Investigating farmers' willingness to participate in the chemical fertilizer reduction scheme: A choice experiment study in Taiwan

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ABSTRACT

Chemical fertilizer has successfully led to a significant increase in food production in previous decades. However, this pursuit of high yields often leads to excessive application of chemical fertilizer, negatively impacting the environment.

Agri-environmental schemes (AES) are a widely used instrument in many countries to provide farmer incentives to reduce negative environmental impacts. The success of the Agri-environmental scheme in each country will depend highly on the farmers' participation.

According to the Environmental Sustainability Index in 2005, world fertilizer consumption per hectare of arable land in many countries was reported over the average of 152.6 kg/ha. Taiwan's fertilizer consumption was 1,525 kg/ha, the second highest in the world. In this paper, we use Taiwan as a case study to investigate the preferences of rice farmers regarding the policy incentives of the chemical fertilizer reduction scheme based on choice experiments.

The survey was conducted in different rice regions in Taiwan and the data was analyzed using both mixed logit and latent class models. The choice experiment results indicate that the preferences for the amount of enrolled land, incentive payments, contract length and the eco-label are significant determinants of policy design. Farmers would be willing to accept small incentive payments for their participation in exchange for receiving an eco-label.

Keywords: agri-environmental scheme; willingness to accept; chemical fertilizer reduction; choice experiments; mixed logit; latent class

JEL classifications: C25, Q12, Q18

1. Introduction

Chemical fertilizer has successfully led to a significant increase in food production in previous decades. However, this pursuit of high yields often leads to excessive application of chemical fertilizer, negatively impacting the environment. Nitrogen and phosphorus are the two nutrients most affecting water quality. Intensive use of chemical fertilizers results in nitrogen leaching into ground water which could potentially lead to health hazards through both surface and ground water pollution (Ghosh 2004). Nitrogen pollution also contributes to climate change and biodiversity loss (Sutton, Oenema et al. 2011, Stuart, Schewe et al. 2014). Agricultural activities related to livestock and fertilizer management release nitrous oxide (N_2O) and methane (CH_4), greenhouse gases with a global warming potential 310 and 21 times higher than CO_2, respectively (EC 2010).

There have been many empirical research studies on strategies to improve the effectiveness of nitrogen utilization by crops (Zebarth, Drury et al. 2009, MacDonald, Blom et al. 2013). Reducing nitrogen fertilizer application was discussed by Stuart et al. (2014) as a climate change mitigation strategy. Hussain et al.(2015) also confirms that changing fertilizer management practices, enhancing fertilizer use efficiency is one of the possibilities for green house gas (GHG) mitigation. Agri-environmental schemes (AES) are widely used in many countries to provide incentives to reduce negative environmental impacts, and include prohibition of agrochemical use (Keenleyside, Allen et al. 2011). Agri-environmental policies and measures aim to change farmers' behaviour and to improve the environmental performance of the farms. For example, research confirms the agri-environmental measure of the rural environmental protection scheme (REPS) in Ireland significantly reduced Nitrate-N (NO_3–N) leaching from a beef farming system over the study period (Richards, Jahangir et al. 2015). Agri-environmental schemes (AES) and payment for ecosystem services (PES) have received great attention by researchers in recent years (Uthes and Matzdorf 2013, Smith and Sullivan 2014).

Many studies have investigated service providers' willingness to participate in PES and farmers' preference for scheme factors of AES (Ruto and Garrod 2009, Christensen, Pedersen et al. 2011, Broch and Vedel 2012, Broch, Strange et al. 2013, Kaczan, Swallow et al. 2013, Barr and Mourato 2014, Garrod, Ruto et al. 2014, Jaeck and Lifran 2014, Greiner 2015, Lienhoop and Brouwer 2015). The success of AES and PES will depend greatly on farmers' participation. Christensen, Pedersen et al. (2011) explain limited success in AES and find farmers are often motivated by factors other than profit maximization. Therefore, it is important to know farmers' preferences about both monetary and non-monetary factors to optimize the scheme design before implementation. Relatively few economic studies exist for investigating farmers' willingness to participate in an agrochemical-free scheme (Christensen, Pedersen et al. 2011). To the authors' best knowledge, none of the studies specifically addresses farmers' preference for reducing agrochemicals gradually and getting non-monetary reward when they comply with regulation successfully.

This study aiming to reduce fertilization rates requires the farmer to limit the level of artificial fertilizer applied to the land. According to the Environmental Sustainability Index in 2005, world fertilizer consumption per hectare of arable land was reported to be 152.6 kg/hectare/year on average. Many developed and developing countries' consumption was far beyond this (Esty, Levy et al. 2005).

