AN ASSESSMENT OF FARMERS' WILLINGNESS TO PARTICIPATE IN WATER TRADING IN SOUTHERN SPAIN

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Abstract

This study applies contingent valuation to assess farmers' willingness to trade irrigation water. We analyse farmers' willingness to pay for water and their willingness to accept the selling of water through a seasonal market, under both normal rainfall and drought conditions. The survey among 241 farmers (irrigators and non-irrigators) in the Guadalquivir River Basin and the Mediterranean (Almanzora) Basin in southern Spain is used as a basis to draw the irrigation water supply and demand curves for both basins. Assuming that each basin operates as a single country, an international commerce framework is applied to study inter-basin trading. Results show that there is scope for both intra-basin (within Guadalquivir) and inter-basin markets. The equilibrium market price increases from 0.17 EUR/m^3 in the baseline scenario to 0.21 EUR/m^3 under drought conditions. These results are in line with observed market prices during 2006-2007. We also find a threshold volume under which start-up costs for irrigation infrastructure make it unprofitable for non-irrigators to enter the market. Finally, farmer's ethical perspective of considering irrigation water as non-tradable commodity refrains them from participating in such markets.

1. INTRODUCTION

In water-scarce regions, water allocation is still mainly based on historical water demand. However, increasing demand and periodic water shortages have led to the establishment of new forms of demand management. An example is water trading, which is intended to make water allocation more flexible, and is seen as an efficient method to allocate scarce water resources to the most productive uses (World Bank, 1997). Chile, the USA and Australia already have a long experience with irrigation water trading, and it has been introduced more recently in Alberta (Canada), China and South Africa.

In Europe, irrigation water trading is still mostly a research and policy discussion topic. It is included in the research agenda of the European Union Commission as a reliable policy instrument, "[...] *which could help to improve water efficiency and overcome water stress, if a sustainable overall cap for water use is implemented*" (EC, 2012). However, to date there is only one European country with an established legal framework and experience for water trading: Spain.

The Spanish Water Law was reformed in 2005 to allow holders of water rights to trade them on a temporary (water allocation) as well as a permanent basis. However, up until now trading has been rare, has mainly occurred under drought conditions and the traded volume has been limited (Hernández-Mora and De Stefano, 2013).

One of the theoretical advantages of water markets is their ability to yield prices that reflect the true marginal economic value of water, which in turn would lead to a more efficient use of water. However, although market prices and traded volumes may offer

useful indications of the value of irrigation water, their interpretation is not straightforward. Young (2005) suggests some caution be applied in using observed water prices for public planning because of market distortions and wide price fluctuations. Bjornlund and Rossini (2005) describe the complexity and diversity of the drivers (including policy drivers) of price in the Australian temporary market. Brown (2006) analyses prices and trends in water markets in the western United States from 1990 to 2003 and highlights that the price of water is highly variable both within and between western states, reflecting the influence of local factors on prices.

Moreover, 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 and Klein, 2006; Bjornlund and Shanahan, 2007; Wheeler *et al.*, 2010). The resulting lack of competitiveness can lead to biased market prices and traded volume.

To conclude, experience with water markets is still limited in many countries and, even where market mechanisms have been active longest, traded volume remains limited (2-5% of total water demand) (Bjornlund *et al.*, 2013; Brown, 2006).

This study aims to increase knowledge of water trading in Spain by focusing on farmers' perceptions and their willingness to trade irrigation water, and thereby assess the value of irrigation water. As water trading in Spain has mainly operated under drought conditions and is dominated by inter-basin transfers, this study also attempts to assess the influence of drought on farmers' willingness to trade and to establish the potential for intra-basin trading.

The analysis is carried out for the Guadalquivir and the Almanzora River Basins. The former is the largest irrigation area in Spain, while the latter is home to the most

profitable irrigation agriculture in the country, with a high concentration of greenhouses and high value crops. Together they represent roughly 25% of Spain's irrigated area.

Water markets in Southern Spain have been previously studied by use of mathematical models (see Gutierrez et al., 2013) though empirical evidence does not reveal the same extent that theoretical and simulation works seem to anticipate. As argued in Giannoccaro et al. (2013) gaps between models and real behaviour encourage the analysis of stakeholder's attitude in order to detect barriers, strategic behaviour as well as ethical issues that may be the explanation for the discrepancy between model and real data. Consequently, in this research, a novel approach based upon CV experiments is used and the supply and demand curves are constructed according to farmers' responses.

Farmers were asked to express their willingness to purchase and to sell irrigation water in a hypothetical seasonal market, both under normal water availability and under drought conditions. We believe that this method can offer valuable insights considering the market imperfections described above. In addition to the revealed market price method, Hussain *et al.* (2007) also include the stated preference approach among the relevant methodologies for water value assessments.

In the next section the study area and the Spanish institutional environment are described and a brief overview of the main water trading operations in the area is provided. This is followed by a description of the survey and its results in Sections Three and Four. In Section Five the water market model is constructed, after which the rationality of farmers' responses is checked in Section Six. In Section Seven results are discussed and compared to previous research. Finally, policy and research recommendations are provided in Section Eight.

