Preferences for familiar and unfamiliar ecosystem insurance services in forests

Wertschätzung bekannter und unbekannter Versicherungs-Dienstleistungen in Waldökosystemen

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Summary

This contribution analyses Willingness to Pay (WTP) for several functional ecosystem services concerning protection against environmental risks in forests. We conducted a postal survey with a random sample of German citizens (n=311). The study uses the stated preference methodology (choice experiment). Nested Logit analysis estimates an annual WTP between € 11,- and € 25,-/year/respondent for ecosystem service improvements. Altogether, the results might indicate a considerable support for fostering forest resistance against environmental risks among the respondents.
Keywords: ecosystem services, Willingness to Pay (WTP), choice experiment, environmental risks, insurance hypothesis

Zusammenfassung

Der vorliegende Beitrag erforscht die Zahlungsbereitschaft für verschiedene Ökosystem-Dienstleistungen in Wäldern, die sich auf den Schutz vor Umweltrisiken beziehen. Im Rahmen einer postalischen Befragung wurde die Zahlungsbereitschaft zufällig ausgewählter deutscher StaatsbürgerInnen (n=311) mittels der *Stated Preference*-Methode (Choice Experiment) erhoben. Mit Hilfe von Nested Logit errechneten wir Zahlungsbereitschaften zwischen € 11,- und € 25,-/ Jahr/Befragtem für die Verbesserung von Ökosystem-Dienstleistungen. Die Ergebnisse deuten auf eine Befürwortung der

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Förderung der Widerstandskraft heimischer Wälder gegen Umweltrisiken seitens der Befragten hin.
Schlagworte: Ökosystem-Dienstleistungen, Zahlungsbereitschaft, Choice Experiment, Umweltrisiken, Versicherungs-Hypothese

1. Introduction

Ecosystem services are generally defined as benefits humans obtain from ecological systems. Economic studies play an important role in specifically highlighting the costs of the loss of these services provided by nature. Although there have been a considerable number of economic studies concerning various aspects of ecosystem services (e.g. BARKMANN et al., 2008; SUSAETA et al., 2010), this has not been the case for one type of important functional regulating services: so-called *insurance services*, which offer protection against ecological risks.
In this paper, we extend a study by RAJMIS et al. (2010) on economic preferences for protection from ecological risks by ecosystem insurance services in forests. Moreover, since socio-demographic characteristics have often been found to effect preferences for environmental goods (e.g. ACHTNICHT, 2012; BATEMAN et al., 2002, 320f), we also check for potential influences of socio-demographics on preferences.

2. Methods

2.1 Study site and administration of the study

We conducted a postal survey in 10 districts of the two German federal states of Thuringia and Lower Saxony from April to October 2009. 1,455 questionnaires were sent to randomly selected households. Target individuals were identified using the *last-birthday* method. The minimum age of participation was 18 years. The response rate was 22.2% (n = 323). Quantitative WTP analyses are based on a set of 311 households.

2.2 Construction of the choice experiment (CE)

We asked respondents to value various precautionary scenarios against environmental risks in forests via a CE. All management scenarios described in the CE referred to local forests in the study area. Thus, we tried to relate the scenarios to respondent personal values and interests.

We generated an orthogonal main effects design (HENSHER et al., 2005, 115ff) with 26 choice sets à three choice cards (incl. a *Status Quo*-card). The choice cards were assigned to four blocks of six and seven choice sets. Each respondent was randomly assigned to one of the four blocks.

The attributes used in the CE refer to forest based ecosystem services that a) mitigate risks from climate change, b) result in an improved resistance of the forests against insect pests and storms, and c) improve forest resistance against unknown environmental risks (see Table 1). We used attributes which are as similar as possible to those used by RAJMIS et al. (2010) to check for transferability of our results. Since the levels of their cost attribute are not equally spaced – a constellation which may lead to correlations within the experimental design (HENSHER et al., 2005, 158) – we tested for correlations using Kendall's tau. No significant correlations were found at the 0.05 level.

