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Valuation of ecosystem services provided by irrigated rice agriculture in Thailand: a choice experiment considering attribute nonattendance

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Abstract

This research investigates how the public of a middle-income country, Thailand, values ecosystem services associated with irrigated rice agriculture using a choice experiment. The results show a significant willingness to pay for services such as drought mitigation, water quality and the environment and maintenance of rural lifestyles and rice landscapes. The iterative procedure developed to fully analyze the incidence of attribute nonattendance (ANA) improved the model fit when compared with a multinomial logit model or an ANA model with potentially only one attribute ignored at a time (ANA-1). Moreover, the inferred probability of the class of respondents having attended all attributes was 45%, compared to 9% with ANA-1 model. However, it also suggests that 55% of the respondents made their choices by considering only two of the five attributes. Finally, this research also suggests that failing to consider ANA does not change the public ranking of scenarios contrasted by the services they would provide but would overestimate the WTP for these scenarios.

JEL classifications: C25, Q26, Q51

Keywords: Choice experiment; Ecosystem services; Irrigated agriculture; Latent class model; Attribute nonattendance (ANA)

1. Introduction

Today, it is generally recognized that agricultural systems are producing more than food. Many of the additional functions produced by agroecosystems (AES) bring numerous benefits to humans, and the concept of ecosystem services (ES) popularized by the Millennium Ecosystem Assessment (2003) can be used to identify them in a systematic way. However, designing policies that influence the provision of ES in AES is complex. First, AES are producing a mix of positive and negative ES, and an increase in the supply of one positive service is often obtained at the cost of an increase in the supply of other negative services. For example, increasing food production in a territory is often related to decreases in ecosystem biodiversity (e.g., loss of wildlife habitat and increase in monospecies fields) and an increase in soil and water pollution (Power, 2010). Hence, production of different mixes of services can be interpreted as different points along a tradeoff curve (Hall et al., 2004; Randall, 2002). Second, many of the ES produced by AES are either externalities or nonrival goods. It is then difficult to give an economic value to these services as most are not traded on markets. Finally, their value is only becoming apparent to end-users once these services have disappeared. All of this will likely result in the undersupply of positive and oversupply of negative ES (FAO, 2011).

In such a context, policy interventions that change farmers' incentives and encourage them to produce the mix of services corresponding to society's demand are needed. These policies include direct norms and rules (mandatory production or ban of services) or the introduction of taxes or subsidies (e.g., Tietenberg and Lewis, 2009). Finding the adequate levels for the subsidies or taxes requires information about the supply and demand functions for the services. More recently, the concept of Payment for Ecosystem Services (PES) explored the idea that these services could be traded on "created" voluntary markets for these services (Wunder et al., 2008), where direct negotiations between buyers and sellers of services would

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help find the adequate societal compromise. However, this market approach has been intensively debated in recent years. In particular, establishing market-like PES schemes is often not practical when large transaction costs, asymmetries of information, and the nonrival characteristic of these ES are prevalent (Muradian and Rival, 2012; Muradian et al., 2010). Therefore, outside of a few market-like PES schemes, designing policies requires, among other things, a better understanding of the demand for the ecosystem services produced by agroecosystems without the possibility of relying on market Data.

The demand for ecosystem services provided by agriculture (ES-A) has already been studied generally for an evaluation of agriculture's multifunctionality (OECD, 2008). However, most studies have been conducted in developed countries characterized by very small agricultural sectors in terms of both population and GNP shares (Campbell, 2007; Kallas et al., 2007; Vera-Toscano et al., 2007) and, to the best of our knowledge, no such evaluation has been conducted in less developed countries. Yet, the case of emergent middle-income countries is of particular interest because the economic contributions (employment, GNP) from the agricultural sector usually decline with development. As the relative importance of agriculture decreases, members of these societies may want to maintain some of the nonmarket functions that are likely to be affected by the decrease in the rural population and the change in production systems.

Economic valuations of ES-A have mainly used discrete choice experiments (DCE) (e.g., Kallas et al., 2007). The theoretical basis of DCE is the Lancasterian theory of consumer behavior (Lancaster, 1966). The random utility models (RUM) developed by McFadden (1974) provided an empirical framework to analyze observed behaviors. In the absence of markets, DCE let potential consumers choose between several alternatives representing hypothetical contrasted combinations of characteristics. The observed choices provide insight into the utility provided by each of these characteristics. Because the utility of the respondents is supposed continuous, RUM assume that respondents are evaluating the tradeoffs between all attributes. However, there is increasing evidence that respondents may have diverse processing strategies to analyze the information given to them (see Hensher, 2014 for a recent review). A specific category of processing strategy, known as attribute nonattendance (ANA), hypothesizes that some attributes are possibly ignored by respondents when they evaluate the proposed scenarios (Hensher, 2010). Being able to identify ANA in DCEs is important because if one attribute is ignored, any deterioration in this attribute cannot be compensated for by an improvement in another attribute. Hence, ignoring ANA strategies could potentially lead to biased coefficients and biased policy outputs.

Two approaches have been used to analyze ANA. First, the stated nonattendance approach analyzes the declarations of respondents about which ANA rules they employed (e.g., Puckett and Hensher, 2008). However, some studies have questioned the reliability of these declarations (Carlsson et al., 2010; Hess and Hensher, 2010). Second, the inferred nonattendance (INA) approach infers the rules used by respondents using equality-constrained multinomial latent class models (LCM). These models calculate the probabilities of occurrence of a given set of pre-established classes defined by their nonattendance decision rule (Hensher et al., 2012; Hess and Hensher, 2010; Hole, 2011; Scarpa et al., 2009). However, taking into account all possible ANA classes would require the estimation of 2^k classes (where k is the number of attributes considered), which is often impossible when k is large and the sample is relatively small. As a result, many existing studies have just focused on a subset of ANA combinations that are given a latent class treatment. However, the choice of variables to be considered for ANA treatment is important; for example, previous studies have suggested that introducing the possibility of joint ANA for two attributes would provide different results than just considering ANA classes with potentially only one attribute ignored (Campbell et al., 2011). Although important, the justification of the choice of variables to be considered is often weak and the consequences of choosing different subsets are not often investigated. A modeling approach that considers ANA for all attributes while remaining feasible with relatively small samples would improve the currently available research on the valuation of ES-A.

