Estimating non-market values of fruit tree diversity in the Czech Republic

Abstract

Inspired by John Krutilla's landmark essay, "Conservation Reconsidered," we investigate the non-use values of fruit tree diversity in the Czech Republic by using stated preference methods to estimate the willingness-to-pay (WTP) of a representative sample of the Czech public for different components of the total economic value of this historic Czech resource. We find significant and positive estimates for all types of value in both samples, with respondents from the Czech representative sample WTP the most for insurance value (with a mean value of $10 per respondent) and respondents from the S. Moravian sample WTP the most for option value (with a mean value of $11 per respondent). The mean WTP for existence and bequest value were found to be lower in both samples (around $7 to $8 per respondent) and statistically lower than the estimate for insurance value (with option value only being found to be statistically higher than the estimate for bequest value). In addition, we find large differences in WTP due to socio-economic characteristics. For example, we find that those who believe it is important to adapt the Czech agriculture sector to climate change were WTP much more for the insurance and existence values stemming from conserving Czech fruit tree diversity, while preferring palenka (Czech fruit brandy) to other kinds of alcohol was highly significant in predicting WTP for option and bequest value value (and retired individuals were found to have a higher WTP for bequest value but a lower WTP for option value). This analysis is of interest both for the local insights it provides into the different values of fruit tree diversity for Czechs, and also as a broader example of how individuals value different non-use values related to crop diversity. Economists have typically focused on estimating the *use* value of crop diversity, though the conservation of genetic resources is likely to be associated with the provision of non-use values as well. Thus, this study contributes to a quite limited literature on the non-use values of agrobiodiversity, and provides specific estimates of existence, bequest, insurance and option values in the case of traditional Czech fruit tree diversity.

1. Introduction

In John Krutilla's landmark essay, "Conservation Reconsidered," he argues that the private and social returns to preserving the environment of a given area in its natural state (such as the Grand Canyon) are likely to differ substantially. In particular, this is because the private landowner cannot fully appropriate the full social value of preserving the natural resource, which includes three particular "passive" values he describes: 1) option value, associated with retaining the option to use the resource in the future; 2) existence value, arising from the mere existence of a resource like an endangered species; and 3) bequest value, related to the value placed on giving one's heirs (or future generations in general) the option to use a public resource such as a national park.

Here, we take the case of fruit tree diversity in the Czech Republic – close to the Slovakian homeland of Krutilla's parents – and use stated preference methods to estimate the willingness-to-pay (WTP) of a representative sample of the Czech public for different components of the total economic value of this historic Czech resource, including several of the "passive use values" described in "Conservation Reconsidered." Fruit trees are an important element of the Czech landscape, appearing in rural areas as well as in the capital city, on the hillsides of Petřín and the slopes below Strahov Monastery and Prague Castle. They are both cultural artefacts and current-day providers of fruit to Czech families for their own consumption and firms such as Prager Cider and Žufánek that produce cider and distilled fruit brandies from old Czech fruit varieties. In addition, the diverse fruit tree genetic resources in the country possess traits of potential value for adapting to future climate changes or pest/disease outbreaks.

We hypothesize that the Czech public has non-zero, positive WTP for different types of value provided by the conservation of Czech fruit tree diversity, and that different subsets of the

population care more about different types of value (i.e. existence, bequest, insurance, and option values).

The non-market values of plant genetic resources for food and agriculture (PGRFA) have long been considered an important component of their total economic value. However, while the total economic value framework has been used to assess the non-market values of many other goods, the literature that empirically investigates the non-use values of agrobiodiversity is quite limited.

Using stated preference methods applied to an online sample representative of the overall Czech Republic, we demonstrate that Czechs have a non-zero WTP for the existence, bequest, insurance and option values associated with conserving Czech fruit tree diversity. In addition, we show how different socio-economic variables affect WTP for the different value types.

The rest of the paper is organized as follows. In section 2, we provide a brief literature review. In section 3, we describe our methodology, from survey development and implementation to data analysis. In section 4, we present our results, and in section 5 we present our conclusions.

2. Literature review

Since Krutilla's original essay on existence value and other non-use values, non-market values have been elicited in a number of cases, from shipwrecks (Whitehead and Finney 2003) and aboriginal cultural heritage sites in Australia (Rolfe and Windle 2003) to museums (Sanz *et al.* 2003) and cultural bequest values related to management of an indigenous fishery in Madagascar (Oleson *et al.* 2015).

