REFEREED ARTICLE

DOI: 10.5836/ijam/2020-09-130

# Eliciting Farmers' Willingness to Pay for Innovative Fertilizer Against Soil Salinity: Comparison of Two Methods in a Field Survey

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**ABSTRACT**

Salt stress noxiously shocks agricultural yield all over the world affecting production whether it is for subsistence or economic outcomes. Although agribusinesses are constantly seeking new technologies or inputs with novel attributes, they are not able to properly price these products and usually are based on the cost of production adding the percentage of profit they are seeking on that market. In order to uncover farmers' preferences for an anti-salinity product as well as, the determinants of farmers' willingness to pay for it, primary data were collected from 150 farmers in the regions of southwest Greece. Our estimates revealed that farmers would be willing to pay almost 22.91 €/lt for an innovative fertilizer against salinity. The results suggested that farmers' willingness to pay for the specific anti-salinity product is influenced by a host of factors. Especially the empirical results showed that the size of cultivated land, the level of education, the knowledge scale about salinity, and the package of liquid fertilizer that farmers usually buy have a positive effect on willingness to pay. The implication is that taking these factors into account while large companies are looking for new and profitable products by investing in research and development enables companies' managers to come up with projects that win acceptance from the farmers.

**KEYWORDS:** Salinity; Willingness to Pay; Contingent Valuation; Inferred Valuation; Dichotomous Choice

**JEL CODE:** C10 C29 C83 D12 M31 Q16

## 1. Introduction

Most plants are exposed to a lot of stresses throughout their life cycle. Abiotic stresses, such as salinity, drought, chemical toxicity, extreme temperatures, and oxidative stress are major threats to agriculture, leading to the downgrading of the environment. Salinity is among one of the most challenging environmental constraints to crop productivity worldwide. Salt stress has a serious impact on agricultural yield all over the world affecting production whether it is for subsistence or economic outcomes. According to Ghassemi *et al.* (1995), more than 12 billion US $ per year losses in agricultural production systems are estimated from salinity and the cost is expected to increase as soils will be further affected.

The term ''salinity'' refers to the presence of dissolved salts in soil and water in high concentrations that are detrimental to the soil. The composition of salts in large amounts mostly are calcium, sodium, magnesium, chloride, and sulfate ions and in relatively small amounts are potassium, carbonates, bicarbonates, borate, and lithium salts (Zhu, 2001). Approximately 17% of the world's cropland is under irrigation, but irrigated agriculture contributes much more than 30% of the total agricultural production (Hillel, 2000). Therefore, secondary salinization of irrigated lands is crucial for global food production (Machado and Serralheiro, 2017). High salt levels cause various effects on plant physiology such as ion toxicity, changes in plant growth, elementary nutrient deficiencies, decreased photosynthetic capacity, nutritional disorders, hyperosmotic stress and ion disequilibrium, leaf burn, necrosis, and defoliation (Shrivastava and Kumar, 2015). These effects vary among species and especially among varieties of a given crop. In fact, it is difficult to accurately determine the level of salt concentration in which the crops are more resistant, due to the fact that plant sensitivity depends on different and mutually interacting factors such as climate (temperature and potential evaporation),

Original submitted April 2020; revision received December 2020; accepted December 2020.

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soil fertility (availability of nutrients), soil physical conditions (porosity, aeration, water regime), genotype and plant age. In addition to the salinity resistance mechanisms developed by the plant itself (salt inclusion, salt exclusion), several techniques have been also developed in order to reduce the phenomenon. Farmers facing several problems with their crops that are affected by salinity and it is of crucial importance for them to be aware of the ways in which plants respond to high levels of salinity, the relative tolerances of different crops, their sensitivity at different rates of growth as well as to find the right products or methods to ameliorate the production of their crops. Resultantly, we could assume that there is a high demand for ''anti-salinity'' products.

For the above reasons, producers and agribusinesses are constantly seeking new technologies or inputs with novel attributes that may help them to reduce production costs and at the same time increase their revenue. However, the novel nature of these products does not imply that prospective suppliers have data from actual markets to estimate the potential demand for these new products or inputs (Zapata and Carpio, 2014). Even if they roughly estimate the demand for new technologies or inputs, they are not able to properly price these products and usually are based on the cost of production plus the percentage of profit they are seeking on that market.

Contingent valuation, a survey-based methodology, was initially developed to elicit the value (i.e. Willingness to Pay) that people place on nonmarket goods and services. The majority of the theoretical and empirical studies have been focused on the consumer side, rather than on the producer side. These studies are focused on consumers' Willingness to Pay (WTP) for novel products, food quality enhancements or specific attributes. However, little conceptual or empirical work has been conducted to understand the monetary value that producers place on the new technologies or novel products that will reduce their cost production (Lichtenberg and Zimmerman 1999; Qaim and Janvry 2002; Danso *et al*. 2006; Bakopoulou *et al*. 2010; Ulimwengu and Sanyal 2011; Abaidoo *et al*. 2014; Uddin *et al*. 2016; Etim and Benson 2016; Bozorg-Haddad *et al*. 2016; Adnan *et al.* 2017) compared to the numerous studies have been conducted for consumers' perceptions. It is worthwhile to mention that most of these studies have been mainly conducted in developing countries while a very small number of studies including information about farmer acceptability and WTP are not widely reported in Greece. There is a statement that the studies conducted in developing countries could result in lower external validity for the agriculture sector in developed countries where the figures in terms of wages and access to resources (e.g., improved technology, people employed in agriculture, farm size and production) are completely different. There are several challenges of conducting field experiments with farmers especially when there are no economic incentives for them to participate in a survey and this may be a significant reason for the small number of studies that had been conducted with farmers. This may also justify the small number of farmers participating in surveys involving producers, which is evident in most published studies we have already mentioned above. Limited research suggests that farmers are more likely to respond when promised monetary incentives (Weigel *et al*., 2020), too. The present study has a sufficient number of participants and it is worth noting that their recruitment was quite difficult as we targeted specific types of crops where the good under valuation can be applied.

