INSTITUTIONS, THIRD-PARTIES AND WATER MARKETS

AN ANALYSIS OF THE ROLE OF WATER RIGHTS, THE NO-INJURY RULE, AND WATER CODE 386 ON WATER MARKETS IN CALIFORNIA COUNTIES

by

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ABSTRACT

Given the apparently large potential gains from the trade of water, why do we observe so few market transactions? This paper argues that policy-driven transaction costs are an important trade-hindering factor. More specifically, this paper examines the allocation of property rights under the No-Injury Rule, which gives rights to riparian users, and Water Code 386, which gives quasi-blocking rights to third-parties, making water rights less clear. Both laws are predicted to decrease the likelihood of observing an active export market and the volume of exports in the county. To test these predictions, this paper uses the cross sectional variation in the number of riparian rights holders and the number of third-parties to estimate their effect on all county-level water trades in California from 1990 to 2001. The empirical results show that the effect of Water Code 386 on exports is inconclusive. The results for the No-Injury Rule indicates that for the average county, a one standard deviation increase in the ratio of riparian rights holders to the total population will decrease the likelihood that the county will have an active export market by 30 percent and will decrease the ratio of exports to appropriations by 7.4 percent. This suggests that if California's goal is, as stated in the 1970's, to reallocate water to its highest valued use via water markets, the current allocation of property rights may be creating policy-driven costs that hinder reaching that goal.

CHAPTER 1

INTRODUCTION

According to World Bank estimates, approximately 1.1 billion people in developing countries have inadequate water supplies, and 700 million people in 43 countries live without enough water to meet their basic needs. In the United States, cities around the country are facing falling water tables and drought conditions that have been costly to local economies. In North Carolina, city officials reported the estimated lost crop revenues in 2007 to be $500 million due to insufficient water supplies (Roberson 2008).

In the past, governments have responded to growing water demands by damming major rivers and implementing water storage projects like the California Water Project, which began in the 1950s. These historic options, however, have "long-since been exploited" and the potential for conservation measures alone to meet growing water demands around the world is limited (Libecap 2005, 1). As a result, in regions with severe constraints on water usage, there has been mounting pressure to re-allocate water from its dominant historic uses in agriculture[1] to more pressing urban uses and environmental purposes (e.g., to protect species and riparian lands).

Studies suggest that there are significant social gains from the creation of water markets that move water from its current historic allocations to the highest valued uses in the region (Carey and Sunding 2001; Howitt and Sunding 2003). Such gains are made

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[1] For example, 84 percent of California's water supply is used for agricultural irrigation, most of which is used to produce highly subsidized, low profit crops (Howitt and Sunding 2003, 1).

evident by the large price differences observed between the highly subsidized agricultural users and the urban and environmental demanders. For example, from 1970 to 1990, municipal and commercial buyers in the Rio Grande Valley budgeted up to $600 per acre-foot to purchase water from farmers who were paying as little as $15 per acre-foot (Griffin and Boadu 1992, 274-275).

Economists predicted that because of these observed price differentials between water uses, the gains from trade would create incentives for a substantial water market. In such a market, (given zero or low transaction costs) higher valued water users could simply contract around the historic allocation of water rights, thus reallocating water through market transactions (Anderson and Lueck 1992, 436). Contrary to expectations, however, the number of water markets and the activities within established water markets are not as prevalent as was predicted (Libecap 2005, 2). One potential explanation is that the transaction costs associated with the trade of water are so large that they greatly inhibit exchanges.[2]

The key issue for policy decisions is whether the apparently high transaction costs are just another unavoidable component of the costs associated with water trade or whether they are, at least in part, an artifact of the way policy has been set (e.g., see Demsetz 2003, 282-300). As the Coase Theorem shows, if transaction costs are present the initial allocation of property rights may influence how resources are allocated among alternative uses (Hirshleifer and Hirshleifer 2005, 513-514). In fact, according to Anderson (2004, 461), certain configurations of property rights "may make transaction

[2] The persistent price differentials between water uses and locations suggest that the low trade volume is not a result of zero gains from trade.

costs so high that bargaining is impossible without redefinition". Moreover, Lueck (1995, 644) reminds us that this outcome may occur even when the value of the resource is high, as is the case for water in some regions.

In Chapter 2, this paper applies a general framework of transaction cost sources, developed by Libecap (1989, 21-28), to argue that two common laws observed in water trading states allocate water rights in such a way that increases the number and heterogeneity of competing claimants in the water transfer process. Specifically, the assignment of property rights via the No-Injury Rule, which gives instream flow claimants (i.e., riparian rights holders) rights in the water transfer process, and California Water Code 386 (W.C. 386), which makes prior appropriative rights less clear by giving third-parties (i.e., those not directly involved with buying or selling) the ability to protest (and potentially block) beneficial trade, creates added information and negotiation costs that would not exist if the property rights were assigned exclusively to the seller. Thus, regions that allocate property rights in this manner should export less water relative to the first-best outcome (i.e., less than the ideal quantity indicated by a theoretical benchmark, denoted as Q_0 in the model).

Chapter 3 develops a model that combines the effects of the No-Injury Rule and W.C. 386 on a farmer's decision to trade water. The model shows that as the number of claimants who can block trade increases, the information and negotiation costs associated with trade increases. In California's case, claimants come in two forms: instream flow claimants and undefined third-parties. Through the No-Injury Rule, a prior appropriator wishing to sell water that he or she has a right to use incurs a higher cost of negotiating with an instream flow claimant than negotiating with another prior appropriator. Through W.C. 386, there is a higher cost for a prior appropriator to negotiate with third-parties than to negotiate with another water rights holder. Moreover, because the law fails to clearly define what type of harm is protected under the law, there are differing degrees of negotiating costs associated with different types of third-party groups. Under both laws, the prior appropriator has a clear and exclusive right to use his water (and can do so without incurring transaction costs), but not a clear right to sell his water without incurring transaction costs because the right to sell is not exclusive to the prior appropriator. This should result in both a decrease in the volume of water exported within a given water market and a decrease in the probability a region will have an active water market[3] for exports (i.e., water transfers in which the seller and the buyer did not reside in the same county).

Using empirical models developed in Chapters 4 and 5, this paper tests the effects of riparian rights holders (representing costs from the No-Injury Rule) and third-parties (representing cost from W.C. 386) on the volume of water exported and traded locally in each county in California from 1990 to 2001. Because California has a unique blend of water rights, along with cross sectional variation in the number of third-parties, these data

[3] With respect to exports, active water markets within a county are defined as any county with at least one recorded export transaction from 1990 to 2001. Although it is possible that an unrecorded market transaction may occur if the seller and the buyer are neighbors living on their respective county borders, it is unlikely that even these transactions would not be recorded. This is because any change in diversion or use of water must be approved by the SWRCB or the seller risks losing his or her water rights permanently. With respect to local sales, active water markets within a county are defined as any county with at least one recorded local transaction from 1990 to 2001. It is more likely that informal transactions may go unrecorded in this setting in comparison with the export markets. However, as before, any change in diversion or use of water must be approved by the SWRCB or the seller risks losing his or her water rights permanently. In consideration that most of California's watercourses are fully appropriated, it is unlikely that an informal, unapproved transfer would go unnoticed by neighboring users.

provide a unique opportunity to test if the property rights distribution under these two laws is facilitating or deterring water trades.

The final chapter summarizes the paper's main conclusions drawn from the empirical results presented in Chapter 6. The effect of the No-Injury Rule has the predicted impact on water exports; however, the effect of W.C. 386 is inconclusive. The combined two stage least squares and tobit (IV-TOBIT) specification shows that for the average county, a one standard deviation increase in the ratio of riparian rights holders to total population will decrease the likelihood that the county will have an active water market for exports by 30 percent. Furthermore, in counties with export markets, a similar increase in the ratio of riparian rights to total population will decrease the annual ratio of exports to appropriations by 7.4 percent. For the county with the median level of prior appropriations (Siskiyou County) this would be equivalent to 219,551 acre-feet of forgone exports, if the acre-feet in appropriations remain constant in the county. This suggests that if California's goal is, as stated in the 1970's, to reallocate water to its highest valued use, the current allocation of property rights may be creating policy-driven costs that hinder reaching that goal.

CHAPTER 2

BACKGROUND

Correlative Riparian Doctrine

Riparian water doctrine, derived from English common law, was the predominant convention in the United States prior to 1855 and remains so in most of the eastern regions of the country. Riparian doctrine requires that surface water entitlements (i.e., instream flow claims) stem directly from landownership and do not pertain to water originating from other watersheds. Specifically, landowners whose property touches or contains a pond, lake, or watercourse have equal rights to use the natural flow of water from that course as long as the quantity or quality available is not unreasonably diminished for other riparian owners. Because these instream flow rights are coequal,[4] riparian water ownership is not quantified in acre-feet or cubic meters and the amount of the water right changes according to the time of year and water supply. Additionally, the legal uses allowed by riparian rights are very limited.[5] Water can only be diverted on the adjacent riparian land, which is normally considered land within the watershed, and owners cannot store water for later use. Moreover, because the right is part and parcel to the land, riparian rights are fundamentally not transferable apart from the land.

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[4] Coequal rights are defined as rights that have the same standing before the law and no user has senior or priority rights over another.

[5] Note that in California riparian water rights can be used for agricultural irrigation on riparian lands. In this respect, California differs from many other states, including Montana.

Prior Appropriation Doctrine

In 1855, in the midst of the California gold rush, the diversion and trade limitations of riparian doctrine inhibited miners seeking to divert water to their processing sites. As a result, the California Supreme Court ruled in the case of *Irwin v. Philips* that Irwin – a mining company that "illegally" diverted water to a mining site miles away – had, in fact, a legitimate right to divert the water for a more beneficial purpose. The doctrine born out of this mining dispute was called prior appropriation or "first in time, first in right". This new doctrine set a clear order of priority to use a certain quantified volume of surface water. This implied that, unlike riparian doctrine, in times of limited water supply, junior appropriators are forced to yield all or part of their water use to senior appropriators. In this way, prior appropriation doctrine allowed for the creation of well-defined, enforceable and transferable water rights. Use of such a right was only restricted by auxiliary laws and physically contingent on the availability of the water allotment.

The Effect of Water Doctrine and the No-Injury Rule on Water Trades

Although most regions have chosen to recognize only one form of water doctrine, in some states a blend of riparian and prior appropriative rights is recognized under the law. In these dual doctrine states, the different types of water doctrine in the region, coupled with the No-Injury Rule, change the costs associated with trade. Although the law differs slightly by state, generally, the No-Injury Rule[6] states that any water transfer must not injure[7] or adversely affect the legal[8] rights of any other water rights holders. This implies that all other water rights holders in the region can potentially affect trade through this law. The extent to which each can affect trade volume, however, differs by the type of water doctrine.

Institutional Constraints

The legal contrast between riparian and prior appropriation doctrine means that the direct costs of trading water under the two different types of water doctrine vary substantially. For instance, because riparian water doctrine does not allow for the transfer of water rights off the adjacent lands to which the rights are attached, no trade is possible under this doctrine. In this way, the institutional constraints impose a direct cost on riparian water rights holders that prevents the sale of these rights off their riparian lands. Thus, we would expect trades to be lower in regions with a higher number of riparian rights. Conversely, all else equal, in regions with more rights in prior appropriative doctrine, the volume of water traded should be higher.

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[6] California water code sections 1435 (b) (2) (temporary urgent change), 1702 (change petition for modern rights), 1706 (change other than under Water Commission Act and therefore, applies to pre-1914 water rights), 1725 (temporary change), 23 Cal. Code Regs. Section 791 (a) (change petition), 1736 (long term transfers) and Revised SWRCB Decision 1641, §11.2 (2000).

[7] Common forms of injury recognized by the No-Injury Rule include a reduction in the return flows caused by increases in consumptive rates, stream conveyance losses, reduction in water quality, loss of natural subirrigation where lands are taken out of production and loss of soil moisture.

[8] Some states replace the phrase of "other water rights holders" with "other legal users". This is to emphasize that not all injury is protected by law. For instance, a riparian water rights holder cannot claim injury from a water transfer that results in less stored water being released into the watercourse. This is because the riparian user only has a legal right to the natural flow of the stream and has no claim to the stored water.

Increasing the Number of Claimants

Water rights holders can also have an effect on water trades through the No-Injury Rule. Through this law, the number of claimants that must be addressed in the water transfer process is increased to include all other water rights holders that may be harmed by trade. In effect, through the No-Injury Rule, a farmer's right to sell his or her quantity of water is reallocated to include other water rights holders. Generally, when multiple parties have rights to a single resource, engaging in transactions can be more costly partially due to the added negotiation costs to obtain an agreement among all claimants. This was shown by Anderson and Lueck (1992, 430) when tribal and federal laws gave multiple parties – BIA agents, local tribal officials, the Secretary of the Interior, and multiple private owners – blocking rights to the use of a single plot of reservation land by requiring a unanimous agreement by all shareholders. Anderson and Lueck concluded that these laws made the cost of negotiating prohibitive and stifled Indian land productivity as measured by agricultural output (434). If, as pointed out by Anderson and Johnson (1986, 541), there is only one impaired claimant, the property rights owner would simply compensate the claimant for the damages. As the number of claimants with blocking rights increases, however, the negotiation costs associated with trade will rise. Applying this to the water market context, this paper argues that we would expect fewer trades in regions with a higher number of potential claimants granted rights through the No-Injury Rule (compared to the case where the right to sell is exclusively with the seller). Nevertheless, as shown in the next section, there is a substantial difference in the cost for a prior appropriator to negotiate with a riparian rights holder relative to another prior appropriator.

Information Asymmetries

It is also true that information asymmetries among the claimants can raise the cost to trade. Libecap (1989, 24) showed that information asymmetries occur when each party's expected gains or losses "cannot be conveyed easily or credibly." In the case of water markets, through the No-Injury Rule, prior appropriators wishing to trade their rights in dual doctrine regions incur a higher cost to negotiate with riparian rights holders than to negotiate with other prior appropriators. This is because, unlike prior appropriation rights, riparian rights are not defined in acre-feet and change rapidly according to the time of year and availability of water. Because of this, prior appropriators must incur a cost to determine any potential harm to riparian rights holders that may result from a water transfer. This increase in information costs should result in less water exported relative to the first-best outcome (i.e., Q_0).

