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The economic and financial gains from water markets in Chile

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Abstract

Chile is one of the few countries that has encouraged the use of markets in water resource management. In order to assess the impact of water markets and transactions costs in Chile, four river valleys, the Maipo, Elqui, Limarí, and the Azapa were selected as case studies. Transactions from the Elqui and Limarí valleys, during the years 1986 to 1993, were analyzed to determine the gains-from-trade from market transfers.

In the economic and financial analysis of water markets, crop budgets were used to estimate the value of water in agricultural production. The value of water-use rights to urban water-supply companies was estimated using the avoided cost of an alternative investment in a water-storage reservoir. The analysis demonstrated that the market transfer of water-use rights does produce substantial economic gains-from-trade in both the Elqui and Limarí Valleys. These economic gains produce rents for both buyers and sellers. But buyers, especially farmers growing profitable crops who buy water-use rights and individuals buying water-use rights for potable water supply, receive higher rents then sellers. Large table-grape producers in the Limarí Valley and individuals buying water for human consumption in the Elqui Valley received the highest rents. In the Elqui Valley net gains-from-trade per share were within the range of recent transfer prices of US$1000. In the Limarí Valley, gains-from-trade per share are 3.4 times the recent prices of US$3000 for a share of water from the Cogotí Reservoir.

Where trading was active, especially in the Limarí Valley, transactions costs have not presented an appreciable barrier to trading. Nonetheless, in the large canal systems with fixed flow dividers in the Elqui and Maipo Valley there have been very few transactions. Various factors contribute to the lack of trading, but the absence of trading in these large canal systems highlights the costs of modifying fixed infrastructure, especially for trades between farmers.

1. Introduction

With the growing concern about the increased scarcity and inefficient allocation and use of water resources, much attention has been focused on the use of markets in water allocation. A market based allocation could secure water supplies for high-value uses in urban and rural areas without the need to develop costly, new sources of supply that may be environmentally damaging. Also by securing compensation for water transferred from low valued uses, water markets provide an incentive for more efficient water use in agricultural, industrial, and municipal uses. Furthermore, if markets work properly, price signals can provide the information needed for efficient water allocation more effectively than models developed by a central water resources management agency (Rosegrant and Binswanger, 1994).

The effectiveness of water markets is constrained by the ability of buyers and sellers to measure and transport water, to legalize and enforce transactions, and to account for water quality. Thus, the effect of transactions costs and the infrastructure and institu-

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tions that reduce these transactions costs are critical to the effectiveness of water markets. In addition, the unconstrained movement of water via private exchanges can produce negative external effects on third party users. There is also the fear that the free exchange of water may disadvantage poor people.

Because of these concerns there is continued doubt among water resource managers, policy makers, and analysts of the type and scope of benefits that occur with the establishment of transferable water-use rights. There is continued doubt that the establishment of transferable water-use rights is sufficient for the creation of an active market that will equitably reallocate water. And there is concern that if trading does occur that the benefits of these trades will be captured by only a small group of landowners and investors.

Consequently, it is important to analyze Chile's experience with transferable water-use rights since Chile is one of the few countries that has encouraged the use of water markets. Market allocation in Chile is possible, in part, because a system of transferable water-use rights was reestablished in 1981. These rights are independent of land use and land ownership, thus trade of water rights is fairly unrestricted. The codification of these water-use rights coincided with a series of reforms in the Chilean economy including privatized land rights and liberalized trade.

This paper presents a description and an analysis of water allocation and water markets in Chile, with an emphasis on areas of relatively frequent trades. The first part of the paper provides a brief introduction. This is followed by an analysis of economic and financial gains-from-trade as well as a description of the water markets. The paper then concludes with some observations concerning the water markets in Chile and the institutions that facilitate trading.

1.1. Water markets, transactions costs, and institutions

As an introduction to a discussion of water markets it is useful to distinguish between the exchange of water and the exchange of water-use rights. This is appropriate because the distinction highlights the importance of the institutional arrangements for water resource allocation. The former – sometimes referred to as a 'spot market' – occurs when the owner of a legal or prescriptive right to a certain volume or flow of water sells a portion of that water, sometimes outside of legal sanction, to a neighbor in a simple transaction. These exchanges are for a finite period of time – sometimes for only a few hours of irrigation. Although the unit of sales may not be metered volumetrically, both buyer and seller have good information on the volume involved. A more permanent transaction involves the exchange of the water-use right itself. This generally requires legal sanction to maintain the security of the right after the transfer. These transfers are generally permanent, but can be for a finite, but extended period of time – at least one irrigation season. And the burden of uncertain supply will fall on the purchaser of the right.

Where water is scarce and legally defined transferable water-use rights exist, market trades can be expected when the difference in the value of water between two uses is greater than the costs of transferring the water. In the absence of transactions costs economic incentives would induce water users to trade water-use rights until the marginal value of these rights was equal across all users. Of course, transactions costs do limit the movement of water and the transfer of water-use rights. Transactions costs for water market transfers include: (i) the cost of the physical infrastructure needed to measure and transport water, including the evaporation and filtration losses during conveyance; (ii) the cost of searching and finding willing buyers and sellers, and negotiating a contract; and (iii) the cost of validating legal ownership of the water-use right, legalizing the contract, enforcing contract provisions, and acquiring the necessary permission from regulatory authorities to transfer water. Because these transactions costs can be large, the number of potential buyers and sellers may be limited – which may result in non-competitive pricing.

