other studies use micro-level data for a specific industry to explain either contract duration or vertical integration. Joskow (1987) finds that duration of coal contracts is positively associated with variables meant to proxy for investment in specific assets. Recent work by Brickley, Misra, and VanHorn (2006) finds that long-term franchising contracts are more likely when a franchisee makes investments in relationship-specific assets. Masten (1984) finds that downstream firms in the aerospace industry are more likely to produce specialized inputs themselves rather than contract for their use from upstream manufacturers. Allen and Lueck (2003) find that agricultural buildings are more likely to be leased when agricultural land is rented. Since land is a complimentary asset to agricultural buildings, owning land is a relationship specific investment.

There are several characteristics of water which make the lease-own decision between buyers and sellers rather unique compared to frequently studied assets such as coal mines, trucks, or airplane parts. Most importantly, water is not a fixed asset but instead an asset whose size and quality are subject to substantial uncertainty depending on weather and hydrologic conditions. In addition to uncertainty, transportation costs are relatively high and political factors are relatively important compared to many natural resource markets (Libecap 2007). [3]

We find that uncertainty in the quantity of the asset is an important correlate of contract duration. In short, longer-term contracts are more likely when the water being transferred comes

[2] For reviews of the literature see Shelanski and Klein (1995) and Lafontaine and Slade (2007). Forbes and Lederman (2009) find that the complexity of transactions is also a reason for vertical integration.

[3] There is related work on ownership (i.e., vertical integration) of public utilities by Troesken (1997), Troesken and Geddes (2003) and Masten (2011). The latter two studies find that municipal ownership of water systems is explained by contracting costs.

from streams that have lower coefficients of variation of annual stream flow. Also, longer-term contracts are more likely when the assets held by the buyer holds rights in streams with more variation in annual stream flow. Combined, these results suggest that longer-term deals are used to reduce overall water variability.

Another unique feature of water is that third parties are often affected by transfers. Approximately 80% of water supply in western states is allocated to agriculture, thus the suppliers for water transactions are often agricultural rights holders. Transfers out of agriculture therefore affect both rural agricultural communities and downstream irrigators who benefit from agricultural water use.[4] Rural communities are dependent on agricultural labor, input purchases, and other factors. Previous work on third party impacts of water markets highlights some of the factors which create opposition to transfers by local community residents and downstream appropriators (Vaux and Howitt 1984, Young 1986, Hanak 2003).

The remainder of the paper is organized as follows. Section 2 provides an overview of water supplies and water institutions in the western states. We place particular emphasis on California since our dataset consists solely of transfers within California. Section 3 discusses the literature in economic organization and water economics and develops the predictions that we take to the data Section 4 describes the data and presents the results of our estimates. Section 5 summarizes and concludes.

II. INSTITUTIONS AND MARKETS FOR CALIFORNIA WATER

The allocation and transfer of water is generally not simple and in California it is particularly complicated. Markets are relatively primitive and governed by a complex mix of legal, administrative, and political institutions. The use of water varies and the technology can range from primitive to sophisticated and capital intensive. In addition, there is a mix of users including agricultural, urban, and industrial users. California is the largest of the western states in

[4] It is also possible that transfers might benefit third parties. For example, if water is transferred to an upstream user then more water will be available to those uses just downstream from the new users.

terms of both agricultural and municipal water use. California has the largest agricultural economy of all states and 75-85% of water use is accounted for by agriculture. The fertile soils in the central part of the state are generally unproductive without sufficient irrigation. On average, Californians use 34 million acre-feet of water per year.

Institutions: Legal, Administrative, Political

California's water institutions evolved from the combined forces of Spanish-Mexican law and the law of the mining camps early in California's American history (Kanazawa 1998). Under the western water law doctrine of prior appropriation water rights are defined to allow holders of the right to divert a given quantity during a given time period, most often one period. Under the appropriative water doctrine, water rights are defined in terms of the volume of diverted water per period (usually a year) but not in terms of the amount actually used or consumed.[5] The diversion of water in California by irrigation districts, municipal water districts, and private rights holders is governed mostly by a hybrid of the prior appropriation and riparian doctrines. Appropriative rights allocate water based on the date of initial water use. A user is required to establish use rights by diverting water and putting it to beneficial use. Owners with rights that were established further back in time are referred to as senior appropriators. Junior appropriators are those which have established rights in more recent history. Riparian rights allocate water based on ownership of land adjacent to rivers and lakes. Because of the separation between land ownership and water rights holdings, appropriative rights are generally easier to transfer than riparian rights.[6]

Water allocation is governed by a set of legal requirements based on land ownership and seniority. The users of water are also diverse, ranging from farmers to urban residents to fishermen. It has been widely noted that the marginal values of water vary widely between user

[5] While previous work indicates that defining rights on the basis of consumptive use has the potential to improve efficiency while protecting downstream users, still diversion rights are the standard (Johnson, Gisser, Werner 1981)

[6] Transfers of appropriative rights are governed by laws which are highly variable by state. For a more detailed description of state regulations, see Getches (1997, pp 155-176.)

groups. The potential for mutual gains from the establishment of water markets has been widely discussed in the early literature on water transfers (Vaux and Howitt 1984, Young 1986). In many areas water used for municipal purposes is valued at upwards of 10 times the value of agricultural water (Brewer et al. 2007). Contracting is required for transfer participants to realize these gains from trade. Yet, the determinants of contractual forms have yet to be investigated by the literature.

