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COMBINING REVEALED AND STATED PREFERENCE METHODS TO ASSESS THE PRIVATE VALUE OF AGROBIODIVERSITY IN HUNGARIAN HOME GARDENS

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Abstract

Hungarian home gardens are small-scale farms managed by farm households using traditional management practices and family labor. They generate private benefits for farmers by enhancing diet quality and providing food when costs of transacting in local markets are high. Home gardens also generate public benefits for society by supporting long-term productivity advances in agriculture. In this paper, we estimate the private value to farmers of agrobiodiversity in home gardens. Building on the approach presented in EPTD Discussion Paper 117 (2004), we combine a stated preference approach (a choice experiment model) and a revealed preference approach (a discrete-choice, farm household model). Both models are based on random utility theory. To combine the models, primary data were collected from the same 239 farm households in three regions of Hungary. Combining approaches leads to a more efficient and robust estimation of the private value of agrobiodiversity in home gardens. Findings can be used to identify those farming communities, which would benefit most from agri-environmental schemes that support agrobiodiversity maintenance, at least public cost.

Keywords: revealed and stated preference methods; choice experiment model; farm household model; home gardens; agrobiodiversity; Hungary

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INTRODUCTION

Hungarian agriculture today has a dual structure consisting of large-scale, mechanized farms alongside semi-subsistence, small-scale farms managed with family labor and traditional practices. Dualism has persisted in some form throughout Hungarian history. From 1955 to 1989, during the socialist period of collectivized agriculture, families were permitted to produce for their own needs on small tracts adjacent to their dwellings, commonly known as "home gardens" (Szelényi 1998; Kovách 1999; Swain 2000; Szép 2000; Meurs 2001; Cros Kárpáti et al. 2004). These small-scale farms became refuges for a range of local varieties of trees, crops and livestock breeds, as well as soil micro-organisms. Agricultural scientists describe home gardens as micro-agro-ecosystems that are rich in several components of agrobiodiversity (Már and Juhász 2002; Csizmadia 2004).

Despite the changes engendered by transition to market economy during the past decade, the structure of agriculture remains dualistic.[4] In addition to lower agricultural incomes, high inflation and unemployment rates, consumers have difficulties obtaining

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[4] In 1994, less than 0.2% of farms (public, cooperative and private) in Hungary operated 84% of agricultural land, whereas 77% of them operated less than 4% of it on areas smaller than 0.5 ha (Sarris *et al.* 1999).

reliable product information and predicting product availability (Feick et al. 1993). Search costs and transport costs to the nearest food market remain high. The number of hypermarkets in Hungary has grown from only 5 in 1996 to 63 in 2003 (Hungarian Central Statistical Office (HCSO) 2003). A study by the World Health Organization (WHO 2000) found that these have contributed to the disappearance of the few extant local shops and markets.

Consequently, rural families continue to rely on their own production to meet their food needs and maintain diet quality. In 2001, HSCO reported that one fifth of the population produced agricultural goods for their own consumption and as a source of additional income on 697 336 small family farms with an average size of 591 m^2 (HSCO 2001). Szivós and Tóth (2000) estimated that 60 percent of the households in the lowest income quartiles, most of whom located in rural Hungary, consume food from own production, with a value amounting to 19277 Ft (€75.3) per month. Szép (2000) found that income in kind generated by part-time agricultural production in home gardens amounted to 14 percent of total income of the households. Thus, as in other countries with economies in transition, home gardens in Hungary generate substantial private benefits (Wyzan 1996; Seeth et al. 1998).

Many expect that as a result of continued economic transition and the nation's accession to the European Union (EU), the dual structure of Hungarian agriculture and the share of home-produced food will eventually disappear (Sarris et al. 1999; Vajda 2003; Fertő et al. 2004; Weingarten et al. 2004). The rural population is expected to continue to decline and age as younger generations migrate to urban areas (Harcsa et al. 1994; Sarris et al. 1999; Juhász 2001). If this is the case, private provision of public goods generated by home garden management cannot be sustained in the long run. Although the reformed Common Agricultural Policy (CAP) of the EU aims to promote agrobiodiversity and other public goods generated by agricultural production through multi-functional agriculture (Lankoski 2000; Romstad et al. 2000), the contribution of home gardens to multifunctional agriculture in Hungary appears to have been overlooked in other EU and national policies. For example, Hungary's National Rural Development Plan (NRDP) implements several agri-environmental schemes to advance the use of specified farming methods in environmentally sensitive areas (ESAs) (Juhász et al. 2000), but so far the role of home gardens within these schemes has not been elucidated.

This paper identifies the least-cost options for including farming communities in Hungary's agri-environmental schemes, by characterizing those who value agrobiodiversity in their home gardens most. We combine revealed preference and stated preference methods, using survey and choice experiment data collected from 239 farm households across 22 communities in three regions of Hungary. Findings from the combined approach are compared to those obtained separately from the choice experiment and farm household analyses. We conclude that combined estimation enables more robust and efficient identification of least-cost farming communities for maintaining agrobiodiversity in Hungarian home gardens. This result is similar to those found in previous studies that have employed data fusion methods to value non-market, environmental goods (e.g., Adamowicz et al. 1994; Earnhart 2001; 2002).

The analysis makes several contributions to the literature. Perhaps most importantly, it confirms that the data fusion approach leads to policy recommendations that are distinct from those generated by either revealed preferences or stated preferences alone. In the literature about valuing agrobiodiversity, this analysis is the first to combine and compare data for the same households rather than comparing data from different sources (ECOGEN 2005). Third, the study presented in this paper is the first one that combines choice experiment data with farm household data. Other papers have combined choice experiment data with travel cost data, hedonic pricing data, or have combined contingent valuation data with travel cost data (Cameron 1992; Adamowicz, et al. 1994; 1997; Englin and Cameron 1996; Kling 1997; Rosenberger and Loomis 1999; Boxall et al. 2002; Earnhart 2001; 2002). Finally, in the relatively scant literature about data fusion, this analysis is the first related to agrobiodiversity. Previous studies have combined data on recreation, environmental amenity, cultural heritage, and market goods, such as housing markets or transportation (see e.g., Ben-Akiva and Morikawa 1990; Swait et al. 1994; Adamowicz et al. 1994; 1997; Rosenberger and Loomis 1999; Boxall et al. 2002; Earnhart 2001; 2002).

The next section describes the rationale for combining stated and revealed preference valuation methods in this study. The following section summarizes data collection methods and data. Section 4 presents the theoretical basis of the approach. Section 5 reports the results of the econometric analyses and the final sections conclude the paper and state the policy implications.

RATIONALE FOR COMBINING FARM HOUSEHOLD AND CHOICE EXPERIMENT DATA

Methods for valuing non-market, public goods are categorized as revealed preference or indirect methods and stated preference or direct methods. Revealed preference methods use actual choices made by consumers in related or surrogate markets, in which the non-market good is implicitly traded, to estimate the value of the non-market good. Stated preference methods have been developed to solve the problem of valuing those non-market goods that have no related or surrogate markets. In these approaches, consumer preferences are elicited directly based on hypothetical, rather than actual, scenarios.

Both stated and revealed preference methods have advantages and disadvantages. Stated preference methods are commonly criticized because the behavior they depict is not observed (Cummings et al. 1986; Mitchell and Carson 1989) and thus they generally fail to take into account certain types of real market constraints (Louviere et al. 2000). Nonetheless, these methods provide the only means for estimating the value of public goods that have no related or surrogate markets. Stated preference methods can be used to cover a wider range of attribute levels in cases where revealed data do not encompass the range of proposed quality or quantity changes in the attributes of a public good. Hence, they can be used to consider an array of choices that are fundamentally different than existing ones, as well as exploit information about attribute trade-offs[5] (Swait et al. 1994). The choice experiment method, in particular, can be used to measure the value of changing the quantity or quality of multiple attributes of a public good.