The market exchange of water and water-use rights is a relatively rare phenomenon, and thus the economic analyses of actual exchanges are scarce. A few studies have simulated the effects of market and administrative transfers in the western USA (Vaux and Howitt, 1984; Whittlesey and Houston, 1984; Hamilton et al., 1989; Dinar and Letey, 1991; Rosen and Sexton, 1993; and Weinberg et al., 1993). Other studies have relied on data from actual trades in

order to assess the efficiency of water markets. Maass and Anderson (1978) evaluated the water market in Alicante, Spain, and found that the market system produced greater net increases in regional income than the rotation systems. Chang and Griffin (1992) estimated the gains-from-trade for transfers from agriculture to municipal water supply. Finally, Colby (1990) estimated the transactions costs required to obtain approval of water transfers and the litigation costs of third party challenges and suggests that this is not overly burdensome.

1.2. Water allocation institutions in Chile

Chile has a tradition of private development of water resources and private rights to shares of river and canal flows that dates to the colonial era. This tradition was reestablished in the National Water Code of 1981 (D.F.L. Number 1122) which allows private transferable property rights for water use. The 1981 water law stipulates that water is a national resource for public use but that permanent and transferable rights to utilize water can be granted to individuals in accordance with the law. Water-use rights can be granted by the government upon petition, can be purchased from an individual owner, or can be retained based on traditional use. Currently, there is no stipulation that water-use rights must be utilized in order to be retained.

The law stipulates that rights are to be specified by volume of flow per unit of time. But in most river valleys rights are defined as a share of stream flow, because the high variability of natural river flows prohibits volumetric specification. Since consumptive use rights are granted for the full use of all the water stipulated in the right, no downstream user has any right to return flows generated from upstream users. Downstream rights holders are not protected by law from any change in upstream water use that significantly reduces return flows. There is also no restriction on the transfer of upstream water to another basin.

The Dirección General de Aguas is responsible for water resources planning and the development and exploitation of water resources. It collects data on water resources, maintains cadastres of water use, and has limited authority to intervene in conflicts between water users. The Dirección General de Aguas also grants, upon petition, water-use rights for surface and ground water that is not already claimed. These grants are a matter of public record. During times of drought the Dirección General de Aguas can impound water, with compensation to holders of water-use rights.

Although the Dirección General de Aguas does have broad authority in water resources management, much of the actual control over river flows is exercised by the local river monitoring authorities, the *juntas de vigilancia* (JDV). These JDV manage and maintain storage reservoirs, and are responsible for reducing the flow of water to canals during times of water scarcity. The JDV are controlled by the river's water-use rights holders on a particular section of a river. Thus in some river basins, irrigators, mining companies, and water supply companies are part of the same JDV. Currently, the court system is the final arbiter of water-use conflicts.

Historically, the development of irrigation in Chile has been dominated by the private sector. All privately developed irrigation systems and many of those developed by the state are owned and controlled by independent water user associations (WUAs). These WUAs are owned and operated by their members, and charge fees based on the their capital and operating costs. The WUAs maintain the canal systems, keep records of rights holders, apportion water to individual rights holders according to their recorded shares, and enforce water rights. The 1981 Water Code specifies rules for the formation, governance, and obligations of these WUAs.

2. Calculation of gains-from-trade and economic rents

In order to assess the impact of water markets and transactions costs in Chile, four river valleys, the upper Maipo in Chile's central valley, and the Elqui and Limarí valleys in north-central Chile, and the Azapa Valley in the far north of Chile were selected as case studies (Hearne, 1995; Hearne and Easter, 1995). These valleys were identified based on prior information that suggested that there was – or should be – active trading in the area. Attempts were made to identify all transactions of water-use rights in these areas for the years 1986–1993. These years

were chosen because of reports of more active water trading in recent years, because they include both wet and dry years, and because farmers were expected to provide more accurate information on recent transactions. Water transactions in conjunction with land transactions were generally not considered, because they usually do not represent a change in water-use patterns.

A survey instrument was developed to solicit information from farmers who have participated in water market transactions. This information included: (i) individual characteristics of buyers and sellers; (ii) water transactions, including price, quantity, and transactions costs; and (iii) farmer's crop yields. In order to maintain the confidence of the respondent in the survey procedure questions on incomes and tax rates were avoided. [1]

Individuals making transactions were identified from records of WUAs, from local real estate registries, and from other transacting parties. Agronomists from the Universidad Católica of Santiago were recruited as enumerators. Attempts were made to contact all individuals who had made transactions in the areas selected for analysis. Managers of urban water-supply companies and industrial users of water were also interviewed.