For a farmer (producer), it is significant to maximize his/her profit-making decisions according to budget limitations, input, and product combinations. In the same way, companies define their production according to their technological equipment, cost constraints, and the inputs' plurality of combinations in order to produce outputs. Through the willingness to pay (WTP), it is possible to formulate the demand curve for a new entrant product in the marketplace. As a result, the average value could be considered as an estimation of the price that farmers could pay for a desired amount of input. To the best of our knowledge, farmers' preferences, and willingness to pay for fertilizers against soil salinity have not been investigated. Furthermore, additional research into this area demonstrates a number of non-financial variables affecting the decision of farmers on the adoption of new technologies and policies, such as farmer and household characteristics (e.g., age, education, gender), type and size of the farm, grower's social milieu (e.g., local culture, social attitude, fellow farmers, policy environment) and the characteristics of the innovation to be adopted (Murphy, 2012).

The objective of this study is to elicit and evaluate producers' WTP for the adoption of a novel fertilizer against salinity and define the major factors affecting the payment decision amongst greek farmers, employing traditional stated preferences methods augmented with recent methodological advances designed to identify and weed out potential biases. This is important for agrochemical companies or agricultural research organizations promoting new products and technology (i.e. fertilizer, seeds, varieties, etc).

## 2. A Theoretical Review

The theoretical model which employed in this article, was developed by Zapata and Caprio (2014), within the context of neoclassical theories of utility and profit maximization. It allows the analysis of producers' WTP for a change in quality of any factor of production such as a novel fertilizer against the salinity. More specifically, the variation function, or producers' WTP, for novel inputs or technologies is derived using an individual indirect utility function in combination with the firm's profit function. This theoretical model is developed in a context where the production function $f(\boldsymbol{X},\boldsymbol{q})$ has, as arguments, a vector of input quantities $\boldsymbol{X}$ and a vector of input quality levels $\boldsymbol{q}$. The level of $\boldsymbol{q}$ is fixed exogenously; thus, the profit and cost functions are also conditional on $\boldsymbol{q}$. The analysis considers an improvement on a particular input quality level, qi.

The theoretical results imply that the maximum amount of money that a producer is WTP for a new production factor is equal to the difference between the *ex post* and *ex ante* firm's profit levels. Moreover, the producers' WTP is a function of output and input prices and input *ex ante* and *ex post* quality levels.

To elicit valuations for an innovative fertilizer against salinity, we employed the Contingent Valuation Method

(CVM) which belongs to stated preference methods[3]. The CVM has become one of the most widely used methods to measure WTP values for private and public goods, services, or amenities. In simple terms, CV is a survey-based technique regularly used for placing monetary values on environmental goods and services not bought and sold in the marketplace. CVM is simple and has great flexibility, as well as allowing estimation of a total economic value, rather than just components of that total value[4]. This is not possible with many of its alternative non-valuation techniques.

The CVM was initially proposed by Ciriacy-Wantrup (1947) only at a theoretical level. However, the first empirical CV survey started with Davis (1963) who tried to estimate the benefits of goose hunting through a survey among the goose hunters[5]. Its application in other areas in economics such as health economics (e.g., Johannesson *et al*., 1991; Johannesson *et al*., 1993; Liu *et al.,* 2000), transportation safety (e.g., Persson *et al*., 2001) and cultural economics (e.g., Santagata and Signorello, 2000) was being increasingly developed. Except for these areas, it has made significant progress in the valuation of food safety and food products in the last decades (e.g., Gil *et al*., 2000). It is called ''contingent'' valuation since as people are asked to state their WTP, it depends on a specific hypothetical scenario and description of the environmental service.

It is common that CVM can be applied to goods that are and are not traded in regular marketplaces. In particular, a hypothetical valuation scenario is created in which respondents are asked to state their maximum WTP for the product undervaluation. An important aspect of CV surveys is the choice of payment vehicle that is being selected for the valuation question. Besides the fact that a number of payment vehicles give incentives to participants to answer strategically, the Organization for Economic Cooperation and Development suggests that the comparison of mean WTP with different payment vehicles (OECD, 1989) could contribute to the choice of the appropriate payment vehicle in a variety of surveys.

There are many different question modes that can be used such as open-ended (OE), bidding games, payment card, choice experiments, single-bonded and double bounded methods. Nevertheless, CVM is subject to severe criticism as economists have raised several types of objections. A large number of studies have shown that results from the CVM may seriously be sensitive to social desirability bias (hereinafter SDB) (e.g., Phillips and Clancy, 1970, 1972). In fact, SDB is considered to be one of the most common sources of bias affecting the validity of experimental and survey research findings (Peltier and Wash, 1990; Paulhus, 1991) and refers to the tendency of participants to give socially desirable responses instead of selecting responses that reflect their true feelings, placing the speaker in a favorable light (Grimm, 2010). Among the methods that have been developed to restrict social desirability bias is the Inferred Valuation Method (IVM) which addresses SDB by asking participants to state their views concerning the average consumers'/producers' valuation for a good (Drichoutis *et al*., 2017). Lusk and Norwood (2009), noted that the IVM creates valuations that are less likely to suffer from biases such as SDB. Also, they found that responses based on IVM predicted consumers' actual shopping behavior much better than CVM did. The authors proved that when social desirability appeared, the IVM generated less hypothetical bias and that goods with normative dimensions are more acceptable to SDB. Consequently, the IVM is more effective to fill the gap between the laboratory and field evaluations (Drichoutis *et al*., 2017).

The Dichotomous Choice (DC) format (also known as ''take-it-or-leave-it'', closed-ended or referendum) was initially used by Bishop and Heberlein (1979), while Hanemann (1984) developed the conceptual and theoretical arguments in order to use this method to estimate welfare benefits (Ryan *et al*., 2004). Since the panel of National Oceanographic and Atmospheric Administration (NOOA) criticized the open-ended method as causing unstable and biased answers (Arrow *et al.,* 1993), the DC approach gained remarkable acceptance due to its substantial simplicity of use in data collection and Incentive Compatibility (IC). Strategies that are used by respondents have been criticized as problematic in public economic studies. In particular, Samuelson (1954) argued ''*It is in the selfish interest of each person to give false signals, to pretend to have less interest in a given collective activity than he really has*''. Incentive Compatibility can only be proposed for goods in cases that the binary choice exists between two different forms of the undervaluation good.