Some examples of literature that have investigated non-market values of agrobiodiversity include Rocchi *et al.* (2016), who provide an estimate of local WTP for non-use values of an old Italian

tomato variety, "Pomodoro di Mercatello," and Pouta *et al.* (2014), who focus on eliciting non-market values of native Finnish plant varieties and livestock breeds such as goats, chickens, and horses. However, neither of these have attempted to break down the value of a given genetic resource into the various non-market components of value within the total economic framework.

Two recent papers that have analyzed the non-market values of agrobiodiversity in more depth are Zander *et al.* (2013) and Martin-Collado *et al.* (2014). Both use choice experiments to elicit the WTP of respondents for conservation programs for different endangered cattle breeds that target their landscape maintenance, existence and future option values. Zander *et al.* (2013) focuses on two threatened Italian cattle breeds (Modicana and Maremmana), while Martin-Collado *et al*. (2014) focus on the total economic value of the Alistana-Sanabresa cattle breed from Spain. They find that non-market values such as existence and option values in fact constitute a large proportion of the total economic value provided by conserving these breeds.

This paper follows in the footsteps of these two earlier analyses on the total economic value of certain forms of animal genetic resources. However, we focus instead on an example of *plant* genetic resources for food and agriculture: Czech fruit tree diversity.

3. The survey, study design and econometric approach

In this section we describe how the survey was designed and tested, the data collection process, and the econometric approach used in our analysis.

3.1 Survey method and data

A nationally representative sample of individuals aged 18-69 in the Czech Republic was surveyed with funding from the Grant Agency of Univerzita Karlova (GAUK). In addition, a

smaller and separate sub-sample of individuals from the agricultural region of South Moravia in the Czech Republic was also surveyed. The representativeness of the samples was controlled through quota selection depending on region, age, gender, education, and size of the place of residence of the respondent. The quotas were satisfied for each of the sub-samples independently.

Data were collected with the Computer-Assisted Self Interviewing (CASI) method, using an online survey instrument to allow for more flexible experimental designs and randomizations. The survey instrument was programmed and maintained by the Centrum pro otázky životního prostředí of Univerzita Karlova, as were the output data matrices making up the database of results. The hired firm (STEM/MARK) was responsible for incentivizing respondents to answer to the survey, to manage the quotas, and to carry out the data collection in line with the standards of the international research association ESOMAR. Respondents were sampled from an internet panel, properly managed by Český Národní Panel.

To control for respondents who answered questions too quickly without carefully reading them, all surveys in which the respondent took less time than the 48% median for a given sub-sample were excluded from the final sample as speeders (see Table A1 in Appendix), in total leaving 805 valid observations for the Czech representative sample and 463 for the South Moravian sample.

3.2 The instrument

The survey instrument was drafted in English, translated into Czech, and programmed into an online format. The survey questionnaire included three other choice experiments (each with

accompanying explanatory text) in addition to the specific crop diversity experiment that provided the data for this paper. The structure of the survey instrument is outlined below:

- Questions to confirm the quota filling and screening questions
- Questions about values and attitudes towards crop diversity
- Introductory text about crop diversity and its importance
- Stated preference experiments
- Sociodemographic information and other attitudinal questions

The questionnaire was tested and developed through a qualitative pre-survey, and was also further tested on a representative sample of the Czech adult population (ages 18-69) in a three-day pilot (n=175). The main wave of the survey was administered over a 5-day period, with the updated design.

Each respondent was posed two double-bounded dichotomous choice questions, each corresponding to two of the four types of value investigated in the paper. The two values were selected at random. Thus, around 400 respondents per value type were asked about whether they would be willing to pay to fund a certain type of conservation program (corresponding to that given value).

The cost in the first step of each dichotomous choice was selected at random from 30, 80, 150, 350, or 600 CZK (approximately 1.2, 3.2, 6, 14, or 24 US$) and was either doubled or set at a half in the second step. The number of conserved varieties was selected at random from 5, 10, 15, 25, and 35. Both the cost and the number of varieties were selected independently and at random form the pre-defined set for the two dichotomous choice exercises. In total, the design consisted of 25 variants, and two were randomly selected for each respondent.

Table 1 provides a brief summary of the conservation programs offered that correspond to each type of value elicited. In addition, we provide more in-depth descriptions of what respondents were asked regarding the conservation program associated with each value type directly below, and an English translation of the exact text posed to the survey respondents is provided in Appendix A.