2.1. Crop budget analysis in valuing water rights

The net returns, calculated using farm budget analyses, is an upper bound to farmer's willingness to pay for water in irrigation. This is not a marginal analysis, but an estimate of the average value of water. The net returns to a farmer are the maximum that a farmer could pay for water and land, and still break even. In this study, farm budgets are used for both an economic and financial analysis of water markets. Net returns are divided between land and water according to relative market values (solicited in this study using a survey of farmers) of land and water used in crop production. The financial analysis is performed to determine individual incentives to participate in water markets. In contrast, the economic analysis provides the net return to society from market transfers. In an economic analysis, transfer payments are excluded and prices are adjusted for economic values (explained in more detail later in this paper). The following paragraphs explain this procedure and the assumptions used.

Farmer's per hectare yields are based on survey data. In the case where farmers did not respond to this question, average yields from other surveyed farmers were used. [2] Output price and cost of production information were taken from representative crop budgets used by the Dirección de Riego and the Department of Economics of The Universidad Católica of Chile in the financial and economic appraisal of irrigation projects in the Elqui and Limarí valleys, dated 1991 and 1992.

Because a time series of input prices was not available, relative input and output prices are assumed to remain constant. Farmer's cost in supplying labor to clean common canals and water fees paid to WUAs are included as production costs, because they account solely for the cost of water delivery (WUAs are non-profit organizations, and they determine their own fees in accordance with their capital and operating costs). The cost of labor to clean canals within the farm is included in the labor cost of the crop budget. To allocate water costs among crops the farmer's total expenditure for water is multiplied by the percentage of water used for each crop as determined in the interview.

The cost of servicing a debt to cover the costs of initial crop development is included for all permanent crops. These costs are taken from the same crop budget information. Net revenues are discounted by 7% in order to account for management services. In order to account for the risk absorbed by a farmer, a 15% commercial loan rate was used for both interseasonal finance and crop development, since the rate includes a risk premium.

[1] In general, respondents had no incentive to bias responses. Nevertheless, confidentiality of individual survey responses was promised and respected. Because fees paid to notary republics are based on transaction prices, there might be an incentive for buyers to report low transaction prices at the registration of the title. However, transaction prices were often public knowledge, and many buyers wanted transaction prices to be known in order to attract more sellers.

[2] For major crops such as table grapes missing observations on yields were infrequent. Overall, 20% of the respondents did not report yields.

In Chile agricultural taxes are fairly complex. A simple option for farmers is to pay a land tax of 10% of the assessed value. Because land assessments are generally not up to date, the stated assessed value is probably much less than the market value reported in the survey, and for this reason reported market values are discounted by 50%. Land taxes payments were deducted from net revenues in the financial analysis of rents to buyers and sellers. These payments were not deducted from net revenues in the economic analysis because they are transfer payments and do not reflect a net loss to society.

2.2. *Value of water for potable water supply in the Elqui Valley*

The value of water-use rights in the Elqui River for potable water supply can be determined by the purchaser's ability to forego the need to invest in more costly alternatives to obtain water supplies. Since the demand for water in this service area will continue to rise, the least cost alternative for meeting this demand – in the absence of effective water markets – is the appropriate methodology for assessing the value of water. Ground water in this area is very deep, and of poor quality, and would not be a cost-effective alternative, except for emergency supplies in summer months.

The primary alternative for potable water supply would be to construct a reservoir in the Elqui Valley. In fact, ESSCO, the municipal water-supply company which services the valley's urbanized coastal area, opted out of a proposed joint venture with the Ministry of Public Work's Dirección de Riego to construct the Puclaro Dam on the Río Elqui. At a cost of US$23 500 000, ESSCO was offered sufficient capacity in the proposed reservoir to meet its needs for secure water supplies well into the next century. [3] ESSCO's refusal of this offer coincided with its current program to purchase water-use rights on the Elqui River.

Information for the calculation of the value of delaying the construction of this water project is taken from a 1991 feasibility study of the Puclaro project (CIAPEP, 1991) and from conversations with ESSCO's planning department. According to the CIAPEP study, the demand for water in the urban coastal area is growing at a rate of 2.1% per annum. At this rate ESSCO's current supply of water will be insufficient to meet its needs by the year 2011 (which also is a reasonable date to have expected – in 1992 – the full completion of the Puclaro Dam project). Following a procedure outlined by Moncur and Pollack (1988), the value of a water-use right is equal to the costs saved in delaying the need for introducing a more expensive water supply. The value, Φ_t, is the 1992 value of the 570 000 m^3 of water needed in 2010 to cover the increased demand for water, as shown in Eq. (1):

$$\Phi_t = \frac{C_1}{e^{r(T-t)}} \tag{1}$$

where: $r = 0.12$, $T = 2010$, $t = 1992$, $C_1 =$ Ch$1 006 054 000 = the yearly payment for a loan of US$23 500 000, at 12% interest for 35 years, at a 1992 exchange rate of Ch$350 = US$1.00. Thus, Φ_t = Ch$116 023 303 which is the 1992 value of the water needed to fulfil ESSCO's unmet water demand in 2010. One interesting feature of this calculation is that the volume of water needed in 2011 is not a factor in the determination of its value. This is because the Puclaro Reservoir would be large enough to meet any reasonable increase in demand.

