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Factors influencing farmers' willingness to participate in water allocation trading. A case study in southern Spain

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Abstract

This study aims to uncover the factors that influence farmers' attitudes towards water allocation trading. In the study, we simulate two water availability scenarios, an average year and a drought year, in a contingent valuation experiment with 241 farmers. A survey was held in the spring of 2012 in the Guadalquivir and Almanzora River Basins. First, we estimated a multinomial logit model to determine the factors that influence farmers to decide to participate in our hypothetical market. We then analysed the structural and socio-economic factors determining the monetary value of traded water using Heckman's two-step model. Our results indicate that those farmers who are more innovative and have had agricultural training show a higher willingness to participate in water trading. Additionally, low water-supply guarantee and appropriate information about seasonal water availability increase the probability of participation. Higher willingness to pay (WTP) for water is found in horticulture and among farmers who grow citrus and other permanent crops; lower water selling value (WTA) is found in farms with extensive annual crops and traditional olive groves. However, monetary values (WTP/WTA) are strongly dependent on the current cost of irrigation water services. While findings of this research seem to support the idea of diffusion innovation theory, the existence of ethical concerns that might influence farmers' acceptance of irrigation water markets needs further analysis.

Additional key words: contingent valuation; irrigation; farmer's attitude; Heckman model; water markets

Abbreviations used: CV (contingent valuation); MNL (multinomial logit); VIF (variance inflation factor); WFD (water framework directive); WTA (willingness to accept); WTP (willingness to pay); WUA (water user association)

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Introduction

Water trading is increasingly seen as an appropriate method to flexibly allocate scarce water rights and to help achieve economically efficient water use. Using markets can be especially useful in areas that face frequent periods of drought and water shortages. The strategic document on water management by the European Commission (EC, 2012) proposes the use of water markets as one of the instruments to be employed in agriculture to achieve the goals of the Water Framework Directive (WFD).

Spain was the first European country to set up a water-rights market. Irrigators, who are the main water users in Spain, can buy and sell only their yearly water allocations (temporary) within the stipulations of the Water Law and subject to the approval of the Water Authority if a transaction involves an inter-basin transfer.[1] However, since the adoption of the Water Law, the number of actual transactions has been limited and only during times of drought has market trading reached any level of importance (Hernández & De Stefano, 2013; Rey *et al*., 2014).

[1] Formal water markets were first introduced in Spain in 1999. Temporary trading of water rights is permitted while permanent transfer of water rights is not allowed. Notwithstanding, there have been some exceptions. Palomo *et al*. (2015) reported a detailed description of the law evolution since 1999.

Judging by the experience of countries with similar climatic conditions, such as Australia and Chile (Bjornlund, 2003; Wheeler *et al*., 2010), the Spanish water market could be expected to grow in importance. On the other hand, in the United States (California, Colorado and Texas) market mechanisms have been in place longer and trading remains limited (Grafton *et al*., 2010). Alberta (Canada) is another example where water markets, established in the last decade, have only generated limited trading activity (Nicol & Klein, 2006; Bjornlund *et al*., 2014).

Most of the existing research on the topic in Spain has been based on mathematical models and simulation (*e.g.*, Arriaza *et al*., 2002). Although there is a lack of empirical evidence, the little evidence that is available shows that water markets do not achieve the performance that the theoretical and simulation work anticipates. To attain the full potential of water markets, deeper knowledge is required of the factors that influence farmers' acceptance of the mechanism.

For instance, Cook & Rabotyagov (2014) analysed irrigators' preferences for water market lease attributes in the Yakima River basin in Washington state and found that farmers as sellers take account of non-pecuniary elements in the relative comparison of their profit from farming and their profit from agreeing to a deal. Wheeler *et al*. (2009) demonstrated that the water market development in Australia follows an innovation adoption model in agriculture. As a consequence, there would be some other social factors (*e.g.*, farmer's age, his/her education) along with the basic economic convenience that influences farmers' participation.

Ortiz & Ceña (2001) analysed farmers' perception of water rights in the Guadalquivir at the time of the first water reform in 1999. While the law established the water right license (*i.e.*, concession), farmers still perceived it as a property right. It is likely that beyond that, the water right license has been attached to the land (Palomo *et al*., 2015). Giannoccaro *et al*. (2013) highlighted the importance and diversity of stakeholders' attitudes towards water markets in the Guadalquivir Basin, which range from radical opposition, for either ethical or strategic reasons, to their acceptance, although under restricted conditions. These authors find that all stakeholders (*i.e.*, managers, water right holders and non-holders) are highly reluctant to permanently sell their water rights while managers and water rights holders would accept temporary allocation trading mechanisms.[2]

This study will focus on temporary allocation trading in southern Spain where significant market transactions between the Guadalquivir River Basin and the Almanzora Basin took place in 2006 and 2007. While the traded volume in those transactions was considerable (2% of total water allocations), only a small number of agents were involved.[3]

The early stages of market development are usually characterized by unfamiliarity, the existence of trade barriers and slow market activity, resulting in a limited number of transactions among a small number of operators (Nicol & Klein, 2006; Wheeler *et al*., 2010). The resulting lack of competitiveness can lead to biased market prices and traded volume (Giannoccaro *et al*., 2015).

Based on the actual transactions within the Goulburn–Murray Irrigation District, Wheeler *et al*. (2009) analysed the early years of water trading in Australia. Here we aim to provide a wider overview of farmer attitudes towards water trading in the two basins. For this, we carry out a contingent valuation (CV) experiment and analyse how structural, socio-economic and climatic factors (*i.e.*, drought) would influence farmers' participation in irrigation water markets as well as their willingness to pay (WTP) for water allocations and their willingness to accept (WTA) selling them.

