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Abstract

This paper analyzes the welfare effects of improved land and water quality conditions on agricultural production in Damietta, Egypt using a choice experiment. The survey was administered to a random sample of farmers in Damietta governorate, Egypt. In the analysis various econometric models are estimated in order to help identify farmers preferences toward interventions aimed at mitigating poor agricultural soil and irrigation water conditions which has traditionally reduced farmer incomes in rural Damietta. A significant willingness to pay (WTP) for improving agricultural productivity through improved irrigation and especially availability of certified seeds is found. However, relative WTP indicates that the maximum amount farmers are willing to pay for improvements is less to them than the cost of the program.

ملخص

تحلل هذه الورقة الآثار الاجتماعية لتحسين ظروف الجودة للأراضي والمياه في الانتاج الزراعي في دمياط، مصر، وذلك باستخدام تجربة الاختيار .يدار الاستطلاع على عينة عشوائية من المزارعين في محافظة دمياط، مصر .وتقدر في التحليل نماذج اقتصادية مختلفة من أجل المساعدة في تحديد الأفضليات للمزارعين نحو التدخلات الرامية إلى التخفيف من التربة الزراعية السيئة وظروف مياه الري مما أدى إلى انخفاض دخل المزارعين تقليديا في المناطق الريفية في دمياط . وتوجد لتحسين الإنتاجية الزراعية من خلال تحسين الري وخاصة توافر البذور المعتمدة .ومع ذلك، النسبية فى الرغبة الكبيرة للدفع تشير إلى أن الحد الأقصى للدفع للمزارعين من أجل إدخال تحسينات أقل لهم من تكلفة البرنامج.

1. Introduction

Damietta Governorate, on the eastern part of the Nile delta, has a population of about 1.1 million. It has the lowest GDP per capita and surprisingly the lowest poverty rate of all Lower Egypt governorates, and ranks number 6 out of all governorates on the Egyptian Human Development Index (Egypt Human Development Report, 2010). Moreover, Damietta remains very much rural. Population density is about 1,160 per square kilometer, with 61 percent of the population living in rural areas. Cultivated area is 49 percent of its land, somewhat lower than in Lower Egypt overall. Population per feddan of cultivated land is 10 compared to 6.6 in Lower Egypt, albeit with a similar rural population share and labor force in agriculture.[1]The economy in rural Damietta is highly dependent on agriculture. As a result, poor agricultural soil and irrigation water conditions that are to a significant extent a consequence of inadequate drainage and irrigation infrastructure, water resources constraints, as well as sub-optimal farming practices and water management techniques pose a significant economic cost to the region. For example, crop yields in Damietta are on average 25 percent lower than in the rest of Egypt. This amounts to a loss of LE175 million in sales value in 2005.[2] This is equivalent to over 40 percent of farm net income in Damietta. Poor soil and irrigation water conditions have forced farmers to both engage in sub-optimal cropping patterns and cultivate less land, particularly in summer months.

The purpose of this study is to analyze the welfare effects of interventions aimed at mitigating poor agricultural soil and irrigation water conditions which have traditionally reduced farmer incomes in rural Damietta. These policies have the objective of improving the quality of life of low-income groups in rural Damietta by reducing the burden of environmental degradation on farm land, thus increasing income levels. Moreover, this study may help in informing effective and efficient provision of public and private goods and services that relates to agricultural extensions and practices. The paper estimates the benefits of soil and irrigation water improvement programs related to mitigating land degradation and availability of certified seeds in Damietta using a choice experiment (CE). This is a particularly useful approach to compare these benefits to the cost of irrigation water management and certified seeds programs and for policy makers to design land taxes.

The chapter focuses on the magnitude and socioeconomic determinants of the willingness to pay (WTP) to improve land productivity through enhanced irrigation, water quality and quantity and availability of certified seeds. Previous applications involving the assessment of farmers' preference encompass Grosjean et al. (2010) where they assess the sustainability of the Sloping Land Conversion Program in China. Mekonnen et al. (2010) look at farmers' preference in the highlands of Ethiopia for local public goods such as health care centers or water springs and private goods such as seeds and fertilizers. Another study by Yorobe et al. (2010) estimates farmer demand for maize seed and the associated inputs in the Philippines.

The CE is a stated preference method of non-market valuation that originally developed in the marketing and transportation literature (see, for example Louviere and Hensher 1983). Over the last three decades, it has increasingly been applied in other fields such as environment, health and agriculture. The CE is a hypothetical approachto elicit preferences, which allows obtaining rich information about people's preferences, although this at the same time means a more complex choice situation for the respondents. It also requires a careful design of the survey in terms of attributes proposed to respondents. For an overview of choice experiments see e.g. Alpizar et al. (2003), Birol and Koundouri (2008)and Louviere et al. (2000). There are an increasing number of studies using the CE technique in developing countries. Bennett and Birol (2010) survey a variety of applications of CE in developing

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[1]The feddan is a measure of land size that is approximately equivalent to 4200 m^2 and includes 24 kirat.

[2] LE is the Egyptian pound where 1 USD is equivalent to 5.5 LE in February, 2007.

countries, to illustrate the flexibility of the CE method and the ability to apply it to a range of goods from food items, to recreation demand, to protection of unique ecosystems and choices over local public goods. The choice experiment exercise typically requires the presentation of information to the respondent about the terms and conditions of the program offered. This is quite a complex task *per se*. In a developing country where illiteracy is quite prevalent, the task is even more challenging. It is therefore of particular interest to study how choice experiments can be applied in this context.

The remainder of the paper is organized as follows. Section 2 describes the choice experiment. In Section 3 the econometric model, a Random Parameter Logit model and a Covariance Heterogeneity model, are presented. The results together with a welfare analysis are offered in Section 4 and Section 5, respectively. Section 6 concludes.