There are two reasons we choose rice farmers in Taiwan as a case study: (1) rice is the most important staple food for half of the world's population and rice cultivation with a heavy application of fertilizer globally contributes to about 30% of CH_4 and 11% of N_2O from agricultural emissions (IPCC 2007). A study from Cai et al. (1997) indicates that N_2O emission increased significantly with the increase in the nitrogen application rate in rice paddy fields; (2) Taiwan's fertilizer use was 1,525 kg/hectare/year, the second highest in the world.

This study uses choice experiment to measure the marginal value of the attributes of a scheme assuming farmers' choices depend on the scheme's specific characteristics. This paper focuses on exploring how the design of scheme factors can influence farmers participation. The main contribution of this paper is to use a choice experiment to identify farmers' preferences for monetary and non-monetary attributes, as well as to investigate farmers' willingness to accept the chemical fertilizer reduction scheme by providing different alternatives. Additionally, how farmers' fertilization practice, which reflects their awareness of over application of chemical fertilizer, influences their choices is also investigated.

The attributes we investigate are: percentage of land enrolled, level of incentive payment for participating in the scheme, eligibility for additional reduction of chemical fertilizer and corresponding payment, contract length, and eco-label. To our knowledge, no other studies investigate farmers' trade-off between the other four attributes and the eco-label.

The analyses showed eco-label significantly affected farmers' acceptance of the contract. Having the eco-label in the scheme increases in willingness to accept (WTA). Farmers were willing to accept a lower payment when they could receive an eco-label. In general, farmers prefer having a contract offering them an opportunity to gradually improve their farming practices towards less use of fertilizer.

Latent class analysis suggests that our respondent sample can be divided into two distinct groups based on their elicited preferences. The results show that the farmers who had followed an expert's advice, and who stated they ad decreasing the amount of chemical fertilizer application and who had already have other certifications are more willing to participate in the scheme.

This paper is structured as follows. Section 2 presents the study area, while section 3 presents a summary of choice experiment literature and a description of the methods used, the ideas about the selection of attributes, and levels for the design of the choice experiment. Section 4 presents results, including the descriptive statistics, as well as findings from the analysis of the choice data. A discussion of the findings and recommendations is presented in section 5. Conclusions are given in section 6.

2. Case Study Area Description

The provision of the chemical fertilizer subsidies has a long history and has become customary in Taiwan. In order to join the WTO in 2002, chemical fertilizer policy underwent adjustments beginning in 1996. The Council of Agriculture (COA) has started fully subsidizing the price difference to cover the increasing costs of fertilizers since 2008. In other words, due to increasing costs, the government pays subsidies to the manufacturers of chemical fertilizers and manufacturers are requested to sell chemical fertilizers at lower prices to farmers. This policy allows farmers in Taiwan to buy chemical fertilizers at much lower prices than in neighboring markets. The chemical fertilizer subsidy has successfully led to a significant increase of food production over the previous decades. However, this also has resulted in an over application of fertilizer as well as environmental problems.

Taiwanese agriculture is characterized by rice cultivation in paddy fields, with approximately 163,000 hectares, making up 20% of Taiwan's agricultural land area (COA 2013). There is evidence that crop production can affect water quality if water carries contaminants from fields to surface water or groundwater. Non-point pollution from agriculture is also found in some areas in Taiwan (Chen, Guo et al. 2008).

Although the government has been under political pressure to continue the subsidy, the budgetary constraints and increasing environmental issues have led authorities to develop strategies for minimizing environmental impacts through the reduced use of chemical fertilizers. Meanwhile, these strategies should also support the livelihood of farmers. Since 2009, the government has funded a pilot project through agricultural extension services to encourage the rational application of fertilizers. Until now, only a limited number of farmers have participated in this project.

Logically, if the government terminates the chemical fertilizer subsidy, the farmers would reduce the amount of chemical fertilizer used in order to minimize input costs. Nevertheless, canceling the subsidy would result in a chaotic situation in the agricultural supply chain. Moreover, any significant change of the status quo could threaten the political power base of the ruling party.

In terms of mineral and organic fertilizer reduction, the EU Nitrates Directives (EC 1991) set a mandatory limit on "Nitrate Vulnerable Zones"(NVZs) in Codes of Good Agricultural Practices. Many European countries use agri-envionmental schemes for a higher level of conservation by encouraging farmers to practice environmentally friendly farming. For example, Germany encourages farmers to "give up the use of chemical fertilizers" and "give up the use of pesticides" as two of the measures in the Agri-Environmental Scheme (KULAP in Bavaria). Since it is very challenging for European farmers to radically change their farming practices, many farmers are reluctant to participate in such measures.

The main reason why many countries implement pesticide-free and chemical fertilizer-free zones in their agri-environmental schemes may be because a mechanism to monitor the percentage of agrochemical reduction of each farm is not yet established. In Taiwan, the Council of Agriculture (COA) has implemented the Fertilizer Information System (FIS) in

January 2015. In this system, the amount of chemical and organic fertilizers purchased by farmers is recorded. In the future, FIS can potentially serve as a mechanism to monitor the quantity of chemical fertilizer used by each farm.

