Right-to-Choose Auctions: A Field Study of Water Markets in the Limari Valley of Chile

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Field experiments were conducted with farmers in the Limarí Valley of Chile to test extant theory on right-to-choose auctions. Water volumes that differed by reservoir source and time of availability were offered for sale by the research team. The auctions were supplemented by protocols to elicit risk and time preferences of bidders. We find that the right-to-choose auctions raise significantly more revenue than the benchmark sequential auction. Risk attitudes explain a substantial amount of the difference in bidding between auction institutions, consonant with received theory. The auction bidding revealed distinct preferences for water types, which has implications for market re-design.

Key Words: water market, field experiment, auction design

In a thoughtful and influential introduction to experimental economics, Al Roth distinguishes among experiments according to the conversation they belong to and the audience they are intended to persuade (Roth 1995). Experiments that "speak to theorists" test a developed formal model, while those "searching for facts" investigate variables for which existing theory has little to say. Experiments that "whisper in the ears of princes" enhance the dialogue between researchers and policymakers, for example, to shed light on the impact of a change in market organization. We conduct a field experiment that makes contributions to the first and third of Roth's categories by studying farmers' willingness to pay for water in the Limarí Valley of Chile. The experiments speak to theorists by providing fresh evidence on the properties of the right-to-choose—or bidder's choice—auction, which was shown to raise more revenue than bilateral bargaining in a seminal field study (Ashenfelter and Genesove 1992). Secondarily, the experiments "whisper to princes" by providing fresh insights on price discovery, and help identify opportunities to improve the performance of the market for water in Chile.

To achieve our primary objective, the protocol introduces within-subject variation in the "type" of water for sale, which varies by reservoir source and time of delivery, and between-subject variation in the auction institutions, which use sequential and right-to-choose allocation rules. In the sequential auction treatment (SEQ), goods are sold in an exogenously determined order. For the right-to-choose (RTC) institution, the "good" for sale is the right to choose an item from the heterogeneous group of goods that remain in a particular auction phase. The SEQ auction serves as a control for the RTC institution in our study, as it has in previous experimental and theoretical work. Burguet (2007) has shown that when risk-averse bidders differ in their preference orderings for the goods, the right-to-choose auction will lead to higher bids and revenues. However, laboratory studies using induced values provide mixed evi-

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dence on the importance of risk aversion. Goeree, Plott, and Wooders (2004) report results that support Burguet's model. They find that the RTC raises more revenue than the SEQ benchmark, and that an estimate of a common constant relative risk aversion (CRRA) parameter yields both a plausible value and a better fit to their data than a risk-neutral model. Eliaz, Offerman, and Schotter (2008) introduce an RTC variant that should raise less revenue than SEQ, but find that it also generates more revenue. As a result, they argue that risk attitudes cannot entirely explain their data.

Our study extends the previous research in several important ways. First, we bridge a gap between the laboratory evidence just cited and uncontrolled field data since subjects bid for a commodity—water for agricultural use—that is important to them outside the experimental setting. In the lexicon of Harrison and List (2004), our study is a framed field experiment.[1] The benefit of the framed field experiment is that the data-generating process is tied to the field setting of interest, but the use of controlled variation and randomization, as in laboratory studies, supports causal inference (List 2006).

Second, we elicit individual risk attitudes independently of bidding behavior using a multiple price list (MPL) protocol based on the design of Holt and Laury (2002). The exogenous elicitation of risk attitudes for each individual creates a closer link to the theoretical literature than in the previous laboratory studies. Evidence in many populations of heterogeneity of risk attitudes suggests that the elicitation should be important empirically (Harrison and Rutström 2008). We also elicit time preferences using an MPL protocol in order to control for the temporal differences in water types. Finally, we survey respondents to capture additional demographic and market experience variables that may influence bidding behavior.[2]

To implement the framed field experiment we build on an important strand of experimental research that exports incentive-compatible mechanisms—studied in the lab with induced values—into field settings to elicit and study homegrown values. Applications have been prominent in studies of willingness to pay for food characteristics, such as genetic modification, traceability, or organic production (examples include Dickinson and Bailey 2002, Lusk et al. 2001, Noussair, Robin, and Ruffieux 2004).[3] A virtue of these studies is the use of salient incentives, thereby addressing concerns about hypothetical bias in the stated preference literature.[4] Mechanisms that have been used to elicit homegrown values include individual choice designs and auctions of various types, in both research and natural settings such as retail outlets (Rutström 1998, Harrison, Harstad, and Rutström 2004). In our study we implement a sealed-bid, second-price auction—choosing the former due to concerns about bidder privacy, and the latter to provide a clean counterfactual to address the theoretical question, since with the second price rule, risk attitudes play no role in the SEQ treatment.

The elicitation of risk and time preferences along with bids for water allows us to cleanly test hypotheses on the performance of the RTC institution. Our results yield strong evidence in support of the extant theory on the importance of risk aversion. In addition to this primary result, the experimental approach makes several contributions. First, although market institutions for water in the Limarí Valley have been in use—and been studied—for many years, our understanding of price discovery and price dispersion remains tentative. The elicitation of homegrown values yields fresh information, since we observe underlying reservation values for all bidders, including those who are extramarginal traders in the marketplace. Further, by manipulating the characteristics of the goods, our protocol allows us to observe heterogeneity in preferences across types, providing insight into the extent to which thin markets for water might be thickened through alternative trading instruments and institutions. The experiments thus contribute to a longer-term project that investigates the reorganization of the market for

[1] A framed field experiment has field context "in either the commodity, task, or information set that the subjects can use" (Harrison and List 2004, p. 1014).