2. BACKGROUND AND PRIOR EXPERIENCE WITH WATER TRADING IN SOUTHERN SPAIN

Both river basins in this study are located in southern Spain, and have a Mediterranean climate and a heterogeneous precipitation distribution. The variability in water availability and recurrent droughts have led to episodes of critical scarcity.

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 million people. The annual average temperature in the Guadalquivir River Basin is 16.8°C and it has an average precipitation of 630 mm per year. The most common types of land cover/use in the basin are forests (49.1%) and agriculture (47.2%), with the remainder covered by urban areas (1.9%) and wetlands (1.8%). Overall available water resources amount to 3362 hm^3/year, while net demand in 2008 rose to 3578 hm^3/year, of which 2981 hm^3 was for irrigation. The irrigated area in the Guadalquivir Basin comprises 845 000 ha, covering olive groves, fruit orchards (mainly citrus and peaches) and general field crops, such as cotton, maize, sunflowers and, of minor importance, sugar beet. A small area is also dedicated to rice farming near the river estuary. Olive groves make up almost half the irrigated area. Olives are cultivated in both traditional extensive and intensive farming systems. While irrigation has always been part of the latter, application of deficit irrigation has now become quite common in the traditional system as well, which has led to a huge increase in irrigation over the last decade (CAP, 2011; Berbel *et al.*, 2013). The average applied irrigation in the basin is 3324 m^3/ha.

Berbel *et al.* (2013) describe the basin's trajectory towards closure, a state in which available resources are fully or over committed. The current hydrological plan for the basin proposes a programme of measures to tackle the water imbalance (Berbel *et al.*, 2012).

The Mediterranean River District extends from the Strait of Gibraltar to the Almanzora River, covering the Mediterranean coastal area of Andalusia. The area has 2.1 million inhabitants, to which the tourism sector adds around half a million people. Accordingly, urban water use makes up 21% of water demand in the district, while irrigation uses 73%. Industrial water use is of only minor importance. Total demand in 2008 was 1157 hm^3. The Mediterranean River District consists of a number of small and very small reservoirs. It has no unique river system but is formed by a number of shallow streams with uneven flows. Groundwater in the district is also largely exploited and salt intrusion is common along the coastline. The Almanzora Basin in the Province of Almeria is the eastern-most basin in the district, and is characterised by high value, mainly greenhouse crop production which covers 54 000 ha. An important part of the sector's production is exported to northern EU countries. Citrus and olive crops are also grown in the basin, but are less important. On average, 4925 m^3 of irrigation water is applied per hectare, which amounted to an overall demand in 2008 of almost 267 hm^3.

Under Spanish law irrigation water rights used to be strictly linked to the land.[1] A more recent law (Real Decreto Legislativo 15/2005) broke this strict water-land link and granted landowners the right to trade their water rights, wholly or in part, and on a temporary or permanent basis. However, trading in water rights is subject to a number of restrictions. Agricultural rights holders can only transfer rights to those who already hold water rights of their own, and trading can therefore not be used to assist the establishment of new water users (Giannoccaro *et al.*, 2013). The annual volume allocated to water rights holders depends on availability and is specified in the Drought Management Plan. Under drought conditions this management plan comes into force

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[1] Real Decreto Legislativo 1/2001

and water allocation is reduced. For instance, during the last drought (2005-2007) normal water allocation was cut by 50%.

An inter-basin transfer system was built to connect the Guadalquivir River Basin to the Almanzora Basin. Royal Decree 9/1998 (Negratin-Almanzora) established the rules and constraints of inter-basin transfers and limits the maximum volume that can be transferred from the Guadalquivir to the Almanzora Basin. Under normal water availability conditions, a maximum of 50 hm^3 can be transported by the Government and assigned to Almanzora farmers, who pay a fee to the Government. If an official drought is declared in the Guadalquivir Basin, the Government transfers stop and Almanzora farmers can only obtain extra water by buying allocations from Guadalquivir rights holders. The inter-basin market therefore operates more likely under drought conditions.

Figure 1: Map of inter-basin transfers

Despite great interest in water markets, actual trading in southern Spain is still uncommon. The trading that has taken place mainly consisted of sales from low-value, extensive agriculture to higher-value crop producers. Inter-basin transfers involving larger volumes occurred between field crop irrigators in the middle of the Guadalquivir Valley and greenhouse vegetable producers in the Province of Almeria. Smaller volumes have also been traded between agriculture on the one hand and urban uses and the energy industry on the other.

The first inter-basin transaction took place in 2006 when 'Aguas del Almanzora SA' bought rice farms in the Guadalquivir Basin and transferred the attached water rights of 8.5 hm^3 (see Mesa and Berbel, 2007 for an account of this operation). During 2007, 35.5 hm^3 were sold on a temporary basis by four water user associations from the

Guadalquivir Basin to 'Aguas del Almanzora SA'. The water was traded at a price of 0.18 EUR/m^3 at the seller's gate. On top of this, 'Aguas del Almanzora SA' approximately paid 0.20 EUR/m^3 for pumping and physically transporting the water.

On the whole, temporary allocation trading has been more frequent, while permanent water right sales are still rare. Especially with regard to market depth (the number of transfers and market participants), southern Spain is still far behind other areas of the world that allow trading (i.e. California, Australia and Chile).