In Taiwan, a recent study on environmentally friendly direct payment has been carried out by Chen et al. (2012). It suggested that the government implements a “payment for environmental service” as a subsitite for the fertilizer subsidy. Therefore, we assume if the payment of the fertilizer subsidy could be transferred to the Chemical Fertilizer Reduction Scheme (CFRS), this could potentially encourage farmers to reduce chemical fertilizer inputs without increasing the government’s budget.

FIS could be a very efficient tool to record and monitor farmers’ consumption and usage of chemical fertilizers. Based on the FIS, the government can provide a feasible Chemical Fertilizer Reduction Scheme to farmers. Thus, a farmer could choose to start from the 15% entry level reduction instead of a 100% reduction in the first year of participation. The success of the CFRS and therefore the sustainability of agricultural systems will highly depend on the farmers’ participation. Therefore, it is important to make the CFRS scheme as attractive as possible to encourage farmers to participate.

3. Methodology: Choice Experiment

In the design of agri-environmental policy, discrete choice experiments (DCEs) have been applied many times to assess farmers’ willingness to accept these voluntary conservation schemes or farmers’ preference for certain measures (Ruto and Garrod 2009, Espinosa-Goded, Barreiro-Hurlé et al. 2010, Christensen, Pedersen et al. 2011, Kaczan, Swallow et al. 2013, Jaeck and Lifran 2014, Schulz, Breustedt et al. 2014). Choice experiment (CE) study is a stated preference (SP) method which is based on individual choices in hypothetical situations. Using the CE method, it is possible to combine qualitative and quantitative attributes (Broch and Vedel 2012). Lancasterian Consumer Theory (Lancaster 1966) and random utility theory (Luce 1959, McFadden 1974) are the basis for choice experiments.

3.1 Survey Design

This paper focuses on specific scheme design factors to investigate rice farmers’ preference on different attributes of the fertilizer reduction scheme in order to provide the

authorities with useful information. This information aims to develop a more attractive scheme for farmers in the future. We use questionnaires to collect data from farmers.
The questionnaire was divided into two parts:

(1) a CE on the Chemical Fertilizer Reduction Scheme (CFRS)

(2) socio-economic aspects, farm factors and farmers' attitudes

Respondents are asked to choose hypothetical alternatives from the choice sets. We assumed that individual characteristics affect the probability of choice. Therefore, data about age, education level, and farming experience were collected. Farm-specific business data were also collected including farm location, size of rice cultivation area, fertilizer application practices, whether or not the farmer participated in a rational fertilization workshop offered by an agricultural extension service, and whether or not the farmer followed an expert's advice on fertilizer application. The sections below describe the key elements of the CE: the selection of attributes and its levels; the choice card design and scenario; the data collection process and the econometric models.

3.2 Attribute and Level Selection

The attributes of the choice experiment should be both relevant to the requirements of the policy makers and also meaningful to the respondents (Bennett and Blamey 2001, Bateman, Carson et al. 2002). The attributes and their levels must be realistic so they can be evaluated by respondents (Hanley, Wright et al. 1998, Hanley, Mourato et al. 2001). The attributes selected for this study were based on a review of previous studies ooffarmers' preferences with respect to AES as well as current agricultural and environmental policies in Taiwan.

Five attributes were considered to build possible CFRS: percentage of land enrolled in the CFRS, incentive payment for participating in the CFRS (entry level), eligibility of additional reduction of chemical fertilizer and rewards (higher level), contract length, and eco-label. Its levels used are shown in Table 1. We aim to examine respondents' preferences to the above five attributes of the CFRS. A detailed description of these five attributes is given below.

(1) Percentage of land enrolled in the Chemical Fertilizer Reduction Scheme
In Taiwan, farm size is rather small and farmland ownership is highly fragmented. Considering that flexibility of a chosen area and commitment to the measures is an important de-

terminant of entry into a scheme (Wynn, Crabtree et al. 2001, Ruto and Garrod 2009, Espinosa-Goded, Barreiro-Hurlé et al. 2010), we would also like to assess the farmers' willingness to participate in CFRS according to different land use contracts of 25%, 50% and 100% for eligible areas. Farmers are risk averse, therefore they may not want to completely devote their land to a chemical fertilizer-free zone even though their farm size is rather small.

(2) Incentive payment for participating in the CFRS (Entry level)

In order to encourage farmers' participation, an incentive payment shall be implemented in line with a reference level.

Define reference level

In the EU, the Nitrate Directive (1991) is one part of Cross Compliance to prevent nitrates loss from agricultural sources by promoting the use of Good Farming Practices (GFP). Germany, as a member of the European Union, had already implemented the Nitrate Directive through its national fertilizer act (Düngemittel VO). It sets limitations on fertilizer application, mineral and organic, and states that maximum amount of livestock manure can be applied at a value of 170 kg nitrogen/hectare/year. EU direct payment is made to farmers subject to cross compliance with environmental legislation upon their compliance with general mandatory good farming practice requirements, which should be the baseline or reference level for cross compliance.

