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ESTIMATING THE SOCIAL VALUE OF SPECIFIC CROP DIVERSITY CONSERVATION PLANS: DO CZECHS CARE MORE ABOUT CONSERVING HOP, WINE OR FRUIT TREE VARIETIES?

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Estimating the Social Value of Specific Crop Diversity Conservation Plans: Do Czechs Care More About Conserving Hop, Wine or Fruit Tree Varieties?

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Abstract:
We use a discrete choice experiment to elicit the preferences of Czech adults ages 18 to 69 (n=805) for the conservation of wine, hop, and fruit tree varieties. In addition, we also elicit the preferences of a smaller sub-sample consisting solely of respondents from South Moravia (n=463), an agricultural region of the country. Estimating a mixed logit model, we find a strong public preference for fruit tree conservation and derive a mean willingness to pay (WTP) for the conservation of fruit tree varieties of about 280 Kč. Mean WTP for wine variety conservation was found to be about 130 Kč, while WTP for conserving hop varieties was estimated at about 80 Kč. Mean WTP values among respondents from South Moravia for crop conservation programs were found to be between about three and four times higher than for the general Czech population. We further examine the impact of observed preference heterogeneity for several respondent-specific characteristics on WTP for the conservation of the three crops. In total, the Czech adult population was estimated to have an aggregate WTP of at least two billion Kč for additional fruit

tree conservation over next ten years, about one billion Kč for the conservation of additional wine varieties, and ~580 million Kč for the conservation of additional hop varieties, and these values increase by 31–112 percent if the estimated benefits for the maximum number of varieties as offered in our design are added), revealing the previously unmeasured social welfare benefits of these activities. The estimated benefits of specific crop conservation are an important contribution to the valuation of these historic Czech resources, as crop varieties conserved now provide not only option and bequest values but may also be more resistant to biotic stresses (such as pests and diseases) as well as expected adverse weather extremes, providing the potential to help adapt Czech agriculture to future shocks.

JEL: Q18, Q51, Q57
Keywords: Crop diversity; plant genetic resources for food and agriculture; discrete choice experiments; mixed logit; willingness to pay; consumer preferences

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1. Introduction

Crop diversity, or plant genetic resources for food and agriculture (PGRFA), includes cultivated crop varieties (both modern and traditional) and the wild relatives of crops. There is an incredible diversity of crop varieties worldwide, with more than 100,000 varieties of rice, and this diversity has contributed to large increases in agricultural productivity through its use in plant breeding. The use of diverse plant genetic resources has thus played an essential role in helping to raise crop yields in the 20th century alongside the increased use of fertilizers and pesticides.

However, the development of improved crop varieties, along with pressures such as land clearing, development, urbanization and the spread of pests and diseases, has led to the loss of traditional, less profitable varieties (FAO 1997). The loss of this crop diversity is problematic because the genetic diversity found within the hundreds of thousands of crop varieties around the world is essential for breeding new, more productive crops in the future. It is thus essential to identify the causes and drivers of the loss of crop diversity around the world, and clearly determine a strategy for reversing the trend, to ensure that these genetic resources are available when they are most needed. Furthermore, to obtain an appropriate level of financial support, it is also necessary to obtain rigorous estimates of the diverse economic values of crop diversity in order to justify expenditures on the conservation of these genetic resources.

This study uses stated preference techniques to elicit the preferences of the Czech public regarding how much they are willing to pay to conserve three specific types of crop diversity: fruit trees, wine varieties and hops. These crops were chosen because the many varieties of each are usually very distinguishable, and are present in recognizable Czech products such as beer, wine, fruit brandies, fruit, jams, etc., that are of general interest to the Czech population.

This analysis is an important contribution to the literature on valuing crop diversity in that it both captures the value to the public of crop conservation activities and examines the heterogeneity in public preferences for conserving varieties of different crops. Our study elicits the value that the Czech public places on conserving three specific types of crop diversity – hop, wine and fruit tree varieties - and provides an approximation of the aggregate social benefits of conservation activities for these three important Czech crops. While most past research has dealt with farmer preferences, the value placed by the general public on the conservation of crop varieties is also of interest, as most countries have public conservation programs for crop diversity on the national

level. Importantly, estimating the mean willingness to pay (WTP) of a country's residents allows the estimation of the aggregate WTP for genetic resource conservation for specific crops on a country-wide level. In addition, using stated preference methods to focus on the general public makes it possible to capture the "passive use values" (Krutilla 1967) of crop diversity, which are relevant for the public as well as for farmers.