Revealed preference data have high "face validity" because the data reflect real choices and take into account various constraints on individual decisions, such as market imperfections, budgets and time (Louviere et al. 2000). A major drawback of using revealed preference data is that because the attributes and attribute levels of the non-market good do not vary over time in a single cross-section, the value of changes in the

[5] See Louviere et al. (2000), Bennett and Blamey (2001) and Adamowicz and Deshazo (2006) for detailed discussions of advantages and disadvantages of stated preference, choice experiment method.

quality or quantity provided of the public good are difficult to estimate without panel data. Coefficients on attributes in models estimated from choices in actual settings provide only limited predictions of the impact of changing policies (Louviere et al. 2000). In other words, the new situation (after the change in the quality or the quantity of the non-market good) may be outside the current set of experiences (or outside the data range). Thus, simulation of the new situation generally involves extrapolation outside the range used to estimate the model (Adamowicz et al. 1994). Collinearity among multiple attributes is also common in revealed preference data, generating coefficients with the wrong signs or implausible magnitudes, and making it difficult to separate attribute effects (Freeman 1993; Greene 1997; Louviere et al. 2000; Hensher et al. 2005). Separation of these attributes may be necessary, however, in order to accurately represent benefits and costs in policy analysis (Adamowicz et al. 1994).

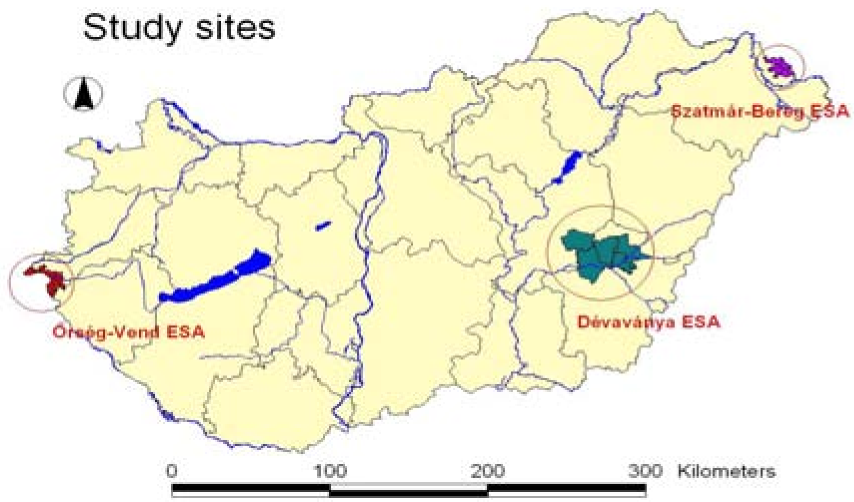
Recent research indicates that combining the stated and revealed preference methods through data fusion, which is also known as the data enrichment method, builds on the strengths and diminishes the drawbacks of each method. The amount of information increases, and findings can be cross-validated (Haab and McConnell 2002). Use of revealed preference data ensures that estimation is anchored in observed behavior. At the same time, inclusion of stated preference responses to hypothetical changes enables identification of parameters that otherwise would not be identified. Fusing data sources is similar to creating an “artificial” panel data, with revealed preference methods generating cross-sectional data about the observed, current choices of consumers facing real market constraints, and stated preference data recording the options the same consumers might choose at another point in time. Revealed preference models are suitable for short term forecasting of small departures from the current state, whereas stated preference models are more appropriate to predict structural changes that occur over longer time periods (Louviere et al. 2000). The choice experiment method, a stated preference approach, also employs statistical design to eliminate collinearity among the attributes of goods. Overall, combining stated and revealed responses improves the efficiency of estimates of values of the changes in the quality/quantity of the non-market good over time (Haab and McConnell 2002). Thus, the accuracy of welfare measures derived from non-market, public goods are improved through applying the data enrichment model (Adamowicz et al. 1994; Earnhart 2001; Haab and McConnell 2002).

The revealed preference approach we employ is a discrete-choice farm household model, similar to the discrete-choice hedonic model applied by Cropper et al. (1993) and Earnhart (2001; 2002). We use the choice experiment method as the stated preference approach, for several reasons. First, the purpose of the study is to value the agrobiodiversity components, or multiple attributes, of home gardens. The choice experiment method also reduces some of the biases inherent in the contingent valuation method. Since the survey format is designed to mimic the actual choices of farm households, it is less prone to hypothetical bias. Respondents have a solid understanding of the good being valued in the choice experiment, so that the likelihood of information bias is greatly reduced (Earnhart 2001; 2002; Bateman et al. 2003). We also analyze the choice experiment data with a discrete-choice econometric model.

DATA COLLECTION

The sample design for the choice experiment and farm household surveys consisted of two stages. In the first stage, secondary data from HCSO (2001) and NRDP were used to select three ESAs (Dévaványa, Őrség-Vend and Szatmár-Bereg) amongst 11 ESAs identified by the NRDP (Figure 1).

Figure 1--Location of the selected ESAs



Source: GIS Laboratory, Institute of Environmental and Landscape Management, Szent István University, Gödöllő, Hungary.

These three ESAs were purposively selected to represent contrasting levels of market development and varying agro-ecologies associated with different farming systems and land-use intensity. In each selected site, pilot agri-environmental schemes were underway and high levels of agrobiodiversity (in terms of crop genetic diversity) have been identified (Már 2002).

Twenty-two communities (5 in Dévaványa, 11 in Őrség-Vend and 6 in Szatmár-Bereg) were included in the sample. Dévaványa, located on the Hungarian Great Plain, is closest to the economic centre of the country of the three ESAs. Soil and climatic conditions are well suited to intensive agricultural production. Populations, areas, and population density are relatively high. Labor migration is not a major problem, although the number of inhabitants is stagnating. The unemployment rate in this region (12.4 percent) is slightly higher than the Hungarian average. Dévaványa is statistically different from the other two ESAs in most indicators of economic development and market integration, including: presence of a train station; distance to the nearest market; number of primary and secondary schools; food markets; and the number of shops and enterprises.

The two isolated ESAs are more similar to each other than either is to Dévaványa. Located in the southwest, Őrség-Vend has a heterogeneous agricultural landscape with poor soil conditions that render intensive agricultural production methods impossible. Communities are very small in area and most are far from towns and markets. Of the three ESAs, Őrség-Vend is the least developed with fewest shops and enterprises. Its small population is declining and ageing, though the unemployment rate of this region is lowest in the country at 4.8 percent. Szatmár-Bereg is situated in the northeast, far from the economic centre of the country. Agricultural landscape of this ESA is heterogeneous and climatic conditions are unfavorable. Communities in Szatmár-Bereg are also small, and it's declining, ageing population reflects a lack of public investments in infrastructure and employment generation. Roads are of poor quality and the regional unemployment rate is the highest in the country (19 percent) (National Labor Centre 2000; Juhász et al. 2000; Gyovai 2002).

In the second stage of the sample design, all communities within each ESA were sorted based on population sizes, and an initial sample of 1800 households (600 households per ESA) was sampled randomly from a complete list of all households compiled from telephone books and village maps. A screening survey was sent to all of the 1800 households to identify all those engaged in home garden management. The response rate to the screening survey was only 13 percent, but the final sample was augmented through personal visits to listed sample households with the assistance of key informants in each community. A total of 239 farm households (74 in Dévaványa, 81 in Őrség-Vend and 84 in Szatmár-Bereg) were personally interviewed in August 2002 with the choice experiment and household surveys. All households sampled had home gardens, and the findings reported in this paper are statistically representative of households with home gardens in the selected ESAs, as well as other ESAs in Hungary to the extent that they share characteristics in common.

Choice Experiment data

The most important components of agrobiodiversity managed in Hungarian home gardens were identified with NRDP experts and agricultural scientists, drawing on the results of informal and focus group interviews with farmers in each ESA. This background work resulted in the attributes and levels used in the choice experiment[6] (Table 1).

[6] Please refer to Birol (2004) for a detailed explanation of the choice experiment survey design.

Table 1--Home garden attributes and attribute levels used in the choice experiment

Home garden attribute	Definition	Attribute levels
Crop variety diversity	The total number of different crop species and varieties that are cultivated in the home garden.	6, 13, 20, 25
Landrace	Whether or not the home garden contains a crop variety that has been passed down from the previous generation and/or has not been purchased from a commercial seed supplier.	Home garden contains a landrace vs. Home garden does not contain a landrace
Agro-diversity	Integrated crop and livestock production on the home garden, representing diversity in agricultural management system.	Integrated crop and livestock production vs. Specialized crop production
Organic production	Whether or not industrially produced and marketed chemical inputs are applied in home garden production.	Organic production vs. Non-organic production
Food self-sufficiency	The percentage of annual household food consumption that it is expected the home garden will supply.	15%, 45%, 60%, 75%

Source: Hungarian Home Garden Choice Experiment, Hungarian On Farm Conservation of Agrobiodiversity Project 2002.

