Impacts of water rights security on water markets: experimental evidence

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January 27, 2011

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Abstract

Water markets are expected to lead to efficient use of scarce water by re-allocating water from low value uses to high value uses. However a water allocation system must not only allocate specific volumes of water among users but also allocate the risk of supply shortages. The existence of both a market of water rights and a market of seasonal water allocations is necessary to allow users to manage better the risk of increased supply uncertainty. Whether the water rights market should be further sophisticated by offering different levels of security for rights is unclear. Indeed, increasing the complexity of water markets can eventually reduce efficiency gains and cost-effectiveness of water trade. We propose an experimental design that captures the main characteristics of water markets. Farmers first participate in the market for water rights while facing uncertainty on water allocations. Once the water supply is known, they can trade their water allocation on the spot market. We examine two water right scenarios, one with a unique security level and another with two levels of security and we compare them in terms of allocation efficiency, risk allocation and cost effectiveness. We vary transactions costs as a treatment variable and elicit risk preferences of subjects. By comparing the performance of the markets in each treatment, we can measure the benefits of having two levels of security for water rights and test whether they are contingent on the characteristics of transaction costs and risk aversion.

JEL Codes: Q25, C91

1 Introduction

Water markets are acknowledged to allocate scarce water available efficiently, by encouraging water conservation and water use efficiency and by moving water from low to high value uses. Although there is now widespread adoption of trading mechanisms to re-allocate water, there is an ongoing debate on how to improve the trading processes. Most of the existing literature has focussed on the issue of transaction costs which reduce efficiency gains [28] and third party impact when trade might affect other users who are not parties in the transaction [13, 14]. However, another important issue deserves attention: what is the role of water markets in the strategy of water users to manage risks of water shortage? The uncertainty of irrigation water supply, due to climatic variations, reduces farmers's benefits because part of their production decisions are made before knowing the water availability for the coming season. This problem is particularly crucial for unregulated river systems where there is no water storage through reservoir dams. But it exists also for regulated systems because the probability of reserve replenishment from one year to another fluctuates increasingly with climatic change. Water markets transform the risk on the availability of the water input into a risk on input prices. Calatrava and Garrido [10] demonstrate theoretically and empirically that allowing farmers to trade water can help to reduce their exposure to risk.

The co-existence of both a market for water rights and a market for water allocation is established in most countries where water can be traded. Farmers can thus obtain water from two sources. They can hold water rights which entitle them to a share of available water each year: for each right held, they get a volume of water, called an allocation, which depends on the total water availability in the system for a given season. They can also buy water from the seasonal allocation market: when water right holders are told what their water allocation is for the year, they can either decide to use it entirely for production, or to sell (buy) excess (missing) quantities on the market [3]. Moreover, as water value rises, property rights are made more precise and markets more complete, as the benefits of doing so can offset the inherent costs involved [32]. Some countries have introduced water rights with different levels of security, low security water rights offering less guarantee that water be delivered than high security rights. They expect that a differentiated water right system could contribute to improve further the efficiency of water and risk allocation across farmers. However, increasing the complexity of water trading markets could also reduce efficiency. This question is at the heart of a number of water market reforms.

Under the statutory water rights law, as in Chile, Mexico and Australia, water rights are defined as a proportion of stream flow or storage [34, 25]. Nevertheless, the quantities of water that holders of rights are permitted to divert depend on the seasonal allocation that is assigned each year to the water entitlement. The seasonal allocation is shared proportionnaly when all water rights are identical (unique level of security). Alternatively, different levels of security for water rights can be defined. In this case, the available water is allocated to the high security rights first. The water authority operates its storage so as to guarantee that the high security water rights can be supplied (reliability of 95-100% in Australia). Once provisions for high security water rights have been made, the remaining volume of water determines the low security allocations. As a result, low security water right owners bear the risk of low water supply. Such ranking of rights is also the basis of the prior appropriation doctrine, much in use in the Western states of United States: when shortage occurs, priority is given to the most senior rights, those which were historically appropriated first. When a water right is sold, it retains its original appropriation date. The security of a water-right can thus be theoretically purchased by buying a senior right on the right market. In Australia, recent water reforms introduced in some States have created a differentiated water right system. Since 1994 in New South Wales and Victoria, farmers can thus constitute a portfolio of water rights of two security levels by trading on the right market. Such reforms are administratively complex and can lead to substantial transaction and learning costs for water users. Before encouraging a wider adoption, it is necessary to better understand whether they can lead to true efficiency gains for water users.

The objective of this paper is to compare the allocative efficiency, cost-effectiveness and risk allocation properties of a market with two levels of security for water rights relatively to a market with a unique type of water rights. Field data are limited to examine this research question because water rights markets are still thin [2]. At the moment in Australia, the market for low security rights still show very little activity. In the Western United States, fear of third party effects makes the trading of senior water rights difficult in the western US[1]. As a result, the possibility to constitute a portfolio of water rights wil different level of security is not yet a reality. Moreover, differences between countries or States in terms of hydrology and socio-economic environment are too important to compare the performance of both systems per-se. This paper therefore uses experimental data. It presents an experimental design capturing the

[1] Libecap[32] reports that appropriative water rights exacerbate third party impacts occasionned by trades initiated by senior rights holders. This raises the likelyhood of protests and litigation by junior rights holders over water transactions. The consequence is less transfers, thus lower allocative efficiency of the system. On the contrary, Libecap mentionned that in the systems where water is allocated through uniform water rights (as in the Colorado Big Thompson project), water transfers are more frequent as they occur with minimal transaction fees and paperwork. He examined wether such proportional shares might be adopted broadly in the West in place of existing prior appropriation rights in order to enhance the activity of water markets.

main characteristics of existing water markets.

The design is noteworthy in two respects. First, it is the first water market experiment that include both the water rights market and the market for allocation. No existing experiment on water markets consider both markets. Cristi and Alevy [17] and Garrido [23] only focus on the allocation market. Hansen and al [29] experiment includes the allocation market and an option market but no rights market. In the emission trading experimental literature, Godby et al [24] designed a market experiment mimicking the canadian emissions trading market, including both a share and a coupon markets. A coupon gives permission to discharge a unit quantity of waste. A share represents an entitlement to a specified fraction of the total available coupons to be issued in future periods. Our experiment is inspired by this design. Subjects first participate in a "share market" (corresponding to the water rights market) without knowing the allocation of "coupons" (corresponding to water allocation) they will get from their shares. In a second stage, they can trade their coupons on the coupon market (corresponding to the market for water allocation). The second novelty of our design is to introduce different levels of security for shares to be able to compare the proportional definition of rights with a system with different level of priority. Calatrava and Garrido[11] compared these two definition of water rights with simulation data but they didn't include the possibility of water rights' trading in their analysis. We are not aware of any market experiment including this design feature. Noussair and Porter[33] ran an auction experiment, inspired by the priority service literature [39, 38], on proportional versus priority rationing. There is no market in their design. On the contrary, the efficient sharing of water can be achieved using both the water rights and the allocation market.

We use a 2x2 design where the treatment variables are the number of levels of security for shares (1 or 2) and the presence of absence of transaction fees in the share and coupon market. With these treatments, we take into account the role of transactions costs which are recognized as an important feature of water markets and show how they can impact the performance of a differentiated system. We also elicit risk preferences of participants. By comparing the performance of the market in each treatment, we can measure the benefits of having two levels of security for water rights and test whether they are contingent on the characteristics of transaction costs and risk aversion.

This paper is organized as follows. Section 2 summarizes the existing literature on the expected benefits and limitations of a system with differentiated security rights. The experimental design and corresponding theoretical predictions are presented in sections 3 and 4. Section 5 analyses the experimental results and section 6 concludes with some implications for policy.

2 Rationale for water rights with differentiated security levels

The benefits from a water market with differentiated water rights rely on the existence and efficiency of the water right market itself. Most of the countries engaged in water markets reforms are investing into the creation - or the enhancement - of water rights markets, for example through the formal separation of water rights from land rights, mainly to facilitate real structural change within the irrigation industry [4]. It is observed that water right trading is slowly picking up [40]. If the water market was perfectly competitive and transaction-cost free, and if water users are risk-neutral, then trading on the seasonal allocation market is sufficient to reach an efficient allocation of water amongst users [21, 24]. Nevertheless, farmers are showing growing interests in water rights trading[2]. A system of differentiated security rights allows to sophisticate the portfolio of rights held, therefore potentially improving the water rights market[3]. We need to further study the arguments in favors of this system where rights are defined with different levels of security and show what are the main limitations.

Firstly, Freebairn and Quiggin [21] argue that the existence of a market for water rights can improve the cost-effectiveness of water allocation by allowing water users to hold water rights which match their water needs in each climatic scenario better, thus reducing trade on the allocation market and corresponding transaction costs[4]. Farmers who are regular buyers or sellers on the allocation market might find more profitable to increase the adapt their portfolio of water rights in order to limit their need to trade in the allocation market and therefore reduce their exposure to transaction costs. Freebairn and Quiggin result is nevertheless controversial because it relies on the assumption that transaction costs on the allocation market are greater than transaction costs on the water rights market. However, australian water markets seem to display

[2]In theory, trading on the water rights market should not occur since all water users have the same expected value for water rights (expected value of the corresponding allocation on the allocation market which is the same for all since there is a unique expected price for water) and thus display the same willingness to pay for rights. Under these assumptions, demand and supply of water rights can only be driven by risk attitudes [16], long term speculation (related to the uncertainty on the level of future water supply) or saving motives. Some irrigators view high reliability water entitlements as a hedge against future uncertainties ([2, 26]).