Tab. 1: Forest management measures/indicators of the choice experiment

Attribute	**Measure/ Indicator**	**Level of change of forest state (Coding in parentheses if not directly given; * : *Status Quo*)**		
Climate change mitigation	Carbon sequestration per capita	Sequestration of 1.5 tons CO_2 per capita (1.5)*	Sequestration of 2.0 tons CO_2 per capita (2.0)	Sequestration of 2.5 tons CO_2 per capita (2.5)
Protection against insect pests and storms	Planting of site-adapted tree species and proportion of mixed stands	Low resistance (1)	Medium resistance (2)*	High resistance (3)
Protection against unknown environmental risks	Changes in diversity of mycorrhizal fungi	Low resistance (1)	Medium resistance (2)*	High resistance (3)
Costs	Income change per month and person by a special levy	0 €*; 5 €; 10 €; 20 €; 35 €; 50 €; 60 €; 80 €		

Source: RAJMIS et al., 2010; own research

To operationalise the afforestation attribute, we assessed the annual amount of CO_2 sequestered in the study site forests. We calculated approximately 3.75 million tons of sequestered CO_2/year, resulting in ~ 1.5 tons/year/inhabitant. As alternatives to the *Status Quo*, we offered respondents two different local afforestation options. Based on the carbon storage rates of forests at the study site, the required afforestation area is about 390 m² per respondent for option 1 and 780 m² per respondent for option 2.

For the attribute *forest resistance to insect pest and storms,* we specified three attribute levels. The high resistance level is characterized by a high number of mixed stands and site-adapted tree species and the low resistance level by a low diversity and a small number of site-adapted species. The *Status Quo* was described as having *middle resistance* since several monocultures or unadapted stands exist in the study region.

Apart from well and reasonably known risks, new and until now unknown environmental risks are likely to exist (WBGU, 1999). Facing risks of this kind is only possible by employing general precautionary strategies (e.g. WBGU, 1999). One potential strategy is the conservation of biodiversity as an insurance for ecosystem functioning. The ecological insurance hypothesis (YACHI and LOREAU, 1999) states that the more species exist in an ecosystem, the higher are the chances that species exist that can take over the role of an extinct one. Hence, higher species diversity can be said to improve the resistance of forest ecosystems against unknown environmental risks. For this insurance attribute, we used species richness of mycorrhizal fungi as an indicator for *general resistance*. We offered three levels to respondents: high, medium and low resistance to unknown threats induced by a high, medium and low number of mycorrhizal species.

The focus on mycorrhizal diversity had an important methodological reason: Changing the diversity of any "visible" species could have changed the forest's aesthetic value for respondents. Thus, respondents may have confounded their preference for a certain aesthetic appearance of the forest with their preference for general resistance. As described above, we excluded any confounding effect of this sort.

2.3 Econometric analysis of the choice experiment

We assumed an additive utility function U_{in} linear in parameters with respect to the attribute levels (see Table 1). U_{in} is the total utility of

alternative *i* for individual *n* and consists of an observable component V_{in} and an unobservable (error) component ϵ_{in}. The probability that individual *n* will choose option *i* over option *j* within the complete choice set C is given by: $Pr_{in} = \Pr(V_{in} + \epsilon_{in} > V_{jn} + \epsilon_{jn})$ (*all j* ϵ *C*).
To include the influences of socio-demographic variables on choices, interaction terms of the respective variables with attributes are calculated: $V_1(Z_1,A) = b_A * Z_1 * A + b_1 * Z_1$ (with Z_1: attribute; V_1: deterministic utility component, linear function of Z_1; *A*: socio-demographic variable; b_A, b_1: utility coefficients) (BARKMANN et al., 2007). We standardized socio-demographics before multiplying them with Z_1 to reduce collinearity between the interaction term and the non-interacted attribute term. The vector of utility coefficients is estimated with maximum likelihood estimation using Nested Logit models (NLOGIT 3.0) to accommodate potential violations of the *Independence from Irrelevant Alternatives* (IIA) condition (HENSHER et al., 2005, 479, 481f). All models include an alternative specific constant (coded: '0' for *Status Quo*, '1' for non-*Status Quo* choice cards) that picks up systematic differences in choice patterns between the choice cards.

2.4 Calculation of Willingness to Pay (WTP)

WTP calculations are based on extrapolations from mean marginal WTP values. For attributes linear in parameters, the marginal WTP (*mWTP*) equals the negative ratio of the respective attribute coefficient and the coefficient of the cost attribute c_y.. The influence of socio-demographics on WTP can be expressed as: $mWTP = -(c_a/c_y) * x_a$ (with c_a: coefficient of the socio-demographic variable and x_a: parameter value for influence of the socio-demographic variable).
We calculated single and overall models. Single models examine the influence of one socio-demographic variable at a time. The overall models were created by putting all variables, which proved to have a significant influence on preferences in the single models, in an overall model. Afterwards those variables which had turned out to be insignificant were excluded from the model.

3. Results

3.1 Socio-demographic statistics of respondents

A summary of the socio-demographic statistics is shown in Table 2.