Hanemann and Carson (1985) proposed to add a follow-up discrete choice question in order to improve the efficiency of discrete choice questionnaires. Hanemann *et al*. (1991) indicate that the double bounded method is more preferred than the single one as they proved that adding a follow-up bid to a conventional, dichotomous choice CV survey significantly ameliorated the statistical information provided by the data. It is believed by many economists that the double-bonded model gives more information on the WTP of the respondents. However, the double-bonded dichotomous choice CV format is believed to produce more precise welfare estimates. However, there are questions about its validity as there are studies (Herriges and Shogren 1996; Alberini*et al*., 1997; Burton *et al*., 2003; Whitehead 2004; Bateman *et al*., 2008) which cast doubt on the double-bounded method indicating that this model can be inadequate and give inconsistent results. In this study, we use the single-bonded elicitation method because the double-bonded method presents a number of drawbacks. More specifically, there are concerns for the existence of starting point bias which occurs in cases where the survey tool provides a prearranged range of choices for answering their values (Ahmed and Gotoh, 2006). For a number of reasons, in CV surveys that include follow-up questions, participants tend to ''anchor'' the value they place on a good on the bid amounts presented to them in the initial and/or subsequent payment questions (Veronesi *et al*., 2011). The presence of starting point (''anchoring'') bias may control individuals' responses in a way that affects the underlying WTP directly if bid information is used by the participants to update their

[3] Techniques for measuring the WTP are categorized in those including revealed preferences (RP) and those including stated preferences (SP). The SP method asks directly individuals about their preferences. On the other hand, the RP method notices individuals' behavior in markets. The advantage of SP method is that it estimates use and non-use values while the RP method estimates the use value of a product or service.

[4] Ecosystem Valuation (Found at: http://www.ecosystemvaluation.org/).

[5] For more details see: Mitchell and Carson, 1989.

true WTP, and/or through the comparison between WTP and the bid (Veronesi *et al*., 2011). Under the double-bonded format answers to the second round are anchored on the value of the first bid (Chien *et al*., 2005; Flachaire and Hollard, 2006). There is also a possibility that responses to the follow-up questions may yield a lower WTP (Cameron and Quiggin, 1994). It is hard for researchers to apply alternative models in order to detect and fix the ''anchoring effect'' which may result in biased estimates of mean WTP, something that is obvious in the outcomes of the study of Veronesi *et al.* (2011) where biases are more severe the stronger the anchoring is, and the severity of the biases varies with the bid design used. The single double-bounded format is easier to implement and has been widely used in surveys for the valuation of water quality (Altaf *et al*., 1993), health (Cropper *et al*., 2004), and forestry (Köhlin, 2001).

There is strong evidence proving that the CV technique frequently overstates real economic value. Much of the literature compares hypothetical and actual values from several CV studies. Hypothetical bias refers to a significant difference between responses to real and hypothetical valuation questions. This situation has motivated research in order to develop methods that either eliminate or adjust the hypothetical bias. The ''cheap talk method'' was initially recommended by Cummings and Taylor (1999). They tried to decrease the hypothetical bias by completely describing and discussing the tendency of participants to exaggerate stated WTP. The use of cheap talk proved to be potentially effective as well as decreasing the mean WTP in several studies (e.g., Cummings and Taylor, 1999; List, 2001; List *et al*., 2006; Aadland and Caplan, 2003; Bulte *et al*. 2005; Landry and List, 2007). Its simplicity makes it an appealing approach in lowering hypothetical bias (Murphy *et al*., 2005). Nevertheless, in other studies this mechanism was not effective (e.g., Brummett *et al*., 2007; Loureiro *et al*., 2009). Empirical findings revealed that participants in CV surveys give answers which are inconsistent with the tenets of rational choice as well as they might underestimate or overestimate their paying ability for a variety of reasons. Carson and Groves (2007) argued that a hypothetical survey might bring in more than hypothetical responses in case the survey is perceived by respondents to be consequential. In consequentiality scripts, survey participants are clearly told that their responses to preference questions will influence competent authorities' decisions regarding the public good undervaluation. Therefore, the respondents' answers represent revealed economic behavior. In their study, Drichoutis *et al*. (2017) found that their consequentiality and cheap talk script had not any effect in mitigating hypothetical bias. External validation of the CV technique continues to be a serious issue. One way to avoid these difficulties, in part, is to design experiments in which an artificial capability is created to pay for private or public goods. Hence, it is recommended the results of a CV estimation of WTP to be compared with the ''real'' behavioral WTP for goods (in a sample or an analogous sample) that can be actually bought and sold (Arrow *et al*., 1993).

## 3. Survey Design

The design survey of the product undervaluation is focused on treating the symptoms of salinity. Its application is mainly proposed in crops with particular sensitivity to salinity. It is a special molecule (metabolite) of natural origin that has the potential to increase the resistance of the cultures to salinity by avoiding the process of protein denaturation when subjected to high salinity water or soil conditions. Its use at low concentrations in the plant promotes the synthesis of biologically active metabolites, which give the plant systemic acquired resistance against the stress of salinity. After the plant is ingested, the inducing agents promote a so-called ''plant-immune response'', leading to greater tolerance of abiotics. What differentiates it from other salinity management methods is that it 'treats' the plant rather than water or soil, promoting its self-defense that results in greater resistance to salinity. It is worth noting that its function is comparable to vaccination (pre-immunization) in mammals and humans. Therefore, all subjects were first informed about the new product against salinity providing a script with relevant information about the product undervaluation. In addition to the empirical objective related to the fertilizer against salinity, we also explore several methodological issues that are relevant to non-market valuation, such as social desirability bias, hypothetical bias, consequentiality of the survey, and certainty of respondents.

To answer the methodological issues, we adopt a design with elements within, as well as between-subjects, design. In order to elicit valuations for the fertilizer against salinity, we examined two packs of 1lt and 5lt capacity respectively. The specific packs were preferred as after a brief survey conducted in three Greek online and physical agricultural stores, it was observed that the packages of liquid fertilizers available on the market are mainly those of 1lt and 5 lt and less often 2.5 lt. Hence, it would be helpful for the company that produces the under evaluation fertilizer to gain knowledge about the offered prices for the capacities that are most preferable by the farmers.

