Seminar Paper in Natural Resource Use and Conservation Economics: Preferences on Biodiversity Conservation

Tilman von Samson-Himmelstjerna (216232989 - MLU Halle-Wittenberg)

2023-02-06

1. Introduction

Biodiversity conservation is one of the most urging responsibilities for modern societies to ensure a living within the planetary boundaries (Steffen et al. (2015)). A sharp decline in the planet's biodiversity has irreversible consequences not only for the stability of ecosystems, but also for the stability of global economies. Recently, the corona pandemic has highlighted the vulnerability of these systems and the interconnections between human activities and the natural environment (Lawler et al. (2021)). A key challenge for biodiversity conservation policies is the right incorporation of it's direct and indirect values(Diaz et al. (2015)). Decision-making must therefore be based on sound economic valuation that captures the diversity of values and utilities that people derive from the ecosystem and its biodiversity in particular, which in most cases are not included in market prices.

To tackle this issue, a growing body of literature investigates on stated preferences for biodiversity over the whole range of low-, middle- and high-income countries (Bhat and Sofi (2021), Bienabe and Hearne (2006), Le et al. (2016)). A cornerstone of this research is the estimation of the respondents Willingness to Pay (WTP) for biodiversity conservation. Bhat and Sofi (2021), for instance, find a high willingness to pay of around 3.32$ per year in the form of increasing water rates for biodiversity conservation in Dachigam National Park, India. Findings like these can have far reaching practical implications for local authorities and the design of preference-based policy measures.

This choice experiment grounds on data that was collected between March and April 2013 in Germany and aims at providing insights on preferences regarding biodiversity conservation in a high-income country. Besides the estimation of the respondents preferences on forest biodiversity and 4 other environmental attributes and the corresponding WTP, this study aims at investigating on socio-demographic and behavioral factors that might influence preferences with regard to biodiversity and thereby could add further perspectives to the existing body of literature. On the one hand it asks whether income might explain some of the effects of preferences for biodiversity. The generic hypothesis would be, that higher levels of income could leverage an individuals preferences for natural goods as basic needs become less important. On the other hand the study focuses on the effects of experiencing natural services by spending days outside in the open landscape. For the latter the hypothesis would follow the line that experiencing environmental attributes might yield direct utility and an increase in the level of biodiversity attributes might increase utility.

I find significant and positive estimates for preferences on the share of forest, the share of unused forest and forest biodiversity, while the estimate for the share of foreign trees is significant and negative. A central finding is the negative impact of higher levels of income on preferences on forest biodiversity.

Section 2. introduces the Econometric approach and provides some general information on the data. While section 3 provides the results of the model estimations and some interpretation, section 4 discusses these and concludes.

2. Method

In order to estimate the respondents preferences over certain environmental attributes I set up a discrete choice experiment that builds up on discrete choice research and data on local land use changes in Germany and especially on the work of Sagebiel, Glenk, and Meyerhoff (2017) (referred to as "the original paper"). Therefore, 1233 randomly German adults were interviewed by a market research company between March and April 2013. The respondents were given a set of choices that were framed as an survey in order to learn more about people's views with regard to the landscape, that was expressed in terms of six attributes. These included *share of forest in the landscape*, *size of individual fields and forest areas*, *share of foreign trees*, *share of unused forest*, *biodiversity within the forest* and *price of improvement* on certain attributes. Within each choice situation the respondents could choose between three alternatives that reflected either improvement, deterioration or persistence of the condition of the landscape with regard to the specific attributes. The first level for the *share of forest in the landscape* was a 10% decrease, the second the maintenance of the status quo and the third an 10% increase in the share, which correspondingly would lead to a proportional shift in the share of agricultural land. Attribute levels for *biodiversity within the forest* ranged between "as today", "slightly raised" and "distinctly raised". The other attribute-levels followed similar patterns. The *price* attribute was framed as a yearly payment to a local fund in order to that ranged between 10€ and 160€.

Two important notes on the structure of the choices should be noted. First, the data set needs to be adjusted for the individual status quo levels, which was done in the original paper by including additional data for the "share of forest" for instance. However, individual data on the level of biodiversity was not available, which is important for my analysis and must be considered by evaluating the results. Second, the structure of the survey reflects mostly a discrete choice situation in which the variables are ordinal, but not continuous and thus discrete. In the original survey the levels of some of the attributes were not ordered linearly. Therefore, I re-ordered them to estimate them in line with the utility function specification, which is derived in the following.