[3]Introducing different levels of security corresponds to a change in the definition of the property rights. But, from the coasian literature, we know that the initial allocation and the definition of rights impact the cost-effectiveness of a Coasian market, as well as the risk born by agents ([27, 41]). As a result, the redefinition of water rights with different levels of security should not be neutral on the water allocation.

[4]Despite the existence of trade-facilitating solutions such as electronic market places or brokers, trading water remains costly. Transaction costs are incurred in searching for a trading partner, ascertaining the caracteristics of the water commodity, negotiating price and other terms of transfer and obtaining legal approval of the transfer. [2, 28, ?]

greater transaction costs on the latter because of differential tax treatment and the administrative complexity and costs associated with trading rights [2, 7]. As a result, the costs of acquiring rights may offset the gains from a portfolio of rights matching water needs.

Secondly, a differentiated system can improve the risk management opportunities offered to risk averse farmers, as well as risk allocation. Water markets contribute to reduce the risk born by farmers by converting a quantity risk into a price risk [10], but they fail to share the remaining risk efficiently. As underlined by Quiggin in [15], "the quest to eliminate uncertainty is futile but uncertainty can be managed, allocated and sometimes mitigated". Howitt [30] shows that allocation markets, as well as right markets, have no risk-sharing propertiess[5]. The principle of risk allocation (or risk sharing) is that risk should be allocated to the party best able to manage or accept it. In principle, this can be achieved through risk-sharing contracts such as options on the allocation market or conditional leases of water: risk-averse users could then trade-off lower expected gains for lower variability of gains with more risk-tolerant users, willing to support a greater share of water variability. According to Bjornlund [5], in Australian water market, the risk differential between high value water users (mainly perenial crops) and producers of annual crops should be sufficiently large to enable sophisticated risk-sharing instruments to operate[6]. Water rights with different levels of security can mimic these risk sharing contract. The agents willing to reduce their risk will pay more to buy secure water rights. It has been observed that uncertainty on water allocation motivates farmers to hold more rights than necessary [7]. With differentitated rights, they can instead of buying more rights, buy secure rights. The agents willing to bear risk can buy cheaper and less secure rights[7]. Resource security

[5] They cause all the risk to be born by one party. "On the allocation market , the buyer bears all the risk as it has no fall-back source of supply. He bears both the uncertainty of supply in the allocation market and the uncertainty on the resulting water price. On the water rights market, the seller bears the burden of correctly valuing the current worth of future water" (Howitt).

[6] Australian National Water Initiative (2004) contains a set of risk assignment provisions that were intended to give entitlement holders greater certainty over who would bear the risks of future reductions in the quantity and security of water allocations. The risk of changes in the aggregate availability of water due to new knowledge about the hydrological capacity of the system are born by users, whereas the risk of reductions in water availability arising from changes in public policy will be born by the public, and water users will receive compensation for such reductions. Our approach is different as we study the possibility of sharing risk among agricultural users (and noy between users and government). In our setting, compensation for higher risk is included in lower market prices for water rights of low security, and "financed" by the higher market prices for high security rights.

[7] In the western US system, Libecap[32] mentionned that junior appropriators bear most of the downside risk of drought. Burness and Quirk [9] emphasize the unequal sharing of risk among water appropriators as a key source of inefficiency for appropriative water rights (under the assumption of equal agents in terms of risk aversion). But if we consider the presence of heterogeneous users in terms of risk aversion, and an endogeneous allocation of high security/senior rights, with more risk averse users buying the senior rights, this system improves on the contrary risk sharing.

being a zero-sum commodity, the more security is given to a group of users, the less there is for everybody else (Quiggin in [15]).

A differentiated system displays thus two major advantages, compared to a single security system: transaction costs saving and better risk allocation. However, it increases the complexity of water market management for the water administrators and the complexity of water market participation for the farmers. In the australian context, where security levels are not based on historical factors, the water administrators will have to define the efficient mix of entitlements (ratio between high and low security rights) in order to match the entitlement mix to farmers' needs, given the constraint that the security levels can be respected [31, 36][8]

Farmers must also be able to understand and to reach the benefits of such system. Overall, the benefits of water rights differentiation will depend on users' participation in the water rights market. Transaction costs on the water rights market (relatively to the allocation market) and the heterogeneity in water users' willingness to bear risk are two essential drivers of participation in the water rights market. Higher profits and improved risk allocation can be only obtained if agents are capable of constituting the best portfolio of rights (minimizing need for trade). The next section describes the experimental design implemented to measure if such benefits are observed in the laboratory.

3 Experimental design

Our experimental design captures the main characteristics of mature water markets where agricultural users participate both in the water right market and in the allocation market. Each water right entitles its owner to a share of available seasonal water, which varies stochastically (with a known distribution) and is only known with certainty at a certain time of year (usually at the end of spring, when water levels in dams have stabilized). Water is used as an input in the agricultural production process with a decreasing marginal productivity. To mimic the relevant features of water markets for the research question we wish to address, the experimental design simplifies the

[8]In Australia, the actual mix is a consequence of historical allocation of rights and "sales water", where sales water was the excess water available in storage. It was made available to farmers, in proportion of their entitlements. During unbundling reform in 1994, sales water was converted into low security entitlements. In the recent years, State and Federal governments have buy-back water entitlements to return water systems to environmentally sustainable levels of extractions (implementation of the National Water Initiative of 2004). Governments need to select a suite of entitlements likely to deliver the required volume for the environment at the required time. A secondary objective could also be to take care that the remaining entitlements suit farmers' preferences in term of security. Of course, the more high security entitlements are bought-back, the higher the cost for the government.

market structure. Subjects trade water rights and water allocation in two successive -non overlapping- phases. Water rights and allocation are available for one period only in the experiment. This choice precludes trading motives associated to long-term strategies such as savings and speculation on the future value of water rights. It enables to observe trading strategies associated with the need to reduce transaction costs and manage risk better, and to compare them for a general security right system (with only one level of security for shares) and for a differentiated right system (with two levels of security for shares).

To prevent prior attitudes about environmental policy from influencing subjects' behaviours, a neutral terminology is used: water rights are called "shares“ and water allocations are called "coupons" (as in Godby and al[24]). A share is thus an entitlement to a pre-specified fraction of the total available coupons to be issued. At the end of each period, coupons held are converted into ECU benefits, the ECU being an experimental monetary unit convertible at a fixed rate into € cash.

Treatments

We use a 2x2 factorial design with 6 observations per cell (table 1). The treatment variables are the number of levels of security for shares (1 or 2) and the presence of absence of transaction fees in the share and coupon market. We use a between subject design where each subject participated in one of four treatments.

—————————— Table 1 here——————————

The first treatment dimension is the number of security levels. In C1 and S1, there is only one type of shares called "shares". In the two levels of security treatment (C2 and S2), high security ("shares A") and low security shares ("shares B") are traded sequentially, with the high security shares being traded first[9].

The second treatment dimension is the transaction fees. Our first set of treatments (C1 and C2) follows Freebairn and Quiggin that suggest that seasonal allocation trading is likely to be associated with larger transaction costs. However, the assumption of Freebairn and Quiggin is challenged by Brennan who suggestted that the financial and administrative costs of allocation trade are small. Field interviews we have conducted

[9] In the Australian context, both markets operate simultaneously but the high security market tends to be the most active. Traders try to buy high security water rights to secure a minimum water allocation (the minimum requirement in dry years), and then eventually buy low security shares. Theoretically, the order of the two markets will not impact the equilibrium of both markets. Experimentally, some order effect may be observed. To limit the number of treatments, we choose to run the experiment with the high security share market first then the low security market.

in Northern Victoria (Australia) also largely provide evidence of higher transaction costs on the water rights market. This constitutes our second set of treatments (S1 and S2)[10]. The transaction fee $TF_{s,c}$ are set to two ECUs per coupon traded for both the buyer and the seller in C1 and C2 and two ECUs per share traded for both the buyer and the seller in S1 and S2[11].

Game structure

Figure 1 presents the game structure. At the beginning of each period, each of the 6 subjects in the session is endowed with an equal number of shares: 9 shares in the treatments with a unique level of security and 3 shares A (high security) and 12 shares B (low security) in the treatments with two levels of security. Each subject is also given an initial cash amount of 50 ECU which enables them to buy shares and coupons if he wishes.

——————————— Figure 1 here———————————

In stage 1, subjects can choose to modify the number of shares they hold by buying and selling in the share market. Between stage 1 and stage 2, a random draw selects the scenario (blue or yellow, equally likely) that determines the number of coupons they get from their shares (table 2). Both the probability of each scenario and table 2 known by the subjects. The scenarios are a simplified representation of the climatic variability. A wet season is described by the "blue scenario" whereas a dry season is called "yellow scenario" and corresponds to three times less water. The distribution of scenarios was randomly drawn in advance and is identical accross treatments and groups. The blue

[10] We could have run complementary and intermediary treatments with no transaction fees at all ($TF_s = TF_c = 0$) or equal transaction fees in both markets ($TF_s = TF_c = 2$). The first case is equivalent to S1 and S2 as there is no gains from share trading if trading in the coupon market is not costly (even if shares trading is not costly neither). In the later case, the gains from shares trading are limited by the transaction fees to be paid (TF_s). As a result, the gains from a differentiated system should not be as clear as in C1 and C2. In the lab, we concentrate on the more "extreme" configurations of transaction fees.