A European Commision report (2005) provides an overview of agri-environmental measures and their application, and it explains agri-enviromental schemes which provide payments to farmers to encourage them to protect and enhance the environment on their farmland. The agri-environment measures must go beyond usual Good Farming Practice (GFP). Agri-environmental contracts offered to farmers should be on a voluntary basis and compensate farmers for the income losses caused by implementing environmentally friendly practices.

In the past four years, several field experiments on the rational use of fertilizer have been done in Taiwan (Hualien District Agricultural Research and Extension Station 2009, Tainan District Agricultural Research and Extension Station 2009). These experiments show that proper fertilizer use can improve soil quality, increase crop yields, and improve the utilization rate of fertilizer. In Taiwan, farmers prefer to buy compound fertilizer due to convenience. However, this results in nutrient waste and non-point pollution. By increasing nutrient use efficiency, environmental damage can be reduced and yields can be increased (Heissenhuber, Schiessl et al. 2014).

From these experiments and by cooperating with the Chemical Fertilizer Reduction Scheme, we expect that a certain reference level for rational fertilizer application can be defined on a national scale (e.g., first rice crop season N: 180 kg/ha, P_2O_5: 20 kg/ha, K_2O: 70 kg/ha, second rice crop season N: 160 kg/ha, P_2O_5: 23 kg/ha, K_2O: 65 kg/ha). For Taiwanese farmers in this study, the national scale for the reference level is used as the entry level for the Chemical Fertilizer Reduction Scheme that farmers must comply with.

Define incentive payment

From 2008 to 2014 the average subsidy paid for price differentiation of the chemical fertilizers was [1]NT$ 3.5 billion (approx. 100 million Euro) annually. The average subsidy of NT$ 3.5 billion, divided by the size of current active arable land (700,000 hectare), is approximately NT$ 5,000 per hectare.

The general overuse of chemical fertilizer for rice farmers in Taiwan is about 30% more than the reference level defined above. Farmers who are willing to join CFRS would need to comply with the reference level, which could be 70% of the chemical fertilizer of their current level.

Farmers usually resist making any change in their agriculture practices. An initial incentive should be higher in order to attract farmers to join the scheme. Three options for the entry level of payment for CFRS are offered to farmers: NT$ 2,000, NT$ 2,500 and NT$ 3,500. The annual quantity purchased will be checked by the FIS to see if the farmers have complied with the quantity the CFRS has defined.

(3) Eligibility of additional reduction of chemical fertilizer and incentive payment (higher level)

This attribute examines farmers' willingness for an even higher level of chemical fertilizer reduction than the reference level. For the entry level, farmers only need to comply with

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[1] NT$ is the abbreviation for New Taiwan Dollar. One Euro equals NT$ 35 (05.2015).

the reference level. The aim of additional reduction incentive payment is to encourage farmers to more aggressively reduce chemical fertilizer usage. According to Chen et al. (2012), canceling the subsidy for chemical fertilizers will lead to a 15% reduction of chemical fertilizer usage. Tainan District Agricultural Research and Extension Station (2009) indicates that the use of chemical fertilizer can be reduced between 10% and 64% for different crops compared to the current amount, while maintaining the same crop yields.

We offer farmers reward payments for further reduction beyond the reference level. These are from NT$ 1,000 (15%), NT$ 2,000 (30%) to NT$ 5,000 (giving up the use of chemical fertilizer completely). The option of zero payment for staying at the reference level is also offered.

(4) Length of the contract

From previous studies, contract length was one of the most important determinants of farmer participation (Ruto and Garrod 2009, Beharry-Borg, Smart et al. 2013, Breustedt, Schulz et al. 2013, Bergtold, Fewell et al. 2014). Farmers appear willing to trade-off compensation payment for shorter contracts (Christensen, Pedersen et al. 2011) and Broch and Vedel (2012) find a preference for flexibility to cancel the contract within a number of years . We offered two types of contract duration to the respondent: a two-year short term contract and a five-year longer term contract.

(5) Eco-label

A considerable amount of literature has focused on consumers' willingness to pay for eco-label products (Loureiro, McCluskey et al. 2002, Gao and Schroeder 2009, Roheim, Asche et al. 2011, Michaud, Llerena et al. 2013, Sorqvist, Haga et al. 2015). However, little attention has been paid to the farmers' perception of adopting environmentally friendly practices in order to obtain an eco-label. Chang (2012) found that eco-labels (Taiwan Good Agricultural Practices, TGAP) use is associated with higher income but also increased income variability. From our perspective, the attractiveness of the eco-label to farmers needs to be investigated. Therefore, in our study, we use eco-label as a new attribute which was not mentioned by other CE research on farmers' preference.