[2] Alevy and Price (2009) are, to our knowledge, the only previous researchers to study the RTC auction in the field. They find no evidence that the RTC results in increased bids or revenues relative to the SEQ benchmark. The difference between their results and ours is a subject for future research.

[3] Water markets have also been studied in induced value settings. See Murphy et al. (2000) for a seminal study.

[4] However, progress has been made with protocols that introduce salience and incentive compatibility into stated preference settings (see, e.g., Lusk, Fields, and Prevatt 2008).

water, including the possible implementation of an electronic marketplace, and thus fit comfortably in Roth's "whispering" category.

Water Law and the Study Area

According to the Chilean Water Code, approved in 1981 and modified in 2005, water rights are private, separable from land holdings, and tradable. Trade can occur through a variety of instruments that include the permanent transfer of rights, long-term leases, and spot market transactions for water used in the current growing season. Our field experiments focus on the spot market since these are the transactions observed most frequently both in current and historical data in the area under study (Cristi 2007).

The study area is in an irrigated zone in the Limarí River Basin in Chile`s Coquimbo region (region IV), which is 472 kilometers north of the capital, Santiago. The hydrologic system is primarily niveous, fed from the snow-covered Andes Mountains, with an average annual precipitation of only 140 mm. Of the 60,000 irrigated hectares in the zone, 40,000 hectares receive water from three interconnected dams that form what is known as the Paloma System. Agricultural production in the Paloma System is diverse, with land planted in traditional crops such as maize, beans, and potatoes, horticultural crops (artichokes, peppers, and tomatoes), grains, pasture as well as valuable perennial crops such as avocados, export grapes, and grapes used for *pisco*, a local liquor. The perennial crops are grown mainly in the area below the dams. The farmer base is also diverse and consists of orchard owners, medium-sized farms, and a few large multinational fruit exporters.

We study water users who rely on the Paloma System, which has a storage capacity of one billion cubic meters and a sophisticated infrastructure that connects the different irrigation districts. Distribution of water among users is managed by the Water User Associations (WUAs), whose members are farmers from a specific river, canal, or geographical area. While the WUAs have legal status related to administration, they do not own water rights, which remain the property of the association's members. Water is distributed at the opening of the agricultural season in April, when each WUA receives a proportion of the water stored in the dams based on historical shares. Members receive allotments from their WUA according to the number of water rights they hold. Thus the amount of water contained in a right can vary from year to year. In September, after the winter rainy season has concluded, it is possible that the amount of water associated with a right will be increased for all rights holders.

Owners of rights can freely transact to reallocate the initial allocation, and an active spot market has been facilitated by the flexible infrastructure and the efficient administration of the WUAs. The spot market is active not only during drought periods, but also in seasons with "normal" water availability. In normal seasons, demand arises from structural motives associated with existing production technologies and plans. Farmers unable to satisfy their water requirements with their stock of water rights are potential buyers, while farmers that have more water rights than they need for their own production are potential sellers.

Farmers that do not participate in the market in normal years may enter the market in drought years. These farmers have higher marginal returns and demand water to stabilize output.[5] Hearne and Easter (1995) have identified significant variation in marginal returns, estimating an average value for the marginal return to water at US$856.7 in the case of table grapes and US$865.7 in the case of grapes used in pisco. In contrast, marginal values for potatoes and peppers, two of the non-perennial crops in the basin, are estimated at US$33.5 and US$317.5, respectively. Thus, stabilization demand comes from farmers with perennial crops such as grapes, which have higher marginal returns and significant costs associated with their maintenance. Some of these farmers may prefer to keep an overstock of rights, eliminating the need to participate in the spot market during drought years, and their decisions depend on their risk aversion and the alternative cost of the water rights. Suppliers of water are largely farmers with non-perennial crops who can modify their water consumption by adjusting their land use or by shifting to less water intensive crops (Zegarra 2002).

[5] According to Howitt (1998), the stabilization motive counters deviations below mean allotments in drought years.

The size of the spot market depends, in part, on the amount of water distributed from the dams. The distribution decision is made by the Administration of the Paloma System, which is required to ensure the availability of water for three years (including the current season). When the dams are full they contain one billion cubic meters and the annual distribution is 362 million cubic meters.[6] In dry years, as little as 115 million cubic meters has been distributed. The spot market has varied in size from 3.5 percent to 9.1 percent of the allocated supply in recent seasons, somewhat less than the 12 percent estimated for the period 1995–2000 (Cristi 2007).

Trade in the spot market occurs through two institutions. The primary market functions through the offices of the WUAs, where farmers can indicate trading interest by declaring offers to buy or sell. In drought years this system is supplemented by market activity in the Ovalle town square. In both cases, most negotiations are bilateral. There are also some water brokers, but they act largely as intermediaries in the water rights market and tend not to be active in the spot market (Palma 2009).