Given these two gaps, this article pursues two objectives. The first objective is empirical, as we want to investigate how the society of a middle-income country values the different services provided by agriculture; we used irrigated rice agriculture in Thailand as a case study. Irrigated rice agroecosystems were chosen because these systems, as inundated interconnected paddy fields, provide important functions and services such as flood control (Groenfeldt, 2006; Huang et al., 2006) and groundwater recharge (Kim et al., 2006). In addition, when good agricultural practices are followed, they produce ecosystem services close to those of natural wetlands, such as providing bird habitat and water filtration functions (Natuhara, 2013). Finally, through irrigation, rice farmers maintain traditional landscapes, social coherence and rural lifestyles in rural areas (MRC, 2010). Thailand was selected because it is a major producer of irrigated rice, but the importance of this sector has declined sharply in recent decades, and the production-oriented support awarded to rice farmers has been heavily debated recently.

The second objective is methodological, as this article proposes to use the step-wise approach developed by Lagarde (2013) to investigate the effect of including the complete set of ANA strategies used by DCE respondents on (a) the detection of ANA strategies, (b) the values found for the different services, and (c) the possible biases of ignoring the ANA strategies on the outcome of the models of contrasted policy scenarios. Finally, we analyze the possible links between detected ANA strategies and the socioeconomic characteristics of the respondents having used these strategies.

2. Methodology

2.1. Study area

The northeast region of Thailand is the most populous and poorest region of Thailand. It contains approximately one third of the country's population. Nakhon Ratchasima province (hereafter, NR), with a population of 2.59 million in 2010, is the second-largest province in the country. The provincial capital is one of the fastest-growing cities in Thailand in terms of infrastructure and social and economic development. NR was chosen because it includes, within a reasonable area, some rural districts where both irrigated and nonirrigated rice agriculture are found and some urbanized districts of the large regional capital.

The activities and resources of the province are diversified and include commerce (22.5% of GPP), industry (19.8%), and agriculture (14.9%). Annual GDP per capita in 2010 was approximately 66,000 Baht ($U.S. 2,100) compared with the 159,000 Baht ($U.S. 5,000) country average. Agricultural land covers a large proportion (66%) of NR's area, half of which is cultivated with rice. Only 7.4% of the agricultural land in the province is currently irrigated. However, the potential for increasing the irrigated area or improving the current irrigated area is deemed important (RID, 2010).

2.2. Identification of attributes associated with irrigated rice agriculture

We conducted nine in-depth interviews with experts from academic and government institutions with recognized experience in the fields of water resources, agriculture, and the environment, and we held three focus groups to produce a list of services and to develop interpretable attributes and levels. The first group consisted of eight officials from national and regional institutions responsible for agriculture, the environment, irrigation and water resources. The second group consisted of 12 NR farmers. The third group consisted of 10 nonfarmer NR residents and included government officials, business owners, and employees.

During this phase, participants gave priority to four types of services that could be enhanced through policy change or the development of projects. First, projects could increase the supply of water to agriculture for those who already have or for those who lack access to water. This would result in yield increases and boost economic activities in the region. In fact, supporting agricultural productivity was seen by many interviewed stakeholders as contributing to local economic activity and could therefore be seen as a mix of private and public benefits. Second, projects could also work on drought mitigation functions. The province is prone to frequent droughts that affect both rural and urban areas. A better organization of water delivery to both areas during drought events could prevent drought-related expenses for households (e.g., purchase of water trucks during dry spells). Third, the project could also work on the quality of water in the irrigated areas. This water is used for production but is also used for recreational purposes. In addition, less polluted water decreases the potential damage to the fauna found in these water systems (fields and canals). Although irrigated rice agriculture is often associated with an increase in the use of chemical inputs and pollution, the project could, for example, promote low external input technologies in irrigated rice areas (through training or incentives). Finally, the project could help in maintaining the rural lifestyle and rice landscapes (RL-RL) in a region where rice is also a cultural crop. The last attribute (payment) was also discussed with experts and stakeholders to find reasonable levels. A local tax that would be paid annually on a per household basis in order to collect additional resources would be devoted to the improvement of goods provided by irrigated rice agriculture. This method was seen as the most practical channel to collect project funds and to make all respondents aware that they would really have to pay if the project started. This tax would be decided by the local authorities.

It was emphasized that all goals were aimed at improving the respondents' own utility. In particular, the increase in yields or the maintenance of RL-RL should be seen as a way to maintain economic activity and amenities in the region and would benefit the respondents.

2.3. Experimental design

To obtain the initial priors necessary to create an efficient design and verify the qualitative properties of the questionnaire, we conducted a pilot study on a sample of 157 randomly selected respondents of NR. We then developed a design with 12 choice tasks and split it into two orthogonal blocks of six choice tasks, each using Ngene v.1.1.2 (Rose and Bliemer, 2009). It was constructed using a WTP-efficient design optimized for the mixed logit model. One choice set was dismissed because it was behaviorally unrealistic. Hence, the final design included two blocks: one with six choice sets and one with five. Each respondent was provided one of the blocks, and we randomized the order of the choice sets presented to each respondent. Each choice set included three unlabeled alternatives, including the status quo. Each alternative was described using the five attributes specified in Table 1. An example of a choice card is provided in Fig. 1.

2.4. Survey methods

In October 2013, we conducted face-to-face interviews in NR with individuals selected from the population of four NR districts, which differed in their levels of urbanization and development. The respondents were selected by stratified random sampling based on residence (urban vs. rural), gender and age. Of the 350 interviews requested, a total of 305 respondents agreed to be interviewed and answered all questions. The

Table 1
Attributes and attribute levels used in the choice experiment

Attribute	Variable Short name	Type	Attribute level 1	2	3
Paddy yield	Yield	Numeric	Average yield 2.25 T/ha/year (SQ)	Increase yield to 3.75 T/ha/year	Increase yield to 7.5 T/ha/year
Drought mitigation	Drought	Numeric	No drought mitigation, affected by drought every year (SQ) (99%)	Mitigate drought, affected by drought every two years (50%)	Mitigate drought, affected by drought every three years (33%)
Water quality & environment	Environment	Dummy 0: Low 1: Medium 2: High	Low quality. Be able to use for industrial purposes	Medium level. Be able to use for agricultural purposes (SQ)	High level. Conservation of aquatic animals and safe swimming
Rural lifestyle & rice landscapes	Lifestyle & Landscape	Dummy 0: Deteriorates 1: Maintained	Rural lifestyle is deteriorating, some agricultural lands are abandoned/ being changed (SQ)	Maintain rural lifestyle and traditional rice landscapes	
Annual payment ($U.S./household/year)	Payment	Numeric	26	52	104

Note: SQ refers to the status quo situation.

personal interviews were conducted in respondents' homes. Questions were addressed directly to the household heads (identified as the person responsible for providing for the most daily expenditures) or to the next household member 20 years of age or older living on the premises.