The first results of this CV experiment are reported in Giannoccaro *et al*. (2015), who reconstructed the market supply and demand for irrigation water. While they focused on the quantitative impacts of allocation trading in southern Spain, here we will analyse the factors influencing farmers' willingness to participate.

Our approach to market acceptance is based on the hypothesis that irrigation water trading might be seen as an innovation enabling a new form of water management as input of farming activity. As a consequence, as a seller the farmer's adoption will occur if the expected utility from trade outweighs the utility from continuing to irrigate or continuing to water. As a buyer, the farmer's adoption is driven by the major utility expected by purchasing water on the market. This also implies that the farmer's utility function may diverge depending on the farmer and according to water productivity (*i.e.*, crops), socio-economic factors and farm-related features. The diffusion of innovation theory (Rogers, 2003) is the main reference for this approach.

The CV methodology has been used in Spain to estimate the WTP for irrigation water, as in Calatrava

[2] Here it is interesting to mention the Goulburn-Murray Basin in Australia, which is probably the most dynamic irrigation water market worldwide. Bjornlund (2003), Bjornlund & Rossini (2005) and Wheeler *et al*. (2010) all analyse its market development and show that the majority of transactions has occurred through temporary allocation trading.

[3] These inter-basin transactions are described in detail in Berbel *et al*. (2014).

& Sayadi (2005) on the Granada coast, or Colino & Martinez (2002) in southeastern Spain. Research on the WTA monetary reward for selling irrigation water, as in Garrido *et al.*'s (1996) study of the Guadalquivir River Basin, is scarcer. The main conclusion from these studies is that farmers much prefer buying water on the market than they do selling it. CV studies have also been applied in the context of irrigation water to evaluate farmers' WTP for water supply guarantees (Mesa-Jurado *et al.*, 2012) or the use of wastewater (Alfarra *et al.*, 2013).

This study seeks to identify the profile of irrigators in the Guadalquivir and Almanzora River Basins who are likely to use water markets to cope with water shortages. First, a multinomial logit model (MNL) is estimated to determine the factors that influence farmers' willingness to buy and sell water in principle. Second, the monetary value of traded water is analysed using Heckman's two-step model.

Material and methods

Study area

The analysis is carried out for the Guadalquivir and the Almanzora River Basins. The first has more irrigated area than any other basin in Spain, and the second, with its concentration of greenhouses and high value crops, is home to the most profitable irrigation agriculture in the country. Together they represent roughly 25% of Spain's irrigated area. Both basins are located in southern Spain and have a Mediterranean climate and a heterogeneous precipitation distribution. The variability in water availability and recurrent droughts, lead to periods in which water scarcity reaches critical levels.

The Guadalquivir River is the longest in southern Spain with a length of around 650 km. Its basin covers an area of 57,527 km^2 and has a population of over 4.2 million people. The annual average temperature in the Guadalquivir River Basin is 16.8ºC and it has an average precipitation of 630 mm/year. The most common types of land cover/use in the basin are forests (49%) and agriculture (47%), with the remainder covered by urban areas (2%) and wetlands (2%). Overall available water resources stand at 3362 Mm^3/year, while net demand in 2008 rose to 3578 Mm^3/year, 2981 Mm^3 of which was for irrigation. The irrigated area in the Guadalquivir Basin comprises 845,000 ha, including olive groves, fruit orchards (mainly citrus and peaches) and general field crops, such as cotton, maize, sunflowers and sugar beet. A small proportion is also dedicated to rice farming near the river estuary. Olive groves make up almost half of the irrigated area, and are cultivated in both a traditional, extensive system and an intensive farming system. Irrigation has always been part of the intensive system, but application of deficit irrigation has now become more common in the traditional system as well, which has led to a large increase in irrigation over the last decade (Berbel *et al.*, 2012). The average applied irrigation in the basin is 3324 m^3/ha. Berbel *et al.* (2013) described the basin's trajectory towards basin closure, illustrating that available resources are already fully or over-committed. The current hydrological plan for the basin proposes a programme of measures to tackle the water imbalances (Berbel *et al.*, 2012).

The Almanzora River is located in the Almería Province. Administratively, it is part of the Mediterranean River District, which consists of a number of small and very small reservoirs. Groundwater in the district is exploited on a large scale and salt intrusion is common along the coastline. The Almanzora Basin is the eastern-most basin in the district and is characterised by high value, mainly citrus, vegetable and greenhouse crop production within the Bajo-Almanzora while olive tree in the Alto-Almanzora. On average, 4925 m^3/ha of irrigation water is applied, which in 2008 amounted to an overall demand of almost 267 Mm^3.

An inter-basin transfer system connects the Guadalquivir River to the Almanzora Basin, through which the Government transports 50 Mm^3/year from the former to the latter in the absence of drought conditions in the Guadalquivir Basin. The transfer system makes inter-basin trading a possibility, but actual trading, at both intra and inter-basin level, is still uncommon. The few markets operations that have taken place consisted of large volume inter-basin transfers, from field crop irrigators in the Guadalquivir Valley to greenhouse vegetable producers in Almería. In 2006 and 2007, both drought years, 8.5 Mm^3 and 35.5 Mm^3 were traded, respectively; the price was 0.18 EUR/m^3.

Hardly any trading operations over the last years have been carried out because of extraordinary rainfall patterns. Indeed the 2009 and 2011 have been the rainiest years over the last 50, and never occurred in 2009 the catchment storage limit was reached.

Survey description

In the spring of 2012, a survey was administrated among 241 farmers in the Guadalquivir and Almanzora River Basins (79% from the Guadalquivir Basin and 21% from the Almanzora Basin). A comparison of the sample and the overall population is given in Table 1. In the Guadalquivir, farmers were sampled

Table 1. Representativeness of the sample.