All water transactions must be reported to the appropriate WUA, which records the amount of water exchanged and makes it available to the buyer. There is no reporting requirement for prices, nor any formal mechanism for disseminating price information, which largely remains private information. Moreover, the quantities exchanged are not publicized by the WUAs. Thus, although the spot market can be active, there is little public information about price and quantity. These institutional arrangements highlight the need for analytical tools to better understand spot market performance.

Using survey data from farmers, Zegarra (2002) was able to generate a time series of spot market prices for the period 1994 to 1997. He reports that water prices in the spot market are highly variable, especially in dry years. He suggests that the variance is due to transaction costs because he assumes that water is a highly homogeneous resource, for which one would not expect significant differences in quality or other attributes affecting prices.

[6] This exceeds the amount of one billion cubic meters in three years because it accounts for expected rain and snow in the coming winters.

Zegarra (2002) focuses on the operation of the spot market in the Limarí Valley in the face of an extremely negative shock. He found that the spot market for water solves differences in the marginal return of water among farmers, promoting the allocation of water from low-value annual crops to high-value permanent crops. Nevertheless, he also shows that in the context of severe drought, the water market starts to be less effective in allocating the resource, with greater water price dispersion, due to inflexibility caused by a more concentrated farming activity on permanent crops.

In addition to Zegarra's (2002) study, previous work on the Limarí basin includes Hearne and Easter (1995), Hadjigeorgalis (2000 and 2004), and Cristi (2007). Hearne and Easter (1995) estimate economic gains (net returns to society) and financial gains (individual net benefits) from water right transactions. Hadjigeorgalis (2004) addresses the link between reservation values for water, risk aversion, and uncertainty cost associated with stochastic water supply. Cristi (2007) describe water market activity in the Limarí Valley and measure the relative size of the spot market with respect to the market for water rights in terms of water exchanged. They also describe farmers' motives to participate in the markets for water and analyzes the factors that explain market transactions of water rights when there is also a spot market for water volumes, and shows that risk heterogeneity among farmers is critical to explaining those transactions.

Theory and Evidence on the Right-to-Choose Auction

The evidence from previous research that outcomes in the water market depend on the risk attitudes of participants helps shape our experimental design (Cristi 2007). In this section we explore how risk attitudes are expected to affect bidding behavior in the auction institutions we implement in the field. In the SEQ treatment, with heterogeneous goods and a second-price rule, bidding one's value for each good is a dominant strategy. In the RTC setting, bidding true value is the dominant strategy only in the final phase of the auction, and bids should be biased upwards in earlier phases if bidders are risk-averse.

The impact of risk aversion in the RTC setting can be demonstrated with a two-bidder, two-good model, originally developed by Burguet (1999). In this model, each bidder has unit demand for one of the two goods and is equally likely to prefer either good. As a result there is a fifty percent chance that both bidders will prefer the same good and a fifty percent chance that they will prefer different goods. Payoff for the (dis)preferred good is 1(0). The right to choose is offered in a sequence of two auction phases, and the bidder that wins the right in phase one is inactive in phase two. In the second phase of the RTC, a bidder that remains active has a fifty percent chance of receiving his or her preferred good. Expected utility in phase 2, therefore, is

$$\frac{1}{2}u(1)+\frac{1}{2}u(0).$$

Given their phase 2 expectations, backwards induction implies that bidders will not pay more than R in the first phase, where

$$u(1-R)=\frac{1}{2}u(1)+\frac{1}{2}u(0).$$

Normalizing $u(1)=1$ and $u(0)=0$ yields $u(1-R)$ = 1/2, and with $u(\cdot)$ concave, $R > 1/2$. Thus, when bidders are risk-averse, the RTC institution raises more revenue than the SEQ alternative in which expected revenues are equal to 1/2 (Burguet 1999, 2007).[7]

Intuitively, the possibility that one's preferred good will be chosen early makes the value of the later auctions less certain. Risk-averse buyers are therefore willing to pay a premium to secure their favored good in an early round. As a consequence, the RTC auction creates competition across goods that individually may have relatively thin markets. In the context of the water market study, increased revenues in the RTC auction imply that the water "types" are in fact perceived as distinct goods, and that attempts to aggregate goods into a thicker market would be unsuccessful.

The bulk of the evidence on the performance of the RTC relative to the SEQ comes from laboratory experiments using induced values. Goeree, Plott, and Wooders (2004) conduct experiments with two goods and four bidders in each auction and find higher revenues in the RTC than in the SEQ. They estimate a model that assumes constant relative risk aversion (CRRA) and find that it yields a significantly better fit to the data than a risk-neutral model. Eliaz, Offerman, and Schotter (2008) also find overbidding in the RTC; however, in a novel treatment in which information about which good is chosen is not revealed, behavior inconsistent with risk aversion is observed. Their "no information right-to-choose" (NIRTC) treatment creates a lottery in which risk-averse bidders should bid less than the SEQ benchmark after the first auction phase. Since the NIRTC outperforms the SEQ in their study, the authors seek an alternative to risk aversion to explain their data. They argue that their results are better understood by assuming that bidders overestimate the extent of competition for their preferred good, an argument consistent with reports from professional auctioneers. In both of the published studies, the empirical analysis imposes a common risk parameter across the pool of bidders, an assumption inconsistent with the experimental evidence (see, e.g., Harrison, Lau, and Rutström 2007). One contribution of the current study is that it addresses the heterogeneity of risk preferences by eliciting individual attitudes to risk that can be used as control variables in econometric estimates of bid functions.

