THE VALUE OF POLICIES TO CONSERVE NATIVE BEES IN NORTHERN THAILAND – A DISCRETE CHOICE EXPERIMENT

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Abstract

This article is an attempt to estimate the economic value of policies aimed at conserving native bees (and their pollination services) in Northern Thailand, by means of a discrete choice experiment. The preferences of 198 longan (*Dimocarpus longan*) farmers for three conservation strategies in particular, namely "bee-friendly pest management", "improving native bee habitats within agro-forest ecosystems" and "fostering the husbandry of native bee species", were analyzed. Thereby, the part-worth utilities of these strategies and of their potential effects on the population of native bees were estimated with conditional logit and random parameter logit models. Furthermore, the contribution of a "cost" attribute to the explanation of the utility associated with the choice alternatives allowed the calculation of willingness to pay estimates for the individual conservation strategies and for changes in the population of native bees. As a result, a positive contribution of the proposed conservation measures to the utility derived from the choice alternatives containing them could be established. Similarly, positive changes in the population of native bees also increased the chances of related conservation policy profiles being chosen. It can be concluded that the population of longan farmers is generally willing to pay for the conservation of native bees in their region, although explaining their preference heterogeneity for the proposed conservation measures will require further analyses.

Keywords

Native Bee Conservation, Crop Pollination, Northern Thailand, Discrete Choice Experiment, Conditional Logit, Random Parameter Logit.

1 Introduction

"Pollination is a keystone process in both human-managed and natural terrestrial ecosystems. It is critical for food production and human livelihoods, and directly links wild ecosystems with agricultural production systems" (FAO, 2008). Crop Pollination is an ecosystem service in that wild pollinators, particularly wild bees, supply a valuable input to agricultural production. It may also be considered a farm management tool when domesticated bees are kept, purchased or rented by farmers in many countries to either supplement the local pollinator fauna or to restore the decline of its services (RICHARDS, 1993; HEARD, 1999; RICKETTS et al., 2008; GALLAI et al., 2009).

The international community is showing increasing concerns regarding the continued decline of both wild and managed pollinator populations worldwide (DIAS et al., 1999; RICKETTS, et al., 2004; MILLENNIUM ECOSYSTEM ASSESMENT, 2005; STEFFAN-DEWENTER, et al., 2005; KLUSER & PEDUZZI, 2007; FAO, 2008; GALLAI et al., 2009; POTTS et al., 2010). Declines of pollinators have been reported in every continent, in at least one region/country (FAO, 2008), pointing at substantial evidence that seems to corroborate a (previously questioned) global pollination crisis (GHAZOUL, 2005; STEFFAN-DEWENTER et al., 2005; POTTS et al., 2010). Agricultural intensification has been recognized as the main driver for the decline of wild bee populations, especially due to the inappropriate use of pesticides and herbicides and for reducing natural habitats through land-use change (KREMEN et al., 2002; POTTS et al., 2010).

Northern Thailand is rapidly orienting its agriculture to the production of high-value crops under intensive systems that are often characterized by the overuse of synthetic pesticides

(SCHREINEMACHERS et al., 2011), at risk of reproducing the case of other regions in the world, where intensive agriculture has driven pollinator populations to important declines (BIESMEIJER et al., 2006; NATIONAL RESEARCH COUNCIL, 2007; POTTS et al., 2010). Thailand has also responded to the continuously growing demand for longan (*Dimocarpus longan* L.), a fruit obtained from an insect-pollination dependent crop, by dramatically expanding its cultivated area and its yields, i.e. from 12,094 ha (corresponding to 45,756 tons per annum) in 1983 to 168,517 ha (i.e. 976,729 tons per annum) in 2014 (ANUPUNT & SUKHIVIBUL, 2005; THAI OFFICE OF AGRICULTURAL ECONOMICS, 2014). Currently, ~82% of that land is cultivated in Northern Thailand (~30% thereof in Chiang Mai province), rendering this region the leading exporter of longan worldwide and its economy highly dependent on this crop (ANUPUNT & SUKHIVIBUL, 2005; MENZEL & WAITE, 2005; BLANCHE et al., 2006; THAI OFFICE OF AGRICULTURAL ECONOMICS, 2014).

Northern Thailand could thus benefit from a policy directed at conserving native pollinating bees that takes into account the perceptions of longan farmers, with regards to the costs and benefits of its implementation vis-à-vis the potential yield losses that could arise in the event of an important decline of pollination services. Among the recommendations of the Plan of Action of the International Pollinator Initiative (IPI-POA) (WILLIAMS, 2003; BYRNE & FITZPATRICK, 2009; FAO, 2014), the authors of this article recognize the following bee conservation strategies as those potentially having the greatest impact and implementation chances in Thailand's current agricultural and political context:

i) offering farmers bee-friendly alternatives to conventional pesticides such as biological control and integrated pest management,

ii) encouraging the protection and improvement of natural bee habitats within agro-forest ecosystems and

iii) fostering the husbandry of native bee species.

This article attempts to contribute to a more informed native bee conservation policy, by:

1. estimating the contribution of the above listed native bee conservation strategies to the probability of alternative policy bundles being prefered over the status quo and by
2. calculating the monetary value that longan farmers place on the implementation of the individual native bee conservation strategies and on changes in the population of native bees in their surrounding environement.

