Meta-analysis of irrigation water pricing

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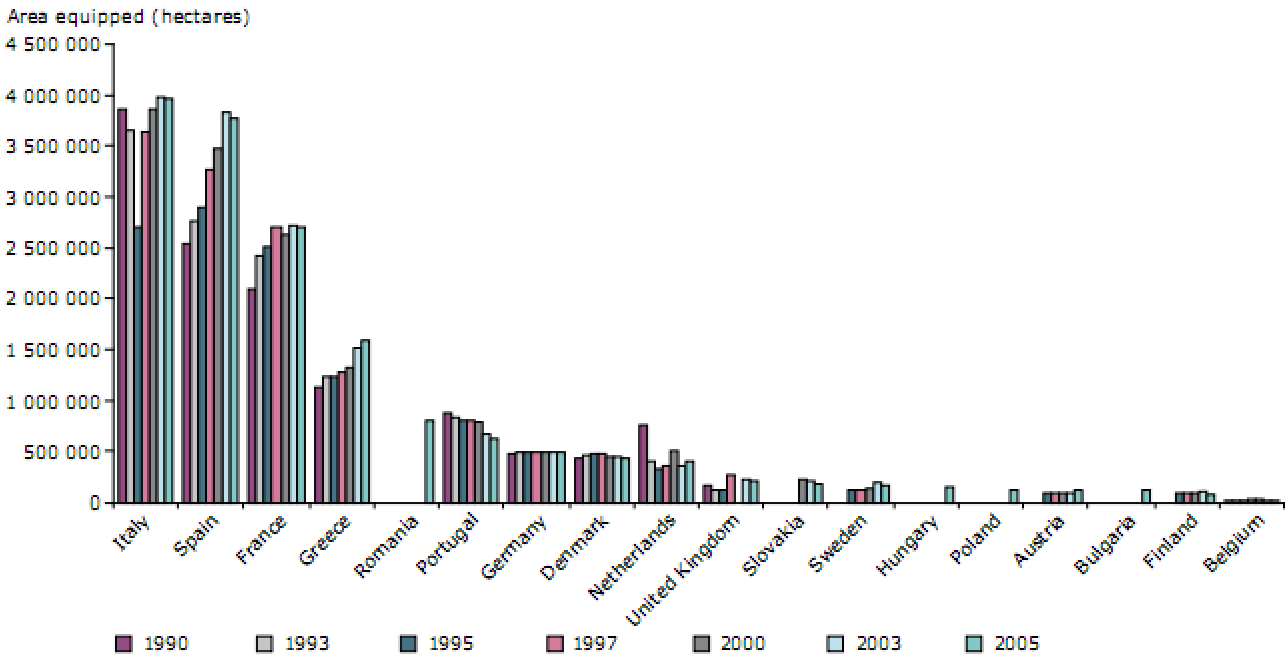
1. Introduction

The planet's uneven distribution of freshwater resources, population growth with rising food demand and predicted increases in droughts due to climate change have set the global community under alert (IPCC, 2007). Worldwide, the agricultural sector captures around 70% of the global water withdrawals. This share is expected to rise to more than 90% in some regions (WWDR, 2009). Although the European agricultural sector is on average only responsible for 24% of total water use, this fraction varies a lot amongst the EU Member States (MS). In the South, water use in irrigated agriculture accounts for up to 80% of total water use in some parts (EEA, 2009). As a result, supply infrastructure has been extended considerably, including the building of reservoirs or inter-basin transfers for both groundwater and surface water.

Figure 1 presents trends in the expansion of irrigated land across EU for the period 1990-2005. The figure shows that Mediterranean countries like Italy, Spain, France, and Greece follow an increasing trend in the use of irrigation water with the exception of Portugal, which has slightly reduced its demand. Predictions about future land occupation for irrigated agriculture imply stability for the Northern Mediterranean countries while for Morocco, Syria, Algeria and Turkey, that compose the south-east part of Mediterranean, extension of the land under irrigation is predicted (Blue Plan, 2005).

Figure 1. Trends in irrigated area (hectares) for selected countries



Source: EEA, 2009

Projections for the supply side indicate that Mediterranean countries should mitigate their water consumption in order to be able to adapt to the upcoming water stress and secure their food supply. To overcome some of the adverse effects of such supply stress, the EU aims to adopt more sustainable policy practices through the EU Common Agricultural Policy (CAP) and Water Framework Directive (WFD). The WFD introduces important demand management policies such as the introduction of water pricing (Directive 2000/60/EC 2000). Policy options for sustainable use of irrigation water can be employed in order to affect either its demand or its supply side.

The main objective of this study is to assess the responsiveness of the demand for irrigation water through worldwide water pricing policies. Water pricing is chosen as a tool of influencing water consumption through regulating the total water volume demanded and also the pattern of its use. The underlying concept of using this particular demand tool is to motivate the end user (the farmer) to reduce unnecessary water deliveries (HRC, 1997). To this end, an overview of the existing studies in a meta-analysis is provided. Meta-analysis is a tool that helps synthesize results from existing studies of the same subject allowing distilling generalizations (Young, 2005). Meta–analysis as a frame of this research treats the results of 26 worldwide studies on irrigation water demand, in order to finally allow for extrapolation of these results in the Mediterranean territory. Of particular interest is to gain an insight into the irrigation water use spatial characteristics in Mediterranean countries and to examine factors that provide potentials to encourage the adoption of sustainable water irrigation technology and reduce the vulnerability of rural livelihoods.

2. Methodology

The main objective of this paper is to assess the differences in the price elasticity of irrigation water worldwide and investigate the factors that influence the farmer's responsiveness to the imposition of water pricing, including irrigation technology. For doing so, the demand elasticity for irrigation water has been chosen as a good proxy. Farmers demand for irrigation water for different price levels can be expressed according to the following formula:

$$e = \Delta \ln Q / \Delta \ln P$$

In other words, price elasticity reveals the change in the quantity of irrigation water demanded by the farmers ($\Delta \ln Q$) when the price changes by 1% ($\Delta \ln P=1$). When the elasticity is equal to zero (perfectly inelastic demand) the farmers do not respond to a change in price. In other cases elasticity takes negative values. If the elasticity is between zero and -1, the demand is said to be inelastic, indicating that the percentage change in water use is less than the percentage change in the price. And finally, the demand is elastic if the price elasticity is lower than -1.

Meta-analysis is a tool that treats statistical data taken from existing studies to synthesize them. More specifically, meta-analysis is a useful tool in order to synthesize research results that show high heterogeneity regarding differences in population characteristics, site characteristics and pricing systems, retrieved from empirical estimates in the literature (Young, 2005). Regarding the aim of this paper, the variations among the elasticity values is the subject under examination. Although the focus of this paper is on farmer's responsiveness to different pricing scenarios, the fact that observations derived from studies referring to different parts of the world necessitates the comparability between them in order to produce a comprehensive assessment.

Meta-analysis is considered to be an important extension of quantitative analysis and can be seen as a supplement to qualitative analysis (Brouwer et al. 1999). It has been chosen over single qualitative analysis in the base of the fact that it doesn't distort or bias the research findings based on the original study's quality, while at the same time it does not make any distinction between the studies by adopting weighting approaches. However attention should be paid regarding the assumptions underlying the research. For example, it might be expected that estimates derived for a given irrigation district to be more similar than those derived from different irrigation districts. Or that estimates coming from the same study were more similar than other estimates. Both the assumptions can set the analysis under risk of getting flawed and consequently "nesting of estimates within sites and within authors" (Bateman et al., 2003: 134). Towards this target, outlier studies and particular observations have been controlled for, in an effort to account for the potentials of the 'authorship effect' or extreme elasticity values.

Despite the other advantages that meta-analysis is popular for, the primary reason for using this powerful tool, is its cost as well as time effectiveness. The existence of a large number of studies on farmer's water demand for irrigated agriculture provides large data availability to the researcher. This fact together with the possibility of incorporating results from different study sites makes possible the avoidance of on-site observations. Consequently, meta-analysis provides the possibility for a research to be accomplished within a restricted time frame, which is the case for this paper.

Exploring the literature, was a useful way to find out factors that can be considered for variations between the estimates that generated by different studies. Consequently, the dataset has been extended, in comparison to the initial one that solely included indicators that significantly influence the price elasticity based on the economic theory. Considering the differences in the estimation models employed by the studies, the assumptions underlying the models and the different pricing scenarios, the idea of the inclusion of more explanatory variables came up.

The final version of the dataset is substantially an extension of the initial one, including, in addition, information about climatic factors of the study area, the sample size used for the estimation of the elasticity values, the adjustment options provided to the farmers in the study area, the average farm size of the irrigation district, the time frame of the analysis and the source of water under pricing.

The problem with the inclusion of these variables was that only a small minority provide all the related information. The rest of the studies, neither incorporate many of the variables in their models nor provide information about them as background. Recognizing the potential that the examination of more explanatory variables generates a more powerful explanation for the variations of the dependent variable, attempts have been made to retrieve the necessary information through various sources.

The results from the personal contact with the authors of the studies have been, in most of the times, encouraging while other attempts failed. For some of the corresponding authors, the contact details seemed not to correspond to the person related to, while there have been cases reported that the author didn't respond for unknown reasons. Seeking for a solution, missing information about climatic data for the study area for the study period has been retrieved from the web pages of climatic centers around the world. Unfortunately, there have been cases that, due to a large number of missing data and due to the limited or inexistent sources, studies were left out of the sample. But, thanks to a large majority of the corresponding authors, which feed this research with the appropriate information, many gaps in the dataset have been filled in. The final version of the dataset is composed by 26 studies that comprise a number of 201 elasticity estimates.[1]

[1] This number considers also, the estimates for which not complete information exist about all the variables included in the dataset.

3. Data collection

This is a basic part of every scientific work since comprehensive knowledge of the field under study is needed to start the research. The literature for review, explores critical points of research in a particular area of interest while it provides a solid background for further investigation.

First of all a piece of selected literature (Determining the Economic Value of Water: Concepts and Methods, Young, 2005) was reviewed that looks at basic economic factors and variables associated with the irrigation water use. This step, contributed in getting an insight about which factors, according to the economic theory, can be expected to determine or affect the irrigation water price elasticity. On this basis, the first criteria to account for the literature under assessment were determined. As a result in the first stage, the provision of important information decided for the inclusion or the exclusion of the studies in the dataset. These were detailed information about the publication of the study (only reviewed studies have been assessed), the estimation method used, the type of data used as input for the estimations, the study year and the study area, the pricing regime, the irrigation technology used, the type of soil and the crops produced and the price reference year.

The literature review took place through different on-line points that literature can be sited. A great part of the literature collected, comes from the Vrije Universiteit online library or from web locations that the same library provided access to. Unfortunately, a number of studies couldn't be assessed either because they belong to 'grey literature', where the access is restricted into certain conditions, or because of the language that they were written. To be more specific, in the first category fall publications from the World Bank while in the second, studies that refer to Spanish irrigating districts in Spanish and those referring to Moroccan written in French. Finally, as mentioned before, the collection does not only respond to estimates for the Mediterranean countries as this was not one of the criteria set for the selection of the studies. Most of the literature survey is focused on existing global, supranational, national and local formal and informal water governance institutions that impact on the irrigation sector. Consequently, a considerable number of studies (almost one third) comes from study areas with large differences in socio-economic and cultural factors with Mediterranean countries and ranges from USA and Canada to Australia. The inclusion of American studies in the sample, couldn't avoid that some of the studies coincide with those used by Scheierling et al. (2004). This happens with four of the studies which are represented in Table 1 under the study id No.1, No.3, No.16, No.17[2]. However the number of estimates provided from these studies is considerably bigger than in the previous meta-analysis, but this is a matter of employing different calculation methods for retrieving the data, which is explained in more detail in Chapter 3.