We demonstrate a strong preference for conserving fruit tree over hop and wine varieties, deriving positive mean WTP values for the general Czech population of about 280 Kč for a fruit tree conservation plan, 130 Kč for the conservation of additional wine varieties, and about 80 Kč for the conservation of additional hop diversity. Summed across the adult Czech population (ages 18+), we obtain aggregate country-wide WTP figures of at least ~2 billion Kč for fruit tree conservation, ~1 billion Kč for the conservation of additional wine varieties, and ~580 million Kč for the conservation of hop diversity (over a ten year period) - substantial sums when compared with the equivalent cost of about 380 million Kč of running the entire Czech genebank system for the same period. These estimated values further increase by 31–112 percent if the estimated benefits for the maximum number of varieties as offered in our design are added. We also find evidence of heterogeneity in the sample in terms of preferences for conserving the three crop types, which varied significantly based on a number of socioeconomic variables.

2. Literature review

While many past analyses have focused on estimating the value provided by crop diversity through genetic contributions to new, improved varieties, a number of studies have also sought to use stated preference methods to elicit non-market values of crop genetic resources not directly dependent on their use in breeding new, improved crop varieties. These studies can be split roughly into two groups: those that used contingent valuation techniques, and those that employed discrete choice experiments.

Among the first group, several studies have used contingent valuation relying on various elicitation formats such as iterative bidding games, open-ended formats and (double-bounded) dichotomous choice questions to estimate how individuals value crop diversity. For example, Poudel and Johnsen (2009) find using an open-ended elicitation format that Nepalese farmers were willing to pay more for *in situ* than *ex situ c*onservation of rice landraces. Other studies have utilized dichotomous (closed-ended) questions, which are thought to provide more realistic,

market-like situations (Bateman *et al.* 2002; Johnston et al., 2017). These include Rocchi *et al.* (2016) who estimate the use and non-use values of an old Italian tomato variety ("Pomodoro di Mercatello") using a single-bounded dichotomous choice model or Tyack and Ščasný (2018), who elicit preferences of the Czechs for general crop diversity conservation using double-bounded dichotomous choice.

Other studies analyzing the economic value of crop diversity use the discrete choice method, which allows respondents to choose between multiple alternatives (instead of just two, as in contingent valuation approaches). For example, Birol *et al.* (2006) utilize the choice experiment method to approximate the private benefits farmers obtain from four types of agrobiodiversity found in Hungarian home gardens using a willingness-to-accept approach: crop variety richness, including fruit trees; integrated crop and livestock production; soil micro-organism diversity; and crop landraces. All of these factors were found to be significant in farmers' choice of home gardens, with agro-diversity being the most important attribute – the respondents on average required between 100 and 404 euros (in 2002 prices) per annum and household to give up this attribute of their home gardens. Birol, Kontoleon and Smale (2006) similarly combine revealed preference (a discrete choice, farm household model) and stated preference (a choice experiment) to investigate the questions described above, confirming the validity of the stated preference results.

Other, more recent papers have also favored the discrete choice method. Birol *et al.* (2007) use a choice experiment and latent class model approach to estimate the value Mexican farmers place on three components of crop diversity (crop species richness, maize variety richness and the presence of maize landraces) maintained in traditional *milpa* production systems, which are characterized by a set of crops and practices that are associated with the cultivation of traditional maize varieties. They show that many of the *milpa* farmers are willing to accept relatively substantial declines in yield to be able to continue to cultivate maize landraces instead of improved or genetically modified varieties. Asrat *et al.* (2010) also analyze the incentives and constraints facing small farmers, using choice experiments to investigate the preferences of Ethiopian farmers for crop variety attributes such as environmental adaptability and yield stability. And most recently, Sardaro *et al.* (2016) employ choice experiments, using a latent class model, to investigate how much olive farmers in Apulia, Italy would require to be

compensated to grow traditional, landrace varieties of olive trees on their land through a regional conservation programme, instead of more modern, improved olive varieties.

As a whole, stated preference techniques offer the potential to capture a closer approximation of the total economic value of crop diversity conservation that includes "passive use values" such as existence, bequest or option value as well as more direct use and market values associated with maintaining crop varieties that might otherwise go extinct. Among these techniques, discrete choice experiments offer a robust and more flexible approach to analyzing tradeoffs between various program attributes.

3. Methodology

In this study, we utilize a discrete choice experiment administered through an online survey to analyze how much the Czech public values the conservation of currently unprotected fruit tree, hop and wine varieties. In this section, we first summarize how the data was collected, describe the survey instrument and discrete choice experiment, and last outline our econometric approach.

3.1 Survey method and data

We collect data through an online instrument in order to more easily randomize and assemble a national sample of individuals (ages 18-69) representative of the Czech Republic of the whole. In addition, we also surveyed a smaller (and separate) sub-sample of individuals from South Moravia, a major agricultural and wine-growing region in the Czech Republic. In order to ensure the representativeness of the sample, respondents were invited from a properly managed internet panel (Český Národní Panel) based upon quota selection satisfied for each sub-sample independently.[1] Our quota variables consisted of region, age, gender, education, and size of the place of residence of the respondent.