To our knowledge, only one other experimental study of the RTC institution has been conducted in a field setting. Alevy and Price (2009) compared RTC and SEQ institutions, auctioning consumer goods that included iPods, hiking equipment, and fine wines. Contrary to the laboratory results, aggregate bids and revenues did not differ across the two auction institutions in their study. Summarizing across experimental studies, there does not appear to be a strong consensus on the impact of risk aversion on bidding behavior. However, we believe that the use of risk and time-preference elicitations in the current study will shed fresh light on the question.

Subject Pool and Experimental Design

The experimental auctions for water were conducted with farm owners in the Limarí Valley in

[7] Methods for breaking revenue equivalence in the risk-neutral setting have been examined by Eliaz, Offerman, and Schotter (2008). Withholding information about which good is sold in a particular phase, and selling only a subset of the available goods, are two approaches they explore.

the city of Ovalle on August 22, 2008. Ovalle is the largest city in the valley, centrally located and frequently visited by our subject population due to the input and output markets, and the financial services that are available in the city. Forty-nine farmers attended the session and bids were received from forty-one. To accomplish the objective of eliciting real WTP for water from the farmers, the research team purchased water in advance from two water user associations and then offered the water for sale in the auctions. The session took approximately 4 hours and included a lunch served to the participants.

The RTC and SEQ institutions were studied with a between-subjects design. Before salient bids for water were requested, subjects were split into two groups and each was introduced to the specific auction institution they would be using. Training auctions were conducted in which items that included pens, calculators, and calendars were sold in distinct phases using procedures identical to those in the water auctions. All auctions were "hand-run," with written bids collected in each auction phase. The person submitting the highest bid was awarded either the specific good for sale (SEQ) or the right to choose (RTC) their preferred good from among those remaining, and was required to pay the second highest submitted bid.

In each auction treatment, four goods were sold in four separate bidding phases. In each phase the good consisted of 1,000 cubic meters of water, and the four alternatives varied by source and by the timing of the acquisition. The goods included:

(i) 1,000 cubic meters from the Cogoti reservoir available the business day following the auction,
(ii) 1,000 cubic meters from the Cogoti reservoir available 30 calendar days after the auction,
(iii) 1,000 cubic meters from the Camarico reservoir available the business day following the auction, and
(iv) 1,000 cubic meters from the Camarico reservoir available 30 calendar days after the auction

(see also Table 1). In addition to the auctions, the session included auxiliary protocols to elicit risk and time preferences for each subject. A short survey to gather information on demographic attributes and on market experience was also conducted. Table 2 provides an overview of the sequencing of tasks in the experimental session.

Table 1. Auction Goods

Goods by Source and Date of Availability	
Good 1 same day, Cogoti	Good 2 30 days, Cogoti
Good 3 same day, Camarico	Good 4 30 days, Camarico

Note: In all cases the volume of water is 1,000 cubic meters.

The elicitation of risk and time preferences made use of the multiple price list (MPL) methodology (Andersen et al. 2008; see also instructions in appendix). Time preferences were elicited over three different periods—(i) 0–30 days, (ii) 30–60 days, and (iii) 0–60 days—for cash payments that ranged from 5,400 to 7,600 Chilean pesos, using 10 questions in each series.[8] One of the thirty questions was selected at random for each subject, and subjects were paid according to the preferences expressed in the selected question. Those receiving payments on day zero were paid in cash at the end of the experimental session. For those receiving payments thirty or sixty days in the future, arrangements were made for payments to be available at the offices of the appropriate WUAs. The results from time-preference elicitation (ii) are used as a control variable in the regression analysis, below. Series (ii) is used since the payment methodology—through the WUAs—is constant for both dates in the elicitation. Thus, the time preferences are not confounded by differences in transaction costs associated with the different methods used to distribute the funds.

Risk preferences were elicited from two MPL sequences, each containing ten questions. In one, the lottery outcomes consisted of cash payments, and in the other the outcomes were in water volumes. The lottery payoffs over water volumes were parameterized to be similar in expected value to the cash payoffs using the prices at which the research team purchased the water on the day prior to the research session. The order of presentation of the two lists was counterbalanced across the subject pool. The values used in the risk and time elicitations are in Table 3, panels A and B.

[8] The exchange rate on the day the experiments were conducted was 520 Chilean pesos per U.S. dollar.

Table 2. Order of Activity in the Experimental Session

Session Activity	Subject Tasks
Time-preference elicitation	3 MPL choice tasks
Risk-preference elicitation	2 MPL choice tasks
Auction	3 good training and 4 good water auction
Determine payments for auxiliary protocols	
Survey	
Settlement of water contracts and payment of subjects	Session close

Experimental Results

Table 4 provides descriptive statistics for the control variables from the auxiliary protocols that elicit individual bidders' risk and time preferences. Using nonparametric tests, we fail to reject the null hypotheses that central tendencies and the shape of the distributions are the same across the RTC and SEQ treatments.[9] We also fail to reject the null hypothesis of risk neutrality for the population as a whole, based on a test of means. However, we do observe significant heterogeneity across individuals. Figure 1 presents the distribution of risk preferences, and Figure 2 the distribution of time preferences, which is bimodal.