A Discrete Choice Experiment (DCE) was conducted with longan farmers of 10 villages in Chiang Mai Province, Northern Thailand, in order to obtain empirical data reflecting their choice behavior with regards to the native bee conservation strategies mentioned above. In a DCE, respondents state their preference for alternative choices, over a series of hypothetical choice situations, allowing for statistical inferences on the systematic component of the unobserved utility that they derive from such alternatives. In the case of the conditional logit model, the preference for the conservation policy attributes is assumed to be homogeneous in the population, while the random parameter logit model allows for taste heterogeneity over decision-makers (TRAIN, 2009) (see section 3.1). Provided that a cost (tax) attribute is specified in the utility function, the willingness to pay (WTP) of respondents for changes in the individual attributes can be elicited (BENNETT & ADAMOWICZ, 2001; CARLSSON & MARTINSSON, 2001; TRAIN & WEEKS, 2005; SILLANO & ORTÚZAR, 2005).

This paper is structured as follows: Section 2 gives a review on different approaches to estimate the economic value of pollination services. The theoretical and econometric framework underlying this study is described in Section 3. Section 4 presents the preliminary results for the analysis with the collected DCE data, which are finally discussed in Section 5.

2 The economic valuation of conserving native bees and their pollination services

In previous studies, the economic value of the contribution of pollinators to agricultural production has been estimated using a dependence ratio[1] that accounts for the partial production loss of specific crops, attributed to the complete absence of pollinators (MORSE & CALDERONE, 2000; LOSEY & VAUGHAN, 2006; GALLAI et al., 2009). GALLAI et al. (2009) for instance estimated the total economic value of pollination services worldwide at €153 billion. Building upon this approach and having estimated the demand functions of a variety of insect-pollination dependent crops, the potential social welfare losses from increases of food prices that would result from the effect of insect pollination shortages on crop yields can be considered (KEVAN & PHILLIPS, 2001). Accordingly, SOUTHWICK & SOUTHWICK JR. (1992) estimated the annual value of crop pollination by managed honeybees (*Apis mellifera* L.) in the USA to range between USD1.6 and USD5.7 billion. In their study, GALLAI et al. (2009) also used this approach, further assuming a constant price elasticity of demand, to estimate consumer surplus losses worldwide ranging between €190 and €310 billion.

Pollination experiments along replicated distance gradients have also been used to estimate the economic value of tropical forest patches that, serving as nesting sites for bees, contribute to the pollination of crops, such as coffee (*Coffea arabica* L. and *Coffea robusta* P.) (RICKETTS, 2004; RICKETTS et al., 2004; OLSCHEWSKI et al., 2006). Other studies have measured the economic value of pollination services by directly observing the market prices of existing commercial pollination services that are contracted by farmers to substitute their failing ecosystem service counterpart, such as it occurs in the almond groves of California, USA (RUCKER et al., 2012). Another approach consists in calculating the cost of potentially having to replace pollination services with labor or capital (e.g., hand pollination, or pollen dusting, respectively), such as to maintain crop production at the same levels that are attained with pollination services from a healthy natural ecosystem (ALLSOPP et al., 2008).

DCEs have been deemed not suitable for the estimation of the economic value of pollination services, with the valid argument that stated preference methods require respondents to possess a sound knowledge of the quantitative contribution that pollination delivers to their agricultural production (MBURU et al., 2006). The authors of this article do not dispute such argument. However, similar to the study regarding wild geese conservation by HANLEY et al. (2003), the authors propose approaching the economic valuation of pollination services from a perspective of public demand for policies aiming at conserving the native bees that deliver this ecosystem service in agro-forest landscapes. The trade-offs that are stimulated in a DCE can capture the economic value of *measures* to conserve native bees, and by extension the option value of preserving their pollination services, disregarding the awareness that respondents may or may not have about how much pollinating bees contribute to the production of their crops.

3 Discrete Choice Experiment

3.1 Economic theory of discrete choice modelling

According to random utility theory (THURSTONE, 1927; MARSCHAK, 1960), human choice can be explained by the utility maximizing behavior of individuals when they are confronted with paired or multiple comparisons of discrete choice alternatives. Each alternative potentially yields a certain level of utility that is known to the decision-maker, but unknown to the

[1] The economic value of insect pollination (IPEV) for all world regions X can be calculated as follows:
$IPEV = \sum_{i=1}^{I} \sum_{x=1}^{X} P_{ix} \times Q_{ix} \times D_i$, where P_{ix} is the per unit price of crop i in region x, Q_{ix} its locally produced quantity and D_i its corresponding ratio of dependence on insect pollination. In their study, GALLAI et al. (2009) calculate D_i as the mean value of pollination reduction in the absence of insect pollinators for 100 crops that finally fall into 5 categories of insect-pollination dependence: essential (95%), high (65%), modest (25%), little (5%) and no decrease (0%), as published by KLEIN et al. (2007).