Variables	Guadalquivir			Almería	
	Study area‡	Sample (191 Obs.)		Study area	Sample (50 Obs.)
Irrigated land (ha)	842,055	6,629		54,290	1,079
Water rights					
holder	81%	80.1%		95%	100%
non-holder	19%	19.9%		5%	0%
Water allocation (normal year)	3,950 m^3/ha	4,170 m^3/ha		n.a.	n.a.
Water use (normal year)	3,324 m^3/ha	2,524 m^3/ha		4,925 m^3/ha	3,963 m^3/ha
Farm size (mean)	16.5 ha	41.16 ha		14.2 ha	19.24 ha
Irrigated land area (mean)	9.3 ha	26.40 ha		9.2 ha	17.38 ha
Irrigated crops‡					
Winter cereals	76,400 ha (9%)	697 ha (10.5%)	Citrus	7,370 ha (12%)	298 ha (27.6%)
General field crops†	144,546 ha (17.4%)	1,409 ha (21.3%)	Olive	19,318 ha (30%)	44 ha (4.1%)
Olive	466,677 ha (55.4%)	3,307 ha (49.9%)	Vegetable	6,834 ha (10%)	92 ha (8.5%)
Citrus and fruit	58,521 ha (7%)	393 ha (5.9%)	Greenhouses	29,000 ha (45%)	591 ha (54.8%)
Others	95,908 ha (11.2%)	824 ha (12.4%)	Others	1,827 (ha) (3%)	54 ha (5%)

Source: Giannoccaro *et al.* (2015). † General field crops: maize, sugar beet, sunflower, vegetables. ‡ In parenthesis, percentage of irrigated area.

from the Seville, Cordoba and Jaen provinces. In the Almanzora Basin, farmers were surveyed in 10 municipalities out of 27. Of these latter respondents, 80% were from Bajo-Almanzora. To study the variation of the perception of water markets across the two basins, the sampling procedure included several features such as location, irrigated farm size, crop pattern, as well as irrigation water availability. Moreover, interviews were carried out with water rights holders and non-holders.

The questionnaire included 35 structured questions over four parts: i) socio-demographic information; ii) farm characteristics; iii) irrigation issues; and iv) contingent valuation questions.

We collected the main farm-related data such as structural (*e.g.*, farm size, irrigated land) and crop systems features as well as data concerning the farmer – namely, farmer's age, educational level, agricultural income and whether he or she was/had an on-farm family employee (see Table S1 [online resource]). Moreover, according to the aim of this research, a number of questions on the irrigation market were asked.

In the CV part of the questionnaire, farmers were first asked whether they would be willing to buy or sell water in principle.[4] Those respondents disagreeing were asked to give the main reason. Four closed options plus an open answer were given as follows: a) fear that the government will reduce my allocation in the future if I sell it; b) lack of enough information about or knowledge of the booking procedure; c) mistrustful information about the water-trading mechanism; d) water should not be a tradable good; and e) specify other reason. These options were set based on the literature review.

When a farmer declared he or she was in favour of water trading, separate auctions were simulated for buying and selling. A first closed bid was made at 0.18 EUR/m^3 and depending on the farmer's response, the price was increased or decreased by 33% (0.24 or 0.12 EUR/m^3 bids, respectively). After this, the farmer was asked the maximum (minimum) water price (s)he would be willing to pay (accept).

The hypothetical auctions were carried out under two water availability scenarios: i) a normal year and ii) a drought year, with allocations in the latter restricted to half their usual level. Two fixed tradable volumes were proposed to all farmers: 500 and 1,000 m^3/ha/year. Both volumes and the starting price in the auctions were in line with real figures from the 2006 and 2007 operations. This is also in agreement with the results of Cook & Rabotyagov (2014) who found that sellers are more likely to accept split-season than full-season leases. Generally, resource scarcity might affect the willingness to engage in a market as a seller (Oses & Viladrich, 2007). Finally, an open section was given for those who left other comments.

[4] As one of the reviewers has noticed, the majority of farmers in Spain are not holders of rights themselves but members of water users associations (WUA) that are the effective holders of the water concessions. Most farmers cannot directly trade water but only through the WUA they belong to. Their individual opinion cannot be taken as an approximation of the real potential for water trading, as such an opinion would be filtered through a voting process in the WUA that they belong to. Palomo *et al*. (2015) also pointed out this kind of barrier.

As a whole, 199 out of 241 farmers (82.6%) had access to water resources. Of them, 195 apply irrigation. In particular, 176 respondents are members of WUA, 67 hold a private well and 25 rely on other sources. The average water use per hectare in the Guadalquivir Basin amounts to 2,524 m^3/ha and 4,000 m^3/ha in the Almanzora Basin. Although these values are below the average water use in a normal year, the figure shows the differences between the two basins. By contrast, on average, farms in the sample are larger than those in the study area as a whole, especially within the Guadalquivir Basin.

Despite the survey's small size, the sample representativeness is satisfactory considering the large variability exhibited within and between the study areas. A comprehensive description of the survey can be found in Giannoccaro *et al*. (2015).

Methodology

The survey data are analysed in two phases: in the first phase, using a multinomial logit model, we determine the variables that influenced a farmer's decision to participate in the hypothetical water market, while in the second phase, the determinants of the WTP/WTA monetary values are estimated using Heckman's two-step model.

As we show later, we used the MNL model to estimate farmers' decisions about water market participation and thereby analysed four independent alternatives, each of which has a different motivation, instead of the simple dichotomic choice (*i.e.*, whether or not to enter the water market), as in Heckman's first step. Indeed, the first step in Heckman's model intends to resolve the possible problem of sample bias rather than estimate the determinants of farmers' participation in water trading.