Random utility model

The key underlying assumption of the choice experiment is that by deciding for one of the alternatives, the respondents reveal their preferences of the attributes which then can be expressed in a indirect utility function and ultimately be estimated within a conditional logit model. Utility theory would imply that utility maximizing agents would choose the alternative that yields the highest utility (Louviere, Hensher, and Swait (2000)). The exact description of people's preferences within a linear utility function is an unrealistic assumption when it comes to estimating real world preferences, as almost certainly randomness is involved in the decision context. Therefore, I include the random parameter Epsilon to the econometric model. The deterministic part from the choice observations is expressed in terms of an indirect utility function. The decision towards the higher valued alternative reflects the solution of the individuals maximization problem and can be captured within the indirect utility function. However, uncertainty demands that conclusions must be drawn in terms of probabilities, due to the unobserved part Epsilon. Therefore the choice results can be understood such that the probability of choosing one alternative over the other is the probability that the utility of one alternative is bigger than the other. The response probabilities then can be derived by using a conditional logit model, which follows a cumulative distribution function and is based on the random utility model which is derived in the next part. In order to estimate the model I used Maximum Likelihood Estimation.

Model specification

With respect to the land use choice experiment I specified three different models. Each model is based on a different utility function that is expressed in terms of the six attributes that are modeled differently each time.

In order to compare the different models I set up a baseline model with a linear utility function:

$$U = \beta_0 * ASC + \beta_1 * ShFor + \beta_2 * FiSizHalf + \beta_3 * FiSizDouble + \beta_4 * FoTre+$$
$$\beta_5 * NoUse + \beta_6 * FoBio + \beta_7 * Pri + \epsilon$$

The attribute for the size of individual fields is coded across all models as two dummy variables for each alternative. The second model is very similar to the baseline model in the original paper by Sagebiel, Glenk, and Meyerhoff (2017). It contains squared terms for *ShFor*, as it is assumed that the marginal utility of forest shares is diminishing. However, it excludes the interaction term between the price attribute and the disposable income:

$$U = \beta_0 * ASC + \beta_1 * ShFor + \beta_2 * ShFor^2 + \beta_2 * FiSizHalf + \beta_3 * FiSizDouble+$$
$$\beta_4 * FoTre + \beta_5 * NoUse + \beta_6 * FoBio + \beta_7 * Pri + \epsilon$$

The third model includes two interaction terms that aimed at the initially postulated research question. The first is between the biodiversity attribute and a mean-centered variable for disposable income, the second is build between the biodiversity attribute and a mean-centered variable for days in the open landscape:

$$U = \beta_0 * ASC + \beta_1 * ShFor + \beta_2 * ShFor^2 + \beta_3 * FiSizHalf + \beta_4 * FiSizDouble + \beta_5 * FoTre+$$
$$\beta_6 * NoUse + \beta_7 * FoBio + \beta_8 * Pri + \beta_9 * FoBio * MCInc + \beta_10 * FoBio * MCNatDay + \epsilon$$

The first interaction aims at capturing possible heterogeneity in preferences that is explained by income. The hypothesis follows the line, that higher income levels might increase the degree of environmental preferences, as other needs, like basic needs, might become relatively less important. However, as the data only captures income on the county level, this can only be seen as a broad approximation. As described above, the hypothesis for the latter interaction states that utility for people that are spending more days in the open landscape would increase by increasing levels of forest biodiversity.

Marginal Willingness to Pay (MWTP)

In the next step I calculated the marginal willingness to pay (MWTP) with respect to the biodiversity attribute. The MWTP relates the marginal utility of the attribute with the marginal utility of the cost attribute and thus should reflect the monetary amount an individual would pay for a marginal change in the level of the respective attribute. The general formula for the MWTP is given by:

$$MWTP = -\frac{\frac{\partial V}{\partial atr}}{\frac{\partial V}{\partial a_c}}$$

This approach can be very practical in order to asses values for certain goods or attributes that do not have a directly accessible market value like the degree of biodiversity in the forest. In order to account for the average willingness to pay one needs to account for a mean-centered variant of the demographic variable that is used in the interaction term. The average MWTP for the degree of biodiversity is calculated as:

$$MWTP_{biodiv} = -\frac{\beta_6 + \beta_8 * MCInc + \beta_9 * MCNatDay}{\beta_7}$$

3. Results

The results are estimated with the Maximum Likelihood estimation by using the "R" software package "Apollo" and are shown in Table 1. Unless otherwise highlighted, the results for model three are discussed in the following. The coefficients for the alternative specific constants (ASC) are negative and do significantly vary from zero at the 0.1% level. As the ASC's are coded as dummy variables they capture effects to not choose the status quo option, that are not displayed by the attributes. In both cases the estimates indicate decreases in utility.