Each attribute represents a different component of agrobiodiversity. The total number of crop varieties grown in a home garden of fixed size is an indicator of crop variety richness. In this choice experiment both inter- and infra-species diversity of field crops, trees and vegetables are considered. Crop variety diversity is one of the most crucial components of agrobiodiversity (FAO 1999). Presence of a landrace or a traditional, local variety in the home garden expresses crop genetic diversity.[7] Preliminary molecular analysis and agro-morphological evaluation conducted on bean landrace samples collected from the sampled households' home gardens reveal that the majority of these landraces are distinct and identifiable and contain rare and adaptive traits, and are genetically heterogeneous (Már and Juhász 2002). The traditional method of integrated

[7] Landraces, or traditional varieties or local varieties, are variants, varieties, or populations of crops, with plants that are often highly variable in appearance, whose genetic structure is shaped by farmers' seed selection practices and management, as well as natural selection processes, over generations of cultivation.

crop and livestock production represents agro-diversity, or diversity in agricultural management practices (Brookfield and Stocking 1999). Organic production takes place if crops are grown without any industrially produced and marketed chemicals, such as pesticides, herbicides, insecticides, fungicides or soil disinfectants. Previous experiments found that use of organic production methods resulted in soil micro-organism diversity (e.g., Lupwayi et al. 1997; Mäder *et al.* 2002). The expected percentage of the annual household food consumption supplied by the home garden, i.e. food self-sufficiency, represents the family's dependence on its own production. This proxy monetary attribute is converted into actual monetary units for each household by using secondary data from HCSO on the regional level household expenditure on food consumption (see, Birol et al. 2004).

A large number of unique home garden prototypes can be constructed from this number of attributes and levels.[8] Using SPSS Conjoint 8.0 software and experimental design theory, main effects, consisting of 32 pair wise comparisons of home garden prototypes, were recovered with an orthogonalisation procedure.[9] These were randomly blocked to 6 different versions, two with 6 choice sets and the remaining four with 5 choice sets. In face-to-face interviews, each farmer was presented with 5 or 6 choice sets, each containing two home garden management strategies and an option to select neither. The farmers who took part in the choice experiment were those responsible for making

[8] The total number of home garden prototypes that can be generated is $4^2*2^3=128$.

[9] Although exclusion of interaction effects in the experimental design may introduce bias into main effects estimations, main effects usually account for more than 80% of the explained variance in a model (Louviere 1988; Louviere *et al.*, 2000). Moreover, the aim of this choice experiment was to investigate farmer demand for each home garden attribute independently of the others. As explained in Section 2 above, an advantage of the choice experiment approach relative to revealed preference approaches is that the effects of each attribute on respondents' demand for the good can be separated, avoiding collinearity between the attributes (Adamowicz *et al.* 1994; 1997).

decisions in the home garden. Enumerators explained the context in which choices were to be made (a 500 m^2 home garden); that attributes of the home garden had been selected as a result of prior research and were combined artificially. Overall, a total of 1279 choices were elicited from 239 farmers taking part in the choice experiment. An example of a choice set is provided in Appendix 1.

Farm household data

The farm household data was collected through a structured survey. The questionnaire elicited information about the social, demographic and economic characteristics of the households and farm production characteristics, including the four components of agrobiodiversity in their home gardens. Information on the percentage of annual household income spent on food consumption was also collected, and this was converted into actual monetary value of food self-sufficiency provided by the home garden for each household, by using secondary data from HCSO on the regional level household expenditure on food consumption.

Actual home garden areas, annual food self-sufficiency and agrobiodiversity levels found in home gardens surveyed are reported in Table 2.

Table 2--Home garden management and agrobiodiversity by ESA

Home garden attribute	Dévaványa N=74	Őrség-Vend N=81	Szatmár-Bereg N=84
		Mean (s.e.)	
Home garden area (m^2)***	460.2 (456)	1817.6 (3257.6)	2548.1 (2850.3)
Annual food self-sufficiency (€)**	526.9 (572)	398.1 (582.6)	661.2 (676.8)
Crop variety diversity***	17.2 (9.1)	28.5 (12.2)	18.6 (7.3)
		Percentage	
Landrace ***	23.4	53.1	55.4
Agro-diversity	71.6	75.3	85.9
Organic production*	16.2	17.3	4.4

Source: Hungarian Home Garden Diversity Household Survey, Hungarian On-Farm Conservation of Agrobiodiversity Project 2002. T-tests and Pearson Chi square tests show significant differences among at least one pair of ESAs (*) at 10% significance level; (**) at 5% significance level, and (***) at 1% significance level.

Home gardens in Dévaványa, the most densely populated region and the most favored ESA in terms of agro-ecological conditions and market and other infrastructure, are the smallest. Those in Szatmár-Bereg, the most isolated ESA, are the largest. The annual value of the food self-sufficiency provided by the home garden is the highest in Szatmár-Bereg, the region with the lowest average incomes. Crop variety diversity is significantly higher in Őrség-Vend than in the other two ESAs. In Dévaványa, the percent of households growing landraces is less than half of that found in the other two. Use of organic production methods in the home garden is similarly represented in Dévaványa and Őrség-Vend. Across the three sites, a majority of households tend livestock along with crops in their homestead plots, with no statistically significant differences. In Szatmár-Bereg, the region with the largest home gardens, only 4.4% of farmers employ organic practices, which is significantly lower than in the other regions.

THEORETICAL FRAMEWORK

The theoretical basis for modeling the choice of farm management strategies in both the farm household and choice experiment analyses is random-utility theory (Luce 1958; McFadden 1974). The farm household chooses a management strategy that determines levels of agrobiodiversity and food self-sufficiency, the attributes of interest. Heterogeneity among farm households, markets, and agro-ecological conditions leads to variation in choices. Variation in choices in turn leads to variation in attribute levels.

The overall utility the farm household n derives from management strategy i, U_{in}, consists of a deterministic component, V_{in}, and a random component, e_{in}: $U_{in}=V_{in}(\mathbf{Z_i}, \mathbf{C_n})+e_{in}$. The deterministic component is modeled as an indirect utility function conditional on $\mathbf{Z_i}$, the vector of management attributes, and $\mathbf{C_n}$, the vector of household, market and agro-ecological characteristics which are specific to individual households and influence utility. Denote $\pi_n(i)$ as the probability that farm household n chooses management strategy i rather than management strategy j among all the feasible management strategies available in the set H_n. If the random components are identically and independently distributed (IID), Type I Extreme Value, with scale factor μ, then $\pi_n(i)$ is of the logit form:

$$\pi_n(i) = \text{Prob}\,(V_{in}+e_{in} \geq V_{jn}+e_{jn} :\ j \in H_n) = \exp(\mu V_{in}) \,/\, \Sigma_{j \in H} \exp(\mu V_{jn}) . \qquad [1]$$

The scale factor μ, which is inversely related to the variance of the error term in the conditional logit model[10] (Ben-Akiva and Lerman 1985), plays a crucial role in the process of combining data. Equation [1] shows that the scale factor and the vector of

[10] Note that unlike the multinomial logit model, which considers choice probabilities as dependent on individual characteristics only, the conditional logit model considers the effects of choice characteristics on the determinants of choice probabilities. Therefore the conditional logit model is the appropriate random utility model for estimation of the choice experiment and discrete choice farm household data (Greene 1997, p 913-914; Maddala 1999, pp 42).

utility parameters of the estimated model are inseparable and multiplicative. Hence, it is not possible to identify μ within a single data set and it is generally assumed to equal one. The scale factor associated with any data source, however, affects the values of the estimated parameters. This in turn implies that one cannot directly compare parameters from different data sources, even if the two data sources were generated by the same utility function. Consequently, a statistical test is required to determine if the parameter equality holds between data sets after accounting for scale (i.e., variance) differences (Swait and Louviere 1993; Louviere et al. 2000).