The studies included in the analysis have a principal focus on different pricing policies of surface water and groundwater used in irrigated agriculture. In general, most of the studies held for Mediterranean countries examine the results of potential pricing scenarios in Mediterranean countries as until what recently has been reported, water supply was for free or it doesn't cover substantial costs (operational and maintenance costs) (Hamdy, 2002). This is also evident throughout the studies performed in the Mediterranean region.

In Spain, farmers from the irrigation districts of Bajo Carrion, Fuente Palmera and Bembezar paid only part of the distribution cost while the water itself was provided to them for free (Berbel et al., 2000) while in a region of Northern Greece the water charging was found to be completely uncorrelated with to the actual water consumption (Latinopoulos and Mylopoulos, 2004 cited at Latinopoulos, 2008).

Both studies examine farmers' reaction to the potential establishment of future pricing scenarios as predicted by the Agenda 2000.

For doing so, almost the three quarters of the elasticity estimates for Mediterranean farms employ mathematical programming models. This intension is explained either by the low requirements of these models in the length of data series or by their ability to incorporate and reports multiple effects and interactions between alternative activities and constraint limitation at the same time (Arriaza et al., 2002). Most of them are based on the Multi-Attribute Utility Theory (MAUT) in order to simulate farmers' behavior.

In an attempt to quantify the dimensions as well as the implications of water charging adjustment, a Multi-Objective Decision Making model has been developed for the farmers in an irrigation district in Portugal (Saraiva et al., 2002).Basically these models consider the objectives that farmers take into account in order to make their decision about the quantities of the inputs to use in the agricultural production.

Considering multiple objective functions(minimization of risk, minimization of labor, maximization of profit) and a set of constraints (total agricultural area, CAP, market and other constraints), they succeed in taking into account several adjustment options provided to the farmer. These options can range from alternative irrigation technologies and changes in the crop mix to changes in irrigation schedule and acreage. The study of Gomez-Limon et al. (2000) examined farmers' adaptation to the rising water prices through changes in the crop mix. The most commonly provided

[2] In the meta-analysis of Scheierling et al. (2004), the results of 18 studies have been included in the sample. Out of the 18, only 4 of them coincide with the studies used by this meta-analysis. In this meta-analysis, in line with the focus on global studies, studies have been collected from all the parts of the world. Due to time limitations on the composition of this research, only few North American studies and those with free access through the web have been assessed.

option is the potential of change in the crop mix (Berbel et al.; Manos et al.; Saraiva et al.; Consuelo et al.). Generally observed is the tendency of Mediterranean farmers to replace the high value crops such as cotton, corn and sugar beet, with those of lower value such as winter cereals and sunflowers (Berbel et al., 2000.). However in more than half of the Mediterranean studies, more than one adjustment options were considered, with the most popular combinations to be changes in the crop mix and in irrigation acreage, followed by changes in crop mix and irrigation schedule.

It has been concluded by Consuelo et al. (1998) that for the "old"[3] irrigation districts, considered in their model, the price responsiveness has been smaller than in the "modern" irrigation districts. The additional option provided to traditional farmers under this study has to do with the adjustment in irrigation technology systems. Consequently, the lower elasticity values for this group of farmers are attributed to their shift in the application of more efficient technology (show that later this is not generally true for the rest of the sample). The study of Sheierling et al. (2004) reached the conclusion that the demand elasticity for consumptive use of irrigation water tends to decrease when scenarios allow for more adjustment options.

However, mathematical programming has been blamed to sacrifice some degree of generality (Young, 2005). Researchers might wish to explore the potential effects in the efficiency of water use (through changes in crop mix or irrigation technology or schedule) but they suffer the disadvantages of using such models. Sheierling et al. (2004) concluded that mathematical programming generally produces higher elasticity values than econometric model do, due to their dependency on both historical and synthetic data. According to (Arriaza et al., 2002), MP models are commonly used in developing countries as they do not require observations on functioning water markets. But, at the same time a majority of the studies coming from the non-Mediterranean countries in the sample also employs mathematical programming models and the reason for this is the focus on substitution in irrigation systems, in the crop mix etc.

Although most of the observations in the sample resulted from MP models, econometric models were employed by almost half of the total of the studies included in the sample. The fact that less observations derived from econometric studies explains why the distribution of the observations between the two estimation methods unequal. These studies use data of actual farmer behavior. In this direction they consider variables such as the local soil index and the monthly temperatures (Madariaga et al., 1973) or the maximum evapotranspiration and the salinity of the water (Rosegrant et al., 2000). Using primary data Nieswiadomy (1976) estimated the water demand for pumped groundwater in the High Plains of Texas, while Bar-Shira et al. (1995) was seeking to investigate the differences in the impacts of a block-rate versus a uniform pricing scheme on farmers' responsiveness.

[3] The terms of "old" and "modern" irrigation district were borrowed by the original paper of Consuelo et al.(1998).

Another trend observed typically in the most recent studies was the construction of models looking for regional and subregional differences in elasticity sensitivity. The demand function of six different irrigation districts has been calculated by Consuelo et al. (1998) and found out that water saving is mainly due to structural, agronomic conditions and budgetary constraints while less of the impact is attributed to water prices. Considering different clusters of the same region, the study of Latinopoulos revealed that differences in elasticity estimates among the different clusters can be explained by productivity variations or due to variations in the crop mix (high/low substitutability between the crops).

Overall, the studies as well as the individual elasticity estimates in the sample show high heterogeneity. Looking through the literature, several factors have been identified to play a potential role to the shape of the irrigation water demand function. Those found significant and recommended by the literature are used for further testing in the following chapters.

4. Study characteristics

The elasticity estimates that comprise the sample population of the meta-analysis have been extracted from 26 studies. Some of them focus on estimating farmers responses to future pricing scenarios, others on incorporating potential adjustments to the agricultural production inputs other than the water demanded. Less commonly, studies compare farmers' responsiveness when farms' characteristics alter, Arriaza et al. (2002) explored the Spanish water markets in Southern Spain and ended up with differences in demand responses among the various farm sizes while the study of Consuelo et al. (1998), highlighted that regional differences, due to dissimilar modernization degree of the irrigation technology applied, create significant implications for water policy.

Table 1 provides an overview of the studies included in the meta-analysis by the year that the study was conducted (and not by publication year) and the number of observations derived from each study. Out of the total population, only one of the observations refers to the period until the 1970s[4], almost a quarter of them are found between 1970 and 1990, while a big majority of them to the period 1990-2008.

Furthermore, it is clear from the table, that all of the studies have been published in journals while three of the studies have been used as discussion papers and one of them is a scientific paper. The fact that the latter four studies haven't been published in a journal does not mean that they haven't been internally reviewed. Although the validity of their results might not be absolutely comparable with the rest of the studies, the data points extracted by them, account only for 5% of the total population in the sample. Consequently, it is doubtless that this fact will affect the quality of the meta-analysis.

Besides that, Table 1 illustrates two other problems in this meta-analysis.

First, a number of people have been involved in several publications and this may result in an 'authorship' effect (Brouwer et al., 1999). Of primary concern is the possibility that authors may use similar datasets. This problem might come up from the studies No.7, No.14, No.18. However the three studies examine different irrigation districts (and thus work with different data), while one district is common in studies No.7 and No.18 (Bajo Carrion). As it is supported by Gomez-Limon et al. (2000), the results differ due to the different estimation methods employed under each study. More specifically, the results show that the estimated water-demand curve is different when a multicriteria utility function rather than the classical profit maximization hypothesis is employed (Gomez-Limon et al., 2000).

[4] As is explained in the "Data Specification", for some of the studies that examine periods longer than one year, the midpoint has been chosen to represent the study year of the study. As such, in the sample some of the observations refer to points in time before the 1970s.

Table 1. Studies included in the meta-analysis

Studies included in the meta-analysis				
Study Id	**Authors**	**Publication**[5]	**Study Year**	**N**
1	Michael Nieswiadomy	Journal article (AJAE)	1976	1
2	Ziv Bar-Shira, Israel Finkelshtain, Avi Simphon	Journal article (AJAE)	1995	2
3	C.Richard Shumway	Journal article (SJAE)	1980	3
4	Bruce Madariaga & Kenneth E. McConnell	Journal article (SJAE)	1973	4
5	Sarah Wheeler et al.	Journal article (AJARE)	2004	2
6	Sussane M.Scheierling, Robert Young, Grant E.Cardon	Journal article (JARE)	1991	20
7	J.Berbel, J.A. Gomez-Limon	Journal article (AWM)	1994	9
8	Lixia He., Theodore M. Horbulyk	Journal article (CJAE)	2002	3
9	Suren N.Kulshreshtha, Dewi D.Dewari	Journal article (WRB)	1986	10
10	D.Latinopoulos	Journal article (CJAE)	2001	16
11	Alberto Garrido	Journal article (AOR)	1984	4
12	Hugo Storm, Thomas Heckelei, Claudia Heidecke	Discussion paper (ARE)	2008	1
13	I.Amir, F.M.Fisher	Journal article (AS)	1994	21
14	M.Arriaza, Jose A., Gomez-Limon, Martin Upton	Journal article (AJARE)	1998	32
15	B.Manos et al.	Journal article (RS)	1998	4
16	Mark A.Hooker, Wendy E. Alexander	Journal article (JAWRA)	1989	8
17	Richard E. Howitt, William D.Watson, Richard D.Adams	Journal article (WRR)	1978	4
18	J.A. Gomez-Limon, J. Berbel	Journal article (AS)	1994	22
19	Claudia Heidecke, Arnim Kuhn, Stephan Klose	Journal article (AJARE)	2007	2
20	M.W. Rosegrant et al.	Discussion paper (EPTD)	1995	3
21	Maher O.Abu-Madi	Journal article (AWM)	2006	1
22	Joao Paolo Saraiva, Antonio Cipriano Pinheiro	Scientific paper	2002	3
23	Parashar B Malla, Chennat Gopalakrisnan	Journal article (IJDRD)	1987	2
24	Karina Schoengold, David L.Sunding, Georgina Moreno	Discussion paper (AAEA)	1997	8
25	Werner Doppler et al.	Journal article (AWM)	1994	2
26	Valera – Ortega Consuelo et al.	Journal article (AE)	1994	16

[5] Abbreviations: AE Agricultural Economics; AJAE American Journal of Agricultural Economics; AJARE Australian Journal of Agricultural Economics; AOR Annals of Operation Research; ARE Agricultural and Resource Economics; AS Agricultural Systems; AWM Agricultural Water Management; CJAE Canadian Journal of Agricultural Economics; EPTD Environment and Production Technology Division; JARE Journal of Agricultural and Resource Economics; JAWSA Journal of American Water Resources Association; RS Regional Studies; SJAE Southern Journal of Agricultural Economics; WRB Water Resources Bulletin; WRM Water Resources Management; WRR Water Resources Research

Secondly, attention should be paid to the uneven distribution of the data points of the sample among the studies. There are, 201 observations, in total, corresponding to 26 studies meaning that a mean of 7 to 8 studies should respect to each study for an even distribution amongst them. More than half of all studies provided two to four observations which represent either different price levels or reflect changes in the irrigation water pricing policy or in other cases changes in the inputs in the agricultural production. Three of the studies contribute to the final population eight to ten observations while more than sixteen data points come from each of the rest seven of the studies. This creates the need to account for the possibility that results from the same study cluster together. It can come as a result of extracting farmers' response from different irrigation districts but from the same country, and that results from the same studies may be more variable than other. Shumway (1973) concluded that water pricing plan in one subregion also have important implications to other subregions. He supported that, the profitability of agricultural production and hence the marginal value of product of water in adjacent areas will be affected by the changes of the pricing plan in the area under study. Consequently this may lead to identical farmer responses within a country or among different districts of the same river basin.