3. SURVEY AND SAMPLE DESCRIPTION

In the spring of 2012 a survey was administrated among farmers in the Guadalquivir and Almanzora River Basins. Based upon the list of farmers available from the official census, the sample was constructed to obtain a representative extract from the farming community with regard to location, farm size, crop pattern, and access to irrigation water. A comparison of the sample and the overall population is given in Table 1. In total, 241 farmers were interviewed, 79% in the Guadalquivir Basin and 21% in Almeria. Interviews were carried out face to face by three different interviewers.

The questionnaire included 35 structured questions, divided in four parts, covering: i) socio-demographic information; ii) farm-related information; iii) irrigation issues; and iv) contingent valuation questions. In part four, before the WTP and WTA questions, farmers were asked whether they agreed with water trading in general, if they would want to sell and/or buy, whether they agreed with trading on a temporary or a permanent basis, and if they were in favour of inter-basin and/or intra-basin trading. An auction simulation was conducted with those farmers who agreed with water trading in general. Questions about buying and selling were asked separately, depending on farmers' stated willingness to do either or both. The survey combined both closed and open-ended WTP and WTA questions. We started with a closed bid of 0.18 EUR/m^3 and according

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to the farmer's response the price was increased or decreased by 33% (0.24 or 0.12 EUR/m^3, respectively). In the event that farmers either refused or accepted all bids they were asked their maximum WTP and/or minimum WTA. An example of an auction simulation can be found in the appendix.

The hypothetical auctions included two water availability scenarios: i) a normal year and ii) a drought year with allocations restricted to half their usual level. All farmers were also asked about two fixed tradable volumes per hectare: 500 and 1000 m^3/ha per year. The volumes are per hectare since water allocation is linked to size of land holdings. All other external variables were assumed invariable. The starting price and volumes in the auctions are in line with observed figures from 2006-2007 transactions.

Table 1: Representativeness of the sample

In the sample, 16% of respondents, all of whom are from the Guadalquivir Basin, lack access to water for irrigation and are completely dependent on rainfall, while 58% have access to one water source, and 26% have access to multiple sources. Almost three quarters of respondents (n=176) are members of a Water User Association (WUA) through which they get their irrigation water, 28% have a private well and 10% rely on other sources. While more than 80% (n=195) of respondents are irrigators, the irrigated area covers only 64% of the total farmland in the sample (11 885 ha). The majority of farms (62%) are fully irrigated, accounting for 45% of the area. Rain fed farms cover 10% of the area, and farms with both irrigated and rain fed crops comprise 19% of the sample and cover 45% of the farmland.

Traditional olive farming both irrigated and rain fed, makes up the largest portion of the sampled area in the Guadalquivir River Basin, while greenhouse crops dominate in the Almanzora Basin. For both areas combined, the most common irrigated crops are intensive olive systems and field crops. These crops cover 63% of the total irrigated

area in the sample (intensive olive systems alone cover 31%), while traditional olive systems cover 13%. Citrus and winter cereal each cover nine per cent of irrigated land.

The sampled farmers' average age is 54; 53% of the respondents also have off-farm jobs; and 91% of farms rely on family labour. The average farm size in the Guadalquivir Basin is 41.16 ha, and the average irrigated area is 26.40 ha. In the Almanzora Basin the averages are 19.24 ha and 17.38 ha, respectively. On average, farms in the sample are larger than those in the study area as a whole, especially within the Guadalquivir Basin. This was expected as the survey only collected information from professional farmers, while the official census reports all types of holdings.

The average water use per hectare is 2900 m^3, with a considerable difference between the Guadalquivir Basin (2524 m^3/ha) and the Almanzora Basin (4000 m^3/ha). These values are below the 2008 figures reported for the basins as a whole (CAP, 2011), but water requirements are also influenced by the annual rain pattern.

The most common irrigation tariff scheme (46% of irrigators) is a binomial system, which combines a fee per hectare with a volumetric tariff. Water charges differ strongly between the two study areas. The Almanzora irrigation district has a higher volumetric rate (0.41 EUR/m^3, on average) and a lower rate per hectare (19 EUR/ha), while in the Guadalquivir Basin, where the binomial system is used by 50% of the irrigators, the rates are 0.06 EUR/m^3 and 183 EUR/ha. Alternatively, 23% of the irrigators (in both areas combined) pay only a fee per hectare (336 EUR/ha, on average), while the remaining 31% did not know the type of tariff they pay.

Overall, we find the sample representativeness satisfactory considering the large variability exhibited within and between the study areas.

4. SURVEY RESULTS: FARMERS' ATTITUDES TOWARDS PARTICIPATION, PRICE AND VOLUME

Valid observation were 196 (out of the 241 administered questionnaires), 150 belong to Guadalquivir Basin and 46 to the Almanzora Basin. Of those that were excluded from the analysis, 23 (12% of the total sample) were planning to quit farming or did not hold water rights and were not interested in irrigation, and 19 respondents (10%) chose not to respond to the questions relating to water markets.