As the farmers surveyed are presented with three choices, the structure of the choice experiment restricts H_n to three. In the farm household analysis, on the other hand, farmers select one specific home garden management strategy from an infinitely large number of management strategies available to them. One means of coping with this mismatch is to select a subset of observations that includes both the strategies chosen by farmers and a fixed number of rejected strategies randomly drawn from the feasible set. Because they take account of both observed and rejected options, regression estimates are consistent and reflect the correct choice model (McFadden 1978; Earnhart 2001; 2002). Parsons and Kealy (1992) show that even a limited number of alternatives, as small as three, is appropriate for randomly drawn opportunity sets in a random utility model. Chattopadhyay (2000) uses only two alternatives.

For the revealed preference analysis, we postulate that the feasible set for each farmer consists of all management strategies that have been employed in the community in which the household is located, as elicited by the farm household survey. Given the similarities in farm household level, agro-ecological and market related conditions within each community, it seems reasonable to assume that any farm household in any one community could feasibly choose any other management strategy that has already been undertaken in its community. For each farm household in the farm household analysis, the feasible set includes two randomly drawn alternatives and the home garden management strategy undertaken by the household.

ECONOMETRIC ANALYSIS

As explained above, it is feasible to combine the two discrete-choice models employed in this paper since they reflect the same process of selecting a home garden management strategy. Both are applications of random utility theory. Each selection model considers the same attributes: four agrobiodiversity components and food self-sufficiency. Since each model is based on random utility theory and can be estimated with the conditional logit model, each can be used for welfare analysis of agrobiodiversity levels. The results of each approach taken alone and the combined approach can be compared (Cropper et al. 1993; Adamowicz et al. 1994; Earnhart 2001).

Separate estimation of revealed and stated preference data

Using the complete data set from all three ESAs, conditional logit models with logarithmic and linear specifications were compared for the two approaches. In both cases the highest value of the log-likelihood function was found for the specification with all of the attributes in linear form. For the population represented by the sample, indirect utility from home garden attributes takes the form

$$V_{in}=\beta_1(Z_{crop\ variety\ diversity})+\beta_2(Z_{landrace})+\beta_3(Z_{agro\text{-}diversity})+\beta_4(Z_{organic})+\beta_5(Z_{foodself\text{-}sufficiency}) \quad [2]$$

V_{in} is the indirect utility from the choice of a home garden management strategy, which is a function of β_{1-5}, the vector of coefficients associated with the vector of attributes describing home garden characteristics. The regression equation is estimated with a conditional logit model using full-information maximum likelihood techniques (LIMDEP 8.0 NLOGIT 2.0). The conditional logit model has the Independence of Irrelevant Alternatives (IIA) property, as a consequence of the IID assumption across both alternatives and individuals. Violations of IIA imply error heterogeneity resulting from omitted variable bias. Following Swait and Louviere (1993), our approach assumes that the conditional logit model is the true model in the application of interest.

The results of the conditional logit estimation for the stated preference, choice experiment model are reported in Table 3.

Table 3--Conditional logit regression of stated preference, choice experiment data

Attribute	Dévaványa	Őrség-Vend	Szatmár-Bereg
		Coefficient (S.E.)	
ASC	0.409* (0.277)	-0.242 (0.247)	0.392*(0.273)
Crop variety diversity	0.009 (0.011)	0.018** (0.010)	0.014*(0.010)
Landrace	0.015 (0.076)	0.185*** (0.071)	0.123**(0.069)
Agro-diversity	0.447*** (0.079)	0.268*** (0.076)	0.40*** (0.074)
Organic production	0.213*** (0.083)	0.084 (0.076)	0.121*(0.075)
Food self-sufficiency	$0.183\text{x}10^{-5}$***	$0.347\text{x}10^{-5}$***	$0.356\text{x}10^{-5}$***
	($0.682\text{x}10^{-6}$)	($0.576\text{x}10^{-6}$)	($0.705\text{x}10^{-6}$)
Sample size	393	436	450
ρ^2	0.092	0.103	0.167
Log likelihood	-381.99	-419.52	-401.01

Source: Hungarian Home Garden Choice Experiment, Hungarian On-Farm Conservation of Agrobiodiversity Project 2002. (*)10% significance level; (**)5% significance level; (***)1% significance level two-tailed tests.

The null hypothesis that the separate effects of ESAs are equal to zero was rejected with a Swait-Louviere log-likelihood ratio test (with 6 d.o.f. at the 0.5 percent significance level) based on regressions with the pooled and separate ESA samples. Findings are therefore reported only for the separate ESA samples.

In Dévaványa, where food markets are fully developed, and home gardens are small in size, the stated preferences of farm households for crop variety diversity is statistically insignificant. Nevertheless, the observed richness of crop varieties in dévaványai home gardens is as high as it is in Szatmár-Bereg, one of the two more remote ESAs. Farmer demand for landraces is also insignificant in this ESA. Few sample farmers in Dévaványa cultivate landraces. The stated demand for agro-diversity is large and significant, owing to complementarity between field crop production and animal husbandry in the home garden. There is also a significant and relatively large stated demand for organic production.

In the isolated ESA of Őrség-Vend, where community level food markets are lacking, farmers state clearly preferences for home gardens with diverse crop varieties and landraces. No stated demand for organic production is evident in this ESA, perhaps reflecting its poor soil quality, even though in reality this ESA supports the highest percentage of home gardens managed with this method.

In Szatmár-Bereg, the other isolated ESA, where market infrastructure is also poor, farm households also state a positive and significant demand for landraces and higher levels of crop variety diversity. Farmers in Szatmár-Bereg also place great importance on agro-diversity. The high unemployment rates in this ESA may render labor intensive animal husbandry practices less costly in terms of the opportunity cost of time. The coefficient on organic production is positive and significant, even though the sample data indicates that among the three ESAs, Szatmár-Bereg supports the lowest percentage of home gardens managed with this method.

Across the three ESAs, the level of food self-sufficiency obtained from the home garden contributes positively and significantly to the demand for a hypothetical home garden management strategy with higher levels of this attribute. An alternative specific constant (ASC) was included in the stated preference model to account for the proportion of respondents selecting one or the other of the management strategies offered in the experiment.[11] The sign on the ASC is positive and significant for Dévaványa and

[11] While coding the data the ASC were set equal to 1 when the respondent chose either home garden A or B and to 0 when the respondent chose 'neither home garden' alternative.

Szatmár-Bereg, which is puzzling. A negative sign on the ASC coefficient would imply that farmers are highly responsive to changes in choice set quality and make decisions that are closer both to rational choice theory and the behavior observed in reality (Dhar 1997; Huber and Pinnell 1994). The sign on ASC coefficient for Őrség-Vend is statistically insignificant, although it carries the expected negative sign.

Table 4 reports the conditional logit estimates for the revealed preference, discrete choice, farm household model.

Table 4--Conditional logit regression of revealed preference, farm household data

Attribute	Dévaványa	Őrség-Vend Coefficient (S.E.)	Szatmár-Bereg
Crop variety diversity	0.009 (0.023)	-0.381 (0.016)	0.065*** (0.023)
Landrace	-0.167 (0.197)	0.044 (0.219)	0.218* (0.169)
Agro-diversity	-0.003 (0.175)	0.175 (0.225)	-0.303 (0.255)
Organic production	-0.268* (0.222)	-0.101 (0.199)	0.029 (0.325)
Food self-sufficiency	0.276×10^{-5}**	0.10×10^{-5}*	0.380×10^{-5}** (0.167×10^{-5})
	(0.133×10^{-5})	(0.619×10^{-6})	
Sample size	74	81	84
ρ^2	0.054	0.022	0.090
Log likelihood	-66.88	-77.00	-73.97

Source: Hungarian Home Garden Choice Experiment, Hungarian On-Farm Conservation of Agrobiodiversity Project 2002. (*)10% significance level; (**)5% significance level; (***)1% significance level two-tailed tests.

The null hypothesis that the separate effects of ESAs are equal to zero was again rejected with a Swait-Louviere log-likelihood ratio test (with 5 d.o.f at the 0.5 percent significance level). Only separate regression results are reported. In Dévaványa, the only significant agrobiodiversity attribute is organic production, and its sign is negative, contrary to the result of the stated preference model reported above. In Őrség-Vend none of the agrobiodiversity attributes affects the home garden management choice. Similarly to the results of the stated preference data, szatmári households are more likely to manage home gardens with higher levels of crop variety diversity and landraces. Across the three ESAs, the food self-sufficiency attribute positively and significantly affects the likelihood that the households would choose to manage a home garden that provides higher levels of food security. Finally, in this model an ASC was not included because all the farmers interviewed manage home gardens.