Participation decision

In the first phase of the CV analysis we determined farmers' attitudes towards water trading. Farmers are firstly positioned in a hypothetical situation of temporal necessity and then asked whether they would be willing to buy water. Subsequently, for the same farmers a hypothetical situation of having a surplus is created when they are asked whether they would be willing to sell. These questions are posed under two scenarios of water availability a normal year and a drought year with allocations in the latter reduced by 50%.

The economic theory underlying stated preferences assumes that the most preferred option yields the highest utility for the decision maker. For instance here, a decision maker is a farmer, labeled i, that faces a choice among J alternatives.

Mutually exclusive alternatives for the different attitudes that farmers can have to water markets are: not willing to participate in a water market; only willing to buy; only willing to sell;willing to both buy and sell.

The decision maker obtains a certain level of utility from each alternative. It is assumed that the farmer chooses the alternative that provides the greatest utility.

For the i-th farmer faced with J choices, suppose that utility of choice j is:

$$U_{ij} = V_{ij} + \varepsilon_{ij} \;\; \forall J \qquad [1]$$

where U_{ij} refers to the utility of farmer i-th obtained from choice alternative j; V_{ij} is an observable portion of the utility function and ε_{ij} captures the unobserved influences on a respondent's choice. The observed (V_{ij}) part of utility is specified to be linear in parameters with a constant:

$$V_{ij} = x'_{ij}\beta + K_j \;\; \forall J \qquad [2]$$

where x'_{ij} is a vector of variables that relate to alternative j as faced by decision maker i-th, β are coefficients of these variables, and K_j is a constant that is specific to alternative j.

On the other hand, ε_{ij} $\forall$ j is not known and therefore these terms are treated as random. Assumption on the distribution form of ε_{ij} makes the differences of discrete choice models. Logistic is by far the most widely used discrete choice model. It is derived under the assumption that ε_{ij} is extreme value for all i. The critical part of assumption is that the unobserved factors are uncorrelated over alternatives, as well as having the same variance for all alternatives. For more details see Train (2003).

The multinomial (logit) model is the most frequently used model for nominal outcomes which cannot be ordered. In the case of multinomial regression, the effects of independent variables are allowed to differ for each outcome. In estimating the model a reference alternative j=0 with β_0 =0 is set while the probability that a farmer chooses alternative j=1,2,3 is given by:

$$\Pr(Y_i = j) = \frac{e^{\beta_j \chi_i}}{1 + \sum_{1}^{3} e^{\beta_j \chi_i}} \; ; j=1,2,3 \qquad [3]$$

The multinomial logit model determines which variables explain a farmer's likelihood to be in each of the aforementioned alternatives (j=1,2,3) against to the reference alternative j=0. The alternative 'not willing to participate in a water market' (No participation) was used as the base option. The estimated coefficients of the independent variables indicate the probability of belonging to the class ‘only willing to buy’ or ‘only willing to sell’ or ‘willing to buy and sell’, compared to farmers unwilling to participate in a water market.

Initially, as predicted by the diffusion innovation theory (Rogers, 2003) variables that most conformed to the technology inspired diffusion hypothesis included: farm’s age, education, agricultural training, farmer’s innovativeness, farm size (total and irrigated). As a consequence, younger, higher educated, with a farming training, and mostly innovative farmers with larger irrigated farmland will be more likely to enter the water market to trade. As further consideration, the awareness of previous trading operation increases the likelihood of participation (Bjornlund, 2006; Giannoccaro *et al*., 2013). Once the decision of adoption is taken, a farmer can act as seller, buyer or both, depending on the seasonal water availability and consumption. In this case, at least two variables might be related to irrigator’s decision, namely the advance knowledge about water availability and the water supply reliability. These pieces of information can help farmers to make rational decisions whether sell or buy water allocation on the market. Finally, we expect that farms with extensive herbaceous crops will be more likely to sell being more flexible in their crop pattern and water consumption while farms with vegetables or intensive olive threes, will be mostly the buyers.

The definition and descriptive statistics of the independent variables can be found in Table S1 [online resource].

Determinants of WTP and WTA values

Several of the observed variables are censored, the most relevant of which are the monetary values for WTP/WTA; they are only available for those who would participate in water trading. Obviously, for non-participating farmers there are no data. Consequently, a simple linear OLS model cannot be used to estimate a function of WTP/WTA, because the self-selection of the sample based on the willingness to trade violates the random selection process assumed in this model.

Heckman (1979) proposed a two-step procedure to account for self-selection processes within a sample. First, the probability of participating in the water market (yes or no) is estimated through a probit model, which is a function of X_i independent variables and is named the ‘selection equation’. The residuals of the selection equation are used to construct a selection bias control factor, which is called lambda (λ) and is equivalent to the inverse Mills’ ratio. For each observation this factor summarizes the effects of all unmeasured characteristics that are related to market participation.

In the second step, the principal (or substantial) equation –in our case the WTP/WTA monetary values– is estimated by OLS, in which the selection bias correction factor (λ) is included as an additional independent variable. Formally:

$$Step1: \hat{\lambda}_i = \frac{\phi\left(X_i'\hat{\beta}\right)}{\Phi\left(X_i'\hat{\beta}\right)} \qquad [4]$$

$$Step2: WTA_i / P_i = W_i'\alpha + a_\lambda \hat{\lambda}_i + u_i \qquad [5]$$

If λ is significant, there is selection bias, and its coefficient corrects the influence that the explanatory variables have on WTP and WTA: upwards (negative coefficient) or downwards (positive coefficient). In this study an adaptation of the Heckman model is used in which the selection equation is estimated by logit rather than probit regression as proposed by Lee (1983), and the principal model is estimated by weighted least squares to avoid bias caused by heteroscedasticity. The statistical package SPSS (version 17) is used to estimate the Heckman model following the method described by Smits (2003).