Table 2: Summary of attitudes towards water trading

Regarding attitudes towards water markets (Table 2), 45% of respondents agree with trading through both inter-basin and intra-basin markets; 27% are only in favour of trading within the same basin; and 28% are against any type of water trading. Comparing the two areas, a majority of Almanzora farmers only want intra-basin trading, while the majority of Guadalquivir farmers are indifferent to the scale (i.e. intra vs. inter-basin). Objections to water trading are much more common in the Guadalquivir Basin. The main motivation for objecting is the view that water is not a commercial good (100% of those against within the Guadalquivir Basin and 76% within the Almanzora District).

Table 2 also shows that farmers generally favour WUAs (46%) to facilitate arrange trading operations, as they for example did in the transfer between 'Aguas del Almanzora SA' and four sellers in 2007 during the last drought.

Table 3 presents farmers' responses to the WTP and WTA questions. There are big differences between the basins. In the Guadalquivir Basin more farmers would sell than buy water allocation in a normal year (i.e. the baseline situation), while the reverse is true for drought years. This difference between normal and drought years is not found in the Almanzora Basin, but farmers there are generally more willing to trade (buy and sell). Farmers with knowledge of the water law and those who are aware of earlier

trading are more willing to sell than farmers without this knowledge or awareness[2].

Table 3: WTP and WTA in EUR/m^3/ha for the different scenarios

5. SUPPLY AND DEMAND CURVES OF IRRIGATION WATER: INTRA VS. INTER-BASIN WATER MARKETS

In general, the findings show that average WTA is higher than average WTP within the basins while average WTP in the Almanzora Basin is higher than average WTA among Guadalquivir irrigators. This suggests that irrigation water will initially be traded from the Guadalquivir to the Almanzora Basin, as was observed during 2006-2007.

The supply and demand curves are estimated based on the survey data to look at likely trading patterns in more detail. We assume that farmers can (fully or partly) buy or sell their annual allocation according to the current legal framework. The supply and demand curves are drawn separately for each basin using the 500 m^3/ha survey results.

The supply curve is estimated by taking the product of each farmer's response (WTA for selling 500 m^3/ha) multiplied by his/her irrigated area (ha), which assumes that each farmer would sell 500 m^3/ha for the whole extension of his/her irrigated land. This gives the available volume at any given price. The aggregated market curve is drawn by summing the amounts that farmers are willing to sell at each price.

The demand curve is estimated in the same way, i.e. by taking the product of each farmer's response (WTP for 500 m^3/ha) multiplied by his/her farm size, assuming that each farmer would procure 500 m^3 for each hectare of his/her farmland. This gives the volume in demand at any given price. Where the curves meet we find the intra-basin market price.

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[2] Chi-square tests for differences in knowledge of the water law: $\chi^2(4)=9.442$; $p=0.05$ for selling in baseline situation and $\chi^2(4)=9.753$; $p<0.05$ for selling in drought condition. For differences in awareness of previous water exchanges: $\chi^2(1)=6.679$; $p<0.01$ and $\chi^2(1)=11.091$; $p<0.001$ respectively.

To analyse water trading between basins, we use an international trade model to reach a partial equilibrium, which is an innovation of this research. For our analysis the case that applies is that of a spatial market equilibrium (i.e. price and quantity) between two large countries. This model is traditionally used to assess changes in trade resulting from trade policy changes, such as the creation of a free trade area (De Arcangelis, 2005 pp. 94-97). The model starts with each 'country's' (basin's) demand and supply curves for the situation without inter-basin trade.

The first scenario is a normal year (no official drought declared). Two intra-basin equilibria, with market prices P_1 and P_2, are reached for the Almanzora and Guadalquivir Basins, respectively (see Figure 2; the Guadalquivir curves are constructed in a mirror image). In the Almanzora Basin, the market is cleared at a price of P_1=0.42 EUR/m^3 and a volume of 0.23 hm^3. The equilibrium price (P_2) and volume in the Guadalquivir River Basin are 0.13 EUR/m^3 and 0.48 hm^3.

When inter-basin trade is allowed, intra-basin and inter-basin markets operate at the same time. Since the Almanzora intra-basin price P_1 is higher, water would be traded from the Guadalquivir Basin to the Almanzora Basin. However, we also have to consider transportation costs. This causes the Almanzora demand curve to shift down by the cost of pumping plus infrastructure tariffs[3], which together are assumed to be 0.20 EUR/ m^3. The new demand curve is shown in Figure 2 (line WTP'). The equilibrium on the inter-basin market will be reached when section LM equals NR. Price P* is the inter-basin equilibrium market price, and lies between P_1 and P_2, the market prices reached on the intra-basin markets. In this scenario P* is 0.17 EUR/m^3 and the total traded volume is 0.71 hm^3, which is made up of 0.28 hm^3 bought by farmers in the Almanzora Basin, and 0.43 hm^3 which is traded within the Guadalquivir Basin.

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[3] This is what happened in real water transfers during 2006-2007

Figure 2: Market equilibrium for inter-basin trading under normal water availability.

The same approach is used to estimate demand and supply for scenario two: a drought year (Figure 3). This induces a change in the demand and supply curves in both basins, but the biggest adjustment takes place in the Guadalquivir Basin, where there is a large increase in the demand for water. Compared to the normal scenario, prices go up by 38% in the Guadalquivir Basin and by and 36% in the Almanzora Basin. The intra-basin prices under drought conditions are P_1=0.57 EUR/m³ for the Almanzora Basin, and P_2=0.18 EUR/m³ for the Guadalquivir Basin. The accompanying traded volumes are 0.20 hm³ and 0.56 hm³, respectively; a total of 0.76 hm³.