Table 1. Types of value elicited and conservation program details

Type of value elicited	Details of conservation program
Option value	X fruit tree varieties conserved for 20 years such that the survey respondent would have the possibility to personally try them.
Bequest value	X fruit tree varieties conserved for 100 years such that personal use is not possible but in order to give future generations of Czechs the opportunity to use them.
Insurance value	X fruit tree varieties conserved for 100 years such that personal use is not possible but in order to help adapt Czech agriculture to climate change and pests/diseases.
Existence value	X fruit tree varieties conserved for 100 years such that they are not available for use of any kind but strictly to ensure that they do not go extinct.

For option value, individuals taking the survey were asked if they would be willing to pay a given amount (one-off payment) to fund the collection and storage of a given number of Czech fruit tree varieties for the next twenty years to ensure that they would have the option to try these varieties in the future (or products made from the varieties).

For bequest value, on the other hand, the respondents were asked if they would be willing to make a one-time payment of a given amount to conserve a given number of fruit tree varieties over the next 100 years, even if the individuals taking the survey would never have the opportunity personally to try the varieties but instead to ensure that future Czech generations would have the option to try them.

For insurance value, respondents had to answer regarding whether or not they would be willing to pay a given amount to fund the collection and storage of a certain number of fruit tree varieties for the next 100 years, so that they could be used to help adapt Czech agriculture to climate change and improve the resistance of Czech fruit cultivars to pests and diseases.

Finally, for existence value, respondents were asked if they would be willing to pay for a conservation program that would conserve a given number of Czech fruit tree varieties for the next 100 years, but with the condition that they were not publicly accessible or used, and were maintained in storage strictly to prevent their extinction.

3.3 The econometric approach

We use the double-bounded dichotomous choice elicitation format, which asks the survey respondent whether he or she is willing to pay for a specific type of value related to Czech fruit tree diversity, and then asks a follow-up question with a higher bid (if the initial response was "yes") or a lower bid (if the initial response was "no"). This approach falls under the general category of binary choice models, which are designed to model the "choice" between two discrete alternatives (pay or not pay for the option) and models the data as utility-maximizing responses within a random utility framework (Luce 1959; McFadden 1974). This approach has been shown to provide more statistical efficiency when compared with the simpler single-bounded dichotomous choice method, as shown by Hanemann et al. (1991).

The data from the survey were analyzed using the maximum likelihood estimator associated with the double-bounded dichotomous choice approach for the main models. The socio-economic modeling was performed using a simple logit model. SAS/STAT software was employed for the data analysis.

4. Results

We present in this section the two main results of our analysis: first, the WTP estimates for the four types of value for the Czech general population and the South Moravian sub-sample, and second, a model for the Czech-representative sample with interacted socio-economic variables.

In Table 2, we present the regression results for the double-bounded dichotomous choice analysis for the Czech general population sample. We assume the disturbances follow the Weibull distribution, as it minimizes the information criteria and maximizes the log-likelihood for our data across all standard distributional forms.

Table 2. DBDC regression results for the Czech general population

Variable	Existence value	Option value	Insurance value	Bequest value
Intercept	4.769*** (0.369)	5.134*** (0.158)	5.201*** (0.178)	4.805*** (0.167)
Varieties	0.015 (0.009)	0.006 (0.008)	0.008 (0.009)	0.012 (0.008)
Scale	1.697 (0.116)	1.396 (0.092)	1.528 (0.103)	1.524 (0.099)
Weibull Shape	0.589 (0.040)	0.716 (0.047)	0.654 (0.044)	0.656 (0.043)
	No. of obs: 408	No. of obs: 405	No. of obs: 388	No. of obs: 409

[1] Note: *, **, and *** represent 10, 5 and 1% significance levels, respectively; standard errors in parentheses.

We find significant WTP for all four types of value in the Czech representative sample, with respondents willing to pay the most for insurance value. We found similar results when running a single-bounded dichotomous choice model (SBDC). The WTP for insurance value was found to be statistically higher than existence and bequest value, while the WTP for option value was only found to be statistically higher than the estimate for bequest value. To check for a possible design effect, we controlled for the order in which the WTP question was asked (i.e., did it matter whether the DBDC for a given type of value was asked before or after a different type of value).

Table 3. DBDC regression results for the South Moravian sample

Variable	Existence value	Option value	Insurance value	Bequest value
Intercept	4.811*** (0.264)	5.252*** (0.236)	5.072*** (0.220)	4.996*** (0.225)
Varieties	0.009 (0.013)	-0.004 (0.011)	0.007 (0.011)	0.013 (0.011)
Scale	1.765 (0.156)	1.553 (0.140)	1.539 (0.135)	1.409 (0.121)
Weibull Shape	0.567 (0.050)	0.644 (0.058)	0.650 (0.057)	0.710 (0.061)
	No. of obs: 233	No. of obs: 233	No. of obs: 240	No. of obs: 220

[1] Note: *, **, and *** represent 10, 5 and 1% significance levels, respectively; standard errors in parentheses.