The positive and significant coefficient at the 0.1% level for the linear term of *ShFor* is large in magnitude across all model specifications. It indicates that people gain utility in marginal increases of forest shares. It can be assumed that with higher levels of forest shares people gain less from an additional unit of forest. By including a squared term for forest share, the model should account for the possibility of diminishing marginal utility with respect to this attribute. As the coefficient "b_ShFor2" is negative and the null hypothesis can be refused at the 0.1% level, this assumption seems to be justified and the hypothesis of an inversely U-shaped can be verified.

A less and a more fragmented landscape might not to be preferred by the participants of the choice experiment. Both estimated dummy parameters for the attribute *FiSiz* are negative. However, the coefficients are not significant across all model specifications. This might imply that the respondents prefer the status quo level over doubling and halving the field and forest area sizes, but reasonable interpretation is not feasible.

The parameter for *share of unused forest* is statistically significant at the 0.1% level, large in magnitude and positive across all model specifications. This implies that individuals gain utility with marginal increases in unused forest shares. This insight might reflect the intensive public discussion about the German "Waldsterben" and calls for a more extensive forest management in the 1980s (Metzger (2015)). The opposite effect can be observed with respect to the parameter *FoTre* that captures increases in the amount of foreign trees, which is negative and statistically significant at the 1% level.

The coefficient for *FoBio* is positive and significant, which implies that on average the utility of biodiversity increases with higher levels of biodiversity. Furthermore, the coefficient for the interaction term between the biodiversity attribute and the mean centered average income is significant at the 1% level and negative. In fact, this refuses the initial hypothesis that higher levels of income lead to higher preferences for biodiversity. The interaction between *days in the open landscape* and biodiversity in the forest is neither large in magnitude, nor statistically significant, which makes reasonable interpretation of the result impossible despite the insight that within this discrete choice setting an impact of experiencing "open landscape" directly has no impact on preferences about biodiversity levels within the forest.

Price has a negative coefficient that is significant at the 0.1% level. This indicates a decrease in utility with increasing costs for improvement measures on the respective environment.

With a look at the two interaction terms it is remarkable that their impact on the model outcomes is relatively small. By comparing the results to the second model, which is termed as the "No Interaction" model Table 2, one can see that further controls on socio-demographic and behavioral variables do not change the model results significantly. However, the coefficient for the income related interaction is considerable in terms of magnitude, this effect would have been unobserved by neglecting this variable. The addition of the second interaction term does not add any explanatory power to the model and could be dropped. However, in terms of the initially stated hypothesis the result remains of interest. The main difference between the baseline model and the subsequent models is the inclusion of the quadratic term for *ShFor*, which has an considerable impact on the magnitude of the models estimates. By comparing the baseline with the "No Interaction" model one can see large differences for the the *ShFor* estimates, as its value drops from 0.43 to 0.07. The decrease in the *ShFor* estimate and a reduction in the standard errors shows that this utility function specification can capture the dynamics and explain the data better than the linear specification. All estimates remain relatively similar when comparing the "No Interaction" model and the "Full Model". A quick look at the Log-Likelihood values indicates a better goodness-of-fit of the third model specification, which can simply be explained by the higher number of predictor variables. A more insightful indicator is the Likelihood ratio test, for which the null hypothesis states that the nested model fits the data equally