[11] This fee is high compared to the relative fee/water price ratio observed in operational water trading platforms in Australia. We chose to set a high transaction fee in the lab to capture all the transaction costs born by farmers including non monetary burdens: writing contracts, locating and identifying trading partners. are time-consuming and stressful tasks although they are not necessarily financially costly. In true market transactions, it is rare that buyers and sellers pay the same transaction fee although theoretically the burden of the fee should be shared equally if the market is competitive. Moreover, transaction costs on the water rights market are usually way higher than on the allocation market but in the real world, the purchase of water entitlements is amortized over several years. In the experiment we set the transaction fee equal for coupons and shares for simplicity, assuming that the annualized transaction costs for right trading may be more or less equivalent to the annual transaction costs for allocation trading.

scenario was drawn in periods 1, 2, 5, 7, 8 and 12 and the yellow scenario in periods 3, 4, 6, 9, 10, 11.

—————————— Table 2 here——————————

In stage 2, subjects can trade coupons in the coupon market: they can either hold back their coupons, or sell them or buy more, provided they have sufficient cash to do so. At the end of stage 2, coupons are converted into ECU according to a benefit function (table 3). The total gains of the period are the sum of ECU held after the trading stages plus the ECUs generated by coupons held. Then a new period starts [12]

The share and coupon markets are organized as a continuous double auction (CDA)[13]. Subjects can place their price bids to buy extra shares or coupons , and/or price offers to sell them. All these strategies -namely purchase, sell and keep- can be pursued simultaneously, letting the market equilibrium price allocate the goods to the most efficient use. Each trading stage is open for 2 minutes.

To summarize:

In a blue scenario, 54 coupons are available whereas in a yellow scenario, only 18 coupons can be allocated. In treatments C1 and S1 (only one level of security), 54 shares are distributed, corresponding to 54 coupons under the blue scenario and 18 coupons under the yellow scenario. In treatments C2 and S2 (two levels of security), 18 high security shares (A) are distributed corresponding to a guaranteed allocation of 18 coupons even in the yellow scenario; and 72 low security shares (B) corresponding to 36 coupons in the blue scenario and no coupon allocation in the yellow scenario.

[12] In one treatment of Godby and al experiment [24], shares are kept from one period to the other (banking). This design feature could be relevant for water markets as water rights are équivalent to an asset yielding returns (in terms of water allocation) every season. As this design places substantial cognitive demands on the subjects, Godby at al provided computerized advice on intertemporal optimization of shares and coupons holding. We want to avoid such complexity. Moreover, banking of shares is not necessary to observe the types of market gains we are interested in (transaction fees saving and better risk allocation). As a result, our design is simpler: each period starts with the same initial number of shares.

[13] This system is similar to the on-line electronic trading system that are used by farmers to trade water. In Australia, Watermove, Murray irrigation Exchange, Water Exchange, Water find ... offer platforms that act as electronic clearing houses for water rights and allocation trades where farmers post buy or sell bids for particular zone, which are then matched in ascending order for sellers and descending order for buyers to clear the market (Brooks and Harris [8]). Most of these platforms work on the basis of posted sell and buy bids (a part from the largest (Watermove) where a pool price is calculated weekly) (Productivity Commission [14]). We choose a CDA because multiple trading opportunities are important in experimental markets to generate increases in efficiency (Cason and Friedman [12]).

Subject types

Subjects have marginal benefit functions parameterized to mimic two types of farmers (table 3, figure 2): Type 1 subjects' marginal benefits mimic a mixed crop producer, with relatively low value of water and elastic water demand. Parameters are chosen so that type 1 subjects sell their total water allocation (coupons) do not use water in the yellow scenario (dry state) at equilibrium: the equilibrium market price is greater than the marginal value of even the first unit of water (first coupon held). Type 2 subjects represent farmers with high-value crops such as orchards or vineyard,who are highly sensitive to irrigation restrictions. They need a minimum volume of irrigation water to preserve the long term productivity of their plantations or to avoid catastrophic harvest losses [14] . Type 2 subjects' display therefore high marginal value of water, rather inelastic water demand, and a minimum water requirement. The first 3 coupons have no value for a type 2 subject because they are insufficient to ensure production, but the fourth unit yields a high marginal value (figure 2). In each market group, we assign marginal benefit functions so as to have three type-1 subjects and three type-2 subjects.

——————————— Table 3 here———————————

——————————— Figure 2 here———————————

Experimental procedure

The experiment was programmed and conducted in the University of Montpellier's experimental lab (LEEM), using the software z-Tree ([20]). The subjects were drawn from the undergraduate students population. Subjects interacted anonymously in 6 person fixed groups. We conducted 2 sessions of 3 groupes each, for each treatment. We have 6 independant observations by treatment (6 groups of 6 subjects), for a total of 144 subjects. Each session lasted 3 hours. Each session was conducted in the following manner (instructions are available in appendix.) Subjects were first invited to play an individual lottery game (slightly modified from Holt and Laury, described in

[14] Brennan argues that the risk of losses to perennial plantings has not been so far a driver of water markets. Indeed, the market prices observed are lower than the gross margin of horticulturalists. The situation where they are willing to pay a very high price for water has not happened yet because "long-term equilibrium between capital investment decisions and dam reservoir yields ensure that investments in perennial agriculture are secure from catastrophe". In our experiment, the equilibrium of the coupon market in the dry scenario is such that type 2 holds a minimum of 4 coupons. This means that in the experiment type 2 is not at threat of catastrophic losses. A "catastrophic loss" will happen only if he had less than 4 coupons.

Gangadharan and Nemes [22]): it enabled us to elicit each subject's risk aversion. The switchpoint of this lottery game[15] was used as a relative indicator of risk aversion: its value ranged from 1 to 10. In the rest of the paper, we used the following clustering: risk loving subjects have a switchpoint from 1 to 4, risk neutral subjects have a switch point of 5 or 6, risk averse subjects dispay of switchpoint which is greater than 6, 10 indicating extreme risk aversion Subjects were then invited to read the instructions of the experiment explaining the different stages of the game, the trading software and the monetary incentives. They also answered a quiz which tested their understanding of the game. Subjects played two practice periods (with the same parameters as the rest of the experiment), which did not count toward subjects' earnings, followed by a series of 9 (C2), 10 (S2) and 12 (C1-S1) periods which could potentially be selected for payment. Participants were compensated according to their gains in one period, randomly chosen at the end of the session. Subjects'earning were 18.50 euros for a 3 hours session on average. At the end of each session, qualitative and quantitative information was collected in the form of questionnaires from the participants. Subjects were also asked to describe their strategies: in particular they were asked to state whether they thought they had taken risks or not during the experiment. This response was coded 1 when they responded yes and 0 otherwise. This variable will be used in the abalysis of results under the name RiskTaking.

In our sample, 57% of the subjects are risk averse, 40% are risk neutral and 3% risk lovers. 60% of the subjects report to have taken risk during the experiment. There is no significant correlation between type (given in the experiment) and elicited risk aversion (r= -0.0837 p=0.3437), nor between type and risk taking reporting (r= 0.0158 p=0.8588) nor between elicited risk aversion and risk taking reporting (r= 0.0125 p=0.8882).

4 Theoretical predictions

This section presents the theoretical predictions on quantitiesd and prices in the share and the coupon markets in each treatment. We solve the model for a two-agent market[16]

[15]Participants had to indicate their preferences between two options: a safe option (X) that yielded 3.5 Euros with certainty or a risky option (Y). The risky option has a probability of winning 6 Euros changing from 10% in the first lottery to 100% in the 10th lottery or correspondingly the probability of winning 1 Euro changing from 90% in the first lottery to 0% in the 10th lottery. One of the games was played at the end of each session. Subjects received an additional 1, 3.5 or 6 Euros, depending on their choice and the outcome of the lottery game. In order to control for wealth effects, the lottery was played and subjects' gains were only revealed to the subjects at the end of the session.

[16]For a market of 6 participants (3 type-1 subjects and 3 type-2 agents), the price predictions are the same and the traded quantities simply multiplied by 3.

Share

Q_i is the initial allocation of shares to agent i.

S_i is the number of shares held at equilibrium.

p_S is the equilibrium price of a share.

Allocation of coupons

t indexes the scenario (2 scenarios: yellow,blue).

W_t is the number of coupons received per share. It can take two values according to the scenario. This value is known before the opening of the coupon market.

Coupon

$c_{i,t}$ is the coupons held by agent i in the scenario t.

$B(c_{i,t})$ is the marginal benefit function from coupon with $B'(c_i) = a_i - 2b_i c_i$, $a_{type1} < a_{type2}$ and $b_{type1} < b_{type2}$.

$p_{c,t}$ is the equilibrium price of a coupon in the scenario t.

Transaction fees

TFc is the transaction fee to buy and to sell in the coupon market.

TFs is the transaction fee to buy and to sell in the share market.

dc_i is the net position of agent i in the coupon market (1 for a net seller, -1 for a net buyer).

ds_i is the net position of agent i in the share market (1 for a net seller, -1 for a net buyer).