The attributes and their corresponding levels selected for the choice experiment are presented in Table 1 and explanations are listed below.

Table 1. Attributes and levels in choice experiment

Scheme attribute	Description	Levels
Land to be enrolled in the FRS	Amount of land to be enrolled in the FRS	- 25% eligible area - 50% eligible area - 100% eligible area
Payment for entry the scheme (reference level)	Fixed payment for join the FRS scheme (ha/year)	- NT$ 2,000 /ha/year - NT$ 2,500 /ha/year - NT$ 3,500 /ha/year
Eligibility of additional reduction of chemical fertilizer and incentive payment	The additional amount of the chemical fertilizer reduction with corresponding reward payments (hectar/year)	- only comply with reference level - apply 15% less than reference level and receive NT$ 1,000 - apply 30% less than reference level and receive NT$ 2,000 - give up the use of chemical fertilizer and receive NT$ 5,000
Contract length	Duration of the contract	- 2 years - 5 years
Eco-Label	An eco-label for farmers who successfully comply with the standard	- Yes - No

The “full factorial” experimental design uses every possible combination of attribute levels. The number of combinations is the result of the number of levels raised to the power of the number of attributes. The design with two three-level attributes, two two-level attributes and one four-level attributes would have $3^2 * 2^2 * 4^1 = 144$ scenarios. However, it would have been difficult for respondents to evaluate and choose among all choice combinations.

One of the most commonly used solutions for reducing the number of combinations is fractional factorial design. The benefit of fractional factorial design is that the number of scenarios can be greatly reduced. We employed a simple orthogonal design using SPSS to reduce the number of scenarios. It can ensure a practical survey length and avoid confusing the respondents . An experimental design is usually “orthogonal”, which guarantees that the attributes presented to respondents are varied independently from one another. The SPSS command produces a minimum sized orthogonal design.

3.3 The Scenario

In the field of environmental economics, it is very common to add a non-choice option to the choice set (Espinosa-Goded, Barreiro-Hurlé et al. 2010, Broch and Vedel 2012, Beharry-Borg, Smart et al. 2013). Small and Rosen (1981) developed the multiple alternatives approach, in which the respondent has the opportunity to choose between different alternatives or to choose none of the alternatives.

Respondents are provided eight choice sets with different combinations of attribute levels and they are requested to select their most preferred alternative from each choice set. Each choice set contains three options including the opt-out option, in order to give farmers a free choice. In our choice sets, two contract options are offered to the respondent, and the respondent is also allowed to choose “I do not wish to participate in the CFRS” (Table 2).

The hypothetical scenario was presented to rice farmers in the following way:

“Assume the chemical fertilizer subsidy will be terminated. The Council of Agriculture will offer you the possibility to join a Chemical Fertilizer Reduction Scheme (CFRS). You will receive the reward payment when you join the program, but you must comply with a reference level of chemical fertilizer application. The reference level will be defined by the authority. Once you reduce the quantity of chemical fertilizer application, you can save the costs of chemical fertilizer, and you can receive the reward/incentive payment according to the degree of reduction. We would like to ask you to make a choice from the following options. There are eight choice sets. Please choose the most preferred condition – only one- from each choice set. Please answer carefully and honesty. These questions will contribute to future contract design.”

Table 2. Example of choice set

	Condition 1	Condition 2	
Land enrolled in CFRS	25%	25%	
Payment for entry level/reference level (ha/year)	NT$2,500/ha	NT$2,500/ha	
Additional chemical fertilizer reduction with corresponding payment	NT$ 1,000 15% less than the reference level	NT$ 2,000/ha 30% less than the reference level	
Contract length	2 years	5 years	I do not wish to participate in CFRS
Eco-label for CFRS	No	Yes	
Please tick your preference	☐	☐	☐

3.4 Data Collection

Based on the recommendations of Bateman and Carson et al. (2002), piloting questionnaires and revising questions are crucial to ensure the survey is properly designed. Therefore, 25 pilot questionnaires were conducted and revised before undertaking the formal survey. The collection period for pre-tests and formal surveys was from November 2014 to April 2015 in different small towns located in seven counties in Taiwan: Hsinchu, Taichung, Changhua, Chiayi, Tainan, Kaohsiung, and Pingtung. These are the rice production areas in Taiwan and usually have practiced intensive double-crop rice cultivation or decades.

We use random sampling to gather surveys from three sources: group administered questionnaires, household drop-off surveys, and face-to-face interviews. In farmer meetings, the interviewers provided a short introduction on the study's background and how the respondents should answer the questions. Each respondent is handed a questionnaire and required to complete it in the meeting. If the respondents were unclear about the questions, they could ask for clarification. For a household drop-off survey, the responsible person goes to the respondent's home and introduces the study's background and tells the respondent to evaluate their preferred set of contract design attributes in eight different choice sets. The respondent is asked to mail back the questionnaire or the responsible person returns to pick it up. Face-to-face interviews were used if the respondents, mainly elder farmers, were unable to read or answer questions alone.