When inter-basin trading is allowed, water will still be traded from the Guadalquivir to the Mediterranean Almanzora Basin due to the over-supply in the former and over-demand in the latter. When transportation costs are included (unchanged at 0.20 EUR/m³), the Almanzora demand curve again moves downwards (curve WTP' in Figure 3). The market clearing price under drought conditions P* is 0.215 EUR/m³ and the traded volume at equilibrium is 0.76 hm³, of which 0.34 hm³ are purchased by Almanzora farmers and 0.42 hm³ are traded within the Guadalquivir Basin.

Figure 3: Market equilibrium for inter-basin trading under drought conditions.

The main difference between the two scenarios is a price rise of 26% (0.045 EUR/m³) in the drought scenario. Traded volume also increases: from 0.71 hm³ to 0.76 hm³. While the volume bought by farmers in the Almanzora Basin increases by 21%, there is hardly any change in the Guadalquivir Basin; at the higher price farmers there are willing to buy roughly the same volume.

A general conclusion from the inter-basin model is that, in drought years, respondents are willing to trade around 4.5% of overall water resources allocated to irrigation.

According to the Drought Management Plan, on average, allocations are reduced by 50% of a normal year, although this varies between water storage sub-systems. Our survey indicates that, in a normal year, the volume that farmers are willing to trade via the inter-basin market is 3.8% of irrigation water.

6. ECONOMIC CONSISTENCY OF FARMERS' RESPONSES

The estimated supply and demand curves correspond to the neo-classical economic paradigm, which assumes that farmers act to maximise their profits. For that to be the case, we expect farmers' stated responses about willingness to buy and sell water to meet the following conditions:

1) Farmers' WTP/WTA depends upon the marginal productivity of water.

We test this by looking at the differences in WTP and WTA between the basins. We know that due to the higher-value crops planted in the Almanzora Basin, the marginal productivity of water is higher there. We would therefore expect the same to be true for WTP and WTA. The average WTP for 500 m^3/ha among Guadalquivir farmers in a normal year is 0.08 EUR/m^3, and 0.14 EUR/m^3 for 500 m^3/ha and 1000 m^3/ha. Farmers' WTP is significantly different in the Almanzora Basin with an average of 0.39 EUR/m^3, regardless of the volume (see Table 3). The difference between basins increases under drought conditions: average WTP in the Guadalquivir Basin is 0.10 and 0.13 EUR/m^3 for 500 and 1000 m^3/ha, respectively, and 0.54 EUR/m^3 for both volumes in the Almanzora Basin. Both differences are statistically significant.[4] The differences in WTA between the Guadalquivir and Almanzora Basins are also statistically significant: the respective values are 0.15 EUR/m^3 vs. 0.40-41 EUR/m^3 under normal conditions,

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[4] Student t-tests results for the baseline scenario are $t(62)=-15.193$, $p<0.001$ for 500 m^3 and $t(62)=-12.007$, $p<0.001$ for 1000m^3; for the drought scenario: $t(112)=-23.389$, $p<0.001$ for 500 m^3 and $t(111)=-24.492$, $p<0.001$ for 1000 m^3.

and 0.16-17 EUR/m^3 vs. 0.55 EUR/m^3 under drought conditions.[5] Both WTP and WTA are therefore higher in the basin with the higher marginal productivity of water, as expected.

2) Farmers' WTP differs between irrigators and non-irrigators.

Assuming that non-irrigators status is due the lack of water access, we expect the marginal productivity of water, and therefore WTP, to differ between irrigated and rain fed (non-irrigated) farms for two reasons. First, while for the irrigator purchased water allocations come on top of his/her original allocation, it is the initial allocation for the non-irrigator. According to the law of diminishing marginal returns, the same volume should therefore have a higher productivity for the latter.

Second, non-irrigators, due to the investment needed to start up irrigation, are only likely to enter the market and become irrigators above a volumetric threshold at which the higher productivity of irrigation compensates the investment costs. For example, olive irrigation requires an average investment in infrastructure of over 3000 EUR/ha for an average net margin of around 0.30 EUR/m^3 (Mesa-Jurado *et al.*, 2010). The exact breakeven point is difficult to estimate as prices of olive oil are volatile and productivity of olive groves varies. Nevertheless, Castro *et al.* (1999) define 1500 m^3/ha as the 'adequate dosage' to guarantee a profitable investment.