[1] The marketing research company (STEM/MARK), selected through a competitive bidding process, was responsible for incentivizing respondents to answer to the survey, to manage the quotas, and to implement data collection in line with the standards of the international research association ESOMAR. The survey instrument was programmed and maintained by the Charles University Environment Center.

We interviewed 965 people that represent general Czech population and another 500 who represent population of the Southern Morava region.[2] 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. After excluding the speeders (6.6% and 7.4%, respectively), the final dataset includes 805 and 463 valid observations. The two samples are for the most part representative of the target populations, although there are slightly less respondents with low and high education and more with medium-level education in the general sample. The average age is 43 years in both samples and there are 50%, and 54% females, respectively. There is the same percentage of respondents in the two samples who are gardeners (64% and 68%, t-stat=1.499) and wine lovers (23% and 26%, t-stat=1.143), but there are more beer drinkers in the sample representing general population (34% and 27%, t-stat=2.426). Only 2% of respondents work in the agriculture sector. Average net monthly household income is 23,460 CZK and 23,950 CZK, and 13% and 14% respondents, respectively, did not provide information about their income (see Table 1).

Table 1. Descriptive statistics of the two samples, speeders and pilot data excluded.

	General population, N=805		Southern Morava, N=463	
	mean	std	mean	std
females	0.504	0.500	0.544	0.499
age	43.185	15.417	43.374	14.157
South Morava	0.104	0.306	1.000	NA
respondent's monthly income, in Kč	14,117	8,839	15,577	11,427
household monthly income, in Kč	23,468	15,141	23,955	15,731
employed in agriculture	0.016	0.126	0.024	0.152
gardener	0.641	0.480	0.683	0.466
beer lover	0.335	0.472	0.270	0.444
wine lover	0.229	0.420	0.257	0.437

Note: There are 16.1% of respondents who are not gardeners, not beer lovers, nor wine lovers.

[2] Data from the pilot survey were also excluded due to changes in the design implemented before the main wave.

In addition, we also defined samples where protestors were excluded (see Table A2 in Appendix). Protestors were defined as those who chose the status quo for every choice task, and indicated that they did not trust the information provided; desired to have more information to make their decisions; or wrote in the comments that they had made a mistake in clicking the status quo. After excluding the protesters, the final samples included 767 and 445 valid observations, respectively.

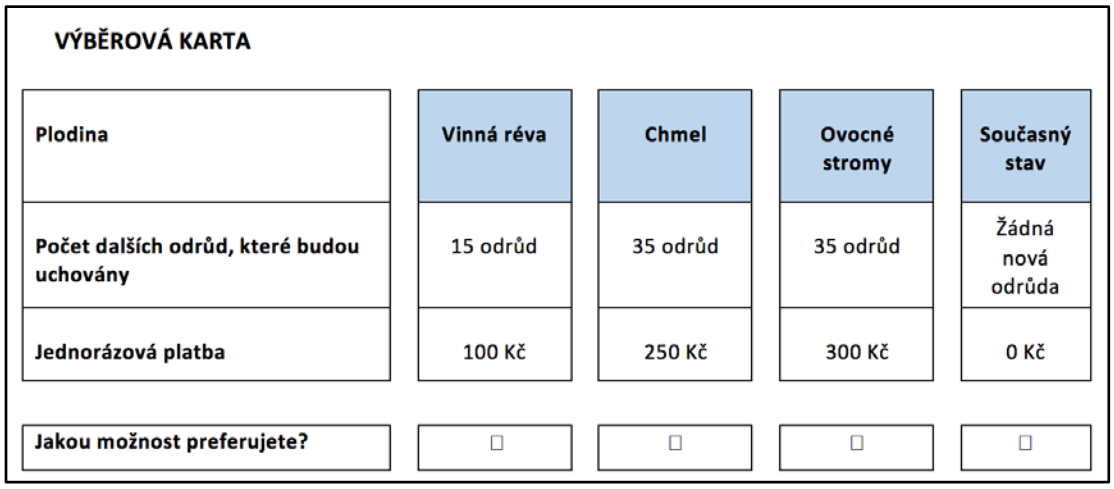
3.2 The instrument

The survey questionnaire included three other choice experiments (each with accompanying explanatory text, see Tyack and Ščasný 2018; 2020) in addition to the specific crop diversity experiment that provided the data analyzed in this paper. The instrument was first drafted in English and tested and developed through a qualitative pre-survey before being translated into Czech and programmed to be accessible online. The choice tasks came after questions regarding the quota filling (and screening), habits and attitudes towards crop diversity and an introductory text about crop diversity and its importance. Socio-economic questions that were potentially more sensitive (e.g. regarding income) were asked after the experiment to avoid affecting the results. The questionnaire was tested in a three-day pilot (n=175) before the main wave of the survey was administered with the updated design over a five-day period in July 2016.