We cannot attest that our sample is representative of the population of all Taiwanese rice farmers. However, the aim of the study is to investigate the preferences of rice farmers who are interested in forming contracts for environmental friendly practices.

We used experimental design techniques (Louviere 2000) and SPSS software to obtain an orthogonal design and then used the R packages (Aizaki 2012, Croissant 2013, Maurico and Ricardo 2015) to analyze the data.

3.5 Econometric Model

Multinomial logit model is based on the assumption of homogenous preferences across respondents. However, farmers possess heterogeneous preferences, and therefore exploiting a random parameters logit model (RPL) would better represent and explain the preference heterogeneity. Mixed logit is highly flexible and can approximate any random utility model (McFadden and Train 2000). It resolves the three limitations of standard logit model by allowing for random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time (Train 2009).

While a RPL provides a continuous distribution of preferences, it is not well appropriated to explain the sources of heterogeneity (Boxall and Adamowicz 2002). A latent class model (LCM) can sort individuals into a certain number of classes in terms of their choices of preferred attributes, such that individuals with similar preferences are grouped into one specific class. The identification of respondents into classes would be essential and practical for policy design.

In this study, we employed mixed logit to identify the preference heterogeneity as well as latent class model to estimate the segment-specific utility. The overall utility function in our study to describe a farmer *n* from alternative *j* in choice occasion *t* is shown in equation (1):

$$U_{njt} = \beta_n x_{njt} + \varepsilon_{njt} \qquad (1)$$

Where X_{njt} are the attributes that relate to the alternative j in choice occasion t faced by farmer n. β_n is a vector of coefficients representing the characteristics of farmer n. ε_{njt} is an unobserved random term that is an independent and identically distributed (iid) extreme value. β_n is unobserved and vary according to farmers in the population with density $f(\beta | \theta)$, where θ represents the parameters of the density function, for example, the mean and covariance of β's in the population.

Individual farmer in occasion t follows his own value of β and ε_{njt} in order to choose alternative i instead of j if and only if $U_{nit} > U_{njt} \forall$ j not equal i. Since the researcher does not know the β_n of an individual farmer, the unconditional choice probability, which is mixed logit probability, is represented as the integral of conditional probabilities over all possible variables of β_n described in equation 2.

$$P_{nit} = \int \left(\frac{e^{\beta X_{nit}}}{\sum_j e^{\beta X_{njt}}} \right) \bullet f(\beta) d\beta \qquad (2)$$

As noted above, θ represents the parameters of the density function. If a normal distribution with mean b and covariance W , equation 2 can be further described as equation 3.

$$P_{nit} = \int \left(\frac{e^{\beta X_{nit}}}{\sum_{j} e^{\beta X_{njt}}} \right) \bullet \phi(\beta \mid b, W) d\beta \qquad (3)$$

where $\phi(\beta \mid b,W)$ is the normal density with mean b and covariance W . In our study, $f(\beta)$ has been specified to be normal due to its popularity in most applications.

In mixed logit model, the distribution of β is continuous, while in latent class model, the coefficients follow a discrete distribution, with $f(\beta)$ taking a finite set of distinct coefficients (Train,2009). Suppose β takes M possible values labeled $b1,...,bM$ with probability S_m that $\beta = b_m$. The choice probability of latent class model is shown in equation 4.

$$P_{nit} = \sum_{m=1}^{M} S_m \left(\frac{e^{b_m X_{nit}}}{\sum_{j} e^{b_m X_{njt}}} \right) \qquad (4)$$

4. Results and Discussion

A total of 309 surveys were gathered: 115 surveys were obtained from farmers' meetings, 112 from household drop-off surveys and 82 from face-to-face interviews. Unfortunately, 17 of total surveys were discarded due to incomplete information. The remaining group used for analysis constituted 292 respondents.

4.1 Descriptive Statistics

The results show the use of chemical fertilizer was 1259 kg per hectare per year, of which 236 kg and 103 kg were Nitrogen and phosphorus consumption, respectively (Table 3). This confirms the finding from Environmental Sustainability Index (Esty, Levy et al. 2005) that Taiwan has a challenge of over-fertilization. Meanwhile, approximately 70 % of farms use more than 80% of chemical fertilizer of total fertilizer application. The results displayed considerable heterogeneity in farm characteristics. In addition to the basic demographics, our study also collected information on respondents' farming practices and whether or not they had an extension service. Descriptive statistics of the farms and respondents' socio-demographic characteristics are shown in Table 4.