Overall, the results of the revealed preference models are not highly significant. The parameters of several attribute levels could not be estimated in this model because of collinearity between attributes[12] and lack of variation in the data for some of the attributes (e.g., agro-diversity). Lack of significance may also in part be attributable to the small size of the sample in each ESA. Some researchers have argued that since the attributes and variables in the revealed preference data sets are likely to be ill-conditioned (largely invariant and suffer from collinearity) parameter estimates will often be biased or statistically insignificant. For this reason, many researchers prefer analyses based on stated preference data. Another alternative is to combine the data sets (Hensher et al. 2005), as presented in the next section.

[12] The issue of collinearity between attributes in each ESA is explored in Birol et al. (2005). While from a stated preference perspective the attributes can be included as explanatory variables because they define the choice of a garden and are given to the farmer (exogenous; hypothetical), it appears that in the revealed preference framework these same attributes could be considered as choice variables that are endogenous. In the revealed preference formulation, attributes are themselves functions of household, farm, and market characteristics. This could also explain the poor results for the revealed preference formulation.

Joint estimation of revealed and stated preference data

Swait and Louviere (1993) describe the appropriate steps for joint estimation of data sources and parameter comparison, followed here. First, we estimated the stated and revealed preference models separately to generate the log likelihood values for each data set (reported in Tables 3 and 4). Second, we concatenated or "stacked" the two data set matrices and estimated the joint model to obtain a single, shared set of parameters.

The most common econometric approach to use when combining revealed and stated preference data is a two-level nested logit model, known as an "artificial tree structure" (Hensher and Bradley 1993). Though this structure has no obvious behavioral meaning, it is a convenient statistical model, designed to uncover differences in scale (i.e., variance) between the data sets while estimating model parameters (Louviere et al. 2000; Hensher et al. 2005).

A nested logit model is a hierarchy of conditional logit models, linked via a tree structure. Conditional logit models underlie the data within each cluster, implying that the assumption of constant variance (scale factors) must hold within each cluster, although they can differ between clusters. By accommodating different scale factors between clusters explicitly, and estimating the scale factor of one data set relative to that of the other, nested logit provides a simple way to accomplish the estimation process required to fuse the revealed preference and stated preference data sources.

In order to illustrate the fusion process undertaken in this paper, consider a nested logit model with two levels (revealed preference farm household model and stated preference choice experiment model), each with a cluster of three alternative home garden profiles. The choice model in each cluster is conditional logit, so that the scale of each cluster is equal to the inverse of the cluster inclusive value. The cluster inclusive value is a parameter estimate used to establish the extent of (in)dependence between linked choices. It is possible to identify only one of the relative scale factors by normalizing the inclusive value of the other data set to unity. The nested structure we used assumes that the inclusive value parameters associated with all revealed preference alternatives are equal and fixes the inclusive value parameter of the stated preference at unity. The nested logit model was estimated in LIMDEP 8.0 NLOGIT 2.0 using full-information maximum likelihood techniques.

The results of the combined model are reported in Table 5.

Table 5--Conditional logit regression of combined stated and revealed preference data

Attribute	Dévaványa	Őrség-Vend	Szatmár-Bereg
	Coefficient (S.E.)		
	Attributes in the Utility Functions		
ASC	-1.373*** (0.195)	-1.356*** (0.187)	-1.406*** (0.189)
Crop variety diversity	0.046***(0.009)	0.053*** (0.009)	0.065*** (0.008)
Landrace	0.062 (0.071)	0.194*** (0.068)	0.164*** (0.066)
Agro-diversity	0.405*** (0.075)	0.287*** (0.073)	0.431*** (0.076)
Organic production	0.223*** (0.078)	0.091* (0.072)	0.169** (0.077)
Food self-sufficiency	$0.442\text{x}10^{-5}$***	$0.415\text{x}10^{-5}$***	$0.276\text{x}10^{-5}$***
	$(0.560\text{x}10^{-6})$	$(0.468\text{x}10^{-6})$	$(0.133\text{x}10^{-5})$
	Inclusive Value Parameters		
RP1	$1.00\ (0.3\text{x}10^{8})$	$1.00\ (0.7\text{x}10^{15})$	$1.00\ (1.27\text{x}10^{8})$
SP1, SP2, SP3	*Fixed Parameters*		
Sample size	467	517	534
ρ^2	0.121	0.136	0.200
Log likelihood	-450.98	-491.40	-469.49

Source: Hungarian Home Garden Choice Experiment, Hungarian On-Farm Conservation of Agrobiodiversity Project 2002. (*)10% significance level; (**)5% significance level; (***)1% significance level two-tailed tests.

Similarly to the revealed and stated preference data, the null hypothesis that the separate effects of ESAs are equal to zero was rejected with a Swait-Louviere log-likelihood ratio test (with 6 d.o.f. at the 0.5 percent significance level) based on regressions with the pooled and separate ESA samples.

The inclusive value parameter for both of the branches is 1 for each of the ESAs, implying that the variances are equal. It is not uncommon for the variance structure of the stated and revealed preference data sets to be statistically similar (Adamowicz et al. 1997; Hensher et al. 2005).

Following Swait and Louviere (1993), we then tested the hypothesis that parameters are equal for the two data sets with the Swait-Louviere log-likelihood ratio test comparing the joint (restricted) and individual (unrestricted) models. We failed to reject the hypothesis that the parameters are equal at the 25 percent significance level for Szatmár-Bereg and Őrség-Vend and at the 95 percent significance level for Dévaványa at 6 degrees of freedom.[13] For all three ESAs, the data are consistent with the hypothesis that the revealed and stated preference data are compatible. By inference, the revealed and stated preference models share the same preference structures.

In Dévaványa, farmers choose to manage home gardens with livestock, organic practices, and higher numbers of crop varieties per hectare, but without landraces. In Őrség-Vend and Szatmár-Bereg, the economically, geographically and agro-ecologically more marginalized ESAs, farmers choose to manage home gardens with not only these attributes, but also landraces. Across the three ESAs, the level of food self-sufficiency provided by the home garden also contributes positively and significantly to the demand

[13] The degrees of freedom equal the number of parameters in the revealed data model plus the number of parameters in the stated data model minus the number of parameters in the joint model plus one additional degree for the relative scale factor (Louviere *et al.*, 2000).

for a home garden management strategy. This finding illustrates the fact that farm households across Hungary still depend on their home gardens for food security and diet quality.

The parameter estimates of the combined model have the same signs as those of the stated preference model, but with the enriched data, two additional factors were identified as statistically significant (crop variety diversity in Dévaványa and organic production methods in Őrség-Vend). The collinearity in the revealed preference model has been reduced by its fusion with the orthogonally designed, stated preference data (Adamowicz et al. 1994). As shown by Swait and Louviere (1993) the combined analysis therefore improves the precision and stability of the estimates of model parameters.

The significance levels for almost all of the attributes improved considerably. Estimation of the combined model also enabled estimation of ASCs, which was not feasible with revealed preference data alone (Adamowicz et al. 1997). Recall also that the ASC coefficients in the stated preference model were positive or statistically insignificant. The joint model resulted in estimations that are closer both to rational choice theory and to observed behavior.

In addition, estimation results reveal that actual and hypothetical home garden management decisions are guided by similar decision processes with regard to each of the agrobiodoversity and food self-sufficiency attributes. Finally, the results of the combined data estimations are more efficient than those of the stated preference data, since for each one of the ESA-level regressions the overall fit of the models, as measured with McFadden's ρ^2, improves with data fusion. The combined model outperforms the individual models, as found in several other studies (e.g., Earnhart 2001; 2002; Haener et al. 2001; Adamowicz et al. 1994; 1997; 2004).