Comparing the studies on the basis of the variety of the estimation models they employ and the factors they consider influencing the price elasticity of irrigation water, leaded the meta-analysis to the inclusion of more explanatory variables than expected. Expectations based on the micro-economic theory imply that the price imposed on a good is the most influential factor on the quantity demanded. Nevertheless, the significance of other explanatory variables couldn't be rejected by the studies held in the field. On-site considerations such as climate, soil and source of irrigation water, institutional characteristics of the water market, together with data-based decisions enriched the table of the independent variables. In the end the variables have been categorized according to the following breakdown:

Study Characteristics:

- *Study Year:* Research on the demand for irrigation water started somewhere in the middle of the previous century. Madariaga et al. (1984) estimated the demand for irrigation water in the Middle Atlantic States for the years 1969, 1974, 1978. The result from the econometric model run predicted that under the assumption of stable marginal irrigation costs, strong competition for the water supplies will be a reality in the future of the region. This conclusion implies that under changing socio-economic scenery, the evolution of time might have an influence on the way farmers compete on irrigation water provision.

Data under this variable reflect the year that the data of the study refer to, such as data regarding crop prices, irrigation water costs, or the annual climatic conditions. In many cases, the time horizons of the data don't come from a specific year and they cover longer periods. For such cases the midpoint of time stands for the study year.

In the study of Hooker (1998) data have been retrieved from the study of Casterline et al. (1989). Due to reasons of limited access to this study and the lack of contact details of the corresponding author of the study included in the sample, assumptions about the study year have been made. Taking into account the time gap between the termination of a research and the publication year, which is approximately two years (Grinnell et al. 2008) 1987 was taken as the study year. For the same reasons, 1978 was taken as the study year for the study of Howitt et al. (1980).

- *Country:* One of the main focuses of the research was to look through the existing global, national, supranational and global water pricing policies and identify their impacts. Consequently although the Mediterranean region is the area of the focus of this meta-analysis, studies examine structures and reactions out of the region couldn't be ignored. As a result, ten studies come from the research done for USA, and one for each of the following countries; Australia, Canada, Chile and Jordan. Within a total of twenty-six studies reviewed, the rest half of the studies comprised of;

Four studies specialized in the Spanish irrigation sector, three in the Israeli, two in the Moroccan and two in the Greek, and lastly one in the Portuguese.

The fact that studies come from both inside and outside the Mediterranean region stimulated the need for testing for variations between the studier leaded to the grouping under this variable. The variable takes a zero if the elasticity values estimated come from studies done for a non-Mediterranean country or number one for estimations made for Mediterranean countries.

Later, the need of a baseline to control for the observations that refer to North American irrigation districts, studies leaded to further categorization of this variable. As such, in the regression analysis, the sample was divided into the five subgroups, namely *North America, South America, Australia, North Africa & Middle East,* and *European Mediterranean.*

- *Estimation Method:* Methods used for the estimation of water demand function vary a lot between studies. Studies performed econometric tests, more commonly used OLS or GLS for their estimations, while mathematical programming models typically employed models based on the MAUT, such as MCDM.

Farmers' responsiveness has been concluded to be higher when derived from econometric studies and mathematical programming models rather than those based on field experiments (Scheierling et al., 2004). Wanting to test the effect of the estimation method on the elasticity values two dummies have been considered under this variable; 1=econometric models while 0=mathematical programming models. The case of field experiment is not an option for this meta-analysis. As a result, expectations are oriented to the direction that mathematical programming generally produces higher elasticity values than econometric modeling does (Sheierling et al., 2004).

- *Type of Data:* The distinction between the estimations calculated based either on primary or on secondary data was made in order to count for their effect on the elasticity values. Primary data have been basically retrieved through interviews and surveys in the study area where farmers have been questioned, for example, for their weighting between different objectives (Arriaza et al., 2002). Willingness to pay for irrigation water (Kulshreshtha et al., 1991) has been subtracted from a derived water

demand function, while water markets in the irrigation district do not permit a fix price for water and the consumers are not direct users and has been included in the category of secondary data together with simulated data and data that have been adjusted and then extended to other areas.
Results from the meta-regressions on the irrigation water demand by Sheierling et al. (2004), do not indicate any significant effect of the type of type on the elasticity estimates. Nevertheless, significant correlations have been identified between the estimation methods and the type of data used. In purpose of testing for such an expectation, when the dummy under this variable takes the value of zero then the elasticity is estimated by secondary data while it is estimated by primary when the dummy takes the value of one.

- *Sample size:* The idea underlying the participation of this variable in the database is in line with the assumption that bigger samples are relatively more representative. Great farmers' participation in such surveys might generate less unbiased results regarding their evaluation of irrigation water. Bias can be generated when, for instance only owners of relatively small farms are questioned. The extrapolation of the results in the irrigation area then might not reflect the reality. In an attempt to count for potential variations in the elasticity estimates when sample size changes, the population taken into account in the studies reviewed is presented as a different independent variable.

Difficulty has been faced in the determination of the measurement unit as part of the studies included individual farmers in the sample, while others irrigation districts or even a whole river basin. Some others did not include any information about the sample size as, for example the study of Wheeler et al. (2008) was not survey based and the prices were based on whoever traded with Watermove, so there is a lot of missing information under this variable. In an attempt to eliminate the missings, the number of farmers included under each sample has been considered as it presents the comparatively biggest availability of information amongst the studies. (Still for only one third of the observations the sample size is known).

- *Time frame:* Long-run or short-run irrigation water demand functions have been treated under different assumptions by the studies. The study of Schoengold et al. (2004) shed light to the difference between long-run and short-run elasticities of demand. The study calculated that adjustments in technology and changes in output prices over time resulted in a 17% increase of the short-run elasticity when the indirect effects that count for these adjustments are incorporated. The assumption underlying the distinction between the two time frames is in line with the study mentioned above and the border is defined by the fixity of inputs used in the agricultural production process. This assumption has been used to derive information about the studies that didn't make clear the time frame of their analysis. Consequently, and with the guidance of the economic theory, when the production technologies or the land allocation has been adjusted over time, then the time frame has been perceived as long-run (Timeframe=1) otherwise as short-run (Timeframe=0). When the assumption couldn't be adopted and the personal contact with the corresponding author hasn't been successful the variable has taken a missing value. (This holds true for one of the studies).

Farm characteristics:

- *Adjustment Options:* Mathematical programming models have the flexibility to incorporate a number options provided to the farmers in order to adjust in the rising water prices. These options represent adjustments followed by the farmers after the change in the price. For the cases that the adjustment options were not incorporated by the model, the reaction of the farmer in the imposition of a higher price has been accounted for as an adjustment option. As such:

1. *Changes in irrigation technology* include potential increases in farm productivity due to technological improvements or shifts from one method of irrigation technology used to another.
2. *Changes in the crop mix* embody changes that happen when, along with the rise in prices, farmers shift from high value to low value crops. The latter are less water demanding and the shift towards them results in considerable water savings. However, it has been generally supported in the literature, that due to their lower value, the shift creates devastating losses to farmers' income.
3. *Changes in irrigation schedule* refer to changes in water allocations throughout the study period. In their study, Bar-Shira et al. (2006) reported changes in the irrigation planning amongst the different time periods (May to September and November to February)
4. *Changes in irrigation acreage* can be gradual from a price range to another, where some of the irrigated activities lose their optimal basis, or can even imply the termination of irrigation in agriculture when water price reach extremely high levels. (Amir et al., 1999)
5. *No Adjustment Options.* These are the cases where the models do not incorporate any adjustment option to the farmer.

Comparison between two irrigation districts by Consuelo et al. (1998), concluded that the more the adjustment of other (than water) inputs in the agricultural production the less responsive the demand will be. In this direction, the meta-analysis by Sheierling et al. (2004), didn't confirm that effect, however the reason was explained to, possibly, be the low variation of the adjustment options among the studies.
The different adjustment options, as well as their combinations, have been categorized into five groups, and the description can be found in Table 5 of the Appendix.

- *Farm size:* The study of Arriaza et al. (2002) focused on the estimation of the utility function of three irrigated areas in Spain with differences in the farm size. The study provides significant evidence, that under the establishment of a traded water allocations market, the marginal utility of water for small farmers is greater than the price. As a result big farmers sell water to the small and medium farmers. It can be expected then, that the bigger the size of the farm the easier the adjustment to the rising water prices. The feasibility of changing their field of activity has been higher for big farmers while for small and medium the dependency on the optimal agricultural production is the primary objective.

Consequently, the potential of a positive relationship between elasticity estimates and farm size can be expected. However, for half of the population in the sample, farm size is omitted. For the cases that farm size has been available it has been measured in ha.

- *Irrigation technology*: Technology is one of the inputs in the production process. Agricultural productivity depends on the irrigation efficiency of the crops and this implies the use of different technologies. Results from the study of Schoengold et al. (2004) reveal that different irrigation technologies used on different crops present differences in the water saving rates. Efficiency in irrigation technology can have a broader term, if the grouping is based on the modernization of the system itself. According to Consuelo et al. (1998), irrigation districts equipped with old irrigation technologies are more responsive to price changes, while the opposite is true for those using more updated technologies.

Exploring the literature, furrows, sprinklers, drip irrigation, open-ditch and flood irrigation systems as well as combinations of them have been applied for the agricultural production in the various irrigated districts. Furrows are small, parallel channels, made to carry water in order to irrigate the crop. It is supported by the literature that together with the flood and open-ditch irrigation is probably one of the oldest methods of surface irrigation. In the category of more modern technologies fall the sprinkler and the drip irrigation. In contrast with sprinklers, drip irrigation includes a more precise watering of the crop as only the part of the soil in which the root grows is wetted (FAO, 1988). The precision of the system ensures a comparatively more efficient irrigation use of water.

In purpose of testing how the various irrigation technologies combined or alone might explain the steepness of the demand curve, six groups have been created. The first five, represent one irrigation technology applied each time (among furrows, sprinklers, and drip irrigation, open-ditch and flood irrigation systems) while the other four groups represent the cases where different technologies are combined in order to provide irrigation in a comparatively more efficient way, from a water saving perspective. A full representation is provided in Table 5 of the Appendix.