2. The Choice Experiment

The data for this chapter comes from part of a rural survey on identifying cost-efficient policies aimed at mitigating poor agricultural soil and irrigation water conditions which have traditionally reduced farmer incomes in rural Damietta. The data was collected through a World Bank funded study. In January 2007, a survey of 300 farming households was carried out to cover six villages in two different *markaz* in rural Damietta governorate,[3] namely Kafr-Saad and El-Zarka. Farms were randomly selected at various locations along irrigation canals to reflect potential differences in irrigation water quantity and quality as well as soil conditions.

The final questionnaire was preceded by a number of focus group discussions and a major pilot study. The questionnaire contained a number of sections, other than the choice experiment, related to basic farm information; the condition of soil, drainage system and irrigation water, and farming practices. Moreover, some information about socio-economic characteristics of the farmer was collected. Focus groups and pre-testing with a sample of individuals were used to determine some measurable attributes associated with the causes of land degradation in Damietta. These attributes were: (1) An attribute relating to the infrastructure leading to soil improvement. This was described by means of drainage systems: one offering the installation of a tiled drain the other an open drain with its maintenance. (2) Irrigation water quality. This attribute has medium and good levels of water quality described by the turbidity level of the water ways. (3) Irrigation water quantity. The level of this attribute is varied by way of changing the current irrigation policy that builds on water duties. The suggested levels are continuous and periodical flow, where the latter is defined as water gates one week opened and one week closed. (4) The availability of certified seeds, that is identified as percentage coverage in farmer's demand of certified seeds. Full and half accessibility were utilized as the levels of this attribute. (5) Finally, the cost attribute was formulated as an increase in the land tax due to the program. This increase was presented as an extra fixed annual charge on the land tax. Three price levels were used, LE 20, 30 and 40, based on the expected cost of the interventions indicated by the experts.

It is worth noting that several potential agricultural programs were offered to the focus groups, a consensus was reached to use the above mentioned attributes (drainage, irrigation and certified seeds). The choice seemed reasonable since a drainage system is important to enhancing productivity and ensuring sustainability of the irrigated agriculture. It is not possible for a rural area to turn into highly intensive and diversified irrigated agriculture without effective drainage to control water logging and salinity. Larsen (2004) and ECON (2007) find that yields are particularly low in Kafr-Saad *markaz* compared to average yields in Damietta governorate. By further examining data of the Damietta Agriculture Directorate

[3] *Markaz* is an Arabic term for a governorate subdivision. Egypt is subdivided into 26 governorates which are in turn subdivided into several *markaz*.

(DAD), 23 percent of the cultivated land in Kafr-Saad had no drainage system while 47 percent relied on open drains that are suffering from management issues. Given the location of Damietta at the tail of the river Nile, farmers complained about water quality and quantity, mostly during the summer season. According to DAD around 20 and 26 percent of the cultivated land in Kafr-Saad relied on drainage and mixed water for irrigation, respectively. While in El-Zarka only 15 percent of the cultivated land depended on drainage water for irrigation. Despite the fact that using drainage water for irrigation exhibits larger effect on crop yield in the summer, it is also likely to affect crops in the winter through deposits of salt and other substances in the soil. Moreover, low water quantity directly affects farms yield. Hence, it seemed reasonable to consider water quality and quantity as attributes. As concerns the certified seeds, it is seen as a good starting point to a successful crop as well as an important risk management tool.

The attributes, as well as the levels, are described in Table 1. The set of attributes and levels form a universe of (2^4x3) x (2^4x3) possible combinations. By means of experimental design techniques (Louviere et al. 2000) an orthogonal fraction of the complete factorial was obtained, giving 60combinations to present to respondents. This design allowed for both main effects and two-way interactions to be modeled. Since it is unrealistic to ask a respondent to answer 60choices, the 60 combinations were divided into 10 groups of 6 choices, using a blocking factor. Focus group work showed that respondents could cope with up to six choice triplets each. In the survey, each farmer was randomly assigned to one version.[4]

The scenario began with a brief text describing the proposed interventions. The interviewer first read the text aloud and then asked the respondents to describe how the program would affect their land. After eliciting perceived impacts, the choice experiment portion of the question detailed the resulting outcomes (services to be obtained) from the program. Respondents were asked if they had any questions regarding the project. An example of one of the choice sets is presented in Table 2. Each respondent was thus presented with 6 three-way choice cards, each containing a constant *status quo* "policy off" option, and two alternative "policy-on" situations referred to as option A and option B. The respondents then indicated their preferred choice on each card. The *status quo* option represented the current situation. Alternatives A and B represented the potential interventions that will implicitly cause the reduction of soil salinity allowing the reductions in land degradation. Due to the illiteracy of the respondents it was almost necessary to use visual aids. According to the World Bank Indicators, in 2006 the adult illiteracy rates of Egyptian females and males were 42 and 25 percent, respectively. Hence, the use of visual materiel was inevitable in order to facilitate the task of the respondents to understand the trade-offs that must be made when making a choice. Therefore, colored visual material was prepared illustrating each type of intervention. Additionally, as respondents were completing the choice tasks, a color card was provided illustrating what each attribute meant, and the levels it could take. The cards, along with the survey instrument itself, may be obtained from the author on request.

3. Econometric Models

The standard approach in the analysis of choice experiment responses is the random utility model, where it is assumed that the utility function consists of both a systematic and a stochastic part. The utility function for farmer *f* of alternative *i* in choice set *t*is therefore written as

$$U_{fit} = V_{fit}\left(X_{it}, Z_f, y_f - c_{it}\right) + \varepsilon_{fit} = \beta X_{it} + \gamma Z_f + \delta(y_f - c_{it}) + \varepsilon_{fit} \tag{1}$$

[4] The ten sets were offered in the form of different questionnaires. Each questionnaire was randomly assigned to a sample ranging from 24 to 35 farmers.

where X_{it} is the attribute vector, which does not contain the cost attribute but includes an alternative-specific constant, Z_f is a vector of socio-economic characteristics, y_f is income, c_{it} is the cost associated with the alternative and ε_{fit} is an error term.