Welfare measures of agrobiodiversity management in the home garden

The choice experiment method and the discrete choice, farm household model are both consistent with utility maximization and demand theory. From the parameter estimates reported in Tables 3-5 above, welfare measures can be estimated from the conditional logit model using the following formula:

$$CS = \frac{\ln \sum_i \exp(V_{i1}) - \ln \sum_i \exp(V_{i0})}{\beta_{monetaryattribute}} \qquad [3]$$

where CS is the compensating surplus welfare measure, $\beta_{monetaryattribute}$ is the marginal utility of income (represented by the coefficient of the proxy monetary attribute, i.e., food self-sufficiency) and V_{i0} and V_{i1} represent indirect utility functions before and after the change under consideration. The marginal value of change in a single attribute can be represented as a ratio of coefficients, reducing equation (3) to

$$W = -1\left(\frac{\beta_{agrobiodiversityattribute}}{\beta_{monetaryattribute}}\right) \qquad [4]$$

This part-worth (or implicit price) formula represents the marginal rate of substitution between the monetary value of food self-sufficiency and the agrobiodiversity attribute in question, or the marginal welfare measure (i.e., willingness to accept (WTA) compensation) for a change in any of the agrobiodiversity attributes.[14,15]

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[14] Notice however that specifying t-ratios or standard errors for these ratios presented in equation [4] is more complex. Each estimate is the ratio of two parameters, each of which is also an estimate surrounded

The implicit prices of each of the agrobiodiversity attributes for each model and ESA are estimated using the Wald procedure (Delta method) in LIMDEP. The WTA compensation values for each agrobiodiversity component are reported in Table 6.

Table 6--Willingness to accept compensation welfare measures for each agrobiodiversity attribute per ESA per household per annum*

Regression	Crop variety diversity	Landrace	Agro-diversity	Organic production
Welfare measures from stated preference, choice experiment regressions				
Dévaványa	--	--	-1841.4	-878.4
Őrség-Vend	-19.6	-402.4	-583	--
Szatmár-Bereg	-13	-266.4	-877	-256.4
Welfare measures from revealed preference, farm household regressions				
Dévaványa	--	--	--	--
Őrség-Vend	--	--	--	--
Szatmár-Bereg	-64.8	-432.8	--	--
Welfare measures from combined stated preference nd revealed preference regressions				
Dévaványa	-40	--	-715.8	-394.6
Őrség-Vend	-49.6	-366	-540	-172.2
Szatmár-Bereg	-41.3	-200.6	-544.4	-213.2

* Welfare measures are calculated with the Delta method, Wald procedure contained within LIMDEP. -- indicates that the Wald procedure resulted in insignificant WTA values for this attribute. Figures are in € ** Wald procedure resulted in insignificant welfare estimates

by a range of uncertainty. Even when the t values are 'statistically significant' it does not follow that the ratios are. One approach commonly used to calculate standard errors of the welfare measures involve simulation techniques to establish the empirical distribution of the marginal welfare measure (Bateman *et al.*, 2003). One such method is the Wald (Delta) method contained within LIMDEP, which computes values and standard errors for specified linear functions of parameter estimates.

[15] Note that for the effects coded binary agrobiodiversity attributes (i.e., landrace, agro-diversity and organic production) the implicit price formula becomes $W = -2\left(\frac{\beta_{agrobiodiversityattribute}}{\beta_{monetaryattribute}}\right)$ (Hu *et al.*, 2004).

Signs on the WTA values derived from estimated demand functions can be viewed as a test for theoretical validity, as all of them are negative, implying that the welfare estimates are consistent with theoretical expectations.

For the stated preference data set, neither the crop genetic nor the crop variety diversity component of agrobiodiversity yields significant benefits for farmers in Dévaványa. Agro-diversity and organic production, however, yield the highest benefits to these farmers compared to farmers in other ESAs. Farmers in Őrség-Vend value agro-diversity about a third as much as those in Dévaványa, though they do not value organic production methods. Landrace cultivation and crop variety diversity are valued most highly by farmers in Őrség-Vend. In this ESA, an additional landrace benefits farmers twenty times as much as any additional seed type purchased from the shops. In Szatmár-Bereg, the agro-diversity attribute yields the highest benefits to farm households.

The welfare estimates obtained from the revealed preference data analysis are all insignificant with the exception of crop variety diversity and landraces in Szatmár-Bereg. These values are considerably higher than those obtained from the stated preference method. As explained above, the difference between the two models could be explained by the collinearity between the attributes, which appear to confound the calculation of the welfare measures (Earnhart 2001).

Relative to the WTA measures based on each individual data set, combining the revealed and stated data improves benefit valuation and generates estimates that are statistically significant and more robust. Across the ESAs, crop variety diversity is valued most highly by őrségi farm households, followed by those located in Szatmár-Bereg and Dévaványa, which have similar WTA estimates for this attribute. The highest values for agro-diversity and organic production methods are found among farmers in Dévaványa. Farmers in Őrség-Vend value landraces the most.

The implicit prices for attributes reported in Table 5 do not provide CS values for the alternative home garden management strategies. Unlike the attributes, the strategies that provide the attributes could be directly supported by programs such as the NRDP in order to promote on farm conservation of agrobiodiversity. In order to calculate the CS for farm households, four home garden management scenarios were developed and the total value of private benefits to farm households were calculated for each management scenario (Table 7).

Table 7--Willingness to Accept Compensation welfare measures for home garden management scenarios per ESA per household per annum*

Regression	Scenario 1- High agrobiodiversity	Scenario 2 - High crop biodiversity	Scenario 3- Traditional methods	Scenario 4 – Low agrobiodiversity
Welfare measures from stated preference, choice experiment regressions				
Dévaványa	-2719.8	--**	-2719.8	--
Őrség-Vend	-1377.4	-892.4	-837.8	-117.6
Szatmár-Bereg	-1659.8	-591.4	-1302.4	-78
Welfare measures from revealed preference, farm household regressions				
Dévaványa	--	--	--	--
Őrség-Vend	--	--	--	--
Szatmár-Bereg	-1728.8	-2052.8	-842.4	-388.8
Welfare measures from combined stated preference and revealed preference regressions				
Dévaványa	-697.3	213.1	-417.3	973.1
Őrség-Vend	-793.4	-329.2	-80.2	979.2
Szatmár-Bereg	-895.2	-344.1	-404.2	641.2

*Figures are in € *** Welfare measures are calculated with the Delta method, Wald procedure contained within LIMDEP. -- indicates that the Wald procedure resulted in insignificant WTA values for this attribute.

Scenario 1 represents a home garden with a high level of agrobiodiversity, including 20 crop varieties and at least one landrace managed with organic production techniques, as well as livestock. The home garden in scenario 2 has a high level of crop biodiversity only, containing 25 crop varieties and at least one landrace. In scenario 3, the home garden is managed with traditional methods of organic production and mixed livestock and crop production, contains fewer (13) crop varieties and at least one landrace. In the final scenario, the home garden has a total of only 6 crop varieties.[16]

According to the stated preference method, under the high agricultural biodiversity scenarios, the private value that an average farm household appropriates from a home garden is the highest in Dévaványa. As expected, however, CS scenarios generate very different welfare values for the revealed, stated and combined methods. On average, across scenarios and ESAs, the welfare measures derived from the revealed preference method are insignificant for Dévaványa and Őrség-Vend, whereas they overestimate the private values associated with home garden management scenarios in Szatmár-Bereg. Those generated by the stated preference method also overestimate the private values relative to the combined approach.

The CS calculations for the combined data are more efficient than those estimated by either approach taken singly. The results confirm that farmers in Dévaványa value the high agrobiodiversity and traditional methods scenarios positively, but they derive large negative use values from the other two home garden management scenarios. In the isolated ESAs, farmers derive higher levels of utility from home gardens managed with more agrobiodiversity. Farm households in Szatmár-Bereg value home gardens with

[16] Note that in order to estimate overall CS for each home garden management scenario it is necessary to include the welfare measure on ASC, which captures the systematic but unobserved information about farmers' choices.

high agrobiodiversity levels, and high crop variety diversity the most, and traditional methods almost as mush as those in Dévaványa. These results support the evidence that farmers located in the most economically, geographically and agro-ecologically marginalized communities derive the highest private benefits from the public goods generated by these home gardens. Furthermore, the value estimate for high agrobiodiversity home garden scenario for Szatmár-Bereg, the region with the lowest average incomes, is similar to the estimations by Szivós and Tóth (2000), who found that 60 percent of the households in the lowest income quartiles in Hungary consume food from own production with a value amounting to 19277 Ft (€75.3) per month, i.e., €903 per annum.