State Water Code: The Effect of Expanding Third-Party Rights on Water Trades

Prior to 1982, in most states, the principal constraint on any water transfer came from the No-Injury Rule. This clause protected other water rights holders from unreasonable injury, as defined by the law. In many states, however, the courts and local water codes have expanded those protected from unreasonable injury to include third-parties in the transferor's county. Third-parties in this paper are defined as individuals who are potentially negatively affected by water trades and reside in the county of origin, but do not hold water rights and do not participate directly in the water transfer. In practical terms, the law gives third-parties in the county of origin a right to protest any water trade that negatively affects them in an unreasonable manner, but fails to clearly define who the third-parties in the county are and what type of harm is protected under the law. In a world where transaction costs are low and rights are well defined, the Coase Theorem tells us that these third-parties and potential transferors would simply contract with one another to obtain the optimum use of water (Lueck 1992, 657). The following section will show, however, that these types of laws act to not only raise the transaction costs associated with trade by expanding quasi-veto rights (i.e., rights to protest and perhaps block trade) to include a group of heterogeneous non-water rights holders, but also substantially increases the amount of restrictions associated with water ownership, thus, making prior appropriative water rights less clear (Barzel 1997, 3).

Increasing the Number of Claimants

To understand how these laws have, in practical terms, amounted to expanding a quasi-veto right to an undefined group of third-parties, it is beneficial to analyze California's water transfer process. According to State Water Resource Control Board (SWRCB 1999), in order to obtain permission for a short-term transfer,[9] the transferor must submit a petition with investigation fees to the SWRCB. These fees (later referred to as α) can be as little as a few hundred dollars or as much as $50,000, depending on the volume of water proposed in the trade and the complexity involved. Within ten days after

[9] Long-term transfers (greater than one year) differ only in that they are more heavily investigated.

the receipt, the board will send notice of the petition to all legal users of the water who are known to the board. Those included would be other water rights holders and any parties that may be protected under California Water Code section 386. This section states that “water transfers must not unreasonably affect fish, wildlife or other instream beneficial uses and must not unreasonably affect the overall economy of the area from which the water is being transferred” (State of California's Legal Information Division). The transferor must also publish notice in newspapers within all affected counties. Any third-party in the county of origin may file an objection to the proposed transfer within thirty days after the notice. There are virtually no organizational costs incurred by individuals in the local economy to submit a protest because the board will accept protests from any individual at no charge, however, the SWRCB reserves the right to deny any protests it deems frivolous.

The transferor and the protestors have approximately 35 days to negotiate a resolution, perhaps through compensation or a change in the proposed time of the transfer. If the transferor cannot successfully come to an agreement with all protestors, the SWRCB will hold a hearing to rule on the petition. Most hearings will likely delay temporary transfers to the point that they would not take place in the proposed year (SWRCB 1999, section 6). If the buyer is a farmer looking to fill a short term need or if the transferor, looking to sell a temporary excess, does not have access to water storage, a one year delay might be enough to block the transfer altogether.[10] This is one way that this law effectively gives third-parties quasi-veto rights. Additionally, if successful

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[10] Since municipalities are typically looking for reliable long-term suppliers, a one year delay in this type of contract should not be enough to deter their interests in the trade.

negotiations cannot be completed and delays are long enough, transferors often withdraw their request rather than proceed with a water hearing. This was the case when, after six years of negotiation, the Department of Water Resource (DWR) and the State Water Project finally abandoned a proposed transfer because of local economic protests (personal communication Greg Wilson June 6, 2008 and SWRCB 1999). Effectively, in order for a local group of protestors to extract rents in the form of compensation from potential transferors, the groups must incur organizational costs. Conversely, there is no organizational cost for a potentially injured individual in the local economy to invoke his quasi-veto right. This is true because all individuals in the protesting group must agree on a compensation package in exchange for each individual to withdraw their protests to allow the trade.

As this process shows, W.C. 386 makes a prior appropriator's selling rights less clear by expanding quasi-veto rights to third-parties in the county of origin without clearly defining which groups can successfully claim harm (and therefore, have blocking rights) and which do not. As with the No-Injury Rule, this increases the negotiation costs associated with trade. Thus, in regions with a higher number of third-parties, we would expect a decrease in the volume of water traded within a given water market.

Heterogeneous Groups: Farmers, Tractor Dealers, and Teachers

Water Code 386 also forces transferors to negotiate with a more heterogeneous group of potential protestors than the No-Injury Rule. According to Anderson and Lueck (1992, 434-437) multiple heterogeneous groups, such as those found in water markets, make the costs of contracting for resource uses systematically higher, because they raise the information cost associated with trade. Through W.C. 386 prior appropriators incur a higher cost to negotiate with third-parties, who may be made up of bureaucrats, teachers, environmental groups and tractor dealers, than to negotiate with other water rights holders, who are most likely (but not always) other farmers protected under the No-Injury Rule. This is true because, although information asymmetries may still exist, a farmer can more credibly confirm the losses to a neighboring farmer because of low irrigation flows than the decrease in sales to a tractor dealership because of a reduction in agricultural output. Furthermore, it is even more costly for the farmer to credibly confirm losses due to a decrease in school enrollment or losses due to a decrease in the demand for diesel at the local truck stop. As a result, these heterogeneous groups may lead to fewer water exports relative to regions where all claimants are similar.

CHAPTER 3

THEORY

Consider a farmer's decision to export water given both his legal and physical constraints on water usage. As mentioned previously, the first legal constraint is the type of water doctrine: the farmer must have a prior appropriative right in order to export.[11] The second is the potential quasi-veto power held by both harmed riparian rights holders and harmed third-parties; this requires the exporting farmer to incur information, negotiation and compensation costs. Figure 1 graphically depicts the possible export outcomes from the perspective of a farmer who owns a prior appropriative water right. For simplification, we assume that any given farmer is a price taker in the water export market (but not necessarily in the local water market). Moreover, the farmer can live in a county with no riparian water rights holders or third-parties or both, few riparian water rights holders or third-parties or both, or a large number of riparian water rights holders or third-parties or both. Finally, the farmer has three income sources in any given period – income from agriculture (which is a function of the water used), income from local water sales, and income from water exports.

In Figure 1, the marginal cost line, labeled MC_{farmer}, represents the farmer's cost per acre-foot of water exported if there is no third-party resistance, no resistance from other riparian water rights holders and no SWRCB fees. In other words, this line reflects the farmer's opportunity cost of exporting the water, which includes forgone crop

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[11] The cost for a riparian right holder to change the law to allow for trade would force τ to be so large that we would not observe any trades at any historical price for water to date.

revenues or forgone revenues from local water sales or both. Also included in MC_{farmer} are any legal fees and costs associated with the buyer and seller negotiating for the export. Therefore, a profit maximizing farmer would export Q_0 in a county with all water rights well-defined and transferable (i.e., no riparian water rights), no third-party resistance and no SWRCB investigative fees.

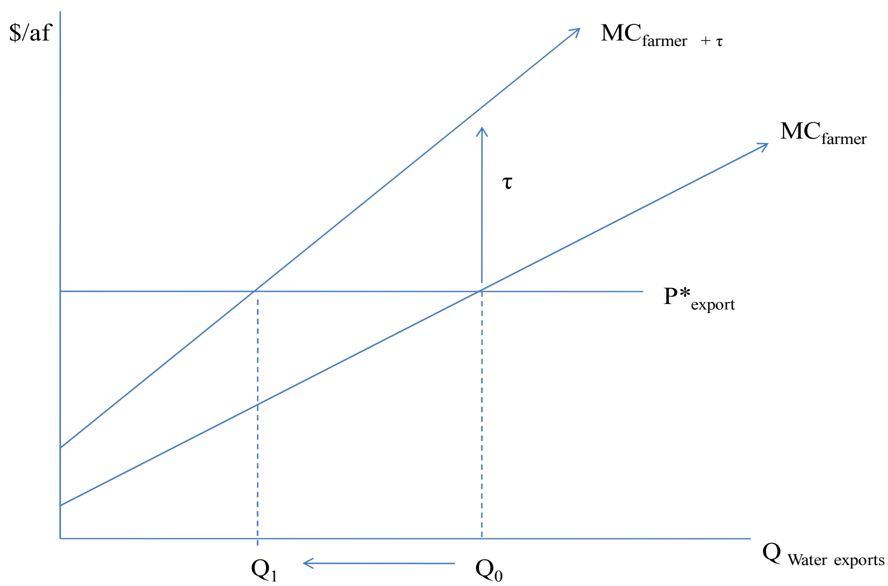

Figure 1. Model of One Farmer's Decision to Export Water.

In regions with laws that recognize other rights holders or give third-parties quasi-veto rights or both, the cost to export each acre-foot of water is higher by τ, which is a function of the quantity of water exported, where

$$\tau = \alpha + \beta \cdot (Q_{exports}) \text{ where } \alpha \geq 0 \text{ and } \beta \geq 0. \qquad (1)$$

With $\alpha > 0$ and $\beta > 0$, the marginal cost line is higher and steeper, as shown by $MC_{farmer + \tau}$ in Figure 1. The magnitude of τ will reflect the farmer's additional costs as a direct result of riparian water rights holders and third-party rights in the water transfer process, as well as SWRCB's investigative fees.

Now consider more specifically how α and β are influenced by the water transfer process and the expected losses attributable to trade. The value of α, which affects the location of the y-intercept on $MC_{farmer + \tau}$, will depend on the SWRCB's investigative fees and any other *per unit* costs that do not vary with the quantity of water traded. The value of β, which may be zero or positive, affects the slope $MC_{farmer + \tau}$. It will depend on the number of riparian rights holders in the county and the number of third-parties with legal standing in the county of origin, as well as their expectations about the potential harm caused by the water export. At low levels of export, there may be little or no resistance from third-parties (or, similarly, riparian rights holders) because the stakes are so low. This is because individual participants lack a sufficient incentive to act. As the quantity of water exported rises, however, more third-parties are likely to act and they may put up more resistance per unit of exports because the magnitude of injury per acre-foot increases as more acre-feet are exported.

To demonstrate the impacts of these costs on trade, consider Lueck's model of establishing property rights for wildlife. In it, Lueck shows that resource outcomes, in our case water usage, will depend primarily on the interaction of the resource's values (i.e., prices) with owner contracting costs (a component of τ in our model) (1995, 645). Using three possible stochastic export prices a farmer might face (P_{low}, P_{middle}, or P_{high}), Figure 2 illustrates Lueck's idea in the context of markets for water exports. Assuming both α and β are greater than zero, Figure 2 shows the possible export outcomes under the three different export prices. If the price is P_{high}, the farmer would trade Q_0 in a county with well-defined and transferable water rights, no third-party resistance and no SWRCB investigative fees. If, however, the farmer faced additional costs to trade in the amount of τ, at a price of P_{high}, the quantity of exports would decrease from Q_0 to Q_1 as predicted by the model. Thus, if $MC_{farmer + \tau}$ shifts up (as a result of τ increasing), the quantity of water exported will decrease.

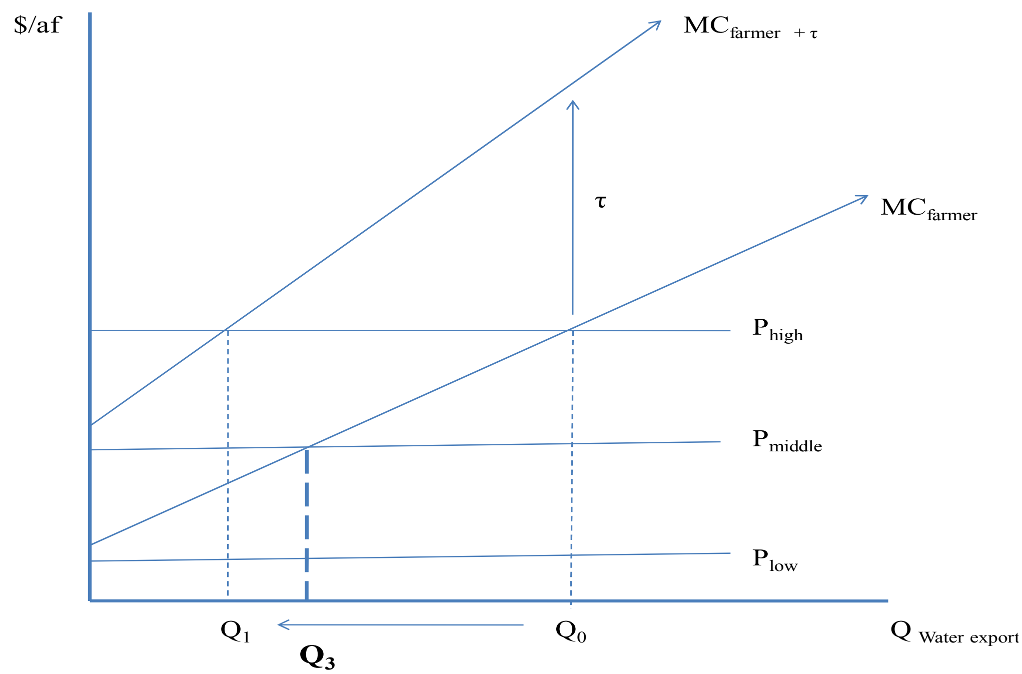

Figure 2. Possible Export Outcomes.

If, however, the farmer faced P_{middle}, the quantity of water exported would be Q_3 in a county with well-defined and transferable water rights, no third-party resistance and no SWRCB investigative fees. Yet, if τ were positive in the way depicted in Figure 2, at a price of P_{middle} the marginal cost to trade would outweigh the gains to export and there would be no water exported. At a price of P_{low}, the cost for the farmer to trade would be higher than the gains even in a county with well-defined and transferable rights, no third-party resistance and no SWRCB investigative fees.

Overall, Figure 2 generates two testable predictions. First, at any given export price, real world factors analogous to a high τ will generate a lower volume of trade. In this way, these legally driven contracting costs act in the same way as a tax on potential water sellers, decreasing the volume of trades relative to regions without these same laws. Second, given a stochastic export price (e.g., perhaps P_{high} or P_{middle}) factors analogous to a high τ will lead to a lower probability of observing trades. This is because when the gains from exporting water are overwhelmed by the costs of contracting among riparian rights holders and third-parties, no water will be exported. This is similar to Lueck's argument that when resource values are higher "interested parties can more easily bear" the transaction costs associated with trade, because the gains from negotiating an agreement among all claimants will be greater (Lueck 1995, 657 and 663).

Finally, it is important to consider another aspect of the farmer's water allocation decision: the water not exported is then divided between crop production and local sales (i.e., water transfers between a buyer and a seller who both resided in the same county). There are three key factors that influence a farmer's decision to reallocate. First, as the export price declines relative to P_{local} and crop prices, one would expect the individual farmer to allocate more to crop production or local sales or both. Second, conditional on the level of exports, the allocation of water between local trades and own-farm use is unaffected by third-parties, because W.C. 386 cannot be applied to local trades.[12] Third, conditional on the level of exports, the allocation of water between local trades and own-farm use is most likely unaffected by riparian rights holders. This is because the injury that normally is claimed by riparian rights holders – a decrease in return flows – would theoretically not exist with most local trades. Thus, ceteris paribus, at higher values of τ or low export prices or both, the farmer will choose to sell more water locally if P_{local} minus the costs to trade locally, which may be affected by the No-Injury Rule, is greater than the value marginal product of own-farm water.