In this paper two different econometric models are estimated and compared: a Random Parameter Logit (RPL) model and a Covariance Heterogeneity (CovHet) model. In addition, the results from a standard Multinomial Logit model (MNL) are reported. There is an ongoing development of the econometric analysis of discrete choice data; this is due to several reasons such as a development of better simulation techniques, a better understanding of the role of the scale parameter and increased computer capacity. One approach that is rather popular is the RPL model, also called the Mixed Logit Model. Compared with the MNL model the random parameter model has several advantages including an explicit modeling of unobserved heterogeneity and that the model does not exhibit the independence of irrelevant alternatives (IIA) property; see for example Train (2003). Moreover, McFadden and Train (2000) show that this estimator is flexible and is able to approximate any random utility model, by considering individual-specific random parameters. Therefore, IIA property is completely avoided, with a higher computational cost, however. Numerical integration is required to evaluate individual choice probabilities which are needed to construct the likelihood of the same adaptive Gaussian quadrature; see Ng et al. (2006).In the Mixed Logit Mdel a random parameter is the sum of the population mean, $\overline{\beta}$, and a respondent deviation, $\tilde{\beta}_i$, i.e. $\beta_i = \overline{\beta} + \tilde{\beta}_i$. More generally, the vector of attribute coefficients, β, varies among the population with $f(\beta \mid \theta)$, where θ is a vector of the true parameters of the taste distribution. If the error terms are independently identically distributed (iid) type-I extreme value, the conditional probability of alternative *i* for farmer *f* in the choice situation *t*, symbolized by w_{fit}, is

$$P(w_{fit} \mid \beta) = L_f(it \mid \beta) = \frac{\exp(\beta X_{it} + \gamma Z_f - \delta c_{it})}{\sum_{j \in \mathbf{A}_t} \exp(\beta X_{jt} + \gamma Z_f - \delta c_{jt})}, \qquad (3)$$

where $\mathbf{A}_t = \{A_1, ..., A_N\}$ is the choice set. The conditional probability of observing a sequence of choices, denoted w_f,[5] from the choice sets is the product of the conditional probabilities:

$$P(w_f \mid \beta) = \prod_t L_f(w_{ft} \mid \beta). \qquad (4)$$

In the choice experiment, the sequence of choices is the number of hypothetical choices each respondent makes in the survey. The unconditional probability for a sequence of choices for individual *f* is then the integral of the conditional probability in equation (4) over all values of β:

$$P(w_f \mid \theta) = \int P(w_f \mid \beta) f(\beta \mid \theta) d\beta. \qquad (5)$$

In this simple form, the utility coefficients vary among individuals, but are constant among the choice situations for each individual. This reflects an underlying assumption of stable preference structures for all individuals (Train 1999). Without loss of generality, it is assumed that the attribute parameters and the alternative-specific constant are normally distributed, which means that a mean and a standard deviation for each of the normally distributed parameters are estimated. However, no correlation between the random parameter

[5] Note that w_{fit} is a component of the set w_f.

is allowed and the parameter of the price attribute is assumed to be fixed hence the distribution of mean WTP is then given by the distribution of the attribute.

However, it is not at all obvious that the RPL model is the preferred model. One aspect that this model does not address is the possibility to discriminate between mean and scale effects on behavior (Louviere 2001/2004). In the literature there is an increasing concern about the role of the scale parameter in discrete choice models and also increasing empirical evidence of the importance of modeling the scale parameter in an appropriate way. In particular, attributes may have effects both on behavior in terms of affecting the level of the utility but also in terms of affecting the variance of the utility; remember that this is a random utility model. In order to assess the potential effect on the level of utility, for example for a welfare analysis, it is important to make sure that one is not capturing effects on the variance instead. Therefore, an alternative approach for the analysis of discrete choice data that has been developed is the CovHet model (Louviere et al. 2000), or what Islam et al. (2007) denote as Scale Decomposition Model and what Swait and Adamowicz (2001) call a Parameterised Heteroscedastic MNL model. In the CovHet model it is assumed that the probability that alternative *i* in choice situation *t* is chosen can be written as

$$L_f(it) = \frac{\exp\left(\exp(\theta W_{it})(\beta X_{it} + \gamma Z_f - \delta c_{it})\right)}{\sum_{j \in \mathbf{A}_t} \exp\left(\exp(\theta W_{jt})(\beta X_{jt} + \gamma Z_f - \delta c_{jt})\right)}. \tag{6}$$

where W_{it} is a vector of alternative-specific covariates and θ is the corresponding parameter vector. This is another approach to the modeling of heterogeneity than the random parameter model. By including the attributes used in the choice experiment both in the systematic part (X_{it}) and in the random part (W_{it}) we can discriminate between mean and scale effects of the attributes (Islamet al. 2007). When estimating the model it will be allowed for a scale effect of all the attributes included in the choice experiment (in addition to a mean effect).Additionally, a quadratic price variable in the scale component will be included in order to allow for an inverse U-shaped function in the scale, which was found in Islam et al. (2007).

4. Results

In January 2007, an in-person survey concerning mitigating the cost associated with poor land and water conditions for agriculture was administered to about 300 farmers in Damietta. The survey was conducted in 6 different villages spread along 2 different *markaz* (Kafr-Saad and El-Zarka) in rural Damietta governorate. The sample was designed to generate information to assess costs of land degradation and propose interventions to improve the situation. For details on the sample design, see ECON (2007). Farms were selected at various locations along irrigation canals to reflect potential differences in irrigation water quantity and quality as well as soil. In total, 45 percent of the farms were located at the tail of irrigation canals, 43 percent around the middle of canals, and 12 percent at the beginning of canals. The explanatory variables are chosen based on the adoption of agricultural innovation literature [for a survey see Feder et al.(1985)] and the expectation of affecting the demand for an extension package. The specification includes three sets of variables. The first includes standard socio-economic variables expected to affect choices including age and literacy of the respondent, farm size, land ownership and revenues. The second set of explanatory variables is chosen to control for the availability of the proposed goods. The third set describes the attributes of the experiment: that is whether the farmer has chosen the tiled drainage or the drain and managing it package; whether the irrigation water is of good or medium quality; whether continuous or periodical flow of irrigation water is picked; whether a full or half availability of certified seeds is selected; the amount of annual increase in land tax. Table 3 reports the descriptive statistics over the full sample and in each *markaz* for the selected explanatory variables. As may be seen, from the table there are differences between the two markazs. This is later substantiated in the regression analysis through the responsiveness to the experiment's attributes.