Once the value of the quantity of water needed to delay the investment in the more expensive technology is determined, it is necessary to convert this value into a per-share basis. It is assumed that 2.5 shares of the Elqui River are needed to ensure each liter per second, because in 95 of 100 months, the lower Elqui River delivers at least 0.4 l/s per water-use right. [4] Thus, Φ_t = Ch$116 023 303 is divided by 45.3 shares to reach a value of Ch$2 561 220 for

[3] Conversation with Dirección de Riego, Santiago, June 1992. The Dirección de Riego also offered reservoir water at a lower price but without the security of delivery that ESSCO is required to have.

[4] Municipal water-supply companies are, by law, required to have 95% security in water delivery. The estimate of 2.5 shares per liter/second, is taken from a review of the Junta de Vigilancia de Río Elqui's records of water flow in the river, and corresponds with ESSCO's stated plan to purchase 1300 additional shares of the Elqui River by 2020.

each of the first 45.3 shares purchased in 1992. The value of all 217.8 net shares of Elqui water purchased by ESSCO in 1992–1993 are listed in Table 1.

Many of the water-use rights transactions in the Elqui Valley involved the transfer of water from agriculture to potable water uses outside of ESSCO's service area. The most likely alternative source of crude water supplies for all of these residential and tourist developments is the same source as ESSCO's. Therefore, the avoided cost of water for ESSCO is also the value of a water-use right to others needing potable water supplies downstream of the proposed Puclaro Dam.

2.3. Economic analysis of gains-from-trade

Financial prices taken from representative crop budgets were adjusted to present economic values. Information from the 1991 CIAPEP study of the Puclaro Dam was used in this adjustment because it contains both economic and financial prices. Because Chile has a relatively open economy with low tariffs, free exchange rates, and open markets, the difference between economic and financial prices are small. For exportable goods, such as table grapes, a percentage of the exporter's commission is added to the farm-gate price in order to account for this transfer payment. For imported inputs, financial prices are adjusted for both import tariffs (11%) and the foreign exchange premium (10%). An adjustment was not made to differentiate between the economic and financial costs of constructing the Puclaro Reservoir, because the adjustment factor is very close to one (0.991) and the percentage of imported goods is assumed to be relatively small.

Table 1
Value of water rights for ESSCO's purchases

Year of purchase [a]	Year of demand [b]	Number of shares	Value of a share (Ch$)
1992	2010	45.3	2561220
1992	2011	21.9	2204690
1993	2011	25.0	2475505
1993	2012	47.7	2157305
1993	2013	48.5	1881798
1993	2014	36.6	1643589

[a] ESSCO purchased 67.2 shares in 1992 and 157.8 shares in 1993.
[b] Projected demand based on current growth in water use.

Gross gains-from-trade were calculated by subtracting the value of water to the seller before a sale from that of the buyer after a purchase, as in Eq. (2):

$$GFT_t^{b,s}(w) = \left\{V_t^b\left[w\left(W_{t-1}^b + w\right)\right] - V_t^s\left[w\left(W_{t-1}^s - w\right)\right]\right\} - TC^{b,s}(w) \quad (2)$$

where: $GFT_t^{b,s}(w)$ = the gains-from-trade to society of a transfer in time t, of a water-use right w, from seller s, to buyer b; $TC^{b,s}(w)$ = the total transactions costs of a transfer of w from s to b; $V_t^b[w(W_{t-1}^b + w)]$ = the buyer's value of w, as a percentage of the average value of total post-trade water-use rights $(W_{t-1}^b + w)$; and $V_t^s[w(W_{t-1}^s - w)]$ = the seller's value of w, as a percentage of the average value of total post-trade water-use rights $(W_{t-1}^s - w)$. Efforts were made to identify and interview both buyer and seller of each transaction. When only the buyer was interviewed, the value of water from sellers on the same canal or area for the same year was used to substitute for the other party. When only the seller was interviewed, the value of water to similar buyers was used.

In cases where the seller of a water-use right was known not to have used the water prior to the transaction, the right was valued at the weighted average value of water to neighboring buyers and sellers of water. This is because unused water is generally distributed to other water users, along the same canal or river. (This would tend to place a high value on the transferred water-use right – because the weighted average emphasizes the value of water to the larger farmers who are buying water because they own very profitable farms – and consequently make the estimate of gains-from-trade conservative.) Because of the interconnections in the Limarí Valley, average values of water for above and below the Paloma Reservoir were used. In the Elqui Valley water was divided among users of the Río Claro and Río Cochiguaz, users of the Río Elqui, and users of the Herradura Canal.

All values were adjusted to June 1993 values using Chile's consumer price index. Transactions costs were obtained in the survey. These costs in-

clude: fees for attorneys, notaries, and engineers; payments for modifications of canals or gates; the costs of soliciting information; and the value of the time involved in the process. A summary of total transactions costs for the Elqui and Limarí Valleys is presented in Table 2. Net gains-from-trade were calculated by subtracting the transactions costs to both buyers and sellers from gross gains-from-trade.