researcher. From the researcher's perspective, the utility that an individual i derives from a choice alternative j $(U_{ij}, j = 1, \dots, J)$ can be decomposed into a systematic (explainable) component (V) and a stochastic (unexplainable) component (ε) that represents unobservable influences on the decision-maker's choice. This can be formalized as follows:

$$U_{ij} = V_{ij}(X_j) + \varepsilon_{ij} = \beta' X_j + \varepsilon_{ij} \, , \tag{1}$$

where X_j is a vector of observed variables that relate to the choice alternative. The decision-maker chooses from a given choice set the alternative h that maximizes her utility, strictly holding that the utility associated with alternative h is superior to that of any other alternative j. The probability P_{ih} of this choice outcome can be expressed as follows:

$$P_{ih} = P[(U_{ih} > U_{ij}) \ \forall j \neq h] = P[(V_{ih} - V_{ij}) > (\varepsilon_{ij} - \varepsilon_{ih})] \tag{2}$$

Assuming independent and identically distributed (extreme value distribution type I) error terms ε_{ij}, the choice probabilities can be expressed in terms of the logistic distribution (TRAIN, 2009):

$$P_{ih} = \frac{\exp(\beta' X_h)}{\sum_{j=1}^{J} \exp(\beta' X_j)} \tag{3}$$

This general model is known as the conditional logit (CL) and its parameters β can be estimated by means of standard maximum likelihood procedures (HOFFMAN & DUNCAN, 1988; RODRÍGUEZ, 2007). Under this model specification, the taste coefficients β are assumed to be homogenous over the population (i.e. the standard deviation about the mean of a taste parameter is equal to zero). A more flexible model extension, which is not based on the assumption of independence of irrelevant alternatives and allows for random taste variation, is the mixed (random parameter) logit model (ML). Taste variation is accounted for by coefficients β_i varying over decision-makers i in the population, with density $f(\beta|\theta)$, as specified in equation (4):

$$U_{ij} = \beta_i' X_j + \varepsilon_{ij} \qquad \beta_i \sim f(\theta) \, , \tag{4}$$

where θ refers to the distribution moments (e.g., the mean and covariance of the β's in the population). As the researcher does not know β_i, the (unconditional) choice probability can be expressed in an open-form integral over all possible parameters β_i, as shown in equation (5):

$$P_{ih} = \int_{\beta_i} L_{ih}(\beta_i) f(\beta_i|\theta) d\beta_i \, , \tag{5}$$

where $L_{ih}(\beta_i)$ is the standard logit probability. The parameters of the distribution assumed by the researcher (in this study a normal distribution) are optimized via repeated computational simulations of P_{ih}, for different values of θ, applying the maximum likelihood approach (TRAIN, 2009; HENSHER & GREENE, 2002; HENSHER et al., 2005). A decision on which parameters will be set to be random has to be made by the researcher. Furthermore, it is recommended to hold at least one of the coefficients fixed, especially if the goal of the analysis is to determine substitution patterns (TRAIN, 2009; HENSHER et al., 2005).

A measure of WTP can be derived by calculating the marginal rate of substitution between a given attribute and the cost attribute (TRAIN, 2009). This is equivalent to the ratio of the estimated coefficient of the attribute of interest to the estimated cost coefficient, as given by:

$$WTP = -\frac{\beta_k}{\beta_c} \tag{6}$$

where β_k refers to the parameter of interest and β_c to the cost parameter.

3.2 Hypotheses underlying this study and experimental design

Against this background, the authors aim at establishing a relationship between the choices made by longan farmers, regarding alternative policy profiles for the conservation of native bees, and the conservation measures that constitute them. Accordingly, the alternative hypotheses stated in this study are:

Hypothesis 1: The presence of each of the three proposed bee conservation strategies has a positive contribution, ceteris paribus (c.p.), to the utility derived from the conservation policy alternatives that contain them, thus increasing their chances of being chosen.

Hypothesis 2: An increase in the population of native bees increases c.p. the probability that a policy presenting this attribute level will be chosen. Conversely, a decline in the population of native bees will have a negative impact on the utility of the choice alternatives that are associated with this attribute level.

Hypothesis 3: The preference for the attributes that constitute the choice alternative profiles varies among the population of longan farmers. This heterogeneity should be reflected in parameter standard deviations that are significantly different from zero.

The choice attributes considered in this study were defined with the assistance of provincial officers from the Thai Ministry of Natural Resources and Environment and from the Department of Agricultural Extension, who helped identifying the IPI-POA recommended conservation measures that could be implemented under the local political infrastructure. Focus group discussions with local longan farmers additionally contributed to formulating and phrasing plausible attribute levels that could be easily comprehended by the DCE participants. Consequently, the attributes and levels presented in Table 1 were defined as measures that would hypothetically be implemented at the village level and take effect with the support of extension services. With the implementation of a “bee-friendly pest management” program, the farmers would get information on methods (e.g., integrated pest management and spraying during times with low bee activity levels) and products that offer an alternative to conventional agro-chemicals, reducing the risk of bee poisoning.

The “improving native bee habitats within agro-forest ecosystems” measure would consist of the provision of expertise and native tree seedlings to promote local reforestation and habitat management campaigns in public lands and near cropland, aiming at offering nesting sites and food sources for native bees.