About 11 percent of the sample chose the *status quo* in the six offered choice sets, while 63 percent never chose the *status quo*. Around 25 percent of the farmers in the sample perceive the irrigation water to be of good quality the whole year round. It is also clear that the water conditions are least favorable during the summer cropping season with nine and 36 percent of the farmers perceiving the water to be of bad quality and not of sufficient quantity, respectively. Moreover, 87.6 percent of the land has a water table of a depth less than 1.2 meter while only 59.7 percent of the farmers indicated that their cropping choices are affected by the level of water table. In the sample some on-farm agricultural practices are observed with the aim of soil treatment water and/or crop management. Among the 85.2 percent of farmers who do not apply soil amendment 57.5, 16.9 and 25.5 percent say that their land does not need it, labor is not available and that they cannot afford it, respectively. Some of the farms adopt integrated irrigation water management, around 92 percent apply night irrigation, 73.4 percent adopt critical period irrigation and 83.6 percent furrow irrigation. Among farmers, 49.3 percent and 46 percent spread over short duration and salt tolerant crop varieties, respectively. Among the respondents that always chose the *status quo* alternative in the experiment around 94 percent, 78 percent and 87 percent employ night, critical period and furrow irrigation, respectively. Thus there is no clear difference with respect to these characteristics between the respondents that always choose the status quo and the other respondents. This comparison is based on between sample tests. However, this finding is corroborated by a model which explicitly controls for those always choosing the status quo.

Table 4 presents the results for the RPL and the CovHet models, as a reference case the results from a standard MNL model are also included. The random parameter model is estimated with simulated maximum likelihood using Halton draws with 250 replications. LimdepNlogit4.0 was used in all the estimations. Most of the socio-economic characteristics that interact with the alternative-specific constant are significant. Farms with higher revenues, as well as literate farmers are more prompted to choose an alternative that is not the *status quo*. Perhaps surprisingly, the larger farms are more likely to choose the opt-out alternative. This negative effect of farm size could stem from the greater probability of already using modern inputs when a larger area of land is held. Note that the alternative-specific constant is positive indicating that, all else equal, respondents have a preference for choosing an extension offered in the CE instead of the opt-out alternative. All coefficients of the choice experiment attributes are significant and have the expected sign. The only exception is the soil improvements attribute, nevertheless it does not have a significant effect. The result of the respondents not caring about such improvements was expected, because 96percent of the sample said that their land had an effective drainage system. About 55 percent of farmers surveyed had an open drainage system and 45 percent had tiled drainage (no farmers were without drainage). Cropping patterns seem to be different among farmers with open drainage versus those with tiled drainage. Farms with open drainage cultivated broad beans and fruit trees more frequently than farms with tiled drainage, and farms with tiled drainage cultivated wheat, clover, rice and cotton more frequently. Crop yields were generally lower on farms with open drainage. However, farmers seem to adapt to their soil condition but controlling for type of existing drainage it was found to have an effect on the farmer's preference. Therefore, Table 5 offers a model that allows interaction between the soil attribute and the type of on farm drainage.

Moreover, there are no fundamental differences among the three models with respect to sign and significance of the mean parameters. The estimated standard deviations for the random parameters for the irrigation water quality attribute, the certified seed attribute and for the alternative specific constant are significant indicating an unobserved heterogeneity. In the covariance heterogeneity model, none of the scale components are significant. Thus in this case, the levels of the attributes do not affect the variance of the responses to any large extent. However, in order to evaluate the potential difference in results between the RPL and the CovHet model the test proposed by Ben-Akiva and Swait (1986) for non-nested choice models is performed. Based on this test we can conclude that the RPL is slightly statistically superior to the CovHet model. Consequently, when modeling preference variation, between types of drainage and then allowing for *markaz* differences, the random parameter is used in order to exploit the wealth of information that this type of model offers.

Table 5display the results of random effects logit estimation for two models. The first takes into consideration differences in drainage systems across farms that are likely to affect their preferences *vis-à-vis* the soil improvement attributes. The second allows for *markaz* discrepancy since there are expected differences in agro conditions, potentials in agricultural productivity and profitability and subsequently in preferences between the two *markazs*. The selection of these models is strengthened by the results depicted in Table 4 where the dummies for the type of drain and the Kafr-Saad *markaz* are highly significant. Looking at the differences between the attributes of the CE in the RPL model of Table 4 and the first model of Table 5 one can conclude that the soil improvement attribute interacted with a dummy for the type of existing drain does not alter the result and the effect of the soil improvement attribute remains insignificant. However, the picture is altered when interaction terms of *markaz* are included. A clear evidence for preference variation between *markaz* is found especially regarding the soil improvement and irrigation water quality attributes. The farmer's preference towards the former attribute in Kafr-Saad is negative though a positive effect is found in El-Zarka. This may be due to the fact that farmers in Kafr-Saad were exposed to a soil improvement program that was malfunctioning and had a negative impact on their fields such as water logging. Meanwhile, the latter attribute has an insignificant effect in Kafr-Saad indicating the farmer's lack of interest for improved irrigation water quality. There is a complete opposite attitude in El-Zarka where coefficient is positive and highly significant.

As concerns the coefficients of the remaining attributes, namely irrigation water quantity and certified seeds, they are both positive and significant in Kafr-Saad and El-Zarka suggesting a need for packages that offer such extensions to eliminate the risks on field productivity involved with water scarcity and availability of good quality seeds. The socio-economic characteristics also give some insights. The probability of choosing an extension package increases with literacy of the farmer and total revenues.