The interviews were organized to minimize the biases that may reduce the quality of the information collected. To minimize the differences in information or interpretation among the respondents, the concepts and purposes of the survey were thoroughly explained, the enumerators presented an overview of the different functions to be valued using pictorial cards (A4 size), and brief descriptions along with the terms and a description of attributes were discussed with respondents to reach an agreement on the meaning of the attributes and levels presented. To minimize possible biases introduced by having several interviewing styles, all interviews were conducted by the same person. To minimize the hypothetical bias, a cheap-talk script was used to remind respondents about the general tendency to exaggerate their willingness to participate in paying for new alternatives and that they would eventually have to annually pay a compulsory local tax from their household budgets, and we urged respondents to give "honest" answers. We also emphasized that responses would remain anonymous to minimize the social desirability bias. No incentives were given to stimulate participation.

2.5. Modeling framework

The model chosen for the analysis of responses is based on the multinomial logistic Latent Class (LC) because it leaves the possibility to divide the respondents into separate groups of preferences (Greene and Hensher, 2003). The LC approach identifies clusters of respondents that have the same utility function (i.e., clusters are defined by different parameter vectors, but all members of the same group share the same parameters). Contrary to other formulations, the LC approach does not require a choice of functional forms for the distribution of preferences within the population and gives results that are more intuitive to interpret and communicate.

The LC approach uses two submodels to calculate the probability that an individual will choose a specific alternative. One submodel estimates the probability that each individual will belong to the classes, while the other submodel estimates the class probabilities of choosing one alternative conditional on the preferences within each class. Both submodels use a multinomial logistic formulation.

The probability that an individual i who belongs to a specific class $c \in \{1, \ldots, C\}$ will choose one alternative $j \in \{1, \ldots, J\}$ proposed in choice situation t is written as (Greene and Hensher, 2003):

$$\Pr(y_{i,j,t} = 1 | i \in c) = \frac{\exp\left(\beta_c'.X_{i,j,t}\right)}{\sum_{j'=1}^{J} \exp\left(\beta_c'.X_{i,j',t}\right)}\,, \tag{1}$$

where $y_{i,j,t}$ is an indicator variable that takes the value 1 when respondent i chooses the alternative j and 0 otherwise, $X_{i,j,t}$ is a vector describing the attributes of the choice situation, and β_c is a vector of utility parameters specific to class c.

Because the analyst does not know which respondent is in which class, the model estimates the probability that individuals belong to a certain group. The prior probability

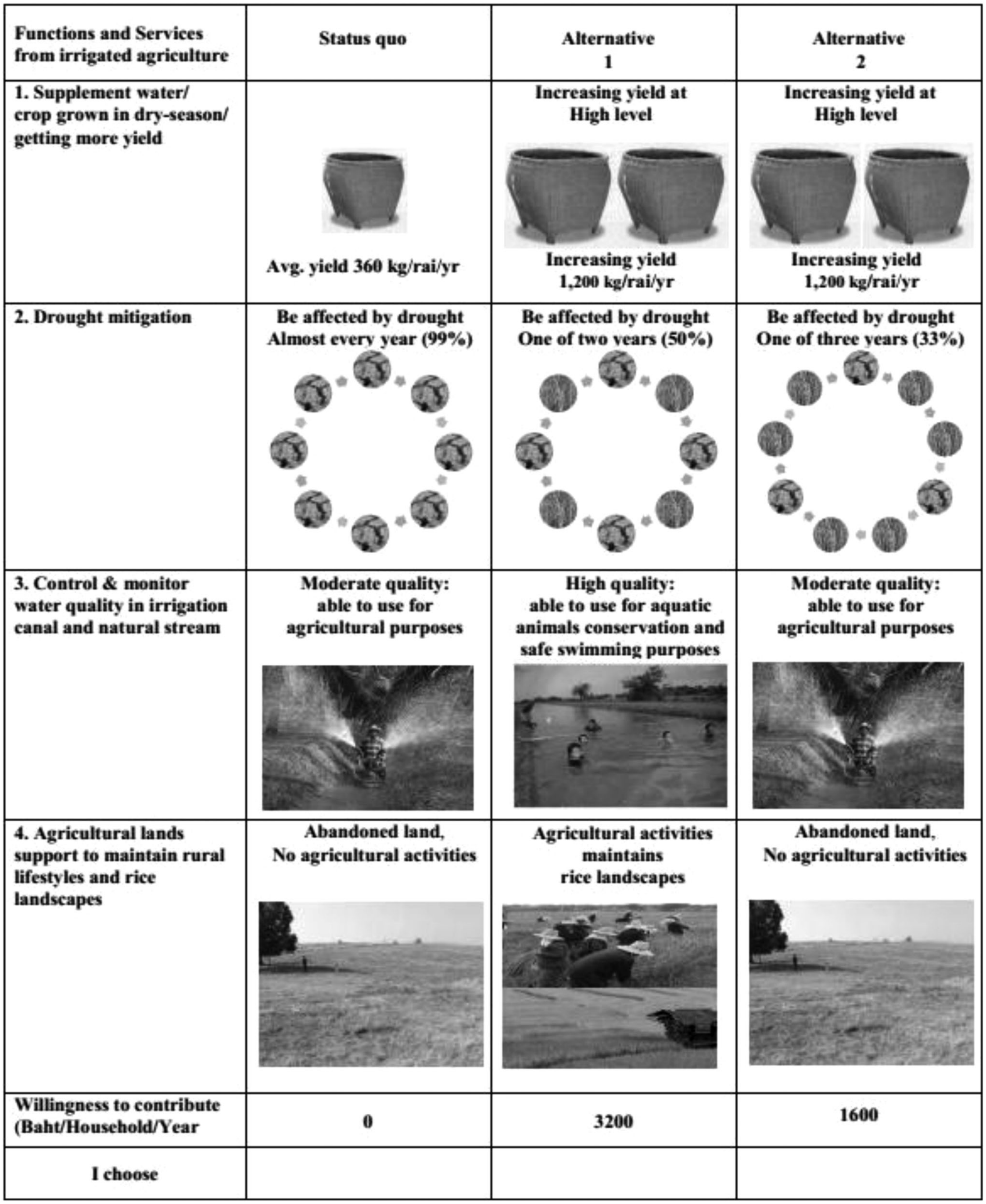

Fig. 1. Example of choice card.