At this point, it should be stressed that the price for the fertilizer undervaluation has not yet been established, since the specific salinity product is in the final experimental stage. Therefore, the ten bid amounts used for the Discrete Choice format (10 € vs. 12 € vs. 15 € vs. 17€ vs. 20 € for the package of 1lt and 37€ vs. 45€ vs. 56€ vs. 63€ vs. 75€ for the package of 5tl) were indicated by the competent company based on prices of other similar products.

For the between-subjects design, each questionnaire examined the WTP for both packages of fertilizer. The order of each package had been considered. So, half of the participants were asked to answer the WTP question for the 1lt package first and then for the 5lt package. Conversely, the rest of the sample had to answer the WTP question for the 5lt package first and then for the 1lt package. We followed this technique in order to avoid any order effects and sequential bias. Table 1 summarizes the survey's experimental design.

Moreover, a salinity knowledge index was constructed via ten ''True / False'' sentences related to salinity issues. The higher the number of correct answers, the higher the knowledge that producers have of the problems associated with soil salinity.

**Table 1:** Survey's experimental design

| Packages 1lt – 5lt | | | | |
|---|---|---|---|---|
| a. 10 – 37<br>10 – 45<br>10 – 56<br>10 – 63<br>10 – 75 | b. 12 - 37<br>12 - 45<br>12 - 56<br>12 - 63<br>12 - 75 | c. 15 - 37<br>15 - 45<br>15 - 56<br>15 - 63<br>15 - 75 | d. 17 - 37<br>17 - 45<br>17 - 56<br>17 - 63<br>17 - 75 | e. 20 - 37<br>20 - 45<br>20 - 56<br>20 - 63<br>20 - 75 |

Afterward, the cheap talk script was compiled from several studies (e.g., Drichoutis *et al*. 2017; Bulte *et al*., 2005) and reads as follows:

> *"In a minute you will be asked whether you are willing to pay a certain amount for the specific fertilizer.*
>
> *This question will be hypothetical, that is, you will not actually have to pay. In general, people experience difficulties in answering hypothetical questions. They often state they are willing to pay an amount larger than the amount they are willing to pay in reality.*
>
> *One reason why this happens is that when the time comes to actually make the payment, they also consider that this money won't be available for other purchases. Therefore, when the question is hypothetical, their response exaggerates.*
>
> *Before answering the willingness to pay question, try to think whether you are really willing to pay this amount for the fertilizer and that this amount will no longer be available for other purchases."*

The consequentiality script was adopted by Vossler and Watson (2013) and Vossler and Evans (2009) and read as follows:

> *"We would like to inform you that the survey results will become available to producers, traders, and retailers of agricultural supplies as well as to the wider general public of consumers. This means that this survey could affect the decision of producers, traders, and retailers to adopt practices for the production of innovative agricultural products and as a result of the average price of the fertilizer."*

After the above scripts were read, the valuation questions followed. We used a dichotomous choice question as recommended by the NOOA (Arrow *et al*., 1993). Farmers were asked to the following yes/no questions:

> *"Would you be willing to pay ___€ (including VAT) to buy 1lt bottle of the specific liquid fertilizer?"*
>
> *"Would you be willing to pay ___€ (including VAT) to buy 5lt of the specific liquid fertilizer?"*

According to the literature on certainty scales (Champ *et al*., 1997), every CV discrete choice question was followed by a question asking the participants to state how certain they were about their answer on a 10-point scale characterized by the labels "Not certain at all" and "Very certain".

Following the spirit of CV questions, IV questions were formatted to elicit the WTP for each package of the fertilizer.

> *"Do you think that an average producer would be willing to pay ___€ (including VAT) to buy 1lt bottle of the specific liquid fertilizer?"*
>
> *"Do you think that an average producer would be willing to pay ___€ (including VAT) to buy 5lt bottle of the specific liquid fertilizer?"*

A consequentiality question (Vossler *et al*., 2012; Vossler and Watson 2013) was included to allow us to test for differences between participants with different consequentiality perceptions of the survey. Respondents had to point out the indirect consequences of the survey on a 5-point Likert scale characterized by the labels "not at all" and "very much". The question read as follows:

> *"To what extent do you believe that your answers in this survey will be considered by producers, traders, and retailers?"*

According to Drichoutis *et al*. (2017), the questionnaire, in order to elicit respondents' beliefs about the likelihood of hypothetical bias and social desirability bias, employed the Social Desirability Scale of Stöber (2001). A set of demographic questions on age, gender, education level, income level, source of information, his/her experience as a farmer, his/her main suppliers of agricultural inputs, and his/her knowledge regarding salinity as well as farm characteristics related to the type of crop and on size of the farm was also asked.

## 4. Data Collection Methods

A pilot questionnaire was pre-tested in Messinian regions in a small sample of subjects. Through this process, some "strengths and weaknesses" could be estimated in the structure of the questionnaire. Furthermore, it was helpful for us to know where problems might arise during the interview. Thus, it was found that some of the existing questions needed redesign in order to be clearer and some others removed. The full-scale survey was then launched on May 14, 2017, and questionnaires were filled in until August 21, 2017.

The study was conducted in 3 regional units in south Greece, named Messenia, Argolida, and Corinthia. These regional units were selected after an evaluation of their availability and the type of crops that are cultivated. The main categories of crops selected were those of vegetables (tomatoes, potatoes, cucumbers, lettuce), citrus fruit (orange, lemon, mandarin), peaches, apricots, almonds, cherries, vines, and pomegranates

that are more sensitive to salinity. Also, most of the chosen areas face salinity problems due to reasons that have been referred to above. The meetings with the farmers were arranged after a telephone communication. During the telephone conversation with the farmers, we introduced ourselves and the aim of this study, before asking them if they were willing to participate. The personal interviews took place on their farms. In all, 189 subjects were asked to participate in the survey and 150 agreed to take part resulting in a cooperation rate of 79.36%. The questionnaire took participants around 15 minutes to complete. Nevertheless, a small number of the participants refused to respond to certain questions which further reduced the available sample for statistical analysis. Data were subjected to analysis using the software STATA v14.0.