5. Welfare Analysis

A number of welfare measures can be obtained from the estimated model. The marginal WTP is reported for each attribute and the WTP for a certain proposed change in the attributes. The marginal WTP (MWTP) for a certain attribute is, given the assumptions about a linear income effect, the ratio of the attribute coefficient and the marginal utility of income (Hanemann 1984), where the coefficient for the cost attribute (in absolute value) is interpreted as the marginal utility of money. Table 6 presents the MWTPs for the attributes. The standard errors are calculated with the Krinsky-Robb method using 1,000 replications (Krinsky and Robb 1986).

There are slight differences in MWTP between Kafr-Saad and El-Zarka with regard to the MWTP for the irrigation water quantity and certified seeds. The MWTP for irrigation water quality is not significant in Kafr-Saad while it amounts to LE14.24 in El-Zarka. The differences between the two *markazs* with regard to MWTP for soil improvement if the field has an open drain is exceptionally large; it varies from around LE-41.8 in Kafr-Saad to LE5.7 in El-Zarka. The prevailing negative preference that is manifested by a negative MWTP in Kafr-Saad may be due to previous negative experience with such intervention programs. Egypt is a very centralized country where the responsible central authorities have a history of significant physical progress. However, when it comes to efficient maintenance of installed infrastructure it becomes more challenging.WTP can also be computed relatively to revenue or program's cost. The relative WTP for irrigation water quality and quantity and for certified seeds is 33, 22 and 61.5 percent, respectively. The fact that all relative WTPs are less than 100 percent means that the maximum amount farmers are ready to pay for improvements is to them less than the cost of the program.

One interesting aspect of RPL models that has been explored is the possibility of retrieving individual-level parameters from the estimated model using the Bayes Theorem. This means that the distribution of a specific parameter for a specific group of respondents can be obtained. Similarly, the distribution of the random parameters for the group of individuals that are observed making the sequence of choices w_f may be evaluated. The mean β for this group of respondents is in turn (Train 2003):

$$E[\beta_f] = \frac{\int \beta P(w_f \mid \beta) f(\beta \mid \theta) d\beta}{\int P(w_f \mid \beta) f(\beta \mid \theta) d\beta}. \tag{7}$$

The individual-level marginal WTPs for the significant coefficients of attributes in *markaz* Kafr-Saad and El-Zarka are shown in Figures1and 2, respectively. Panels (a) and (b) of Figure 1 illustrate the farmer MWTP for the soil improvement attribute if the field has an open or tiled drain, respectively. Very few farmers (0.07 percent) in the former category have a positive MWTP. The subsequent two figures represent the WTP for the irrigation water quantity and certified seeds. Contrary to the case of Kafr-Saad, Figure 2(a) depicts MWTP of all El-Zarka farmers for the soil improvement attribute if the field has an open drain as positive. The subsequent two panels of Figure 2 represent the WTP for the irrigation water quality and quantity, respectively. The last panel of the figure illustrates the WTP for the availability of certified seeds.

The derivation of discrete welfare measures in CE is implicitly based on the assumption of alternative specific experiments, and involves the problem that the analyst does not know which alternative an individual would choose. Under some assumptions, the welfare effect of a discrete change in the set of attributes can be expressed as the so-called log-sum formula (Hanemann 1999):

$$WTP = \frac{1}{\delta}\left[\ln \sum_{f \in A} e^{V_{f0}} - \ln \sum_{f \in A} e^{V_{f1}} \right], \tag{8}$$

where V_{f0} and V_{f1} are the utility levels before and after the change, respectively, for each alternative. However, in this case the CE has generic alternatives and therefore another, more intuitive way, of deriving the welfare measure is suggested. Since any welfare evaluation can be formulated as a binary choice, the problem of not knowing which alternative a particular respondent would choose is non-existent in that case. Therefore, WTP may be derived by solving the following equality:

$$\alpha_1 + \beta X_1 + \gamma_1 Z_f + \delta(y_f - WTP_f) + \varepsilon_{1f} = \beta X_0 + \delta y_f + \varepsilon_{0f}, \tag{9}$$

where X_1 is the attribute vector after the change and X_0 is the attribute vector for the *status quo*. Since an alternative-specific constant is included for the non-opt-out alternatives, the constant is only included in the left hand side of the expression, together with the interacting socio-economic characteristics.[6] Mean WTP is then given by

$$E\left[WTP_f\right]=\frac{\beta\left(X_1-X_0\right)+\alpha_1+\gamma_1 Z_f}{\delta}. \quad (10)$$

This expression could have been obtained using the traditional approach with the log-sum formula by specifying only one alternative and a base case. Hence, it could not be argued that this suggested approach gives a different result than the traditional one. The difference is that it is more straightforward and allows one to think in a simpler and more straightforward way about other functional forms that might be more suitable. The welfare estimates for a proposed program that offers an improvement moving from the *status quo* to as oil improvement that makes a tiled drain available, a medium improvement in the quality of irrigation water, a periodical flow of irrigation water and making the certified seeds 50 percent available are assessed using the estimated coefficients. Standard errors are calculated with the Krinsky-Robb method with 1000 draws. The resulting mean WTP for Kafr-Saad and Al-Zarka for such a program are -19.89 (64.21) and 100.81 (46.13), respectively. As a comparison, the welfare effect not considering the alternative-specific constant—and consequently not the socio-economic characteristics that are interacting with the constant—is calculated. It has a value of LE -74.41 (46.84) and LE 46.4 (3.77) for the two respective *markazs*. It should be noted that the WTP of this specific program is only significant for *markaz* El-Zarka. Moreover, the latter measure can be seen as a measure of the WTP given that farmers are willing to make a trade-off.

6. Discussion and Conclusion

In many developing countries rural development is of utmost importance, crucial in combating poverty and supporting the transformation to more sustainable development. Over time, several tactics and interventions have been attempted to support rural development activities. These interventions are either directed to support the rural community through various local public goods like health care, roads and schools, or by directly supporting the rural household with subsidized food, and agricultural inputs. Both approaches are currently implemented in Egypt, but given the high centralization in decision making, the decisions rarely meet the rural community needs which creates a general dissatisfaction. As previously mentioned, the responsible central authorities have a history of significant physical progress. However, as the management of diverse and often competing water demands, coupled with the efficient maintenance of installed infrastructure become more dominant issues, the trend towards greater decentralization is pressing. This trend will likely require close cooperation between central authorities, local water associations/boards, private contractors and individual farmers during the planning and construction phase, with management, administration and maintenance being shifted to the water associations following construction.