Overall, similar to Lueck's (1995) explanation of the relative values of wildlife resources versus the cost to contract for these resources, this model shows that the amount of water exported will depend on the export price less all the costs (including τ). If positive rents exist after transaction costs are incurred, then $Q_{exports}$ will be positive. If, however, the price is low relative to τ (i.e., the transaction costs) it may not be beneficial to export water and, therefore, water will be used locally or for own-farm use.

[12] Note that Water Code 386 cannot be applied to local trades because a local trade necessarily produces an increase in local productivity. A local farmer who trades with another local farmer does so only if the value of water on the buyer's land is greater than the value of water on the seller's land. Thus, any local trade produces more output than would occur if trade was blocked and therefore, cannot "unreasonably affect the overall economy".

CHAPTER 4

EMPIRICAL METHOD

Regression Equations

To test these refutable hypotheses, we would ideally analyze water exports and local trades at the farm level in each county. Such data are, however, unavailable. In place of farm level observations, a dataset containing all water trades in 57 California counties is used, excluding San Francisco as an outlier.[13] This dataset is simply an aggregated measure of all farmers' decisions in the county to consume, sell locally or export their water allotments. Because California counties recognize a blend of riparian doctrine, prior appropriation doctrine, and an influential water code, when the state of California decided to adopt policies and infrastructure to encourage water markets across the state, each county's potential transferors faced differing participation costs. The summation of each individual farmer's choices in regards to water use will then be reflected in the volume of water exported and sold locally in each county.

Based on the economic theory presented above, I estimate an econometric model of the ratio of acre-feet traded to the total acre-feet appropriated in each county in California from 1990-2001 as a function of key variables of interest. These variables

[13] San Francisco County exported 4,736 acre-feet of water in 1992 and nothing else from 1991-2001. San Francisco's trades were omitted from the data set because it is the only county in California with exclusively pre-1914 prior appropriation water rights, which can be traded, but at a higher cost than post-1914 prior appropriation rights. In addition, San Francisco County is the most densely populated county in all of California with 16,625.278 people per square mile. It contains almost no irrigated acres and its major industries are comprised of world banks and shipping companies. Lastly, San Francisco County obtains approximately 85 percent of its total water needs from the Hetch Hetchy watershed (containing the O'Shaughnessy Damn). This implies that San Francisco County is one of the few counties in California that gets the majority of its water supplied from an abundant source located outside the county.

represent potential sources of information and negotiation costs associated with trade in each county. Total acre-feet appropriated is defined as the number of acre-feet in post-1914 prior appropriated rights,[14] which represents all rights in the county that are well-defined and can be legally transferred. The analysis asks, out of the water available for legal trade, how much trade do we actually observe in the county.

The data show that despite state-wide efforts to create water markets, only 34 counties have active water markets (i.e., recorded transactions) for exports or local sales or both. In these counties, the yearly acre-feet of water exported and traded locally were recorded for all years with no missing records. Water exports were defined as water transfers in which the seller and the buyer did not reside in the same county. Under such contracts, the water will not be used in the county of origin for the duration of the contract. Note that all environmental purchases were recorded in this category. Local transactions were defined as water transfers between a buyer (purchaser) and a seller (transferor) who both resided in the same county. All explanatory variables were measured at the county level from 1990-2001.

The following regression equation was estimated:

$$\text{Water Exports}_{it} = \rho_1 + \delta_1 x_{it} + \gamma_1 z_{it} + \lambda_1 w_{it} + \theta_1 v_{it} + \mu_{it} + a_i \qquad (2)$$

where Water Exportsit is the volume of water exported in county i during year t divided by the volume of water appropriated in county i during year t. The term x_{it} is a vector of

[14] Note that pre-1914 prior appropriative rights are diversion rights established prior to a central agency permitting and documenting appropriative rights in California. Prior to December of 1914 to claim a diversion right, a user would simply post notice in the form of a sign at the point of diversion. To prove such a right existed post 1914, the user had to undergo a lengthy investigation process, using neighbors and other water users as witnesses to amount of the right. As a result, according to the SWRCB, most pre-1914 appropriative rights were lost during the transition and such rights are rare today.

institutional variables that represent sources of costs, which influence the size of τ. The ratio of riparian rights holders to total population is used to represent these institutions. The term z_{it} is a vector of third-party indicators that proxy for individuals that generate sources of third-party costs, which influences the size of τ. The per capita number of employees in the farm machinery industry plus the number of employees in the irrigation industry, the percent of farm employment to total employment, and the per capita value of agricultural production are used to represent sources of third-party costs. The term wit is a vector of supply and demand measures and proxies that influence MCfarmer and the market demand for water. Total water supply in thousands of acre-feet, annual precipitation in inches, and a proxy for transportation costs are used to represent factors that change the location of MCfarmer. Lagged population growth rate is used to represent shifts in the residential demand for water across counties and time. Finally, the interaction of lagged population growth rate and precipitation is used to proxy for changing relative water scarcity within and across counties, which shifts the market demand for water across counties and time. The interaction term was added because the population growth rate might have a different effect for counties with different variable water supplies. The term vi is a vector of control variables, some of which are used to test the sensitivity of the results. These include a time trend variable, local laws, the number of employees in the gold and silver mining industry in 1998 and the inverse of total population in the county. The term uit is the idiosyncratic component of the error term. The term ai is the county fixed effect component of the error term and includes the effects of time invariant unobserved variables.

Regression (3) is used as an additional means to test the implications of these laws:

$$\text{Local Sales}_{it} = \rho_2 + \delta_2 x_{it} + \gamma_2 z_{it} + \lambda_2 w_{it} + \theta_2 v_{it} + \mu_{it} + a_i, \quad (3)$$

where Local Sales_{it} is the volume of water traded locally in county i during year t divided by the volume of water appropriated in county i during year t. A farmer who faces higher export costs due to these laws should export less water and reallocate his water use between own-farm uses and local sales. The farmer will choose to sell more water locally if P_{local} minus the costs to trade locally, which may be affected by the No-Injury Rule, is greater than the value marginal product of water on the farm. Note that, under the current law, the farmer would not choose to leave any water unused because he risks losing that part of his water allocation.

Specifications Used

As a baseline for comparison, I begin by using the ordinary least squares (OLS) model, with the assumption that the number of riparian rights holders in each county is exogenous to the model. One problem with estimating (2) and (3) using pooled OLS is that in reality riparian water doctrine in each county may be endogenous. In other words, there may be unobserved historical variables that caused the individuals in the county to choose riparian water rights over prior appropriation rights. If this is the case, then these unobserved and omitted variables not only drove the establishment of different water doctrines in the 1850s, but they may also drive the willingness to use water markets as a solution for water scarcity today. This means that a_i is most likely correlated with the ratio of riparian rights to total population, thereby, biasing my estimates. Because panel data are being used, the most obvious solution to this problem would be to include county fixed effects. According to the SWRCB, however, because most rights in California were issued prior to 1950 the number of riparian rights in the county did not change during this study. Therefore, including county fixed effects estimates would completely eliminate all cross sectional variation in this variable. Instead, I attempt to correct for this potential bias using the IV-TOBIT model and four instrumental variables, each of which played a historical role in the establishment of the two types of water doctrines in California.

In addition, there is evidence that the error terms within each county are correlated with each other over time, but not with other counties' error terms. Ignoring this within-county correlation would lead to inconsistent estimations of the standard errors of the estimated coefficients. Therefore, in order to obtain consistent estimates, all models cluster the a_i error terms by county, which resulted in more conservative estimates of the standard errors than if this clustering was ignored.

Expected Signs of Coefficients

As mentioned previously, theory predicts that regions with a greater number of potentially affected riparian rights holders should be less likely to have active water markets and, given a market exists, should have a lower volume of water exported relative to regions with fewer riparian rights holders. Using Regression 2, the null hypothesis will be that $\delta_1 = 0$, which implies that the probability of an active water market developing and the activities within it are unaffected by the No-Injury Rule. This will be tested against a two-tailed test that $\delta_1 \neq 0$.

Local trades in the county provide an additional opportunity to test the implications of the No-Injury Rule. This is true because farmers who face higher export costs due to these laws should export less water and reallocate their water use between own-farm uses and local sales. Using Regression 3, the null hypothesis will be that $\delta_2 = 0$, which implies that the volume of local trades developing is unaffected by the No-Injury Rule. This will be tested against a two-tailed test that $\delta_2 \neq 0$. Notice that the effect of the No-Injury Rule on local trade could be positive if, as a result of less water being exported out of the county, more water is traded locally. Conversely, the effect of the No-Injury Rule on local trade could be negative if the type of local trade is covered under the No-Injury Rule and, thus, raises the cost for prior appropriators to trade locally.

The third hypothesis is that regions with a greater number of potentially affected third-parties with legal exclusion rights should be less likely to have active water markets, and given a market exists, should have a lower volume of water exported relative to regions with fewer and less influential third-parties. Using Regression 2, the null hypothesis will be that $\gamma_1 = 0$, which implies that the probability of an active water market developing and the activities within it are unaffected by the third-parties in each county. This will be tested against a two-tailed test that $\gamma_1 \neq 0$.

As before, local trades in the county provide an additional opportunity to test the implications of giving third-parties quasi-veto rights. Using Regression 3, the null hypothesis will be that $\gamma_2 = 0$, which implies that the volume of local trades developing is unaffected by the third-parties in each county. This will be tested against a two-tailed test that $\gamma_2 \neq 0$. Note that, unlike the No-Injury Rule, W.C. 386 cannot be applied to local trade.

CHAPTER 5

DATA

Dependent Variables

Summary statistics and a correlation coefficient matrix for all variables can be found in Tables 4 and 5 in the Appendix. Data for the volume of water exported in county i during year t and the volume of water traded locally in county i during year t were gathered by Ellen Hanak, a Senior Fellow at Public Policy Institute of California, using a variety of state, federal and local sources on individual water transfers from 1990-2001 (2005).[15] Hanak reported data as $exports_{it}$ and local $sales_{it}$ where i = 1…58 and t = 1…12. Each category is the summation of surface water and groundwater transfers,[16] as well as short term and long term transfers[17] for water agencies (state or private) within a county for a given year. Where agencies had multiple county jurisdictions, Hanak weighted the

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[15] Resources included the following: the DWR, the Bureau of Reclamation Offices, water districts throughout the state, *The Water Strategist,* and the SWRCB, which approves any transfer that involves public facilities. Water transfers between federal and state projects that do not require SWRCB approval will require approval from the project themselves and will therefore be included in the dataset. There is potential for certain types of groundwater transfers and the rare transfer using pre-1914 appropriative rights to be missing from this dataset if the transfers do not involve using public facilities (State Water Resoure Control Board 1999). According to both the SWRCB and the DWR, very few pre-1914 rights exist today, because proving these rights is very difficult owing to the lack of historical documentation. Because most transfers are either approved by or involve state or federal agencies, this dataset is thought to be a good indicator of water markets in California.

[16] No record was kept of how much water came from surface water transfers versus groundwater transfers. Although the legal requirements to sell groundwater do vary slightly, groundwater in known channels and groundwater that replaces surface water use are all considered surface water entitlements in California.

[17] There were 14 long-term water transfers with contract lengths between 2 and 35 years. The majority of these transfers were local in nature.

acre-feet transferred by area, recording partial amounts of the transfer in different counties with each transaction counted only once.

I gathered data for the denominator of both the dependent variables, the volume of water appropriated in county i during year t, using the SWRCB's database that documents all public water rights that must legally be registered (SWRCB 1990 and SWRCB 2009). The pertinent section of the database reports the characteristics of each post-1914 prior appropriation water right. From this, the annual number of acre-feet in post-1914 prior appropriative rights in each county is obtained. This serves as a proxy for the number of acre-feet in the county that can be legally traded. Dividing trade by this variable allows us to distinguish counties with few trades because of a small number of tradable acre-feet from counties with few trades because of legal constraints.[18] Note that the variable, acre-feet appropriated, contains only cross sectional variation.

Surpassed only by Colorado, California's water market is the second largest water market in the nation, accounting for about fifteen percent of the nation's transactions

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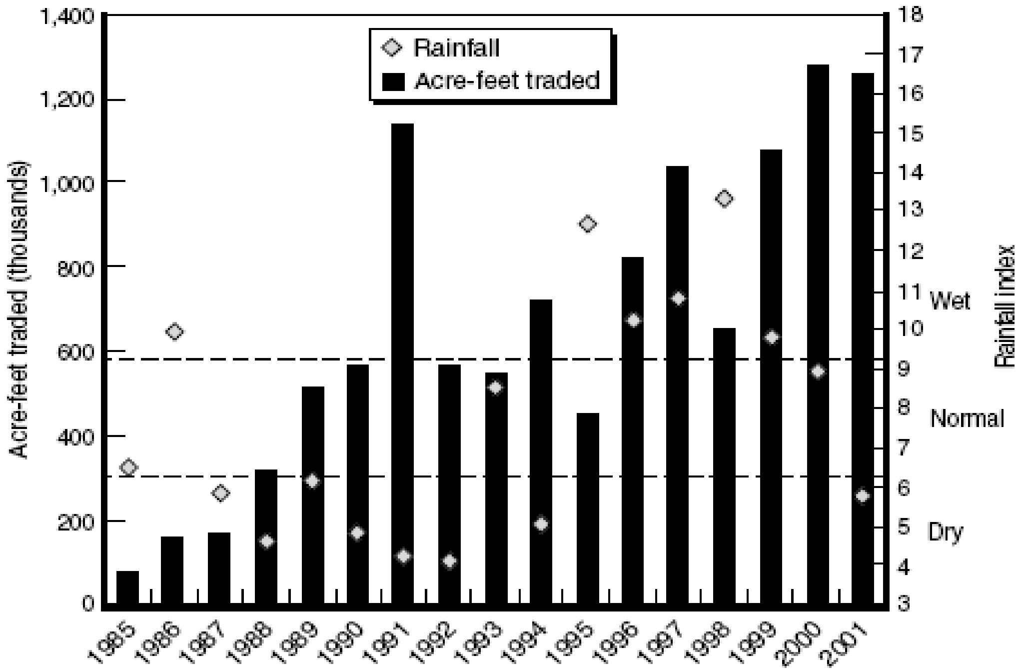
[18] Note that 71 percent of California counties have more acre-feet appropriated than acre-feet in dedicated water supply. There are two major reasons for this. First, a paper water right (i.e., the amount listed in the water right license as the maximum annual diversion amount) does not guarantee a water supply. The hydrology of the state varies considerably from year to year and as a result, some junior water rights may only be satisfied in wet years. Historically, water agencies would approve a diversion right if water was available at least 20 percent of the time. Second, many rights were issued before an accurate hydrologic record was available. Thus, according to an email from Vicky Whitney, the Deputy Director for Water Rights at the SWRCB, many streams and watercourses are "significantly over appropriated". For instance, according to Whitney, studies have shown that water rights issued after 1950 in the Central Valley are not available in most months of some years. This implies that the observable acre-feet in prior appropriations is an overestimate of the true acre-feet available for trade in any given year. Thus, the econometric model contains left hand side measurement error.