Since all surveyed farmers in the Almanzora District are irrigators, the analysis is carried out on the Guadalquivir sub-sample. Table 4 shows Guadalquivir farmers' average WTP for both irrigated and rain-fed farms. Statistically significant differences between the groups are found in both the baseline and drought scenarios, but only for

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[5] Student *t*-tests results for the baseline scenario are $t(84)=-16.245$, $p<0.001$ for 500 m^3 and $t(84)=-19.869$, $p<0.001$ for 1000m^3; for the drought scenario: $t(63)=-23.389$, $p<0.001$ for 500 m^3 and $t(63)=-21.101$, $p<0.001$ for 1000 m^3.

the 500 m^3/ha option.[6] The differences in WTP for 1000 m^3/ha are not statistically significant. None of the non-irrigators are willing to pay for 500 m^3/ha, but they are willing to pay amounts similar to those of irrigators for 1000 m^3/ha (see Table 4). We therefore find evidence to support the second argument, i.e. that there is a certain volumetric threshold before non-irrigators will enter the market, and the data suggest that 1000 m^3/ha is sufficient to offset the investment costs, which is lower than the 1500 m^3/ha estimated by Castro *et al.* (1999). The similarity in WTP for 1000 m^3/ha between irrigators and non-irrigators seems to contradict the first argument, i.e. that an initial allocation would have a higher marginal return than an additional one. However, it may also be that at these volumes (1000 m^3/ha) the marginal returns have already evened out, hiding potentially higher initial marginal returns at lower volumes, which in turn are obscured in the data by the existence of a volumetric threshold.

Table 4: Guadalquivir farmers' WTP (EUR/m^3): irrigators vs. non-irrigators

3) Demand and WTP for water are higher in a drought year than in a normal year.

The percentage of Guadalquivir farmers who are willing to buy water increases significantly from 12% in a normal year to 46% under drought conditions ($\chi^2(1)=9.074$; $p<0.005$), and the average price for 500 m^3/ha increases from 0.08 to 0.10 EUR/m^3; for 1000 m^3/ha it changes from 0.14 to 0.13 EUR/m^3, but these price differences are not statistically significant. To isolate the price effect, we separately looked at the 12% of farmers who want to buy water in both scenarios. We found that WTP does increase (for 500 m^3/ha from 0.08 to 0.09 EUR/m^3 and from 0.14 to 0.17 EUR/m^3 for 1000 m^3/ha), but not at a statistically significant level. While this may be due to the low number of observations (n=18), the data only support the conclusion that drought conditions lead

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[6] Student *t*-tests results for the baseline scenario are: $t(18)=-3.441$, $p<0.005$; for the drought scenario: $t(68)=-2.644$, $p=0.01$.

to an increase in the number of farmers who are willing to buy water, but we cannot say that it influences WTP of those participating in a normal year.

On the contrary, in the Almanzora Basin no increase is found in the number of farmers who are willing to buy water (96%) under drought conditions, but they are willing to pay significantly more for the water. WTP increases from 0.39 EUR/m^3 to 0.51 EUR/m^3, both for the 500 and 1000 m^3/ha quota (t(43)=-14.742; p<0.001).

4) Supply is lower and WTA is higher in a drought year than in a normal year.

The percentage of Guadalquivir farmers who declare a willingness to sell decreases in drought years from 27% under normal conditions to 15% (χ^2(1)=24.366; p<0.001). Average WTA is higher in drought years than in the baseline scenario, but the increase is only statistically significant for the 500 m^3/ha scenario: it rises from 0.14 EUR/m^3 to 0.17 EUR/m^3 (t(22)=-2.091; p<0.05). To look at the price effect in more detail, we again separately analyse those Guadalquivir farmers who want to participate in both scenarios (15% or 23 farmers). This group's WTA changes only slightly from 0.16 EUR/m^3 to 0.17 EUR/m^3 for 500 m^3/ha, and from 0.15 EUR/m^3 to 0.16 EUR/m^3 for 1000 m^3/ha, but the changes are not statistically significant. Again, this may be due to the small number of observations, but the differences themselves are small as well.

In the Almanzora Basin there is no significant difference in the proportion of farmers who are willing to sell (89-91%). WTA in the drought scenario (0.55 EUR/m^3) is significantly higher than in the baseline scenario (0.40-0.41 EUR/m^3) for both quotas (t(41)=-11.35; p<0.001 for 500 m^3, and t(41)=-13.666; p<0.001 for 1000 m^3).

Looking at conditions 3 and 4 together, it seems that drought conditions mainly have a price effect in the Almanzora basin, while an increase in participants is more important in the Guadalquivir Basin.

7. DISCUSSION

In Europe, stated preference methods such as CV have not been used before to assess the value of water trading as we do here. Their use to assess the value of irrigation water more generally is also limited in Europe, but there are a few studies that have focussed on the Spanish case. A good example is the one by Calatrava Leyva and Sayadi (2005), who carry out a CV study among tropical fruit growers on the Granada coast and find a WTP for extra water supply ranging from 0.27 to 0.60 EUR/m^3. Another example, this time of a choice experiment, is Rigby *et al.* (2010) who estimate a marginal value of irrigation water to horticultural producers in southern Spain of 0.45 EUR/m^3. Mesa-Jurado *et al.* (2012) estimate the same metric, but specifically for olive growers in the Guadalquivir Basin, and find it to be 0.35 EUR/m^3. In Berbel *et al.* (2011) an average residual value of 0.19 EUR/m^3 is found for irrigated crops in the basin as a whole.

In the Almanzora District we find a WTP between 0.39 EUR/m^3 in a normal year and 0.55 EUR/m^3 in a drought year. Guadalquivir farmers' WTP ranges from 0.08 to 0.14 EUR/m^3, depending on water availability conditions (normal or drought) and on the quota (500 or 1000 m^3/ha).