Table 5 presents descriptive statistics for the auction bids, distinguishing bidding behavior by auction type and by rank order of preference for the goods. On average, bids are 34.82 pesos per cubic meter in the RTC auction, and 9.44 pesos per cubic meter in the SEQ institution. Statistical tests confirm that bids are significantly higher in the RTC institution in aggregate and for each preference ranking of the goods.

To better understand the consequences of the two different auction institutions, we estimate a model of bidding behavior as a function of the auction treatment, explanatory variables, and relevant interactions. For some agents the optimal choice is to bid an amount equal to 0, i.e., a corner solution for a subset of the goods. The bidding behavior suggests the use of a Tobit model, which allows for that type of corner solution and ensures that predicted values of bids are always non-negative (Woolridge 2001, p. 518).

[9] P-values for the Wilcoxon test of central tendencies for risk (time) preferences are p = 0.54 (p = 0.69), and for the Kolmogorov-Smirnov test of the shape of the distribution, p = 0.97 (p = 0.88).

Thus, our statistical problem takes the form of

$$y^*_{it} = \mathbf{x}_{it}\beta + v_i + \varepsilon_{it}$$

$$y_{it} = \max(0, y^*_{it}),$$

where y^*_{it} is a latent variable, y_{it} is the bid of individual i in auction phase t, $\mathbf{x}_{it}$ is a set of exogenous variables that explain the bidding behavior which includes the experimental treatment dummies, and β is a vector of unknown parameters. We estimate an error-components model because of the repeated observations on bidders across auction phases. Thus the component v_i is the random disturbance characterizing the ith individual and is constant across auction phases. The component ε_{it} is a random disturbance that varies across individuals and across auction phases. We assume that v_i and ε_{it} both are distributed normally with mean value 0 and constant variance σ^2_u and σ^2_ε, respectively. We assume further that $E[\varepsilon_{it}v_j] = 0$ for all i, t, and j; that $E[\varepsilon_{it}\varepsilon_{js}] = 0$ if $t \neq s$ or $i \neq j$; and that $E[v_i v_j] = 0$ if $i \neq j$.

Table 6 presents Tobit estimates for two models of bidding behavior. Model 1 in Table 6 includes an indicator variable for the auction institution, *RTC*, which is 1 (0) for the RTC (SEQ) institution, and for each good in order of bidder preference (*Prefx*, where $x \in \{1,2,3,4\}$ indicates the preference ranking), and interactions of the auction institution and the *Prefx* variables. The use of the preference ranking as an explanatory variable, rather than the specific good, is driven by the theoretical model, which assumes heterogeneity of preferences and therefore that bids for different goods in the same phase of the RTC drive the differences across institutions. This heterogeneity is in fact observed in the auction data.

Table 3. Risk and Time Preference Elicitation Questions

PANEL A: RISK-PREFERENCE QUESTIONS

Question	Lottery A		Lottery B	
1	.1, 1,400	.9, 900	.1, 2,500	.9, 250
2	.2, 1,400	.8, 900	.2, 2,500	.8, 250
3	.3, 1,400	.7, 900	.3, 2,500	.7, 250
4	.4, 1,400	.6, 900	.4, 2,500	.6, 250
5	.5, 1,400	.5, 900	.5, 2,500	.5, 250
6	.6, 1,400	.4, 900	.6, 2,500	.4, 250
7	.7, 1,400	.3, 900	.7, 2,500	.3, 250
8	.8, 1,400	.2, 900	.8, 2,500	.2, 250
9	.9, 1,400	.1, 900	.9, 2,500	.1, 250
10	1.0, 1,400	0.0, 900	1.0, 2,500	0.0, 250

Each cell presents the probability and the payoff for a component of a lottery. Payoff amounts are in cubic meters of water. The *risk* variable is a count of the number of choices of Lottery A.

PANEL B: TIME-PREFERENCE QUESTIONS

Question	A: Payment in 30 Days	B: Payment in 60 Days
1	5,400	5,490
2	5,400	5,580
3	5,400	5,670
4	5,400	5,760
5	5,400	5,850
6	5,400	5,940
7	5,400	6,030
8	5,400	6,120
9	5,400	6,210
10	5,400	6,300

Payment amounts are in Chilean pesos. The exchange rate for U.S. dollars was 520 pesos per U.S. dollar at the time of the experimental session. The *time* variable is a count of the number of A choices.

Model 2 in Table 6 adds several explanatory variables to the Model 1 specification. The categorical variable for risk attitude, *risk*, ranges from 0 to 10 and is increasing with risk aversion. The value represents the number of times the safe lottery (Lottery A) is chosen in the ten-question risk-elicitation protocol. Time preference (*time*) is defined similarly, with the value representing the number of times that “early” (Choice A) is chosen. We also include an indicator for market ex-

Table 4. Risk- and Time-Preference Descriptive Statistics

PANEL A. RISK-PREFERENCE RESULTS			
Auction Treatment	Mean	Std. Dev.	Median
SEQ	3.87	1.92	4
RTC	4.18	2.49	5
Total	4.00	2.17	5

PANEL B. TIME-PREFERENCE RESULTS			
Auction Treatment	Mean	Std. Dev.	Median
SEQ	5.50	3.38	6
RTC	4.93	3.87	5
Total	5.27	3.59	5

Note: Cell values represent number of A choices in the risk or time elicitation protocol. Choices are displayed in Table 3.

perience, which takes the value of 1 (0) if the subject has (has not) ever participated in the spot market for water as a buyer. The variable *risk* is also interacted with the *RTC* indicator variable, in Model 2, since theory suggests that risk attitude has different effects in the two institutions. We also examine the impacts of *time* both directly on bidding behavior, and interacted with an indicator variable (*now*) that takes on the value of 1 (0) for goods available today (in 30 days).