In Table 3 we present similar results but for the South Moravian sample. Again, mean WTP is found to be significant for all value types, though for this sample the mean WTP is found to be highest for option value, not insurance value. The number of varieties conserved by a given program was not found to be significant for any value type.

Table 4 presents the estimated mean WTP figures for each type of value and by sample, in dollars. Overall, the estimates range from around $7 - $10, and are similar between samples, with only option value being found to be statistically higher in the South Moravian sample.

Table 4. Estimated mean WTP figures for each type of value and by sample[1]

Type of value	Estimated WTP (Czech sample)	Estimated WTP (S. Moravian sample)
Existence	$7.40 ($0.65)	$8.10 ($1.00)
Bequest	$6.70 ($0.50)	$7.50 ($0.75)
Option	$8.55 ($0.60)	$10.70 ($1.15)
Insurance	$10.00 ($0.80)	$8.85 ($0.90)

[1] Rounded to the nearest five-cent interval; standard errors in parentheses.

We present the results of a logit regression of socio-economic variables below in Table 5. Here we find significant differences in the WTP of the respondents based on certain variables. For example, we find that those who believe that it is important to adapt the Czech agriculture sector to climate change were WTP much more for the insurance and existence values stemming from

conserving Czech fruit tree diversity, as well as for bequest value (to a lesser extent). Those with higher education also had a slightly higher WTP for existence value. In addition, those with higher incomes were WTP more for insurance and option value.

Table 5. Logit results for the Czech general population with socio-economic variables[1]

Variable	Existence value	Option value	Insurance value	Bequest value
Intercept	0.0854 (0.618)	0.339 (0.630)	0.893 (0.658)	-0.228 (0.603)
Cost	-0.004*** (0.001)	-0.005*** (0.001)	-0.005*** (0.001)	-0.004*** (0.001)
Varieties	0.009 (0.011)	-0.004 (0.011)	0.011 (0.012)	0.015 (0.010)
Age	-0.022* (0.011)	-0.005 (0.012)	-0.022 (0.013)	-0.013 (0.011)
Low education	-0.163 (0.255)	0.252 (0.259)	-0.079 (0.273)	0.297 (0.250)
High education	0.002*** (0.342)	0.098 (0.375)	0.640 (0.391)	0.293 (0.392)
Retired	0.214 (0.395)	-0.703* (0.421)	0.731 (0.464)	1.031** (0.406)
Student	-0,598 (0.527)	0.427 (0.529)	-0.672 (0.583)	-0.728 (0.481)
Unemployed	0.172 (0.671)	-0.091 (0.765)	0.263 (0.556)	-0.085 (0.585)
Children	-0.003 (0.317)	-0.048 (0.310)	-0.431 (0.322)	-0.253 (0.302)
Adaptation important	0.861*** (0.241)	0.296 (0.238)	0.909*** (0.254)	0.580** (0.227)
Personal income	-0.014 (0.160)	0.279* (0.168)	0.372** (0.163)	0.069 (0.158)
P. income missing	-0.470 (0.689)	-0.857 (0.918)	-0.208 (0.770)	-0.282 (0.737)
S. Morava	0.580 (0.369)	-0.371 (0.397)	-0.370 (0.368)	0.483 (0.400)
Male	0.091 (0.251)	-0.155 (0.254)	-0.219 (0.266)	0.242 (0.243)
Gardener	-0.016 (0.243)	0.166 (0.252)	0.307 (0.257)	0.180 (0.243)
Farmers' market	-0.307 (0.369)	0.012 (0.333)	-0.211 (0.357)	0.327 (0.326)
Palenka	-0.227 (0.344)	0.828*** (0.319)	0.267 (0.350)	0.502* (0.304)
	No. of obs: 408	No. of obs: 405	No. of obs: 388	No. of obs: 409

[1] Note: *, **, and *** represent 10, 5 and 1% significance levels, respectively; standard errors in parentheses.

Interestingly, we find that almost all of the WTP in the sample for bequest value came from respondents who were retired and/or those who stated that they preferred drinking palenka (Czech fruit brandy such as slivovice) to beer or wine; while preferring palenka to other kinds of alcohol was also highly significant in predicting WTP for option value (while retired individuals had a lower WTP for option value). Thus, the characteristics of the individuals who cared about certain value types were quite different.