## 5. Descriptive Data Analysis

All the basic descriptive statistics for a set of demographic variables are presented in Table 2. The ages of the subjects ranged between 23 and 92 years and averaged 49 years. The vast majority of respondents were males (94%) while females were 6 %. Also, farmers' educational level was measured at five levels: up to primary school, primary school, secondary school, college graduate, a university graduate. Other variables measured were farmers' experience in agriculture, the household income, and the application of a new method. According to the educational background, the results revealed that most farmers (48.67%) had secondary school education. The vast majority of the sample (74.67%) stated that they do not apply a ''new method'' in their cultivation technique. Furthermore, 57.33% of the participants claimed that they face salinity problems in their crops. Of those whose crops suffer from salinization about 72.58% have used a product to face this problem and the majority was ''Little/Medium'' satisfied with its effectiveness. Finally, 33.33% of the sample usually buys packages of liquid fertilizer with a capacity of more than 10 lt. This implies that the producers prefer mainly larger packages.

Table 3 presents the farmers' opinions regarding which factors they consider are responsible for their choice of fertilizer. So, it is revealed that 33.33% of the farmers affirmed that ''price'' is a ''Very important'' factor for their choice of fertilizer. This was followed by 68.67% and 30.67% of the participants who stated that the ''quality-composition'' and the existence of ''innovation-patent'', respectively, are ''Very important'' reasons for choosing a fertilizer. It is worthwhile the fact that 37.33% of farmers claimed that ''packaging quality characteristics'' is ''Not important at all'' reason for their choice of fertilizer. Furthermore, 24% agreed that ''brand name'' is ''Important'' for their decision to buy fertilizer. Finally, the majority of the respondents (about 79.33%) said that ''rapid action'' is a ''Very important'' factor behind their choice of fertilizer.

Concerning the farmers' WTP for the package of 1lt (Figure 1), it seems that as the proposed bids increase,

**Table 2:** Summary of descriptive statistics

| Definition of Variables (Variables) | Variable levels | Frequency | Mean |
|---|---|---|---|
| Age (age) | | | 48.94 |
| Farm experience (years) | | | 25.77 |
| Gender (gender) | Male | 141 | 94.00% |
| | Female | 9 | 6.00% |
| Education (edu) | Up to primary school | 11 | 7.33% |
| | Primary school | 36 | 24.00% |
| | Secondary school | 73 | 48.67% |
| | College graduate | 11 | 7.33% |
| | University graduate | 19 | 12.67% |
| Income (income) | Very bad | 2 | 1.33% |
| | Bad | 7 | 4.67% |
| | Below average | 19 | 12.67% |
| | Average | 58 | 38.67% |
| | Above average | 30 | 20.00% |
| | Good | 26 | 17.33% |
| | Very good | 8 | 5.33% |
| Application of a ''new method'' (innov) | Yes | 38 | 25.33% |
| | No | 112 | 74.67% |
| Salinity problem (salpr) | Yes | 86 | 57.33% |
| | No | 26 | 25.33% |
| | I don't know | 38 | 17.33% |
| Product against salinity (proion) | Yes | 90 | 72.58% |
| | No | 34 | 27.42% |
| Satisfaction (satisf) | Very little | 1 | 2.95% |
| | Little | 12 | 35.30% |
| | Medium | 13 | 38.23% |
| | Very | 4 | 11.76% |
| | Very much | 4 | 11.76% |
| Package of fertilizer that farmers usually buy (susk) | Unpacked | 0 | 0.00% |
| | 1 lt | 22 | 14.67% |
| | 2,5 lt | 8 | 5.33% |
| | 5 lt | 31 | 20.67% |
| | Do not buy liquid fertilizer | 39 | 26.00% |
| | Package > 10 lt | 50 | 33.33% |

**Table 3:** Factors responsible for farmer's choice of fertilizer

| | Not important at all | | | | Very important |
|---|---|---|---|---|---|
| Price | 8 (5.33%) | 27 (18.00%) | 21 (14.00%) | 44 (29.33%) | 50 (33.33%) |
| Quality-composition | 1 (0.67%) | 0 (0.00%) | 9 (6.00%) | 37 (24.67%) | 103 (68.67%) |
| Packaging quality characteristics | 56 (37.33%) | 37 (24.67%) | 30 (20.00%) | 13 (8.67%) | 14 (9.33%) |
| Brand name | 31 (20.67%) | 20 (13.33%) | 36 (24.00%) | 28 (18.67%) | 35 (23.33%) |
| Ease of application | 17 (11.33%) | 26 (17.33%) | 33 (22.00%) | 36 (24.00%) | 38 (25.33%) |
| Rapid action | 0 (0.00%) | 0 (0.00%) | 2 (1.33%) | 29 (19.33%) | 119 (79.33%) |
| Innovation-Patent | 18 (12%) | 17 (11.33%) | 26 (17.33%) | 43 (28.67%) | 46 (30.67%) |

Note: Figures in brackets represent percentages, while others are frequencies.

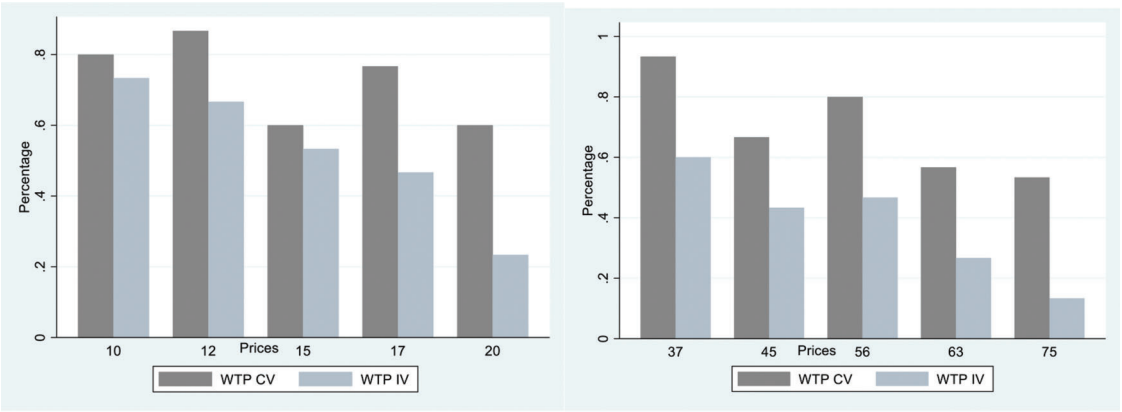


**Figure 1:** Percentage of WTP for the 1lt package (left) and 5lt package (right) with CV and IV methods

the percentage of farmers' WTP for the good is reduced. Also, WTP based on IVM is lower than CVM. The same trend is observed for the 5lt package.