To further test the implications of over appropriated counties, a binary variable equal to one if the county's water supply is over appropriated was added to the baseline IV-TOBIT specifications (Tables 2 and 3) with no significant changes in the results.

from 1987-2007.[19] Figure 3 illustrates that California's water market growth was initially driven by a severe five-year drought from 1987-1992, but remained substantial after the drought conditions subsided. In fact, from 1995-2001, despite a stretch of wet years in California, the volume of water traded continued to exceed even the market activities seen in earlier dry years. The exceptions to this upward trend in trade came in 1995 and 1998, when parts of the state experienced flood conditions. Today, much of the market is dominated by short-term contracts, direct government purchases for environmental purposes and transfers among users within the same irrigation district or water project. In most years, the agricultural sector supplied 90 percent of the water traded (Hanak 2002, 7 and 42). Figure 6 in the Appendix shows the aggregated total sales in acre-feet (exports plus local sales) for each county. As the map shows, there is considerable variation across counties in the amount of trade during the period studied. Specifically, during the period studied acre-feet in exports ranged from zero to 252,377 and acre-feet locally traded ranged from zero to 98,000.

[19] Author's calculation based on the Bren School's Western Water Transfer Data Base used in Libecap's paper, "The Problem with Water".



NOTES: For details, see Table A.1. Rainfall is measured by the Sacramento Valley 40-30-30 index, an indicator of water supply conditions for the state's primary river system (see Appendix D).

Source: (Hanak 2005, 46)

Figure 3. Annual Rainfall vs. Volume of Water Traded.

Variables of Interest

To account for the institutional variation across counties (x_{it} vector and component of τ) the ratio of riparian rights holders in county i to the total population in county i during year t was used. Data for the numerator of this variable were gathered by the author using the Statement of Water Diversion and Use section of the previously mentioned SWRCB database. According to Division 2 of Part 5.1 of the California Water Code all water diverted under a claim of riparian rights must be reported in this section. From this, I obtain the number of riparian water rights holders in the county, which, as depicted in Figure 7 in the Appendix, varies only across counties. Data for the total population in county i during year t come from the US Census Bureau. Dividing by the total population in the county standardizes the effect of riparian rights holders across all counties and accounts for their relative importance, which can affect their ability to reach unanimous agreements in regards to compensation. It also more effectively captures the variation from the more rural exporting counties.

Using these preliminary data, Figure 4 displays a possible slight negative correlation between the number of riparian rights holders in the county and the aggregated exports in acre-feet in the county (summation of each county's exports between 1990 and 2001). When the total population in the county is controlled for, the negative correlation is more pronounced. This gives some credence to the model's predictions.

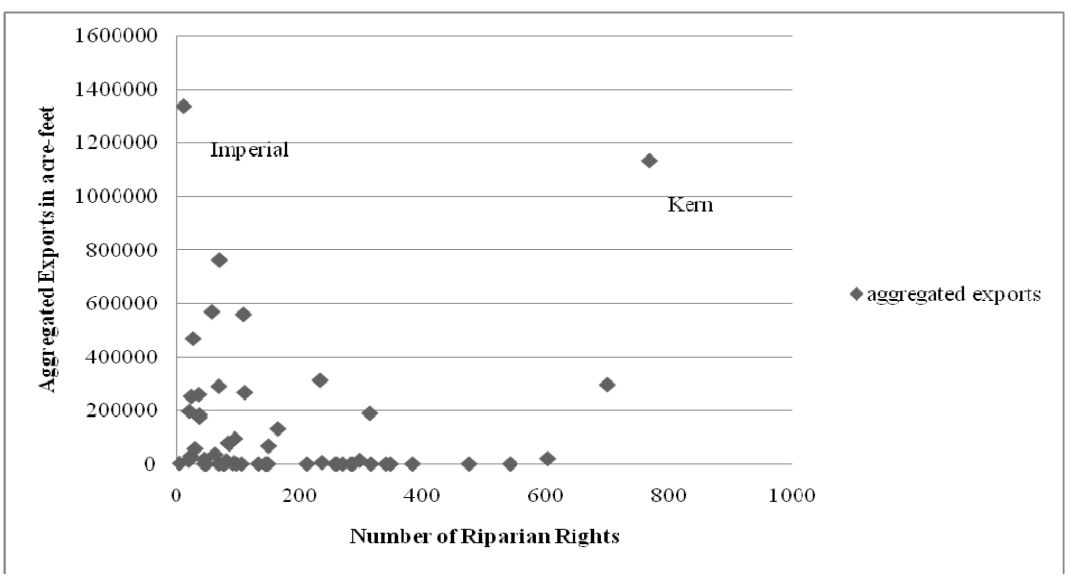


Figure 4. Correlation between Exports and Riparian Rights.

To measure the third-party component of τ (z_{it} vector) three proxy variables were assembled by the author: per capita number of employees in the farm machinery industry and the irrigation industry, percent of agricultural employment to total employment, and per capita value of agriculture. All variables are in per capita terms to more effectively capture the variation in agricultural employment in the rural exporting counties. For all variables employment can be full time, part time, or seasonal. The per capita number of employees in the farm machinery plus the irrigation industries_{it} is measured by adding the number of employees in the farm machinery industry in 1997 to the number of employees in the irrigation industry in 1997 and dividing that summation by the county's population. This variable only contains cross sectional variation. The number of employees in the farm machinery industry_i is a summation of four categories reported in the 1997 Economic Census: heavy truck and tractor wholesalers, farm and garden machinery and equipment wholesalers, farm machinery and equipment wholesale distributors and commercial and industrial machinery and equipment (except automotive and electric) repair and maintenance. Essentially, this category includes all available measures of individuals directly associated with the farm machinery industry in any form, whether in the repair sector or the sales sector, but excluding the lumber industry.

The number of employees in the irrigation industry_i is a summation of three categories reported in the 1997 Economic Census: hydraulic and pneumatic machinery and equipment wholesalers, hydraulic and pneumatic pumps and motors wholesalers and hydraulic and pneumatic parts, accessories and supplies wholesalers. This category includes all available measures of individuals directly associated with the irrigation industry in any form, whether in the repair sector or the sales sector.

The percent of agricultural employment to total $employment_{it}$ is measured by dividing farm $employment_{it}$ by total $employment_{it}$ and multiplying by 100. Farm $employment_{it}$, as measured by the Bureau of Economic Analysis (BEA), is "the number of workers engaged in direct production of agricultural commodities, either livestock or crops; whether as sole proprietor, partner, or hired laborer" (BEA 1990). It contains both between and within variation. There exists a measure for the number of individuals in the agricultural *service* industry; however, this measure is not as useful because in many counties the information was withheld for disclosure reasons.

Per capita value of $agriculture_{it}$ (in 2000 dollars) is measured by dividing the value of agriculture by the county's population. The monetary value of agriculture by county for each year between 1990 and 2001 includes all farm production (excluding timber) in the county whether it is sold or used on the producing farm (compiled by the California County Agricultural Commissioner's Office). These Annual Crop Reports provide the most detailed annual data available on the gross value of agricultural production by county. Although this is not a direct measure of the potential harm to third-parties in the county, value of agriculture is an indication of the county's total expenditures on farm inputs. Figure 8 in the Appendix maps the aggregated per capita value of agriculture in each county throughout the state from 1990 to 2001.

Choosing proxies for third-party costs is difficult because, under W.C. 386, all residents in the county could potentially be included, some of which may not be directly associated with the agricultural industry and may not protest regarding a loss of income from the transfer. According to Libecap (1989, 19), however, focusing on individuals with the greatest potential for income losses due to the change should increase the odds of capturing the "third-party effect". Therefore, for the purposes of this study, the individuals in the agricultural service industry were chosen because they will be most affected by the land-fallowing practices that typically accompany transfers and will, therefore, be likely to protest water exports. This is true because these groups have most likely invested in sunk costs specific to their location and are, therefore, willing to protest in order to protect the economic rents generated by these regional specific assets from the potential harm caused by water exports.[20] It is important to note that although the scope of harm caused by land fallowing may stretch beyond a county's borders, the law only recognizes the rights of third-parties from the county of origin.

For a crude test of the third-party effect, Figure 5 graphically depicts the correlation between the volume of exports (in acre-feet) and the per capita number of employees in the farm machinery and irrigation industries. There is some indication from this graph that when the proxy for third-parties in the county is high, the volume of exports is lower, although this implication is not definitive.

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[20] Note that it is rational for third-parties in the county of origin to expect losses due to water exports for two reasons. First, the majority of transfers come from the agricultural industry and the lowest cost method for a farmer to prove a decrease in consumptive use is to fallow land. For instance, in California if a farmer wishes to change her crop patterns and shift to low water use crops in order to transfer water, 5-20 years of crop history must be produced along with water budgets and other costly investigations. Second, according to Howitt (1994, 362) farmers often use the revenue from water sales to reduce debt rather than to buy additional farm implements.

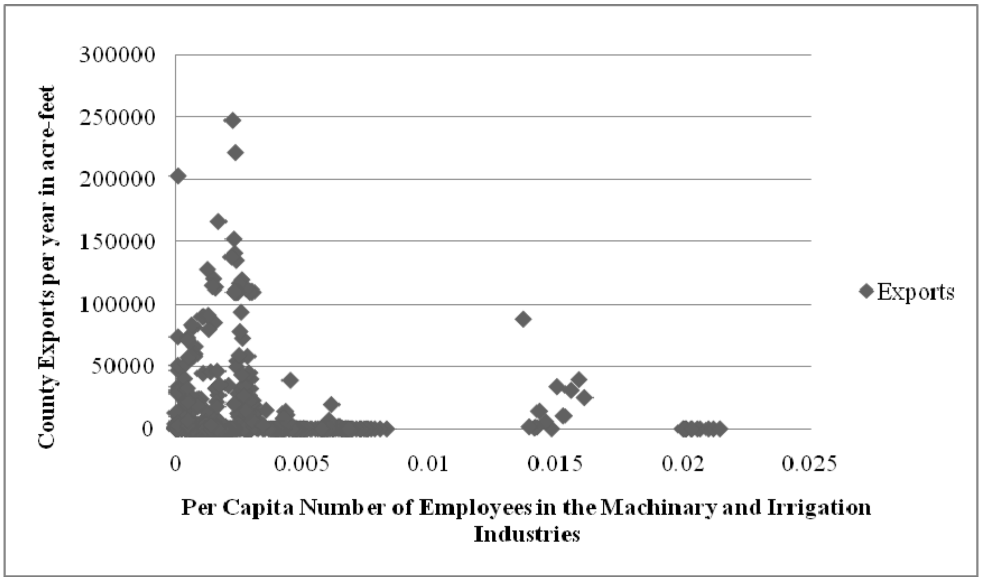

Figure 5. Correlation between Exports and Total Machinery/Irrigation Employees.

Demand and Supply Proxies

A number of variables that influence the supply and demand of water exports must be controlled for (w_{it} vector). First, I use three variables to represent factors that change the location of MCfarmer: total water supply in thousands of acre-feet, annual precipitation in inches, and a proxy for transportation costs. The county's available water supply was held constant with two variables. The dedicated water supply in 1999 (a wet year and the only year in the time span that can be broken down by county) is taken from DWR's Division of Planning and Local Assistance, which produces a hydrological assessment of California's water usage and supply by county, planning area and hydrological region. This variable is a realistic representation of the total water supplied in the county in response to county water demands and is composed of agricultural use, urban use, managed wetlands, environmental use and reused water in the county.[21] Note that stored water and the evaporation from storage are not included in these county level measures. Including the precipitation rate in inches controls for the variable water supply that is available to the county each year. It was assembled by the author using a program produced by the National Climate Data Center that accumulates historical weather data from each station in a county on a daily, monthly and yearly basis. For the purposes of this paper, the yearly data among all stations in the county was averaged to obtain one estimate for average rainfall in inches in the county. A variable controlling for the relative differences in transportation costs across counties was added because some counties do not have canals or aquifers that are connected to the state's main water distribution system: the Sacramento San Joaquin Delta. In these counties, any potential export of water must necessarily be preceded by investments in infrastructure or costly hiring of tanker trucks, which, depending on the gains from trade, may discourage transfers. To account for this, a binary variable, Canal/Aquifer, was created that is equal to one if the county has a canal or aquifer running through any part of the county and zero otherwise. Because of the way this variable was constructed, there may be attenuation bias in the estimation if some parts of the county do not have access to canals.

Two variables were assembled to represent factors that shift the market demand for water: lagged population growth rate and lagged population growth rate multiplied by precipitation. A variable for lagged population growth rate was added based on yearly

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[21] Note that the DWR technically refers to this variable as a county's water usage because it includes reuse. For the purposes of this study, reuse is considered part of a county's water supply because it can be used to meet water demands.

county population rates taken from the US Census Bureau. This was added to account for differences across counties and time in the residential demand for water. According to Griffin and Boadu (1992, 275), high population growth rates in regions lead to abnormally large benefits from water trade to municipal buyers. In addition, the interaction of lagged population growth rate and precipitation was added to proxy for the changing relative water scarcity within and across counties, which shifts the market demand for water. The interaction term was added because the population growth rate might have a different effect for counties with different variable water supplies. It is important to control for these variables because, as demonstrated by Lueck (1995), when resource values are higher sellers can more easily bear the high transaction costs associated with trade.

Control Variables: v_i vector

The time trend variable was included to control for any linearly trending state-level variables such as the initial government actions aimed at facilitating California's water markets (the DWR purchased 74 percent of the 1.1 million acre-feet of water traded across the state in 1991) and the effect on potential water traders as they became familiar with water markets (open market water transactions in California did not begin until the late 1980's) (Hanak 2003, 89). In addition, the inverse of population in the county was used to insure that the county's population levels were not driving the results on the ratio of riparian rights to total population.

Finally, three variables were used to test the sensitivity of the results obtained in the next section. The first, county level export ordinance is a binary variable equal to one if the county passed a law restricting water exports by requiring an environmental review of each potential water export. The second, the average number of employees engaged in any form of gold and silver mining in 1998 was gathered by the author using the US Census Bureau's 1998 County Business Patterns. This variable represents the number of employees engaged in developing the mine site, mining, and preparing ores valued chiefly for their gold or silver content. For some counties, for disclosure reasons, a range of employees was used instead of an exact number. When this occurred an average of the range was used. The final set of variables used was a set of year dummy variables from 1990 to 2001.