2.4. Financial analysis of economic rents to buyers and sellers

Financial prices were employed in the crop budgets used in the analysis of individual economic rents to buyers and sellers. In this analysis, a water-use right that was not used by the seller prior to the transaction was valued at zero. The seller's net rent is the sale price, adjusted to 1993 values using Chile's consumer price index, less both the value of the water to the seller and the seller's transactions cost, as shown in Eq. (3):

$$NR_t^s(w) = P_t^{W(b,s)}w - \left\{V^s\left[w\left(W_{t-1}^s - w\right)\right] + TC^s(w)\right\} \quad (3)$$

where: $P_t^{W(b,s)}$ = the transfer price of w negotiated between seller s, and buyer b; $NR_t^s(w)$ = the net rent to seller s of a sale of w to the buyer b; and $TC^s(w)$ = seller s's transactions costs. To the buyer, the net rent is the difference between the value of water to the buyer and the sum of the buyer's purchase price and transactions cost, as shown in Eq. (4):

$$NR_t^b(w) = V_t^b(w) - \left[P_t^{W(b,s)}w + TC^b(w)\right]. \quad (4)$$

As reported, the sum of rents to buyers and sellers does not equal the calculated gains-from-trade. This is because economic gains differ from financial rents. Also, for some transactions both buyer and seller were not interviewed, and financial rents are calculated and reported only for interviewed parties.

3. Results

Only the transactions from the Elqui and Limarí valleys were analyzed to determine the gains-from-trade from market transfers. In the upper Maipo valley transactions were rare – except for water-use rights ceded to municipal water companies from developers of urbanized land – and were not included in the analysis. Similarly, in the Azapa valley only a few transactions were identified and gains-from-trade were not calculated. In the Elqui valley transactions were infrequent, but there is significant intersectoral transfer as well as a slow transfer of water-use rights within agriculture. In the Limarí Valley, with its well-developed system of irrigation infrastructure and well-organized WUAs, transactions are fairly frequent.

3.1. The Elqui Valley

The Elqui Valley in Chile's Region IV supplies water for 18 700 ha of farmland as well as potable water for a medium-sized city (250 000 inhabitants) with a very large summer population. A small tourist industry in several small communities in the scenic

Table 2
Transactions costs

	Elqui Valley		Limarí Valley	
	Buyers	Sellers	Buyers	Sellers
Total transactions costs as a percentage of transaction price	0.21	0.02	0.05	0.02
Costs of attorneys, notaries, and obtaining legal inscription of rights as percentage of total transactions costs	0.59	0.79	0.16	0.34
Costs of engineering and modifying canal infrastructure as a percentage of total transactions costs [a]	0.20	0.03	0.64	0.62
Opportunity cost of time invested as a percentage of total transactions costs	0.20	0.18	0.18	0.00
Costs of gathering information on buyers and sellers as a percentage of total transactions costs	0.00	0.00	0.02	0.04

[a] Estimated expenditures for engineering services, modification of gates and canals, and indemnities for transferring water through canals. Includes expenditures through 1993 and does not include planned expenditures for modifications needed in the future.

valley complements the large coastal tourism boom. Major crops include table grapes, pisco grapes, other fruit crops, potatoes, and pasture. One small mine in the upper reaches of the basin utilizes water from a tributary of the Río Elqui. Rainfall is scarce in this region with average yearly precipitation of less than 120 mm. Wet and dry years follow a cyclical pattern, with two and three-year droughts common. The Río Elqui is divided into 25 000 total shares. Each share is supposed to deliver 1 l/s in a good year, although 0.5 l/s is generally considered to be the actual average delivery.

In the Elqui Valley a limited population of 47 permanent transactions for the period of 1986–1993 were identified with the assistance of the JDV and other WUAs in the Elqui Valley. For 41 of these transactions representing a total of 712 shares of the river, either the buyer or seller or both were interviewed. In total, 14 individuals selling 491 shares and 18 buyers purchasing 467 shares were interviewed. [5] Some individuals were involved in more than one transaction.

Of the shares sold in this valley, 90% had not been used by their sellers in recent years. Some of these sellers had surplus water, others had rights to water along canals that did not conduct water efficiently, others had quit farming, and still other sellers owned rights to water but did not own land. In general water that is not used by its owner is used by neighboring farmers in the same canal or section of the river.

Purchase prices of shares of the Río Elqui are quite variable, reflecting differences in transactions costs and in many cases the particular conditions of buyers and sellers. ESSCO's average purchase price in 1992–1993 was near US$1100 per share. During the same period, small plot developers in the lower Elqui Valley were paying US$2500 per share for water in a conveniently located canal. Exchange prices between individual irrigators ranged from US$250 to US$1000 per share. Often these disparities in prices reflect the individual circumstance of the seller. Transactions costs for most transfers were low because this is a narrow valley with many short canals flowing directly from the Río Elqui and its tributaries (see Table 2).