- *Irrigated crops*: The cropping mix presents high variability among countries, irrigation systems, soil types and farm sizes. The cropping mix varies from horticultural crops and winter cereals to fruit trees and orchards. Due their high diversity a first try that categorizes them has the following breakdown:

-Fruits: Mellon and Watermelon
-Trees: Citrus, Oilseeds, Orchards, Pineapples
-Winter Cereals: Wheat, Barley, Oats
-Horticultural: Onions, Potatoes
-Other Field Crops: Sugar Cane, Dry Beans, Sorghum

While Alfalfa, Vegetables, Flowers, Sunflowers, Sugar Beets, Corn, Cotton and Rice are considered as separate categories, due to the difficulty in including them in larger categories. Each of the variables is represented by a dummy which takes a zero value when the crop is not irrigated for the individual estimation or the value of one when the crop is irrigated.

This categorization serves the purpose of checking for expected correlations between the irrigated crops and other independent variables as irrigation technology, country etc.

In line with the expectations of Scheierling et al. (2004) that the exclusion of high value crops from the crop mix results in more elastic irrigation water demand, a further categorization has been done. In this stage, the dummy variable takes the name *High Value Crops* and counts for the number of the different high value crops that synthesize the cropping mix for each elasticity estimate.

Determining which crop to consider as high value has been difficult. The primary attribute of high value crops is that they are comparatively more water-demanding. According to Latinopoulos (2008), cotton, rice, fruit trees, and sugar beets are all highly water-consuming crops. Shumway (1973) confirmed this attribute of sugar beet and extended it for alfalfa, barley and melons. The study of Berbel et al.(2000) treated cotton, corn and sugar beets as water intensive crops while supported that winter cereals, horticultural crops and sunflowers are of lower value. What created confusion in this stage was that the latter study supported that climatic conditions in Spain permit wheat, barley, oats and sunflowers to be grown under rain only water supply. In an attempt to make it clear for barley whether it should be considered as high or low water demanding crop, the opinion of a third source has been taken into account. Yang et al. (2002) in a case study for the Southern Mediterranean countries used the FAO database, to determine about the water demand of the various crops. According to the water demand index studies the all the crops, apart from the horticultural and the winter cereals are perceived as high value crops.

For the sample under this meta-analysis, the cropping mix might not include any of the high value crops while the maximum number reported is seven.

Geo-climatic conditions:

-*Precipitation*: Econometric regressions for the water demand in irrigated agriculture In the studies of Nieswiadomy (1985), Bar-Shira et al. (2006) and Malla (1995) were found to be significantly affected by the precipitation levels of the area under study. More specifically, in the study done for two irrigated areas in Hawaii, rainfall coefficients were negative and significant at 1% and 5% confidence levels while water price was not significant for any of the two levels. Wheeler et al. (2008), showed that between others, the average demand for water allocations is significantly influenced by seasonality factors and drought. During periods of drought irrigators' demand for water is high, meaning that irrigators are willing to pay high prices in order to avoid losing their plantings and to stay in business and as a result demand is inelastic overall. According to this result, it can be expected that scarcer rainfall implies less elastic water demand.

Information about precipitation levels, provided by the studies, refers to annual precipitation levels of the study areas, derived from annual reports of the local climatic centers. For studies, such information were not provided, personal contact with the authors succeed to give a solution. For others, that related data have been of free access through the web, precipitation levels have been calculated using the average of the district based on monthly records. For studies, that information about average precipitation levels for the whole region was not provided, precipitation levels have been calculated using information from different climatic stations in the region. For instance, for a study performed for the region of Alberta, annual average precipitation levels from four stations in the region has been assumed to give a good approximation of the average of the region. Consequently, annual precipitation levels of High level, Pincher Creek, Grande Prairie, and Lloydminster which are located in the north, south, west and east of the Alberta region respectively, have been taken into account. In order to fill these gaps, secondary data sources were consulted. Web pages from national and regional climatic centers of Alberta, Australia, Hawaii (respectively) that were consulted are the following:

1. http://www.weatheroffice.gc.ca/forecast/canada/index_e.html?id=AB
2. http://www.bom.gov.au/climate/averages/
3. http://cdo.ncdc.noaa.gov/climatenormals/clim20/hi/519523.pdf

All the information provided are measured in mm.

- *Temperature:* Other studies, instead of the local precipitation levels, test the effect of the temperature on local farmers' demand. In the study of Schoengold et al. (2004) it was expected that higher temperature would result in higher demand for irrigation water. Assuming the same relationship, annual average temperature -measured in Celsius degrees-of the study areas, has been included to test for any significance in explaining variations of the elasticity estimates.
Again, due to the great lack of data, the same procedure has been followed to fill in the gaps under this variable. The inclusion of temperature data for less than one third of the elasticity estimations, proved the constrained free availability of such data.
- *Soil Type:* The inclusion of this variable reveals the willingness to account for exogenous factors that influence the agricultural productivity. In the study of Madariaga et al. (1984), a variable for soil has been employed as a proxy of land productivity. According to the authors of the study, the higher the soil sandiness the lower the water-holding capacity. This implies that irrigation of sandy soils has higher water demands in achieving profitable water applications. As a result, a lower elasticity is expected for farmers irrigating on sandy soils (HRC, 1997). In purpose of simplicity, the variable is tested under a dummy to represent the irrigation applied on sandy soils.

Personal contact with authors satisfied approximately two thirds of the sample needs for data. Internet sources have been used to derive relative information about Hawaii (http://websoilsurvey.nrcs.usda.gov/app/) and Morocco (http://www.impetus.uni-koeln.de/en/impetus-atlas/impetus-atlas-morocco.html), while the rest remains with missing values.

- *Water source:* Groundwater and surface water has been found, in general, to be priced differently. This evidence might be due to the different applications of the two forms of water in irrigated agriculture. Groundwater is not or comparatively lower priced, as it is more saline with limited applicability in terms of crop mix. In the Middle Draa River Basin Heidecke et al. (2008), reported that the distribution of groundwater is made for free, while only the pumping cost is born by farmers.
On the other side, when surface water is highly priced, according to Hooker et al. (1998) the agricultural sector is challenged either to move to a more efficient irrigation technology or to a more salt-tolerant crop. The other options provided under the same study, is the change to groundwater. In study areas that elasticity has been estimated based on the substitutability between the two types of water, the estimate has been excluded from the sample. This is the reason why the estimates based on the study of Heidecke et al. (2008) were not, finally, included in the sample.
Water source has been dummy coded for surface water. Zero represents the case that pricing is implemented on groundwater. One third of the observations do not acquire any information for this variable.

Pricing characteristics:

- *Pricing regime:* Although the most commonly used scenario in the literature is the volumetric pricing, different pricing policies on irrigation water have been identified. In their study Saraiva et al. (2007), they test the impact of the imposition of water quotas, flat tariffs and volumetric pricing on the demand elasticity. Their findings imply significant differences on the elasticity estimates under the different pricing regimes. Another example that comes from Arriaza et al. (2002), tested how an institutional change in water market can influence the agricultural production patterns. Howitt et al. (1980), Schoengold et al. (2004), Wheeler et al (2008), Madariaga et al. (1984), estimated demand elasticities for irrigation water under charging per unit of irrigated land while in the studies of Malla (1995) and Bar-Shira (2006) the same was done considering a block-rate pricing regime.
The grouping has been done for the four different pricing regimes found in the literature without any prediction about the potential correlation between them and the elasticity estimates.
The categorization has been made for the six different ways of irrigation water charging found in the literature. A full overview is provided in Table 5 of the Appendix.

- *Price*: By definition, price elasticity measures the reaction of the farmers regarding the irrigation water quantity demanded when the price imposed on the good changes. According to the economic theory, even if the slope of the demand curve is constant, elasticity changes, for the different combinations of price and quantity demanded. Demand is elastic at higher prices and inelastic at lower prices when the demand curve is a straight line (Sheierling et al., 2004). Elasticity has been estimated in the literature, either considering situations where irrigation water was provided for small or for middle prices and high prices and different price levels as well. There hasn't been any elasticity estimates provided from the literature, for the case of zero pricing, so the price never takes a zero value in the dataset. In cases that the point elasticity is estimated by the study, then the price level to which the elasticity value corresponds is presented under this variable. On the other hand, when elasticity represents the change in irrigation water demand for a particular price range, then the mean price was assigned to this observation[6]. Furthermore, in cases that elasticity estimates have not been provided by the study, changes in water quantity demanded have been used as an input to calculate the elasticities for the different price levels. As such, for the cases that measured the reaction of the irrigation water demanded by the introduction of a pricing scheme (meaning that irrigation water had previously been provided for free), the arc elasticity has been calculated. In cases that changes in quantity has been provided in percentages then log expression ($e=\Delta \ln Q/\Delta \ln P$) of the elasticity equation ($e=(\Delta Q/\Delta P)*Pa/Qa$[7]) has been used.

The fact that water prices come from different countries using different currencies, made it necessary for the currencies to be converted in a way that ensures their comparability. After expressing the prices in 2005 prices by inflating or deflating them based on the GDP deflators of the World Bank[8], national currencies were converted in international dollars, based on the PPP factor of the IMF[9]. An example of the data conversion is provided in the Appendix. (Table 2)

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[6] The mean price has been calculated based on (Pb-Pa)/2, where Pb=final price, and Pa=initial price

[7] The factor represents the initial level of the price and the quantity demanded.

[8] World Bank's on-line source for GDP deflator: (http://data.worldbank.org/indicator/NY.GDP.DEFL.KD.ZG/countries/latest?display=default)

[9] International Monetary Fund's on-line source for PPP factor: http://www.imf.org/external/pubs/ft/survey/so/2008/res018a.htm

5. Results

The descriptive statistics for the dependent variable irrigation water price elasticity showed a non-normal distribution, as the skewness and kurtosis are highly indifferent from zero (-3,084 and 11,147 respectively). The negative value of skewness indicates, at first, that the distribution of the demand elasticity is not normal and secondly that the pill up of the scores are on the right of the distribution, while the positive value of kurtosis indicates a pointy distribution. The mean elasticity for the whole population given is -1,572 while the median is considerably lower, in absolute terms (-0,460).