This paper offers an application of the Choice Experiment (CE) approach to policies for mitigation of land-degradation, through agricultural extensions that encompasses drainage infrastructure, better water quality and quantity and availability of certified seeds in a developing country setting. The study asked the farmers to value various bundles of interventions that the interviewers described to them. This provides information that can be used to better understand the structure of the benefits of drainage systems and irrigation water improvements, the provision of certified seeds, or other integrated land management programs in Damietta. The analysis of the social determinants of the willingness to pay can

[6]Note that it is not necessary to include an opt-out alternative in each choice set to derive this measure. What would be recommendable is to include the opt-out levels of the attributes as possible levels.

also be used to give insights concerning other issues such as designing agriculture policy and tax scheme construction.

The estimated Random Parameter Logit (RPL) model shows that farmers in Damietta have a positive WTP to improve productivity through irrigation water quality and quantity and the purchase of certified seeds with some between *markaz* differences. The mean WTP concerning an improvement in the availability of a tiled drain, medium improvement in the quality of irrigation water, periodical flow of irrigation water and 50 percent availability of certified is found to be significant in El-Zarka and amounts to about LE101 per farmer per year. This corresponds to around 0.5 percent of the yearly mean of farm revenues. It is also found that there is a significant heterogeneity among the farms, both in terms of observed characteristics such as whether they experience soil salinity, educational level, the farmers' perception on the quality and quantity of irrigation water, but also in terms of unobserved characteristics. The latter is found by modeling a RPL model, where the heterogeneity in preferences regarding the attributes included in the choice experiment is allowed. The richness of information that can be obtained from this type of modeling approach is illustrated by estimating individual level marginal WTP and, as mentioned, the mean WTP for a particular policy program.

Furthermore, it may be concluded that the CE as such proved to work fairly well in this context. The visual aids were helpful for the respondents and many respondents found the CE interesting and even fun. However, it is suspected that a number of respondents did not quite understand the experiment, resulting in a random response. One major reason may be due to cognitive effort as the CE was conducted as a part of a large survey instrument and came at the end of the interview. That the CE at least was partly successful is also indicated by the fact that a significant WTP is obtained for most of the attributes, even though surveyed farmers are fairly heterogeneous.

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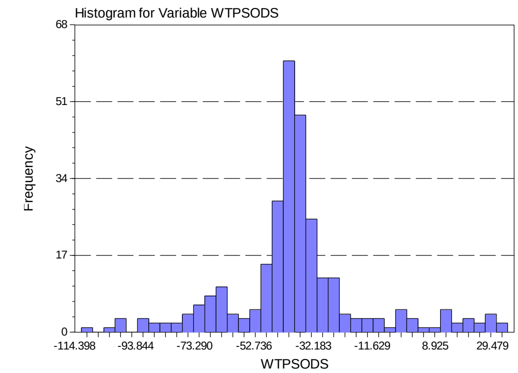
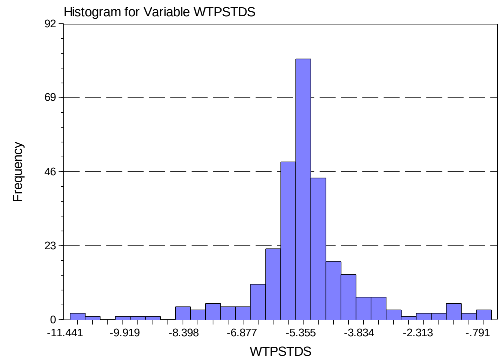
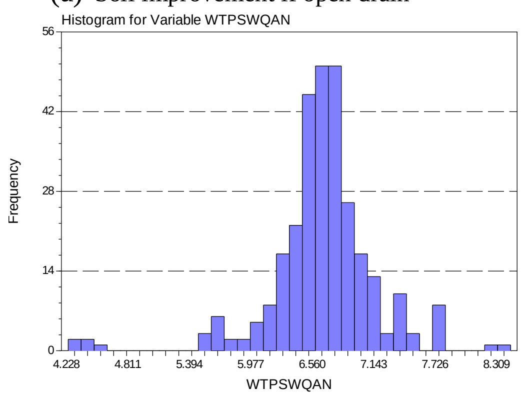
Figure 1: Kafr-Saad Farm Specific Estimates of WTP