	Base Model	No Interaction	Full Model
b_alt1	-0.60^{***}	-0.59^{***}	-0.59^{***}
	(0.06)	(0.06)	(0.06)
b_alt2	-0.51^{***}	-0.50^{***}	-0.50^{***}
	(0.06)	(0.06)	(0.06)
b_ShFor	0.42^{***}	0.07^{***}	0.07^{***}
	(0.03)	(0.01)	(0.01)
b_FiSizHalf	-0.04	-0.04	-0.04
	(0.04)	(0.04)	(0.04)
b_FiSizDouble	-0.02	-0.02	-0.02
	(0.03)	(0.03)	(0.03)
b_price	-0.01^{***}	-0.01^{***}	-0.01^{***}
	(0.00)	(0.00)	(0.00)
b_FoBio	0.26^{***}	0.26^{***}	0.26^{***}
	(0.02)	(0.02)	(0.02)
b_NoUse	0.22^{***}	0.22^{***}	0.22^{***}
	(0.02)	(0.02)	(0.02)
b_FoTre	-0.34^{***}	-0.34^{***}	-0.34^{***}
	(0.03)	(0.03)	(0.03)
b_ShFor2		-0.00^{***}	-0.00^{***}
		(0.00)	(0.00)
b_IncXFoBio			-0.03^{**}
			(0.01)
b_NatDayXFoBio			0.00
			(0.01)
No Observations	11349	11349	11349
No Respondents	1261	1261	1261
Log Likelihood (Null)	-12468.15	-12468.15	-12468.15
Log Likelihood (Converged)	-11011.67	-10987.07	-10974.42

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 1: Model Specifications

well as the full model. The resulting Chi-squared test-statistic is around 25.31 with a corresponding p-value at 3.193e-06, whereby the null hypothesis that both models fit the data equally well can be rejected at the 0.1% level. Therefore, including the interaction terms adds more explanatory power to the model.

MWTP

A good way to find a practical interpretation of the results of a discrete choice experiment is the calculation of the MWTP, which was exemplary derived for *biodiversity in the forest* in the previous section. Table 2 shows the MWTP for each attribute. Most of the MWTP estimations for the attributes are significant at the 0.1% level. On average the willingness to pay of the respondents for an marginal increase of *FoBio* is 33.92€. The interpretation of the value is more relevant in terms of the general direction of the value, then in precise monetary units or units of biodiversity. As the scale of biodiversity levels ranged from "as today" over "slightly increased" to "distinctly increased" it is impossible to pin down a precise unit of biodiversity that the MWTP would cover. It rather reflects the willingness to pay for a subjectively perceived slight or distinct increase. Furthermore, the data set was not adjusted for the individual specific status quo as data for this attribute was unavailable. Therefore, only a general ordering of preferences with regard to this attribute is covered by the data and reflected in the MWTP value.

The MWTP for *ShFor* is positive but declining with further shares of forest. This can be seen due to the positive value around 8.86€ that the respondents would pay on average for an additional 1% share of forest

	Full Model
b_alt1	-77.8542^{***}
	(9.6318)
b_alt2	-66.4556^{***}
	(9.1829)
b_ShFor	8.8649^{***}
	(0.9088)
b_ShFor2	-0.0584^{***}
	(0.0135)
b_FiSizHalf	-5.4316
	(4.8120)
b_FiSizDouble	-2.5068
	(4.5473)
b_FoBio	33.9293^{***}
	(3.0979)
b_NoUse	29.3035^{***}
	(3.2899)
b_FoTre	-44.7053^{***}
	(3.8281)
b_IncXFoBio	-3.5940^{**}
	(1.3741)
b_NatDayXFoBio	0.5075
	(1.6679)
No Observations	11349
No Respondents	1261
Log Likelihood (Null)	-12468.1509
Log Likelihood (Converged)	-10974.4192

$^{***}p < 0.001$; $^{**}p < 0.01$; $^{*}p < 0.05$

Table 2: Marginal Willingness to Pay

and the negative value around -0.06€ for the quadratic term that indicates diminishing marginal utilities. Both terms are significant at the 0.1% level.

4. Discussion and conclusion

In the context of the United Nations decade on biodiversity in the years of 2011-2020 this study offers some insights on possible behavioral and socio-demographic determinants of individual preferences for biodiversity. Especially in the face of the ongoing increase of anthropocentric driven biodiversity loss it is essential to determine its drivers and possible angles for policy measures {Jaureguiberry et al. (2022)}. Whether or not contributions towards ecosystem services lead to gains in individuals utility, has profound policy implications.