Extension services would also transfer technical knowledge on how to build bee hives to keep native bee species such as the Asian honeybee (*Apis cerana* F.) and stingless bee spp. (HEARD, 1999; HEPBURN & RADLOFF, 2011), under the “fostering the husbandry of native bee species” measure. The cost attribute represents a one-time fee that the farming households would pay to the local authorities for the implementation of the chosen policies.

The full factorial design yields a total of 72 ($2^3 \times 3^2$) possible combinatorial profiles of attribute levels[2]. These are too many choice alternatives to be evaluated by a single respondent and thus have no practical application in a field study. Therefore, an efficient subset of the full factorial design was generated using the Ngene 1.1.1 software. Efficient designs, in contrast to the traditionally preferred orthogonal designs, aim at data results that generate parameter estimates with as small as possible standard errors, as opposed to solely minimizing the correlation in the collected data. Efficiency is achieved by pivoting the design around prior parameter estimates that are generated using data obtained from a pilot study (ROSE et al., 2008; CHOICEMETRICS Ltd., 2012). The prior parameter estimates used to generate the design for this study were based on a pilot study that was conducted with 27 respondents. Table 1 also gives one example of the 12 choice sets that were generated.

[2] The zero implementation cost level was only present in the status-quo alternative, for which it does not contribute to the combination possibilities of the full factorial.

Table 1: All attribute levels (left from dotted line) and an example choice set (right)

All attribute levels [a]	Please choose the alternative giving you the greatest satisfaction:			
		Policy A	**Policy B**	**No Policy**
no, yes	Bee-friendly pest management	yes	no	no
no, yes	Native bee habitat improvement	no	yes	no
no, yes	On-farm native bee husbandry	no	yes	no
-50, 0, +50	Changes in native bee population (%)	+50%	0%	-50%
0, 250, 500, 750	Policy implementation costs (THB) [b]	500	500	0
	I choose:	**Policy A** ◯	**Policy B** ◯	**No Policy** ◯

[a] The levels marked in bold correspond to the status quo alternative.
[b] €1= 44.43 Thai baht (THB), as of February 19, 2014.
Source: Own representation and design using Ngene 1.1.1

At the beginning of each DCE, respondents were asked to imagine a hypothetical scenario under which a conservation plan was not instituted, therefore leading the population of native bees to a decline of 50%, as compared to the current population. This scenario represented the status-quo alternative, "No Policy", and it did not entail policy implementation costs. Alternatively, the respondents had the option to choose one of two generic (unlabeled) policies (i.e. Policy A or Policy B), containing *at least one* of the three proposed conservation measures, which if implemented could avoid a native bee population decline (0% change from the current population), or even increase it by 50%. Nevertheless, some of the policy implementation profiles also included the 50% native bee population decrease level. The implementation of a conservation policy was always bound to a single-payment implementation cost ranging between THB250 and THB750. Choice sets were randomized across questionnaires before administering them to the interviewees, in order to avoid biases from order effects.

In addition to the choice questions, the respondents were asked to provide information on their farm and socio-economic characteristics and on their attitude towards the proposed native bee conservation measures. Previous to each interview, the respondents were informed about the importance of bee-mediated pollination for the fruit-set of longan and about the current trends and consequences of pollinator declines worldwide. This supporting information was complemented with text and illustrations that, similar to the choice cards, were conveyed in colored cards.

3.3 Survey and sampling

The DCE survey was conducted in May-June 2013, in 10 villages of the districts of Chom Thong and Saraphi, which are located along the Upper Ping River Basin, in the lowlands of the Chiang Mai–Lamphun valley. These are the two districts in Chiang Mai Province with the greatest extension of land cultivated with longan. The villages were randomly selected with the sampling technique of probability proportional to size, using the villages' total longan acreage as the allocation criterion. Thereby, six villages were drawn from Chom Thong, while the other four were drawn from Saraphi.

A total of 208 longan farmers were interviewed, of which 198 understood and completed the choice exercise. The results presented in this article are based only on the data collected from the respondents that successfully completed the DCE. Each respondent faced twelve choices, resulting in 2,376 observations. Table 2 presents statistics that describe the sampled population with selected variables.

Table 2: Descriptive statistics of the sampled population

Descriptive statistics for selected variables	
Number of observations (N)	2,376
Average age (years)	56
Share of male participants (%)	59
Share of individuals self-employed in agriculture (%)	85
Share of individuals keeping bees (%)	18
Average Total cultivated acreage (ha)	1.2
Average longan cultivated acreage (ha)	1.0
Average gross annual income from longan (€)	2,055
Average net annual agricultural income (€)	1,723
Average net annual household income (€)	5,750
Share of individuals that reached highest education in primary school (%)	72
Share of choices in favor of implementing a bee conservation policy (%)	89

€1= THB 44.43 as of February 19, 2014
Source: Own calculations

4 Results

The three conservation strategy attributes of this study's choice experiment entered the estimated models as dummy variables that take the values zero, if absent, and one if implemented. On the other hand, the native bee population change variable takes one of three levels that were coded with the two dummies "50% population increase" and "50% population decrease". For the cost attribute a quantitative variable was assigned, which means that its corresponding coefficient tells how much a cost increase of one Thai baht changes the utility.

The data for the 2,376 choice observations resulting from the DCE were analyzed with the NLOGIT 5/LIMDEP 10 econometric software. Initially, a CL model was estimated, under which the assumption of a homogeneous taste for the alternative attributes, over the whole population of longan farmers, is imposed. The results show highly significant estimates for all attribute coefficients (Table 3).

Table 3: Results for a Conditional Logit model

Variable	Coefficient	*Wald* [a)]
Bee-friendly pest management	0.3512	3.58*
Improving native bee habitats within agro-forest ecosystems	0.4037	4.21**
Fostering the husbandry of native bee species	0.3091	4.44**
Changes in the population of native bees (versus 0% change)		
50% decrease	-2.5652	-20.48**
50% increase	1.3046	10.20**
Policy implementation costs (THB)	-0.0019	-11.34**
Log-Likelihood (LL)	-1800.539	
AIC/N [b)]	1.521	
McFadden pseudo *R*-squared [c)]	0.212	

[a)] Wald-statistic = $\hat{\beta}/\widehat{se}(\hat{\beta}) \sim N(0,1)$, with significance levels: * $p<.001$, ** $p<.0001$
[b)] AIC = Akaike information criterion
[c)] Based on the LL function from a model with choice probabilities set to each choice alternative's sample shares
Source: Own calculations using NLOGIT 5/LIMDEP 10

An alternative specific constant (ASC) that is common for the alternatives "Policy A" and "Policy B", and normalized to zero for the status-quo alternative, was initially incorporated to the CL model. The estimated coefficient for this ASC would represent possible preferences for a conservation intervention being implemented over a scenario with no intervention at all. Nevertheless, the estimated model yielded non-significant estimates for the ASC coefficients (10% significance level), for which it was re-estimated without intercept constants.

In order to reveal taste heterogeneity among the population, a ML model (accounting for panel data structure) was estimated (Table 4). The simulations to approximate the choice probability P_{ih} (see equation 5) were done using 100 Halton draw sequences (TRAIN, 2000). All parameters were set to vary (with an assumed normal distribution), except for that of the cost attribute, which was held fixed in order to find economically meaningful WTP estimates (TRAIN, 2009; HENSHER et al., 2005). This model is statistically significant (likelihood ratio test: χ^2 = 1423.07 with 12 d.f., p<.0001)[3] and the reported pseudo R^2 indicates a good model fit[4].

Table 4: Results for a Mixed Logit model

Variable	**Coefficient**	***Wald*** [a)]
Random parameters		
Bee-friendly pest management	0.8020	4.55**
Improving native bee habitats within agro-forest ecosystems	0.8748	5.91**
Fostering the husbandry of native bee species	0.6476	4.97**
Changes in the population of native bees (versus 0% change)		
50% decrease	-4.4100	-14.31**
50% increase	2.5753	11.00**
Non-random parameters		
Constant (implement any policy A or B versus no policy at all)	0.3257	2.50
Policy implementation costs (THB)	-0.0034	-13.83**
Derived std. dev. of random parameter distributions		
Bee-friendly pest management	1.3658	10.42**
Improving native bee habitats	0.9008	7.26**
Fostering the husbandry of native bee species	1.1570	10.54**
Changes in the population of native bees (versus 0% change)		
50% decrease	1.8441	10.26**
50% increase	1.5224	6.80**
Log-Likelihood (LL)	-1573.666	
AIC/N [b)]	1.335	
McFadden pseudo *R*-squared [c)]	0.311	

[a)] Wald-statistic = $\hat{\beta}/\widehat{se}(\hat{\beta}) \sim N(0,1)$, with significance levels: * p<.001, ** p<.0001
[b)] AIC = Akaike information criterion
[c)] Based on the LL function from a model with choice probabilities set to each choice alternative's sample shares
Source: Own calculations using NLOGIT 5/LIMDEP 10

The "implement any policy" ASC was reincorporated for the estimation of the ML model, yielding a significantly different from zero parameter estimate, however only at a 1.2% significance level.

[3] Calculated using the LL function of the restricted "constants only" model, which sets each choice probability to the sample shares of each choice alternative.

[4] LOUVIERE et al. (2000) state that a pseudo-R^2 between 0.2 and 0.4 indicates an extremely good model fit and is equivalent to an ordinary least squares adjusted R^2 between the values of 0.7 and 0.9.

The estimates for the means of the coefficients corresponding to the three conservation measures are highly significant, leading to a rejection of the null hypotheses associated with *Hypothesis 1* (see section 3.2). These values can be used to calculate the mean WTP of longan farmers for these measures, using equation 6. Accordingly the mean WTP estimates for the implementation *c.p.* of "bee-friendly pest management", "improving native bee habitats" and "fostering the husbandry of native bee species" correspond to a single payment of 236 THB, 257 THB and 191 THB respectively. The model also shows that in average and in addition to the specific measures contained in the policy alternatives the farmers are willing to spend 96 THB for any conservation policy being implemented.

The model also yielded significant estimates for the mean coefficients of the dummy variables related to the "changes in the population of native bees (versus 0% change)" attribute. The null hypothesis associated with *Hypothesis 2* could thus also be rejected. The estimate for the mean WTP of a 50% decrease in the population of native bees is -1,297 THB, which stands as a considerably higher absolute value when compared to the 757 THB that the population is willing to spend for a 50% increase in the population of native bees.

The standard deviation estimates for the non-monetary attributes indicate a statistically significant preference heterogeinity among the population of longan farmers, leading to the rejection of H_0 associated with *Hypothesis 3*. These values can be used to calculate the point estimates of the standard deviations of the WTP for the non-monetary policy attributes, as given by σ_k/β_c (TRAIN, 2009; HENSHER et al., 2005). Thereby, the estimated standard deviations of the WTP for "bee-friendly pest management", "improving native bee habitats" and "fostering the husbandry of native bee species" are 402 THB, 265 THB and 340 THB, respectively. Similarily, the standard deviations of the WTP for a 50% decrease and a 50% increase in the population of native bees were estimated at 542 THB and 448 THB, respectively. These values give an indication of how widely spread the population's WTP for the proposed policy attributes is.

5 Discussion and Conclusion

The significant estimate for the ASC coefficient in the ML model suggests that respondents inherently grouped policies A and B in a distinct category that they compared with the status quo alternative, when making their choice decision. Although policies A and B are generic with respect to each other, they were collectively associated with a label that, in general, generated *c.p.* a higher utility level than that generated by a "no policy at all" label. The hierarchical decision framework of a nested logit model could thus also describe the choice behavior of the sampled population of longan farmers (RODRÍGUEZ, 2007).

The CL and the ML models yielded discrepant estimates for the coefficients' means, nevertheless maintaining proportionality in their relative contribution to utility. Both models showed overall high significance, but a relative improvement in the model fit could be determined for the ML model by comparing its AIC values with those of the CL model.

The slopes of "changes in the population of native bees" dummies indicate that a 50% loss of native bee populations is relatively higher valued than an equally sized population increase. This behavior is consistent with the *endowment effect* and *loss aversion* aspects of *prospect theory* (KAHNEMAN & TVERSKY, 1979; KAHNEMAN & TVERSKY, 1984).

A large variation in the value perceptions regarding the policy attributes was determined by the significant estimates of the corresponding standard deviations. The variance in the value perceived by the population for the "fostering the husbandry of native bee species" measure could, for instance, be related to the diffence in opinions that members of some of the surveyed communities expressed regarding bee husbandry. Modern beekeeping with the European honeybee (*A. mellifera*) is widely practiced in this region, due to the valuable honey that can be obtained from longan nectar. Beekeepers therefore practice migratory beekeeping (i.e. relocating the hives in search for new bee foraging sources). In some villages, the respondents expressed a negative opinion regarding bee husbandry, based on their belief that bees carry parasites that serve as vectors for the *witches' broom* disease, which affects longan and lychee (*Litchi chinensis* S.) trees in the region. In contrast, other communities showing a greater acceptance for this attribute could have had a general interest for technical advice in native beekeeping and/or already had an established native beekeeping tradition. Furthermore, the heterogeneity in the value perception for "improving native bee habitats" could be explained with the geographical differences in the quality of the nature surrounding the surveyed villages. As such, individuals living in villages with abundant vegetation may not see the need for further improvements with this respect, while the opposite may be the case in communities where habitat deterioration may be visible. On the other hand, the large preference variation for the "bee-friendly pest management" strategy and the "changes in the population of native bees" may greatly relate to the socio-economic differences in the population of longan farmers. These and other hypotheses will be tested in further analyses by including interaction terms, representing attitudinal differences in the respondents and covariates that capture farming and socio-economic differences in their population.

In this study, point estimates for the mean and standard deviation of the WTP were obtained by holding the cost coefficient fixed, which allows calculating WTP distributions easily from the distributions of the non-monetary coefficients. Fixing the cost coefficient also circumvents the challenges that result from dividing the distributions of two random parameters. This approach however ignores the sampling variances of the point estimates found and imposes the unrealistic assumption that the preference of respondents for incurring costs is homogeneous[5]. In order to obtain WTP estimates that account for heterogeneity in the cost coefficient, the mixed model can be respecified, such that its parameters capture the marginal WTP for each attribute (i.e., estimation in WTP space), instead of their corresponding marginal utility (i.e., estimation in preference space) (HENSHER et al., 2005; TRAIN & WEEKS, 2005; RISCHATSCH, 2009), as done in this study. These issues will be considered in future analyses that are expected to deliver methodologically more accurate part-worth and WTP estimates.

To summarize, from the results of this study we can establish a statistically significant relationship between the preference of longan farmers for native bee conservation policy profiles and the attributes that constitute them. Placing the derived WTP estimates in the context of the average income earned by the sampled population of respondents (see Table 2) also leads to the conclusion that these values conform to their expenditure capacity, especially due to the single-payment nature of the policy implementation costs. On the other hand, one must be careful when interpreting the estimated WTP for a 50% decrease in the population of native bees, since the abosulute value of this estimate substantially exceeds the range of policy implementation costs that was presented to the respondents during the DCE.

6 References

ALLSOPP, M. H., LANGE, W. J. & VELDTMAN, R. (2008). Valuing Insect Pollination Services with Cost of Replacement. *PLos ONE, 3(9): 3128*.