Local supply agencies such as irrigation districts and water supply districts are the most common source of water for farmers in California. These are public entities that are responsible for holding water rights and allocating water to individual farmers within their districts. For instance, the Imperial Irrigation District (IID) in Southern California owns rights to divert water from the Colorado River. IID sells this water to the individual farmers that make up the district. Irrigation districts are also responsible for developing and maintaining the facilities necessary to convey water to irrigators. These include ditches, canals, and storage facilities. Board members are elected by landowners in order to manage district activities.[7]

These agencies often rely on water from California's Central Valley Project (CVP). The United States Bureau of Reclamation created the CVP in the late 1930s as a way of capturing water from the relatively wet northern counties and transporting it to agriculturally productive areas in the central part of the state. In addition to the CVP, the California State Water Project (SWP) also supplies irrigation water to farmers. The SWP is a system of lakes and reservoirs, canals, pumping plants, and storage facilities that transport water from north to south for both agricultural and municipal purposes.

Municipal users are the other major user group in the state. Most municipal customers are served by public municipal water providers. Cities and towns have water departments that are

[7] It should be noted that some agricultural producers also hold rights directly without the involvement of irrigation districts. We don't discuss this situation directly, as our empirical analysis considers only transactions between identifiable holders of water rights. We do not consider transactions between individuals, as many of our legal and economic variables are unknown for such transactions.

responsible for distributing water to those living within the boundaries of the city. In addition to distribution, municipal water utilities are also responsible for acquisition of water rights, treatment and storage, and seeking additional water supplies when necessary. A municipal water district is similar to an irrigation district; with the main difference being the final use of its customers.

Finally, environmental water use is important in California. Unlike agricultural and urban uses, environmental use is generally for instream use and therefore is not consumptive (Anderson and Johnson 1986). Environmental users are most interested in maintaining water in streams for recreation and fish/wildlife habitat . The U.S. Fish and Wildlife Service, California Department of Water Resources, and the California Department of Fish and Game are the major public entities that secure water for environmental purposes. Private entities such as wildlife refuges and fishery conservation groups are also common buyers of water for instream flows. Environmental users are generally the most junior holders of water rights and therefore rely on markets to satisfy their demands.

Water Transfer Agreements

Given that there are multiple interests and different user groups for water in California, there is significant potential for markets to reallocate water between these users. Contracts in these markets take a wide variety of forms; they range from simple two page agreements to complex agreements with numerous different contract terms (Brewer et al 2007).[8] A simple

[8] The state is the true legal owner of all surface water under California water law (California Water Code Section 102) . The State Water Resources Control Board oversees all transfers.. Participants of a transfer are required to submit a petition to the board in order to obtain a permit for the transfer. The petition requires the parties to state the proposed points of diversions, places of use, and estimated impacts on instream flows, fish habitats, and water quality. There are additional oversights for permanent transfers of rights. The legal oversights by the state clearly make it impossible for participants in a water transfer to overlook the impacts on third parties. Details can be found at: http://www.swrcb.ca.gov/laws_regulations/ accessed June 26, 2014.

contract specifies duration, price and quantity schedules, conveyance procedures, and timing and location of diversion.[9]

More complicated contracts include land fallowing commitments, conservation measures by sellers, terms on how environmental impact reports will be prepared, environmental mitigation cost sharing, water quality requirements, transfer quantities that are contingent upon availability, arbitrage clauses, and termination clauses.

An example of such a complicated agreement is the recent long-term leasing agreement between the Imperial Irrigation District (IID) and San Diego County Water Authority (SDCWA). The agreement involves transferring the water conserved from IID irrigation canals in the Lower Colorado River basin to San Diego. While reducing consumptive use in agriculture made water available to transfer, reduced return flows were judged to be potentially harmful to the Salton Sea, which is a downstream body of water dependent upon return flows from irrigation by IID. The no harm clause to third parties forced the contract between IID and SDCWA to also include mitigation efforts. The IID-SDCWA transfer shows that varying environmental and economic conditions can cause transfer contracts to vary substantially in complexity. The contract includes contingencies in both prices and quantities, price adjustments over time, resale terms, and predetermined delivery schedules.

Opposition to transfers by rural communities is not unique to the IID-SDCWA agreement. Rural areas are often wary of water transfers out of agriculture. Much of the wariness results from the historic case of the land purchases by the city of Los Angeles in the Owens Valley (Libecap 2007). The city purchased agricultural land in the valley during the early part of the 20th century in order to secure the water to be transferred through the Los Angeles aqueduct which it built and continues to own and operate. The decrease in the viability of the valley as an agricultural region created abundant opposition by valley residents (and politicians) to the

[9] Agreements for water transfers are typically more complicated than contracts for other assets, such as agricultural land or trucking equipment (Allen and Lueck 2003).

transfer. The Owens Valley – Los Angeles transfer is the most commonly cited case by opponents of water transfers (Libecap 2007, 2008).