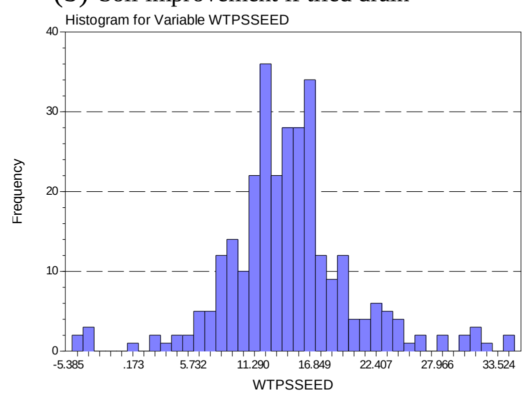
(a) Soil improvement if open drain



(b) Soil improvement if tiled drain

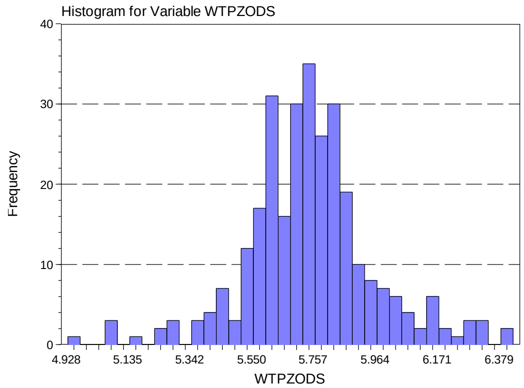


(c) Irrigation Water Quantity

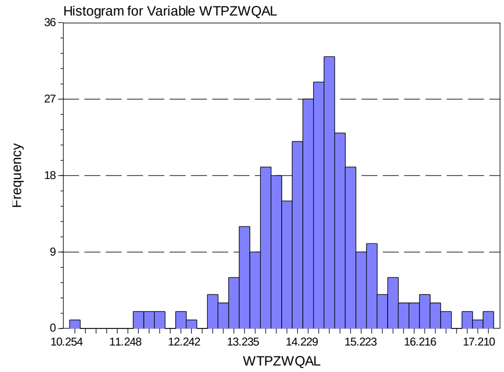


(d) Certified seeds

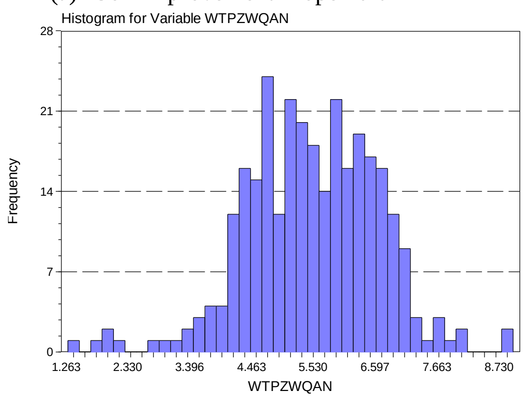
Figure 2: El-Zarka Farm Specific Estimates of WTP



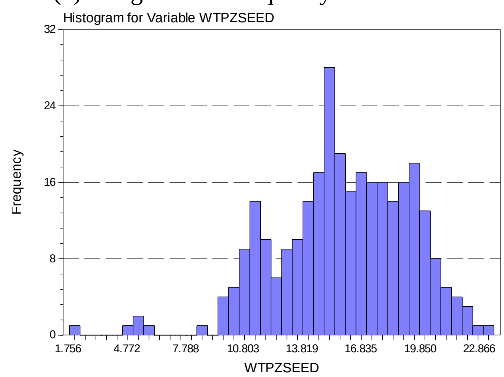
(a) Soil improvement if open drain



(b) Irrigation water quality



(c) Irrigation Water Quantity



(d) Certified seeds

Table 1: Attributes and Levels of the Choice Experiment

Attribute	Levels
Soil improvements	Tiled drainage. Drain and managing it
Irrigation water quality	Good Medium
Irrigation water quantity	Continuous flow Periodical flow, defined as water gates one week opened and one week closed
Availability of certified seeds	100percentavailable 50percent available
Price (an annual increase in land tax)	LE0[a], 20, 30, 40

Notes: [a] 1 USD = LE5.5 in February, 2007.

Table 2: Choice Set Example*

Attributes	Option A	Option B	Status Quo
Soil improvements	Tiled drain	Drain and managing it	Same as today
Water quality	Medium	Good	Same as today
Water quality	Continuous flow	Periodical flow	Same as today
Certified seeds	50 percent available	100 percent available	Same as today
Cost in Egyptian pounds	20	30	Zero
SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME TO MAKE A CHOICETHEN CROSS ONE OF THE CHOICES	☐	☐	☐

Notes: *This is an example of a choice set containing three profiles of a given two alternative interventions versus no intervention. Each profile is described in terms of 5 attributes, including the intervention cost. Each attribute has two or more levels. A choice experiment contains a sequence of such choice sets.

Table 3: Description of the Sample and Variables Used in the Analysis

		Mean (Std.)		
Variable	**Description**	**Full Sample**	**Kafr-Saad**	**El-Zarka**
Farm size	Total land holding in kirat[a]	81.46	80.64	82.29
		(75.46)	(48.61)	(93.23)
Own land	= 1 if farmer owns his land	0.946	0.97	0.92
		(0.226)	(0.162)	(0.272)
Age	Farmer's age in years	53.98	53.88	54.08
		(11.124)	(10.572)	(11.617)
Literacy	= 1 if farmer is literate	0.423	0.329	0.516
		(0.494)	(0.47)	(0.5)
Open drain	= 1 if farm has an open drain	0.547	0.611	0.483
		(0.498)	(0.488)	(0.5)
Salinity	= 1 if farmer perceives the level of salinity in his land to be of medium or high	0.43	0.7	0.16
		(0.496)	(0.459)	(0.368)
Awareness	= 1 if the farmer alters his cropping choices due to the degradation of his farm conditions	0.597	0.68	0.52
		(0.491)	(0.467)	(0.5)
Good water quality	= 1 if self-assessed irrigation water quality status of the farm is good in summer	0.218	0.19	0.25
		(0.414)	(0.391)	(0.432)
Sufficient water quantity	= 1 if self-assessed irrigation water quantity available to the farm is sufficient in summer	0.272	0.05	0.49
		(0.446)	(0.225)	(0.5)
Revenue	Total revenue of yield per area in Egyptian Pounds	21693	20334	23052
		(23038.6)	(17145)	(27.581.5)
Status quo	= 1 if the Farmer always chose the opt out	0.107	0.15	0.06
		(0.31)	(0.361)	(0.238)
Cost	Annual increase in Land Tax in Egyptian Pounds	19.89	19.98	19.88
		(15.53)	(15.533)	(15.526)
Soil	The improvement in drainage system management (attribute levels coded 0, 1, 2)	0.994	0.99	1
		(0.813)	(0.812)	(0.814)
Irrigation water quality	Change in irrigation water quality (attribute levels coded 0, 1, 2)	0.979	0.98	0.98
		(0.803)	(0.803)	(0.803)
Irrigation water quantity	Change in the type of flow of irrigation water (attribute levels coded 0, 1, 2)	1.002	1	1.01
		(0.818)	(0.815)	(0.82)
Certified seeds	The percentage of covering the farms needs of certified seeds	49.75	49.76	49.74
		(40.75)	(40.683)	(40.671)
Kafr-Saad	= 1 if farm is located in markaz Kafr-Saad	0.5	n.a.[b]	n.a.
		(0.5)		