π_c that respondent i belongs to class c is

$$\pi_{i\in c} = \pi_c = \frac{\exp\left(\theta_c'.Z_i\right)}{\sum_{c'=1}^{C}\exp\left(\theta_{c'}'.Z_i\right)}; \quad c = 1, \ldots, C, \theta_1 = 0, \tag{2}$$

where Z_i is a vector of observable characteristics of individuals related to class membership (Greene and Hensher, 2003). In Eq. (2), θ_1 is normalized to zero to secure identification of the model. Because each of the N respondents was given T different choice sets (a quasi-panel configuration), the log-likelihood function to be maximized becomes (Greene and Hensher, 2003):

$$\ln L = \sum_{i=1}^{N} \ln\left(\sum_{c=1}^{C} \pi_c \cdot \prod_{t=1}^{T} y_{i,j,t} \cdot \frac{\exp\left(\beta_c'.X_{i,j,t}\right)}{\sum_{j=1}^{J}\exp\left(\beta_c'.X_{i,j,t}\right)}\right). \tag{3}$$

Having retrieved the parameter estimates (β_c and θ_c), Bayes' formula can be applied to calculate the posterior probabilities of the latent classes for each individual (Greene and Hensher, 2003).

The INA approach uses analytical models based on LCMs in which some additional constraints are imposed on the values that β_c can take for the different classes. The ANA classes are pre-defined as different combinations of attendance and nonattendance across attributes. For each attribute, there exists a nonzero coefficient used in the attendance classes, while the coefficient is set to zero in the nonattendance classes (Hensher and Greene, 2010). As in a classical LCM, we can also obtain the posterior probabilities of the different ANA classes (Greene and Hensher, 2003) and can conclude that a particular pattern of ANA is used by some respondents if the posterior probability of the associated ANA class is significantly different from zero.

When all possible combinations of nonattendance are considered, this becomes a latent class model with 2^k pre-defined classes. Because we considered five attributes, 32 classes need to be evaluated simultaneously. However, given our sample size, one might end up with too few individuals in each class. To make sure we would consider all the 2^k combinations while having reliable results with this limited sample, we used the simple step-wise approach proposed by Lagarde (2013). Having identified all 32 possible ANA patterns in the present experiment, the first model (ANA-1) included six classes: one class in which all attributes are considered (class 1), and five others in which only one attribute at a time can be ignored (classes 2–5). To focus only on ANA patterns and not on other forms of heterogeneity, all parameters are constrained to be equal to each other across all classes. Based on the results of this first ANA-1 model, a second LCM is estimated, which includes only those classes from the first model that had a class probability that was significantly different from zero and additional classes with ANA patterns corresponding to two nonattended attributes at the same time (ANA-2 model). The same procedure is used to iteratively introduce the strategies in which respondents ignore three, then four, and finally five attributes at the same time. Overall, five successive latent class models were estimated to test the simultaneous use of nonattendance strategies by respondents. This stepwise strategy relies on the assumption that if a simple response pattern is found to be irrelevant at an early stage, it will continue to be irrelevant if we introduce more complex strategies in subsequent models (Lagarde, 2013). Based on this final ANA model, we estimated an additional ANA-5-SE model in which additional observable socioeconomic characteristics of the respondents were added to Eq. (2) of the model to establish possible associations between ANA classes and socioeconomic characteristics of the respondents.

Models were estimated using Latent Gold Choice version 5.0 (Vermunt and Magidson, 2005). To minimize the possibility of finding only local maxima, we employed 150 random starting values, and the starting values associated with the maximizers that gave the highest log-likelihood were retained to replicate the final solutions. To evaluate the possible improvements between the models, we relied on the Bayesian information criteria ($BIC = -2LL + \log N \times npar$, where LL is the log-likelihood of the model, *npar* is the number of parameters to be estimated, and *N* is the number of cases).

Table 2
Policy scenario hypotheses

	Current	Agric. intens. only	Env. + lifestyle
Yield (T/ha/year)	2.25	4	2.5
Drought mitigation (% of droughts not mitigated)	99	90	90
Env-M (0/1)	1	0	0
Env-H (0/1)	0	0	1
Rural lifestyles–rice landscapes (0/1)	0	0	1
Status Quo	1	0	0

Using the coefficient estimates obtained in a standard multinomial logit model (MNL) and the final ANA model, we computed the willingness-to-pay (WTP) for different services provided by irrigated rice agriculture as the ratio of the marginal utility for one attribute (i.e., the coefficients estimated by the model) and the marginal utility for money (i.e., the coefficients estimated for the payment attribute).

We also calculated the proportion of respondents who would favor the implementation of contrasted policies aiming at improving the nonmarket functions provided by irrigated agriculture using results from the MNL and the ANA-final models. To do so, we calculated the probabilities of moving from a baseline situation (low yields, high susceptibility to drought events, medium environmental impact, and degrading RL-RL) to two policies contrasted by the emphasis they give on the different services provided.

The first policy ("agriculture intensification only") would concentrate on increasing yields but would have a negative impact on the environment and not help maintain RL-RL. The second policy ("environment + landscapes") would enhance environmental protection and maintain RL-RL.

Payment required under the two policy scenarios varied from $U.S. 1 to $U.S. 200/year/household. All scenarios would include an increased capacity of respondents to mitigate drought effects by 10%. The values used for the two scenarios are presented in Table 2.