3.3 The discrete choice experiment

The discrete choice experiment focused on three crop types: hops, fruit tree, and wine varieties. Respondents were asked to choose between several proposed conservation plans. Figure 1 provides an example of the choice cards used in this experiment, in the Czech language, in which there is a “Status Quo” option (zero costs and zero varieties conserved), a “hop conservation” option, a “wine conservation” option, and a “fruit tree conservation” option.

Figure 1. Example choice card



VÝBĚROVÁ KARTA

Plodina	Vinná réva	Chmel	Ovocné stromy	Současný stav
Počet dalších odrůd, které budou uchovány	15 odrůd	35 odrůd	35 odrůd	Žádná nová odrůda
Jednorázová platba	100 Kč	250 Kč	300 Kč	0 Kč
Jakou možnost preferujete?	☐	☐	☐	☐

Note: "Vinná réva," "Chmel," "Ovocné stormy," and "Současný stav," mean "Wine," "Hops," "Fruit trees," and "Status quo" in English. The Czech word for varieties is "odrůd" (genitive form), while "Žádná nova odrůda" means "No new variety." The equivalent of the text in the four rows at the left should read in English, "Crop," "Number of other varieties to be conserved," "One-time payment," and" Which option do you prefer?", from top to bottom.

Each of the choice tasks proposed a programme to conserve a given number of currently unconserved varieties of the type of crop listed (hops, fruit trees or wine) for 10 years at a certain cost. Bid values were adjusted in the main wave to reflect the findings of the pilot. Specifically, the final bid values for the main wave were 25, 50, 100, 150, and 250 Kč for hops and wine, while the bid values remained the same as in the pilot study for fruit trees (with 50, 100, 200, 300, and 500 Kč), as reflected in Figure 1. The number of varieties varied between 5 and 35.

Full factorial design was not possible due to the high number of permutations because of the greater complexity of this choice experiment, and so a D-efficient design was generated using NGENE software (Choicemetrics, 2014), a software program designed to create experimental designs for stated choice experiments, using the prior values between 0.5 and 1.0 for the varieties and -1.0 for the cost.[3] The design resulted in 100 unique choice situations divided into 25 blocks, allocated randomly to each respondent.

[3] Prior coefficients for the utility components resulting from conserving hop, fruit tree and wine varieties were originally set in the pilot based on the author's judgement according to the approach laid out in Bliemer and Collins (2016). We hypothesized that hops would be preferred (prior coefficient estimated at 1.0), followed by wine (0.70) and then fruit trees (0.60). However,

3.4 The econometric approach

Our econometric analysis is based on the assumption that the responses to the discrete choice questions are driven by a random utility model (McFadden 1974), in which respondent *i*'s utility associated with choosing alternative *j* out of the *J* alternatives in a given choice task *t* is expressed as follows:

$$V_{ijt} = \mathbf{X}_{ijt}\mathbf{b}_i + p_{ijt}a_i + e_{ijt} \quad (1)$$

We estimate a mixed logit model (MXL) to analyze our survey response data. Since MXL relaxes the assumption regarding the independence of irrelevant alternatives, MXL is generally considered to be a superior model for analyzing discrete choice experiment data. In contrast to the conditional logit model, and consistent with the random utility model, the utility parameters are modeled as random rather than fixed, following a specified multivariate parametric distribution and hence allowing preferences to differ for each individual. In this way MXL models unobserved preference heterogeneity. The term X_{ijt} represents a vector of alternative-specific attributes (hop, wine, fruit tree varieties), *p* is an additively separable cost, and vector b and scalar *a* are coefficients and indicate the marginal utilities associated with the conservation of crop varieties and marginal utility of income, respectively.

In the mixed logit models, we assume all coefficients are random and freely correlated, and normally distributed, except for the cost coefficient, which is lognormally distributed and enters the model as negative. Willingness to pay is given as the ratio of the two coefficients, b/a, both with predefined distribution. An individual will choose alternative j if $U_{ijt} > U_{ikt}$ for all k ≠ j, and the probability that alternative j is chosen from a set of J alternatives is expressed as:

$$P_{(j|J)} = \frac{exp\left(X_{ijt}(\sigma_i b_i) + p_{ijt}(\sigma_i a_i)\right)}{\sum_{k=1}^{J} \exp(X_{ikt}(\sigma_i b_i) + p_{ikt}(\sigma_i a_i))} \quad (2)$$

There exists no closed form expression of (2), but it can be simulated by averaging over *D* draws from the assumed distributions (Train 2003). We estimate the model using a maximum

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the pilot data revealed that the opposite was in fact true, and so priors were re-estimated based on the pilot data, resulting in the final priors shown in the equations above.

likelihood technique. Specifically, we use the *mixlogit* procedure in STATA with 1,000 Halton draws used for the simulation (Hole, 2007). The mean WTP is estimated using the *nlcom* STATA procedure for nonlinear combinations of estimators, based on the delta method.[4]

4. Results

In this section, we present first the main results for the Czech and South Moravian samples, then an additional regression including elements of observed heterogeneity (gardening and drinking habits), and finally discuss the policy implications of the analysis.