In general, the Maximum Likelihood estimates of the conditional logit model that is applied to the discrete choice experimental data in this study are largely significant at the 0.01% level. With regard to forest biodiversity the estimates indicate strong utility gains towards higher degrees of biodiversity. In order to get more insights of these effects I controlled for average regional income as a proxy for personal income and for a variable that captures days spend in the open landscape. The results show that higher levels of income lead to negative changes in marginal utility of biodiversity. Therefore, the initial hypothesis that income has positive impacts on biodiversity preferences needs to be rejected. This finding is at odds with research done by Bienabe and Hearne (2006) in a middle-income country, where the choice experiment revealed that higher income groups have a higher WTP for Payments for Ecosystem Services that enhance biodiversity conservation. However, overall MWTP for increases in biodiversity levels is positive and indicate on average a WTP around 34€ annually for slight increases in forest biodiversity. This finding has important policy implications, as taxes aiming on forest biodiversity protection could thereby be justified. For example, a unit tax on the volume of timber harvested would be conceivable (Michanek et al. (2018)). However, further research would be necessary to verify the findings here with personal income data and more precise choice-levels in order to find solid estimates for the magnitude of possible policy interventions.

Experiencing days in the open landscape had no significant effect on the respondents preferences on forest biodiversity. The empirical finding, that direct experience and thus "usage" of biodiversity has no significant impact on biodiversity preferences could theoretically indicate the role of non-use "existence values". Nevertheless, a reasonable determination of this relationship cannot be provided here and could be an interesting trace for further research.

A possible limitation to these findings is the weak representatives of the sample. Sagebiel, Glenk, and Meyerhoff (2017) report that the respondents are on average younger, less female, more educated and live in smaller households than the German average. Another limitation is the lack of data on the individual status quo of levels of forest biodiversity and personal income data, which prevents the determination of exact estimates. Furthermore, the estimation of the conditional logit model prevents from controlling for preference heterogeneity, whereby, a mixed logit approach could solve this issue. The large sample size of the survey and the high significance of the results, nonetheless, can provide strong inferences about the research question as initially formulated.

Bibliography

Bhat, Mohammad Younus, and Arfat Ahmad Sofi. 2021. "Willingness to Pay for Biodiversity Conservation in Dachigam National Park, India." *Journal for Nature Conservation* 62: 126022.

Bienabe, Estelle, and Robert R Hearne. 2006. "Public Preferences for Biodiversity Conservation and Scenic Beauty Within a Framework of Environmental Services Payments." *Forest Policy and Economics* 9 (4): 335–48.

Diaz, Sandra, Sebsebe Demissew, Julia Carabias, Carlos Joly, Mark Lonsdale, Neville Ash, Anne Larigauderie, et al. 2015. "The IPBES Conceptual Framework—Connecting Nature and People." *Current Opinion in Environmental Sustainability* 14: 1–16.

Jaureguiberry, Pedro, Nicolas Titeux, Martin Wiemers, Diana E Bowler, Luca Coscieme, Abigail S Golden, Carlos A Guerra, et al. 2022. "The Direct Drivers of Recent Global Anthropogenic Biodiversity Loss." *Science Advances* 8 (45): eabm9982.

Lawler, Odette K, Hannah L Allan, Peter WJ Baxter, Romi Castagnino, Marina Corella Tor, Leah E Dann, Joshua Hungerford, et al. 2021. "The COVID-19 Pandemic Is Intricately Linked to Biodiversity Loss and Ecosystem Health." *The Lancet Planetary Health* 5 (11): e840–50.

Le, Thi Ha Thu, Don Koo Lee, Yong Shik Kim, and Yohan Lee. 2016. "Public Preferences for Biodiversity Conservation in Vietnam's Tam Dao National Park." *Forest Science and Technology* 12 (3): 144–52.

Louviere, Jordan J, David A Hensher, and Joffre D Swait. 2000. *Stated Choice Methods: Analysis and Applications*. Cambridge university press.

Metzger, Birgit. 2015. *Erst Stirbt Der Wald, Dann Du!: Das Waldsterben Als Westdeutsches Politikum (1978-1986)*. Campus Verlag.

Michanek, Gabriel, Goeran Bostedt, Hans Ekvall, Maria Forsberg, Anouschka R Hof, Johnny De Jong, Juergen Rudolphi, and Astrid Zabel. 2018. "Landscape Planning—Paving the Way for Effective Conservation of Forest Biodiversity and a Diverse Forestry?" *Forests* 9 (9): 523.

Sagebiel, Julian, Klaus Glenk, and Juergen Meyerhoff. 2017. "Spatially Explicit Demand for Afforestation." *Forest Policy and Economics* 78: 190–99.

Steffen, Will, Katherine Richardson, Johan Rockstroem, Sarah E Cornell, Ingo Fetzer, Elena M Bennett, Reinette Biggs, et al. 2015. "Planetary Boundaries: Guiding Human Development on a Changing Planet." *Science* 347 (6223): 1259855.