The probabilities of willing to vote for the policy scenarios were calculated with the estimated utility functions of the MNL and ANA-5 models. For the latter, we compared two calculation methods for the probability of adoption. First, we calculated a weighted sum of the class probability of adopting. The weights were the class probabilities, but we excluded from this calculation the classes that did not attend the payment attribute and recalculated the probability of the remaining classes so they sum to one. ANA for other attributes only mean nonresponsiveness to the scenarios proposing these attributes, thus other ANA classes were kept in the analysis. Second, we considered only the population attending all attributes as our valid base for probability calculations with a weight of one. For all cases, the WTP for the scenarios were calculated as the area under the different probability curves.

Table 3
Provincial statistics and sample characteristics

Characteristics		Sample percentage	NR province percentage
Place of residence	Rural	53.8	75.4
	Urban	46.2	24.6
Gender	Male	45.9	49.4
	Female	54.1	50.5
Age	20–35	37.7	35.5
	36–50	46. 9	37.2
	>50	15.4	27.3

3. Results and discussion

3.1. Sample characteristics

The sample characteristics are presented in Table 3. It shows that the sample was able to reproduce the provincial population structure in terms of age and gender proportions. However, the rural to urban ratio was deliberately not respected to sample a larger diversity in urban respondents. We introduced corrective sampling weights in the model. When the sampling weights are specified, Latent GOLD Choice estimates the model parameters by means of pseudo-ML estimation (further details can be found in Vermunt and Magidson, 2005). Some respondents were considered protesters when they chose to keep the status quo option for all choices and justified their choice by one of the following statements: (a) "government should take all responsibility for this investment," (b) "policies are unlikely to happen," (c) "direct beneficiaries should pay," or (d) "I do not want to pay for any proposed plan." Those respondents choosing SQ but not mentioning one of those four reasons were kept in the analysis. Sixty-five respondents (21%) were identified as protesters, thus leaving an effective sample of 240 respondents for subsequent analysis.

3.2. ANA patterns and their relationship to socioeconomic characteristics

Table 4 describes the ANA strategies tested in each model, as well as the proportion of respondents who subscribed to each of them. The results of the final model ANA-5 suggest that the respondents used only 6 of the 32 possible response patterns.

ANA-5 model results suggest that two broad types of attribute processing strategies have been used by respondents. Forty-five percent of the respondents considered all of the attributes. This percentage is higher than the one obtained by comparable studies in environmental economics looking at ANA using INA. For example, Campbell et al. (2011) found that only 9% of their sample considered all attributes and that 61% did not attend the cost attribute. However, these authors used an ANA specification in which only one attribute could be ignored at a time. In fact, our ANA-1 model, equivalent to the model of Campbell et al. (2011), finds that only 10% of the respondents fully attend attributes and that 56% do not attend the payment attribute, both results being close to the ANA incidence found in Campbell et al. (2011). This suggests that limiting ANA to one attribute potentially affects the conclusions we may draw about the incidence of ANA.

Other respondents (55% of the sample) ignored three attributes out of five and analyzed the tradeoffs between two attributes only. The most common tradeoffs were made between payment and drought mitigation (20% of the sample) and drought and environment (13% of the sample). Other equally important strategies compared yield and RL-RL (9%), price and yield (7%), and price and environment (6%). This result suggests that many respondents made their decisions based on very little information, a result similar to those of Lagarde (2013). Overall, the important share of respondents having ignored three attributes or more highlights the importance of using a procedure to estimate the presence of processing strategies where many attributes are not attended at the same time.

After summing up the probabilities of the latent classes obtained for the ANA-5 model where each of the attributes was ignored alone or in combination,[1] the results indicate that the RL-RL was ignored by 46% of the respondents, yield improvement by 39%, environment by 37%, drought mitigation by 22%, and finally the payment attribute by 21%. These results are in sharp contrast with the ANA-1 model results that suggested that 56% of the respondents ignored the payment attribute and 14% ignored the RL-RL attribute and the environment attributes. Again, considering that several attributes may be ignored at the same time has important consequences on our estimation of the presence of the different processing strategies.

We ran an additional model using the final ANA model in which we added socioeconomic covariates potentially related to the probability of belonging to one of the seven classes detected in ANA-5. Practically, this is done by adding socioeconomic variables to the vector Z of Eq. (2). The introduction of these variables did not affect the marginal utility coefficients (hence, the results are not presented here) but allowed us to identify significant influences of socioeconomic characteristics of respondents on the probabilities of belonging to one of the six ANA classes. The estimated parameters of the probability submodel of this last model are presented in Table 5. The parameters cannot be interpreted directly but give an indication of the probability of belonging to one class: a higher value than the average will result in a higher probability of belonging to that class.

The class of respondents who attended all attributes in ANA-5 contained a higher proportion of urban young males with a higher level of education. Two reasons may explain this association: (a) respondents were more able to handle the information that was provided to them due to differences in formal education that helped respondents of this group make abstract decisions or (b) they were more interested in the scenarios and

[1] By doing so, we may count classes several times, so the sum of the percentages obtained will be more than 100%.

Table 4
Detailed ANA patterns and average class membership probabilities

Pattern no	Attributes attended†,‡					Model names					
	P	Y	D	E	L	ANA-1	ANA-2	ANA-3	ANA-4	ANA-5	ANA-5 final
1	1	1	1	1	1	9.6%	20.8%**	35.7%***	41.5%***	42.7%***	44.9%***
2	0	1	1	1	1	56.4%***	13.9%	–	–	–	–
3	1	0	1	1	1	0.8%	–	–	–	–	0.0%
4	1	1	0	1	1	5.3%**	0.1%	–	–	–	–
5	1	1	1	0	1	14.0%*	5.4%	4.3%*	3.5%	–	–
6	1	1	1	1	0	13.9%	0.8%	–	–	–	–
7	0	0	1	1	1		1.6%	–	–	–	–
8	0	1	0	1	1		8.8%	–	–	–	–
9	0	1	1	0	1		7.9%	–	–	–	–
10	0	1	1	1	0		12.4%	–	–	–	–
11	1	0	0	1	1		0.1%	–	–	–	–
12	1	0	1	0	1		0.3%	–	–	–	–
13	1	0	1	1	0		3.8%	–	–	–	–
14	1	1	0	0	1		0.7%	–	–	–	–
15	1	1	0	1	0		5.8%*	2.9%	–	–	–
16	1	1	1	0	0		17.8%***	0.5%	–	–	–
17	0	0	0	1	1			7.5%	–	–	–
18	0	0	1	0	1			0.4%	–	–	–
19	0	0	1	1	0			11.8%**	12.3%**	12.6%**	12.3%*
20	0	1	0	0	1			3.7%	4.5%	7.1%*	8.9%**
21	0	1	0	1	0			0.2%	–	–	–
22	0	1	1	0	0			7.7%*	5.8%	0.0%	–
23	1	0	0	0	1			0.1%*	–	–	–
24	1	0	0	1	0			4.2%*	4.8%*	5.3%*	6.1%**
25	1	0	1	0	0			16.2%***	17.3%***	16.8%***	20.6%***
26	1	1	0	0	0			4.7%	6.9%*	6.5%*	7.2%*
27	1	0	0	0	0				0.2%	–	–
28	0	1	0	0	0				2.0%	–	–
29	0	0	1	0	0				0.2%	–	–
30	0	0	0	1	0				0.2%	–	–
31	0	0	0	0	1				0.7%	–	–
32	0	0	0	0	0					9.2%	–