(with one agent of each type) under the assumption of risk neutrality. We solve the model by backward induction: the equilibrium of the coupon market is computed first, then the equilibrium on the share market is deducted. In the experiment, the share trading takes place first, followed by the coupon trading, once the scenario is drawn.

A risk neutral agent chooses his number of shares as well as his number of coupons in order to maximize his net expected benefit from trading and coupons holding.

$$\underset{S_i,c_{i,t}}{Max} \qquad \mathrm{E}\left[B(c_i) + p_c.\,(W.S_i - c_i) - TF_c.\,|W.S_i - c_i|\right] + p_S.\,(Q_i - S_i) - TF_S.\,|Q_i - S_i|$$

Equilibrium on the coupon market

Trading of coupons takes place until coupons' marginal benefits, net of transaction fees, are equal for the two agents. At equilibrium, type 1 is a net seller and type 2 is a net buyer. When the scenario is yellow, type 1 sells of his coupons to type 2 as the equilibrium price is higher than the marginal benefit from the first unit. The equilibrium price is between the price type 1 is willing to sell and the price type 2 is willing to buy (table4, figure 2). The bargaining power of each type in the game will determine the observed price. In treatments C1 and C2 (compared to S1 and S2) in the blue scenario, the final number of coupons held is greater for a type 1 net seller (because he sells less in the presence of transaction fees) and lower for a type 2 net buyer (because he buys less).

——————————————— Table 4 here———————————————

Equilibrium on the share market

The maximum willigness to pay for the purchase of one share (or the minimum willingness to accept for the sale of one share) is its expected value: it is equal to the expected number of coupons obtained from this share multiplied by the expected price of coupons. The equilibrium price is between the seller's minimum price is willing to sell and the buyer's maximum price is willing to buy (table 5). The marginal benefits of coupons have no impact on the willingness to pay for share because the coupon market plays the role of a reconciliation market: agents can buy more or sell extra coupons in the coupon market.

An agent is willing to buy a share if

$$p_S < E\left[W \times (pc - TF_c.dc_i)\right] + TF_S.ds_i$$

An agent is willing to sell a share if

$$p_S > E\left[W \times (pc - TF_c.dc_i)\right] + TF_S.ds_i$$

In the absence of transaction fees in the coupon market (S1 and S2), the expected value of a share is equal for all risk-neutral agents. As a result, no trade should take place in the share market. The transaction fees in the share market reenforce this result. On the contrary, transaction fees in the coupon market (C1 and C2), create heterogeneity in the expected value of a share across subjects if they anticipate that they will have a different position in the coupon market. As a result, trading of shares occurs at equilibrium in treatments C1 and C2. Being net buyers in the coupon market, type 2 subjects are willing to pay more for shares than type 1 subjects. As a result, type 1 will sell shares to type 2. The equilibrium allocation of shares in C1 and C2 is such that the need of costly trade in the coupon market is minimized. When only general security shares are available (C1), the equilibrium number of shares held by each subject is such that coupon trading is required only in the yellow scenario. Shares are allocated according to the need of coupons in the blue scenario. A simple calculation shows that any other allocation of shares is less efficient as it requires more trade in the coupon market. When two levels of security for shares are available (C2), the experiment is parametrized such that, by constituting an efficient portfolio of shares, no trade is required in the coupon market in either scenarios. High security shares are bought to cover the need for coupons in the yellow scenario. Low security shares are bought to complement the allocation from high security shares in the blue scenario.

——————————— Table 5 here———————————

From the equilibrium predictions in the share market, one can compute the number of coupons that will be received by each type in each treatment and scenario. This need to be compared to the equilibrium number of coupons held by each type to determine the equilibrium number of trades in the coupon market. Equilibrium predictions for the number of trades are presented with the observed data in table 8.

Profits

The different treatments lead to different theoretical profits because of transaction fees (table 6). Under risk neutrality assumption, profits are in theory equal in S1 and S2 because no trade is expected in the share market, thus no transaction fees are paid at equilibrium. Profits are on average higher in C2 than C1 because there is no coupon trading at equilibrium in C2. This is due to the fact that the differentiated system offers the possibility to subjects to hold of portfolio of shares which matches perfectly their needs of coupons in each scenario. Subjects thus save transaction fees in C2 compared to C1. We only have interval predictions as the price of shares and coupons depends on the bargaining power of sellers and buyers.

——————————— Table 6 here———————————

The variability of profits (measure by the difference between profits in the blue scenario and profits in the yellow scenario) is also expected to be different accross treatents. The variability of profits is decreased in C2 compare to C1 but this effect is type-dependant: type 2 has less variable gains in C2 than C1 but it's the opposite for type 1.

Hypotheses

From these theoretical predictions and observed behaviour in other experiments , we draw the following hypothesis:

Hypothesis 1: When there are transaction fees on the coupon market, a share system with two levels of security increases overall profits.

Higher profits are obtained because the need to trade on the coupon market is reduced. It can be readily seen from table 6 that total profits are only increased under the yellow scenario (dry season): type 2 profits are greater and compensate the loss of profits of type 1 subjects. This outcome can be observed only if subjects manage to take advantage of the differentiated system and play as equilibrium predictions suggest.Test of hypothesis 1 will enable us to measure whether the net positive effect of the differentiated system outweighs the negative impact of increased complexity, leading to sub-optimal choices.

Hypothesis 2: The differentiated system improves risk management: the overall variability of profits is decreased (H2a) and risk allocation is improved (H2b).

This hypothesis is supported by the theoretical predictions. However, it also relies on behavioral assumptions concerning the role of intrinsic risk aversion (as elicited in the lottery game) versus willingness to take risk induced by the experimental design. Risk sharing theory tells us that agents should bear a share of the risk proportional to their risk tolerance([6, 37, 18]). An improved risk allocation thus will decrease the variability of profits for the less risk-tolerant and will increase it for the more risk-tolerant. Because type 1 and type 2 benefit functions have been allocated randomly to subjects, there is no reasons why the group of type 2 subjects should diplay different intrinsic risk aversion on average than the group of type 1 subjects[17]. Nevertheless, type 2 benefit function, which is more concave than type benefit function, induces more reluctance to adopt risky decisions. Therefore, we expect on average that type 2 subjects will behave "like" agents who are more risk-averse than type 1 subjects (see Schoemaker [35] for a good review of the difference between elicited risk aversion and observed risk taking behaviours). If this is the case, then subjects will adjust their trading strategy in order to manage their risks better and we expect that, since the differentiated system offers better options to adjust, the variability of observed profits is decreased for more "risk-averse" subjects (type 2) and increased for less "risk-averse" subjects (type 1) under C2 and S2 compared to C1 and S1.

Hypothesis 3: Because the differentiated system increases complexity, it induces greater deviation from optimal porfolio of shares and coupons and from maximum profits attainable.

Increasing the complexity of a market can reduce its efficiency of markets because of the limited cognitive capacity of market agents (REF?). This can be captured in the experimental lab as well. We will thus test whether the outcomes in S2 and C2 are further away from the optimal outcomes than in S1 and C1.

[17]We confirm that risk elicitation in the lottery is not significantly statistically different between the type 1 subject group and the type 2 subject group. There is no significant correlation between type (given in the experiment) and elicited risk aversion (r= -0.0837 p=0.3437)

5 Results

We present first the results of the treatments for which the gains of the differentiated system are expected theoretically to be higher: (C1 and C2). Then, we present the results for the treatments that are closer to empirical reality (S1 and S2) and show how the transaction fees in the share market impact the performance of the differentiated system. We measure the performance of the treatment with a differentiated system in terms of profits, variability of profits and allocative efficiency[18] We conduct nonparametric Wilcoxon's signed-rank tests with exactly one summary statistic value per group (in order to satisfy the statistical independence required for this kind of a test). We have six independant data per treatment. When relevant, we also report additional results from multivariate regression models. The regression models evaluate the contribution of different factors on the decisions made by subjects. Unless precised, we compute the statistics relative to the last four periods of the experiment commons to all the treatments (periods 6 to 9) to avoid taking into account the learning effects of the beginning of the experiment. The last four periods include 2 blue periods (7 and 8) and 2 yellow periods (6 and 9).

5.1 When expected gains of the differentiated system are expected to be high: comparison of C2 relative to C1 results

5.1.1 Profits

Hypothesis 1 is supported as average profits are significantly higher when two types of shares are available (C2 compared to C1) in both scenarios (table 7)[19]. This can be easily explained by the number of coupons traded and the transaction fees paid in each treatment (as predicted by theory). In theory, the profits are higher in C2 because no trade of coupons is required, thus saving on transaction fees. In the experiment, 39.6% of subjects reach the equilibrium and do not have to trade coupons in treatment C2. There is also on average significantly less trade of coupons in C2 compared to C1 (table

[18] Prices, quantities traded and subjects' portfolio will be described in a subsequent paper focussing on individual strategies in water markets.