4.1 Main results

All MXL models presented in this section are estimated in preference-space. We specify all attributes as random parameters of a normal distribution, given the finding of significant heterogeneity for each demonstrated by the significance of the standard deviation coefficient estimates, with the exception of cost, which we specify as random and distributed lognormally, following the practice of Tuhkanen *et al.* (2016), Karloseva *et al.* (2016), and Hess and Train (2017) in restricting the utility of cost to be strictly negative.

The MXL estimate for the Czech general population (excluding speeders) are presented below in Table 2. In the first model, we examine preferences for a "conservation package" including the type of crop and the number of varieties to be conserved. This basic model corresponds to a labelled experiment in which the alternative-specific constant (ASC) captures the entirety of the utility for conserving the respective crop variety, except for the quantity of varieties conserved. All coefficients are positive and statistically significant (see Table 2). The estimated standard deviations are also all significant, indicating that heterogeneity in preferences for the number of varieties, type of crop specified in the conservation program and cost is present. Mean willingness to pay is ~278 Kč for a generic fruit tree conservation program, ~127 Kč for wine, and ~77 Kč for hops. Respondents sampled from the general Czech population were also willing

[4] Finney (1971) argue that the delta method is an adequate method for statistical inference of a ratio of two random variables if the z-statistics on the denominator is above 8.75; see also Carson and Czajkowski (2019). This requirement is satisfied in all our MXL models.

to pay on average about 2.5 Kč more for each additional variety conserved, irrespective of the crop.[5]

Table 2. Mixed logit model results for the Czech general population

Variable	Mean	Standard deviation
ASC Fruit Trees	1.850*** (0.175)	1.395*** (0.279)
ASC Wine	0.843*** (0.166)	1.315*** (0.264)
ASC Hops	0.513*** (0.189)	1.525*** (0.266)
Varieties	0.016*** (0.006)	0.028*** (0.008)
-Cost	-5.013*** (0.223)	3.773*** (0.374)
No. of obs: 12,880		
No. of ID's: 805		
No. of parameters: 20		
Log-likelihood: -3403.626		
Halton draws: 1,000		

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

We find considerably higher WTP for conservation programs for the three crops in the more agrarian region of South Moravia, as shown in Table 3, though again with fruit tree conservation programs being preferred the most, followed by wine, and then hops programs. The mean respondent WTP in the South Moravian sample for fruit tree conservation is estimated to be ~790 Kč, ~525 Kč for wine conservation, and ~385 Kč for hop conservation. Despite the fact that respondents from the South Morava region are willing to pay more than 3- to 5 times more than respondents from the Czech population for crop conservation (alternative-specific constants), South Moravians were not found to be sensitive to the number of varieties conserved (indicated by not significant coefficient for number of variety).

Table 3. Mixed logit model results for the South Moravia sub-sample, including protestors[1]

Variable	Mean	Standard deviation
ASC Fruit Trees	2.619*** (0.271)	1.747*** (0.328)
ASC Wine	1.741*** (0.265)	1.372*** (0.340)
ASC Hops	1.274*** (0.274)	1.216*** (0.336)
Varieties	0.004 (0.007)	0.014 (0.012)
Cost	-5.710*** (0.390)	4.639*** (0.584)
No. of obs: 7,408		

[5] Regressing the number of varieties variable interacted with each crop type did not yield significantly different results, indicating that the average respondent was willing to pay roughly the same for programs with more varieties conserved irrespective of the specific crop type conserved by the program.

No. of ID's: 463
No. of parameters: 20
Log-likelihood: -1985.102
Halton draws: 1,000

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

As a robustness check, we estimate the same MXL model specification when protesters are excluded; these results are reported in Table A2 in Appendix. Table 4 presents a summary of the mean WTP estimates for both the Czech representative sample and the South Moravian sample, with protestors included or excluded. We interpret the WTP values after protestors were removed from the sample as an upper-bound estimate of mean WTP, while the values derived from the full samples (i.e. that include protestors) may be considered more conservative estimates of WTP. We find that excluding protestors leads to between ~20 to 30% higher mean WTP estimates (depending on the crop) for the Czech representative sample, while excluding protestors in the S. Moravian sample does not lead to a substantial change in WTP estimates.

Table 4. Mean WTP estimates for conservation of specific crop and their quantity, by sample, in Czech crowns

Model	Fruit Trees	Wine	Hops	for each additional variety
General Czech population				
full sample	278.1***	126.8***	77.2**	2.5**
	(60.0)	(25.3)	(31.6)	(1.05)
protestors excluded	333.6***	153.7***	99.4***	2.9**
	(70.0)	(42.5)	(37.8)	(1.23)
S. Moravian sample				
full sample	790.4***	525.4***	384.5**	1.2
	(291.2)	(205.1)	(157.2)	(2.16)

Note: Mean, s.e., confidence interval estimated by delta method, using nlcom in STATA. Standard errors are reported in parentheses.