†A value of 1 in a cell means the attribute was supposed attended for this ANA pattern, and 0 otherwise.
‡Attribute codes: P, payment; Y, yield; D, drought mitigation; E, environment; L, rural lifestyle and rice landscapes.
*, **, *** Denote significance at 5%, 1%, and 0.1% levels, respectively.

Table 5
Estimates of the likelihood of the probability submodel (ANA-5-final with socioeconomic variables)

	Cl 19	Cl 20	Cl 24	Cl 25	Cl 26
	θ_c	θ_c	θ_c	θ_c	θ_c
Intercept	−12.75***	−54.23***	−5.23	1.00	−30.33***
Age	0.15*	0.88***	0.08	−0.02	0.62***
Urban	−21.75**	−8.62*	−1.01	−0.09	−12.06***
Educ—M	−32.77***	−3.02	1.28	−1.24	−13.56**
Educ—H	−5.50*	−2.51	0.47	−0.89	−3.21*
Female	4.29***	4.58***	0.12	0.69	2.31
Income—LM	10.71***	7.93**	1.22	0.64	−0.01
Income—M	35.45***	25.66***	−1.34	2.03*	19.38***
Income—H	34.44***	15.19***	2.73	0.76	1.07
Occup—Business	−24.36***	5.74*	−2.66	−2.25*	4.36*
Occup—govt. officer	−25.20***	−5.76	−6.46**	−1.47	−10.61*
Occup—employees	−24.46***	−6.06*	−0.84	−1.40	−12.14**
Occup—others	6.90**	10.97***	6.53***	−0.89	5.95*

Notes: The coefficients of the class 1 (all attributes attended) are arbitrarily set to 0 (see Eq. (2)).
Cl19: only drought and environment attended; Cl 20: only yield and RL-RL attended; Cl 24: only payment and environment attended; Cl 25: only payment and drought attended; Cl26: only payment and yield attended.
*, **, *** Denote significance at the 5%, 1%, and 0.1% levels, respectively.

Table 6
Estimates and model fit for the MNL, ANA-1, and ANA-5 models

Attribute†	MNL		ANA-1		ANA-5-final	
	β	SE	β	SE	β	SE
Pay	-0.02^{***}	0.00	-0.14^{***}	0.01	-0.11^{***}	0.01
Yield	0.24^{***}	0.05	0.11^{**}	0.04	0.39^{***}	0.06
Drought mitigation	-0.03^{***}	0.00	-0.41^{***}	0.06	-0.54^{***}	0.05
Env-M	1.18^{***}	0.13	1.54^{***}	0.23	2.18^{***}	0.26
Env-H	1.49^{***}	0.14	1.91^{***}	0.21	3.01^{***}	0.24
RL-RL	1.10^{***}	0.13	1.29^{***}	0.18	2.75^{***}	0.27
ASC	-0.95^{***}	0.23	-1.18^{***}	0.28	-1.03^{***}	0.25
Log likelihood	−1128.9		−993.3		−971.6	
pseudo-R^2	0.081		0.191		0.209	
Percent correctly predicted (%)	60.4		76.9		79.2	
BIC	2296.1		2052.4		2009.0	

†Env-M, water quality and environment at a medium level; Env-H, water quality and environment at a high level; RL-RL, rural lifestyles and rice landscapes are maintained.
*, **, *** Denote significance at the 5%, 1%, and 0.1% levels, respectively.

attributes, as they corresponded to real challenges for young urbanites. Then, three classes of respondents only considered the tradeoff between payment and another attribute. These classes contained higher proportions of lower income respondents, a fact that could explain their focus on the payment attribute. The respondents considering the payment–environment tradeoffs were younger and more likely to live in urban areas. Those considering payment–yield tradeoffs were more likely to either be farmers or living in rural areas; they were also older and less educated. Finally, the remaining two classes did not attend the payment attribute. Respondents belonging to these classes had a higher level of income and a higher proportion of women. One class considered only the tradeoffs between drought and the environment. The second class considered only the yield–RL-RL tradeoff. Small business owners were more likely to be in that class.

Overall, these results suggest that the socioeconomic characteristics influenced which attributes were ignored: respondents with lower income less often ignored the payment attribute, while younger and more educated respondents tended to address more attributes. This suggests that further improvements in the design of our DCE may be possible.[2] As suggested by Hensher et al. (2012): "the range and levels of specific attributes might be such that some respondents do not see merit in some of the levels (. . .) being traded, with one or both attributes having levels that do not matter"; thus a more careful assessment of respondent-specific attribute ranges would be needed in the design of future choice experiments.

Alternatively, we may have introduced some bias by considering heterogeneity only in terms of attribute processing because the models hold all parameters not constrained to zero to be equal across the classes. This might lead to an overestimation of the presence of ANA (Hess et al., 2013). The modeling frameworks developed by Thiene et al. (2015) that considered several sources of heterogeneity could be adapted with the iterative procedure developed in this article to see whether such bias exists for our case study. However, developing a latent class approach with both preference and ANA heterogeneity would imply that up to 96 classes being potentially tested simultaneously (if three preference classes are considered). Thiene et al. (2015) solved this problem by reducing the number of ANA combinations on a reasoned *ad hoc* basis. As a further research, we would adapt this iterative procedure to reduce the number of classes to be simultaneously estimated. However, even with this iterative approach, it may be necessary to have a larger sample size. In the meantime, our empirical results should be interpreted with caution. Finally, another point of view would be to conclude that different types of populations would have different processing strategies that are not compatible with the RU framework. A possible extension of this work would be to develop a latent class model, where individual classes make use of different underlying paradigms, RUM models, random regret minimization models (Chorus, 2012), and elimination by aspects models (Tversky, 1972) as suggested by Hess et al. (2012) and Chorus et al. (2013).