Results

Participation decision

Of the 241 administered questionnaires, 172 provided valid observations in the valuation section of the questionnaire, 129 from the Guadalquivir Basin and 43 from the Almanzora Basin. The following cases were excluded from the analysis: farms without irrigation or current water rights (as only those farms that hold rights are allowed to trade under the current legislation); farmers who intended to exit the sector; and farmers who did not answer the valuation questions.

Farmers’ attitudes towards water trading differed substantially between the basins (Table 2). Almost all irrigators in the Almanzora Basin were willing to trade, both buying and selling water allocations under both rainfall scenarios. Diversely, in the Guadalquivir Basin, the majority was unwilling to trade in either scenario (59% in a normal year and 52% under drought conditions). For those who were willing to participate, most wanted to sell in a normal year and buy when there is a drought.

Table 3 reports the results of the MNL models. The predictive ability of the estimated models is good (see -2LL ratio and pseudo R^2) while 79% of the observations are classified correctly in all models (classifica-

Table 2. Participation frequency (number of observations).

	Guadalquivir Basin		Almanzora Basin	
	Normal year	**Drought year**	**Normal year**	**Drought year**
No participation	76	67	2	2
Only-Buy	4	37	1	1
Only-Sell	39	4	0	0
Buy-and-Sell	10	21	40	40
Total	129	129	43	43

Source: Own elaboration of survey data.

Table 3. Farmers' participation in a seasonal water market.

Variables	Normal year[a]		Drought year[b]	
	Buy-and-Sell	**Only-Sell**	**Buy-and-Sell**	**Only-Buy**
Constant	–10.824	9.477*	–6.423	–4.536
Irrigation area (ha)	0.029	0.003	0.047	0.023
Water consumption (m^3/ha)	0.147	–0.172**	0.044	0.024
Farmer's age	–0.004	–0.066*	–0.003	0.005
Educational level	–1.849*	–0.666	–1.670*	0.134
Farm training	3.465**	0.123	2.988***	0.772
Aware of water trading	1.293	1.081	1.058	1.342*
Innovation	3.393*	1.767*	3.710***	–0.144
Rain fed crops	1.247	0.341	0.440	–2.131*
Advance knowledge about water availability	22.002***	3.220***	3.961*	0.172
Guarantee water supply	–3.092*	0.987	–1.789	–0.684
Multiple water sources	–0.637	–0.094	0.916	1.223
Extensive herbaceous crops	–5.007*	1.583*	–4.693**	1.045
Vegetable crops	–0.779	–1.455	–1.329	–0.429
Traditional olive crop	–5.768***	–0.384	–4.062***	0.802
Intensive olive crop	–1.061	0.135	–0.923	–0.908
Other permanent crops (citrus, fruit, vineyard)	–1.883	1.193*	–2.726*	–3.051**
	–2 Log Likelihood: 138.018 R^2 MacFadden: 0.626		–2 Log Likelihood: 164.946 R^2 MacFadden: 0.525	

[a] The class *Only-Buy* had very few observations, therefore was excluded; [b] The class *Only-Sell* had very few observations, therefore was excluded; *** significant at 0.01 level; **significant at 0.05 level; * significant at 0.1 level.

tion plots are reported in Table S2 [online resource]). The variance inflation factor (VIF) to check for multicollinearity is 2, below the tolerance limit. Table 3 reports the coefficients β and the significance of each variable influencing the farmer's decision to participate in the market. The sing of coefficient can be interpreted as a major or minor probability for a farmer being in one of the different classes of participation *(i.e. Buy and Sell, Only-Buy* or *Only-Sell)* against the *No-participation* decision. The intensity of effect, known as the marginal effect, refers to the impact on the likelihood of a change in one variable while all other variables are set at the mean. In this research, due to the small size of the sample, the marginal effects are neglected and the qualitative aspects of model results are focused on. In Table 3, the models for the options *Only-Buy* in the normal rainfall scenario and *Only-Sell* in the drought scenario are not shown, as the number of observations for these options was too small. All independent variables that were significant or helped improve the fit of the models are included.

First, in the normal scenario, farmers are more likely to participate as buyer and seller if they (i) have had farm training; (ii) undertook farm improvements in the last five years (*innovation*)[5]; and (iii) have advance knowledge about water availability. Meanwhile, farmers are less likely to participate in water trading if they (iv) have a higher level of education; (v) grow extensive herbaceous crops (winter cereals, maize, oilseed); or tend (vi) traditional olive groves. Addition-

[5] The innovation variable refers to both changes on the farm and farming practices as well as investments implemented over the past 5 years. We used it as a proxy of farmer's innovativeness. A list of options is reported in the Table S2 [online resource].

ally, (vii) guaranteed water supply decreases the likelihood of participating.

Second, again in a normal year, farmers are more likely to want to *Only-Sell* if they (i) undertook farm improvements in the last five years; (ii) have advance knowledge of water availability; (iii) grow extensive herbaceous crops; or grow (iv) other permanent crops. On the other hand, lower probability is related to (v) higher average water consumption per hectare and (vi) farmer's aging. In practice, the higher the on-farm water consumption, the lower is the probability that farmers will sell water. This is the same for the farmer's age.

Turning to the drought scenario (Table 3), all the previous variables are confirmed for those who would operate in the market as seller and buyer except for guaranteed water supply; other permanent crops (citrus, fruit, vineyard) reduce the probability of farmers being both sellers and buyers. In other words, moving from normal to a drought year, the farmer's profile of participation in the market does not change.

On the contrary, the profile of farmers that *Only-Buy* in drought years is quite different to the previous one. Indeed, the only statistically significant variable that increases the likelihood of participation refers to the awareness of previous water trading, while having rainfed crops or other permanent crops reduces the probability.