CONCLUSIONS

This paper employed a stated preference method (a choice experiment) and a revealed preference method (a discrete choice, farm household model) to estimate the private values of agrobiodiversity managed to farmers in Hungary. The results of the stated and revealed preference methods are compared, and the data from these two methods are also combined.

The main advance of the combined model presented in this paper is the use of the stated preference approach to improve the quality of the estimates from the revealed preference approach. In this application, the revealed preference approach is based on a household farm model of on farm diversity in a discrete choice framework. Combining data sources resulted in more robust and efficient estimates of private values of agrobiodiversity, revealing that fusion of data sources not only enriches the results but also reduces certain problems that are associated with either method. In applied research, combining data sources will have research design and cost implications that need to be assessed.

Still, similar preference functions were retrieved from the revealed preference and stated preference data. This suggests two conclusions. First, farmers like those interviewed can evidently handle hypothetical questions about observable components of agrobiodiversity on their farms. Second, stated preference methods can be useful, and in some research projects less costly, tools to investigate farmer choices with respect to agrobiodiversity.

POLICY IMPLICATIONS

There are two major policy implications that arise from this paper. Firstly, this paper estimates only the private use values of agrobiodiversity managed in home gardens as they accrue to the farmers who manage them. Neither the private non-use values (e.g., cultural heritage value) nor the possible use and non-use values derived by the Hungarian public from management of home gardens were estimated. It should be expected that the value estimates reported in this paper represent lower bounds for the total economic value of agrobiodiversity managed on Hungarian home gardens.

Secondly, ESA-level differences in private valuation of agrobiodiversity should be taken into consideration when designing agri-environmental schemes to support provision of these public goods. Calculation of the compensating surplus values for home gardens with different levels of agrobiodiversity revealed that farmers located in the most marginalized regions, especially those in Szatmár-Bereg, appropriate the highest private values from the agrobiodiversity they manage. Szatmár-Bereg is the least-cost option for agri-environmental schemes that encourage farmers to undertake management practices to support agrobiodiversity. Findings also have implications for the design of cost-effective agri-environmental schemes in other EU member Central and Eastern European Countries (CEECs) with similar dual agricultural structures, such as Slovenia and Poland.

REFERENCES

Adamowicz, W.L. and J.R. Deshazo. 2006. frontiers in stated Preferences Methods: An introduction. *Environmental and Resource Economics* 34(1): 1-6.

Adamowicz W.L., J. Swait, P. Boxall, J. Louviere, and M. Williams. 1997. Perceptions versus objective measures of environmental quality in combined revealed and stated preference models of environmental valuation. *Journal of Environmental Economics and Management* 32(1): 65-84.

Adamowicz, W.L., J. Louviere, and M. Williams. 1994. Combining stated and revealed preference methods for valuing environmental amenitie*s. Journal of Environmental Economics and Management* 26: 271-292.

Bateman, I. J., R. T. Carson, B. Day, W. M. Hanemann, N. Hanley, T. Hett, M. Jones-Lee, G. Loomes, S. Mourato, E. Ozdemiroglu, D. W. Pearce, R. Sugden, and S. Swanson. 2003. *Guidelines for the use of stated preference techniques for the valuation of preferences for non-market goods*. Cheltenham: Edward Elgar.

Ben-Akiva, M. and S. R. Lerman. 1985. *Discrete choice analysis, theory and application to travel demand*, MIT Press, Cambridge MassachusettsBennett, J.J. and R.K. Blamey. 2001. *The Choice of Modelling Approach to Environmental Valuation.* Cheltenham: Edward Elgar Publishing Limited.

Ben-Akiva, M, and T. Morikawa, Estimation of switching models from revealed preferences and stated intentions, *Transportation Research A* 24A(6): 485-495.

Birol, E., M. Smale and Á. Gyovai. 2005. Explaining farmer demand for agricultural biodiversity in Hungary's Transition Economy. In *Valuing crop biodiversity on farms during economic change*, ed. Smale, M. Wallingford, UK: CAB International.

Birol, E., M. Smale and Á. Gyovai. 2004. Agri-environmental policies in a transitional economy: the value of agricultural biodiversity in Hungarian home gardens. Environment and Production Technology Division Discussion Paper No. 117, Washington, D.C.: International Food Policy Research Institute. http://www.ifpri.org/divs/eptd/dp/papers/eptdp117.pdf

Birol, E. 2004. Valuing agricultural biodiversity on home gardens in Hungary: An application of stated and revealed preference methods, London, UK: University College London, University of London.

Boxall, P.C., J. Englin, and W.L. Adamowicz. 2002. Valuing undiscovered attributes: A combined revealed-stated preference analysis of North America aboriginal artifacts. *Journal of Environmental Economics and Management* 45: 213-230.

Brookfield, H., and M. Stocking. 1999. Agrodiversity: definition, description and design. *Global Environmental Change* 9: 77-80.

Cameron, T.A. 1992. Combining contingent valuation and travel cost data for the valuation of nonmarket goods. *Land Economics* 68(3): 302-317

Chattopadhyay, S. 2000. The effectiveness of McFadden's nested logit model in valuing amenity improvements. *Regional Science and Urban Economics* 30: 23–43.

Csizmadia, G. 2004. Analysis of small farm useful soil nutritive matter from Dévaványa, Őrség-Vend and Szatmár-Bereg Regions of Hungary. Working Paper. Tápiószele: Institute of Agrobotany

Cropper, M., L. Deck, N. Kishor, and K. McConnell. 1993. Valuing product attributes using single market data: Comparison of hedonic and discrete choice approaches. *Review of Economics and Statistics* 75 (2): 225-32.

Cros Kárpáti, Z., C. Gubicza, and G. Ónodi. 2004. Kertségek és kertmûvelõk : Urbanizáció vagy vidékfejlesztés? Budapest, Mezõgazda.

Cummings, R. G., D. S. Brookshire, and W. D. Schulze. 1986. *valuing environmental goods: A state of the arts assessment of the contingent valuation method.* New Jersey: Rowman and Allanheld.

Dhar, R. 1997. 'Consumer preference for a no-choice option'. *Journal of Consumer Research* 24, 215--231.Earnhart, D. 2001. Combining revealed and stated preference methods to value environmental amenities at residential locations. *Land Economics* 77(1): 12- 29.

Earnhart, D. 2002. Combining revealed and stated data to examine housing decisions using discrete choice analysis. *Journal of Urban Economics* 5(1): 143-169.

ECOGEN. 2005. *Economic literature on crop and livestock genetic resources*. Washington, DC and Rome, Italy: International Food Policy Research Institute and International Plant Genetic Resources Institute.

Englin, J., and T.A. Cameron. 1996. Augmenting travel cost models with contingent behaviour data: poisson regression analyses with individual panel data. *Environmental and Resource Economics* 7: 133-147.

FAO. 1999. Multifunctional character of agriculture and land. Maastricht: Conference Background Paper No. 1.

Feick, L.F., Higie, R.A., and L.L. Price. 1993. Consumer search and decision problems in a transitional economy: Hungary 1989-1992. Report No. 93-113. Massachusetts: Marketing Science Institute.

Fertő, I., Fogács, Cs., Juhász, A., Kürhty, and Gy. *Regoverning markets.* Budapest: Country report. http://www.regoverningmarkets.org/docs/country_study_Hungary_new2005.pdf

Freeman, M.A. 1993. *The measurement of environmental and resource values: Theory and methods*. Washington, D.C.: Resources for the Future.

Greene, W.H. 1997. *Econometric analysis.* Prentice Hall International.

Greene, W.H. 1998. *LIMDEP Version 7.0 NLogit Version 2.0, Econometric Software, Inc*. New York: Plainview.

Gyovai, Á. 2002. Site and sample selection for analysis of crop diversity on Hungarian small farms. In *The economics of conserving agricultural biodiversity on-farm: research methods developed from IPGRI's global project 'strengthening the scientific basis of in situ conservation of agricultural biodiversity,* ed M. Smale, I. Már, and D. I. Jarvis. Rome: International Plant Genetic Resources Institute.

Haab, T.C., and K.E. McConnell. 2002. Valuing environmental and natural resources: the econometrics of non-market valuation. Cheltenham: Edward Elgar.

Haener, M., P.C. Boxall and W.L. Adamowicz. 2001. Modeling recreation site choice: Do hypothetical choices reflect actual behavior? *American Journal of Agricultural Economics* 83(3):629-642.