We conclude that the "pure" WTP of the Czech general population for crop conservation (i.e. based on the alternative specific constant) is on average between ~278 Kč and ~334 Kč for additional fruit tree conservation; between ~127 Kč and ~154 Kč for additional wine variety conservation: and between ~77 Kč and ~99 Kč for the conservation of hop varieties.

Czechs are found to be sensitive with respect to how many varieties will be conserved in a genebank, with mean WTP at 2.47 Kč for each additional variety conserved, while respondents

living in South Moravia are not sensitive to the scope of the conservation programme. For 35 varieties – the maximum offered in our experiment – WTP is 163 Kč for hops, 213 Kč for wine, and 364 Kč for fruit trees. In other words, WTP for a conservation package with 35 varieties is 112%, 68%, and 31% larger than for the "pure" WTP.

4.2 Observed preference heterogeneity

In addition to the basic specification of mixed logit model, we also run a model interacting the attributes with three variables related to respondent' drinking preferences and habits: whether she prefers drinking beer ("Beer Lover"=1) or wine ("Wine Lover" =1) over other alcoholic beverages, and whether she gardens frequently ("Gardener"=1). These three covariates enter the model as interactions with each of the three crop types and are assumed to be random and normally distributed. Cost enters the model as negative and its coefficient is assumed to be log-normally distributed, as with the previous regressions. All factors enters the model additively, implying that, for instance, the utility of wine lovers for wine is equal to the sum of the coefficients for ASC(wine) and the coefficient for the interaction between wine and the wine lover dummy. The result for this model is displayed in Table 5.

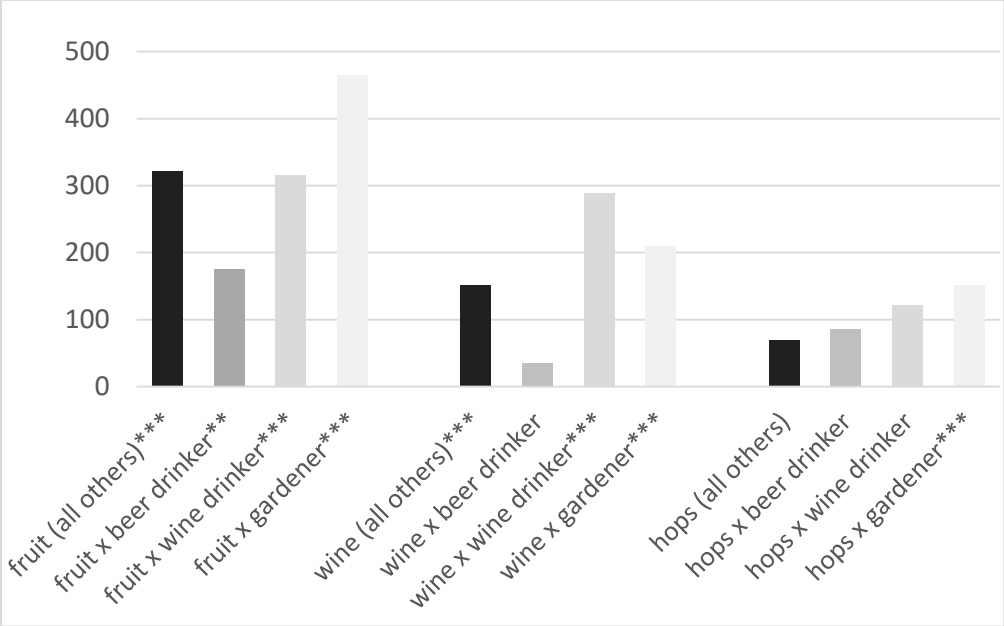
Table 5. MXL with random interaction terms for drinking preferences and gardening habits, Czech-representative sample

Variable	mean		s.e. (mean)	Standard deviation		s.e.(std)
ASC Hops	0.387		(0.304)	1.846	***	(0.523)
Hops x Beer Lover	0.097		(0.347)	1.298		(0.798)
Hops x Wine Lover	0.296		(0.398)	0.869		(0.901)
Hops x Gardener	0.465		(0.336)	1.690	***	(0.607)
ASC Fruit Trees	1.804	***	(0.308)	1.746	***	(0.440)
Fruit Trees x Beer Lover	-0.820	**	(0.352)	1.863	***	(0.600)
Fruit Trees x Wine Lover	-0.030		(0.399)	1.496	**	(0.754)
Fruit Trees x Gardener	0.812	**	(0.340)	2.131	***	(0.636)
ASC Wine	0.852	***	(0.290)	1.628	***	(0.488)
Wine x Beer Lover	-0.659	**	(0.323)	1.341	***	(0.514)
Wine x Wine Lover	0.771	**	(0.387)	0.978		(0.812)
Wine x Gardener	0.326		(0.312)	1.383	**	(0.654)
Varieties	0.012	**	(0.005)	0.032	***	(0.007)
-Cost[#]	-5.182	***	(0.215)	3.440	***	(0.318)
No. of obs:	12,272					
No. of ID's:	767					
No. of parameters:	119					
Log-likelihood:	-3291.59					

[1] Note: *, **, and *** represent 10, 5 and 1% significance levels, respectively; standard errors in parentheses. Protestors are excluded. [#] Cost is lognormally distributed, the implied estimate of mean is -0.005622 (s.e.=.001215) with standard deviation -0.006132.