Model 1 yields insights similar to those gleaned from the tabulated data in Table 5; it provides evidence that bids are dramatically higher in the RTC institution, with the *RTC* coefficient equal to 48.28 ($p < 0.0001$).[10] In addition, we find that subjects had similar values for their two most preferred goods. Evidence for this finding arises from the coefficient for *Pref2*, which, both on its own and when interacted with *RTC*, is found to be not significantly different from zero, and thus bids do not differ significantly from the omitted category of the most preferred good. Bids decline substantially for the less preferred goods (*Pref3* and *Pref4*) in both auction institutions, reinforcing the finding of heterogeneity in preferences.

Model 2 sheds light on the underlying factors associated with the observed outcomes and on the theoretical propositions outlined above. We find that the *risk* variable does not have a direct effect in our model as the coefficient (-1.41) is not statistically significant ($p = 0.65$). However, when interacted with the RTC institution, there is a large and statistically significant effect. The coefficient of *RTC* × *risk* is 8.80 ($p = 0.02$). Thus, for the median level of risk aversion in the sample (median *risk* = 5), we find bids more than 40 pesos per cubic meter higher in the RTC treatment. Time preferences also have a significant effect on bids, with a marginal increase in *time* leading to a fall in bids by 2.97 pesos per cubic meter ($p = 0.02$). This effect is moderated for the subset of goods available for immediate purchase, with the coefficient on the interaction of *now* × *time* equal to 0.82 ($p = 0.06$) and the net effect still negative, as determined by a Wald test in which the null hypothesis that the coefficients are jointly equal to zero is rejected ($p = 0.09$). Thus, those with higher discount rates have lower willingness to pay for goods regardless of the date of availability, with the effect moderated, but not eliminated, for goods available immediately. Finally, we note that those with experience as buyers in the spot market bid significantly more for water than their inexperienced colleagues (coefficient on *experience* = 17.17, $p = 0.07$).

The key substantive finding from Model 2 is that, after adding the control variables, the *RTC* indicator is substantially smaller (5.03) and no longer statistically significant ($p = 0.79$). Thus, the differences in bidding behavior between the two auction institutions are explained by the controls we introduce in the model. Risk attitudes play the largest role in explaining the results, and thus our results provide additional support for Burguet's (2007) theory. Market experience also plays an important role. However, caution is required in interpreting the effect, since *experience* serves as a proxy for variables associated with farm production practices that are correlated with higher values for water. Thus, while we might expect those who have been in the market to be willing to pay more for water relative to those who have not, the magnitude of the premium is somewhat surprising. The average bid of the experienced buyers reflects a price 68 percent higher than the price paid by the research team the previous day. The lack of censoring at market price suggests that under the existing institution

[10] Bidders who submitted any positive bids are included in our sample and we report marginal effects for the latent variable. Other models that restrict the sample to positive bids yield similar conclusions.