It should be mentioned that some variables were not found to have statistically significant coefficients in any of the model specifications, namely: (i) the size of the irrigation area; (ii) having access to multiple water supply sources; (iii) growing vegetable crops; and (iv) having intensive olive groves. Variables that were tested but were neither significant nor added to the fit of the models are: (i) being a part-time farm; (ii) using hired employees; (iii) having full-time family workers; (iv) having knowledge of the Water Law; and (v) the legal status of the farm.

On the other hand, it should be stressed that among the variables expected to be significant under the diffusion innovation theory, educational level demonstrated the opposite (namely, the higher the level, the less likely it is for the farmer to be in the adopting class); this is the same in the normal and drought scenarios. This is a surprising result and opposed to results obtained in other studies such as Wheeler *et al.*'s (2009) where the educational level increases the likelihood of participation in the ex-post water market in both buying and selling water.

The results allow us to classify farmers according to their stated attitudes towards water trading:

- The participative farmer, who is willing to both buy and sell. The likelihood of being in this class is higher among farmers with farm training who make frequent innovations and who have advance information about their water allocation.
- The non-participative farmer, with the opposite attitude, who neither wants to buy nor sell. Farmers in this class innovate less, and their assigned water allocations are nearly always guaranteed. Moreover, the farmer's age is also significant, with older farmers being less likely to enter the market. This type of farmer is more likely to grow extensive arable crops and have traditional olive groves.
- Between these extremes, two types of participants can be distinguished:
  a) Those who will only sell in a normal year. While variables such as innovation and advance knowledge of water allocation are also significant, farmers who only sell in a normal year can be distinguished by lower on-farm water consumption, a younger age and tending of arable crops or other permanent crops. One possible explanation for the negative sign of water consumption in the model explaining willing to sell could be that those farmers with larger consumption per hectare are the ones performing intensive agriculture.
  b) Those who will only buy in drought years. These farmers have irrigated crops that are different from other permanent crops such as citrus or vineyard. Within this group, being aware of previous water market transactions increases the likelihood of market participation.

Willingness to pay for and to accept selling water

In this section, farmers' WTP and WTA values for buying and selling water allocations are analysed by estimating the two-step Heckman model. In the regression model (second step) only positive WTP and WTA values are analysed. This prevents getting inconsistent results from the model when there are too many zero bidders. In the survey the number of legitimate zero responses varies between WTP and WTA, between tradable volumes (500 and 1,000 m^3/ha), as well as between the water availability scenarios[6]. No protest bidders were identified among the zero values.

[6] The number of answers with zero value are in a normal year, 4 and 2 in the case of WTP, 4 and 3 in the case of WTA, for 500 and 1,000 m^3/ha respectively; while in drought condition, 20 and 11 in the case of WTP, 1 and 2 in the case of WTA, for 500 and 1,000 m^3/ha, respectively.

Table 4. Number of observations and mean WTP and WTA (€/m³/ha) ‡.

Scenarios		Volume (m³/ha)	Obs.	Combined sample	Guadalquivir Basin	Almanzora Basin
Normal year	WTP	500	52	0.35	0.15	0.39
		1000	53	0.34	0.16	0.39
	WTA	500	79	0.28	0.15	0.41
		1000	80	0.28	0.15	0.40
Drought year	WTP	500	78	0.37	0.17	0.54
		1000	86	0.36	0.16	0.54
	WTA	500	61	0.42	0.17	0.55
		1000	60	0.42	0.17	0.55

‡ zero values excluded.

Table 4 reports the number of observations and the mean WTP and WTA values. WTP and WTA were higher in the drought scenario than in a normal year; values were higher in the Almanzora than in the Guadalquivir Basin; WTA values were slightly higher than WTP values in the Almanzora Basin, and virtually the same in the Guadalquivir Basin; volume had only a small effect on the WTP and WTA values.

While valuation studies of pure public goods mean WTA was usually considerably higher than mean WTP, here the differences were small, which is consistent with the type of good being valued, *i.e.* water as a productive input in agriculture (Horowitz & McConnell, 2002).

Table 5 reports the modelling results for farms from both catchments combined, including both the selection function and the main model. The fit of the models is good (adjusted R^2> 0.8 in all scenarios). The number of observations in the model is lower than those in Table 4 because of missing data for several variables.

Initially a location variable in the pooled regression to justify basin specific behaviour was included with the result of hindering many of explicative variables. As a consequence regression models were also estimated for each basin separately. However, for the Guadalquivir Basin only models with a sufficient number of observations were estimated, these were the cases of drought scenario for WTP values and a normal year for WTA values. Moreover, in the Almanzora Basin almost all farmers participated in both scenarios, which means there cannot be sample selection bias and there is no need for the first step of the Heckman procedure. A simple OLS regression is fitted for this basin. Tables 6 and 7 report these results. The goodness of fit of these models is lower, especially of the Guadalquivir Basin model.

The results of the three models are summarized below:

- Farmers' current water costs have a significant and strong positive effect on both WTP and WTA in all combined models, most likely acting as a reference for farmers' bids. It is the only variable in the combined models with a significant effect on WTP in a normal year. Water costs are higher in the Almanzora Basin than in the Guadalquivir Basin, and are therefore an important driver of the differences in WTP and WTA values between the basins. In the Almanzora model water costs remains an important explanatory variable, having the only significant coefficient across all scenarios. In the Guadalquivir Basin it only has a significant explanatory effect on WTP under drought conditions (500 m³/ha).
- Water consumption per hectare also has a positive significant coefficient in the combined model and is higher in the Almanzora Basin than in the Guadalquivir Basin.
- Regarding the crop variables, a higher proportion of on-farm vegetables and permanent crops (*e.g.* citrus) leads to higher WTP values in the drought scenario. Vegetables and permanent crops are not significant in the basin-specific models. A higher proportion of olive groves, either traditional or intensive, reduces WTA values in the drought scenario. The proportion of intensive olive groves keeps its negative effect on WTA values under drought conditions in the Almanzora Basin, but has the opposite effect in the Guadalquivir Basin in normal years, increasing the WTA values. The proportion of extensive herbaceous crops is only significant in the Guadalquivir model, lowering the WTP prices for 500 m³/ha under drought conditions.
- The presence of rain fed crops has an opposite effect in the two basins. In the Guadalquivir Basin (and in the combined model) it increases WTP in the drought scenario (1000 m³/ha), while lowering WTA values in a normal year (500 m³/ha). In the Almanzora Basin, on the other hand, WTP values in the drought scenario are lower if a farm has rain fed crops (and there is no significant effect on WTA).