[19] Using Mann-Witney tests based on one observation per group (average total profits over period 6 to 9), the data reject the hypothesis that profits are the same with one or two levels of security for shares (p-value = 0.04 for pairwise comparison between C1 and C2 with alternative hypothesis C1<C2). This effect is driven by the yellow periods. One cannot reject the hypothesis that total profits are equal in the blue scenario (one-tailed p-value=0.11 with alternative hypothesis C1<C2) but one can reject that there are equal in the yellow scenario (one-tailed p-value=0.03 with alternative hypothesis C1<C2). We also compute a robust-rank order test as the samples dispersions seem different between treatments ([19]). With U=-6.25, the robust rank order test leads to the same conclusion and is significant at the 0.5% level (U left-tail critical value=-4.803).

8)[20]. It suggests that subject are able to take advantage of the differentiated system to reduce the burden of transaction fees in the coupon market. The average transaction fees paid are lower in C2 than C1 (Figure 3) (MW p-value with alternative hypothesis C1>C2=0.16).

—————————————— Table 7 here——————————————

—————————————— Table 8 here——————————————

We present results from panel random effects generalized least squares regressions with clustering, where the dependent variable is the individual profit in C1 and C2 (table 9). We cluster the errors at the market group level to capture any unobserved heterogeneity in the group. Explanatory variables are (i) treatment dummies, (ii) scenario dummies , (iii) type dummies as well as periods, elicited risk aversion, and reported risk taking. As expected, profits are lower under the yellow scenario and lower for type 1 subjects. The parameter of the treatment dummy (C2) is significant, and positive, confirming the non parametric test results that profits are higher under C2 (thus supporting H1). We also observe a significant and positive effect of period, revealing a learning effect. Reported risk taking is also significant suggesting that profits of subjects who report that they have taken risks during the experiment are lower. The elicited risk aversion (ERA) is not significant.

—————————————— Table 9 here——————————————

5.1.2 Risk management

Hypothesis 2a is rejected as data suggest that one cannot reduce overall risk with a differentiated system: standard deviation of profits is not significantly different accross treatments (35.45 in C1 - 35.93 in C2)[21]. However, a differentiated system helps to share risk more efficiently: it increases the risk for type 1 and decreases it for type 2, thus supporting hypothesis 2b. This result is confirmed using the average standard deviation of profit over period 6 to 9. It is significantly lower in C1 (18.58) than in

[20]Using Mann-Witney tests based on one observation per group (average number of coupons traded in a group over period 6 to 9), the data reject the hypothesis that the number of coupons traded is identical for one or two levels of security for shares (p-value = 0.02 for pairwise comparison between C1 and C2 with alternative hypothesis C1>C2).

[21]Using Mann-Witney tests based on one observation per group (average standard deviation of profits in a group over period 6 to 9), one cannot reject the hypothesis that the standard deviation of profits is equal with one or two levels of security for shares (two-taileded p-value=0.70).

C2 (21.05) for type 1 and higher in C1 (52.33) than C2 (50.81) for type 2[22]. Table 10 reports the regression of the difference between average profit in the blue scenario and average profit in the yellow scenario (diff Blue Yellow). Treatment is a significant explanatory variable only for type 1 (as for non parametric tests). We do not observe any significant effect of elicited risk aversion (switchpoint) and reported risk taking.

——————————— Table 10 here———————————

5.1.3 Deviation from optimal portfolio and efficiency

We measure the deviation from theoretical predictions of profits and portfolio of shares and coupons to verify if subjects' strategies and performance are impacted by the increased complexity of the treatment with two markets for shares.

Efficiency is defined as the actual gains from trade expressed as a percentage of the potential maximum gains. The point of reference is the share and coupon allocation that would minimize transaction costs and maximize profits given the institutions available in each treatments. We find high efficiency ratio (table 11). The efficiency ratio are in average lower in C1 than C2. Nevertheless, this difference is not significant.We also compare the observed profits to the theoretical profits if subjects don't trade at all[23] (no-trade-efficiency). The no-trade-efficiency ratio are higher than 100%, which indicates that subject achieve to increase their profits by trading in the different markets, even if they don't reach maximum potential gains (defined by the efficiency ratio). The no-trade-efficiency ratio are in average significantly lower in C1 than C2.

——————————— Table 11 here———————————

Higher efficiency in C2 can be explained by the fact that subjects reach the efficient portolio of shares, such that they minimize their needs to buy and sell coupons in stage 2. Table 12 presents the observed portfolio of shares and coupons and theoretical predictions. We also present the number of coupons received after stage 1 as it enables to compare the number of shares held across treatments. Deviation from optimal portfolio is not significantly different between C1 and C2[24].

[22] Mann-Witney tests run by type yield significant results. One can reject the hypothesis that the average standard deviation of profits for type 1 subjects of a group are the same between C1 and C2 (one-tailed p-value = 0.07 with alternative hypothesis C1<C2). However, this effect is less significant for type 2 (one-tailed p-value = 0.24 with alternative hypothesis C1>C2).

[23] With the parameters of the experiment, even if agents don't trade at all during the experiment (they keep their their initial allocation of shares and coupons obtained from it), they can reach an efficiency of in average more than 85%.

[24] We run mann-witney tests to compare deviation from equilibrium portfolio of shares. In order to

——————————————— Table 12 here———————————————

All these results suggests that not only observed profits are higher in C2, but also the capacity of subjects to take advantage of this institution and realize the potential gains (equilibrium prediction). As a result, hypothesis 3 is not supported. The complexity of C2 is not detrimental to efficiency.

We are now analyzing the results for the treatment S1 and S2 in order to verify if the gains from a differentiated market are identical when there are transaction fees on shares' trading.

5.2 Performance of the differentiated system under disadvantageaous conditions: S1-S2

5.2.1 Profits

Hypothesis 1 is not supported when there are transaction fees to trade shares. This is predicted by theory as profits are theoretically equal in S1 and S2. In the experiment, we obtain that profits are significantly lower with two levels of security[25] (table 7).

This can be explained by the fact that subjects fail to reach the no-trade equilibrium in the share market and this is more costly in S2 than S1. In treatments with no gains from trade (S1 and S2), theory predicts no trading activity in the share market. We observe that the number of shares traded is lower when there are transaction fees on shares

eliminate the differences of types of shares accross treatments, we measure this deviation by computing the deviation between the number of coupons received at the end of stage 1 and the theoretical number of coupons received, taking into account the equilibrim number of shares and the scenario drawn in each period. We run the test using one observation per group (average over period 6 to 9). One cannot reject the hypothesis that deviation from equilibrium portfolio of shares is the same in C1 and C2 (two-tailed p-value =0.63). We also run this test on the deviation between coupons held at the end of the experiment and equilibrium number of coupons. One cannot reject the hypothesis that deviation from equilibrium number of coupons is the same in C1 and C2 (two-tailed p-value =0.24). We also have run random effects generalized least squares regressions with clustering, where the dependent variable is the difference (in absolute terms) between the observed variable (profit, number of shares and coupons held) and the theoretical prediction over period 1 to 9. Treatment has no significative effect, as mentionned with the previous tests.

[25]Using Mann-Witney tests based on one observation per group (average total profits over period 6 to 9), the data reject the hypothesis that profits are the same with one or two levels of security for shares (one-tailed p-value = 0.04 with alternative hypothesis S1>S2). This effect is driven by the yellow periods. One cannot reject the hypothesis that total profits are equal in the blue scenario (one-tailed p-value=0.15 with alternative hypothesis S1>S2) but one can reject that there are equal in the yellow scenario (one-tailed p-value=0.04 with alternative hypothesis S1>S2). We reach the same conclusion with the robust rank order test. With U=3.07, the test is significant at the 2.5% level (U right-tail critival value=2.55).

trading but subjects fail to reach the no-trade equilibrium (table 9)[26]. Nevertheless, around one quarter of the subjects reach the equilibrium prediction and don't trade shares in treatment S1 and S2 (29.86% don't trade any shares in S1, 25.65% don't trade low security shares and 25% high security shares in S2). Moreover, there is evidence that subjects learn to approach the no-trade equilibrium as the transaction fees paid in S1 and S2 decreases over time (figure 3)[27]. The failure to reach the no-trade equilibrium can be interpreted as an experimental demand effect [42]. There is more shares traded (table 8) thus more transaction fees paid (figure 3) in S2 compare to S1[28]One explanation is that there are two occasions to trade shares in S2[29]. This leads to the lower performance of the differentiated treatment in terms of average profits when it's costly to trade shares.

Table 10 presents results from random effects generalized least squares regressions with clustering, where the dependent variable is the individual profit in period 6 to 9 in S1 and S2[30]. The treatment variable has a negative sign (as suggested by the non-parametric tests) but the variable is not significant[31]. Contrarily to regressions for treatments C1 and C2, we have no significant learning effect, and no effect of elicited risk aversion and reported risk taking level. The other variables have similar effects than in C1 and C2.

5.2.2 Risk management

The results concerning risk allocation are similar to the C1-C2 comparison. It suggests that a differentiated system do not reduce risk but it improves risk allocation even

[26]Mann-Whitney tests (using one observation per group: the mean number of trades hapenning in a group in the share market over periods 6 to 9) reject the null hypothesis of no impact of transaction fees on quantities traded (one-tailed p-value=0.09 with alternative hypothesis C1>S1 and one-tailed p-value=0.07 with alternative hypothesis C2>S2 for high security shares, p-value=0.02 for low security shares). One can reject the hypothesis that trade of shares is significantly different in with and without transaction fees on shares.

[27]This is consistent with Angrisani and al [1]. They ran side-by side markets with an without gains from trade. By comparing trading activity under the two conditions, they assessed how effectively and through which channels, the no-trade logic is incorporated over time to the behavior of experimental subjects.