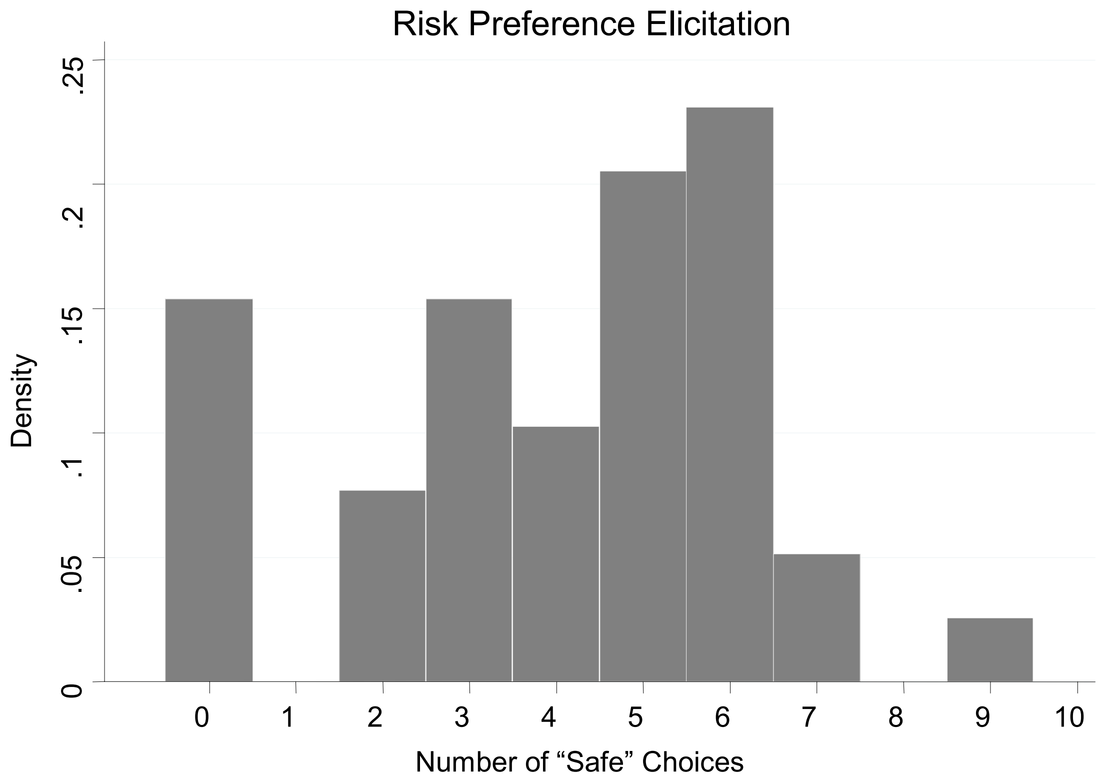

Figure 1. Distribution of Risk-Preference Elicitation Results

Notes: Variable values represent the number of safe choices made in the water lottery treatment. A total of four safe choices is consistent with risk neutrality. The median number of safe choices is 5.

of bilateral negotiation, information on prices is not widely dispersed, even among those who have participated in the market in the past. Thus, it seems likely that an alternative institution, in which prices are publicly announced, could play an important role in price discovery.

Conclusion

The functioning of the spot market for water volumes in the Paloma System was studied using field experimental techniques. Willingness to pay for water of distinct types was elicited from farmers in both sequential and right-to-choose auction institutions. We find strong evidence in this setting that risk attitudes explain a substantial portion of the difference between the two auction institutions, lending support to the theory of Burguet (2007). Our results thus extend a literature that has relied primarily on induced values, by working with field context and homegrown values. We also relax the assumption of risk-preference homogeneity, and directly elicit heterogeneous risk attitudes. The results on risk are consistent with the results of Cristi (2007), who found that heterogeneity of risk preferences was important in motivating participation in the spot market. Our results contrast with the earlier field study of Alevy and Price (2009). The cause of these differences is an area for future research.

Our findings have implications for policy proposals aimed at improving market functioning in the Limarí Valley. The competition across goods engendered by the right-to-choose auction clearly indicates that specific characteristics are important to buyers and that access to contracts with temporal and spatial variability is likely to improve the functioning of the market. The finding

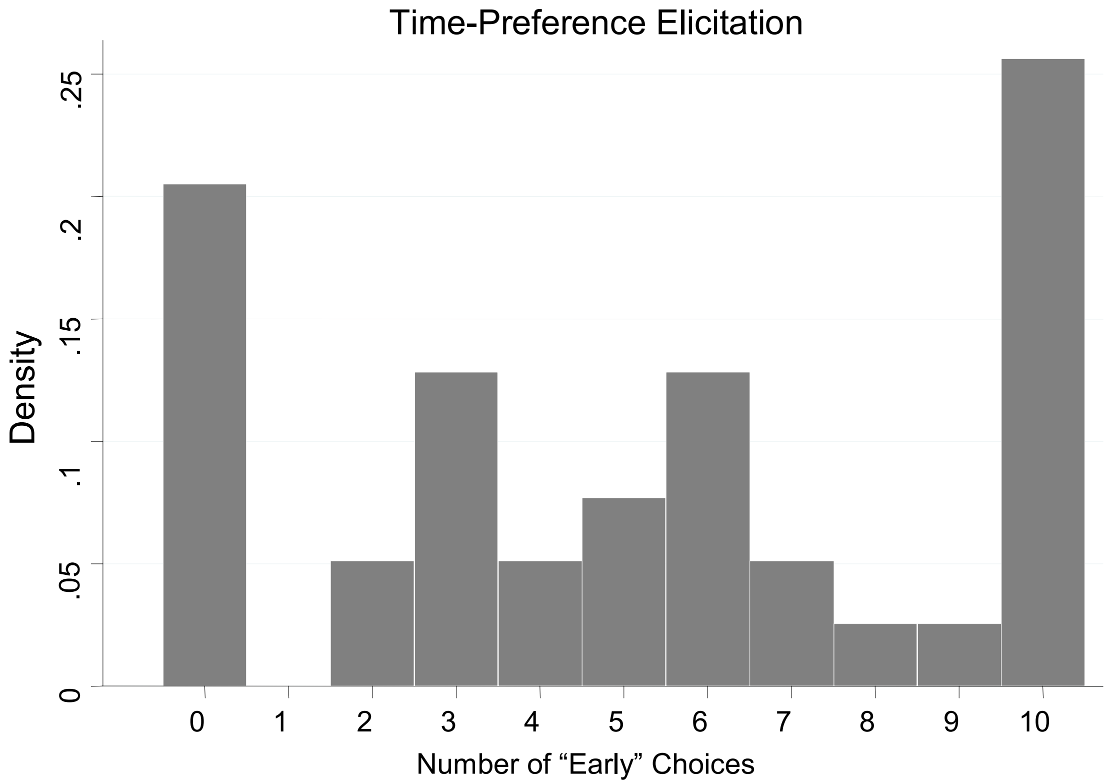

Figure 2. Distribution of Time-Preference Elicitation Results

Notes: Variable values represent the number of choices indicating a preference for the early payout. The median number of early choices is 6.