Table 5. Heckman model: Both basins.

	SELECTION MODEL: LOGIT MODEL							
	Willing to buy water allocation				Willing to sell water allocation			
	Normal year		Drought year		Normal year		Drought year	
	500 m³/ha	1000 m³/ha	500 m³/ha	1000 m³/ha	500 m³/ha	1000 m³/ha	500 m³/ha	1000 m³/ha
Intersection	-3.030	-2.517	-2.006***	-1.124***	-2.008***	-2.604***	-2.659***	
Water consumption (m³/ha)	0.131*	0.104*						
Educational level	-1.249*	-0.874*						
Farm training	2.736***	2.065**	1.211**	1.103**				
Aware of water trading				1.591***				
Innovation	2.600***	2.139***	1.783***		1.735***	1.928***	2.265***	2.257***
Rain fed crops				-1.337**				
Advance knowledge about water availability			1.069*		-1.913***	-2.231***	2.127**	1.965*
Guarantee water supply	-3.137*	-3.098*						
Extensive herbaceous crops	-3.550**	-3.408**	-1.704***				-2.405***	-3.366***
Vegetable crops				1.585**				
Traditional olive crop	-3.515***	-2.488**			-1.061*		-1.708**	-1.830**
-2 Log Likelihood	68.981	83.367	164.532	179.110	166.292		123.017	110.239
Correct classification rate	92.2%	91.6%	80.7%	77.3%	76.7%	86.6%	86.6%	88.4%
Number of observations	166	166	176	176	173	172	172	172
	PRINCIPAL MODEL: REGRESSION							
	Maximum WTP (€/m³)				Minimum WTA (€/m³)			
Intersection	0.031	0.015	-0.040	-0.008	0.022	0.018	0.220	0.196***
Water costs (€/m³)	0.881***	0.933***	0.433***	0.525***	0.557***	0.527***	0.464***	0.488***
Water consumption (m³/ha)			0.004*		0.002*	0.003***	0.005***	0.006***
Rain fed crops					-0.050*			
Well						-0.042**		
Reservoir on farm			0.065*				0.073***	0.074***
Vegetables farmland			0.002***	0.002***				
Traditional olive crop farmland							-0.002***	-0.002***
Intensive olive crop farmland							-0.002***	-0.002***
Other permanent crops farmland			0.002***	0.002***				
Buyer and seller			0.080**	0.101***	0.083***	0.079***		
Lambda (inverse Mills' ratio)	-0.010	-0.010	0.038	0.051	0.0002	-0.016	-0.041*	-0.049**
	(*p*=0.489)	(*p*=0.532)	(*p*=0.171)	(*p*=0.081)	(*p*=0.992)	(*p*=0.506)		
Adjusted R^2	0.884	0.890	0.863	0.828	0.828	0.849	0.939	.937
Number of observations	48	48	73	77	78	78	59	58

*** significant at 0.01 level; **significant at 0.05 level; * significant at 0.1 level.

Table 6. Heckman model: Guadalquivir Basin farms.

	Willing to buy water allocation		Willing to sell water allocation	
	Drought year		Normal year	
	500 m³/ha	1000 m³/ha	500 m³/ha	1000 m³/ha
SELECTION MODEL: LOGIT MODEL				
Intersection	-2.060***	-2.206***	-2.711***	-2.415***
Irrigation area (ha)		0.046***		
Farm training	1.900***			
Aware of water trading	1.692***	2.092***	1.106*	
Innovation				1.264**
Rain fed crops		-2.188**		
Advance knowledge about water availability			1.849***	1.905***
Intensive olive crop			1.028*	
Others permanent crops	-3.072**	-2.408***		
-2 Log Likelihood	110.854	109.764	130.622	136.974
Correct classification rate	81.1%	79.5%	72.1%	73.6%
Number of observations	136	136	135	134
PRINCIPAL MODEL: REGRESSION				
	Maximum WTP (€/m³)		Minimum WTA (€/m³)	
Intersection	0.249***	0.214***	0.115***	0.184***
Water costs (€/m³)	0.188*			
Farm training				0.037**
Rain fed crops		0.082**	-0.048***	
Share of agricultural income				
Hired employees	-0.122*	-0.064*		
Extensive herbaceous crops farmland		-0.00005*		
Intensive olive crop farmland			0.0004*	0.0003*
Lambda (inverse Mill ratio)			0.046**	0.038*
Adjusted R^2	0.240	0.267	0.311	0.319
Number of observations	36	44	40	40

*** significant at 0.01 level; **significant at 0.05 level; * significant at 0.1 level.

Table 7. OLS Regression: Almanzora Basin farms.

	Maximum WTP (€/m³)		Minimum WTA (€/m³)		
	Normal year[a]	Drought year[a]	Normal year		Drought year[a]
			500 m³/ha	1000 m³/ha	
Intersection	-0.005	0.355***	0.064	0.038	0.376***
Water costs (€/m³)	0.973***	0.503***	0.820***	0.879***	0.412**
Farm training		-0.044*			-0.048*
Rain fed crops		-0.132**			
Reservoir on farm		0.058*			0.066***
Full-time family worker					0.040*
Intensive olive crop farmland					-0.001**
Adjusted R^2	0.702	0.554	0.512	0.620	0.552
Number of observations	40	40	38	38	39

[a] The same findings for 500 and 1000 m³/ha. *** significant at 0.01 level; **significant at 0.05 level; * significant at 0.1 level.