The core of this study is the analysis of the water market and the estimation of the demand and supply curves. The value observed in the 2006-2007 transactions was of 0.18 EUR/m^3 while the range of inter-basin market clearing prices estimated varies from 0.17 to 0.21 EUR/m^3 under normal and drought conditions, respectively. While it could be said that this previous experience with water markets, which operated under strong government intervention, established a reference point for the simulated market in this survey, the fact that the stated values are consistent with the marginal value of irrigation in both study areas gives us confidence in our results. However, according to the average values within both basins, the WTA is slightly higher than the WTP. As

argued in Jaghdani et al. (2012) farmer's strategic responses in CV experiments lead to undervaluation bias of WTP. At the same time, the economic value of a given reduction in the water supply is larger than that of the same increase (Ward and Michelsen, 2002). Indeed, for example, agricultural water rationing in a drought that reduces water use by 20% produces higher losses than the same users would gain from a increased volume by 20% over reference level.

The main advantage of using stated preferences arises from the better understanding of farmer's attitudes. While a production economics approach used in mathematical models takes into account only economics returns of water, generally resulting in overestimation of supply and demand curves, by using the CV approach, other non-economic issues can be taken into account. In fact our findings reveal that farmer's ethical issue refrains from their participation in water trading in line with our initial hypothesis. This proves that there are issues regarding whether water market is ethical.

Finally, our results point out that there is a considerable interest in water trading among farmers within the Guadalquivir Basin, in particular during conditions of drought. Three to five per cent of current water use could be traded on a temporary basis within the Guadalquivir Basin (intra-basin trading), and our results further show that this is likely to rise as familiarity with the market grows: the willingness to participate in water markets in our survey was higher for those farmers who were more familiar with water trading.

8. CONCLUDING REMARKS

Water markets already are a relevant academic and policy issue in Europe. The European Commission (2012) has listed water trading as a potential economic instrument to improve water sustainability in the European Union. Most of the existing research on the topic in Europe and Spain has been based upon mathematical models

and simulation (e.g. Arriaza *et al.*, 2002; Pujol *et al.,* 2006), but experimental research on farmers' attitudes has not yet considered.

In this study, responses to a stated preference survey were shown to be consistent with economic theory of WTP and WTA, which in turn implies the utilitarian ethical perspective of farmers. The slopes changing of supply and demand curves based on the survey are in line with the neo-classical paradigm that demand increases under scarcity (i.e. drought) while supply decreases. Stated water values were also higher in the more productive area, the greenhouse system of the Almanzora Basin. Moreover, farmers' responses took account of a breakeven point for irrigation volumes, below which the increase in production from irrigation is not enough to compensate the investment costs in the necessary infrastructure. On the other hand, findings have also shown a right-based viewpoint of farmers who do not agree to trade water, basically for considering it as a non-tradable good. This fits in Giannoccaro *et al.*'s (2013) finding that the existence of ethical concerns might influence farmer's attitudes towards irrigation water markets.

Finally, of relevance to future research is the observation that the upper reaches of the price range in our analysis is close to the cost of desalinated water. We suggest it would be interesting to test whether the cost of desalinated water is acting as a ceiling to water market prices.

The use of stated preference methods can provide a satisfactory approximation of farmer's behavior in regions where there are not well established water trade mechanisms therefore it also may serve as an analytical tool for policy design. While the main advantage of using experimental auctions lies on the power of capturing other non-economic attributes influencing farmer's attitudes towards irrigation water markets (e.g. ethical perspectives), the main weakness remains the possible influence of farmer's

behavioral responses on the outcome. We believe this study has made a relevant contribution to the research on the use of economic instruments in water governance, namely water markets. A final remainder is on the consideration of this research as exploratory in the view of better understanding the farmer's attitudes.

Appendix I: Sequence of CV questions (WTP)

Maximum price:	YES: ....(EUR/m3) NO
Increasing pathway: 0.24 EUR/m^3	YES - - - - - → NO - → WTP=0.18€/m^3
First bid: 0.18 EUR/m^3	YES
	NO
Decreasing pathway: 0.12 EUR/m^3	NO - - - - - → YES - → WTP=0.12€/m^3
Minimum price:	YES: ....(EUR/m3) NO

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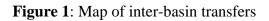
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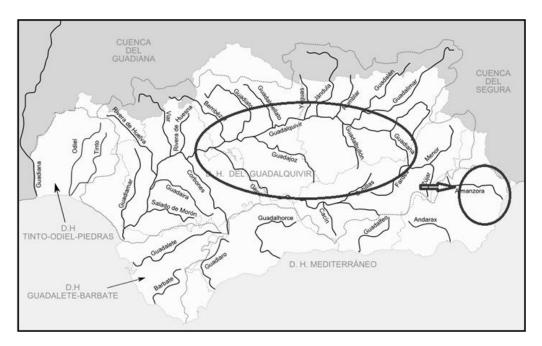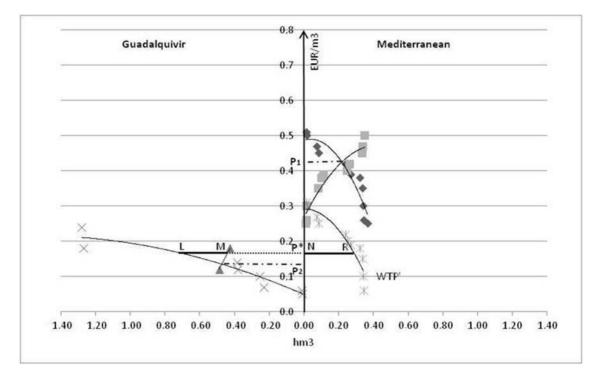
Figure 1: Map of inter-basin transfers