III. Economics of the Lease-Own Decision in Water

Building on these institutional details, we next discuss the economics of the lease-own decision in water and how important economic, environmental, and legal factors are expected to influence this decision. The lease-own decision for an asset has been studied for both general capital assets (Schall 1974, Miller and Upton 1976, Wolfson 1985) and for agricultural assets (Ford and Musser 1994). We build on these studies by considering transfer duration from an economic organization perspective. We focus on asset specificity and related contracting costs, uncertainty, and externalities.

Asset Specificity

An asset is 'specific' if it has little value outside of an existing relation between buyers and sellers. The general result from the literature is that vertical integration is likely to dominate temporary contracting when asset specificity is present (Klein et al. 1978, Williamson and Riordan 1985). If either side of a transaction makes investments that are specific to that relationship, then there is scope for opportunistic behavior in renegotiation of short-term contracts. Long-term contracting arises to avoid such behavior.

Asset specificity (especially physical asset specificity) can be important for water markets. Water must be delivered from seller to buyer and the costs of transportation are relatively high (compared to value). Existing conveyance facilities may be inadequate to transport water between geographically separated buyers and sellers. Investments in assets which are specific to the particular transaction are then needed for appropriate conveyance.

Water transactions are linked to the results derived in the theoretical literature on specific assets. When specific investments are required to convey water between transacting parties, longer agreements are expected to arise. MacLeod and Malcomson (1993) show that price

escalator clauses are expected to arise under such long term agreements as mechanisms to prevent renegotiation. Energy costs are the most significant determinant of the costs of conveying water between parties. Water transfer contracts often include provisions that allow transfer prices to vary with the cost of conveyance. While our empirical analysis focuses on contract duration, it is important to keep in mind that other contract terms are affected by specific assets and opportunism.

Uncertainty

In their most simplified form, transaction costs can all be related to uncertainty. Water is unique in that the asset being traded is not fixed. Two parties negotiating a transfer are uncertain as to how much of the water is truly going to be available during a given period. As an example, appropriative rights allocate water based on seniority (Getches 1997). In years where streamflow is limited, junior rights holders may not have access to their entire endowment. The combination of the water rights system and hydrologic conditions therefore create a natural form of uncertainty that would be expected to impact the choice of contract duration for transfers.

We also consider the uncertainty of existing water rights held by participants in a transaction (i.e., buyers current period demand will depend mostly on current weather). Buyers of water are unsure about whether their existing rights will be sufficient during dry years. Sellers with more senior rights may expect to have excess water (i.e., supply will depend on current weather and on rights' seniority.). The length of the agreement is expected to reflect these relative preferences toward risk. Risk averse buyers with uncertain water supplies are expected to counteract risk by negotiating for longer term transfers when the asset being contracted for is associated with high degrees of certainty.[10]

[10] An interesting empirical test of uncertainty and contract duration comes from the labor economics literature. Several studies have observed an inverse relationship between inflation uncertainty and contract duration (Gray 1978, Vroman 1989, Rich and Tracy 2004). Labor contracts are certainly different from contracts for physical assets. The directional effect of uncertainty on contract duration depends critically upon the type of uncertainty and the risk aversion of the agents.

Third Party Effects

The effects of third party impacts on the organization of transactions are not a significant component of the economic organization literature. Indeed, many transactions between private parties have little or no third party impacts and the parties have relatively limited collective action problems themselves. In other cases, however, and for water in particular, third party impacts seem to be important, so the structure of the transaction may depend not only on the incentives of the direct participants, but also on the incentives of the individuals that are affected by a transfer.

There are various third parties that are affected by a water transfer (Johnson, Gisser and Werner 1981). For transfers of water originating from agriculture, rural agricultural communities often oppose transfers on the grounds that reduced agricultural water use leads to less demand for agricultural inputs (including labor). While these affects are pecuniary, their significance in rural communities is not negligible. Further, transfers which include a change in the point of diversion will lead to reduced return flows for users downstream of the seller. For these reasons transfers are generally viewed negatively by rural agricultural communities.

The obvious remaining question is why do participants in a transaction care about the effects of the transfer on third parties? In terms of agricultural transfers, the actions of irrigation and water supply districts are quite visible in rural communities (Hanak 2003, Libecap 2008). Board members are elected by district members and expected to act in the best interest of all irrigators.

Transfers of water outside a district's boundaries are viewed negatively in areas where agriculture contributes significantly to the local economy. In addition to pecuniary externalities, agricultural water supply districts have to consider the different effects of the transfer on all types of irrigators within the district. The point of diversion for a transfer is an example of a contract term that has differential impacts on irrigators. Depending on the location of diversion, different

irrigators may be affected differently by the reduction in return flows.[11] Irrigation districts and other agricultural water supply agencies are thus faced with the additional burden of being constrained by political forces and the divergent opinions of heterogeneous irrigators. We expect irrigation districts to consider these political constraints when negotiating the terms of a transfer.