Harcsa, I., Kovách, I., and Szelényi, I. 1994. A posztszocialista átalakulási válság a mezőgazdaságban és a falusi társadalomban. (Postsocialist Transitional Crisis in Agriculture and Rural Society). *Szociológiai Szemle* 3: 15–43.

HCSO. 2001, 2003. http://www.ksh.hu/pls/ksh/docs/index_eng.html. Budapest.

Hensher, D.A., and L.W. Johnson. 1981. *Applied discrete choice modelling*. London: Croom-Helm/New York: John Wiley.

Hensher, D.A., J. M. Rose, and W. H. Greene. 2005. *Applied choice analysis. A primer*. Cambridge: Cambridge University Press.

Hensher, D.A. and M. Bradley. 1993. Using stated choice data to enrich revealed preference discrete choice models, *Marketing Letters* 4, 139-152.

Hu, W., Hünnemeyer, A., Veeman, M., Adamowicz, W. and Srivastava L., 2004. Trading off health, environmental and genetic modification attributes in food. *Eur. Rev. Agric. Econ.* Sep 31: 389 - 408.

Huber, J and J. Pinnell. 1994. *The impact of set quality and choice difficulty on the decision to defer purchase.* Working paper, Duke University: The Fuqua School of Business.

Juhász, I., J. Ángyán, I. Fésûs, L. Podmaniczky, F. Tar, and A. Madarassy. 2000. *National agri-environment programme: For the support of environmentally friendly agricultural production methods ensuring the protection of the nature and the preservation of the landscape.* Budapest: Ministry of Agriculture and Rural Development, Agri-Environmental Studies.

Juhász, P. 2001. Mezőgazdaságunk és az uniós kihivás (Hungarian Agriculture and the EU Challenge). *Beszélő* April.

Kling, C. L. 1997. The gains from combining travel cost and contingent valuation data to value nonmarket goods. *Land Economics* 73 (3): 428-439.

Kovách, I. 1999. Hungary: Cooperative farms and household plots. In *Many shades of red: State policy and collective agriculture*, ed. M.Meurs. Boulder: Rowman and Littlefield.

Lankoski, J. (ed.). 2000. *Multifunctional character of agriculture.* Research Report No. 241. Helsinki: Agricultural Economics Research Institute.

Louviere, J.J. 1988. *Analyzing decision making: Metric conjoint analysis.* Newbury Park: Sage Publications, Inc.

Louviere, J. J., D.A. Hensher, J.D. Swait, and W.L. Adamowicz. 2000. *Stated choice methods: Analysis and applications.* Cambridge: Cambridge University Press.

Luce, D. 1959. *Individual choice behaviour*. New York: John Wiley.

Lupwayi, N., W. Rick, and G. Clayton. 1997. *Zillions of lives underground*. APGC Newsletter, http://www.pulse.ab.ca/newsletter/97fall/zillion.html.

Maddala, G.S. 1999. *Limited dependent and qualitative variables in econometrics,* Cambridge: Cambridge University Press.

Mäder, P., A. Fliessbach, D. Dubois, L. Gunst, P. Fried, and U. Niggli. 2002. Soil fertility and biodiversity in organic farming. *Science* 296: 1694-1697.

Már, I. 2002. Safeguarding agricultural biodiversity on-farms in Hungary. In *The Economics of Conserving Agricultural Biodiversity on-Farm: Research methods developed from IPGRI's Global Project 'Strengthening the Scientific Basis of In Situ Conservation of Agricultural Biodiversity,* ed. Smale, M., I. Már, and D. I. Jarvis. Rome: International Plant Genetic Resources Institute.

Már, I. and A. Juhász. 2002. *A tájtermesztésben hasznosítható bab (Phaseolus vulgaris L.) egyensúlyi populációk agrobotanikai vizsgálata* (Agrobotanical analysis of bean - Phaseolus vulgaris L. - equilibrium populations suitable for regional land cultivation). Debrecen.

McFadden, D. 1974. Conditional logit analysis of qualitative choice behaviour. In *Frontiers in Econometrics*, ed. P. Zarembka. New York: Academic Press.

McFadden, D. 1978. Modeling the choice of residential location. In *Spatial interaction theory and planning models,* ed. Karlqvist, A. et al. Amsterdam: North-Holland.

Meurs, M. 2001. *The evolution of agrarian institutions: A comparative study of post socialist Hungary and Bulgaria*. Ann Arbor: University of Michigan Press.

Mitchell, R.C., and R. T. Carson. 1989. *Using surveys to value public goods: The contingent valuation method.* Baltimore: Johns Hopkins Press.

National Labor Centre. 2000. http://www.ikm.iif.hu/english/economy/labour.htm., Budapest.

Parsons, G., and M. J. Kealy. 1992. Randomly drawn opportunity sets in a random utility model of lake recreation. *Land Economics* 68 (Feb): 93-106.

Romstad, E., A. Vatn, P.K. Rørstad, and V. Søyland. 2000. *Multifunctional agriculture: Implications for policy design.* Report No. 21. Agricultural University of Norway, Department of Economics and Social Sciences.

Rosenberger, R.S., and J.B. Loomis. 1999. The value of ranch open space to tourists: Combining observed and contingent behavior data. *Growth and Change* 30(3): 366-383

Sarris, A.H., Doucha, T., and Mathijs, E. 1999. Agricultural restructuring in central and eastern Europe: implications for competitiveness and rural development. *European Review of Agricultural Economics* 26: 305-329.

Seeth, H. T., S. Chachnov, A. Surinov, and J. v. Braun. 1998. Russian Poverty: Muddling Through Economic Transition with Garden Plots. *World Development* 26(9): 1611-1623.

Swain, N. 2000. Post-Socialist Rural Economy and Society in the CEECs: the Socio-Economic Contest for SAPARD and EU Enlargement. Paper presented at the International Conference: European Rural Policy at the Crossroads, The Arkleton Centre for Rural Development Research,King's College, University of Aberdeen, Scotland.Swait J, Louviere J. The role of the scale parameter in the estimation and comparison of multinomial logit models. J Marketing Res 1993; 30: 305–314.

Swait, J., Louviere, J. and Williams, M. 1994. A sequential approach to exploiting the combined strengths of SP and RP Data: Application to Freight Shipper Choice. *Transportation* 21:135-152.

Szelényi, I. ed. 1998. *Privatising the land*. London: Routledge.

Szép, K. 2000. The chance of agricultural work in the competition for time: case of household plots in Hungary. *Society and Economy in Central and Eastern Europe* 22(4).

Szivós, P., and I. G. Tóth. 2003. Stabilization of the structure of society (Stabilizálódó társadalomszerkezet). Budapest: TÁRKI MONITOR Reports.

Vajda. L. 2003. *The view from Central and Eastern Europe*, Agricultural outlook forum 2003, Washington, D.C.: USDA. http://www.usda.gov/oce/waob/oc2003/speeches/vajda.pdf.

Weingarten, P., S. Baum, K. Frohberg, M. Hartmann, and A. Matthews. 2004. *The future of rural areas in the CEE new member states.* Network of Independent Agricultural Experts in the CEE Candidate Countries. , http://europa.eu.int/comm/agriculture/publi/reports/ccrurdev/text_en.pdf

WHO. 2005. *The impact of food and nutrition on public health: The case for a Food and Nutrition Policy and an Action Plan for the European Region of WHO, 2000-2005 and the Draft Urban Food and Nutrition Action Plan*. http://www.hospitalitywales.demon.co.uk/nyfaweb/fap4fnp/fap_26.htm.

Wyzan, M. 1996. Increased inequality, poverty accompany, economic transition. *Transition* 2(20): 24-27.

APPENDIX

Appendix 1--Sample choice set

Assuming that the following home gardens were the ONLY choices you have, which one would you prefer to manage?

Home garden characteristics	Garden A	Garden B	
Total number of crop varieties grown in the home garden.	25	20	Neither home garden A nor home garden B: I will NOT manage a home garden.
Home garden has a landrace	No	Yes	
Crop production in the home garden is integrated with livestock production	Yes	Yes	
Home garden crops produced entirely with organic methods	No	No	
Expected proportion (in %) of annual household food consumption met through food production in the home garden	45	75	

I prefer to cultivate Garden A… Garden B….. Neither garden ……

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