CHAPTER 6

RESULTS

This section presents the results from several specifications that measure the effects of riparian water rights and third-parties (measured with three different proxies) on water exports and local trade. All specifications attempt to test the model's prediction that riparian rights holders and third-parties increase the cost to export (i.e., raise τ), thus resulting in a decrease in the volume of water exported (i.e., less than the theoretical benchmark of Q_0) and a decrease in the probability an active water market exists. Local trade is used to verify the effect of the No-Injury Rule, which could either increase or decrease local trade depending on whether riparian users have grounds to protest and W.C. 386, which should increase local trades.

Ordinary Least Squares: Table 1

As a baseline for comparison, Table 1 presents the OLS estimates of the effect of the No-Injury Rule and W.C. 386 on the volume of exports in a county. The results are consistent with predictions, although imprecise. As a further test of these findings, the model's predictions were checked with the annual volume of local trade. The effect of riparian users and third-parties on local trade lends further support to the model's predictions. The results in Column 2 indicate that the No-Injury Rule may also raise the cost to trade locally in a way similar to that depicted in Figure 1.[22]

[22] Note that when Regression (3) is reestimated using either the percent of agricultural employment or the per capita value in agriculture for the OLS model, the statistical significance of the effect that W.C. 386 has

Table 1. Ordinary Least Squares Estimates of Riparian Rights and Third-Parties on Exports and Local Trade.

Y:	**1** **Regression (2) exports/prior appropriations**	**2** **Regression (3) local/prior appropriations**
Costs influencing the size of τ		
Ratio of riparian holders to total population	-.24215	-.0050964
	(.2202941)	(.0044158)
Per capita number of employees in the farm machinery plus irrigation industry	-.9252234	.0465271
	(1.033855)	(.0384405)
Supply/Demand Proxies for Trade		
Lagged population growth rate*precipitation	5.23e-06	-1.23e-06
	(.0000229)	(1.11e-06)
Lagged population growth rate	-.0000397	.0000696
	(.0012987)	(.000066)
Total Water Supply in thousands of acre-feet	-1.94e-06	1.57e-08
	(2.48e-06)	(2.57e-08)
Precipitation in inches	-.0001039	-1.89e-06
	(.0000977)	(3.57e-06)
Controls		
Canal or Aquifer	.0277954	**.0006361****
(binary variable)	(.0232877)	(.0002014)
Time trend	.0037953	.0000153
	(.0033733)	(.000023)
1/population	-1.81e-08	-9.39e-11
	(2.40e-08)	(4.42e-10)
R^2	.0174	.0548

N = 684; T = 12; i= 57

Notes: Clustered robust standard errors are in parentheses and are adjusted by county name. All models are estimated with a constant. Columns report the estimated effects of the explanatory variables on the probability of exports (i.e., Regression (2)) and local trades (i.e., Regression (3)). San Francisco was dropped. For binary variables the coefficient is the effect from a discrete change from 0 to 1. Estimates are significant at the 5 percent (*p < .05), 1 percent (** p < .01), or .1 percent (*** p < .001) level.

There are two initial problems with the OLS specification. First, because only 34 counties have active water markets and some do not trade in all the years recorded, a maximum-likelihood estimate may better control for the censored nature of these data. Second, there are both theoretical and empirical reasons to believe that riparian water doctrine is endogenous to the model. Ignoring this endogeneity may bias the coefficients

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on local trade changes. Specifically, the results indicate statistically significant support for the model's prediction at the 2 percent level.

on the variables of interest. In consideration of both of these issues, the next section presents the results from the IV-TOBIT specification, as well as tests of the relevance and validity of the instruments used.

Combined Two Stage Least Squares and Tobit: Tables 2 and 3

The main results are presented in Tables 2 and 3. Table 2 estimates Regression (2) and Table 3 estimates Regression (3). Columns 1-3 of Table 2 (Table 3) report the marginal effects of the explanatory variables, measured at their means, on the probability of exports (local trade). Columns 4-6 of Table 2 (Table 3) report the marginal effects of the explanatory variables, measured at their means, on the ratio of exports (local trades) to acre-feet appropriated for all trading counties. Each column in the tables reports the results from a different proxy for third-parties. Results from Tables 8, 9 and 10 suggest that the estimates are not sensitive to the addition of local ordinances, mining today, or year fixed effects, although controlling for transportation costs (represented by the canal variable) remains vital.

Table 2. IVTOBIT Estimates of the Marginal Effects of Riparian Rights and Third-Parties on Exports.

	Y: Pr(ratio of exports to p.a. > 0)			**Y: E(exports to p.a.|exports to p.a. > 0)**			
	1	**2**	**3**	**4**	**5**	**6**	**Mean of X**
Costs influencing the size of τ							
Ratio of riparian holders to total population	**-24.09542****	**-25.26959****	**-25.2422****	**-5.881654*****	**-6.343829*****	**-6.196608*****	0.004946
	(8.51997)	(8.94433)	(8.25174)	(1.56357)	(1.52214)	(1.63855)	
Per capita number of employees in the farm machinery plus irrigation industry	1.477851			.360741			0.002607
	(3.6818)			(.8751)			
Percent of agricultural employment to total employment		.0028669			.0007197		5.54441
		(.0026)			(.00051)		
Per Capita Value in Agriculture			5.44e-06			1.34e-06	2485.963
			(.00001)			(.00)	
Supply/Demand Proxies for Trade							
Lagged population growth rate*precipitation	.0005594	.0005326	.0006153	.0001366	.0001337	.000151	33.4625
	(.00033)	(.00033)	(.00034)	(.0009)	(.00009)	(.00009)	
Lagged population growth rate	-.0103445	-.0105883	-.0132158	-.0025251	-.002067	-.0032443	1.35913
	(.0095)	(.00979)	(.0107)	(.00247)	(.0026)	(.00273)	
Total Water Supply in thousands of acre-feet	-5.13e-06	-4.98e-06	-6.03e-06	-1.25e-06	-1.25e-06	-1.48e-06	1790.6
	(.00001)	(.00)	(.00001)	(.00)	(.00)	(.00)	
Precipitation in inches	-.0009361	-.0008233	-.000864	-.0002285	-.0002067	-.0002121	28.475
	(.00075)	(.00075)	(.0008)	(.00019)	(.00019)	(.00021)	
Controls							
Canal or Aquifer	**.2113694*****	**.1890757*****	**.1924546*****	**.0501182*****	**.0461381****	**.046165****	0.45614
(binary variable)	(.04782)	(.04865)	(.05138)	(.01399)	(.0151)	(.01623)	
Time trend	**.0089387*****	**.0086215*****	**.0039904*****	**.0021819**	**.0021644***	**.0022905***	6.5
	(.00222)	(.00216)	(.00228)	(.00097)	(.00099)	(.00101)	
1/population	-2.88e-07	-2.32e-07	-2.64e-07	-7.03e-08	-5.82e-08	-6.48e-08	19809.3
	(.00)	(.00)	(.00)	(.00)	(.00)	(.00)	
Pseudo R^2	.00402687	.00336916	.00355045	.00402687	.00336916	.00355045	

N = 684; T = 12; i= 57. Notes: Columns 1-3 report the marginal effects of the explanatory variables, measured at their means, on the probability of exports (i.e., Regression (2)). Columns 4-6 report the marginal effects of the explanatory variables, measured at their means, on the ratio of exports to appropriations for all exporting counties. Clustered robust standard errors are in parentheses and are adjusted by county name. All models are estimated with a constant. San Francisco was dropped. For binary variables the coefficient is the effect from a discrete change from 0 to 1. I control for the endogeneity of riparian doctrine using four instrumental variables: population by county in 1850, population by county in 1860, the value of farm products by county in 1900, and the value of gold and silver production from mining by county in 1880. An F-test for the joint significance of lagged population growth rate, precipitation, and the interaction term rejected the null hypothesis that the variables were jointly insignificant with a p-value from the $\chi 2$ distribution of .000. Estimates are significant at the 5 percent (*p < .05), 1 percent (** p < .01), or .1 percent (*** p < .001) level.

Table 3. IVTOBIT Estimates of the Marginal Effects of Riparian Rights and Third-Parties on Local Trades.

	Y: Pr(ratio of local to p.a. > 0)			**Y: E(local to p.a.|local to p.a. > 0)**			
	1	**2**	**3**	**4**	**5**	**6**	**Mean of X**
Costs influencing the size of τ							
Ratio of riparian holders to total population	-4.530394	-6.761188	-4.939874	-.0243124	-.0370959	-0.0248866	0.004946
	(7.02061)	(5.781)	(5.69671)	(.03798)	(.02466)	(0.02627)	
Per capita number of employees in the farm machinery plus irrigation industry	7.654723			.0410791			0.002607
	(7.09762)			(.03616)			
Percent of agricultural employment to total employment		**.0058976***			**.0000324******		5.54441
		(.00293)			(.00001)		
Per Capita Value in Agriculture			0.00000746			3.76E-08	2485.963
			(.00001)			(.00)	
Supply/Demand Proxies for Trade							
Lagged population growth rate*precipitation	-.0001521	-.0001694	-0.0001423	-8.16e-07	-9.30e-07	-0.000000717	33.4625
	(.00039)	(.0002)	(.00025)	(.00)	(.00)	(.00)	
Lagged population growth rate	.0124401	.0086238	0.0081627	.0000668	.0000473	0.0000411	1.35913
	(.01707)	(.01162)	(.01325)	(.00009)	(.00006)	(0.00006)	
Total Water Supply in thousands of acre-feet	.0000119	7.28e-06	0.00000746	6.36e-08	3.99e-08	3.76E-08	1790.6
	(.00001)	(.00)	(.00001)	(.00)	(.00)	(.00)	
Precipitation in inches	-.0016603*	-.0007119	-0.0008811	**-8.91e-06***	-3.91e-06	-0.00000444	28.475
	(.0008)	(.00041)	(.0005)	(.00)	(.00)	(.00)	
Controls							
Canal or Aquifer	**.3015342******	**.2306889******	**0.2594317******	**.0015562******	**.0011088******	**0.0011738******	0.45614
(binary variable)	(.06345)	(.05428)	(.06321)	(.00028)	(.0002)	(.00023)	
Time trend	.0018634	.0011921	0.0020578	.00001	6.54e-06	0.0000104	6.5
	(.00299)	(.00248)	(.003)	(.00001)	(.00001)	(.00001)	
1/population	**2.25e-07***	**2.12e-07***	**0.0000002***	1.21e-09	1.16e-09	1.01E-09	19809.3
	(.00)	(.00)	(.00)	(.00)	(.00)	(.00)	
Pseudo R^2	.04640601	.04966662	.05528319	.04640601	.04966662	.05528319	

N = 684; T = 12; i= 57. Notes: Columns 1-3 report the marginal effects of the explanatory variables, measured at their means, on the probability of local trades (i.e., Regression (3)). Columns 4-6 report the marginal effects of the explanatory variables, measured at their means, on the ratio of local trades to appropriations for all trading counties. Clustered robust standard errors are in parentheses and are adjusted by county name. All models are estimated with a constant. San Francisco was dropped. For binary variables the coefficient is the effect from a discrete change from 0 to 1. I control for the endogeneity of riparian doctrine using four instrumental variables: population by county in 1850, population by county in 1860, the value of farm products by county in 1900, and the value of gold and silver production from mining by county in 1880. An F-test for the joint significance of lagged population growth rate, precipitation, and the interaction term rejected the null hypothesis that the variables were jointly insignificant with a p-value from the $\chi 2$ distribution of .000. Estimates are significant at the 5 percent (*p < .05), 1 percent (** p < .01), or .1 percent (*** p < .001) level.

Ratio of Riparian Rights
Holders to Population

There is strong evidence in Columns 1 – 3 in Table 2 to suggest that the No-Injury Rule may raise the cost to export in the way depicted in Figure 1. Column 1 in Table 2 shows that, all else equal, a one standard deviation increase from the mean in the ratio of riparian rights holders to total population will decrease the probability that a county will have an active water market for exports by 30 percent. This is statistically significant at the .5 percent level.

To verify these findings, the model's predictions were checked with the annual volume of local trade.[23] The specification in Table 3 indicates that a one standard deviation increase from the mean in the ratio of riparian rights holders to total population will decrease the probability that a county will have an active water market for local trade by 6 percent. This result implies that although most local trades do not meet the legal definition needed to prove harm, the local trades we are observing may be moving water within a county in such a way that it decreases the return flows to riparian rights holders in the watershed. In these cases, riparian rights holders would still have standing through the No-Injury Rule to block beneficial local trades.

Consistent with Columns 1-3, Columns 4 – 6 of Table 2 support the model's predictions of the effect of the No-Injury Rule on the volume of exports. Column 4 in Table 2 shows that for counties that have export markets, all else equal, a one standard deviation increase from the mean in the ratio of riparian rights holders to total population

[23] The findings in Table 3 were confirmed with the addition of the county export ordinance variable. These findings are available upon request.

decreases the annual ratio of exports to acre-feet in appropriations by 7.4 percent or 47.45 percent of one standard deviation; the coefficient is statistically significant at the .1 percent level. For the county with the median level of prior appropriations (Siskiyou County) this decrease in the acre-feet exported would be equivalent to 219,551 acre-feet (assuming the acre-feet in appropriations remains constant in the county at 2,966,902 acre-feet).[24]

As before, to verify these findings, the model's predictions were checked with the annual volume of local trade. The results from Column 4 of Table 3 show that for all locally trading counties, a similar increase in riparian rights to total population leads to a trivial decrease (.03 percent) in local trades to acre-feet appropriated. The results are statistically insignificant and essentially show that the No-Injury Rule has no apparent effect on the volume of local trade for all trading counties. This may imply that P_{local} is less than the value marginal product of water on most of the farm acres in the county. Conversely, it may be that there is both a positive and a negative effect, which cancel each other out.[25]

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[24] Although the assumption that the acre-feet in post-1914 prior appropriation rights remains constant in the county is not a trivial one, it is most likely a realistic assumption. This is because, according to the SWRCB, the majority of available rights were allocated prior to 1950.

[25] As a further test of the paper's main findings, several specifications were run using the number of riparian rights holders in place of the ratio of riparian rights to total population. The point estimates in Table 6 in the Appendix show support for the model's predictions, but not surprisingly, the results are smaller in magnitude and less precise. One explanation for this is that the raw number of riparian rights holders does not effectively account for the variation in the number of riparian rights in the rural exporting counties.

Endogeneity of Riparian Water Rights

A remaining question is whether the results for the effect of riparian rights holders on exports remain biased by the potential endogeneity of riparian rights doctrine. Although an attempt has been made to control for this using instruments with strong historical support, if these instruments are weak, the attempt to correct this may only mitigate and not solve this problem. The following assesses the relevance and validity of these instruments, both theoretically and statistically.