Table 3
Economic analysis of gains-from-trade: Elqui Valley

	Number of shares	US$ per share [a]
Total gains-from-trade	712	846
Net gains-from-trade	712	790
Trades with ESSCO total gains-from-trade	298	675
Trades with ESSCO net gains-from-trade	298	658
Other intersectoral trades total gains-from-trade	63	1160
Other intersectoral trades net gains-from-trade	63	1139
Intra-agricultural trades total gains-from-trade	351	934
Intra-agricultural trades net gains-from-trade	351	839

[a] The June 1993 exchange rate of Ch$403 = US$1.00 was used.

Results of the economic analysis of gains-from-trade in the Elqui Valley are shown in Table 3. The average gross gains from trade for the 712 shares were US$846 [6] per share. With an average transactions cost of US$56 per share, net gains-from-trade are US$790 per share. ESSCO has purchased 292 shares, which amounts to 28% of its current water-use rights. The estimated net economic gains from these transfers (US$658 per share) are relatively modest. One reason for this is that much of the water sold to ESSCO was not used by its previous owners, and the procedure of using the value of water to neighboring farmers may be biased by more productive farmers. This bias would result from the fact that a weighted average of water values is greatly influenced by the value of water to a few profitable buyers of water-use rights.

There are some small transfers of water to developers of small residential and tourist housing along the valley and on the coast north of La Serena. The gains-from-trade from these transfers are higher than those for transfers to ESSCO. This reflects the fact

[5] The number of transactions for which both buyer and seller were interviewed was relatively small and the use of only these transactions would limit the study results.

[6] The average exchange rate reported by the Central Bank of Chile for June 1993 was used. This rate is Ch$403 = US$1.00.

Table 4
Financial analysis of economic rents to buyers and sellers: Elqui Valley

	Number of buyers or sellers	Number of shares	Mean net rent per share (US$) [a]
All sellers	14	491	1156
All buyers	18	452	3047
Individuals selling to ESSCO	4	292	1071
ESSCO	1	218 [b]	3104
Other sellers of intersectoral transfers	3	32	1041
Other buyers of intersectoral transfers	6	40	4890
Other sellers	7	167	1327
Other buyers	11	194	2603

[a] The June 1993 exchange rate of Ch$403 = US$1.00 was used.
[b] Some of ESSCO's shares are reduced upon purchase by the Junta de Vigilancia de Río Elqui in order to account for conduction losses.

that the value of water to the sellers of these shares is relatively low. The large gains-from-trade in intrasectoral trades reflects the high value of water to a few profitable farmers buying water-use rights.

Results of the financial analysis of individual rents in the Elqui Valley are presented in Table 4. The net rent to 14 individuals selling 491 shares of Elqui water averaged US$1156 per share. In contrast, net rent to 18 buyers, purchasing 452 shares, averaged US$3047 per share. In general individuals and firms buying water-use rights received larger net rents than water sellers. Intersectoral trades produced higher net rents than trades between farmers. The fact that many of the water-use rights sold in this valley were valued at zero because they were not employed by their owners at the time of sale is a large factor in these high economic rents.

3.2. The Limarí Valley

South of the Elqui Valley in Region IV is the productive Limarí Valley, which contains the Río Limarí and its tributaries the Cogotí, Grande, Guatalame, Hurtado, and Rapel. This valley has 50000 ha of irrigated farmland producing table grapes, pisco grapes, horticultural products, basic grains, and pasture. A central feature of this valley is the presence of a large interconnected system of three interseasonal storage reservoirs: Paloma (750 million m^3), Cogotí (150 million m^3), and Recoleta (100 million m^3). This storage along with gated canals and well-organized WUAs allows for volumetric specification of water-use rights. This is a dry area with mean annual precipitation of 140 mm. There is one small city, Ovalle, with a population of 80000 that draws water from the Río Limarí.

In the Limarí Valley, a population of all water transactions was not developed. Instead, data collection was concentrated on areas with frequent transactions and individuals with many transactions. Attempts were made to balance interviews in these areas with other areas of less market activity. In the areas of the Río Hurtado and Río Grande which irrigate a total of 5400 ha above the Recoleta and Paloma Dams respectively, only a handful of transactions were identified. All other identified transactions were in areas below the reservoirs. Each WUA assigns a different amount of water to each share. [7] Because of this all water-use rights were converted to an average volumetric denomination, based on survey results.

The low transactions costs and frequent trades in the valley can be attributed to both modern infrastructure and well-developed WUAs. Because of reservoir storage and gated canals, water is delivered to farmers on demand and a water transfer is almost costless. Thus, the frequency of transfer is high and the market for water-use rights is active. Individuals easily separate water from land and farmers make marginal water-use decisions.

In total, 37 farmers selling water-use rights accounting for 2 million m^3/year were interviewed along with 19 buyers purchasing 7.2 million m^3/year. [8] Results of the economic analysis of

[7] Because of the volumetric denomination, it is dangerous to directly compare the volume of water rights in the Elqui River to those of the Limarí Valley. In the former, 15750 m^3 are delivered in an average year, but without regard to the time of delivery. In the latter, water is delivered to farmers at times that they request water.