[28]Using Mann-Witney tests based on one observation per group (average transaction fees paid over period 6 to 9), the data reject the hypothesis that transaction fees paid are the same with one or two levels of security for shares (p-value = 0.08 for pairwise comparison between S1 and S2 with alternative hypothesis S1<S2).

[29]One can assume that in a design with simultaneous trading of high and low security shares, we will not observe more trades of shares in a the differentiated treatment (compare to the treatments with a single type of shares).

[30]These panel regressions employ a random effects error structure, with the subject representing the random effect. We also cluster the errors at the group level to capture any unobserved heterogeneity in the group.

[31]Nevertheless, if we ran the same regression including all periods (1 to 10 for S2 and 1 to 12 for S1), the treatment variable becomes significant in regressions (1), (2) and (3).

if there is no gains from trading shares. Figure 4 shows that the difference between profits in the blue and the yellow scenario increases for type 1 in S2 (compare to S1) and decreases for type 2. Nevertheless, the significancy of this effect is weak [32].

5.2.3 Deviation from optimal portfolio

The efficiency ratio are significantly lower in S2 than S1 (table 11).

As in the comparison between C1 and C2, looking at the observed portfolio and theoretical predictions (table 12), one can not conclude that deviation from optimal portfolio of shares and equilibrium number of coupons is significantly different between S1 and S2[33].

The complexity of S2 do not have any impact on the capacity of subjects to reach the equilibrium portfolio of shares and coupons as they do not deviate more than in S1. Nevertheless, because they trade more shares than necessary (and even more in S2 than in S1), it has a mechanical negativ effect on efficiency. Hypothesis 3 is supported.

Summary of Hypotheses

Hypotheses		Support
H1: Profits	C1<C2	supported **
	S1<S2	not supported **
H2: Variability of profits	C1>C2 for type 1	supported **
	C2>C1 for type 2	supported NS
	S1>S2 for type 1	supported **
	S2>S1 for type 2	supported NS
H3: Efficiency	C1>C2	not supported *
	S1>S2	supported *
** significant , * partially significant, NS not significant		

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[32] This result is confirmed using the average standard deviation of profit over period 6 to 9. It is lower in S1 (17.79) than S2 (21.27) for type 1 and higher in S1 (55.69) than S2 (52.66) for type 2. However, these differences are not highly significant according to Mann-Witney tests computed on the average standard deviation of profits in a group: Type 1: one-tailed p-value = 0.12 with alternative hypothesis S1<S2 - Type 2: one-tailed p-value = 0.15 with alternative hypothesis S1>S2. Regressions results presented in table 8 are similar than for treatment C1 and C2.

[33] Using the deviation between number of coupons received and theoretical predictions, one cannot reject the hypothesis that deviation from equilibrium portfolio of shares is the same in S1 and S2 (two-tailed p-value =0.48). Moreover, one cannot reject the hypothesis that deviation from equilibrium number of coupons is the same in S1 and S2 (two-tailed p-value =0.87). Results from regression presented in table 16 shows that treatment is not a significant variable to explain the deviation from theoretical predictions.

6 Conclusion

The economic gains expected from water markets depends on the characteristics of the market design and how participants react to the design in the field. In this paper we focus on one market design detail relevant for water market performance: the effect of having different level of security for water rights. This can provide the first steps towards designing more optimal water market regulations to achieve an efficient and cost-effective allocation of water and risks.

While most policy discussions of water markets plans envisage the development of future markets in allocation, no previously reported laboratory experiments have implemented any form of trading future entitlements to water allocation. Godby and al [24] have shown than the introduction of shares improve the performance of the emission trading markets. This result certainly holds for water markets, as illustrated by the increasing activity on water rights market [40]. We have shown that differentiating shares in terms of security can further increase efficiency.

Our results suggest that formal trading of different types of future entitlements to water allocation improve the efficiency of water markets only if trading shares is less costly than trading coupons (treatment C2). However, as soon as allocation market trading is efficient and costless, there is no gains from shares trading, thus no gains from a complexified water rights market. We do observe in the lab that the costs of trading shares offset the gains from a portfolio of shares matching coupon needs (treatment S2). However, a differentiated system seems to improve risk allocation irrespectively of the transaction fees configuration. It suggests that there is a trade-off between water allocation and risk allocation. In the actual configuration of transaction fees in water markets economies (close to S1), introducing different levels of security can decrease the efficiency of water allocation by decreasing total profits from water trade and use but it can improve the risk allocation by decreasing the variability of profits for less risk-tolerant water users. At the moment, there is no exact tool to evaluate the weight of each objective (efficient water allocation and risk allocation) in the farmer and water manager objective functions. As risk becomes a major concern for farmers, a differentiated water rights market will become a valuable water policy option.

In the short term, we could run other treatments and test what is the transaction costs configuration which increases the gains from a differentiated system. Further research could include field experiment with farmers trained in water trading to see if they take better advantage of a differentiated system than non-experimented students.

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Instructions

The instructions are given for treatment C2. There are only minor changes for the other treatments (transaction fees and the type and return of shares).

This document describes the instructions of the second part of the experiment[34]. As a participant in this experiment, you will be asked to make decisions using a computer. This document gives you the instructions of the experiment. Please make sure you understand them correctly. The computer will calculate your gains at the end of the experiment. They will be paid to you privately in cash at the end of the experiment.

General principles of the experiment

The server computer will form randomly 3 groups of 6 participants. You will be part of one group, fixed during all the experiment. You can't identify the other members of your group and they can't identify you.

In this experiment, you will have the opportunity to realize transactions (buying or selling) of different goods: shares A, shares B and coupons. All transactions will be realized in ECUs. Shares and coupons are only intermediary goods that enable to win ECUs.

You can only trade with participants of your own group.

You will play over a number of periods. You will not learn the number of periods until the end of the experiment.

The same rules apply to each period: You are endowed with an initial number of shares and an initial cash endowment of 50 ECUs to start with. In stage 1, you can buy or sell shares A (stage 1A). Then, you can buy or sell shares B (stage 1B). At the stage 1, shares will be converted into coupons according to their "return" and according to the draw of a scenario. In stage 2, you can buy or sell the coupons you received. At the end of stage 2, coupons are converted into ECUs, according to their "benefit".

The following details the relation between shares, coupons and gains in ECUs. Each stage within a period is further detailed.

Shares, coupons and gain of the period

Return of shares

At the end of Stage 1, shares are converted into coupons according to a « return rate ». The number of coupons you obtain from one share depends on the scenario, drawn in each period by the central computer. The scenario can be "Blue" or "Yellow". The scenario is the same for all participants in each period. Both scenario are equally likely (50% chance of being "Blue" and 50% of being "Yellow"). Table 2 gives the number of coupons received from each share according to the scenario.

The number of coupons you receive will always be an integer (nearest highest integer).

For example, if you hold 30 shares A and 9 shares B, you will get

- in the blue scenario: 30*1+round(9*0.5)=35 coupons

[34]The first part was the lottery game to elicit risk aversion

- in the yellow scenario: 30*1+9*0=30 coupons

Benefits from coupons

Each coupon you hold at the end of stage 2 gives you benefits, according to table 3[35]. The marginal benefit of each unit is given in the second column. The total benefit you get is the sum of the marginal benefit of each coupon you hold. The total benefit is given in column 3.

The benefit of each coupon held is typically different from the benefits of other coupons held and your benefits may be different from the benefits of other participants.

For example, imagine your first coupon gives you a benefit of 50 Experimental dollars, your second coupon gives you a benefit of 49, etc. If you hold 2 coupons, your total benefits would be 50+49=99.

Gains

Your gains in ECUs for each period are determined as follows: Gains = Benefits from coupons held at the end of the period + Cash left at the end of the period (=Initial endowment of 50 ECUS + Gains from shares and coupons trading - Expenses from shares and coupons trading).

Detailed information on each stage within a period

Initial endowment

Everyone starts each period with 3 Shares A and 12 Shares B. You also get an initial amount of cash of 50 ECUs at the beginning of each period. You can use this money to buy in the share and coupon market. You can buy shares or coupons only if you have enough cash to do so (no borrowing is allowed). This initial allocation is the same for all participants and for all periods.

Stage 1: Share market

Anyone can adjust their own holding of shares by buying and selling them in the share market in stage 1 that will operate over the computer network. You won't know the return of a share when trading shares as the scenario (blue or yellow) will be drawn only at the end of stage 1.

If you buy a share, you will have to spend ECUs buy shares allow you to get some coupons in stage 2. You will get benefits from each coupon held or you can sell these coupons in stage 2.

If you prefer to buy coupons in the coupon market, you don't need to hold shares. You can get some gains from selling your shares.

You will be first allowed to trade shares A (Stage 1A) and then shares B (Stage 1B).

[35]The table 3 given to the subjects is slightly different as we give them both the marginal benefit and total benefit of each coupon. We also give them only the marginal benefits of their type.

Stage 2: Coupon market

The coupon market (Stage 2) occurs after you learn the scenario and the number of coupons you get from one share. Anyone can adjust their own holding of coupons by buying and selling them in the coupon market in stage 2 that will operate over the computer network.