Table 3. Amount of chemical fertilizer application kg/ha/year

Total chemical fertilizer	N	P
1259.57	236.06	103.33

Table 4. Descriptive statistics

Variable	Description	Mean	Std.Err
age	Age of the farmer: years	58.81	0.769
education	1 = primary school, 2 = junior high school, 3 = high school, 4 = agricultural school, 5 = college/university above	2.31	0.079
full	Full time farmer: 1 = yes; 0 = otherwise	0.74	0.027
exp	Farming experience: year	28.98	1.12
scr	Successor: 1 = yes; 0 = otherwise	0.35	0.028
ipt_rice	Importance of income source from rice production 1—5, from not important at all to most importan	3.48	0.065
ipt_off	Importance of income source from off-farm income 1—5, from not important at all to most important	3.63	0.065
hinc	Household income per year (currency: NTD) 1 = < 200,000; 2 = 200,000 ~ 300,000; 3 = 200,000 ~ 300,000; 4 = 300,000 ~ 400,000; 5 = 400,000 ~ 500,000; 6 = 500,000 ~ 600,000; 7 = 700,000 ~ 800,000; 8 = > 800,000	4.52	0.143
finc	On-farm income per year (currency: NTD) 1 = < 50,000; 2 = 50,000 ~ 500,000; 3 = 100,000 ~ 200,000; 4 = 200,000 ~ 300,000; 5 = 300,000 ~ 400,000; 6 = 400,000 ~ 500,000; 7 = 500,000 ~ 600,000; 8 = > 600,000	3.39	0.128
ownsp	Ownership of the land 1 = 100% owned; 2 = partially owned; 3 = 100% rented	1.33	0.034
r_size	Rice cultivation area: hectar	1.46	0.14
80fer	Using more than 80% of chemical fertilizer 1 = yes; 0 = otherwise	0.70	0.027
Qty_d	Application amount of chemical fertilizer was decreasing since last decade 1 = yes; 0 = otherwise	0.20	0.023
cer_N	Number of certification of the product 0 = none; 1 = 1 certificate; 2 = 2 certificates; 3 = 3 certificates	0.21	0.025
follow	Degree of following the advice on fertilizers use by the extension agents 1–5, 1 meaning not at all and 5 meaning fully	2.32	0.07
wks	Participate in chemical reduction workshop: 1= yes; 0= otherwise	0.49	0.031
apply4	Amount of fertilizer applied according to suggestions from the extension service: 1 = yes; 0 = otherwise	0.07	0.015
Action	Action to the termination of chemical fertilizer subsidy: reduce the amount of chemical fertilizer 1 = yes; 0 = otherwise	0.35	0.028

4.2 Mixed Logit Model

The results of mixed logit model are reported in Table 5. The explanatory power of the model is adequate (McFadden Pseudo-R^2 = 0.215). The standard deviations of all the random coefficients are not statistically significant which indicates less heterogeneity in the population. The results show that farmers prefer less land enrollment and shorter contract length. As expected, they have positive preference on obtaining an eco-label.

Table 5. Mixed logit model of contact preferences

	Coefficient		(Std. Err.)	Standard deviation	(Std. Err.)
Constant (ASC)	−1.792	**	(−0.792)	—	—
Entry payment	0.01	*	(0.005)	—	—
Additional payment for further CF reduction	0.001		(0.001)	—	—
Enrolled land 50%	0.338	***	(0.127)	− 0.039	0.506
Enrolled 100%	0.049		(0.12)	− 0.170	0.432
Contract length 5	-0.408	***	(0.128)	0.133	0.315
Eco-label	0.328	****	(0.079)	0.090	0.339
No. of choices	7008				
Log likelihood	-2004.3				
McFadden pseudo - R^2	0.21492				
Chi-squared	1097.4				
Significance level	0.0000				

*, **, ***, **** represent significance level at 10%, 5%, 1%, 0.1% respectively.

Frequencies of alternatives
alternative 1: 34.46% alternative 2: 28.55% alternative 3: 36.99%

4.3 Willingness to Accept

Table 6 shows the willingness to accept based on parameter estimates from Table 5. The results suggest increasing compensation (approximately NTD$ 810) to encourage full enrollment (100%) of their land. The results show that the option of extending the contract length to 5 years requires additional compensation (approximately NTD$ 450). When the eco-label is provided to the farmers for participating in the CFRS, they are willing to accept a lower compensation level.

Table 6. Willingness to Accept

	WTA	2.5%	97.5%
Land 50% enrollment	-68.45561	-1084.03024	575.48605
Land100% enrollment	810.09428	-93.92169	1328.55687
Additional payment	-0.07871	-0.25240	0.01552
Length 5 years	448.90960	246.14502	848.26672
With eco label	-796.38974	-1406.24071	-542.52232

Method = Krinsky and Robb

4.4 Latent Class Model Estimation

The results from the latent class model with two classes are shown in Table 7. We included a socio-demographic variable, but focused particularly on fertilization practices and extension service variables. The purpose of the latent class model is to observe the impact of their preferences on the scheme factors.

