TRADING ACTIVITY IN AN INFORMAL AGRICULTURAL WATER MARKET: AN EXAMPLE FROM CALIFORNIA

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INTRODUCTION: THE ROLE OF WATER MARKETS IN THE AMERICAN WEST

In the American West, there is a well-known divergence between the spatial and temporal supply of surface water and the demand of agricultural and urban users for that water. In general, mountainous regions with high precipitation and winter snowfall tend to be sparsely populated or poorly suited to agriculture. Conversely, large agricultural and urban centers have often outgrown local water supplies. Water for agricultural, urban, and environmental uses is most needed during precisely those summer months when there is no precipitation. Historically, these concerns have been addressed through the construction of large-scale public water storage and distribution projects (for general accounts, see Worster, 1985 or Reisner, 1986). However, in recent years, increasing environmental concerns and changes in the political climate have reduced the feasibility of further dam building in the American West. As a result, there has been an increase in emphasis on institutions and mechanisms that attempt to reallocate the limited available water supply amongst competing users (Vaux & Howitt, 1984, Howe et al., 1986).

What is the economic rationale underlying the reallocation of water? In the United States (U.S.), water rights are usufructuary, implying a right to use water rather than outright ownership. In the arid West, the institutions used to determine water rights are the result of the historical interplay between the legacy of English common law and the westward expansion of settlers, agricultural and mining interests in the 19th century (Anderson, 1983; Johnson & DuMars, 1989). As a result, the distribution of the ownership of water rights is quite distinct from the spatial pattern of potential productivity of water. The most common water rights system in the West is the appropriative, or queuing, system. Under the appropriative water rights regimes, holders of senior water rights will receive their full annual allocation before junior rights holders receive any water. This means that during droughts, senior rights holders may receive a full allocation and junior rights holders may receive no water. Because many urban centers hold junior rights and many agricultural producers that grow low-value crops hold senior rights, there are clear economic gains to be made from systems that allow trade of water between users. Indeed, the driving force for any water market is a difference in the values of the water in use between two water users (for general descriptions, see Hartman & Seastone, 1970; Saliba & Bush, 1987; Howe et al., 1986). Note that this does not mean that users must be systematically different for gains from trade to be possible. Two farms of the same size with identical cropping patterns will both gain from trading water if they start with different initial allocations of water (for example, if one is a senior rights holder and the other a junior rights holder).

Hence, in economic terms, the price at which water is actually traded is unimportant. Trade is driven by differences in the value of the water in use between two potential traders. This value in use is quantified by the value of the marginal product, namely the incremental value of the increased output resulting from having an additional unit of water. Thus, differences in the value of the marginal product of water (VMP) are a prerequisite for trade. Moreover, the difference in the VMP between two potential traders must be larger than any transaction costs that the traders incur in the course of searching for trading partners. These transaction costs include not only any transfer charges levied by water districts and wheeling expenses, but also the costs of finding suitable partners to effect a transaction.

In an agricultural setting, a farmer's VMP of water will vary not only from year to year as a function of his overall allocation and cropping decisions, but also throughout the growing season as the farmer adjusts to changes in climate. In studying trading behavior in water markets, it is critical to understand this distinction between the price of water and its value in use. This difference explains why at certain times of year or in certain regions, "cheap" water can go unsold.

Of course, there are many difficulties in establishing functional water markets (Young, 1986; Frederick, 1986; Howitt, 1994). These range from the existence of legal constraints on the transfer of water rights, to the issue of third-party impacts, to the need for adequate transportation capabilities if the water is to be transported large distances. As a result, although a number of water markets exist in the western U.S., they have tended to be quite distinct in their nature and institutional design (Saliba, 1987; Carey & Sunding, 2001). Some water markets, such as the Colorado-Big Thompson Project in Colorado, have well-established market prices and anonymous exchange between buyers and sellers. Other markets, such as those found in the Central Valley Project (CVP) in California, have no such institutions (Carey & Sunding, 2001). Instead, individual buyers and sellers must engage in costly search to find trading partners, negotiate a price, and effect the legal transfer of the water right. Despite these high transaction costs, true arms-length transfers (as opposed to barters between members of the same kinship or corporate group) do still occur in informal water markets without posted prices and a centralized trading location. In this paper, we consider one such informal water market, the Westlands water market in the Central Valley of California (Olmstead, 1998). Westlands Water District is the largest agricultural water district in the country. Moreover, because it holds junior rights within the Central Valley Project allocation, it represents an agricultural setting with extreme water scarcity. As a result, there are few administrative barriers to trading water between users within the water district, and an active agricultural water market exists. In terms of the volume of water traded, this water market is the largest in the country. As such, it offers a glimpse into the possible future of agricultural water trading in California and elsewhere in the West.

Using water-trading data from Westlands for the period 1993-1996, we describe how seasonal and annual changes in climate and the crop cycle interact with the existing institutional mechanisms in Westlands to determine trading behavior. Moreover, we discuss how farmers of different sizes use the market and the role of individual loyalty in determining how trading partners are chosen in this informal market setting. Finally, we discuss how changes in market structure could affect Westlands farmers, and the possible distribution of these changes.