Table 5. Auction Bidding Descriptive Statistics

	Pref. 1		Pref. 2		Pref. 3		Pref. 4		Aggregate	
Auction	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
SEQ	17.72	25.55	12.50	22.80	6.00	12.19	1.55	3.07	9.44	18.90
RTC	51.29	37.86	43.95	34.72	25.43	32.35	18.62	28.87	34.82	35.60

Note: Cell values are the mean and standard deviation of auction bids by order of bidder's preference.

that participants with market experience were willing to pay a substantial premium over current market prices deserves additional study. In combination with the volatile prices observed in previous empirical studies, it suggests that there may be opportunities to increase market efficiency through formalizing and modernizing exchange mechanisms, and by publicizing market prices.

Table 6. Tobit Estimates of Bidding Behavior

Variable	Model 1	Model 2
RTC	48.276	5.025
	0.000	0.791
Pref 2	-7.397	-9.165
	0.226	0.131
Pref 3	-19.262	-20.339
	0.001	0.001
Pref 4	-35.659	-36.980
	0.000	0.000
RTC × *Pref 2*	6.123	9.662
	0.494	0.278
RTC × *Pref 3*	-17.019	-16.744
	0.049	0.051
RTC × *Pref 4*	-20.089	-19.598
	0.016	0.018
Experience		17.172
		0.074
Risk		-1.410
		0.654
RTC × *Risk*		8.796
		0.028
Time		-2.971
		0.021
Time × *Now*		0.821
		0.0582
_cons	21.030	39.051
	0.008	0.012
N	156	156
AIC	1124.44	1118.78
Log likelihood	552.22	544.38

Note: Dependent variable is the auction bid; p-values are displayed beneath the coefficients.

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Appendix. Experimental Instructions

Translations of the right-to-choose auction instructions from the original Spanish are included below. The sequential auction instructions use the same second price rule; the order of sale of the goods is chosen exogenously. [Risk and time preference elicitations closely follow Andersen et al. (2008).]

Experimental Instructions: RTC Auction

Welcome. Today you have the opportunity to bid in an auction where we will be selling the goods described below. If you have a question at any time during the session, please raise your hand and a monitor will come to your seat and answer it in private.

AVAILABLE GOODS

Good 1: 1,000 cubic meters of water from Camario, today

Good 2: 1,000 cubic meters of water from Camario, in a month

Good 3: 1,000 cubic meters of water from Cogotí, today

Good 4: 1,000 cubic meters of water from Cogoti, in a month

EXPLANATION OF THE AUCTION

The auction consists of four phases. In every phase, instead of selling a specific good, we will sell the *right to choose* one of the goods.

The highest bidder in every phase wins and chooses their preferred good from among those that remain.

At the end of the first three phases every buyer will be informed about the goods that have been selected and what remains available.

In the final phase (4), all the buyers offer a price for the only good that remains.

THE AUCTION PRICE

In every phase you should bid a price that corresponds to the maximum that you are willing to pay for acquiring the right to choose. The offered prices can be of any total in intervals of 10 pesos. For example: 10, 20, 100, 110. In addition to the price you must indicate the good that you want to choose if you win.

Once each of the buyers has entered his price, all prices will be ordered from largest to smallest to determine which buyer obtains the right to choose.

Important: the price that the winner of every phase pays is not the price that he bid, but the value of the second highest bid in that phase.

If you do not win the right to choose, you do not have to pay anything.

If there is a tie for the highest bid, the winner will be chosen by means of a coin flip. In this case the winner will pay a price equal to his bid, since it is also the second highest price.

Example: Suppose that the following goods are offered for sale:

(i) A bicycle
(ii) A computer
(iii) A chair

The results of the first phase are in the following table.

AUCTION RESULT		
Buyer's ID	Price	Product
ID 1	25,000	3 – chair
ID 2	27,000	1 – bicycle
ID 3	36,000	3 – chair
ID 4	50,000	2 – computer
ID 5	8,000	2 – computer
ID 6	35,000	1 – bicycle

Next the prices are ordered from highest to lowest.

AUCTION RESULT		
Buyer's ID	Price	Product
ID 4	50,000	2 – computer
ID 3	36,000	3 – chair
ID 6	35,000	1 – bicycle
ID 2	27,000	1 – bicycle
ID 1	25,000	3 – chair
ID 5	8,000	2 – computer

Buyer 4 wins the right to choose his preferred good, in this case the computer. The price that he will pay is equal at the second highest price, that is to say: 36,000 pesos.

In the second phase the process repeats and every buyer offers a price for the goods that remain. The results are noted down in the following table:

AUCTION RESULT		
Buyer's ID	Price	Product
ID 1	25,000	3 – chair
ID 2	27,000	1 – bicycle
ID 3	36,000	3 – chair
ID 4	15,000	3 – chair
ID 5	5,000	3 – chair
ID 6	35,000	1 – bicycle

Who is the winner?

Please write down on your sheet the ID of the winner and the price he/she pays in this example.

RESULT

Buyer 3 gains the right to choose his preferred good—in this case, the chair. The price that he will pay is equal to the second highest price: 35,000 pesos.