To address the issue of the endogeneity of riparian doctrine I use four instrumental variables: population by county in 1850, population by county in 1860, the value of farm products by county in 1900,[26] and the value of gold and silver production from mining by county in 1880.[27] These instruments were chosen because, historically,

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[26] Although irrigation accessibility influenced the geography of farming as early as 1860, data from The Statistics of Agriculture 1900 Census was chosen to obtain the value of farm products in county i over historical farming data from other Census years because county boundaries in 1900 are almost identical to the county boundaries today. The one notable exception to this is that the territory known as Imperial County was part of San Diego County in 1900. This roughly doubled the size of San Diego County. Based on the 1910 Agricultural Census, this was corrected by recoding half of the 1900 value of farm products in San Diego to present day Imperial County.

[27] The 1880 Census for Precious Metals (volume 13 of the 1880 Census) was chosen to account for historical mining across counties because it is the most accurate accounting of historic mining by county between 1850 and 1880. This is because it is the only report that focuses exclusively with gold and silver mining and the county boundaries in 1880 more closely resemble the county boundaries seen today compared with earlier reports. The drawback of using 1880 data on mining and not the earlier 1860 Manufacturer's Census data is that some regions boomed between 1850 and 1860, but were all mined out by 1880. The only county this was an issue for was Tulare County, which reported $199,953 (in 1860 dollars) worth of products from gold mining in 1860 and no mining in 1880. To account for this, the value of products in 1860 was used for the 1880 value. In addition, according to the 1880 Census reports, this variable also suffers from a systematic underreporting of the value of mining by county due, in part, to the unavailability of records in some areas.

Note that since some county boundaries in the year 1880 are different from the county boundaries in 1990-2001, the value of gold and silver $\text{mining}_{i,1880}$, which is calculated by multiplying the quantity of valuable material raised in both deep and placer mines by the market price, was adjusted to correct for these boundary differences. Where historic mines were located outside present day county boundaries, a portion of the value of mining was recoded to the appropriate county, weighting production according to the percent of mines in that region. This reallocation was completed using two thematic maps of the location of prior appropriation water doctrine was established to meet the needs of mining camps – and to a lesser degree, farmers – to divert water from riparian lands. In 1852, a new hydraulic mining technology emerged that used large volumes of water to strip the ground and substantially increased the gains from acquiring divertible water rights. This water-intense technology, along with the value of water for agricultural irrigation off riparian lands, led California to recognize, in addition to riparian water rights, a new type of divertible water doctrine called prior appropriation. Thus, the presence of (or lack of) valuable resources, such as gold, silver and fertile farm land, in a county between 1855 and 1900 drove individuals in each county to choose either riparian water rights, if these resources were not abundant, or prior appropriation doctrine, if these uses for water existed. Population in 1850 and 1860 were included because even in counties with little or no farming or mining, large populations may have led to a sprawl far from water sources, thus leading to individuals choosing differing water doctrines. Therefore, these instruments should be correlated with water doctrine, but have no direct effect on the existence of active water markets today.[28]

An F-test for the joint significance of the instruments (and controls) regressed on the ratio of riparian rights holders to total population produces an F(3,671) statistic of 22.08 for the OLS specification. This is well over the usual standard for establishing

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gold mines in 1850-1880 (Division of Mines and Geology 1998 and USGS 2005), along with maps comparing the county boundaries in 1880 to present day boundaries (Census 2009).

[28] Note that there is little correlation between the historical value of farm products and the value of farm products today. Specifically, the correlation coefficient between value of $\text{agriculture}_{i,t}$ (in year 2000 dollars) and the value of farm products in 1900_i (in year 1900 dollars) is .1825. Moreover, the correlation coefficient between the value of $\text{agriculture}_{i,t}$ (in year 2000 dollars) and the value of farms in 1850_i (in year 1850 dollars) is .0296.

significance (i.e., an F statistic of 10). Similar results were obtained from the IV-TOBIT specification, which rejected the null hypothesis that the instruments were jointly insignificant with a p-value from the $\chi 2$ distribution of .0381. Table 7 in the Appendix displays the results from the first stage regressions for both the TSLS and the IV-TOBIT models. The results are similar when other proxies for third-parties are used. This implies that these instruments are relevant predictors of riparian rights today. The exogeneity of these four instruments was confirmed using a Lagrange Multiplier test (i.e., an over identification test), which produced a p-value from the $\chi 2$ distribution of .665 using the TSLS and OLS specifications. This test implies that the correlation of the instruments and the error term from the TSLS specification is not statistically different from zero. These results are consistent with using the IV-TOBIT estimates.[29]

Third-Party Proxies

There are three variables used as proxies to control for the number of third-party individuals in the county that influence the size of τ: the per capita number of employees in the farm machinery plus irrigation industries (Columns 1 and 4 of Tables 2 and 3), the percent of agricultural employment to total employment (Column 2 and 5 of Tables 2 and

[29] It is worthwhile to note that using unclustered OLS and TSLS specifications, the Hausman test for the correlation between the ratio of riparian rights holders to the total population and the error term produced a p-value from the χ^2 distribution of .9967, indicating the standard errors from the OLS and TSLS specifications are similar. This was supported by a Wald test from the clustered IV-TOBIT specification, which produced a p-value from the χ^2 distribution of .5997. There are two possible explanations for the Hausman test rejecting the plausible endogeneity of riparian rights doctrine. First, it might be that the standard errors on the OLS and TSLS specification are so similar that an OLS regression would produce more precise estimates. An alternative explanation for this outcome is that the large standard errors are driving the results. Given the large changes in the magnitudes and statistical significance of the variables of interest between the OLS and IV-TOBIT regressions, it is likely that the alternative explanation is correct. Thus, they do not necessarily imply the OLS specification should be used over the IV-TOBIT specification.

3), and the per capita value in agriculture (Column 3 and 6 of Tables 2 and 3). Each variable attempts to estimate the effects of those individuals who are most likely to protest a water transfer under W.C. 386.

Empirical results from Column 1 of Table 2 show that all else equal, if the per capita number of employees in the farm machinery industry plus the irrigation industry increases by one standard deviation from the mean, the probability that a county will have an active water market for exports increases by a trivial amount (.51 percent). Though the coefficient is not statistically significant, it is opposite of the model's predictions. The estimates for the effect on the volume of exports from Columns 3 – 6 in Table 2 were also opposite of the model's predictions and statistically insignificant.

As a further test of the effect of W.C. 386, the model's predictions were checked with the annual volume of <u>local</u> trade. The specification in Column 1 of Table 3 shows that a similar increase in the per capita number of employees in the farm machinery plus the irrigation industry increases the probability that a county will have an active market for local trades by 2.6 percent. The results from Column 4 of Table 3 show that for all locally trading counties, the same increase in the per capita number of employees in the farm machinery plus the irrigation industry would increase the annual ratio of local trades to acre-feet appropriated by 8.5 percent of one standard deviation. These results are consistent with the model's predicted effects of third-parties on local trades. Results are similar when other proxies for third-parties are used (with some changes in statistical significance among different proxies).

The True Third-Parties Effect may be Larger

The estimated effects of the third-party proxies may indicate that third-parties have little effect on exports. This is plausible if a profit maximizing farmer chooses to fallow her land in such way that mitigates the impact on third-parties, perhaps by fallowing only the lowest producing acres (Howitt 1994, 370). Another possible explanation for these results, however, is that the estimated effects understate the true effects of third-parties on exports. There are three potential reasons to believe this is plausible: first, percent of agricultural employment to total employment and per capita value in agriculture do not effectively control for Libecap's list of possible sources of transaction costs; second, the proxies chosen may not represent the third-parties that most inhibit trades; and third, low variation in the proxies lead to large standard errors.

First, some proxies for third-party costs fail to capture the major sources of transaction costs. Specifically, the percent of agricultural employment to total employment does not differentiate between the many types of agricultural employment including farm owners versus farm laborers. Therefore, this variable does not effectively control for a major source of τ: heterogeneous claimants that raise the information costs to trade. In addition, the per capita value in agriculture tells us little about who really owns the income stream related to agriculture. Therefore, this variable does not effectively capture two important components of τ: the number of potential claimants in the county and their heterogeneous makeup, both of which raise the information and negotiation costs to trade. Although the per capita number of employees in the machinery and irrigation industries most effectively incorporates the sources of transaction costs specified in Chapter 2, this variable may suffer from attenuation bias on the coefficient, which is attributable to the construction of the variable.[30]

Second, the third-party variables chosen may be proxies for the third-parties who can most easily negotiate with farmers. Consider that a farmer (and potential trader) already has some form of contractual relationship with employees in the agricultural service industries. Therefore, it might be that farmers and agricultural service employees act as if rights are clearly defined and successfully contract around one another for the optimal water use. If this is the case, individuals in the agricultural service industries are actually the lowest cost third-party group for the farmers to negotiation with because these individuals are a more homogeneous group for farmers to contract with (thus, implying a low τ). If this is true then the magnitudes of the coefficients on the third-party proxies are being offset by side payments that allow trade. This may explain the positive sign found on all three coefficients on the third-party proxies. Overall, this implies that these chosen proxies fail to pick up the third-party individuals who are much more costly to negotiate with such as teachers who may be concerned that school enrollment will drop or the local commercial builder who may be concerned that the tractor dealer will put off renovations. Thus, the three chosen proxies in the empirical model fail to control for the effects from the most heterogeneous third-party groups influencing exports.

In addition, the low variation in the proxies for third-party costs may be leading to large standard errors on the coefficient and imprecise estimations. For example, we

[30] For disclosure reasons, the Census often gives a range of employees in these industries rather than the actual number. Because the range was recorded with minimums, there may be a systematic underreporting of the true number of employees in the farm machinery and irrigation industries (although this will be small because the ranges are not large).

observe only a small degree of within county variation in agricultural related employment in the 12 year time span. The variable per capita value in agriculture has the greatest amount of variation, but as stated previously, conveys the least information about who owns the potentially affected income stream and how easily they can interact with the buyers and sellers.

Note that the proxies for third-parties may be correctly predicting the effect on local trades because these variables are an indication of whether there is agriculture in the county. Naturally, where there is agriculture, there are potential buyers and sellers for local water markets.

Robustness Tests: Tables 8, 9, and 10

The sensitivity of these results was explored under a number of alternative specifications. First, in consideration of Hanak's 2003 study of the effect of county restrictions on exports, Regression (2) was reestimated using a binary variable equal to one if the county passed a law restricting water exports by requiring an environmental review of each potential water export. If counties with more third-party individuals are more likely to pass such measures, the omission of this variable may bias the estimates on the variables of interest. The results show that with the addition of the county ordinance variable, the importance of riparian rights on exports increases slightly from the marginal effects estimates seen in Table 2 (Table 8 in the Appendix). This result lends additional support to the significance of the No-Injury Rule on trade and also confirms the need for better proxies for third-party individuals.

Second, in consideration of the historical context in which California counties acquired differing water doctrines (i.e., as a direct result of the presence of – or lack of – valuable resources to mine), it might be that gold and silver mining today is highly correlated with the number of riparian rights holders in a county, and that this may bias the estimate on riparian rights if left omitted. Therefore, Regression (2) was reestimated using a county level variable that represents the average number of employees engaged in any form of gold and silver mining in 1998. Table 9 in the Appendix shows that the variable, mining today, was never significant as a control and the marginal effects on the variables of interests were similar to those reported in Table 2. This seems reasonable considering that the correlation coefficient between the value of mining in 1880 and the average number of employees in the mining industry today is -.04.[31]

Finally, because the time trend variable might not be effectively controlling for the growing familiarity with the water transfer process or the initial importance of the government's role in facilitating trades, the variable was replaced with individual year fixed effects. The point estimates on the variables of interest had no significant change in the sign, magnitude or significance (Table 10 in the Appendix). In addition, only three years – 1993, 1995, and 2000 – were statistically significant. The positive trend (indicated by the change from negative to positive in the signs of the year coefficients) lends support to Hanak's theory of the impact from a familiarity of the markets on trades.

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[31] When both export ordinances and the average number of employees in the gold and silver mining industry in 1998 are simultaneously added to the baseline IV-TOBIT specification (Table 2), there are no significant changes in the magnitude, sign or statistical significance of the marginal effect coefficients.

CHAPTER 7

CONCLUSION

The economic literature suggests that institutions and third-parties not directly involved in transactions may significantly affect trade by raising the information and negotiation costs associated with transactions (Libecap 1989 and 2005; Anderson and Lueck 1992; Anderson and Johnson 1986; Lueck 1995; Bretson and Hill 2008; Anderson and Snyder 1997; Hanak 2005; Coase 1960; Heller 1998; Landry 2008). California water markets provide a unique opportunity to test the effects of assigning property rights via the No-Injury Rule, which gives instream flow claimants rights in the transfer process, and Water Code 386, which gives third-parties quasi-veto rights in the transfer process, making prior appropriative rights less clear. Although all 58 counties in California faced state-wide actions whose goal was the creation of water markets, only 34 counties responded by establishing active water markets. Moreover, the volume of trade within the active markets has been substantially less than what economists predicted. The empirical results indicate that the No-Injury Rule, transportation costs (as represented by a binary variable equal to the availability of a canal or aquifer), and a time trend variable (which controls for the state and federal actions to facilitate trade, as well as a growing familiarity with the markets) have a strong, highly significant impact on the probability a county will have an active export market and the volume of exports within a given market. Although precipitation[32], residential water demand (as represented by lagged population growth rate)[33], and relative water scarcity (as represented by the interaction of lagged population growth rate and precipitation) all have a jointly significant effect on exports, the magnitudes of these effects are trivial. For the average county, a one standard deviation increase in the ratio of riparian rights holders to total population will decrease the likelihood that the county will have an active water market for exports by 30 percent. Furthermore, in counties with export markets, a similar increase in the ratio of riparian rights to total population will decrease the annual ratio of exports to appropriations by 7.4 percent. For Siskiyou County (the county with the median level of prior appropriations) this would be equivalent to 219,551 acre-feet of forgone exports.[34] Controlling for other factors such as county-imposed export ordinances, present day county level gold and silver mining, and replacing the time trend variable with year fixed effects did not substantially affect these results.

[32] Column 1 of Table 2 shows that for the average county a one standard deviation increase from the mean in the precipitation rate will decrease the probability the county will have a market for exports by a trivial amount (.38 percent), when lagged population growth rate is evaluated at its mean of 1.36 percent. In addition, column 4 of Table 2 shows that for all exporting counties, a similar increase in the precipitation rate will decrease the ratio of exports to appropriations by a trivial amount (.09 percent), when lagged population growth is evaluated at its mean.