3.3. *Impact of ANA on model estimates and WTP*

Table 6 reports the model fit statistics and coefficients estimated for the standard MNL, the ANA-1, and the ANA-5-final models. In terms of model fit, the ANA model shows a significant improvement compared to the standard model, with a higher McFadden's pseudo-R^2, a lower BIC, and a higher percentage of correctly predicted choices. Similar conclusions were found in Scarpa et al. (2009) and Campbell et al. (2011), especially when all of the possible ANA strategies are accounted for, as in Lagarde (2013).

[2] As rightly pointed out by one anonymous referee, despite all the precautions taken during the survey, we cannot discard the possibility of un-noticed misunderstanding by some respondents, or involuntary bias introduced by the interviewers when describing or citing the attributes leading to ANA for some of them. However, as only one person conducted the interviews, we were unable to check the presence of such interviewer's bias.

Table 7
WTP estimates

	MNL	SE	ANA-1	SE	ANA-5-final	
	WTP		WTP		WTP	SE
Yield	11.16***	1.93	0.77**	0.26	3.50***	0.44
Drought mitigation	1.28***	0.19	2.94***	0.45	4.80***	0.52
Env-M	56.00***	7.52	11.22***	1.87	19.42***	3.25
Env-H	70.50***	7.49	13.85***	1.79	26.85***	3.30
RL-RL	52.27***	5.20	9.40***	1.60	24.59***	2.44
ASC	−45.17***	11.84	− 8.56***	2.06	−9.22***	2.25

Note: Env-M, water quality and environment at a medium level; Env-H, water quality and environment at a high level; RL-RL, rural lifestyle and rice landscapes are maintained.
*, **, *** Denote significance at the 5%, 1%, and 0.1% levels, respectively.

The three models gave similar results in terms of the sign and significance of the coefficients. All coefficients were highly significant and of the expected signs: the marginal utility of increased payment and the increased occurrence of drought that cannot be mitigated were negative, and the marginal utility of increased yields, increased environmental indicators, and of maintenance of rural lifestyles and rice landscapes were positive.

The WTP estimates obtained for the five attributes by dividing their parameters by the payment parameter are reported in Table 7 for the three models. They are expressed in $U.S./household/year per unit of change for the different attributes. The standard errors of the WTP coefficients were obtained using the delta method. The environmental attribute was treated as two dummy variables, and two WTP coefficients were calculated according to the two environmental levels that were presented to the respondents, that is, the WTP coefficients represent the WTP to go from ENV0 to ENV1 state, and the WTP to go from ENV0 to ENV2 state, respectively.

The calculated WTP for yield, environment, and RL-RL was lowest under ANA-1 and highest under MNL. In contrast, the WTP for drought mitigation was highest under ANA-5 and lowest under MNL. In both cases, the WTP obtained from the ANA-5-final model gave some intermediate results for most attributes. As this is the preferred model in terms of the BIC and pseudo-R^2, we will comment on the WTP obtained from that model.

The WTP for Yield was 3.5 $U.S./ton of additional yield. This is very small when compared with current farm-gate prices (180–300 $U.S./ton). Because the yield attribute was considered by many respondents as a private good resulting in either very low additional WTP (in fact, the WTP for the economic boost provided to the region) or nonattendance, a part of the sample likely considered it unnecessary to spend their funds on this attribute. This is similar to findings that respondents in Australia did not exhibit any significant WTP for income from irrigated agriculture but were more inclined to pay for recreational fishing quality (Zander and Straton, 2010). The WTP for drought mitigation of 4.8 $U.S./year/household to reduce the potential risk linked to drought by 1% was noted. The WTPs were 20–25 $U.S./year/household for "environmental quality" and 25 $U.S./household/year for RL-RL. This suggests that some part of the population is paying attention to the environmental and social issues related to agriculture and attached some value to them. This is consistent with the results obtained regarding agricultural functions in other more developed countries (Campbell, 2007; Kallas et al., 2007). This is also reinforced by the idea that 63% of the respondents attended the environmental attribute and compared it with at least another attribute and that 54% of the respondents attended the RL-RL attribute. Symmetrically, the presence of substantial nonattendance also suggests, if we consider that zero attendance means disinterest in the attribute, that there is important heterogeneity in the preferences toward these parameters.

3.4. Probabilities to pay for new policy scenarios

The probabilities of willing to vote for the two contrasted scenarios are shown in Fig. 2. For the upper-panel, all the classes that attended the payment attribute were considered for calculating the weighted probabilities (79% of the sample). For the lower panel, only the full attendance class was considered (45% of the sample).

On the one hand, the two types of models, and the two modes of probability calculations suggest the same ranking of policies. Therefore, not taking into account ANA would not significantly alter the likely policy recommendation. In both cases, the WTP of the population is higher for scenarios that improve the environment and preserve RL-RL. Both models also capture the fact that the WTP for policies that concentrate on agricultural intensification alone is lower than for the other scenario. This is understandable, as this first policy can be seen as only benefitting farming households. In addition, the respondents probably felt that farmers could benefit directly from higher sales without having to get extra support from society.

On the other hand, the two types of models provide different probability patterns as a function of payments. First, when the ANA-5 model is used, the probabilities of accepting the policy scenario are usually lower than when the MNL model is used. The scenario "agriculture Intensification only," when the payment is lower than 50 $U.S./household/year, is the only exception. Second, for all of the scenarios, the probabilities of accepting the policy scenarios decline rapidly after 50 $U.S./household/year when using the hypothesis of the ANA-5 model, while they decline smoothly when using the hypothesis of the MNL model. As a result, the WTP for all scenarios was lower when using the ANA-5 model instead of the MNL model. The results are more in line with the doubts raised by focus group participants that individuals would not be willing to pay more than 50–80 $U.S. per year for projects supporting agriculture.