Predictions

The discussion up to this point has led to some testable predictions which are the focus of our investigation of the correlates of contract duration. We summarize our predictions as follows:

1: As specific assets for conveyance become more important long-term agreements are more likely.

2: When buyers face uncertain water supplies long term agreements are more likely.

3: When the transfer has fewer third party impacts long term agreements are more likely.

IV. EMPIRICAL ANALYSIS

In this section we provide an overview of the water transaction data and outline the econometric model we use to test the predictions about the length of transfer agreements. We then present results.

Data and Empirical Strategy

Our water transaction data are taken from a publicly available database on water transfers.[12] The data consist of transactions from1987-2008. To avoid unobservable differences in water institutions across states, and to collect a data set with micro-level information on the participants in the transactions, we focus our analysis on transfers in California. These data allow

[11] Rosen and Sexton (1983) use a combination of club theory and game theory models to demonstrate the conflicts that can arise within an agricultural water supply district from a transfer. Their results indicate that disagreements between irrigators within districts can cause transfer outcomes to diverge from predicted optimal outcomes.

[12] The database is available at the University of California, Santa Barbara, and is the first comprehensive database on western water transactions. The data were collected from the trade journal *The Water Strategist*, published by Stratecon Inc. Brewer et al. (2007) use these data in their larger study of western water markets.

us to identify the buyers and sellers for the transactions and supplement the transaction data with explanatory variables of interest.[13] We also use publicly available data from the California Department of Water Resources, California Irrigation Management Information System, California State Parks Department, California Department of Finance, U.S. Geological Service, U.S. Fish and Wildlife Service, and U.S. Bureau of Economic Analysis. Additional data details are shown in the Appendix.

Our transaction data are cross-sectional in nature.[14] Given that our identification comes from cross-sectional variation in attributes of transacting parties, caution must be taken with regards to pure causal interpretation of our estimates. We use these data to estimate an ordered probit model (Green and Zhang 2003) explaining variation in the length of transfer contracts.[15] Our basic model is

$$(1)\quad y_i^* = x_i'\beta + \mu_i \qquad \text{and}$$

$$(2)\quad y_i = \begin{cases} 0\ if\ y_i^* < 0 (short\ term\ lease) \\ 1\ if\ 0 < y_i^* < \mu_i\ (long\ term\ lease) \\ 2\ if\ y_i^* > \mu_i\ (sale - permanent) \end{cases}$$

where y_i^* is the unobserved latent variable describing the propensity for a longer term agreement in transaction i, y_i is the observed categorical variable for the three types of contracts, x_i is a

[13] Some transactions in the database do not have identifiable buyers or sellers. For example, it is common for transactions to be listed as between "irrigators" and "municipal interests". We do not include such transactions in our analysis as we are unable to identify buyers and sellers.

[14] In an ideal data environment we would be able to guarantee that the explanatory variables used to test our predictions would be strictly orthogonal to all unobserved factors affecting contract duration. Randomization would provide such a guarantee. Asset specificity, supply uncertainty, and third party impacts obviously cannot be randomly assigned to transacting parties. Panel data are desirable because the researcher can control for unobserved time invariant characteristics of buyers and sellers that affect contract duration and are potentially correlated with variables of interest.

[15] Classic empirical studies in the transaction cost economics literature have taken one of two forms. In cases where contract duration is continuous and finite, standard econometric procedures for continuous variables are used to test predictions (Joskow 1985, 1987). In other cases the outcome of interest is qualitative (i.e. make/buy or buy/lease) and binary probit or logit models are sufficient (Monteverde and Teece1982, Masten 1984). Our water transaction dataset is similar to the literature on qualitative decisions, yet we are able to observe the length of lease agreements.

column vector consisting of the explanatory variables, β is a column vector of parameters to be estimated, and μ_i is a random error term which is distributed as a standard normal.

Table 1 provides descriptions and summary statistics of the variables used in the model. The dependent variable is a discrete ordered variable that is set to 0 for short-term (one year) lease, 1 for a long-term (more than one year) lease, and 2 for a permanent transfer.[16] Of the 416 transactions where at least the buyer or seller is identified, 286 are short-term leases, 65 are long-term leases, and 65 are permanent transfers. Short-term leasing is obviously the dominant contracting type. This dominance of short-term leasing is consistent with water markets in all western states.

Table 1

Turning to control variables, we control for current water availability using two variables. First, precipitation in the area of the buyer is a measure of short-term water availability. Given that leases can be used to supplement current supplies, we expect an inverse relationship between contract duration and buyer precipitation. Second, the buyer long-term stream flow represents average stream flow on sources where buyers hold water rights as a percentage of the long-term average (10 years preceding transaction).[17] If current stream flow is less than average, then we expect leasing to be more likely.

We use two variables to measure asset specificity. First, we use the geographic distance between the buyer and seller. Transporting water is simple when the parties are close in distance. In many cases the water is simply left in a stream by the seller for the buyer to then divert. Physical conveyance of the water is likely to be much more complicated when buyers and sellers are further apart. Investments in conveyance facilities are needed to move water between

[16] We do not report summary statistics for the dependent variable in the table, as the mean value is largely irrelevant.