According to CVM, the vast majority of the sample (86.7%) is willing to pay the amount of 12 € for the 1lt package and about 73.3% is willing to pay 10 € for the 5lt package with the IVM.

As we can see from Figure 1 about 93.3% of the farmers would offer the amount of 37 € for the 5lt package and finally with the IV method the majority of the respondents would also pay 37 € for the 5lt package.

Explanatory variables considered in the econometric model are presented in Table 4. Observations with missing variables were left out from the econometric analysis. Accordingly, the sample for the WTP model consists of 145 subjects.

## 7. Empirical Results

In this paper, we choose to estimate the model using the Interval Regression Model. In the interval regression, the upper and lower limits are set to the price if the answer is a "No" and "Yes", respectively. As explained in Hanemann and Kanninen (2001), procedures such as the delta method, Monte Carlo simulation, or bootstrapping (Poe *et al.*, 1994, falls in this category) are used to calculate the variance of WTP estimates that are constructed using functions (e.g. ratios) of maximum likelihood estimators, because the distribution of these functions is not asymptotically normal (even when the original estimators are). So, we have used interval regression which is completely equivalent to a probit model with price as one of the independent variables but with the likelihood function re-parameterized in terms of WTP (Cameron and James, 1987; Cameron, 1988). Due to this re-parametrization, it provides a direct estimate of WTP via the appropriate element of the inverse of the information matrix (Hanemann and Kanninen, 2001). One of the advantages of the interval regression model is that the estimated parameters can be interpreted analogously to the results from OLS regression. Therefore, while the parameters from other models (e.g. probit) require some transformation for interpretation in the WTP space (Cameron, 1991), our estimated coefficients can directly be interpreted as WTP values. Thus, the corresponding ***p-values*** of the estimated coefficients from the output of the interval regression model are exactly what we are interested in. According to the above, the econometric model takes the following form:

$$\mathbf{WTPi} = b_0 + b_1 CVIV_2 + b_2 order + b_3 conseq_3 + b_4 conseq_4 + b_5 hbias_2 + b_6 hbias_3 + b_7 hbiasot_3 + b_8 hbiasot_4 + b_9 sunesp + b_{10} sunpur + b_{11} kt + b_{12} ku + b_{13} sunloi + b_{14} sunel + b_{15} know\_new_3 + b_{16} know\_new_4 + b_{17} know\_new_5 + b_{18} age_2 + b_{19} age_3 + b_{20} years + b_{21} edu_2 + b_{22} edu_3 + b_{23} edu_4 + b_{24} income_4 + b_{25} income_5 + b_{26} income_6 + b_{27} susk_3 + b_{28} susk_4 + b_{29} susk_5 + b_{30} susk_6 + b_{31} innov + b_{32} salpr_2 + b_{33} salpr_3 + u + b_{34} bottle + ui$$

The empirical results are presented in Table 5. Count $R^2$ is the number of correctly predicted observations using the model divided by the total number of observations. It measures how well the model predicts the correct value of the dependent variable, using known values. For our model Count $R^2$=0.707. Our hypothesis is that the IV method would better manage to mitigate social desirability by generating less exaggerated valuations. The estimated coefficient of variable ***CVIV*** which is associated with the method of willingness to pay is -4.332 and is statistically significant at a 5% significance

**Table 4:** List of Explanatory variables

| | | Definition of variables |
|---|---|---|
| Dummies | CVIV* | Contingent Valuation=1, 0 otherwise |
| | $CVIV_2$ | Inferred Valuation=1, 0 otherwise |
| | order | The order of the package in the WTP question, where 0=5lt is the display of 5lt first and where 1=1lt is the display of 1lt first |
| | $bottle_1$* | Package of 1lt=1, or 0 |
| | $bottle_5$ | Package of 5lt=1,or 0 |
| | $Conseq_1$* | 1 if producer believes that his answers will be taken ''Not at all/Low'' into account, 0 otherwise |
| | $Conseq_2$ | 1 if producer believes that his answers will be taken ''Moderate'' into account, 0 otherwise |
| | $Conseq_3$ | 1 if producer believes that his answers will be taken ''Very/Very much'' into account, 0 otherwise |
| | $hbias_1$* | 1 if producer believes that it is ''Not likely at all'' to exaggerate his answers, 0 otherwise |
| | $hbias_2$ | 1 if producer believes that it is ''Unlikely'' to exaggerate his answers, 0 otherwise |
| | $hbias_3$ | 1 if producer believes that it is ''Neither likely, nor unlikely/Likely/Very likely'' to exaggerate his answers,0 otherwise |
| | $Hbiasot_1$* | 1 if producer believes that it is ''Not likely at all/Unlikely'' for the other participants to exaggerate their answers, 0 otherwise |
| | $Hbiasot_2$ | 1 if producer believes that it is ''Neither likely, nor unlikely'' for the other participants to exaggerate their answers, 0 otherwise |
| | $Hbiasot_3$ | 1 if producer believes that it is ''Likely/Very likely'' for the other participants to exaggerate their answers, 0 otherwise |
| | $know\_new_1$* | 1 if producer has scored ''Minimum/Low'' knowledge, 0 otherwise |
| | $know\_new_2$ | 1 if producer has scored ''Good'' knowledge, 0 otherwise |
| | $know\_new_3$ | 1 if producer has scored ''Very good'' knowledge, 0 otherwise |
| | $know\_new_4$ | 1 if producer has scored ''Excellent'' knowledge, 0 otherwise |
| | $age_1$* | 1 if age category $<$ 40 years, 0 otherwise |
| | $age_2$ | 1 if age category 41 – 60 years, 0 otherwise |
| | $age_3$ | 1 if age category $>$60 years=1, 0 otherwise |
| | $edu_1$* | 1 if education level ''Up to primary school'', 0 otherwise |
| | $edu_2$ | 1 if education level ''Primary school'', 0 otherwise |
| | $edu_3$ | 1 if education level ''Secondary school'', 0 otherwise |
| | $edu_4$ | 1 if education level ''University/College graduate'', 0 otherwise |
| | $Income_1$* | 1 if income characterized ''Very bad/Bad/Below average'', 0 otherwise |
| | $Income_2$ | 1 if income characterized ''Average'', 0 otherwise |
| | $Income_3$ | 1 if income characterized ''Above average'', 0 otherwise |
| | $Income_4$ | 1 if income characterized ''Good/Very good'', 0 otherwise |
| | $susk_1$ | Purchase of bulk package=1, or 0 |
| | $susk_2$* | Package purchase of 1lt=1, or 0 |
| | $susk_3$ | Package purchase of 2,5lt=1, or 0 |
| | $susk_4$ | Package purchase of 5lt=1, or 0 |
| | $susk_5$ | 1 if producers do not buy liquid fertilizer, 0 otherwise |
| | $susk_6$ | 1 if Package purchase $>$10lt, 0 otherwise |
| | innov | Are you applying a new method to your cultivation technique? where 1=Yes and 0=No |
| | $Salpr_1$* | 1 if farmer faces with salinity problems in his crops, 0 otherwise |
| | $Salpr_2$ | 1 if farmer doesn't face with salinity problems in his crops, 0 otherwise |
| | $Salpr_3$ | 1 if farmer doesn't know if his crops suffer from salinity, 0 otherwise |
| Continuous | Sunesp | Total area (in acres) of citrus fruit. |
| | Sunpur | Total area (in acres) of nuts. |
| | Kt | Total area (in acres) of greenhouse horticulture. |
| | ku | Total area (in acres) of horticultural under cover. |
| | Sunloi | Total area (acres) of other crops. |
| | Sunel | Total area (in acres) of olive trees. |
| | Years | Producer's working years with agriculture |