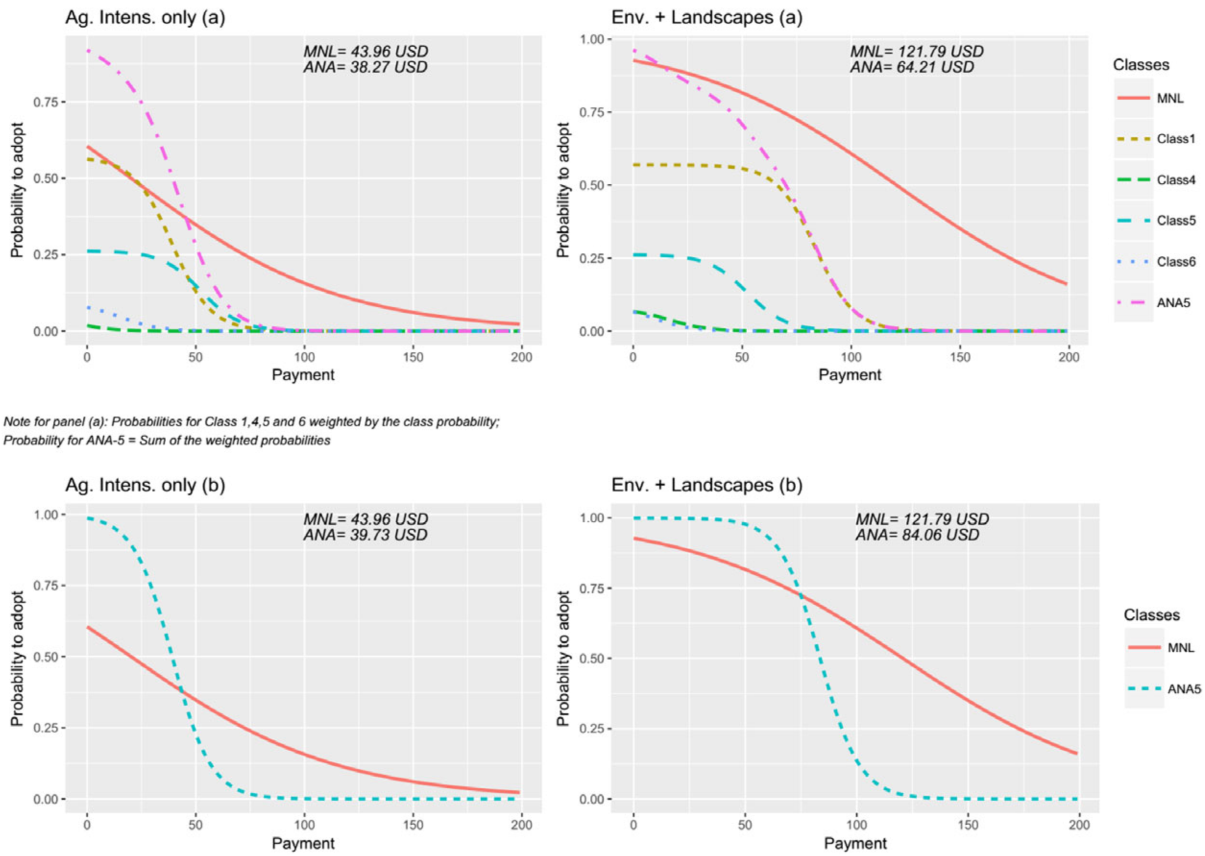

Fig. 2. Predicted probabilities of willingness to participate to the two contrasted scenarios. [Color figure can be viewed at wileyonlinelibrary.com]

For the ANA-5 model, calculated WTP were lower when using weighted probabilities instead of using only the full attendance class. These WTP were obtained after discarding 21% (panel a) or 55% (panel b) of the sample and adjusting the probabilities of the remaining classes. Members of the discarded classes of panel (a) were not responsive to price, so we could not conclude on their potential behavior. Our hypothesis is that if we had identified a low marginal utility of income instead of nonattendance for these respondents, the overall WTP found would likely to be higher.

Overall, the results suggest that the ranking of the projects would not change under the different mode of calculations. However, the WTPs for the projects are likely to be overestimated when using MNL and underestimated with the proposed calculations.

4. Conclusions

This article developed a DCE to elicit the WTP for the ES provided by irrigated rice agriculture in Thailand. We found that the respondents, on average, were willing to pay for the nonmarket functions of irrigated agriculture such as drought mitigation, water quality improvement, and maintenance of the rural lifestyle and rice landscapes.

This potentially provides a rationale for orienting irrigated rice agriculture toward a greater provision of these services. Currently, the government subsidizes crop prices and provides water for free. However, societal demand requires additional specific functions from irrigated rice agriculture, especially regarding water quality and rural quality of life. As such, support for irrigated rice agriculture would respond better to society's demand if it was not only aimed at increasing rice production and income but also at ensuring that these ES are preserved. Therefore, support for irrigated agriculture would be more efficient if it were channeled to those farmers willing to provide these services.

The article also showed the importance of considering the possibility of ANA when modeling the choices of DCE respondents. The results suggest that many respondents are likely to make their decision based on a limited set of attributes. While the identification of ANA led to different conclusions in terms of overall WTP for the scenarios, it did not change the rankings of the different policy scenarios. Finally, we found that the introduction of ANA gave results that were more in line with the expectations of the working groups in terms of the overall WTP of such policies.

These findings suggest two complementary areas for further research. First, it would be necessary to analyze whether the results found using INA are not overstating ANA because the INA models used are not separating respondents who did not attend the attributes from those respondents who had a low marginal utility for the same attributes. Modeling frameworks developed by Hess et al. (2013) or Thiene et al. (2015) suggest that the combination of preference and ANA heterogeneity could lower the probability of confounding the two. Their approach could be adapted using this iterative approach to investigate the possible biases we may have introduced by considering ANA only. Alternatively, modeling tools that could accommodate different processing strategies, such as elimination by aspects, could also be tested (e.g., Erdem et al., 2014). Second, ANA patterns were correlated with some sociodemographic variables, and further research should pay more attention to the range of relevance of the proposed attributes to different segments of the population (rural vs. urban, young vs. old, etc.). This can take two directions: create subdesigns for pre-established segments or leave the possibility for some dynamic adjustment built into the experiment at the time of the interview.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix.