The Value of Policies to Conserve Native Pollinating Bees in Northern Thailand – A Discrete Choice Experiment

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1. Abstract

This study attempts at estimating, with a discrete choice experiment, the preference of longan (*Dimocarpus longan*) farmers for changes in the population of native bees and for three (widely recognized) strategies to conserve them in Chiang Mai Province, Thailand. Thereby, the part-worth utilities of these policy attributes were estimated with a conditional logit model, indicating a positive contribution, *ceteris paribus*, of the analyzed policy elements to the probability of a conservation policy profile being chosen. The inclusion of a *cost* attribute allowed the calculation of willingness to pay estimates. Significant taste heterogeneity was also identified within a mixed logit model.

2. Introduction

The international community is showing increasing concerns regarding the continued decline of both wild and managed pollinator populations worldwide (Millennium Ecosystem Assesment, 2005; FAO, 2008). Agricultural intensification has been recognized as the main driver for this trend, 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; Potts et al., 2010). The economy of this region is also highly dependent on longan (*Dimocarpus longan*), a fruit obtained from a crop that depends on bee-mediated pollination, as it is its leading exporter worldwide. A failing provision of natural pollination could thus put at stake the livelihood of many smallholder farmers.

The authors 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.

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. Thereby, the contribution of the policy attributes to the probability of a policy profile being prefered over the status quo were calculated and the corresponding point estimates of the willingness to pay (WTP) of farmers obtained with a conditional logit (CL) model. Subsequently, a mixed logit (ML) model was estimated in order to allow for heterogeneity in the taste parameters.

3. Discrete choice experiment and modelling

Human choice can be explained by the utility maximizing behavior of individuals when evaluating paired or multiple comparisons of discrete choice alternatives (Thurstone, 1927). From the researcher's perspective, the unknown utility derived by an individual i from a choice alternative j ($U_{ij}, j = 1, \dots, J$) can be decomposed into a systematic component (V) and a stochastic component (ε) as given by (1):

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

where X_j is a vector of observed variables that relate to the choice alternatives. The probability P_{ih} of a decision-maker choosing from a given choice set the alternative h that maximizes her utility is strictly given by equation (2):

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

Assuming an independent and identically Gumbel extreme value distribution for the error term ε_{ij}, the choice probabilities can be expressed as the conditional logit (CL) model (3):

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

The taste parameters β of this general model are assumed to be homogenous over the population and can be estimated by means of standard maximum likelihood procedures. A measure of WTP is derived by calculating the ratio (4):

$$WTP = -\frac{\beta_k}{\beta_c} \,, \quad (4)$$

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

A more flexible model extension that allows for random taste variation, is the mixed logit model (ML). Taste heterogeneity is accounted for by coefficients β_i varying over decision-makers in the population, with density $f(\beta_i|\theta)$, where θ refers to the distribution moments. The parameters of the distribution (in this study a normal distribution is assumed) are optimized via repeated computational simulations of P_{ih}, for different values of θ, applying the maximum likelihood approach (Rodriguez, 2007; Train, 2009; Hensher, Rose & Greene, 2005).

4. Hypotheses and experimental design

This study proposes the following hypotheses regarding the relationships between the choices made by longan farmers and the conservation measures that constitute them:

H1: 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.

H2: An increase in the population of native bees increases c.p. the probability that this policy 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.

H3: The preference for the policy attributes varies among the population of longan farmers, as reflected in parameter standard deviations that are significantly different from zero.

Each hypothesis is associated with one (or a bundle of) policy attribute(s), which provided at different levels in the experiment (as shown in Table 1), constituted the different alternative policy profiles. Trade-offs between attributes were stimulated in the sampled population by confronting the respondents with an *efficient* subset of the full factorial design, i.e. 72 ($2^3 \times 3^2$) possible combinatorial profiles. A total of 12 choice sets, similar to that presented in Table 2, was generated using the Ngene 1.1.1 software, each of which was evaluated by the 198 individuals that completed the DCE.

Table 1. Alternative attributes and corresponding design levels.

Bee conservation policy attribute	Levels [a]
Bee-friendly pest management	**no**, yes
Improving native bee habitats within agro-forest ecosystems	**no**, yes
Fostering the husbandry of native bee species	**no**, yes
Changes in the population of native bees (%)	**-50**, 0, +50
Policy implementation costs (THB)[b]	**0**, 250, 500, 750

[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

Table 2. An example choice set.

Please choose the option that gives you the greatest satisfaction:			
	Policy A	**Policy B**	**No Policy**
Bee-friendly pest management:	yes	no	no
Native bee habitat improvement:	no	yes	no
On-farm native bee husbandry:	no	yes	no
Changes in native bee population:	+50%	0%	-50%
Policy implementation costs:	500 THB	500 THB	0 THB
I choose:	**Policy A** ◯	**Policy B** ◯	**No Policy** ◯

Source: Own representation

5. Results and discussion

The three conservation strategy attributes were coded as dummy variables taking the values zero, if absent, and one if implemented. The native bee population change variable, on the other hand, was coded with the two dummies “50% increase” and “50% decrease”, to contrast with the “0% change” level. A quantitative variable was assigned to the cost attribute.

The data for 2,376 DCE observations were analyzed with the NLOGIT 5/LIMDEP 10 software. The CL model is statistically significant (likelihood ratio test: χ^2 = 969.32 with 5 d.f.[1], p<0.0001) and yielded highly significant parameter estimates for all attributes (Table 4), leading to a rejection of the null hypotheses associated with *H1* and *H2*. Thereby, WTP point estimates could be calculated using equation 4. Accordingly, the *c.p.* WTP estimates for “bee-friendly pest management”, “improving native bee habitats” and “fostering the husbandry of native bee species” correspond to single payments of 185 THB, 213 THB and 163 THB respectively. Furthermore, the WTP of a 50% decrease in the population of native bees was estimated at -1,350 THB, which stands as a considerably higher absolute value when compared to the 687 THB that the population is willing to spend for a 50% increase in the population of native bees.

[1] Calculated using the Log-L function of the restricted “constants only” model, which sets each choice probability to the sample shares of each choice alternative.

Table 4: 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		-1800.539	
AIC/N [b)]		1.521	

[a)] Wald-statistic = $(\hat{\beta} - \beta_0)/\widehat{se}(\hat{\beta}) \sim N(0,1)$, where $\beta_0 = 0$, with significance levels: * p<0.001, ** p<0.0001
[b)] AIC = Akaike information criterion, N = 2,376
Source: Own calculations using NLOGIT 5/LIMDEP 10

In order to reveal taste heterogeneity among the population, a ML model (100 Halton draw sequences, accounting for panel data structure) was estimated, allowing all parameters to vary with an assumed normal distribution (Table 5). This model's likelihood ratio test (χ^2 = 1551.1 with 11 d.f., p<0.0001) indicates statistical significance and a comparison of the CL and ML AICs suggests that adding heterogeneity to the taste coefficients leads to a model improvement.

Table 5: Results for a Mixed Logit model

Variable	Coefficient	*Wald* [a)]
Random parameters		
Bee-friendly pest management	0.987	5.80**
Improving native bee habitats within agro-forest ecosystems	0.944	6.33**
Fostering the husbandry of native bee species	0.727	5.65**
Changes in the population of native bees (versus 0% change)		
50% decrease	-4.711	-15.03**
50% increase	2.653	10.68**
Policy implementation costs (THB)	-0.004	-10.73**
Derived std. dev. of random parameter distributions		
Bee-friendly pest management	1.10	8.47**
Improving native bee habitats	0.82	5.61**
Fostering the husbandry of native bee species	1.15	9.42**
Changes in the population of native bees (versus 0% change)		
50% decrease	2.36	8.44**
50% increase	1.32	6.60**
Policy implementation costs (THB)	0.004	10.93**
Log-Likelihood	-1509.210	
AIC/N [b)]	1.280	

[a)] Wald-statistic = $(\hat{\beta} - \beta_0)/\widehat{se}(\hat{\beta}) \sim N(0,1)$, where $\beta_0 = 0$, with significance levels: * p<0.001, ** p<0.0001
[b)] AIC = Akaike information criterion, N = 2,376
Source: Own calculations using NLOGIT 5/LIMDEP 10

The statistically significant estimates of the standard deviations around the mean attribute parameters point at a large taste heterogeneity in the respondents, also leading to the rejection of the null hypothesis associated with *H3*. When the cost attribute parameter is also allowed to vary, equation 4 fails at obtaining WTP estimates, which instead must be calculated in WTP space. This was not possible due to technical issues related to the statistical software.

The variance in the respondent's value perceptions for the "fostering the husbandry of native bee species" measure could, for instance, be related to general opinion differences regarding bee husbandry between some of the surveyed communities. Beekeeping with the European honeybee (*A. mellifera*) is widely practiced in this region, where beekeepers often search for new bee foraging sources from village to village. In some communties, migratory beekeepers are not welcomed, based on the belief that bees carry parasites that serve as vectors for diseases affecting longan and lychee (*Litchi chinensis* S.) trees. Other communities, instead, already have an established native beekeeping tradition and/or a general interest for technical advice in native beekeeping that could explain a greater acceptance for this attribute. Furthermore, the large taste heterogeneity determined for "improving native bee habitats" could relate to geographical differences in the environemental quality of the surveyed villages; individuals living in villages with abundant vegetation may not see the need for further habitat improvements, while the opposite may be the case in communities where habitat deterioration is visible. Further population variance in the preference for policy attributes may be explained with socio-demographic and attitudinal characteristics of the individuals. These and other hypotheses will be tested in further analyses by including the relevant interaction terms.

6. References

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