Figure 2: Market equilibrium for inter-basin trading under normal water availability

Figure 3: Market equilibrium for inter-basin trading under drought conditions

Table 1: Representativeness of the sample

Variables	Guadalquivir	
	Study area	*Sample (191 Obs.)*
Irrigated land (ha)	842,055	6,629
Water rights		
holder	81%	80.1%
non-holder	19%	19.9%
Water allocation (normal year)	3,950 m^3/ha	4,170 m^3/ha
Water use (normal year)	3,324 m^3/ha	2,524 m^3/ha
Irrigated crops		
winter cereals	76,400 ha (9% of irrigated area)	697 ha (10.5%)
general field crops (*maize, sugar beet, sunflower, vegetables*)	144,546 ha (17.4%)	1,409 ha (21.3%)
olive	466,677 ha (55.4%)	3,307 ha (49.9%)
citrus and fruit	58,521 ha (7%)	393 ha (5.9%)
others	95,908 ha (11.2%)	824 ha (12.4%)
Farm size (mean)	16.5 ha	41.16 ha
Irrigated land area (mean)	9.3 ha	26.40 ha
	Almeria (*Agua del Almanzora*)	
	Study area	*Sample (50 Obs.)*
Irrigated land (ha)	54,290	1,079
Water rights		
holder	95%	100%
non-holder	5%	0%
Water allocation (normal year)	n.a.	n.a.
Water use (normal year)	4,925 m^3/ha	3,963 m^3/ha
Irrigated crop system		
citrus	9,092 ha (16.7% of irrigated area)	298 ha (27.6%)
olive	2,138 ha (3.9%)	44 ha (4.1%)
vegetable	10,382 ha (19.1%)	92 ha (8.5%)
greenhouses	30,852 ha (56.8%)	591 ha (54.8%)
others	1,827 (ha) (3.4%)	54 ha (5%)
Farm size (mean)	14.2 ha	19.24 ha
Irrigated land area (mean)	9.2 ha	17.38 ha

Source: our elaboration from CAP (2011). Note: study area data refer to 2008;

Table 2: Summary of attitudes towards water trading

Farmers' preferences	Yes, only within the same district	Yes, regardless of scale	No, regardless of scale	
Agrees with water trading? (Guadalquivir)	13.3%	52%	34.7%	
Agrees with water trading? (Almanzora)	71.7%	23.9%	4.3%	
	Public administration	WUA	Farmers themselves	Others
Preferred facilitating institution (overall sample)	26.1%	45.8%	26.1%	2.1%

Source: survey data; n=196.

Table 3: WTP and WTA in EUR/m^3/ha for the different scenarios

| | **Guadalquivir** | | | | | **Almanzora** | | | | |
| | *% farmers willing to buy/sell* | *Price (EUR/m^3/ha)* | | | | *% farmers willing to buy/sell* | *Price (EUR/m^3/ha)* | | | |
Baseline		*Min*	*Average*	*Max*	*S.D.*		*Min*	*Average*	*Max*	*S.D.*
500_WTP	12%	0.00	0.08	0.18	0.08	96%	0.20	0.39	0.50	0.08
1,000_WTP	12%	0.00	0.14	0.40	0.08	96%	0.20	0.39	0.50	0.08
500_WTA	27%	0.00	0.15	0.24	0.06	89%	0.00	0.40	0.50	0.09
1,000_WTA	27%	0.00	0.15	0.18	0.06	91%	0.20	0.41	0.50	0.07
Drought year										
500_WTP	47%	0.00	0.10	0.50	0.11	96%	0.35	0.54	0.70	0.08
1,000_WTP	46%	0.00	0.13	0.50	0.09	96%	0.35	0.54	0.70	0.08
500_WTA	15%	0.00	0.17	0.24	0.05	91%	0.35	0.55	0.70	0.08
1,000_WTA	15%	0.00	0.16	0.24	0.06	91%	0.35	0.55	0.70	0.08

Source: survey data; n=150 and 46 for the Guadalquivir and Almanzora Basins, respectively.

Table 4: Guadalquivir farmers' WTP (EUR/m^3): irrigators vs. non-irrigators

	Irrigated farms			**Rain-fed farms**		
Baseline	% farmers	Average	SD	% farmers	Average	SD
500_WTP	10.4%	0.11	0.08	40%	0.00	0.00
1000_WTP		0.14	0.09		0.14	0.04
Drought year	% farmers	Average	SD	% farmers	Average	SD
500_WTP	44.4%	0.11	0.11	80%	0.04	0.08
1000_WTP		0.13	0.09		0.14	0.06

Source: survey data; n=135 and 15 for irrigators and non-irrigators, respectively.