[8] The number of transactions for which both buyer and seller were interviewed was relatively small and the use of only these transactions would limit the study results.

Table 5
Economic analysis of gains-from-trade: Limarí Valley, constant table-grape prices

	Cubic meters per year	US$ [a] per cubic meter per year
Total gains-from-trade	9218000	2.47
Net gains-from-trade	9218000	2.40
Total gains-from-trade purchases of large table-grape producers [b]	5834000	2.85
Net gains-from-trade purchases of large table-grape producers	5834000	2.84
Total gains-from-trade other purchases	3384000	1.81
Net gains-from-trade other purchases	3384000	1.65

[a] The June 1993 exchange rate of Ch$403 = US$1.00 was used.
[b] Table grape producers with over 100 ha in production.

Table 6
Financial analysis of economic rents to buyers and sellers: Limarí Valley, constant table-grape prices

	Number of buyers or sellers	Cubic meters per year	Mean net rent per m^3/year (US$) [a]
All sellers	37	1708000	0.00
All buyers	19	7510000	1.78
Individuals selling to large table-grape producers	20	857000	0.08
Large table-grape producers	3	5834000	2.05
Other sellers	17	851000	−0.08
Other buyers	16	1677000	0.84

[a] The June 1993 exchange rate of Ch$403 = US$1.00 was used.

gains-from-trade in the Limarí Valley are presented in Table 5. An average gross gains-from-trade of US$2.47 for each m^3/year transferred was estimated. After subtracting transactions costs the average net gains-from-trade is US$2.40 for each m^3/year. Trades that involved the transfer of water to large grape producers produced higher net returns than other trades.

Results of the financial analysis of individual rents show net rents to 37 individuals selling water rights, amounting to 1.7 million m^3/year averaged US$0.00 per m^3/year [9] (Table 6). Net rents to 19 individuals purchasing water-use rights that deliver 7.5 million m^3 averaged US$1.78 m^3/year. The zero net rents to individuals selling water reflects the need of many farmers to sell their water-use rights to help make debt payments, even though the water was slightly more valuable to them in crop production than the price they received.

Rents to buyers are generally higher than those of sellers. For example, rents to large table-grape producers – purchasing 78% of the water-use rights included in this analysis – are high relative to all sellers. This reflects the high value of water to these profitable farms. Much of this difference in individual rents from market transactions is due to the short term financial stress of many sellers and the market power enjoyed by buyers. [10] Since transaction prices are generally well known in these valleys, little advantage is derived from asymmetric information.

Prices range from US$3000 for a right with an average volume of 4500 m^3/year in the table-grape producing area above the Paloma Reservoir to US$500 for a share with the same volume below Paloma. This difference in price reflects both the premium placed on water in the hot, dry sunny uplands, and the prohibition on transferring water-use rights from below Paloma Reservoir to canals above the dam. [11] Also, the value of reservoir storage is demonstrated by the fact that a water-use right in the Limarí Valley is worth more than a water-use right in the Elqui Valley that in some years delivers five times as much water.

Many of the permanent transfers of water-use rights in this area involve large acquisitions of both land and water by a few large table-grape exporters. The land and transactions are generally reported separately because of the mobility of water rights in this valley. Some of these transactions entail a shift away from traditional crops to higher valued fruit crops. Also, in the last few years, many small and medium sized farmers have forfeited land and water

[9] The actual figure is −0.0023.

[10] Although there are many potential buyers in the valley, in each canal one or two large farmers are able to determine the price.

[11] Without this prohibition it would be relatively inexpensive to pump water directly from the Paloma Reservoir to the adjacent grape producing areas irrigated by upstream canals.

rights to fruit-exporting companies in lieu of debts owed to the companies.

3.3. The Maipo Valley

The first section of the Maipo River supplies water to 4.5 million people in the Santiago area as well as irrigating over 30 000 ha. The river is divided into 8133 shares, each representing 8 l/s, 85% of the time. In this first section of the river, there have been very few transactions of water-use rights in the past eight years. The Metropolitan Sanitation Works Company (EMOS) has contracted a team of lawyers to purchase rights but has purchased only 33 shares of the upper Maipo in the last eight years, with prices averaging US$10 000 per share. The only industrial concern to purchase water rights was a paper mill which made two purchases totalling 4.5 shares. There are also very few permanent trades between farmers. In the large canal systems of five WUAs, distributing 65% of the irrigation water in this section of the river, there were only a handful of trades between farmers. All of the canals serving these five WUAs have fixed flow dividers regulating the distribution of water.