If you buy coupons and keep them until the end of the period, you will get some benefits from these coupons. If the price of a coupon in the market is lower than your benefit from this coupon, you will have a net gain from buying this extra coupon. If the price of a coupon in the market is higher than your benefit from this coupon, you will have a net gain from selling this coupon.

Transaction fee

Each time you buy or sell a coupon, you will have to pay a transaction fee of 2 experimental dollars. This fee will automatically be withdrawn from your cash amount.

For example, if you find a buyer for one of your coupon at the price of 5 experimental dollars, your net gain from trade will be 5-2=3. The buyer will pay a total of 5+2=7 experimental dollars for this coupon.

You pay no transaction fee to buy or sell a share

Period Results

A summary of the results from the period are shown on the Period Results screen. At the end of the instructions you will find a sheet labeled Personal Record Sheet, which will help you keep track of your earnings. You can copy this information onto your Personal Record Sheet at the end of each period, and then click "continue" to begin the next period. You are not to reveal this information to anyone. It is your own private information.

Earnings

You will play for several periods but you will be paid for only one period. This will be randomly determined at the end of the experiment, where one of the participant will pick a ball from bag where there will be as many balls as periods played. Your final earnings will be the earnings of the period corresponding to the number of the ball drawn.

All earnings on your computer screens are in ECUs. These ECUs will be converted to real euros at the end of the experiment, at a rate of 1 ECUs= 0.2 real euro.

Before you begin making decisions for real money, we will conduct 2 practice periods for you to get comfortable with the trading software. This practice period does not affect your experiment earnings.

How to Buy and Sell

The trading software enables to trade one share or one coupon at a time. At any time during either market stage, everyone is free to buy an extra unit:

- by making an offer to buy and choose the price offered,

- by buying at the best offer price specified by someone wishing to sell,

You can also sell a coupon or a share:

- by making an offer to sell and choose the price offered,
- by selling at the best offer price specified by someone wishing to buy.

You will enter offer prices and accept prices to execute transactions using your computer.

A screenshot of the market stage is given to the subject.

Some information is given on the upper right of the screen (time left, cash, number of shares ...). This information is updated after each trade in the period.

Each time you enter an offer to buy or sell, this offer price is immediately displayed on all traders' computers on the part of the screen labeled "Buy Offers" or "Sell Offers". Once an offer price has been submitted, anyone can accept this price offer. Such an acceptance results in an immediate trade at that price. The previous trading prices in the current period are displayed in the "Trading Prices" list in the center of your computer screen.

If there are already buy offers displayed in the current period, then new buy offers submitted by anyone wishing to buy must provide better trading terms to the sellers. Sellers prefer higher prices, so any new buy offers must be higher than the current highest buy offer. Your computer will give you an error message if you try to offer a lower price than the best price currently available. If there are already Sell Offers displayed in the current period, then new sell offers submitted by anyone wishing to sell must provide better trading terms to the buyers. Buyers prefer lower prices, so any new sell offers must be lower than the current lowest sell offer. Your computer will give you an error message if you try to offer a higher price than the best price currently available.

Eventually, after your trade has been finalized, all your previous offers will be removed from the system. To trade another coupon or share, you will need to submit a new offer. For each share or coupon you want to sell or buy, the price you offer can be different.

Summary

Figure 1 summarizes the different stages of the game. Note that you will make decisions only in the stages represented by solid lines boxes.

- Your gains in ECUs for each period is the sum of the cash you have at the end of a period and the benefits you get from the coupons you held.
- You can trade shares A in stage 1A and shares B in stage 1B, before knowing the scenario. You can then trade coupons in stage 2, once the scenario is known.
- The number of coupons you get from one share depends on the scenario ("Blue" or "Yellow") and the type of share (A or B). see Table 2

- Your benefits from holding coupons are shown in Table 3 (in ECUs).
- You pay a transaction fee of 2 ECUs to buy or sell a coupon. There is no transaction fee to trade shares.
- Everyone starts the experiment with an initial endowment of 50 ECUs and some initial number of shares (3 shares A and 12 shares B). These numbers are the same for all the participants in the room.
- Shares are not kept from one period to the other. At the beginning of a period, you start with the initial number of shares.
- Your final earning will be the earning from the period corresponding to the number drawn randomly from the bag at the end of the experiment. You gains of this period in ECUs will be converted to Euros at the end of the experiment, at a rate of 1 ECU = 0.2 Euro.

Figures

Table 1: Treatments

	One level of security	Two levels of security
Transaction fees in the coupon market only	C1	C2
Transaction fees in the share market only	S1	S2

Figure 1: Game structure

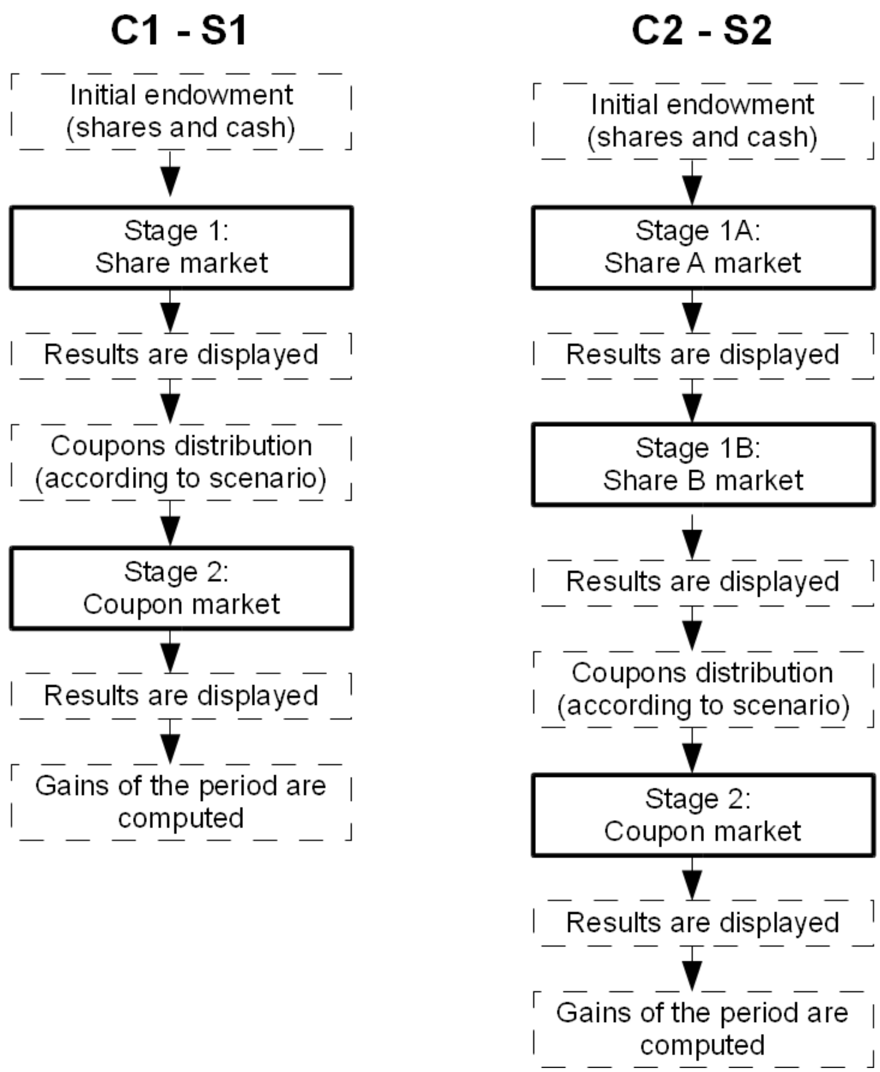

Table 2: Coupons allocation

	Blue scenario	Yellow scenario
Number of coupons received from 1 Share	1	0.33
Number of coupons received from 1 Share A	1	1
Number of coupons received from 1 Share B	0.5	0
Total number of coupons allocated in a group	54	18

Table 3: Marginal benefit (in ECUs) for coupons held at the end of a period

Coupons	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	>=16
Type 1	10	9	8	7	6	5	4	3	2	1	0	0	0	0	0	0
Type 2	0	0	0	24	22	20	18	16	14	12	10	8	6	4	2	0