[17] Some buyers do not hold appropriative water rights licensed with the California State Water Board. We used two alternatives to measure the variable for these observations. If the buyer was a CVP contractor, we used the stream flow data from the nearest CVP canal or Sacramento River station. In the event that the buyer is not a CVP contractor, we used stream flow from major streams within a 40-mile radius of the buyer's office.

geographically separated parties. While transfers do not generally require construction of entirely new canals, investments in pumping and storage facilities and extensions to existing conveyance facilities are more likely as buyers and sellers become more distant. As is seen in Table 1, our data include transactions from buyers and sellers within the same zip code (where the distance is zero) to transactions where buyers and sellers are located at extreme ends of the state. We also include a squared distance term to investigate potential non linear relationship between the ordered probit index function and the distance between buyers and sellers.

As a second measure, we use a dummy variable for urban buyers to control for variation in contract types preferred by different buyer types -- 49% of the transactions have buyers that are municipal water districts. We expect a positive association between the urban buyer indicator and contract duration. We note that the urban dummy might also be interpreted as a specific asset variable.

Turning to uncertainty, the 10 year coefficient of variation in stream flow is used as a measure of uncertainty in water supplies. The mean coefficient of variation is around 0.75 for both buyers and sellers. We expect buyers to be averse to this supply risk. A long-term purchase of a water right with little uncertainty is one way of creating less uncertainty in water supplies for buyers. Longer-term agreements are expected when buyers have uncertain water supplies and sellers hold more certain rights. Consistent with prediction 2, we expect a positive relationship between buyer supply uncertainty and contract duration. The opposite relation is expected between seller supply uncertainty and length of agreements.

Our last testable prediction relates to the impact of third party effects on contract duration. The relevant third party impacts vary by the origin of the water being transferred. For transfers originating from agriculture, rural communities with productive agricultural economies are likely to oppose transfers, especially long-term transfers. To test whether these concerns impact contract types chosen by irrigation districts, we constructed a variable that is the ratio of total agricultural income in the county of the seller to the total personal income in the county. The

variable is a measure of the significance of agriculture in the area of the seller. If sellers are constrained by these third party impacts, then we expect short-term leasing to be more common in counties where the agricultural income ratio is higher.

Other third party impacts are tested using two variables. As a proxy for instream flow values, we include the ratio of state park water feet to county land area in the county of the seller. The assumption in using this proxy is that in stream flow values are higher in areas with more lakes and streams in state parks. We expect greater opposition from environmental interests and short-term leasing to dominate in these areas. We also look at the effect of endangered species listings on the length of transfer agreements. We construct a variable that is the number of endangered or threatened fish species that were newly listed by the U.S. Fish and Wildlife Service within the last ten years in the county of the seller.[18] From Table 1 we see that there are some transactions with no species listings, while at a maximum there are transactions where there were four new listings in the county of the seller in the ten years preceding the transaction. We expect a negative relationship between contract length and the number of endangered and threatened species listed in the seller's county.

Table 2

Table 2 presents mean values for short-term leases, long-term leases, and permanent transfers. While these mean values clearly do not constitute a formal test of our predictions, it is useful to highlight some trends in the data. Our measure of asset specificity, the distance between buyers and sellers, is increasing in mean for longer contract types. The means provides some initial evidence that longer-term contracts may be associated with buyers and sellers that are further apart in distance. The state park water area variable also has a clear trend in mean value between contract types, potentially indicating a negative relationship between duration and instream water use in the area of the seller. For the other variables the direction of the relationship is not clear from the mean values.

[18] We relied upon the Nature Serve online conservation database for identifying habitat areas of species.

Econometric Estimates

Table 3 presents the results from estimating three versions of (1) using different subsets of our data. Specification 1 uses the entire data set and allows us to test our predictions on asset specificity and uncertainty (Predictions 1 and 2). Specification 2 limits the sample to transactions where the seller is an agricultural entity. This allows us to test the hypothesis that leasing is more likely in areas with highly productive agricultural economies (Prediction 3). The third specification excludes transfers to environmental users and allows us to test the effects of in stream use and endangered species on contractual form (Prediction 3).

Table 3

Focusing on control variables, precipitation in the area of the buyer has the expected sign and is statistically significant in two of the three specifications. Shorter term agreements tend to dominate when buyers are experiencing relatively dry conditions. The impact of buyer stream flow conditions is however not consistent with our expectations. The results indicate that longer term agreements are more likely when buyers are in low stream flows. While the sign of the estimate is counterintuitive, the absolute magnitude of the coefficient is small. The marginal effects (see Table 4) are noticeably small across all specifications. The results for the other control variables indicate that longer-term agreements are more likely for urban buyers and that contracts have tended to increase in duration over time

Table 4

The estimate on the distance variable is consistent with our expectations (Prediction 1). The estimated relationship between distance and the ordered probit index function is concave. Using the results from column 2 of Table 3, the index function is increasing with distance initially and then is decreasing after a distance of 234 miles. Considering that only 20% of the observations lie outside this range, the marginal effects of distance on the probabilities of long-

term leases and permanent contracts are generally positive, but decreasing in distance.[19] The marginal effects at mean values from Table 4 suggest that at mean values the probability of short-term leases is decreasing in distance while the probabilities of long-term leases and permanent transfers are increasing in distance. As an example, if the distance between buyers and sellers is increased by 100 miles --- slightly less than one standard deviation --- then the probability of short-term leasing decreases by 15.96 percentage points, or 23%. At the same time, the probability of long-term leasing is expected to increase by 9.24 percentage points (59%) and that of permanent transfers is expected to increase by 6.72 percentage points (43%). These results are consistent with asset specificity influencing contract duration.