OVERVIEW OF THE WESTLANDS WATER DISTRICT

The Westlands Water District is the largest district in the Central Valley Project in California, serving nearly eight hundred farms, which cover 600,000 acres. In comparison to other water districts served by the Central Valley Project, Westlands holds junior rights for its water deliveries. Thus, in most years, it receives less than its full allocation of 1,500,000 acre-feet (where 1AF equals 326,000 gallons of water). Because of its size and its lack of senior water rights, Westlands is the largest agricultural water markets in the United States.

Moreover, even within the Westlands Water District, water is allocated according to a priority rights system, with farms belonging to one of two main priority areas (Olmstead, 1998; Carey and Sunding, 2001). The most senior water right is priority area one, covering 337,000 acres. This land was part of the original Westlands Water District, and under a 1963 contract with the Bureau of Reclamation, is entitled to 900,000 acre-feet of water in a full-delivery water year. This means that farms with land in priority area one will receive 2.6 acre-feet of water per acre of land in full-delivery years. Priority area two represents a more junior right than priority area one. Covering 187,000 acres, this land was originally part of the former Westplains Water District, and was annexed to Westlands. Land in priority area two is entitled to 250,000 acre-feet of water in a full-delivery water year, corresponding to 1.3 acre-feet per acre. Finally, there is also a priority area three, with the most junior water rights. However, this area only covers 10,000 acres, and will not be considered further in this paper.

As previously mentioned, in a water queue system of the kind found in Westlands, in a dry year, senior water rights holders (in priority area one) may receive their full allocation, while junior rights holders (those in area two) receive a reduced allocation or none at all. The water allocation in Westlands operates on a water year basis, where the annual interval is defined from March of one year to March of the following year (Carey & Sunding, 2001). The Bureau of Reclamation typically announces its annual allocation in several stages at the beginning of the water year. Since Westlands Water District operates a sophisticated hydraulic and metering system, farms may take delivery of their allocation on demand throughout the water year. Whether they use all of it or not, farmers must pay for their entire water allocation at the start of the water year. However, depending on hydrological conditions and storage capacity in the San Luis reservoir, a portion of each farm's allocation may be carried over into the following water year. In wet years, carry-over may not be allowed.

Farms in all priority areas grow a variety of crop types, including both annual and perennial crops. In particular, many of the farms in priority area two (with junior water rights) have very good soils and grow high value tree crops. Because the spatial distributions of water queue priority and crop type are quite different, it should be clear that there are significant gains to be made from the trade of water rights. By purchasing water in the water market, farms acquire an option that expires at the end of the water year, when the original allocation expires. Moreover, because water may only be sold within the Westlands Water District, and all deliveries are carefully metered, third-party effects are negligible. As previously mentioned, there are few administrative barriers to trading. Though there is no formal water market, an active informal market operates. This means that farmers wanting to trade water must locate potential trading partners. This informal market is referred to as a 'coffee-shop market' after the coffee shops where farmers meet to look for trading partners and to negotiate trades.

THE WESTLANDS WATER MARKET, 1993-1996

The data used in this study are a subset of a larger dataset containing farm-level information on every water trade carried out in Westlands Water District for the four water years from 1993 to 1996 (Olmstead, 1998). During this period, there were 8,611 recorded transfers of water in Westlands Water District. However, most of these trades do not represent market transactions occurring between separate entities and driven by differences in the value in use of water. This situation is a result of farm acreage limitations stipulated by the Reclamation Act of 1902 and subsequently modified (Carey and Sunding, 2001). Under the 1982 amendment to the Reclamation Act, farms of less than 960 acres in size may receive Central Valley Project at a reduced rate. Farms may purchase water for use on acreage in excess of the 960-acre limit, but must pay a higher rate for that portion of the water. As a result of this pricing scheme, larger farms have been parsed into 960-acre units and distributed amongst family members and family trusts (Hundley, 1992). This allows technical compliance with the 960-acre limit; operationally the farms remain much larger. Although on paper, there are eight hundred separate farms in Westlands, these are grouped by common ownership into around three hundred and fifty trading networks. Farms within the same network may trade water internally for efficiency reasons or tax purposes, but in both cases, a true market transaction has not taken place. Details of network transactions are given in Carey and Sunding (2001). For the purposes of this study, we have excluded all such internal transactions between farms that belong to the same corporate entity and are operated as a single unit. Instead, we consider only those transactions where an arms-length transfer between farms belonging to different networks occurred. In 6481 of the 8611 trades during the four water years 1993-1996, internal transfers occurred between subunits of a larger network. This leaves 2130 trades where the two parties involved in the transaction were distinct entities; that is to say, a true arms-length transfer of water occurred.

Even when water is transferred between two operationally distinct farms, trading may be undertaken for a variety of reasons not related to differences in the value of the water in use. For this study, we are interested in transactions occurring at a point in time between two distinct corporate entities, driven by differences in the value of the marginal product of water in use (VMP) between the two traders. Although it is not possible to observe directly VMPs, the dataset used in this study contains evidence for several fundamentally different sorts of behavior, which are not consistent with trading driven by differences in VMP. Thus, as described below, we have excluded some of the remaining 2130 trades.