ANUPUNT, P. & SUKHIVIBUL, N. (2005). Lychee and longan production in Thailand. *Acta Hort. (ISHS), 665*, 53-60.

BENNETT, J. & ADAMOWICZ, V. (2001). Some Fundamentals of Environmental Choice Modelling. In J. Bennett, & R. Blamey, *The Choice Modelling Approach to Environmental Valuation* - (37-72). Edward Elgar Publishing.

BIESMEIJER, J. C., ROBERTS, S. P., REEMER, M., OHLEMÜLLER, R., EDWARDS, M., PEETERS, T. et al. (2006). Parallel Declines in Pollinators and Insect-Pollinated Plants in Britain and the Netherlands. *Science, 313*, 351-354.

[5] Another restrictive assumption imposed in the mixed logit model estimated in this study is that of uncorrelated random parameters.

BLANCHE, K., LUDWIG, J. A., & CUNNINGHAM, S. A. (2006). Proximity to rainforest enhances pollination and fruit set in orchards. *Journal of Applied Ecology, 43*, 1182-1187.

BYRNE, A. & FITZPATRICK, Ú. (2009). Bee conservation policy at the global, regional and national levels. *Apidologie, 40*, 194-210.

CARLSSON, F. & MARTINSSON, P. (2001). Do Hypothetical and Actual Marginal Willingness to Pay Differ in Choice Experiments? - Application to the Valuation of the Environment. *Journal of Environmental Economics and Management, 41*, 179-192.

CHOICEMETRICS Ltd. (2012). *Ngene 1.1.1 user manual and reference guide - The cutting edge in experimental design.* ChoiceMetrics.

DIAS, B. S., RAW, A. & IMPERATRI-FONSECA, V. L. (1999). *International Pollinators Initiative: The São Paulo declaration on Pollinators - Report on the Recommendations of the Workshop on the Conservation and Sustainable Use of Pollinators in Agriculture with Emphasis on Bees.* São Paulo: Brazilian Ministry of the Environment.

FAO (2008). *Rapid assessment of pollinators' status - a contribution to the international initiative for the conservation and sustainable use of pollinators.* FAO.

FAO (10. 02 2014). *Pollination Information Management System*. From International Pollinator Initiative: http://www.internationalpollinatorsinitiative.org/jsp/intpollinitiative.jsp

GALLAI, N., SALLES, J.-M., SETTELE, J., & VAISSIÈRE, B. E. (2009). Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. *Ecological Economics, 68*, 810-821.

GHAZOUL, J. (2005). Buzziness as usual? Questioning the global pollination crisis. *Trends Ecol. Evol., 20*, 367-373.

HANLEY, N., MACMILLAN, D., PATTERSON, I. & WRIGHT, R. E. (2003). Economics and the design of nature conservation policy: a case study of wild goose conservation in Scotland using choice experiments. *Animal conservation, 6*, 123-129.

HEARD, T. (1999). The role of stingless bees in crop pollination. *Annu. Rev. Entomol., 44*, 183-206.

HENSHER, D. A. & GREENE, W. H. (2002). *The Mixed Logit Model: The State of Practice and Warnings for the Unwary.* Institute of Transport Studies, the University of Sydney and Monash University.

HENSHER, D. A., ROSE, J. M. & GREENE, W. H. (2005). *Applied Choice Analysis - A primer.* Cambridge University Press.

HEPBURN, R. & RADLOFF, S. E. (2011). *Honeybees of Asia.* Springer.

HOFFMAN, S. D. & DUNCAN, G. J. (1988). Multinomial and Conditional Logit Discrete-Choice Models in Demography. *Demography, 25*, 415-427.

KAHNEMAN, D., & TVERSKY, A. (1979). Prospect Theory: An Analysis of Decision Under Risk. *Econometrica, 47*, 263-291.

KAHNEMAN, D., & TVERSKY, A. (1984). Choices, Values, and Frames. *American Psychologist, 39*, 341-350.

KEVAN, P. G. & PHILLIPS, T. P. (2001). The Economic Impacts of Pollinator Declines: An Approach to Assessing the Consequences. *Ecology and Society, 5(1): 8*. From Ecology and Society: http://www.consecol.org/vol5/iss1/art8/

KLEIN, A.-M., VAISSIÈRE, B. E., CANE, J. H., STEFFAN-DEWENTER, I., CUNNINGHAM, S. A., KREMEN, C. et al. (2007). Importance of pollinators in changing landscapes for world crops. *Proc. R. Soc. B, 274*, 303-313.

KLUSER, S. & PEDUZZI, P. (2007). *Global Pollinator decline: A literature review.* UNEP/GRID-Europe.

KREMEN, C., WILLIAMS, N. M., & THORP, R. W. (2002). Crop pollination from native bees at risk from agricultural intensification. *PNAS, 99*, 16812-16816.

LOSEY, J. E. & VAUGHAN, M. (2006). The economic value of ecological services provided by insects. *BioOne, 56*, 311-323.

LOUVIERE, J. J., HENSHER, D. A. & SWAIT, J. D. (2000). *Stated Choice Methods: Analysis and Applications.* Cambridge University Press.