- Having a reservoir on the farm for private use increases both WTP and WTA values during periods of drought. The coefficient is significant in the combined and Almanzora models, but not in the Guadalquivir model.
- Several socioeconomic variables also have an effect on WTP and WTA. In the Almanzora Basin, farm training reduces WTP and WTA values under drought conditions, and the presence of at least one full-time family worker increases WTA, also

under drought conditions. Instead, in the Guadalquivir Basin farm training increases the WTA values in a normal year. Also in this last Basin the presence of hired employees reduces WTP values in the drought scenario.

- In the combined model the prices depend on the type of market participation so that farmers participating as buyers and sellers (variable "buyer and seller") would pay (WTP) and would accept (WTA) higher prices than those participating only as buyers or sellers, respectively. The variable "buyer and seller" is significant for WTP in the drought scenarios and for WTA in normal conditions, the scenarios with the highest participation. However, it is not significant in the Guadalquivir and Almanzora individual models.
- The bias factor lambda is significant in the drought scenarios of the combined model for WTA. Without the negative lambda coefficient, the effect of the independent variables on WTA would have been underestimated. In the Guadalquivir model lambda is significant and positive for WTA in a normal year meaning it prevents an overestimate of the effects of the independent variables on WTA.

Discussion

As a whole, the findings show a good acceptance of irrigation water markets among farmers, with 28% against any type of water trading. The findings of regression models of farmers' stated preferences suggest that the decision-making process proceeds in two steps. The entrance to the market occurs first and the price-related preference is processed after. In fact, determinants of a farmer's decision in our models are different between the two decision-making processes.

The factors that influence farmers' willingness to participate in the water market in our study are generally in line with the diffusion innovation theory as well as other authors' results. First, the fact that more innovation-oriented farmers are more likely to accept water markets can be seen in the results of Colino & Martínez (2002) and Calatrava & Sayadi (2005). The former also find a positive effect of specialized farm training, while in the latter study, low supply security makes farmers more eager to trade. Wheeler *et al.* (2009) claimed that irrigators perceive water markets as another management tool and, that its adoption by Australian irrigators fits the theory of innovations. While they found a positive relationship between educational level and market acceptance, the farmer's age was not significant which is contrary to the diffusion of innovations theory. Moreover, Bjornlund (2006) found that Australian farmers' prior knowledge of market operations encourages their participation.

As a whole, our results partly support these findings, as those irrigators most willing to enter the market are more innovative, have an agricultural training or are younger. Likewise, awareness of past water-trading operations and advance knowledge of actual water availability increase the farmer's participation. On the other hand, relevant variables such as farmland size (total and irrigated) did not show significance, while educational level had an opposite influence. In this regard, it is worth mentioning that the main reason for farmers to refuse market participation is the view that water is not a commercial good (for more details on this issue see Giannoccaro *et al.*, 2013).

In the second stage of the decision-making process, WTP and WTA values were strongly influenced by irrigators' current water costs and the crops the farmers grew: values were higher for high value crops with a low water-deficit resistance such as vegetables and citrus, and lower among olive growers, who cultivate a water-deficit tolerant crop. Also the most active participants in the market (*i.e.* buyer and seller) would pay or accepts higher prices for water. Although the number of variables across all models seems to influence the farmer's WTP for buy or accept selling water, when one takes into account the estimated coefficients of each variable, only the current cost of the irrigation water services has a noteworthy impact.

Concluding remarks

Water markets give power to farmers and water users rather than to technicians and governments in deciding how to make the best use of the resource. It has been demonstrated in Australia, Spain and California that water trading has increased agricultural production and helped farmers and communities survive severe droughts.

This study has investigated which factors influence farmers' acceptance of water trading and the results can be of help if policy makers decide to further implement water trading within their irrigation water management. In Europe, irrigation water markets have been operating solely in Spain, while recently the European Commission through the Water Blue Print document (EC, 2012) has recognized the market among other instruments useful for the WFD's goals achievement.

Although water markets have received special attention by economists, the extent of its adoption is, in many cases, supported by little evidence. The optimistic perspective of irrigation water markets resulting from mathematical modelling contrasts with the diffusion pattern of water trading. While findings of this research seem to support the idea of diffusion innovation theory, with a large acceptance among farmers, the passage of time is necessary for innovations to be adopted; they are rarely adopted instantaneously. This work just shows the main profile of likely early adopters of the water market as a tool of farm management; the relative diffusion pattern falls out of scope. On the other hand, even with high learning curve, potential adopters might not adopt the innovation anyway. Innovations can have symbolic value (*e.g.* ethical) that discourages adoption. In this respect, identity aspects (*e.g.* to be a farmer and farm) and social concerns might play a relevant role. The existence of ethical concerns that might influence farmers' attitudes towards irrigation water markets needs further analysis.

The CV methods can improve the analysis taking into account some no-economic attributes of farmer's decision, but as known the outputs should be taken with caution, due to the context-related influence.

Finally, our results indicate a positive relationship between the willingness to participate in the market and the level of information about the annually available water, suggesting that uncertainty hinders decision making about the purchase or sale of water, thereby potentially leading to lower market participation. Considering these results, it could be beneficial to bring forward the yearly decision whether or not to bring the drought protocol into force (the quota allocation mechanism in case of shortages). This would increase farmers' ability to adapt to droughts, for example buying or selling water, and thereby improve water allocation efficiency, which in turn may reduce the economic losses caused by droughts.

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