Table 2 Summary statistics irrigation water price eslaticity

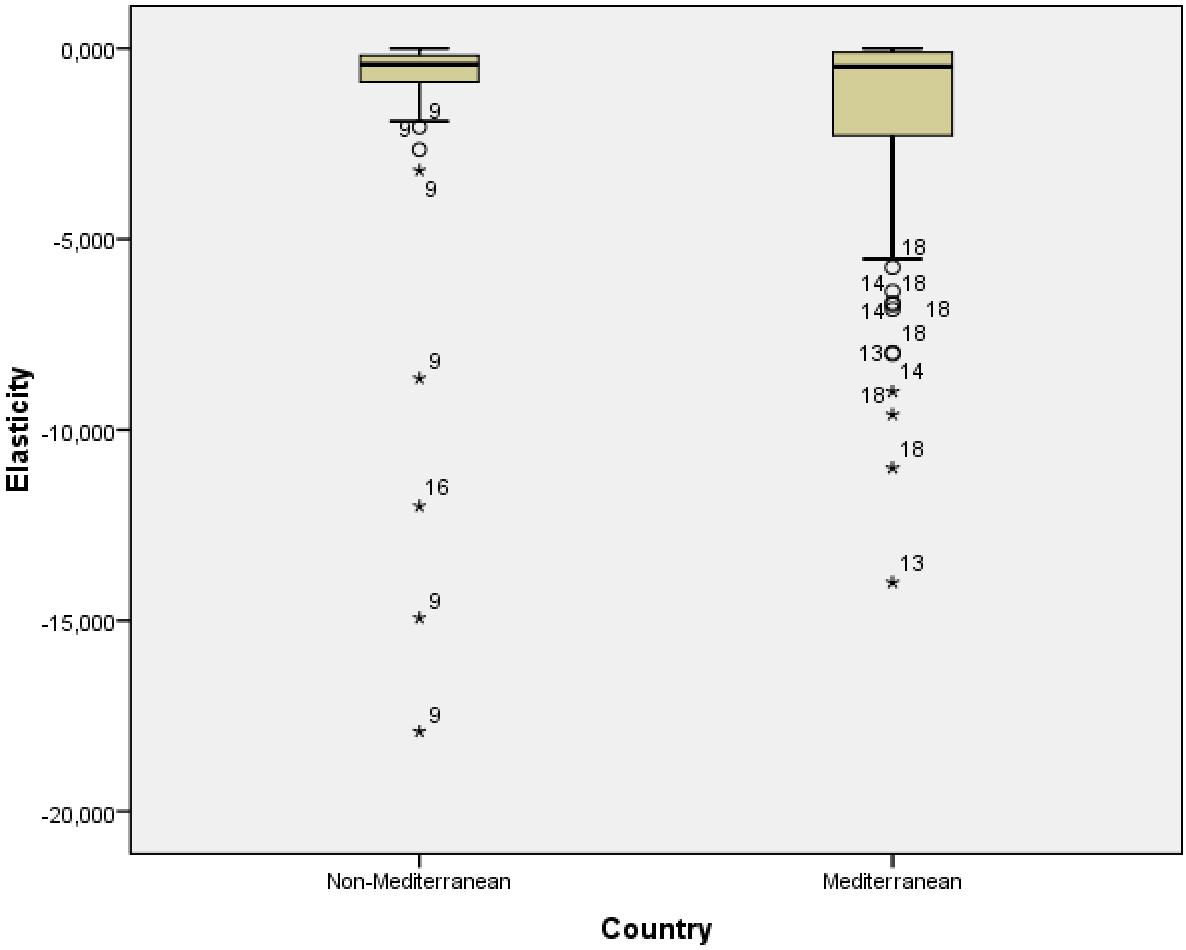
N	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
201	-17,910	,000	-1,57240	2,779290	7,724	-3,084	,172	11,147	,341

Exploring the dataset in purpose of spotting extreme values that could influence the direction of the results, descriptive statistics have been developed for the dependent variable.

Figure 2 indicate that 4 estimates come from the studies No.18 and No.13 for the Mediterranean countries, while 5 from the non-Mediterranean countries meaning that together they result in 4% of the sample.

For the non-Mediterranean countries extreme elasticity values were observed in 1986 while the outliers for Mediterranean countries respond to the years 1994 and 1998. According to the literature reviewed, the high elasticity values under study No.9 for the Saskatchewan River Basin refer to high water prices which in turn reflect that water use becomes uneconomic for the local farmers so that the demand for water turns into highly elastic.

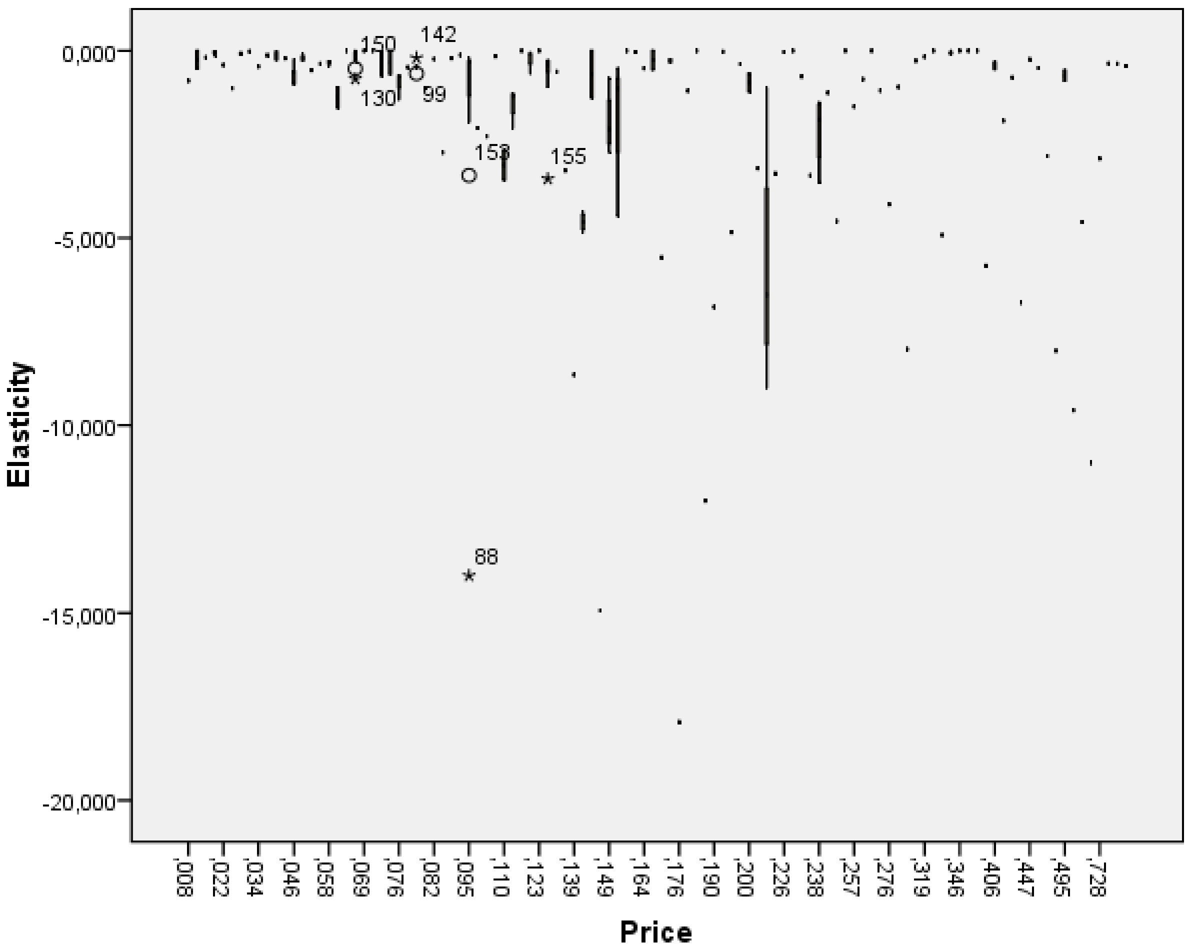
Figure 2. Outlier elasticity estimates



As for study No.18, the high elasticity values again reflect a comparatively high level of price on water (considering that the irrigation water supply is provided at a zero price to the study area) where the farmers suffer great income loss by changing their crop mix as a mean of reducing their consumption of irrigation water (Gomez-Limon et al., 2000). Under study No.13, the price increase find farmers to alternate their irrigation activities until the time that their consumption gets highly responsive to prices and they quit all of them (Amir et al. 1999), while in study No.14, under a cyclical drought scenario, the potential establishment of a water traded allocations scheme is examined. Its implementation implies that large farmers in Spain change their crop plans toward less water demanding crops and they partially offset by the income from selling water so that the marginal utilities of all the three groups be-come equal under a water traded allocation scenario (Arriaza et al.2002). All the nine observations have been accounted for in the model.

In order to test for the expectation that a higher price level result in a higher demand responsiveness a boxplot has been produced. As it is clear from Figure 3, the assumption that links elasticity with price level is validated.

Figure 3. Demand responses under various price levels reported in the literature



In conclusion, the rejection of the normally distributed observations within the sample implies that the data should be treated as non-parametric as one of the primary conditions of parametric data is not valid for this sample.

Independent variables

In an attempt to eliminate the assumptions lying under the dataset, non-parametric tests were selected. Their advantage over the parametric tests is that they allow the data to be treated regardless their distribution, so that time can be saved by not testing for the distribution of the data as these tests are assumptions free. Non-parametric tests provide the user with information about the significance of the difference between the distributions of the various groups. What a non-parametric test does is to rank the data, so that the analysis is carried out with ranks rather than data. (Field, 2005). Non-parametric Mann-Whitney and Kruskal-Wallis tests were run in order to acquire information about the differences between the observations under the categorical variables included in the analysis. More specifically Mann-Whitney tests, each time for two independent samples, that their populations are equivalent in location. It gives as an output a U-statistic and a significance level for each group, which compared to different significance levels inform as about the possibility of existence of deviation between the groups 'distributions for different confidence intervals. Despite the expectations about the direction of the relationship between to variables, expressed in the previous section, predictions haven't been accounted for in this stage, so the two-tailed probability was taken into account in order to check for asymptotic significance of the test. Testing for variations in distributions among K independent groups (K>2), Kruskal-Wallis tests were run which are equivalent to the Mann-Whitney tests[10].

Moreover, the interest in testing whether the expectations about the relationship between the variables are valid for this particular sample, lead to the performance of bivariate correlation analysis. For this reason Spearman's correlation coefficient has been used while it provides information about whether two variables are linearly interrelated when the data are non-parametric.

Study characteristics

The output of the Spearman's test performed for the year that the studies refer to showed significant correlation with the elasticity price at 0.05 level. The negative coefficient[11] shows the opposite direction that the two variables change. This fact implies that in the more recent study years elasticity was found to be less elastic in comparison to older times. The high correlation coefficients that relate the various study years with climatic conditions could partly explain the negative relationship with the dependent variable. Positive Spearmans'coefficients for precipitation and temperature levels significant at 1%, indicate that changes in climatic conditions affect the change in the elasticity value throughout the years. High temperature levels and change in frequencies of rainfall events is reality under the climate change concept. Consequently changes in vulnerability of agricultural production and increase

[10] The results of the non-parametric tests (Kruskal-Wallis) for different levels of significance for a number of the possible explanatory variables according to the literature reviewed are presented in Table 1. The table includes only the test that the variables proved significance at the level of 5%. These are the categorical variables that reflect the different irrigation systems applied and the various means for adjustment that farmers undertake. A full display of the summary statistics for all the categorical variables is provided in the Appendix (Table 7).

[11] Reminder: elasticity values were treated in absolute terms in the end of facilitating the interpretation of the results.

in the dependence on irrigation water could create an impact on farmers ‘responsiveness regarding the demand for irrigation water.