The results for the uncertainty variables are consistent with the hypothesis that long-term contracting is a way for buyers to protect themselves from uncertainty in water supplies. The probabilities of longer-term agreements are increasing with buyer water uncertainty and decreasing with seller water uncertainty. The combined results suggest that holding all else constant, long-term leases and permanent transfers are more likely when buyers have uncertain existing supplies and sellers are able to offer more certain supplies.

The magnitude of the uncertainty effect is economically significant. Using the marginal effects from specification 1, a one standard deviation increase in buyer water uncertainty is associated with an decrease in the probability of short-term leasing by 18.1 percentage points (26%). Conversely, the probability of long-term leases increases by 10.4 percentage points (67%) and the probability of permanent transfers increases by 7.6 percentage points (49%). A one standard deviation increase in seller water uncertainty is associated with a 14 percentage point (20.3%) increase in the probability of short-term leasing, an 8.1 percentage point (51.9%) decrease in the probability of long-term leasing, and a 5.9 percentage point (37.8%) decrease in the probability of a permanent transfer.

[19] A plausible reason for the non-monotonicity of distance is that more distant markets are thin and uncertainty becomes relatively more important with distance.

There is no strong evidence that third party impacts are important determinants of contract duration. Focusing on the coefficient estimates in Table 3, only the agricultural income ratio has the expected sign and is statistically significant. This could be considered as moderate evidence that agricultural sellers consider pecuniary affects on rural communities when negotiating the length of water transfer agreements. However the estimate on the state park water area variable does not provide convincing evidence in support of prediction 3. Further, the estimate on the endangered species variable is actually counterintuitive and marginally statistically significant (p-value 0.07). The result indicates that long-term agreements are actually more likely when sellers are located in areas with more endangered and threatened species listings. Overall, the data suggest that individual incentives, rather than effects on third parties are most important for determining contract duration.[20] The Appendix reports the parameters estimates from probit estimates of the lease-own decision (Tables A2 and A3). These estimates are similar to those discussed above.

V. CONCLUDING REMARKS

The allocation of water is not simple and the organization of water transactions is also not transparent. In this study we have used the economics of organization and transaction costs to explain the economic logic of the structure of emerging western water markets. This is the first study that uses micro-level data to look at contractual form for water transfers. We first outlined the economics of water transfers as a way of generating testable predictions on the determinants of contract duration. Empirical studies on contracting from the transaction cost economics literature use this framework to identify the key incentives affecting contracting outcomes. Asset specificity is no doubt the most commonly cited determinant of contract duration, buy/lease, or

[20] Since we only observe transactions that took place – and failed negotiations or transactions that did not meet regulatory approval – we are unable to rule out that third party effects are important for actually allowing transactions to take place. Our estimates must therefore be interpreted as conditional on a transaction occurring.

vertical integration decisions. Consistent with the literature, our results indicate that asset specificity is a key determinant of the length of water transfer agreements. The type of asset specificity that we have observed is unique to an asset that requires specific investments to physically transfer the asset between buyer and sellers. Buy/lease decisions for traditional goods are not affected by these investments. Goods that require transport between buyers and sellers can often be transferred without any additional investments in infrastructure.

We have also examined a unique characteristic of water: water rights are uncertain. There are always elements of (natural) uncertainty in transfer agreements. We found that long-term contracting is less likely when sellers hold rights to streams with highly variable stream flows (more uncertainty). The reverse is true for uncertainty of a buyer's water supply. Buyers holding rights to more uncertain streams are more likely to choose long-term leases or permanent sales. The results suggest that long-term contracting is a way for water agencies to manage uncertainty in water supplies and to decrease the risk of their overall portfolio. The effect of uncertainty in the quantity of the asset being traded is not a common determinant of contractual outcomes.

Our results on third party effects are mixed. While there is moderate evidence that long-term agreements are less likely in areas where agriculture contributes significantly to the local economy, we do not find evidence that the impact on instream flows is considered by sellers of water rights. Third party impacts do not appear to be important determinants of contract form, at least conditional on the occurrence of a transaction.

A limitation of our study is that we only look at a single contracting outcome. Empirical studies in transaction cost economics are mostly focused on how various incentives affect the structure of economic agreements. The length of agreements is almost always the endogenous variable being analyzed. It is plausible to consider the effects of asset specificity, uncertainty, and

third party effects on other contract outcomes, such as price or quantity. There are no theoretical developments on the impacts of asset specificity on other endogenous contracting variables.[21]

Combining results, we have shown that asset specificity and uncertainty are important determinants of contract length. Considering transactions for natural resources from an economic organization perspective can therefore provide important insights into how contracts are formed.