Notes: Variables with an * were not included in the econometric model in order to avoid the problem of Perfect Multicollinearity. The dummy **susk1** was not included to the econometric model, as it had zero observations.

level. Overall, this implies that the average difference between the CV and IV methods for both packages is 4.33 €/lt. In particular, the farmers' willingness to pay per liter of packaging is 4.33 € lower with the IV method than the CV method. This indicates that subjects under the IV method elicited lower the product, which is a likely clue that this method successfully mitigates social desirability and hypothetical bias as it was stressed above. This is in accordance with the results that Lusk and Norwood (2009) found in their study where the responses to the IV method better predicted actual shopping behavior than did those from a CV method. This simple twist in the wording of the valuation question generated (inferred) valuations that were close to real valuations (as compared to an experiment) and lower than hypothetical valuations (Stachtiaris *et al.*, 2012). Also, another study used both the CV and IV methods and proved that CV yields higher WTP (Drichoutis *et al.*, 2017). Hence, it seems interesting to examine both stated and inferred WTP evaluations and be able to see the differences between these two methods. There is no other study in the agricultural sector that uses both the above elicitation methods and this indicates the uniqueness of our study.

Also, there is significant evidence of ***order*** effects. When the 1lt package of fertilizer was asked first, farmers tended to pay 3.86 €/lt more than the others who were first asked for the 5lt package of fertilizer. This could be

due to the fact that answering the 1lt package question first, made the subjects think that it would be better for them to begin testing the product on a smaller field of crops in order to control its effectiveness before they decide to pay more for the bigger package. Additionally, the coefficient of the variable ***bottle*** indicates that farmers on average are willing to pay 9,95 €/lit more for 5lt packages than for 1lt packages.

As far as the consequentiality (***conseq***) is concerned, it appears that farmers who stated that they believed their answers will be considered by producers, traders, and perceptions on a "Moderate" and "Very/Very much" response were willing to pay 3.86 €/lt more than the others who believed that their responses of "Not at all/ Low" will be taken into account. Also, participants who noted that it is "Likely/Very likely" for their colleagues to exaggerate in their answers (***hbiasot***) were willing to pay 5.72 €/lt less, compared to those who stated "Not likely at all/Unlikely".

Moreover, the empirical results suggest that the type of farming affects farmers' WTP. Specifically, for an extra acre of greenhouse crops (***kt***) and the crops of vine and pomegranate (***sunloi***) farmers were willing to pay 12 cents/lt and 19 cents/lt more respectively. Regarding the level of education, farmers who have acquired a "Secondary school" education and the "University/ College graduate" were willing to pay 5.85 €/lt and 6.16 €/lt more respectively compared to those who declared an "Up to primary school" level. This element supports the hypothesis that human capital plays a positive role in the adoption and evaluation of new ideas (Etim and Edet, 2013; Etim and Benson, 2016). Also, farmers who have "Very good" knowledge were willing to pay 4.82 €/lt more than those who have "Minimum/ Low" knowledge while farmers who usually buy liquid fertilizer in a 2,5 lt package were willing to pay 13.2 €/lt more than the others who bought the 1 lt package. It is notable that the age of farmers, their income, the years being a farmer and the salinity problems that they might face (***salpr***) do not influence farmers' willingness to pay.

Figure 2 presents the graph of the aggregate demand curve from the common regression of CVM and IVM for the novel product under examination. For graphing the aggregate demand curve, we used predicted valuations from the estimated model. The inclusion of the demographic variables and farm characteristics provide more variation in the predicted values between subjects and avoids graphing a step function. We then sort the