The coefficient found from the Mann-Whitney test run for the dummy that represents the Mediterranean countries, turned out to be non-significant (two tailed), as p>0.05. Consequently, this particular grouping doesn’t seem to explain the variable elasticity values observed in the sample. However, the mean elasticity values indicate that in non-Mediterranean countries (-1.317) lower elasticity values are observed in comparison with Mediterranean (-1.702).This difference could be explained by the extreme elasticity prices observed based on the boxplot (Figure 2)that detected the outliers of the study. What these observations do is to increase the mean score of the group that they are obtained.

Elasticity estimations derived from econometric models compose only a quarter of the sample while 156 observations come from mathematical programming models. Comparing the mean elasticities between the two groups, it was shown that econometric models produce less elastic responses to irrigation water pricing than mathematical programming which is in consistency with prior theory. The existence of extreme elasticity values does not seem to affect the means as outlier observations are found to both of the estimation methods. It can be easily seen (Table 2) that maximum elasticity values elasticity values refer to outliers in both of the groups. One theory supports that this difference is partly explained by the different assumptions underlying under the two models (Sheierling et al, 1991). Also, the fact that mathematical programming do not require long data series (Arriaza et al.1998), so the fact that these models are mostly used in developing countries to simulate farmers’ responses - where limited data series are available- , could explain the distance between the means. However, the results of the Mann-Whitney test performed for the variable of the estimation model, does not imply any significant difference in the distributions of the observations generated by the different models. Consequently the choice of the model to estimate the elasticity value of irrigation water doesn’t have any significant explanatory power at 5% significance level and this conflicts with the expectations about the relationship between these two variables (see Data Specification; *Estimation Method*).

Neither the Type of Data has the ability to explain the variation in the elasticity estimates. The descriptives for the two groups have pointed out similar tendencies in their means. The mean elasticity prices indicate sensitive responsiveness of the irrigation water demand no matter the type of data is used in the analysis.

Expectations about the potential effect of the sample size of the various studies on the elasticity estimates haven’t been validated. Spearmans’test didn’t approve any significant coefficient that relates the price of demand elasticity with the degree of the representativeness of the sample.

As for the timeframe, that the different elasticity values were estimated for both the long run and the short run, studies provided observations with elastic mean demands for irrigation water. However, in contrast with what was expected, short-run mean elasticity has a higher value than the long run one. Considering the endogeneity of the production inputs in the short-run there has been limited flexibility left to the farmers in order to adjust to a more water saving scenario. Consequently their demand for irrigation water is not comparatively as sensitive as it would be under a long-term scenario. Furthermore, the results from the Mann-Whitney test signify that there is no significant variation between the mean elasticities between the long and the short-term time frames. Thus the distinction of the *Timeframe* into long and short run does not present any considerable explanatory power over the dependent variable.

Farm Characteristics

The results for the Kruskal-Wallis test performed for two of the variables that describes the farm's specific characteristics are presented in Table 3 and 4.

Table 3.Summary Statistics and significant results univariate analysis independent variables

Group Variable	Mean Elasticity	Standard Error	Min	Max	N**	x2 (p<)
Irrigation Technology					126	14.408 (0,057)
Furrows	-0,275	0,175	-1,09	0	7	
Sprinkler	-1,812	0,715	-17,9	0	33	
Drip Irrigation	-0,397	0,098	-0,496	-0,299	2	
Open Ditch	-0,456	0,09	-1,3	0	20	
Flood	-1,268	0,555	-4,846	0	10	
Furrows & Sprinklers	-3,094	0,586	-11	0	29	
Sprinklers & Drip Irrigation	-0,739	0,301	-4,571	0	15	
Furrows, Sprinklers & Drip Irrigation	-1,622	1,483	-12	0	8	
Furrows, Sprinklers & Open-Ditch	-0,575	0,115	-0,69	-0,46	2	
Adjustment Options					165	18,238(0,024)
None	-0,426	0,134	-2,81	0	20	
Change In Crop Mix	-0,402	0,092	-1,52	0	24	
Change in Irrigation Schedule	-0,39	0,098	-0,499	-2,99	2	
Change in Irrigation Acreage	-1,279	0,726	-4,571	0	6	
Change In Crop Mix & Irrigation Schedule	-2,219	0,893	-17,9	-0,049	26	
Change In Crop Mix & Irrigation Technology	-1,268	0,555	-4,846	0	10	
Change in Crop Mix & Irrigation Acreage	-2,481	0,457	-14	0	51	
Change In crop Mix, Irrigation Schedule & Acreage	-0,567	0,188	-1,49	-0,08	7	
Change in Crop Mix, Irrigation Technology & Acreage	-1,622	1.483	-12	0	8	
All the adjustment options	-0,417	0,142	-1,3	0	11	

The output of the Kruskal-Wallis test implies that the choice of the irrigation system applied in irrigated agriculture does significantly affect the elasticity ranges. A value of 14.408 for the Chi-squared statistic was found to be significant at a 99% confidence interval. Out of the 126 valid observations, sprinklers, as well as the combination of furrows and sprinklers were found to be the most frequently used irrigation technologies, with the latter combination generating the highest of the mean elasticity values amongst the different systems used. Applying irrigation with furrows and sprinklers results in high sensitivity in the irrigation water demand, followed by less sensitivity when sprinklers and the combination of furrows, sprinklers and drip systems have been applied. However the mean value estimated for sprinkler irrigation might seriously be biased by the outliers as both of the extreme elasticity values (-17.9 and -14) are included in this sample. The relatively big standard error observed in this population is another indicator of the low representativeness of the data under this group[12]. The same is true for the population lying under the combination of furrows sprinklers and drip irrigation. The mean value under the scenario of flood irrigation indicates sensitivity in the water demanded while the demand under the comparatively more modernized irrigation technologies is inelastic. Valera-Ortega reports that technical endowments in the irrigation districts have a considerable effect on the response of water quantity demanded. Irrigation water pricing in districts equipped with old irrigation systems induces larger water savings than in the "modern districts". This is attributed to the fact that less adjustment options are left to farmers using modern irrigation technologies in comparison with those irrigating with old irrigation systems. As a result, investment in sprinklers and drip irrigation technology is appealing to the more "traditional" farmers while this option turns to be more expensive for those already irrigating with efficient equipment. The descriptives validate this conclusion. Water saving happens in a greater scale under furrow and sprinkler irrigation or by using flood systems. But when the irrigation technology was replaced either by drip technologies or by a more modern or inclusive system then the water demand became inelastic. The number of the observations retrieved from this study might also affect the explanation made. This might be true for the mean value found for the flood as all the observations under this system belong to this study. However, for sprinklers and drip irrigation equipment, elasticity takes values smaller than one, for 83% of the observations.

As far as there are a lot of missing values under this category, and due to the fact that most of the observations under each system comes from the same study, conclusions about the responsiveness of each of them, is difficult to be formulated.

Despite the fact that close to one fifth of the observations misses from the sample, the Kruskal-Wallis test performed for the *Adjustment Options*, pointed out a high significance of the z-value (18,238) at 5% significance level. The interpretation of this output supports that the different adjustment options given to the farmers can significantly affect the elasticity estimates. Change in the crop mix together with the

[12] The variances the two groups have been calculated and they are extremely high as well (16.873 for sprinklers and 17.610 for furrows, sprinklers and drip irrigation)

option of the changes in the irrigation acreage has most frequently been an option for the farmers to adjust to the rising prices. Changes in the crop mix together with changes in irrigation schedule have the same popularity as the option of the changes in irrigation schedule followed by the option of the changes in crop mix while the rest of the options and the combinations of them are less commonly incorporated by the models. However due to the great variances reported for some of the possible adjustment options, the latter cannot be considered as reliable samples. Thus the comparison of the mean values across the different options cannot be fruitful. Consequently, in this stage the validity of the projections, regarding the relationship between farmer's flexibility in adjusting to the different price levels and the dependent variable, is difficult to be confirmed.

The variable that counts a farm's dependency on high value crops didn't prove any significance under the Kruskal-Wallis testing. However looking through the different rankings of the choices under this variable, it can be observed that mean elasticity values range a lot as the inclusion of high value crops in the mix changes. When irrigation is totally based on horticultural and winter cereals, the mean elasticity does not provide evidence of sensitivity. This might happens if considering that change to low value crops is not an option for these farmers to the rising water prices.

Exploring the potential impact of farm's size on the elasticity of the demand for irrigation water, the expectations for their interaction have been validated. A positive Spearmans' coefficient between the two variables at 5% significance level, indicates that linearity connects the changes of the two variables. In other words, elasticity is observed to be higher for comparatively bigger farms and less elastic for the smaller ones. As Arriaza et al. (2002) showed when relatively bigger land allocations are occupied by irrigation, more flexibility is provided to the farmers to adjust to the rising water prices in comparison with the medium and small farmers.

Geo-climatic Conditions

Exploring the data for the *Soil Type*, approximately three quarters of the population in the sample give information on whether the soil of the study area is sandy or not. Out of them, only 8 observations refer to a sandy soil composition while the great majority involves other different types of soil. Elasticity has a lower mean when the observation corresponds to a sandy study area in comparison to the mean when the area does not present a high-sandiness composition. However, the extreme elasticity values might bias the values found, as all of them are captured by the cases were the soil under irrigation is not or of low sandiness. Performing a non-parametric test to check for significant variations amongst the two types of soil, there has been no indication of significance at 5% level. This fact implies that the composition of the soil has no considerable explanatory power over the elasticity estimates.

According to the assumption of the enhanced quality of the surface water over the groundwater (see the Data Specification; Water source) could be expected that a dif

Table 4. Summary statistics and univariate analysis results independent variables

Group Variable	Mean Elasticity	Standard Error	Max	Min	N[13]	x2 (p<)[14]
Country					201	(-)1,005 (0,315)
Mediterranean	-1,702	0,219	-14	0	133	
Non-Mediterranean	-1,317	0,389	-17,9	0	68	
Pricing Regime					201	3,873 (0,628)
Volumetric	-1,723	0,22	-17,9	0	177	
Block Rate	-0,418	0,06	-0,496	-0,299	3	
Charge per Unit of Land	-0,493	0,084	-1,52	-0,19	17	
Traded Allocations	-0,665	0,145	-0,81	-0,52	2	
Flat Pricing	0	-	-	-	1	
Fixed Quotas	-0,077	-	-	-	1	
Estimation Model					201	(-)0,808(0,419)
Econometric	-1,1	0,36	-14	0	45	
Mathematical Programming	-1,708	0,229	-17,9	0	156	
Irrigation Technology					126	14.408 (0,057)*
Furrows	-0,275	0,175	-1,09	0	7	
Sprinkler	-1,812	0,715	-17,9	0	33	
Drip Irrigation	-0,397	0,098	-0,496	-0,299	2	
Open Ditch	-0,456	0,09	-1,3	0	20	
Flood	-1,268	0,555	-4,846	0	10	
Furrows & Sprinklers	-3,094	0,586	-11	0	29	
Sprinklers & Drip Irrigation	-0,739	0,301	-4,571	0	15	
Furrows, Sprinklers & Drip Irrigation	-1,622	1	-12	0	8	
Furrows, Sprinklers & Open-Ditch	-0,575	0,115	-0,69	-0,46	2	
Irrigated Crops					197	7.297 (0,190)
None	-0,507	0,114	-1,49	-0,095	12	
One	-2,639	1,036	-17,9	-0,049	22	
Two	-0,844	0,239	-4,846	0	30	
Three	-2,12	0,385	-14	0	69	
Four	-1,362	0,256	-9	0	56	
Five	-0,301	0,098	-0,75	0	7	
Seven	-0,48	-	-	-	1	
Water Source					128	(-)1,074(0,283)
Surface Water	-2	0,381	-17,9	0	84	
Groundwater	-1,083	0,367	-14	0	44	
Adjustment Options					165	18,238(0,024)*
None	-0,426	0,134	-2,81	0	20	
Change In Crop Mix	-0,402	0,092	-1,52	0	24	