[33] Column 1 of Table 2 shows that for the average county a one standard deviation increase from the mean in the lagged population growth rate will increase the probability that the county will have a market for exports by 2.23 percent, when precipitation is evaluated at its mean of 28.48 inches. In addition, column 4 of Table 2 shows that for all exporting counties, a similar increase in the lagged population growth rate will increase the ratio of exports to appropriations by a trivial amount (.55 percent), when precipitation is evaluated at its mean.

[34] Assuming an average price per acre-foot of $234, which was obtained using the Bren School's Western Water Transfer Data Base, the average cost for Siskiyou County in terms of forgone revenue from exports attributable to the No-Injury Rule is $51,374,934 (in 1987 dollars).

Although the empirical results indicated that the effect of the No-Injury Rule has the expected impact on water exports, the effect of W.C. 386 is still inconclusive. Several explanations for this outcome were offered. First, it was suggested that two of the proxies for third-party costs – percent of agricultural employment and the per capita value in agriculture – failed to identify the number of potential claimants and their heterogeneous makeup (components of τ) and are therefore, noisy measures of the actual third-party resistance in the county. Second, the third-party variables chosen may be proxies for the groups who can most easily negotiate with transferors to allow trade. Third, the low within and between variation of these third-party proxies may be leading to large standard errors and imprecise estimates. Overall, it is not surprising that the effect of W.C. 386 is harder to estimate than is the effect of the No-Injury Rule because the very nature of W.C. 386 makes all residents in the county potential claimants.

The implications of this study suggest that despite the large potential gains from water market transactions, the No-Injury Rule (and perhaps W.C. 386) may hinder the realization of these gains. This implies that the apparently high transaction costs are, to a substantial degree, an artifact of the way policy has been set and not exclusively inherent to water trade. For regions, such as the southeastern United States, that are considering the potential for water markets to reallocate scarce water supplies, this paper suggests that they need to look carefully at their property rights assignments if they want to realize the potential gains from trade.

More specifically, the findings point to three important policy recommendations to promote trade. First, for regions that are just beginning to fully allocate watercourses define water rights in terms of consumptive use as opposed to divertible acre-feet. For regions whose watercourses are already fully appropriated, limit transfers to historic consumptive use rather than divertible acre-feet. This will lower the probability of a given water transfer reducing the return flows available for other users and thus, decrease the transaction costs to trade by avoiding many protests under the No-Injury Rule. Second, in regions with laws that grant third-parties rights, policy makers should clearly define the type of harm that can be claimed under these laws. For example, a law could specify that claims of harm must demonstrate a substantial expected decrease in their future income stream in percentage terms. Lastly, states should have water transfer processes that facilitate negotiations among claimants and the free flow credible information regarding expected losses to other water rights users and third-parties. Although the reallocation and redefinition of rights does not come without costs, considering the non-trivial losses to a county as a result of forgone exports, such measures should be considered as a means to facilitate trade and reallocate scarce water resources.

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APPENDIX A

TABLES AND FIGURES

Table 4. Summary Statistics for California Counties, 1990-2001.

	Sample Mean	Standard Deviation	Max	Min
Dependent Variables				
Exports (acre feet)	11410.79	31403.26	0	252377
-zero exports	*64.50%*			
Local Sales (acre feet)	1916.38	7689.036	0	98000
-zero local sales	*79.31%*			
Ratio of Exports to Acre-Feet in Prior Appropriation	*0.014*	.155	0	2.933
Ratio of Local Trades to Acre-Feet in Prior Appropriation	.0004	.002	0	.024
Costs influencing the size of τ				
Number of Riparian Holders to Total Population	0.01	0.013	1.38E-06	0.214
Per Capita Number of Employees in the Farm Machinery Plus Irrigation Industry	0.00	0.003	0	0.0214
Percent of Agricultural Employment to Total Employment	5.54	5.62	0	33.25
Per Capita Value in Agriculture (in 2000 dollars)	2485.96	3361.83	0	19471
Supply/Demand Proxies for Trade				
Lagged Population Growth Rate*Precipitation	33.46	221.53	-5509.92	814.94
Lagged Population Growth Rate	1.35	-3.959958	90.11968	28.83467
Total Water Supply in Thousands of acre-feet	1790.60	2878.66	35.5	18860.2
Precipitation (in inches)	28.48	21.87	1.95	274.57
Controls				
Canal or Aquifer (1= canal)	0.46	0.498	0	1
Time Trend	6.50	3.45	1	12
1/Population	19809.30	87928.55	4.67	724637.7
Export Ordinance (1= restrictions)	0.52	0.500062	0	1
Employees in Gold and Silver Mining (average 1998)	22.89	61.7	0	374.5
Instruments				
Value of Gold and Silver Production from Mining in 1880	322648.90	634197.7	0	3267971
Value of Farm Products in 1900	2063501.00	1908619	61011	8029158
Population in 1850	1624.51	3894.77	0	20057
Population in 1860	5636.65	5729.25	0	24142
Counties	57.00			
Years	12.00			
N	684.00			

Table 5. Correlation Coefficients.

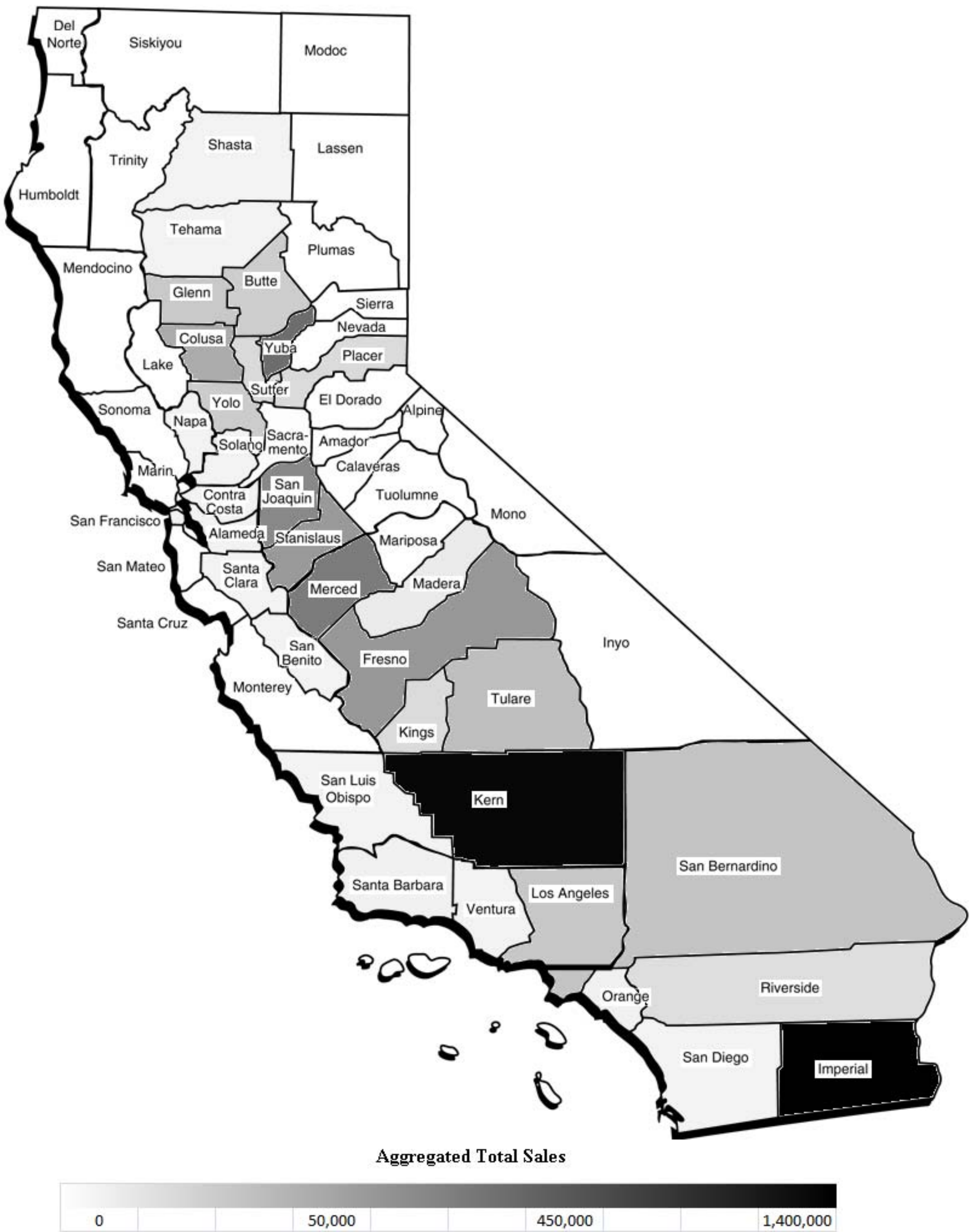
	Rip./Pop	1/Pop	E. Mach/ Irr.	% Farm E.	Value Ag	Lagged* Precip	Lagged
Riparian/Pop	1						
1/Pop	-0.09	1					
E. Machinery/Irr.	0.11	-0.05	1				
% of Farm E.	-0.05	-0.18	0.48	1			
P.C. Value of Ag	0.06	-0.14	0.42	0.88	1		
Lagged*Precip	-0.08	-0.01	0.01	0.01	0.004	1	
Lagged Pop Growth	-0.11	0.005	-0.03	0.01	0.02	0.96	1
Water Supply	-0.14	-0.07	0.06	0.05	0.07	0.08	0.05
Precipitation	0.05	-0.08	0.04	-0.06	-0.06	0.05	-0.06
Canal	-0.20	-0.05	-0.03	0.25	0.32	0.03	0.04
Time Trend	0.02	0.01	-0.03	0.004	-0.03	-0.07	-0.06
Export O.	0.17	-0.2	0.1	0.25	0.21	-0.04	-0.05
E. in Mining 1998	-0.03	-0.03	0.14	0.06	0.16	0.002	0.03
Pop 1850	-0.10	-0.06	-0.11	-0.13	-0.18	0.03	0.05
Pop 1860	-0.14	-0.1	-0.15	-0.34	-0.35	-0.01	-0.04
Mining in 1880	0.32	-0.1	-0.05	-0.21	-0.15	-0.007	0.03

P.C. = Per Capita; E. = Employees; Irr. = Irrigation; Precip = Precipitation; O. = Ordinance; Pop = Population; Ag = Agriculture; Rip. = Riparian

Table 5. Correlation Coefficients – continued.

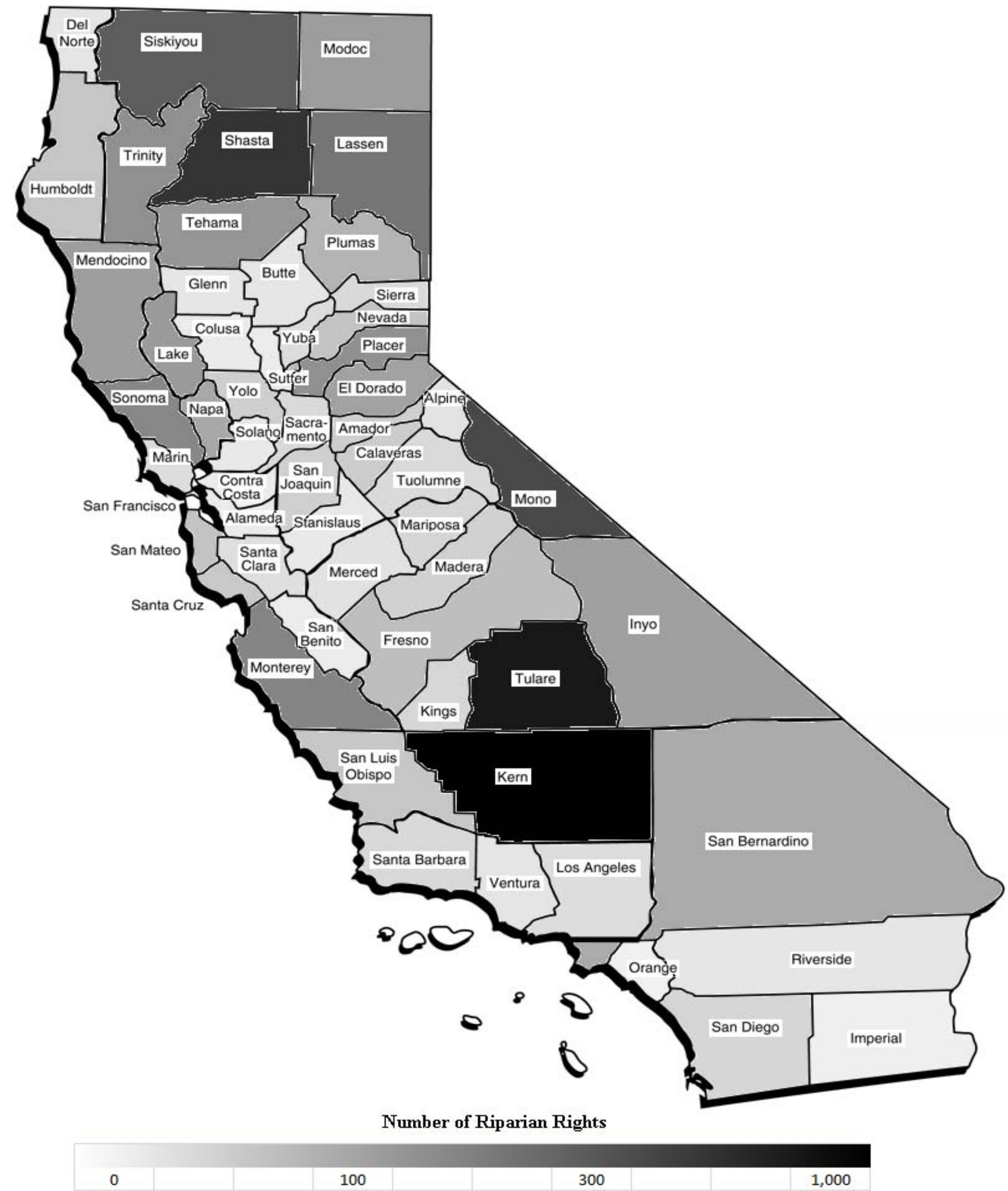
	Water Supply	**Precip**	**Canal**	**Time**	**Export O.**	**Mining 1998**	**Pop 1850**	**Pop 1860**
Water Supply	1							
Precipitation	0.28	1						
Canal	0.17	-0.04	1					
Time Trend	0	0.07	0	1				
Export O.	-0.01	0.04	0.16	0	1			
E. in Mining 1998	0.03	-0.10	0.11	0	0.26	1		
Pop 1850	-0.09	0.01	-0.13	0	0	-0.13	1	
Pop 1860	-0.09	0.1	-0.13	0	0	-0.17	0.68	1
Mining in 1880	-0.07	0.002	-0.28	0	0	-0.05	0.01	0.22

P.C. = Per Capita; E. = Employees; Irr. = Irrigation; Precip = Precipitation; O. = Ordinance; Pop = Population; Ag = Agriculture; Rip. = Riparian



Source: Original map. Data from (Hanak 2005)

Figure 6. Aggregated Total Sales in Acre-Feet from 1990-2001.