6. Conclusion

We find significant and positive estimates of mean willingness-to-pay for all types of value in both samples, with respondents from the Czech representative sample WTP the most for insurance value (with a mean value of $10 per respondent) and respondents from the S. Moravian sample WTP the most for option value (with a mean value of $11 per respondent). Furthermore, while we do not find that the mean estimates of WTP for the four types of value were substantially different, we do find large differences in WTP due to socio-economic characteristics. For example, the WTP for bequest value is almost entirely driven by respondents who were retired and/or preferred drinking palenka (Czech fruit brandy) to other types of alcohol.

This analysis is of interest both for the local insights it provides into the different values of fruit tree diversity for Czechs, and also as a broader example of how individuals value different non-use values related to crop diversity. Economists have typically focused on estimating the *use* value of crop diversity, though the conservation of genetic resources is likely to be associated with the provision of non-use values as well. Thus, this study contributes to a quite limited literature (including, for example, Zander *et al.* 2013 and Martin-Collado *et al.* 2014) on the non-use values of agrobiodiversity, and provides specific estimates of existence, bequest, insurance and option values in the case of traditional Czech fruit tree diversity.

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Appendix A: Preferences for conserving types of value

Instructions for programming: Each respondent will be asked two of these four questions which of the four are chosen is randomly selected.

These questions focus on preserving **the different types of value provided by crop diversity.**

In these scenarios, you have the option to make a **voluntary, one-time payment** into a public fund to **finance the collection and conservation** of a given number of fruit trees that **are not currently conserved** (and risk being irreversibly lost if they are not conserved) under different conditions.

Some people may not be willing to pay for collecting and conserving any crop varieties for any reason. In the case that you are not willing to pay for any of the three presented conservation programs, just respond "No."

However, if you do decide to pay for one of the conservation programs, please consider that you will have less money available to purchase other goods.

********* NEW SCREEN *********

Please consider carefully which options you would realistically pay for, given your current budget. Also, while answering**,** please try to forget your previous answers in the survey and imagine a scenario where you have made no payments or commitments to fund the conservation of Czech crop diversity of any kind.

We are going to ask you two questions about whether you are willing to make a one-time payment to conserve Czech crop diversity in a given scenario, but please consider these choices to be independent, meaning that you should not consider the amount you were willing to pay in the previous tasks when making a decision about the choice at hand.

IF DCQUESTi=you

1. Would you pay **X** CZK into a public fund to **finance the collection and conservation of an additional Y varieties of fruit trees for the next 20 years** of your life, to ensure that you will have the possibility to try these varieties in the future (or products made using these varieties)?

   → If yes, would you be willing to pay $\mathbf{X_2}$ CZK to accomplish the same purpose? **($X_2 > X$)**

   → If no, would you be willing to pay $\mathbf{X_3}$ CZK to accomplish the same purpose? **($X_3 < X$)**

IF DCQUESTi=gener

2. Would you pay **X** CZK into a public fund to **finance the collection and conservation of an additional Y varieties of fruit trees for the next 100 years** in a scenario where you will never be able to personally try these varieties, but in order to give future generations of Czechs the opportunity to enjoy trying these historic Czech crop varieties?

→ If yes, would you be willing to pay **X_2** CZK to accomplish the same purpose? (**$X_2 > X$**)

→ If no, would you be willing to pay **X_3** CZK to accomplish the same purpose? (**$X_3 < X$**)

IF DCQUESTi=exist

3. Would you pay **X** CZK into a public fund to **finance the collection and conservation of an additional Y varieties of fruit trees for the next 100 years**, if these varieties were not made available to the public by the seed bank **for use of any kind**, but simply to ensure that they do not go extinct?

   → If yes, would you be willing to pay **X_2** CZK to accomplish the same purpose? (**$X_2 > X$**)

   → If no, would you be willing to pay **X_3** CZK to accomplish the same purpose? (**$X_3 < X$**)

IF DCQUESTi=insur

4. Would you pay **X** CZK into a public fund to **finance the collection and conservation of an additional Y varieties of fruit trees for the next 100 years,** in order to potentially provide traits to help adapt Czech agriculture to climatic changes or to provide resistance to a pest or disease? In this scenario you would not be able to directly use these varieties, they would be available only for use in breeding.

   → If yes, would you be willing to pay **X_2** CZK to accomplish the same purpose? (**$X_2 > X$**)

   → If no, would you be willing to pay **X_3** CZK to accomplish the same purpose? (**$X_3 < X$**)

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