[13] Number of observations does not sum up to 201 in all cases as a result of missing values

[14] Z-values of the non-parametric Mann-Whitney test for two independent samples which has approximately a standard normal distribution under the null hypothesis, or non-parametric Kruskal-Wallis test statistic based on 10000 sampled tables and has approximately a Chi-squared distribution under the null hypothesis of equal average elasticity in all groups
*According to the outcome of the non-parametric test, the two variables present significance at 5%

Change in Irrigation Schedule	-0,39	0,098	-0,499	-2,99	2	
Change in Irrigation Acreage	-1,279	0,726	-4,571	0	6	
Change In Crop Mix & Irrigation Schedule	-2,219	0,893	-17,9	-0,049	26	
Change In Crop Mix & Irrigation Technology	-1,268	0,555	-4,846	0	10	
Change in Crop Mix & Irrigation Acreage	-2,481	0,457	-14	0	51	
Change In crop Mix, Irrigation Schedule & Acreage	-0,567	0,188	-1,49	-0,08	7	
Change in Crop Mix, Irrigation Technology & Acreage	-1,622	1.483	-12	0	8	
All the adjustment options	-0,417	0,142	-1,3	0	11	
Time Frame					197	(-)1,556(0,120)
Long Run	-1,263	0,217	-17,9	0	132	
Short Run	-2,222	0,404	-14	0	65	
Soil Type					146	(-)0,778(0,436)
Sandy	-0,654	0,317	-2,81	-0,025	8	
Non-Sandy	-1,706	0,242	-17,9	0	138	
Type of Data					193	(-)0,794(0,427)
Primary	-1,551	0,2	-14	0	148	
Secondary	-1,631	0,524	-17,91	0	45	

ference in the mean elasticity can be explained by the higher pricing of surface water. Thus, in line with the theory that supports that demand responsiveness is higher as the price level rises, surface water could react with larger water savings than groundwater could do. However, there is not any evidence validating this prediction. The negative U statistic found from the Mann-Whitney test for this dummy, is not significant at 5% level meaning that there isn't any considerable difference between the surface water and groundwater.

When it comes to the climatic conditions of the study area, the correlation tests reveal significant results. The level of precipitation presents a linear relationship with the dependent variable. However, the negative coefficient found to relate elasticity estimates and precipitation levels at 0.01 level, doesn't seem to confirm the expectations about this particular relationship. As it was expected lower precipitation levels, reduce the dependency of farmers on rainfed agricultural production patterns. As a result, farmers get more dependent on irrigation water. Consequently demand for irrigation water increases in periods of drought (Bar-Shira et al., 2006). Under a water pricing scheme, farmers, especially those with greater dependency on high value crops[15], are insensitive to the rising water prices. The fear for potential gross margin loss from their yield due to inadequate irrigation leaves their demand for irrigation water stable or disproportionately changes to the rising water prices. Consequently, in drought periods, low precipitation levels were expected to reduce farmers' re-

[15]In the literature, the substitution of hhigh value crops by lower value ones, is supported to result in income loss to the farmers.

sponse for water demand in rising water costs. On the contrary, the negative correlation coefficient implies the opposite.

Spearman's test for the variable that represents the temperature level failed to prove a significant linearity in the changes of this variable and the changes in demand elasticity. Nevertheless, a high coefficient for temperature and irrigation systems at 0.01 level was found. The interpretation of this output, reveals that in hotter climates, more efficient irrigation technologies have been adopted. Another high coefficient at 0.01 level positively relates temperature and farm size. This implies that relatively bigger farms can be found under warmer weather conditions. However none of the results have been supported in the literature and their validity remains ambivalent, as these outputs might be biased by the low number of valid observations.

Pricing Characteristics

Given the summary statistics for the different pricing regimes, a great majority of the observations under the volumetric pricing makes it the most popular amongst the various charging systems applied. The demand under such a charging system was found to be elastic in contrast with all the other charging systems. The effect of the two outliers in the population under the volumetric pricing cannot be ignored. Both the outliers are included under this scenario and bias the results by increasing the mean elasticity price. On the other hand, pricing per unit of land, resulted in only inelastic responses of demand. A zero value under the flat pricing represents the case that farmers didn't respond at all to the water pricing by reducing their water demand while under a fixed quotas scheme the elasticity estimate is roughly higher than zero. Both the schemes are represented in the sample only by one estimate, and consequently their results cannot be accountable. However the small number of observations under the majority of the pricing systems does not allow any significant result for the Kruskal-Wallis test. Therefore, the test results highlight that there are no significant differences of the distributions in the mean values found under the different pricing schemes. Thus, the variable that embodies the different pricing schemes does not present any significant explanatory power over the elasticity variations.

Nevertheless, the correlation test confirmed the assumption of the economic theory for the price level and its impact on the elasticity value. The positive coefficient that linearly connects elasticity with price changes has a positive sign, implying that higher levels of price generate more sensitive responses to the farmers regarding their irrigation water consumption. As such, and in line with the economic theory, the higher price imposed on water the higher the water savings will be.

Regression Results

The bivariate analysis, performed and described in the previous section has been able to explain the possible correlations between two variables. The purpose of this meta-analysis though, under a systematic approach concept, is to test how individual predictors can be combined and interact with each other while taking into account the effect of this interaction on the dependent variable. Multivariate analysis is a powerful tool that contributes to this end.

At first, the group of American studies has been perceived as the baseline. In purpose of testing the differences between the interactions of groups between them, dummy variables have been created in order to represent each of the different group of countries, as described in 'Data; Data Specification; Country'.

After testing for several combinations taking into account the models that came out from the correlation analysis, one model was found to comparatively better fit the data. Only the results associated with this model are presented in this section.

For the parameters of the model, the estimated coefficients in the semi-log function represent the constant proportional rate of change in the dependent variable per unit change in the independent variables. (Field, 2005).

Thus, the 'best fit model' is defined by the following linear equation:

$$Loge_i=b_0+b_1Year+b_2Price+b_3Volumetric+b_4Precipitation+b_5EuropeanMediterranean+b_6Australia+b_7AfricaMiddleEast+b_8SouthAmerica+b_9Rice+b_{10}Vegetables+\varepsilon_i$$

In ANOVA the regression coefficients are defined by differences between group means. The total sum of squares (SS_T), explains the variation within our data. In this case this variation is equal to 55,555 units. The model's sum of squares informs us about how much of this variation the regression model can explain. Out of the 55,555 units the regression model is able to explain 37.451 units of variation (*df*=9). Therefore, the rest of the variance (which is the number that corresponds to the residual sum of squares) cannot be explained by the model (*df*= 84). This means that, the rest 18,104 units of variance are caused by exogenous factors. These factors could be variables considered by the analysis but not captured by the regression model (all the variables included in the dataset), or variables that did not participate in the variables selection (such as the educational level of the farmer). A less unbiased number to consider is the mean square of the model which is not influenced by the number of the scores. Dividing the sum of squared by the degrees of freedom, the output indicates that 4,161 of variation in average can be explained by the model.

The F-ratio is used to test the overall fit of a regression model to a set of observed data. It is basically the ratio of the explained to the unexplained variation (Field, 2005). So:

$F=MS_M/MS_R$

Where MS_M= means squares for the model and MS_R=the residual mean squares.

The high value of the F-ratio (19.308) indicates the goodness of the model as it is considerably greater than 1 and is significant at 0.01 level to the corresponding degrees of freedom (93).

Moreover, the R^2 of the model provides information about the explanatory power that the independent variables included in the model have upon the dependent variable. According to the R^2, the independent variables included in the 'best fit' model explain 67,4% (Table 5) of the elasticity variations. In other words, two variables from the study characteristics, two from the pricing conditions and one variable for each of the farm and geo-climatic conditions are able to interpret more than half of the variations of the demand elasticity for irrigation water.

In Table 5, the numbers attributed to each of the variables of the model represent the mean effects of each variable for the OLS regression model. The coefficients, hence, capture the effect that 1% change in the independent variable, *ceteris paribus*, has over the price of elasticity for the different levels of significance (1%, 5%, 10%). The number in the first row is the constant number that equals to b_0 of the model.

The coefficient estimated for the continuous variable *Year*, reveals a highly significant relationship with the elasticity. The negative sign of the coefficient implies that the demand for irrigation water is more inelastic compared to older periods in time. Despite the small impact of the time variable (-0,073), there is high confidence that this effect exists (1% significance level).

Regarding the differences among the geographical zones, no conclusion can be formulated for the European Mediterranean as well as for the Australian farmers since both the coefficient of the dummies are not significant at any of the levels examined. The category of the South American countries is not represented in the regression, as there has only been one observation under this group. However for Africa and Middle East it is clear that they present lower elasticity sensitivity compared to the baseline countries.

At 1% significance level, geo-climatic conditions also play a role in explaining the demand elasticity for irrigation water. Changes of 1% in precipitation level, when the other variables in the model are held constant, can reduce the elasticity by 0.2%. However, considering the fact that the elasticity is expressed in absolute terms, a positive coefficient has been expected. Hence this result is in disagreement with results found in literature. Having tested for the frequencies of the data under the precipitation variable, it was found that there is several missing information for the sample given. Together with the low variability of precipitation levels in the population of the sample, they could justify this unexpected result about the coefficient sign of this particular variable.

The effect of the farm characteristics over the dependent variable is approved by the model at comparatively lower, but still significant levels. The coefficient found for the irrigation of rice represents the fact that this crop creates less sensitive response when included in the crop mix than the other crops included in the sample. The same is not true for vegetables, since their positive coefficient reflects a higher sensitivity in water pricing comparatively to the other crops.

As for the pricing conditions, the impact of the price level confirms the expectations based on the economic theory at the highest confidence level. This is that, at higher price levels, the demand elasticity for irrigation water increases. More specifically, the coefficient predicts that a change of one unit in the price can increase by almost 4, 45 units the elasticity level. Moreover, out of the various pricing regimes, the model supports with high confidence (5%) that, volumetric charging for irrigation water is more effective in passing water saving patterns than the other types of charging represented in the sample.

It is also important to notice the effect of the sample size in the regression model. According to Miles and Shevlin (cited in Field, 2005), when 10 predictors are included in the model a sample size of 60 can result in a large effect of the sample size, while a sample of 150 observations can reach a medium effect. Therefore the smaller the effect of the size of the effect the better our predictors predict the outcome. In the current model, 94 observations are included, and thus it can be assumed that there is a medium to large effect of the sample size on the explanatory power of the model.