[21] Our empirical model does not consider the possibility of endogenous matching of buyers and sellers. It has been shown that econometric estimates can be biased when participants in a transaction contract with each other based on incentives that are considered as explanatory variables in the estimating equation (Ackerberg and Botticcinni 2002). If certain types of districts choose to transfer to other types of districts based on distance or uncertainty, then a two-staged estimation procedure would be required to estimate the coefficients in (1). Our estimation does not test for the existence of endogenous matching of transfer participants.

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Data Appendix

The data were obtained from the online water transfer database from the University of California, Santa Barbara. The database includes transactions from 12 western states from 1987-2009. We chose to limit our analysis to California in order to maintain the ability to collect micro-level data on the specific participants in each transfer. Identification of buyers and sellers was necessary before matching in explanatory variables on buyer and seller characteristics. When possible, we identified the buyer and seller using a combination of matching logic and manual matching between the water transfer data and a list of water utilities provided by the California Department of Water Resources (DWR). Many of the transactions in the data are between unidentified individuals or municipal entities. Also, some transactions involve state or federal agencies. These transactions are not included in the analysis as we were not able to identify the physical location of the buyer or seller. The resulting dataset consists of 207 observations where both the buyer and seller are identified. Table A1 shows the data sources.

Table A1: Variable Sources

Variable	***Source***
Buyer Precipitation	California Irrigation Management Information System
Buyer Long-Term Streamflow Percentage	U.S. Geological Service
Urban Buyer	Original transaction data
Distance Buyer and Seller	Calculated from longitude and latitude using Haversine formula
Buyer Water Uncertainty	U.S. Geological Service
Seller Water Uncertainty	U.S. Geological Service
Agricultural Income Ratio	Bureau of Economic Analysis
State Park Water Area	California Department of State Parks
Endangered and Threatened Species Listings	U.S. Fish and Wildlife Service

The DWR list of water providers was used to obtain the postal code and hence county of each transfer participant. The approximate longitudes and latitudes were obtained based on matching by postal code. The explanatory variables were collected from a variety of sources. Table 6 provides the source of each variable. The buyer precipitation variable was collected from the California Irrigation Management Information System. The value corresponds to the average annual precipitation across CIMIS weather stations in the county of the buyer during the of the transaction. The stream flow variables (buyer stream flow percentage, buyer water uncertainty, and seller water uncertainty) were collected using stream flow data from the U.S. Geological Service. The California Electronic Water Rights Information System (eWRIMS) was used to identify the appropriate streams where districts hold water rights with the California State Water Board. We also used stream flow values at the nearest CVP canal or Sacramento River station when the district was identified as a CVP contractor. The stream flow values at all major streams within a 40 mile radius of the district's office were used for districts that did not have water rights at streams for which we had stream flow data and were not CVP contractors.

The distance between the buyer and seller was calculated by the Haversine calculation, which is a standard way of calculating distance between two points based on their longitude and latitude values. The agricultural income ratio is calculated as the ratio of agricultural income to total personal income in the county of the seller during the of the transaction. The income data were obtained from the Bureau of Economic Analysis online database. State park water area was collected from the California State Park System Statistical Report. The 2008 values were used for all transactions in the dataset, as state park water area does not vary much over time. The endangered and threatened species listings were obtained from the U.S. Fish and Wildlife Service website. We identified the counties for which each fish species was known to exist using the Nature Serve free online database.

An alternative approach is to make the economic distinction between leasing and owning rather than the duration of the transaction. Below we present estimates (Table A2) .

Table A2: Probit Results for Lease-Own Decision. Dependent variable Y = 0 if lease and Y = 1 if ownership transfer.

	Specification		
Explanatory Variable	**(1)**	**(2)**	**(3)**
Constant	-2.5423***	-0.7289	-2.3950***
	(0.5644)	(0.9788)	(0.5688)
Controls			
Buyer Precipitation	0.0330*	-0.0145	0.0435**
	(0.0200)	(0.0376)	(0.0211)
(Buyer Long-Term Streamflow Percentage	-0.0007	0.0017	-0.0015
	(0.0014)	(0.0025)	(0.0015)
Time Trend	0.0428*	-0.0363	0.0339
	(0.0256)	(0.0418)	(0.0269)
Asset Specificity			
Distance Buyer and Seller	0.8005*	1.7070**	0.6542
	(0.4146)	(0.7355)	(0.4274)
Distance Squared	-0.1492	-0.4234*	-0.1303
	(0.0963)	(0.2258)	(0.1011)
Urban Buyer	0.4651	1.5470**	0.4245
	(0.2956)	(0.6519)	(0.3120)
Uncertainty			
Buyer Water Uncertainty	0.3812	-0.6730	0.2965
	(0.4412)	(0.9002)	(0.4561)
Seller Water Uncertainty	-0.6317	-2.6222**	-0.7049*
	(0.3941)	(1.0697)	(0.4187)
Third Party Effects			
Agricultural Income Ratio		-7.9917	
		(6.5486)	
State Park Water Area			-0.0006
			(0.0016)
Endangered and Threatened Species Listings			0.1505
			(0.1264)
Number of Observations	168	107	164
Pseudo R^2	0.203	0.406	0.214
Log-Likelihood	-59.0134	-25.7474	-56.3507