**Table 5:** Interval regression estimates

| Variables | Coef. (SE) | Variables | Coef. (SE) |
|---|---|---|---|
| $CVIV_2$* | -4.332* | $know\_new_5$ | 0.747 |
| | (1.099) | | (2.329) |
| order* | 3.867* | $age_2$ | -1.449 |
| | (1.166) | | (1.696) |
| $bottle_5$* | 9.947* | $age_3$ | -2.661 |
| | (2.069) | | (2.859) |
| $conseq_3$* | 3.861* | years | 0.076 |
| | (1.405) | | (0.056) |
| $conseq_4$* | 3.864* | $edu_2$ | 3.511 |
| | (1.537) | | (2.682) |
| $hbias_2$ | 1.514 | $edu_3$* | 5.852* |
| | (1.503) | | (2.809) |
| $hbias_3$ | 3.260** | $edu_4$* | 6.166* |
| | (1.904) | | (3.065) |
| $hbiasot_3$ | -2.725** | $income_4$ | -1.068 |
| | (1.491) | | (1.722) |
| $hbiasot_4$* | -5.727* | $income_5$ | -2.549 |
| | (1.499) | | (1.870) |
| sunesp | -0.028 | $income_6$ | -1.675 |
| | (0.048) | | (1.896) |
| sunpur | -0.074 | $susk_3$* | 13.200* |
| | (0.061) | | (4.382) |
| kt* | 0.128* | $susk_4$ | -0.988 |
| | (0.059) | | (1.849) |
| ku | -0.014 | $susk_5$ | -0.441 |
| | (0.011) | | (1.904) |
| sunloi* | 0.195* | $susk_6$ | -0.783 |
| | (0.086) | | (1.798) |
| sunel | -0.018 | innov | -2.102 |
| | (0.016) | | (1.411) |
| $know\_new_3$ | 2.103 | $salpr_2$ | -1.958 |
| | (1.858) | | (1.945) |
| $know\_new_4$* | 4.822* | $salpr_3$ | 0.023 |
| | (1.914) | | (1.426) |

Notes: * and ** represent significance at the 5% and 10%, respectively.

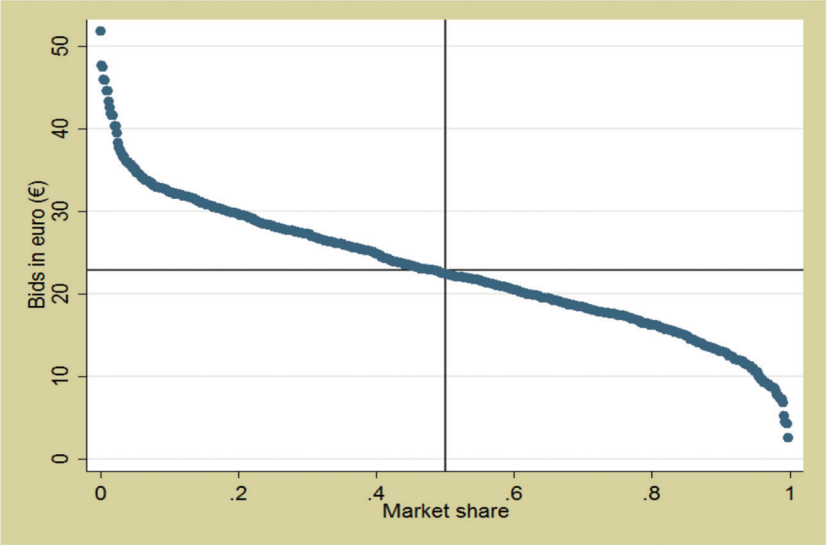


**Figure 2:** Demand curve from the common regression of the CV and IV elicitation methods

predicted valuations from the lowest positive to the highest positive value. Note that the predictions are not precluded from being negative, which are to be interpreted as cases for which subjects do not value the product offered as of higher quality. The lowest positive predicted valuation can be interpreted as a price point which all subjects with positive valuation would be willing to pay. The highest positive valuation can be interpreted as a price point which none of the subjects would be willing to pay. A similar exercise can be performed for each individual prediction, achieving a one-to-one correspondence between predicted WTPs and the percent of subjects willing to pay that particular price. The points can then be plotted to produce a scatter graph similar to Figure 2. The extraction of the demand curve is based on the acceptance that we refer to buying a unit per product per consumer. Each point of this curve indicates the percentage of respondents that would buy fertilizer at the bids projected on the Y-axis. According to the results, the expected willingness to pay ranges from 2.55 € to 51.87 €. As we clearly see in Figure 2, the average willingness to pay for the under-valuation product is 22.91 €. Also, the average value for each liquid fertilizer package is 17.94 € for the 1lt and 139.4 € (27.88 €/lt) for the 5lt.

## 8. Conclusions and Discussion

Salinity is one of the most brutal environmental factors limiting the productivity of crop plants because most of the crop plants are sensitive to salinity caused by high concentrations of salts in the soil, and the area of land affected by it is increasing day by day. For all-important crops, average yields are only a fraction – somewhere between 20% and 50% of record yields. Unfortunately, large areas in the world including a large proportion of cultivated land in Greece remain unexplored due to salinization. On the other hand, efficient fertilizer can help to overcome salinity stress. Although agrochemicals companies produce anti-salinity fertilizers, they usually price these products based on the cost of production ignoring the farmers' WTP for a novel fertilizer in order to give a radical solution to the problem they face.

This paper attempts to elicit farmers' WTP for a novel anti-salinity product in the agricultural field. To do so, we used a CVM to uncover the underlying preferences of Greek farmers for two packages (1lt and 5lt) of an innovative fertilizer against salinity.

The survey results revealed that 57.33% claimed they face salinity problems in their crops and the vast majority of these farmers (72.58%) have used a product to tackle this problem without great success regarding the effectiveness of the product. On average, farmers would be willing to pay 22.91 €/lt for an innovative fertilizer against salinity. They are willing to pay on average 17.94 € for the package of 1 lt and 27,88 € for the package of 5 lt. A possible explanation for this awkward result is that the undervaluation product that is examined in this study doesn't exist in the real market hence, it is possible that there are systematic differences between farmers' estimation of hypothetical product alternatives and the real options.

Also, the econometric analysis indicates that the most critical determinants which had a positive effect on farmers' willingness to pay for the fertilizer were the level of education, the farm size, and the scale of knowledge about salinity. It also emerges that the liquid fertilizer package usually purchased by farmers and the farmers' perception of the extent to which they believe it will influence their responses are positively influenced farmers' willingness to pay. In contrast, a negative effect on willingness to pay was farmers' perception of the extent to which they believe that the other respondents in the survey will overtake their responses. The findings of this research are encouraging for the industries of agricultural supplies that try to differentiate their products and are wondering if costs associated with product differentiation can be recouped from potential customers.

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## Acknowledgements

The authors would like to thank Mr Dimitris Drollias from Compo Expert Hellas for his valuable help with the technical information regarding the product. Also, we would like to thank Dr Achilleas Vassilopoulos for his constructive comments and finally all the farmers who participated in the survey.

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