Figure 2: Equilibrium in the coupon market

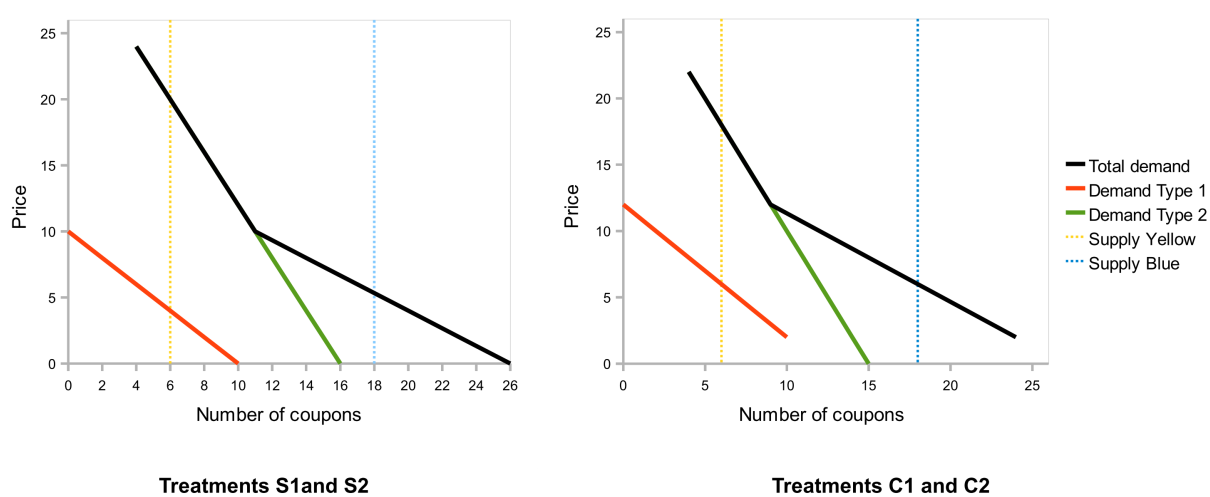

Table 4: Coupon market equilibrium

	C1-C2	S1-S2
Blue scenario		
Coupons held by Type 1 at equilibrium	6	5
Coupons held by Type 2 at equilibrium	12	13
Equilibrium price	6	4.67
Yellow scenario		
Coupons held by Type 1 at equilibrium	0	0
Coupons held by Type 2 at equilibrium	6	6
Equilibrium price	[10;20]	[12;18]

Table 5: Share market equilibrium (C1 - C2)

	C1	C2	
	Shares	Shares A	Shares B
Number held by Type 1	6	0	12
Number held by Type 2	12	6	12
Equilibrium price	[4.67;6.33]	[8;13]	

Table 6: Equilibrium profits

	C1	C2	S1	S2
Blue scenario				
Type1	[109;114]	[119;134]	109	109
Type2	[175;180]	[155;170]	181	181
Total (6 subjects group)	[852;882]	[822;912]	870	870
Yellow scenario				
Type1	[84;101]	[74;89]	[80;110]	[80;110]
Type2	[57;74]	[77;92]	[56;86]	[56;86]
Total (6 subjects group)	[423;525]	[453;543]	[408;588]	[408;588]
Average difference between scenarios				
Type1	19	45	14	14
Type2	112	78	110	110
Total (6 subjects group)	393	369	372	372

Table 7: Average profits

	C1	C2	S1	S2
Average profit	626	656	655	629
Blue scenario	796	836	839	815
Yellow scenario	455	475	471	443
Difference Blue Yellow	341	361	368	372

*These statistics are computed as average of period 6 to 9

Table 8: Number of trades in a group

	C1	C2	S1	S2
Shares				
Shares	8.33 (9)		5.42 (0)	
Shares A		6.29 (9)		4.62 (0)
Shares B		9.08 (0)		4 (0)
Coupons				
Blue scenario	2.83 (0)	3.17 (0)	9.42 (12)	5.75 (12)
Yellow scenario	4.08 (6)	2.17 (0)	5.75 (9)	3.92 (9)
Average	3.46	2.67	7.58	4.83

*Equilibrium predictions are presented in parenthesis
***These statistics are computed as average of period 6 to 9

Figure 3: Transaction fees paid by each subject

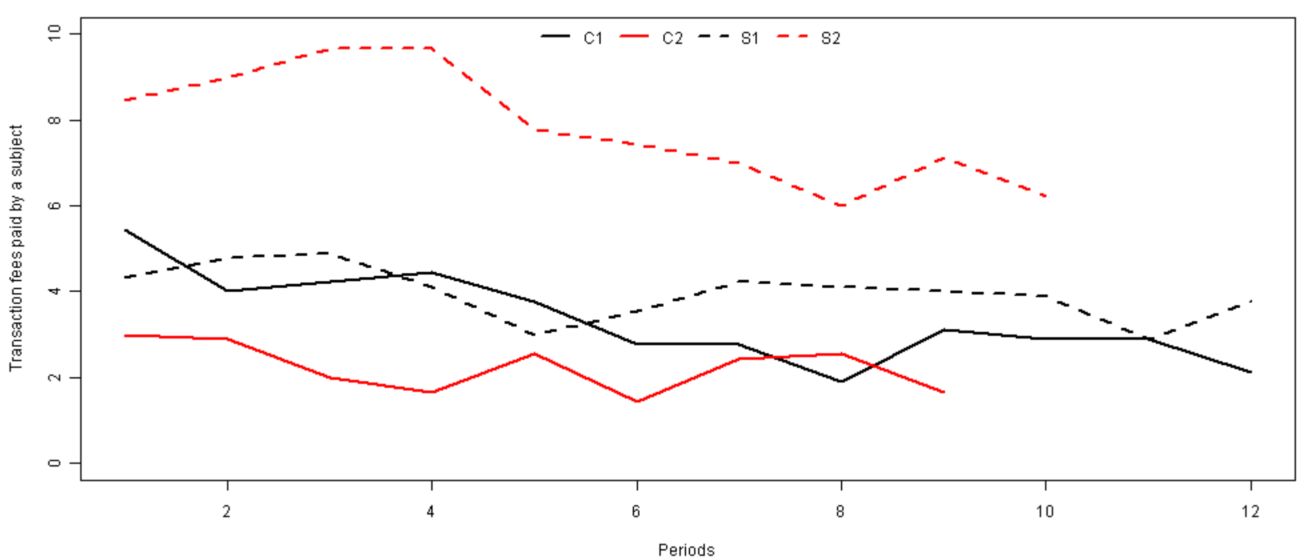

Table 9: Regression Profits

	C1-C2		S1-S2	
periods	all	6 to 9	all	6 to 9
period	0.494***	0.492**	0.669***	0.153
	(0.132)	(0.214)	(0.136)	(0.318)
treatment C2	4.531***	4.223**		
	(1.530)	(1.691)		
treatment S2			-3.945*	-2.859
			(2.115)	(2.041)
yellow scenario	-59.77***	-59.66***	-62.38***	-63.27***
	(2.940)	(2.792)	(1.468)	(1.592)
type1	-15.12***	-15.56***	-16.57***	-15.98***
	(3.908)	(3.932)	(3.644)	(3.617)
ERA	1.231	0.431	0.345	0.0537
	(0.938)	(0.855)	(0.964)	(1.041)
reported risk taking	-9.775**	-6.409*	-4.395	-3.273
	(4.048)	(3.517)	(3.342)	(3.331)
Constant	137.6***	141.5***	144.4***	149.5***
	(6.313)	(5.848)	(5.341)	(6.837)
Observations	672	256	728	264
Number of subject	64	64	66	66
chi2	10358	19981	8367	49994
sigma_e	23.25	23.10	20.47	21.50
sigma_u	11.24	2.746	11.21	7.017
rho	0.189	0.0139	0.231	0.0962
r2_w	0.642	0.692	0.713	0.745
r2_o	0.600	0.650	0.659	0.682
r2_b	0.413	0.401	0.311	0.288

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 10: Regression Variability of profits

	C1-C2		S1-S2	
Type	1	2	1	2
Treament C2	7.877**	-7.941		
	(2.561)	(7.671)		
Treatment S2			7.245	-1.908
			(4.239)	(5.927)
ERA	-2.064	-2.295	-2.318	-2.230
	(1.227)	(1.794)	(1.431)	(1.906)
Reported risk taking	3.084	10.137	-4.091	12.105*
	(6.118)	(7.544)	(5.464)	(6.600)
Constant	36.863***	106.696***	45.789***	100.109***
	(8.059)	(9.930)	(9.475)	(10.118)
Observations (period 6 to 9)	132	124	128	136
R-squared	0.144	0.169	0.210	0.104

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 11: Efficiency ratio

	C1	C2	S1	S2
Efficiency	93.25	96.10	95.80	91.96
p-value	*alt. hyp. C1<C2:*	*0.12*	*alt. hyp. S1>S2:*	*0.02*
No-trade-efficiency	102.46	107.43	105.78	101.53
p-value	*alt. hyp. C1<C2:*	*0.04*	*alt. hyp. S1>S2:*	*0.02*

*These statistics are computed as average of period 6 to 9

Table 12: Number of shares and coupons held

		C1	C2	S1	S2
Shares					
Shares	Type 1	7.96 (6)		8.18 (9)	
	Type 2	10.04 (12)		9.82 (9)	
Shares A	Type 1		1.56 (0)		2.18 (3)
	Type 2		4.44 (3)		3.82 (3)
Shares B	Type 1		11.14 (12)		11.75 (12)
	Type 2		12.86 (12)		12.25 (12)
Coupons received after stage 1					
Yellow scenario	Type 1	2.69 (2)	1.53 (0)	2.78 (3)	2.17 (3)
	Type 2	3.42 (4)	4.47 (6)	3.39 (3)	3.83 (3)
Blue scenario	Type 1	8 (6)	7.56 (6)	8.36 (9)	8.36 (9)
	Type 2	10 (12)	10.94 (12)	9.64 (9)	10.17 (9)
Coupons					
Yellow scenario	Type 1	2.06 (0)	0.94 (0)	1.08 (0)	1.11 (0)
	Type 2	4.06 (6)	5.06(6)	5.08 (6)	4.89 (6)
Blue scenario	Type 1	7.39 (6)	6.69(6)	6 (5)	6.61 (5)
	Type 2	10.61 (12)	11.81 (12)	12 (13)	11.92 (13)

*Equilibrium prediction are presented in parenthesis

**These statistics are computed as average of period 6 to 9