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 1: Variable Descriptions and Summary Statistics

Variable	Description	N	Mean	SD	Min	Max
Controls						
Buyer Precipitation	Precipitation in buyer county during transaction year	231	12.44	7.37	1.80	41.09
Buyer Long-Term Stream flow (%)	Stream flow percentage for buyer during transaction year	275	101.92	109.40	2.25	648.42
Asset Specificity						
Distance Buyer and Seller	Distance between buyer and seller (100 miles)	207	1.02	1.27	0	5.28
Urban Buyer	1 if buyer is urban municipality, 0 otherwise	277	0.49	0.50	0	1
Uncertainty						
Buyer Water Uncertainty	10 year coefficient of variation for buyer water supplies	275	0.79	0.42	0.03	1.96
Seller Water Uncertainty	10 year coefficient of variation for seller water supplies	341	0.73	0.53	0.04	2.55
3rd Party Effects						
Agricultural Income Ratio	Agricultural income / total personal income in seller county	346	0.03	0.03	0	0.22
State Park Water Area State	park water feet / total land area in seller county	346	65.17	136.38	0	611.12
Endangered and Threatened Species Listings	No. of endangered and threatened species listed in seller county, 10 years prior to transaction	346	0.82	1.09	0	4

Sources: see Appendix.

Table 2: Mean Values of Independent Variables, By Contract Type

Variable	Short-Term Leases	Long-Term Leases	Permanent Sales
Controls			
Buyer Precipitation	10.80	15.77	14.03
Buyer Long-Term Stream flow Percentage	93.11	114.70	119.68
Asset Specificity			
Distance Buyer and Seller	0.85	1.02	1.77
Urban Buyer	0.29	0.72	0.65
Uncertainty			
Buyer Water Uncertainty	0.71	1.02	0.84
Seller Water Uncertainty	0.73	0.76	0.72
Third Party Effects			
Agricultural Income Ratio	0.03	0.03	0.02
State Park Water Area	75.17	56.27	22.93
Endangered and Threatened Species Listings	0.71	1.00	1.22

TABLE 3: Ordered Probit Results for Contract Duration

	Specification		
Explanatory Variable	**(1)**	**(2)**	**(3)**
Controls			
Buyer Precipitation	0.0608***	0.0154	0.0722***
	(0.0169)	(0.0254)	(0.0179)
Buyer Long-Term Streamflow Percentage	-0.0025**	-0.0012	-0.0035***
	(0.0012)	(0.0019)	(0.0013)
Time Trend	0.0481**	0.0072	0.0381*
	(0.0200)	(0.0294)	(0.0209)
Asset Specificity			
Distance Buyer and Seller	0.7508**	0.8802**	0.6709*
	(0.3393)	(0.4411)	(0.3524)
Distance Squared	-0.1603**	-0.2256**	-0.1690**
	(0.0793)	(0.1074)	(0.0839)
Urban Buyer	0.6962***	1.3908***	0.6372***
	(0.2293)	(0.3643)	(0.2457)
Uncertainty			
Buyer Water Uncertainty	1.1680***	1.0836*	1.1170***
	(0.3585)	(0.5644)	(0.3674)
Seller Water Uncertainty	-0.7164**	-1.6377***	-0.7323**
	(0.3069)	(0.5919)	(0.3195)
Third Party Effects			
Agricultural Income Ratio		-9.3604*	
		(5.0191)	
State Park Water Area			-0.0012
			(0.0013)
Endangered and Threatened Species Listings			0.1925*
			(0.1060)
μ_1	2.5464***	1.3218**	2.4588***
	(0.4265)	(0.6603)	(0.4343)
μ_2	3.5259***	2.2618***	3.4692***
	(0.4566)	(0.6788)	(0.4650)
Number of Observations	168	107	164
Pseudo R2	0.225	0.344	0.242
Log-Likelihood	-121.7946	-57.3619	-115.9001

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4: Marginal Effects on Contract Choice

	(1)	(2)	(3)
Controls			
Buyer Precipitation	-0.0224	0.0130	0.0095
Buyer Long-Term Stream flow Percentage	0.0009	-0.0005	-0.0004
Time Trend	-0.0178	0.0103	0.0075
Asset Specificity			
Distance Buyer and Seller	-0.1596	0.0924	0.0672
Urban Buyer	-0.2532	0.1424	0.1107
Uncertainty			
Buyer Water Uncertainty	-0.4313	0.2497	0.1816
Seller Water Uncertainty	0.2645	-0.1531	-0.1114
Third Party Effects			
Agricultural Income Ratio	2.6240	-1.8582	-0.7659
State Park Water Area	0.0004	-0.0003	-0.0002
Endangered and Threatened Species Listings	0.0705	-0.0426	0.0279

Marginal effects calculated at mean values of independent variables.
Specification 1 is used for all variables other than those measuring third party impacts.