Source: Original map. Data from e-WRIMS.

Figure 7. Map of the Number of Riparian Rights.

Source: Original map. Regional data from (NASC for 1990-2001)

Figure 8. Aggregated Per Capita Value of Agriculture from 1990-2001 (in 2000 dollars).

Table 6. IVTOBIT Estimates of the Marginal Effects of the Number of Riparian Rights and Third-Parties on Exports.

Y:	**1** **E(ratio of exports to p.a. |ratio of exports to p.a. > 0)**	**2** **Pr(ratio of exports to p.a. > 0)**	**Mean of X**
Costs influencing the size of τ			
The number of riparian rights holders	-0.0003379	-.0012583	0.004946
	(0.00029)	(.00105)	
Per capita number of employees in the farm machinery plus irrigation industry	-0.1295168	-.4822668	0.002607
	(1.34881)	(5.02287)	
Supply/Demand Proxies for Trade			
Lagged population growth rate*precipitation	0.0001693	.0006305	33.4625
	(0.00013)	(.00049)	
Lagged population growth rate	-0.0012782	-.0047594	1.35913
	(0.00419)	(.01557)	
Total Water Supply in thousands of acre-feet	8.67E-08	3.23e-07	1790.6
	(0)	(.00001)	
Precipitation in inches	**-.0006902***	-.00257	28.475
	(.00037)	(.00135)	
Controls			
Canal or Aquifer	**.0079258****	**.2816554****	0.45614
(binary variable)	(.03659)	(.12222)	
Time trend	**.0032234***	**.0120025***	6.5
	(.00188)	(.00672)	
Pseudo R^2	.00203572	.00203572	

N = 684; T = 12; i= 57

Notes: Column 1 reports the marginal effects of the explanatory variables, measured at their means, on the probability of exports (i.e., Regression (2)). Column 2 reports the marginal effects of the explanatory variables, measured at their means, on the ratio of exports to appropriations for all exporting counties. Clustered robust standard errors are in parentheses and are adjusted by county name. All models are estimated with a constant. San Francisco was dropped. For binary variables the coefficient is the effect from a discrete change from 0 to 1. I control for the endogeneity of riparian doctrine using four instrumental variables: population by county in 1850, population by county in 1860, the value of farm products by county in 1900, and the value of gold and silver production from mining by county in 1880. Estimates are significant at the 10 percent (*p < .1), 5 percent (** p < .05), or 1 percent (*** p < .01) level.

Table 7. First Stage Regressions.

	1 TSLS	2 IV-TOBIT
Y: Ratio of riparian rights holders to total population		
Instruments		
1880 value of gold and silver mining	**0.00000000647*** **	**6.53e-09***
(1880 dollars)	(0.000000000796)	(3.86e-09)
1900 value of farm products	**-0.000000000463***	-4.41e-10
(1900 dollars)	(0.000000000261)	(5.61e-10)
population in 1850	0.000000226	2.32e-07
	(0.000000156)	(4.12e-07)
population in 1860	**-0.000000608*** **	-6.09e-07
	(0.000000112)	(4.10e-07)
Costs influencing the size of τ		
Per capita number of employees in the farm machinery industry plus irrigation industry	**0.273116** **	.2753005
	(0.127545)	(.4921692)
Supply/Demand Proxies for Trade		
Lagged population growth rate*precipitation	**0.0000139***	.000014
	(0.00000732)	(9.85e-06)
Lagged population growth rate	**-0.0010455*** **	-.0010504
	(0.0004073)	(.000556)
Total Water Supply in thousands acre feet	**-0.000000677*** **	**-6.75e-07***
	(0.000000158)	(2.94e-07)
Precipitation in inches	**0.0000434***	.0000433
	(0.0000223)	(.0000475)
Controls		
Canal or Aquifer	**-0.0019875** **	-.0019896
(binary)	(0.0009551)	(.001902)
Time trend	0.0000387	.0000389
	(0.0001242)	(.0000939)
1/population	**-0.00000000993** **	**-9.94e-09** **
	(0.00000000501)	(3.08e-09)
R^2	.2241	-

N = 684; T = 12; i= 57

Clustered robust standard errors are in parentheses and are adjusted by county name. All models are estimated with a constant. San Francisco was dropped. For binary variables the coefficient is the effect from a discrete change from 0 to 1. Estimates are significant at the 10 percent (*p < .1), 5 percent (** p < .05), or 1 percent (*** p < .01) level.

Table 8. IVTOBIT Estimates of the Marginal Effects of Riparian Rights and Third-Parties on Exports with Export Ordinances.

	Y: Pr(ratio of exports to p.a. > 0)			Y: E(exports to p.a.| exports to p.a. > 0)			
	1	**2**	**3**	**4**	**5**	**6**	**Mean of X**
Costs influencing the size of τ							
Riparian holders to total population	**-25.14741****	**-26.22749****	**-26.25209****	**-6.203167*****	**-6.648904*****	**-6.502325*****	0.004946
	(9.20973)	(9.5197)	(8.87328)	(1.68132)	(1.65018)	(1.7794)	
Per capita employees in the farm machinery plus irrigation industry	1.272383			.3138616			0.002607
	(3.50343)			(.83913)			
Percent of Ag employment to total employment		.002409			.0006107		5.54441
		(.00255)			(.00052)		
Per Capita Value in Agriculture			4.86e-06			1.20e-06	2485.963
			(.00001)			(.00)	
Supply/Demand Proxies for Trade							
Lagged population growth rate*precipitation	.0005211	.0005027	.000579	.0001285	.0001274	.0001434	33.4625
	(.00031)	(.00032)	(.00033)	(.00008)	(.00008)	(.00008)	
Lagged population growth rate	-.0093575	-.0097714	-.0121604	-.0023082	-.0024771	-.003012	1.35913
	(.0089)	(.00923)	(.01031)	(.0023)	(.00241)	(.00256)	
Total Water Supply in thousands of acre-feet	-5.59e-06	-5.25e-06	-6.33e-06	-1.38e-06	-1.33e-06	-1.57e-06	1790.6
	(.00001)	(.00)	(.00001)	(.00)	(.00)	(.00)	
Precipitation in inches	-.0009182	-.0008178	-.0008556	-.0002265	-.0002073	-.0002119	28.475
	(.00077)	(.00077)	(.00082)	(.00019)	(.0002)	(.00021)	
Controls							
Canal or Aquifer	**.1985604*****	**.1785511****	**.1818572****	**.0474879*****	**.0439568****	**.0439618****	0.45614
(binary variable)	(.05272)	(.05147)	(.05407)	(.01307)	(.01416)	(.01555)	
Time trend	**.0086119*****	**.0083915*****	**.0090431*****	**.0021243***	**.0021273***	**.0022399***	6.5
	(.00235)	(.00227)	(.00243)	(.00093)	(.00095)	(.00097)	
1/population	-2.48e-07	-2.03e-07	-2.29e-07	-6.13e-08	-5.15e-08	-5.68e-08	19809.3
	(.00)	(.00)	(.00)	(.00)	(.00)	(.00)	
Export Ordinance	.0286049	.0286964	.0298322	.0070749	.0072944	.0074084	0.5263158
	(.02762)	(.02666)	(.02781)	(.00745)	(.00745)	(.0076)	
Pseudo R^2	.0039785	.00343854	.00346498	.0039785	.00343854	.00346498	

N = 684; T = 12; i= 57. Notes: Columns 1-3 report the marginal effects of the explanatory variables, measured at their means, on the probability of exports (i.e., Regression (2)). Columns 4-6 report the marginal effects of the explanatory variables, measured at their means, on the ratio of exports to appropriations for all exporting counties. Clustered robust standard errors are in parentheses and are adjusted by county name. All models are estimated with a constant. San Francisco was dropped. For binary variables the coefficient is the effect from a discrete change from 0 to 1. I control for the endogeneity of riparian doctrine using four instrumental variables: population by county in 1850, population by county in 1860, the value of farm products by county in 1900, and the value of gold and silver production from mining by county in 1880. Estimates are significant at the 5 percent (*p < .05), 1 percent (** p < .01), or .1 percent (*** p < .001) level.

Table 9. IVTOBIT Estimates of the Marginal Effects of Riparian Rights and Third-Parties on Exports with Mining Today.

	Y: Pr(ratio of exports to p.a. > 0)			**Y: E(ratio of exports to p.a.|ratio of exports to p.a. > 0)**			
	1	**2**	**3**	**4**	**5**	**6**	**Mean of X**
Costs influencing the size of τ							
Ratio of riparian holders to total population	**-25.06714*****	**-26.8864*****	**-26.19334*****	**-5.942873*****	**-6.592571*****	**-6.272022*****	0.004946
	(7.78037)	(7.66628)	(7.3986)	(1.57453)	(1.64206)	(1.68405)	
Per capita number of employees in the farm machinery plus irrigation industry	2.014398			.47757			0.002607
	(4.25812)			(.99691)			
Percent of agricultural employment to total employment		.0034463			.000845		5.54441
		(.00264)			(.00057)		
Per Capita Value in Agriculture			5.83e-06			1.40e-06	2485.963
			(.00001)			(.00)	
Supply/Demand Proxies for Trade							
Lagged population growth rate*precipitation	**.0007385***	**.0007312***	**.0007995***	.0001751	.0001793	**.0001914***	33.4625
	(.00033)	(.00033)	(.00034)	(.00009)	(.0001)	(.0001)	
Lagged population growth rate	-.0168004	-.0181234	-.019916	-.003983	-.0044439	-.0047689	1.35913
	(.01013)	(.01084)	(.01152)	(.00275)	(.00304)	(.00312)	
Total Water Supply in thousands of acre-feet	-7.57e-06	-7.70e-06	-8.46e-06	-1.79e-06	-1.89e-06	-2.03e-06	1790.6
	(.00001)	(.00001)	(.00001)	(.00)	(.00)	(.00)	
Precipitation in inches	-.0009365	-.0008081	-.0008696	-.000222	-.0001982	-.0002082	28.475
	(.00081)	(.00083)	(000087)	(.0002)	(.00021)	(.00022)	
Controls							
Canal or Aquifer	**.206276*****	**.1794503*****	**.1871393*****	**.047847*****	**.0431807****	**.0440779****	0.45614
(binary variable)	(.04681)	(.04871)	(.05225)	(.01338)	(.01438)	(.01558)	
Time trend	**.0095024*****	**.0092603*****	**.0098872*****	**.0022528***	**.0022706***	**.0023675***	6.5
	(.00235)	(.00239)	(.00249)	(.00102)	(.00107)	(.00107)	
1/population	-3.11e-07	-2.50e-07	-2.86e-017	-7.37e-08	-6.13e-08	-6.86e-08	19809.3
	(.00)	(.00)	(.00)	(.00)	(.00)	(.00)	
Employees in Gold and silver mining average 1998	.003811	.0004163	.0003711	.0000904	.0001021	.0000889	22.88793
	(.00025)	(.00029)	(.00029)	(.00007)	(.00008)	(.00008)	
Pseudo R^2	.0048998	0.00412345	0.0041476	.0048998	0.00412345	0.00414756	

N = 684; T = 12; i= 57. Notes: Columns 1-3 report the marginal effects of the explanatory variables, measured at their means, on the probability of exports (i.e., Regression (2)). Columns 4-6 report the marginal effects of the explanatory variables, measured at their means, on the ratio of exports to appropriations for all exporting counties. Clustered robust standard errors are in parentheses and are adjusted by county name. All models are estimated with a constant. San Francisco was dropped. For binary variables the coefficient is the effect from a discrete change from 0 to 1. I control for the endogeneity of riparian doctrine using four instrumental variables: population by county in 1850, population by county in 1860, the value of farm products by county in 1900, and the value of gold and silver production from mining by county in 1880. Estimates are significant at the 5 percent (*p < .05), 1 percent (** p < .01), or .1 percent (*** p < .001) level.

Table 10. IVTOBIT Estimates of the Marginal Effects of Riparian Rights and Third-Parties on Exports with Time Fixed Effects.

Y:	1 Pr(ratio of exports to p.a. > 0)	2 E(ratio of exports to p.a. |ratio of exports to p.a. > 0)
Costs influencing the size of τ		
Number of riparian holders to total population	**-25.89727****	**-6.359924****
	(8.68169)	(1.85684)
Per capita Number of employees in the farm machinery industry plus irrigation industry	2.225892	.5466408
	(4.36151)	(1.05495)
Supply/Demand Proxies for Trade		
Lagged population growth rate*precipitation	.0004688	.0001151
	(.00035)	(.00009)
Lagged population growth rate	-.0064981	-.0015958
	(.01128)	(.00282)
Total Water Supply in thousands	-7.32e-06	-1.80e-06
	(.00001)	(.00)
Precipitation	-.0003419	-.000084
	(.00103)	(.00025)
Controls		
Canal or Aquifer	**.2082081*****	**.0498365*****
	(.04821)	(.01416)
1/population	-3.46e-07	-8.50e-08
	(.00)	(.00)
1990	-.0178428	-.0045043
	(.02441)	(.0066)
1991	-.0252146	-.0064471
	(.02325)	(.00652)
1992	-.0283366	-.0072868
	(.02149)	(.00583)
1993	**-.0377009***	**-.0098727***
	(.01724)	(.00409)
1994	-.0241236	-.0061562
	(.01908)	(.00516)
1995	-.061011	**-.0168641****
	(.03153)	(.00596)
1996	-.0223076	-.0056745
	(.02572)	(.0071)
1997	-.0003983	-.0000979
	(.02895)	(.00713)
1998	.0283526	.006718
	(.03449)	(.00921)
1999	.0517426	.0119719
	(.03823)	(.0106)
2000	**.1463522***	.0318636
	(.07336)	(.01902)
Pseudo R^2	.00477682	.00477682

N = 684; T = 12; i= 57. Notes: Column 1 reports the marginal effects of the explanatory variables, measured at their means, on the probability of exports (i.e., Regression (2)). Column 2 reports the marginal effects of the explanatory variables, measured at their means, on the ratio of exports to appropriations for all exporting counties. Clustered robust standard errors are in parentheses and are adjusted by county name. All models are estimated with a constant. San Francisco was dropped. For binary variables the coefficient is the effect from a discrete change from 0 to 1. I control for the endogeneity of riparian doctrine using four instrumental variables: population by county in 1850, population by county in 1860, the value of farm products by county in 1900, and the value of gold and silver production from mining by county in 1880. Estimates are significant at the 5 percent (*p < .05), 1 percent (** p < .01), or .1 percent (*** p < .001) level.