"Wine lovers" are willing to pay almost twice as much as the reference group for the conservation of wine varieties, and gardeners are willing to pay about 50% more than the reference group for the conservation of fruit tree varieties. Still, there is large unobserved preference heterogeneity for the reference group (that is, the 16% of the sample that do not garden or prefer beer or wine) for all three crops. Although no interaction term for hops is significant at any convenient level, there is large unobserved preference heterogeneity, indicated by large and statistically significant estimates of the standard deviation of the mean estimates.

Figure 2. WTP estimates for consumer's segments defined by drinking preference and whether they do gardening, means in CZK per year



Note: ***, **, and * denotes p-values at 1%, 5%, and 10% for the WTP mean estimates.

The corresponding WTP estimates are reported in Figure 2. For hops, WTP is in a range of 69–152 Kč, however, all are not significantly different from zero at any convenient level, except for the WTP for gardeners (mean=152 Kč, s.e.=55 Kč). On the other hand, WTP for fruit trees the largest among the three crops, between 175 Kč for beer lovers and 465 Kč for gardeners, and all estimates are significant at 1%, with exemption for beer lovers that is significant at 5% level only. The WTP for beer lovers 175 Kč (s.e.=74 Kč) is statistically different from mean WTP estimates

for all three remaining segments. WTP for fruit trees by gardeners 465 Kč (s.e.=98 Kč) is larger than WTP for wine lovers (mean=315 Kč, s.e.=96), but the two are not statistically different from each other. WTP estimates for wine variety conservation are in a range of 0–289 Kč, with the lowest value for beer lovers and the largest one for wine lovers (s.e.=92 Kč). Gardeners are also willing to pay for wine variety conservation on average 210 Kč (s.e.=59 Kč), and this estimate is not statistically different from that for wine lovers. WTP estimates for the three crops across the three consumer segments are reported in Table 6.

Table 6. WTP estimates for consumers segments, t test across crops

	fruit trees	wine	hops	t-test, ch2	
gardener	465.39 ***	209.56 ***	151.76 ***	20.64	WTP[fruit]=WTP[wine]
	(465.39)	(209.56)	(151.76)	20.35	WTP[fruit]=WTP[hops]
				2.88	WTP[wine]=WTP[hops]
wine drinker	315.59 ***	288.74 ***	121.58	0.3	WTP[fruit]=WTP[wine]
	(315.59)	(288.74)	(121.58)	7.99	WTP[fruit]=WTP[hops]
				6.44	WTP[wine]=WTP[hops]
beer drinker	175.14 **	34.34	86.18	6.37	WTP[fruit]=WTP[wine]
	(175.14)	(34.34)	(86.18)	2.83	WTP[fruit]=WTP[hops]
				1.06	WTP[wine]=WTP[hops]

***, **, * denotes significance at 1%, 5%, and 10% level, respectively.

As shown here, gardeners (65% of the sample) are willing to pay the most and the three values differ one from the other (for hops and wine at 10% level only). Naturally, fruit trees are more likely to appear in private gardens than hops, which are almost never planted by individuals, and only few individuals maintain personal vineyards. This is also reflected in gardeners' preferences and hence their WTP values. Wine lovers (23% of the sample) have the highest preference for conservation of wine varieties with a WTP equal to 289 Kč, but they are not ready to pay anything for hops. Still, their WTP for wine is smaller than for fruit trees, but the two do differ one from the other. Interestingly enough, beer lovers (32% of sample) are not willing to pay for hops, but they are willing to pay for fruit trees, though their preference for fruit trees is the lowest.

4.3 Policy implications

The estimated social benefits for the Czech public of conserving additional varieties of hop, wine and fruit tree varieties is quite substantial, ranging from about 580 million Kč a year in the case

of hops to 2.1 billion Kč in the case of fruit trees (conservative estimates based on the data that includes protestors and not counting the additional WTP for the number of varieties). Assuming a programme conserving 18 additional varieties – that is the average number of varieties offered in our design – we arrive at a total estimate of social benefits at 0.91 billion, 1.28 billion, and 2.42 billion Kč a year, respectively (Figure 2).[6]

Table 8. Aggregate estimated benefits for the Czech Republic and South Moravia (with protestors excluded in brackets), for a 10-year programme conserving 18 varieties (average number used in the design).