Notes: [a] The kirat is a measure of land size that is approximately equivalent to 175 m^2. [b] n.a. = not applicable

Table 4: Estimation Results of the Choice Experiment

	Multinomial Logit		Random Parameter Logit		Covariance Heterogeneity Logit	
Fixed Parameters	**Coefficient**	***t*-statistic**	**Coefficient**	***t*-statistic**	**Coefficient**	***t*-statistic**
Revenue	0.056	6.311	0.138	4.033	0.068	3.311
Literacy	0.252	1.436	-0.065	-0.139	0.292	1.254
Farmer age	0.010	1.273	-0.002	-0.125	0.012	1.129
Farm size	-0.006	-3.332	-0.012	-1.514	-0.007	-2.290
Salinity	0.081	0.474	-0.652	-1.520	0.092	0.424
Good water quality	-0.960	-4.701	-1.901	-3.338	-1.168	-3.126
Sufficient water quantity	-0.355	-1.075	0.249	0.295	-0.356	-0.781
Kafr-Saad	-3.369	-10.372	-5.094	-6.532	-4.035	-4.107
Open drain	-2.429	-13.061	-4.346	-7.616	-2.939	-4.214
Cost	-0.042	-8.940	-0.049	-9.296	-0.044	-8.575
Random Parameters / Mean Effects						
Alternative specific constant (not choosing opt-out)	2.674	4.540	6.414	4.544	3.416	2.871
Soil improvement	-0.109	-1.514	-0.113	-1.411	-0.104	-1.402
Irrigation water quality	0.386	4.999	0.383	4.046	0.402	4.855
Irrigation water quantity	0.233	3.286	0.278	3.490	0.239	3.155
Certified seeds	0.652	8.907	0.721	8.371	0.679	8.528
Standard deviations (RPL) / Scale components (CovHet)						
Alternative specific constant			3.378	9.021	n.a.	
Soil improvement			0.224	1.825	0.083	0.909
Irrigation water quality			0.643	5.116	-0.124	-1.289
Irrigation water quantity			0.224	1.909	0.031	0.329
Certified seeds			0.482	3.891	0.016	0.175
Cost			n.a.		0.012	0.207
Cost squared			n.a.		-0.0001	-0.122
Scale parameter			n.a.		0.633	1.156
Number of respondents/choice sets	5364 / 298		5364 / 298		5364 / 298	
Log likelihood / restricted log likelihood (constants only)	-1445 / -1932		-1297 / -1932		-1443 / -1932	
Pseudo R^2	0.248		0.325		0.249	

Table 5: Results of the RPL model for the Choice of Agricultural Extension

		Type of Drainage Control		Markaz Control	
	Fixed Parameters	**Coefficient**	***t*-statistic**	**Coefficient**	***t*-statistic**
	Revenue	0.167	6.450	0.139	5.842
	Literacy	0.612	1.298	1.279	2.824
	Farmer age	0.011	0.602	-0.0001	-0.007
	Farm size	-0.028	-5.696	-0.021	-3.832
	Salinity	-1.328	-2.765	-0.419	-1.080
	Good water quality	-1.335	-2.690	0.429	1.020
	Sufficient water quantity	2.147	3.239	-0.024	-0.042
	Cost	-0.053	-9.339	-0.050	-9.583
	Random parameters				
	Alternative specific constant (not choosing opt-out)	0.813	0.668	0.901	0.844
	Soil improvement if open drain	-0.105	-0.894		
	Soil improvement if tiled drain	-0.113	-1.034		
	Irrigation water quality	0.445	4.106		
	Irrigation water quantity	0.296	3.394		
	Certified seeds	0.833	8.222		
Kafr-Saad	Soil improvement if open drain			-2.124	-5.95
	Soil improvement if tiled drain			-0.283	-1.821
	Irrigation water quality			-0.035	-0.272
	Irrigation water quantity			0.333	2.774
	Certified seeds			0.708	5.073
El-Zarka	Soil improvement if open drain			0.288	2.026
	Soil improvement if tiled drain			-0.078	-0.551
	Irrigation water quality			0.716	6.553
	Irrigation water quantity			0.263	2.668
	Certified seeds			0.785	7.530
	Standard Deviations				
	Alternative specific constant	3.659	10.081	3.373	9.552
	Soil improvement if open drain	0.039	0.355		
	Soil improvement if tiled drain	0.154	1.016		
	Irrigation water quality	0.956	7.348		
	Irrigation water quantity	0.410	3.764		
	Certified seeds	0.897	5.822		
Kafr-Saad	Soil improvement if open drain			2.801	7.242
	Soil improvement if tiled drain			0.252	1.291
	Irrigation water quality			0.062	0.648
	Irrigation water quantity			0.062	0.648
	Certified seeds			0.689	5.057
El-Zarka	Soil improvement if open drain			0.032	0.134
	Soil improvement if tiled drain			0.458	1.843
	Irrigation water quality			0.138	0.771
	Irrigation water quantity			0.138	0.771
	Certified seeds			0.362	2.240
	Number of respondents/choice sets	5364 / 298		5364 / 298	
	Log likelihood / restricted log likelihood (constants only)	-1360 / -1964		-1336 / -1964	
	Pseudo R^2	0.31		0.32	

Table 6: Mean marginal WTP in Egyptian Pounds (standard errors in parentheses)

	Full sample	**Kafr-Saad**	**El-Zarka**
Soil improvement if open drain	-1.995	-41.791*	5.719***
	(2.274)	(23.662)	(0.217)
Soil improvement if tiled drain	-2.142	-5.478***	-1.637
	(2.097)	(1.517)	(3.947)
Irrigation water quality	8.43***	-0.695	14.242***
	(2.14)	(0.378)	(0.977)
Irrigation water quantity	5.61***	6.580***	5.364***
	(1.666)	(0.517)	(1.133)
Certified seeds	15.795***	13.664***	15.363***
	(2.365)	(5.662)	(3.327)