To control for the extreme elasticity values in the population, a separate regression has been performed which had excluded the outlier estimates -17.9 and -14. The results under the controlled 'best fit' model present particular interest as the new model is able to explain 69, 1% of the variation of the dependent variable. This fact confirms the assumption that the existence of outliers in the sample biases the results of the analysis.

Apart from the increase in the explanatory power of the model, interesting is the change in individual variables' characteristics. As expected, the standard errors and consequently the t-statistics, for all of the coefficients have been decreased since the outliers are excluded. Since standard errors provide information about the standard deviation from the distribution, excluding extreme values from the sample reduces the standard deviation of the distribution in the sample.

Furthermore, changes have been detected in the significance levels and in the prices of the coefficients as well. European Mediterranean countries have been found to present greater sensitivity in their demand for irrigation water in comparison with the rest of the world while Africa and Middle East have been still comparatively insensitive. A further effect of excluding the extreme elasticity estimates from the sample is that there is greater confidence than previously about the sensitiveness of the irrigation of rice and the vegetables, while the result remained the same (relatively inelastic for rice and elastic for the irrigation of vegetables). At the same time, the power of the price and the year in predicting has been diminished but not considerably so as to change the results formulated from the previous model.

Overall, the exclusion of the outliers from the model, results in an increase in the number of variables able to impact on the dependent variable. At the same time for some of them there is greater confidence for their influence while the magnitude of their effect has been reduced comparatively to the more inclusive model.

Table 5. Representation of the OLS results for the "Best Fit" Model

	Model[16]	**Controlling for outliers**
Independent Variables		
Constant	145,186***	129,449***
	(30.177)	(27.711)
Study Characteristics		
Year	-0,073***	-0,065***
	(0.015)	(0.014)
Country		
Europ.Mediterranean	0,191	0,327**
	(0.177)	(0.164)
Australia	-0,632	-0,53
	(0.590)	(0.538)
Africa & Mid.East	-0,859**	-0,69**
	(0.335)	(0.307)
Farm Characteristics		
Irrigated crops		
Rice	-0,502*	-0,552**
	(0.264)	(0.241)
Vegetables	0,213*	0,213**
	(0.114)	(0.104)
Geoclimatic Conditions		
Precipitation	-0,002***	-0,002***
	(0.001)	(0.000)
Pricing Conditions		
Price	4,451***	4,344***
	(0.444)	(0.405)
Pricing Regime		
Volumetric	0,876**	0,824**
	(0.374)	(0.341)
R Square	0,674	0,691
Adjusted R Square	0,639	0,657
Number of Observations	94	92

[16] In the model, there was no evidence of neither multicollinearity nor autocorrelation, as the results from the SPSS provided VIF values well below 10 and tolerance statistics well above .2 and a Durbin Watson statistic bigger than 1 and smaller than 3.

Note: t-statistics are found in the parentheses; * indicates significance at 10% level while ** and *** indicate significance at 5% and 1% level respectively

6. Conclusions

In the literature, there are several approaches to predict the farmers' responsiveness to a water pricing scenario. Some of them test the existing structure of the irrigation sector, while others elaborate more on potential pricing scenarios. A reason that can well explain the interest around irrigation water pricing is that the existing designs around the world, fail to create sustainable solutions of the use of water in irrigated agriculture. As such, the interest of this analysis is oriented in the identification of the factors and their magnitude in the affecting the water use in the irrigated agriculture sector.

This meta-analysis, is an attempt to a systematic approach on demand elasticity of irrigation water. To this end, the inclusion of four broad categories of variables has been expected to give a better insight of how these variables and the elasticity for irrigation water systematically interact. Hence the variables have been included in the meta-analysis, according to the following breakdown:

(i)Study characteristics, such as the year that the study refers to,

(ii)Farm characteristics like the irrigation technology applied for irrigation in the study area,

(iii)Geo-climatic conditions that range from soil type to precipitation and temperature levels,

(iv)The pricing conditions that incorporate the different price levels for irrigation water as well the various charging methods examined in the literature.

The tension of this meta-analysis to be noticeably inclusive in terms of independent variables, created problems in collecting data for all of the variables that the dataset consist of. Since not all of the studies done in the field, consider the same variables, the gaps under some variables, each time resulted in a considerable amount of missing values. To confront this problem, personal contact with the authors of the studies as well as consultation of reliable on-line sources was pursued.

From a qualitative perspective, attention has been paid in the categorization of the independent variables. Regarding the time horizon of the analysis considered by the study, the distinction was made between long-term and short-term. The problem was that the timeframe of the analysis is not mentioned in some of the studies, so a proper line to represent the border between the short and the long-run, was necessary to be defined. The problem was solved and the definition followed the definition given by the economic theory based on the fixity of the production inputs in the long-term. This definition is also in line with Scheierling et al. (2004).

Another issue related to the estimates included in the sample was the exclusion of the estimates considering substitution effects. There have been examples in the literature that provided elasticity estimates when pricing policies are implemented on both groundwater and surface water. The substitution effect was captured by the elasticity estimates. But, since this analysis is concentrated on the direct effects of the pricing in the water quantity demanded, observations considering substitution effects were not included in the sample. However, is not easy to say that substitution effects can be fully excluded from the sample. As long as precipitation is provided as a water resource to agriculture, it is possible for this variable to encapsulate substitution effects.

On the other side, the quantitative analysis was facilitated by the categorizing of the variables under four main groups. Based on the results of the quantitative analysis a number of inferences can be drawn.

First of all, the way the categorical variables were defined, wasn't able to explain the differences among the various elasticity estimates. The assumption that Mediterranean countries react differently, in the pricing of irrigation water, from the countries outside the Mediterranean territory, appeared to be incorrect. Consequently, the need for testing for another division based on continent location has been tried. The 'best fit model' concluded that Middle Eat and African countries are comparatively less responsive to price changes, while after controlling for the extreme elasticity values presented in the sample, significant results were found for European Mediterranean farmers. Based on high significance, these countries, present relatively more sensitive demand. The outcome says with high confidence that a pricing policy bring about more satisfactory results in water savings in the agricultural sector than in other countries. The speculations about the influence of the year that the study corresponds to, have been confirmed by the correlation test. Moreover, the incorporation of the time variable in the model proved that demand for irrigation water tends to be more inelastic compared to the past. Nevertheless, the expectations about the explanatory power of the rest of the study characteristics were not validated. The type of data and the sample size that each incorporates, didn't prove any significant explanatory power over the elasticity variations. In contrast with the meta-analysis of Scheierling et al. (2004), there has been no significant impact found for the method of analysis on the elasticity estimates. This result might be due to the low number of observations based on econometric models. The same stands true for the time-frame of the analysis, as the Mann-Whitney test didn't show any significant result.

Secondly, the Kruskal-Wallis test gave some interesting results for the farm characteristics. The individual as well as the combinations of the adjustment options that farmers adopt to mitigate their water consumption in irrigated agriculture, were found to significantly explain differences in demand responsiveness. The same is true for the irrigation system that a farm is equipped with. Different irrigation technologies result in different demand responses to the rising water prices. This might be due to the fact that there are differences in their feasibility of substitution by more efficient systems. The farm size was found to be positively correlated with the elasticity estimates, which validates the assumption of the higher demand elasticity for the bigger farms. While the degree of a farm's dependency on high value crops didn't explain the elasticity variations, the model incorporated individual crops in order to test for their responsiveness. For the irrigation of rice and the vegetables, the model produced high significant results. More specifically rice is less responsive to the imposition of a price on water while vegetables are more elastic compared to the other crops included in the sample.

Third, none of the expectations has been validated, regarding the accountability of the geo-climatic conditions. Soil type and the distinction between groundwater and surface water didn't prove any explanatory power over the elasticity estimates. In the case of the soil type this might be due to the really low variability within the sample. Climatic conditions seem to influence more the elasticity estimates as significant effect of the precipitation levels has been found by the correlation analysis. However the expectations that farmers respond to water pricing with more elastic demand is in disagreement with the findings in the literature. Consequently results for the precipitation indicates a significant explanatory power but with an unexpected direction over the independent variable. The same that happened in the meta-analysis of Scheierling et al.(2004) was attributed to the approach of generating the climate data or to particular sample issues. In this research, the possible explanations that might justify this unexpected relationship focus on the low variability of the precipitation levels as well as to the lack of data under this variable.

Fourth, the pricing conditions under which a charging system is implemented seem to have great influence in the model. Non-parametric tests didn't prove any significant effect of the categorical variable that represents the different pricing regimes. However the fact that most of the observations are found under the volumetric pricing scheme lead to the incorporation of this dummy in the model. For volumetric price the conclusion is that is comparatively more responsive to water price changes than other charging schemes.

Lastly, the model proved the speculations based on the economic theory about the influence of the price level. Regression analysis produced a significantly positive impact of price on elasticity estimates which is the relatively larger among the independent variables included in the model. Consequently it is validated that the higher the price level is the more responsive the demand elasticity for irrigation water is.

It can be concluded that overall, despite that only some of the study characteristics and the geographical and climatic conditions can explain the variations of the elasticity estimates, all of the variables that define the farm characteristics and the pricing conditions have a strong explanatory power in the model. This model is able to explain a high percentage of the variation in the elasticity estimates. The performance of this model gets even higher when the outlier values of the dependent variable are excluded.

However, there is still almost a 30% of the variation in the elasticity estimates that is not explained by the model. There have been several variables that couldn't be considered due to the lack of data. For instance, the category that embodies the farmers 'characteristics, could include a variable for the farmer's educational level. The inclusion of more variables in the 'best fit' model that were not included in the dataset or even a different combination of the variables of the existing dataset is recommended for further research.

Another suggestion might be the inclusion of more explanatory variables regarding the institutional framework of the agricultural sector. It is true that several countries present poor records of collecting water fees (Easter et al., 2005). Results like that can create policy implications. In cases that farmers' responsiveness is low might not be related to the level of the water price. Gaps in the institutional setup of the water charging administration can be responsible for the low fees collection. In such an environment, farmers use as much water as if a "price free" scenario because they feel safe not to pay for their consumption. Consequently, policy makers should also be aware of the institutional framework under which a price of water can be imposed, apart from the level that the price can reach.

The results from the model also highlighted that policy practices cannot create the same results in all of the cases. Differences between countries and climatic zones create different responses to farmers around the world. The model validated this assumption since the results support different degrees of sensitiveness in demand for irrigation water around the world. As a result, “one-size-fit-all” policies cannot be expected to create the identical results when applied under different conditions.

Another avenue of further research might be focused on the explanations of the factors that influence the elasticity estimates throughout the years. It has been proved that the demand for irrigation water becomes more inelastic the recent decades, but the reasoning is still missing. It has been assumed that changes in socio-economic factors throughout the years might create changes in the competition among farmers for the water resources in irrigated agriculture. However climatic changes cannot be ignored. Water stress and increase in the temperature level create several implications in the policy cycles. Especially for the agricultural sector, which is more than dependent on water availability, the confirmation of the sustainable provision in irrigated agriculture plays crucial role.

This analysis has proved that a systematic approach including factors from different aspects associated with the irrigation water use should be taken to meet a sustainable solution. Spatial characteristics and study characteristics were included under this holistic framework. Nevertheless, there is still some room for further consideration and inclusion of other aspects that can relate to a more sustainable water management in agriculture.

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