3.4. The Azapa Valley

The Azapa Valley, which is located in the downstream section of the San José river basin in Chile's far north Region I, supports 3280 acres of irrigated farmland and the city of Arica (population 160 000). This valley, bordering the extremely arid Atacama Desert, is very dry and rainfall in the lower reaches is negligible. The Water Supply and Sanitation Company of Tarapaca (ESSAT), which supplies water to Arica, has been able to use rental agreements to meet the short-term crude water needs of the city of Arica. ESSAT rents wells from owners of ground-water rights. Various government agencies, responding to a presidential mandate to give the Arica water supply a priority in government action, have assisted in the process of renting wells. In the negotiations process, ESSAT was able to invoke both the government's appeal to farmers to release water for Arica and the possibility that the state could impound water during periods of severe water shortage. ESSAT has not needed to purchase water from users of a surface canal in the Azapa valley, because the ground-water supplies were made available. Thus the recent additions to the Arica water supply is much more a result of government action than of market activity.

In these arrangements ESSAT digs or rehabilitates a well, installs and operates a pump, delivers free of charge a few hours of water per week to the rights owner, and pays a rental fee for the use of the well. ESSAT will then pump water from the well continuously, whereas an irrigator only uses the water a few hours per week. This rental arrangement is quite lucrative to the individual irrigator, who does not absorb the negative externality of a depleted aquifer, at least in the short run. Since these rental contracts can be terminated by either party, it is probable that a few will be terminated after ESSAT receives water from the wells that are currently being rehabilitated in the Andean highlands.

4. Observations and conclusions

Chile's heritage of privately developed irrigation, and its traditional allocation of river water by shares, has created a favorable climate for the establishment of transferable water-use rights. These rights have secured water supply to irrigators and thus provided an enabling environment for investment in permanent fruit crops and improved irrigation technology. The overall growth in the value of Chile's agricultural output during the last decade can be attributed to various reforms in both input and output markets. The effects of the 1981 Water Code on the agricultural sector cannot be fully separated from the effects of liberalized trade and secured land rights. But the agricultural sector that is highly dependent on irrigation has expanded without new investments in irrigation infrastructure.

This research has demonstrated that the market transfer of water-use rights does produce substantial economic gains-from-trade in both the Elqui and Limarí Valleys in north-central Chile. These economic gains occur in intersectoral trades and in trades between farmers, and they produce rents for both buyers and sellers. Yet buyers, especially large table-grape producers in the Limarí Valley and individuals buying water-use rights for potable water supply in the Elqui Valley, receive higher rents then sellers. In the Elqui Valley total and net gains-from-

trade per share were within the range of recent transfer prices of US$1000 per share. In the Limarí Valley, gains-from-trade from shares of water-use rights are 3.4 times the recent transaction prices of US$3000 for a share of water from the Cogotí Reservoir (one share delivers 4250 m^3 in an average year).

One of the most interesting result of this analysis is the relatively modest economic gains from intersectoral trade in the Elqui Valley. Although the value of water in municipal water supply is high, the value of water to profitable farmers is also high. When water is transferred from these profitable farmers, the economic gains from this reallocation are small. Even if water is not used by its owner, it is generally used by other farmers. If these farmers are profitable, then the economic gains of the reallocation are small, even though the financial gain to the seller is large.

These four case studies demonstrate the diversity of water allocation and water management in northern and central Chile. In three of the four areas studied, especially where large canal systems use fixed flow dividers, market transactions were infrequent. Despite the fact that these valleys were chosen for analysis because of expectations that they had relatively active local water markets, only the Limarí Valley had active trading. In this valley, transactions costs are low and trade between farmers is facilitated by the presence of reservoir storage, gated canals with flow meters, and well-organized WUAs. In the Elqui Valley, the presence of many short canals flowing from the river also reduces the costs of physically changing the flow of water.

In large canal systems with fixed flow dividers, the cost of changing stream flows might be prohibitive especially for trades among farmers, as suggested by the scarcity of trading in the Canal Bellavista system in the Elqui Valley and the large canal systems in the upper Maipo Valley. Sales of marginal amounts of surplus water are far from typical. Many decisions on investment and crop selection have been based on the joint land/water allocation that resulted from the final stages of land reform. [12]

[12] In the final stages of land reform, land expropriated prior to 1974 was divided into family farms equivalent in value to 8 irrigated ha. Water rights traditionally assigned to the land were distributed to the landowners.

Furthermore, WUAs play an important role in facilitating the market reallocation of water, especially in the Limarí Valley where trading is active and in the Elqui Valley where intersectoral trading occurs. Many of these WUAs have been able to adapt to the needs of their members for services that facilitate or impede transactions.

The proposed Puclaro Dam project, on the Elqui River upstream of La Serena, is an example of how the presence of a market alternative to water allocation may reduce political pressure to invest in large water-storage projects. This project has been proposed in different forms since 1956. As recently as 1989, potable water was considered to be the most important benefit of this dam. But when ESSCO did not agree to collaborate with the Directorate of Irrigation in paying for part of the construction costs, the political importance of the dam declined.

This research has demonstrated the economic and financial gains from using markets to reallocate water in the Elqui Valley instead of investing in a large water-storage project. But it also showed how public investments in water-storage and delivery systems in the Limarí Valley have the external benefit of reducing the transactions costs involved in market trading. In the presence of a system of transferable water-use rights further analysis of large water-storage projects should consider the value of storage and adjustable gates in facilitating the reallocation of water.

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