Model	Fruit Trees	Wine	Hops
Estimated total benefits			
Cz. General Population	2.339 billion Kč	1.241 billion Kč	881 million Kč
(in brackets with excluded protestors)	(2.794 billion Kč)	(1.489 billion Kč)	(1.096 billion Kč)
S. Moravian sample*	639 million Kč	425 million Kč	311 million Kč
Cost of crop conservation			
10-year conservation costs by crop**	47 million Kč	16.5 million Kč	15 million Kč

Notes: * No varieties are assumed, since the coefficient for quantity is not statistical significant at any convenient level. ** Cost estimates were provided by Dr. Vojtech Holubec of the Crop Research Institute; further budget documentation available at http://genbank.vurv.cz/genetic/nar_prog_rostlin/Dokumenty/GZ_Zasady_2015.pdf. Costs for fruit tree conservation are lumped together with the costs of maintaining the Czech berry collection.

When the benefits are compared to the 10-year conservation costs by crop, we find that the social benefits of the proposed programs are much greater than the current costs of the relevant conservation programs projected over a ten-year period, ranging from a ratio of 50 (fruit trees) to 75 (wine varieties). These figures indicate that the willingness of Czechs to pay for such conservation activities greatly outweigh the current public funding levels in the case of these three crops – suggesting that an expansion of these collections would be supported by the public.

6. Conclusion

[6] The estimated social benefits are approximated by multiplying the mean WTP figures per person for the respective samples, as reported in table 4, with the respective adult population obtained from the Český statistický úřad (Czech Statistical Office, www.czso.cz) of approximately 7.5 million and 830,000 individuals for this age range in the Czech Republic and South Moravia for 2015, respectively.

The primary objective of this choice experiment was to derive the mean willingness to pay of the Czech population (and of the South Moravian population) for the conservation of additional varieties of hops, wine and fruit trees, and to examine the degree of preference heterogeneity related to this conservation programs. We utilize mixed logit model as our preferred econometric approach for determining WTP.

In conclusion, we find a strong preference among Czechs for conserving fruit tree varieties over hop and wine varieties, and estimate an aggregate WTP for the Czech Republic for a 10-year conservation program for additional fruit tree varieties of at least two billion Kč. Aggregate country-wide WTP for conserving additional wine varieties is estimated to be about one billion Kč, and while aggregate WTP for hop conservation is at least 580 million Kč. These estimates increase by 31 percent, 68 percent, and 112 percent for fruit trees, wine, and hops, respectively, if we add WTP for the maximum number of crop varieties (of 35) as offered in our design. These sums are substantial when compared to the comparable 10-year cost of about 380 million Kč of running the entire Czech genebank system, with holdings consisting of over 50,000 seed samples. In addition, we find evidence of significant heterogeneity in the sample in terms of preferences for conserving the three crop types. This finding was corroborated by further analysis with several variables interacted with socioeconomic characteristics. For example, we find that only those who regularly gardened were willing to pay to conserve fruit tree varieties, while those who prefer to drink wine over other alcoholic drinks were willing to pay more than 50 percent more than the general population for the conservation of wine varieties.

In terms of policy implications, our results suggest that work by the Czech National Programme for Agrobiodiversity to search out, collect and conserve fruit tree, wine and hop varieties that are not currently in the national genebank holdings would have substantial social welfare benefits, particularly when compared to the costs of conservation. We found that the public was most interested in paying to conserve additional fruit tree varieties, indicating that this crop should be prioritized for further collection and conservation efforts; however, the ratios between the WTP estimates for conserving the three crop types to the current 10-year conservation costs were quite large for all three, ranging from a ratio of 44 in the case of fruit trees to 57 in the case of wine varieties. We thus find strong support among the public in terms of their demand for the crop

diversity conservation services provided by the national Czech genebank system, and our results suggest that Czechs would support an expansion of these programs in the case of these crops.

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Appendix A

Table A1. Number of respondents, percentage of speeders and protestors by sub-sample

Sub-sample	mode	N (completed)	% of speeders	**N valid, incl. protestors**	% of protestors	**N final excluding protestors**
Czech Republic representative	**CAWI**	965	6.6%	**805**	4.7%	**767**
S. Moravia representative	**CAWI**	500	7.4%	**463**	3.9%	**445**

Table A2. Mixed logit model results for the Czech general population, excluding protestors[1]

Variable	Mean	Standard deviation
ASC Fruit Trees	1.764*** (0.170)	1.364*** (0.289)
ASC Wine	0.813*** (0.162)	1.335*** (0.261)
ASC Hops	0.526*** (0.179)	1.555*** (0.266)
Varieties	0.015*** (0.005)	0.027*** (0.007)
-Cost	-5.243*** (0.218)	3.267*** (0.330)
No. of obs: 12,272		
No. ID's: 767		
No. parameters: 20		
Log-likelihood: -3350.987		
Halton draws: 1,000		

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

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