Table 7. Results of the latent class model

	Class 1			Class 2		
	Coefficient		Std. Err.			Std. Err.
Attribute						
Constant				−10.99	****	
Land50	0.260		0.235	0.278	*	0.146
Land100	−0.23		0.292	0.123		0.145
Entry_pay	−0.026	****	0.004	0.012	****	0.002
Add_pay	−0.008	***	0.003	0.003	**	0.001
Length5	−0.68	***	0.216	−0.157	**	0.079
Ecolabel	0.062		0.226	0.331	****	0.081
Membership						
Education	—		—	0.56	****	0.151
Follow	—		—	4.842	****	0.718
Qty_d	—		—	4.673	****	1.052
fertilizer80	—		—	2.01	****	0.491
Cer_N	—		—	0.89	*	0.472

*, **, ***, **** represent significance level at 10%, 5%, 1%, 0.1% respectively.

Class 1 is the group with respondents, having less education and not having active practice of applying rational fertilization. They are unwilling to commit to more land enrollment in the scheme. If they were to participate, they would not be prepared to practise further fertilizer reduction, even if they received additional payment. Additionally, they have less interest in obtaining an eco-label. It is very unlikely to attract this group to participate in the scheme by giving a higher compensation level due to the negative coefficient of Entry_pay. For class 2, all the membership variables are significant. This group has higher education, and has already obtained at least one of the certifications for their products. Those certifications could be "Good Agricultural practice", "Traceable Agriculture Product", "Organic Certification" etc.. This group also follows an extension agent's advice (Follow) as well as decreases the amount of fertilizer use (Qty_d) gradually. They currently use more than 80% of chemical fertilizer of the total fertilizer used on the farm. The constant in class 2 is negative which shows they are willing to participate in the scheme. This group appreciates having an eco-label and has a positive attitude towards for additional fertilizer reduction. Both classes prefer a shorter contract length.

5. Discussion

It is apparent that Taiwanese rice farmers overuse chemical fertilizer on their lands (Table 3). Therefore there is a great potential to minimize environmental impact assuming the farmers would participate in CFRS and reduce their amount of fertilizer use to a reference level. Mixed logit results likely imply less heterogeneity among farmers in terms of relatively low standard deviation value. Less heterogeneity of respondents could be due to the fact that our samples are all conventional rice farmers.

Farmers are risk averse (Asci, Borisova et al. 2015). As expected, findings show that the farmers prefer an intermediate step to implement less land enrollment at the beginning instead of committing to 100% of land. Our study also shows that farmers prefer a shorter contract length, this aligns with the findings from previous studies (Ruto and Garrod 2009, Christensen, Pedersen et al. 2011, Beharry-Borg, Smart et al. 2013, Breustedt, Schulz et al. 2013, Bergtold, Fewell et al. 2014).

The latent class analysis in this study provides a basic understanding of the influence of fertilization practices on the respondents' choices. The findings show farmers who stated they are following an expert's advice on rational fertilization and also decreasing the consumption gradually could be potentially the target group for the authorities promoting the scheme. Additionally, from these findings, we suggest that authorities may have the chance to increase farmer participation by enhancing extension services to those groups who may not have a chance either to obtain advice from an expert or to attend a related workshop.

Our results indicate that the prospect of obtaining the eco-label is a positive determinant for opting for the contract. This maybe due to farmers associating an eco-label with a potential higher level of income (Chang 2012). Nevertheless, an eco-label could be an effective policy instrument for fertilizer reduction practice. We suggest that authorities include an eco-label as a non-monetary incentive in their scheme design. Furthermore, the results of WTA show that the respondents are willing to receive less monetary compensation in exchange for receiving an eco-label. It could be advantageous for the authorities who face budget constraints.

6. Conclusions

Our study is one of the few studies (Christensen, Pedersen et al. 2011) that has investigated farmers preferences for agrochemicals reduction using choice experiments. We evaluated attributes related to the scheme preferences of a chemical fertilizer reduction by individual rice-growers. The econometric analysis of the preliminary data demonstrates that farmers prefer shorter contract length, less land enrollment, and are willing to accept smaller incentive payments in order to obtain an eco-label. Furthermore, our study provides preliminary analysis suggesting that enhancing the awareness of over-application of chemical fertilizer is likely to increase the participation rate. This study provides useful information to policy makers for future AES design.

From a policy perspective, our results suggest an alternative way to reduce nitrogen leaching. This study provides useful insights for the design of chemical fertilizer reduction scheme with a gradual approach integrating a non-monetary incentive. The influence of additional compensation should be further investigated in future research. For further studies, it could be interesting to include other farmers' characteristics collected during our survey such as trust of authorities, attitude on environmental friendly practices, and influence from peer farmers.

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