MARSCHAK, J. (1960). Binary choice constraints on random utility indications. *Proceedings of a Symposium on Mathematical Methods in the Social Science* (312-329). Stanford, California: Stanford University Press.

MBURU, J., HEIN, L. G., GEMMILL, B. & COLLETTE, L. (2006). *Tools for the Conservation and Use of Pollination Services - Economic Valuation of Pollination Services: Review of Methods.* Food and Agriculture Organization.

MENZEL, C. M., & WAITE, G. K. (2005). *Litchi and Longan: Botany, Production and Uses.* CABI.

MILLENNIUM ECOSYSTEM ASSESMENT. (2005). *Ecosystems and Human Well-being: Biodiversity Synthesis.* Washington, DC: World Resources Institute.

MORSE, R. A. & CALDERONE, N. W. (2000). The value of honey bees as pollinators of U.S. crops in 2000. *Bee Culture*, 1-15.

NATIONAL RESEARCH COUNCIL (2007). Status of Pollinators in North America. *The National Academies Press*.

OLSCHEWSKI, R., TSCHARNTKE, T., BENITEZ, P. C., SCHWARZE, S. & KLEIN, A.-M. (2006). Economic Evaluation of Pollination Services Comparing Coffee Landscapes in Ecuador and Indonesia. *Ecology and Society, 11(1):7*.

POTTS, S. G., BIESMEIJER, J. C., KREMEN, C., NEUMANN, P., SCHWEIDER, O., & KUNIN, W. (2010). Global pollinator declines: trends, impacts and drivers. *Trends in Ecology and Evolution, 25,* 345-353.

RICHARDS, K. W. (1993). Non-Apis bees as crop pollinators. *Revue Suisse De Zoologie, 100*, 807-822.

RICKETTS, T. (2004). Tropical forest fragments enhance pollinator activity in nearby coffee crops. *Conservation Biology, 18*, 1262-1271.

RICKETTS, T. H., DALLY, G. C., EHRLICH, P. R. & MICHENER, C. D. (2004). Economic value of tropical forest to coffee production. *PNAS, 101*(34), 12579–12582.

RICKETTS, T. H., REGETZ, J., STEFFAN-DEWENTER, I., CUNNINGHAM, S. A., KREMEN, C., BOGDANSKI, A., et al. (2008). Landscape effects on crop pollination services: are there general patterns? *Ecology Letters, 11*, 499-515.

RISCHATSCH, M. (2009). *Simulating WTP values from random-coefficient models, Working Paper No. 0912.* Zurich: Socioeconomic Institute, University of Zurich. From Zurich Open Repository and Archive: http://www.zora.uzh.ch/51922/1/wp0912.pdf

RODRÍGUEZ, G. (2007). Lecture Notes on Generalized Linear Models. From Princeton: http://data.princeton.edu/wws509/notes/

ROSE, J. M., BLIEMER, M. C., HENSHER, D. A. & COLLINS, A. T. (2008). Designing efficient stated choice experiments in the presence of reference alternatives. *Transportation Research Part B, 42*, 395-406.

RUCKER, R. R., THURMAN, W. N. & BURGETT, M. (2012). Honey bee pollination markets and the internalization of reciprocal benefits. *American Journal of Agricultural Economics, 94*, 956-977.

SCHREINEMACHERS, P., SRINGARM, S., & SIRIJINDA, A. (2011). The role of synthetic pesticides in the intensification of highland agriculture in Thailand. *Crop protection, 30,* 1430-1437.

SILLANO, M. & ORTÚZAR, J. D. de (2005). Willingenss-to-pay estimation with mixed logit models: some new evidence. *Environment and Planning A, 37*, 525-550.

SOUTHWICK, E. E. & SOUTHWICK Jr., L. (1992). Estimating the Economic Value of Honey Bees (Hymenoptera: Apidae) as Agricultural Pollinators in the United States. *Entomological Society of America, 85*, 621-633.

STEFFAN-DEWENTER, I., POTTS, S. G., & PACKER, L. (2005). Pollinator Diversity and Crop Pollination Services are at Risk. *Trends in Ecology and Evolution*, *20*(12), 651-652.

THAI OFFICE OF AGRICULTURAL ECONOMICS. (09. 02 2014). *Agricultural Production Data*. From Thai Office of Agricultural Economics: http://www.oae.go.th/ewt_news.php?nid=13577

THURSTONE, L. L. (1927). A law of comparative judgment. *Psychological Review, 34*, 273-286.

TRAIN, K. (2000). *Halton Sequences for Mixed Logit.* UC Berkeley: Department of Economics. From University of California: http://escholarship.org/uc/item/6zs694tp

TRAIN, K. (2009). *Discrete Choice Methods with Simulation.* Cambridge University Press.

TRAIN, K. & WEEKS, M. (2005). Discrete Choice Models in Preference Space and Willingness-To-Pay Space. In R. Scarpa, & A. Alberini, *Applications of Simulation Methods in Environmental and Resource Economics* (1-16). Kluwer Academic Publishers.

WILLIAMS, I. H. (2003). The Convention on Biological Diversity adopts the International Pollinator Initiative. *Bee World, 84*, 27-31.