First, we have aggregated trades occurring on the same date and between the same traders. Many of the traders seem to parse large trades into many smaller trades that take place simultaneously. While this is probably related to field- or farm-level accounting, the underlying transaction of interest is represented by the aggregate amount.

Second, many transactions involve traders swapping the same amount of water, but with differing vintages (a sub-priority area classification). Because the net amount of water traded in such a pair of transactions is zero, this cannot be motivated by differences in the value of the water in use. Such swapping activity is used to show a loss for tax purposes, by swapping a "cheap" vintage for an "expensive" vintage, and is not of interest in this study. Hence, we have removed all swaps from the dataset.

Finally, the limited ability to carry over water into the next water year drives lagged swapping. A trader who is able to carry water over may buy rights from a trader who cannot do so, and sell them back at the beginning of the next water year. Again, differences in VMP do not drive such swaps as the initial seller gets back exactly the same amount of water that he sold, so that the net amount traded is zero.

Once these trading activities have been excluded, 1267 trades remain, which form the basic dataset used in this study. Note that there exist several other activities, such as short term speculation and long term rentals, which are difficult to isolate, and thus may remain in the dataset we have analyzed.

CHARACTERISTICS OF TRADERS IN THE WESTLANDS WATER MARKET

Every trade in a market involves both a buyer and a seller, and thus we can think of two sides to the market: the buyers' side and the sellers' side. There is no inherent reason that these two sides should be symmetric; indeed we might expect to find systematic differences between the kinds of trader who tend to buy water and those who tend to sell water. In the following discussion, we will describe characteristics of both sides of the market. The 1267 water trades in the dataset represent trading activity by 316 separate trading networks (Table 1). Of these, 224 networks bought water and 269 networks sold water in the four water years from 1993 to 1996. Hence, 177 networks both bought and sold water during the four-year interval (Table 1). This does not imply extensive speculative activity with simultaneous buying and selling because, in almost all cases, networks alternated periods of buying with periods of selling.

There are approximately 350 potential traders in Westlands as this is the total number of distinct trading networks. Hence, roughly 90 percent of potential traders in the Westlands Water District (316 out of 350) actually participated in the water market in the period March 1993 to February 1997. This percentage is very high, given the informal market structure. The high participation rate suggests that the 'coffee-shop market' is quite good at matching potential buyers and sellers. However, in order to look at the distribution of benefits from participation in the market, we must also look at the frequency of participation and the amounts of water traded. Note also that we only have data on trades that did occur, and we have no information about refusals and trades that did not occur, even though they might have been profitable to both parties.

As mentioned previously, trading networks are generally composed of several smaller farms, which although legally distinct, are operational subunits of the larger corporate entity. Each of these smaller farms is usually 960 acres in size. A trading network of two farms will generally have an aggregate acreage of 1920 acres, a three-farm network will have 2880 acres, and so on. Thus, the number of farms in a trading network is a rough measure of the total acreage of the network. The smallest farms that traded water in Westlands were composed of a single subunit, denoted by a size of one. The largest farm that traded had a size of 29, implying that it is composed of 29 sub-farms, and encompasses nearly 30,000 acres. The mean buyer size was 5.87 and the mean seller size was 5.84; these are not significantly different.

In Westlands, water allocations are determined by priority area. It is common for farms to hold land in both junior and senior water rights area, and thus to trade both junior and senior rights. Trading networks may sometimes trade from subunits that are in a junior rights area, and sometimes from subunits that are in a senior rights area. We define a single water rights priority area for each trading network as the mean of the priority areas of those network subunits that traded. This is intended to reflect the overall distribution of land with trading potential between priority areas for each trader. In the dataset, senior water rights are labeled as area one and junior rights are labeled as area two. Thus, the mean priority area of farms is a continuous variable with a range from one to two. For buyers, the mean priority area was 1.50, and for sellers it was 1.40. As we might expect given a queuing system for water allocation, buyers tended to have slightly more junior rights than sellers.

Given that the number of trades over the four-year study period exceeds the number of distinct traders, most traders participated in the market on more than one occasion (Table 2). Nonetheless, the modal trading frequency for both buyers and sellers was one: 58 buyers and 62 sellers only traded water once during the four-year interval (Table 2). Whereas most traders bought or sold water only a few times, a small number of traders participated in the market on many occasions. One buyer undertook forty purchases, and two sellers each sold water on forty-one separate occasions (Table 2). Note that the mean frequency of purchases for participating farms (1267/224 = 5.7) is higher than the mean frequency of sales (1267/269 = 4.7). Using a *t*-test we test the null hypothesis that the two populations of trading frequencies have the same mean: the *t*-statistic for this test is 1.70. Thus, at the 5 percent level, we fail to reject the null hypothesis that the means are the same.

In the months in which they traded, 66 percent of buyers and 68 percent of sellers traded only once (Table 3). Only 4 percent of buyers and 11 percent of sellers traded more than three times in any month. The *t*-statistic for the null hypothesis that purchase and sale frequencies have the same mean is 4.95. Thus, we reject the null hypothesis: the mean monthly trading frequency for buyers, 1.53, is significantly different to that for sellers, 1.77. One possible explanation for this is that farms that are left with a large amount of unused water towards the end of the water year are only able to sell it in smaller units, as carryover water is inherently less attractive to buyers.

ANNUAL AND SEASONAL TRADING VARIABILITY

In Westlands, irrigated water is used as an input to agricultural production. Crop water requirements vary significantly throughout the year as a result of both climatic and agronomic factors. Because of this variability, we would expect to see distinct cycles in water trading activity. Moreover, the Central Valley Project allocates water to Westlands on a water-year basis, and this also affects trading activity through the year.

As might be expected, the number of trades was higher in the drought years (1993 and 1994) than in the following wet years (1995 and 1996), but the mean trade size was larger in wet years than in dry (Table 4). For the drought years, Central Valley Project (CVP) allocation to Westlands was 50 percent or less, whereas in the wet years, Westlands received close to a full allocation (Table 5). The total amount of water traded in the market during the period 1993-1996 represented between 8 percent and 15 percent of the total CVP allocation in any year. Given that market trades constitute a relatively small fraction of the total trading activity, as discussed previously, this represents a significant percentage of the total allocation, and suggests that the informal market is reallocating water quite successfully to higher values in use.

There is a distinct seasonality to water trading. Trades in February, at the end of the water year, are attempts to dispose of water options that are about to expire. Water sold at this time of year may be carried over (if permitted), used for preirrigation of fields, or used to replenish ground water for those farmers that have wells. Trading activity in March and April relates to planning for the coming crop growing season. In the Central Valley, there is generally no precipitation during the summer months, so that summer trading is used to compensate for crop water requirements resulting from differences between expected and realized climate, or to make up the shortfall between water input demand and initial allocation.

Hence, there are two peaks in market trading activity, one in the summer, when crop water requirements are highest, and one in February of each year, just before the end of the water year (Figure 1). Moreover, the trading patterns observed have different characteristics between the drought years (1993 and 1994) and the following wet years (1995 and 1996). Because the pairs of wet and dry years are broadly similar, for ease of interpretation we have aggregated the two dry years (1993 and 1994) and the two wet years (1995 and 1996) in the following discussion.

During the drought years, there were two peaks in the monthly frequency of trades (Figure 1). The highest frequency of trades occurred in February, and was presumably related to the sale of unused options at the end of the water year. A second, smaller, peak occurred in August, and probably reflects high crop water requirements in the middle of the summer. On the other hand, there was much less variability in the mean trade size by month in dry years (Figure 2). The smallest mean trades occurred in February. As discussed previously, this may reflect the inability of traders to dispose of large amounts of water at the end of the water year when the ability to carry it over is uncertain. Mean trades in the summer were not different in size to those occurring during the rest of the year. Hence, the total amounts traded by month in the dry years show no recognizable seasonal pattern (Figure 3). It is interesting to note that even during the drought years, there was significant trading towards the end of the water year, and at least some farmers had excess water that they were willing to sell. This suggests that some farmers may keep buffer stocks of water until late in the growing season to cope with increases in crop water demands from unexpected temperature changes. Alternatively, trading late in the water year may reflect the inability of some potential sellers to find trading partners earlier in the year at the prices they are asking for.

During the wet years, trading frequencies in each month were lower than in the same months during the drought years (Figure 1). Once again, the highest frequency of trades occurred in February. However, in 1995 and 1996, there was no pronounced increase in summer trading frequencies, and with the exception of February, trading frequencies remained quite constant throughout the rest of the year. However, the monthly distribution of mean trade sizes was bimodal. In the months from April through August, the mean trade size was roughly twice that found during the remaining fall and winter months. The highest mean trade size occurred in August, and the lowest in March, at the start of the water year. As a result of this, there were two peaks in the monthly trading totals during the wet years, in February and in August. The highest total volume traded occurred in the month of February. This suggests that during wet 1995 and 1996, some farmers in Westlands had more than enough water to meet their crop requirements, and had significant amounts of water left over at the end of the water year.

The larger mean trade size and lower trading frequency in wet years compared to dry years both presumably reflect changes in the overall availability of water in Westlands (Table 5). We suggest that in wet years, traders in the water market were unwilling to buy or sell smaller amounts of water, as the spot market prices would have been lower. In order to overcome significant transaction costs, transaction size had to increase. It is interesting to note that in the dry years, increased summer demand was met by increasing transaction frequency, whereas in wet years, transaction size increased. It is likely that during the dry years, farmers requiring large amounts of water in the summer had to enact many transactions with separate sellers, none of who were willing to sell large amounts.

The previous discussion deals with trading patterns at an aggregate level. Alternatively, we can look at the annual trading activity for each farm that traded (Figures 4 and 5). In this case, the variable of most interest is the annual net trading of each farm; that is to say, whether overall, farms sold or bought water over the course of the water year. For both dry and wet years, there is a wide distribution of net trading activity at the farm level, with some farms in almost all size categories being net sellers and others being net buyers (Figures 4a and 4b). This is not surprising as the priority area of the farms, and thus their initial allocation, are not associated with their size. Moreover, although we have no farm-level data on cropping patterns in Westlands, farms of the same size grow quite different crop types with widely differing crop water requirements in terms of the timing and amount of applied water. No systematic pattern of trading appears as a function of farm size. The range of net trading activity is much larger in the wet years than in the preceding dry years, presumably reflecting the larger overall availability of water and hence a greater flexibility for farms to choose how to augment or reduce their initial allocation (Figures 4a and 4b).

Because subunits within a trading network are in general 960 acres apiece, it is possible to normalize the net trading data by overall acreage and to consider what proportion of their initial allocation farms traded in the water market. Recall that the full allocation for farms wholly in priority area one is 2.6 acre feet per acre of land, and for farms wholly in area two, it is 1.3 acre feet per acre of land. In 1995 and 1996, CVP allocations to Westlands were essentially 100 percent (Table 5), whereas in the preceding drought years, allocations were 50 percent or less. Because of the water queuing system, the cutbacks in drought years would have been allocated asymmetrically between the junior and senior water rights holders.

A striking feature of the normalized net trading data is that for both dry and wet years, a significant number of smaller farms appear to have traded quantities equal to their entire CVP allocation on the water market (Figures 5a and 5b). For comparison, many of the crops commonly grown in Westlands have water requirements of 2.5 – 3.5 AF/acre of water applied for one harvest. There are several possible reasons why farmers might sell a large proportion of their annual allocation. If anticipated water market prices are high enough, farmers growing low value crops may idle some or all of their land. Some farms have access to ground water and crops that can tolerate irrigation with poorer quality water (ground water in Westlands is somewhat saline). Such farms may substitute pumped ground water for the surface water allocation that is sold if spot market prices are high enough. Finally, some of these farms may have acreage in adjoining areas outside of Westlands, and they may be larger farms than their landholdings in Westlands would suggest. In this case, such farms might also sell some portion of their allocation and then bring in water from their entitlements outside of Westlands if it is profitable to do so. Westlands does not allow water to be exported from the water district but there is no such restriction on importing water.

Conversely, those traders that are buying large amounts of water are presumably growing crops with large water input requirements on a large proportion of their land. The observed pattern of trading suggests that small farms that participated in the water market made far larger adjustments to their production decisions than large farms as a result of being able to trade. However, this does not mean that the gains from trading in the market were larger for small farms, as in general the larger farms traded larger total amounts of water (Figures 4a and 4b).

TRADING LOYALTY

Each of the 1267 transactions that occurred represents a trading partnership between a buyer and a seller. Of these partnerships, 729, or 58 percent of them, were unique: the two traders involved had no further water trades (Table 6). Fifteen percent of trades involved traders who had traded with each other four or more times. One trading partnership undertook ten separate trades over the four-year period (Table 6). From this data, we can look at the number of distinct trading relationships that evolved over the study period. There were 920 distinct trading relationships in the Westlands water market during the period 1993-1996 (Table 6). To put this in context, with 316 traders, the total possible number of distinct trading relationships is 316!/(2!314!), or 49770 relationships. Thus, 1.8 percent of all possible trading relationships are represented in the data. If there were no repeated trading relationships, we would see 1267 separate trading relationships in 1267 trades, which would represent 2.5 percent of possible relationships. The difference between this percentage and the 1.8 percent actually observed is a reflection of trader loyalty in the market. These numbers suggest that loyalty to previous trading partners is a major determinant of future trading choices. Moreover, during the four-year period for which we have data, larger farms traded more often than smaller farms. One way of thinking about this is that the farms that did trade in any month were on average larger than those farms that did not trade. Smaller farms participated significantly less often in the informal water market. It is possible to imagine that this is because smaller farms are less able to cope with the risk of committing to production levels or crop types that require significant trading activity away from their initial water allocation. However, the data presented here (Figures 5a and 5b) suggest that at least some small farms relied on the water market to procure supplies of water quite different to their initial allocation. Certainly, as a result of water market participation, these farms altered their production decisions far more than larger farms that traded water. Alternatively, smaller farms may be unable to commit the human capital necessary to engage in costly search and the establishment of extensive trading relationships, even though the potential gains are large.

POLICY IMPLICATIONS

Many studies of water marketing focus on trading between agricultural and urban users. In particular, a very large difference between traders in the value of water in use is often cited as a prerequisite to overcome the significant transaction costs associated with water marketing. However, this study describes a robust agricultural water market between agricultural water users in a single water district. Even though all agricultural producers in Westlands Water District are relatively homogeneous (when compared to potential urban water traders), trading is routine and pervasive. Moreover, this trading occurs without many of the institutions of a well-developed market such as a centralized exchange and posted prices. During the study period, ninety percent of farms in Westlands participated in the informal water market. A significant proportion of the total annual CVP allocation was traded each year (Table 5). Trading patterns suggest that some farms rely on the water market to allow crop production choices (and concomitant capital investment) that would be impossible without trading. Overall, the amount of water traded between farms each year in Westlands is large (often more than 100,000 AF) suggesting that there are also large benefits from trading to those farms that participate.

During the study period, larger farmers traded more often than smaller farms, and traded larger quantities. The introduction of new institutions or technologies to improve the efficiency of the market would certainly improve the aggregate benefits of trading. The distribution of these additional benefits is less clear. As the current informal market appears to favor large farmers, it is likely that smaller farmers in Westlands would benefit more than large farmers under a system with a centralized exchange, brokers and market clearing prices. Because a significant percent of the annual allocation is already traded (Table 5), it is even possible that large traders would be worse off under a centralized exchange system, as they would no longer be differentiated from any other trader.

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Table 1. Westlands water market structure by trader activity, 1993-1996.

Total number of traders	316
Total number of buyers	224
Total number of sellers	269
Buyers who also sold	177
Buyers who did not sell	47
Sellers who did not buy	92

Table 2. Frequency of market participation for buyers and sellers.

Frequency of participation	Number of buyers	Number of sellers
1	58	62
2	37	50
3	24	42
4	14	28
5	15	27
6	13	11
7	10	12
8	6	2
9	7	4
10	8	6
11	6	2
12	4	3
13	1	7
14	4	1
16	1	1
17	3	1
18	0	1
19	1	1
20	1	1
22	2	2
23	1	0
24	1	0
25	1	0
26	2	2
29	1	0
32	1	0
35	1	0
39	0	1
40	1	0
41	0	2
Total	224	269

Table 3. Monthly transaction frequency by trader.

Monthly frequency of transactions	Number of buyers	Number of sellers
1	863	830
2	230	204
3	123	90
4	28	56
5	15	25
6	0	48
7	0	14
8	8	0
Total	1267	1267

Table 4. Water market trades by water year, Westlands Water District.

Water year	Trades	Mean(AF)	Max(AF)	Min(AF)	Total(AF)
1993	428	257.8	5000	1	110329
1994	348	176.4	1743	1	61373
1995	287	550.3	10000	1	157939
1996	204	542.0	13000	1	10570

Table 5. Water market trading as a percentage of yearly Central Valley Project allocation.

Water year	Trades(AF)	Allocation(AF)	Allocation percent	Traded percent
1993	110,329	750,000	50.0 percent	14.7 percent
1994	61,373	637,500	42.5 percent	9.6 percent
1995	157,939	1,500,000	100.0 percent	10.5 percent
1996	110,570	1,425,000	92.5 percent	7.8 percent

Table 6. Trading loyalty, Westlands water market.

Number of transactions between trading partners	Frequency	Distinct trading relationships
1	729	729
2	238	119
3	105	35
4	60	15
5	60	12
6	12	2
7	28	4
8	16	2
9	9	1
10	10	1
Total	1267	920

Figure 1. Frequency of trades by month, Westlands water market

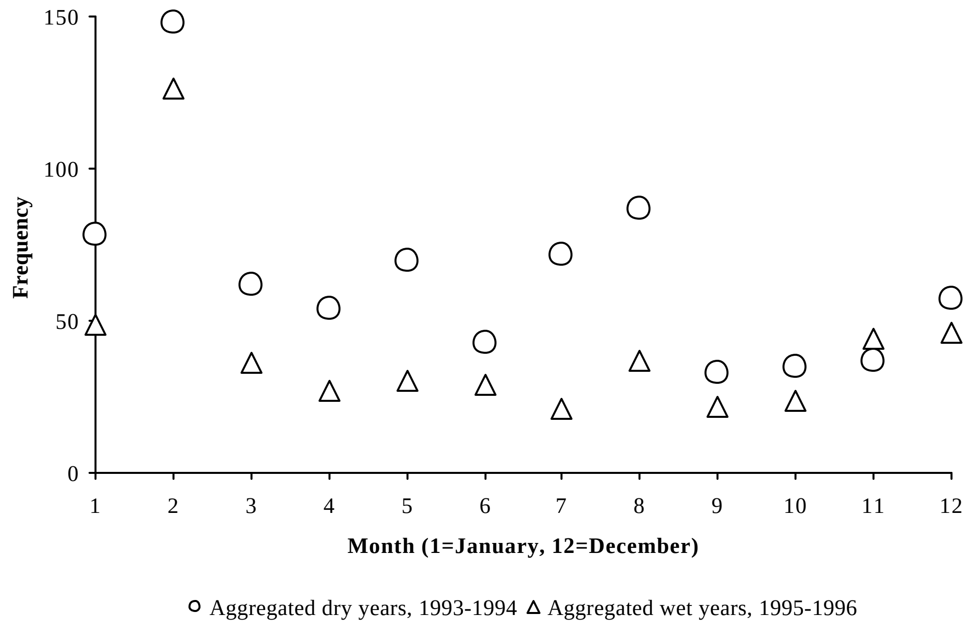

Figure 2. Mean trade size, acre feet/month, Westlands water market

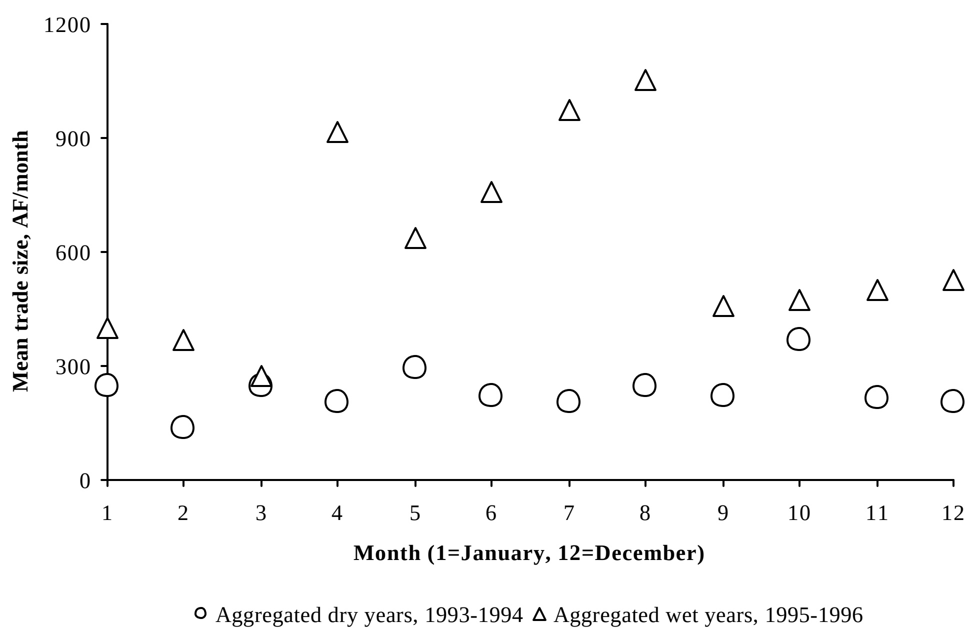

Figure 3. Total acre feet traded by month, Westlands water market

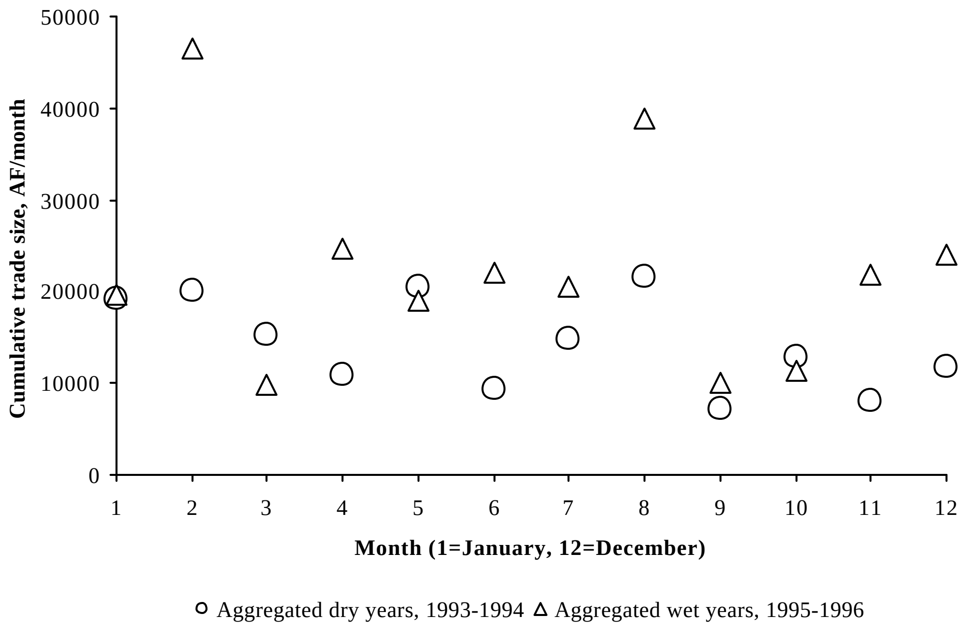

Figure 4a. Net trade size by farm size, dry years (1993-1994)

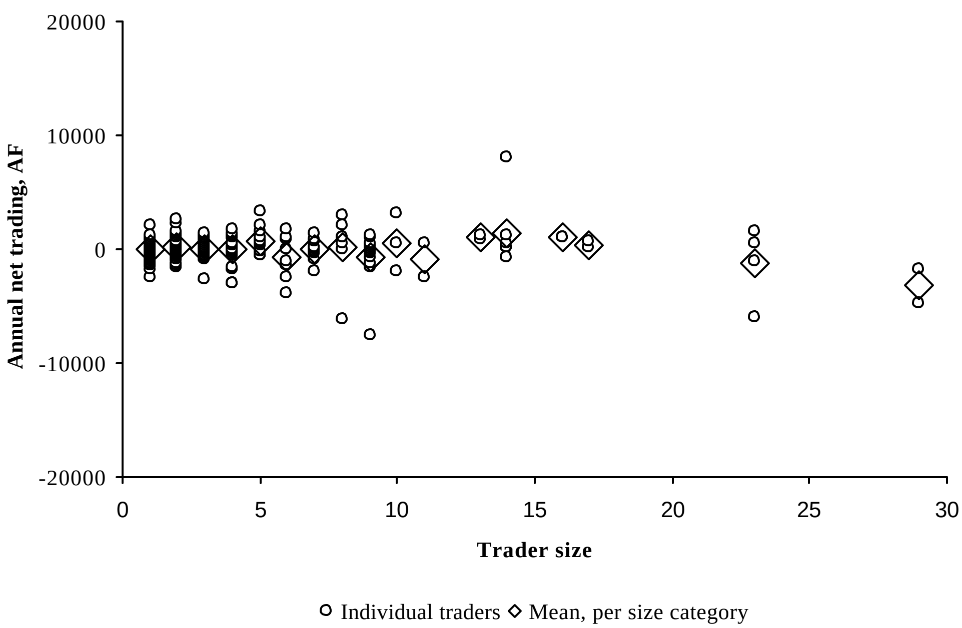

Figure 4b. Net trade size by farm size, wet years (1995-1996)

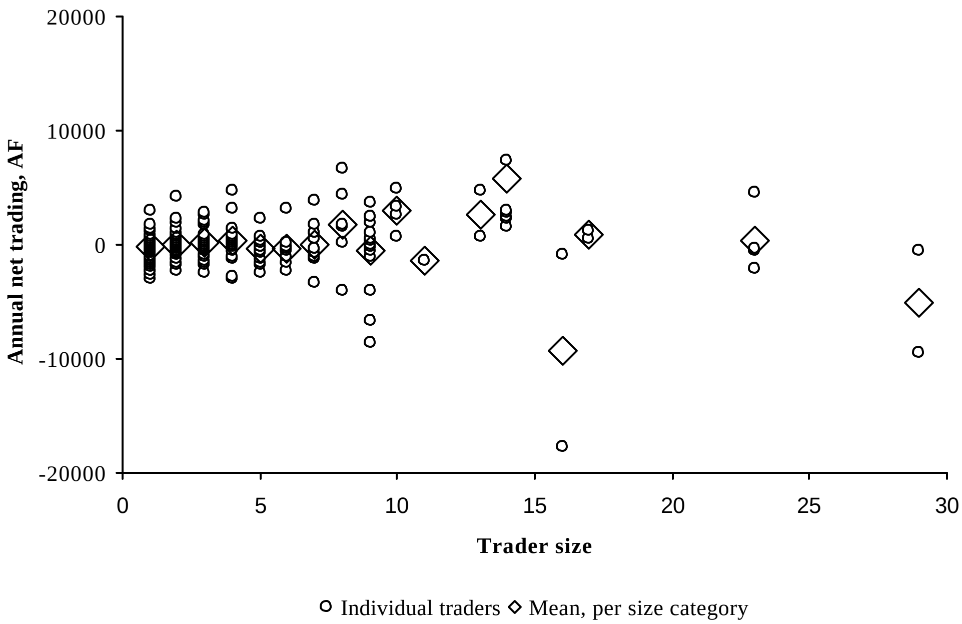

Figure 5a. Net trade size, AF per acre, dry years (1993-1994)

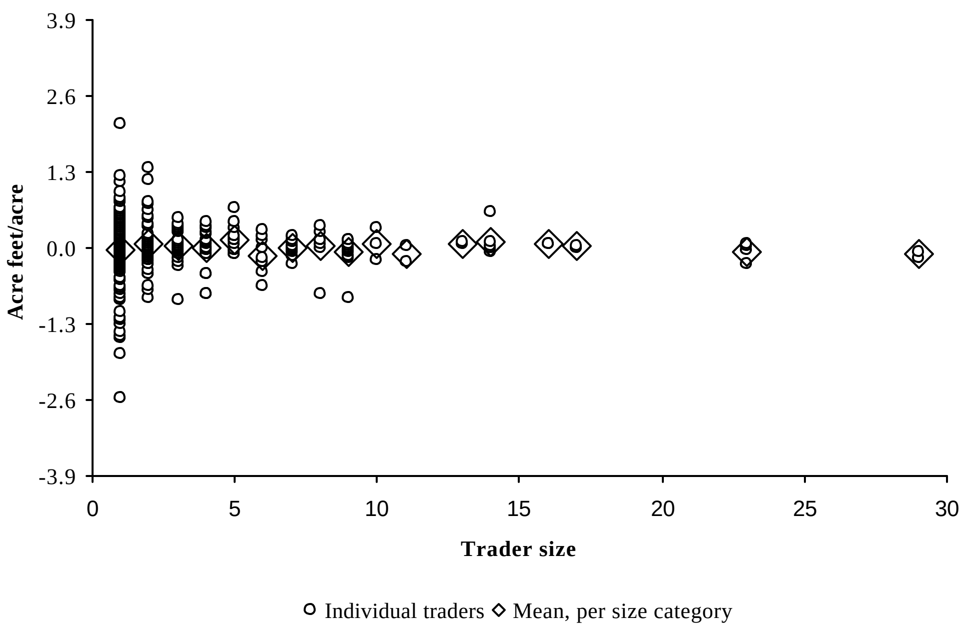

Figure 5b. Net trade size, AF per acre, wet years (1995-1996)