Tab. 2: Socio-demographic characteristics of respondents

Variable	Sample	Germany
	Means or category counts (standard deviation in parentheses)	
Gender[1]	59 % male; 40 % female 1 % no answer	51 % male; 49 % female
Age	51.1 (± 15.8) [range 18-89] 8.7 % : 18-25 years 26.1 % : 26-45 years 40.8 % : 46-65 years 22.5 % : 66 years and older 1.9 % : no answer	9.4 % : 18-25 years 31.4 % : 26-45 years 34.4 % : 46-65 years 24.8 % : 66 years and older
Net Income[2]	2,621.70 €/month and household (± 1,755.15 €/month/household)	2,873.00 €/month and household
Household Size	2.3 members per household (± 1.1)	2.03 members per household
Education[3]	14.4 years (± 2.4)	12.1 years
Residence[4]	79 % Lower Saxony; 20 % Thuringia 1 % no answer	/
Frequency of forest visits	4 % never; 1 % not within the last year; 23 % 1-5 times a year; 14 % 6-10 times a year; 24 % once a month; 18 % once a week; 14 % more often; 3 % no answer	/

[1] Effects coded variable describing gender of respondents [1: male, -1: female]
[2] 11 categories from <500 € to >10,000 €
[3] Comprises years in school and following education
[4] Effects coded variable describing residence [1: Lower Saxony, -1: Thuringia]
Source: Own research, Federal Statistical Office of Germany 2009-2010

The socio-demographic variables age, income and household size are close to the national average. Respondents to our sample received a higher level of education than the average German citizen, though. Furthermore, the percentage of men is above average in our sample.

3.2 Willingness to Pay

The basic WTP model shows respondent WTP without accounting for influences of socio-demographics. This model as a whole is most significant (P_{chi^2}<0.0001) (see Table 3). Respondents express a WTP for all of the three suggested attributes (p<0.0001 for all attributes).

Tab. 3: Nested Logit estimation results of the base model

Attribute	Coefficient	Std.Error	WTP [€/person/year]
Climate change mitigation	0.3197****	0.0505	11.28
Resistance against insect pests and storms	0.7055****	0.0525	24.88
Resistance against unknown environmental risks	0.4949****	0.0510	17.45
Non-Status Quo ASC	-0.3494***	0.0912	-12.32
Costs (special levy)	-0.0284****	0.0017	-
Restricted Log Likelihood			-2337.292
Chi squared			1183.838
Prob[ChiSqd > value]			0.00001
Pseudo-R^2 Adjusted (constants only)			0.16060
Observations			1990

Significant at: ****p<0.0001; ***p<0.001; WTP refers to a marginal one level change in the attributes or – in the case of climate change mitigation – to one ton of additionally sequestered CO_2; n = 311; see Table 1 for the coding.
Source: Own research

3.3 Influence of socio-demographics on respondent preferences

Table 4 shows the influence of each socio-demographic variable on WTP, calculated in single models. The only variable with no impact at all on choices is the county of residence. Apart from the county of residence, all socio-demographic variables show an influence on WTP for climate change mitigation. WTP for forest resistance against insect pests and storms is still influenced by the majority of socio-demographic variables. However, almost none of the variables has an impact on WTP for protection against unknown environmental risks.

When calculating overall models, the variables influencing WTP are considerably reduced. WTP for climate change mitigation is positively and significantly influenced by net income (0.1997, p<0.0001) and education (0.1155, p=0.0039). Gender and age exhibit negative effects on WTP, however, these effects are smaller and less significant (-0.0637, p=0.0971 (gender); -0.0898, p=0.0234 (age)). Since education and income tend to correlate, we tested for correlations using Kendall's tau. The results indicate a rather week correlation (tau_b=0.27, p=0.01).

Thus, income and education might both be integrated in the same model without leading to considerable problems regarding multi-collinearity. In the overall model, WTP for forest resistance against insect pests and storms is significantly and positively influenced by net income (0.2780, p<0.0001). Furthermore, age has a negative, but less significant impact on WTP (-0.1163, p=0.0379). WTP for forest resistance against unknown environmental risks is influenced both by gender (-0.0907, p=0.0786) and age (-0.2053, p=0.0001).

Tab. 4: Influence of socio-demographic variables on WTP for protection against environmental risks, calculated in single models

Interaction with	N	Coefficient of Interaction Term		
		Climate change	Insect pests and storms	Unknown environmental risks
Gender	308	-0.0774*	0.0088	-0.1103*
Age	305	-0.1562****	-0.1987***	-0.2178****
Net income	265	0.2410****	0.3009****	0.0431
Household size	302	0.0948**	0.1246*	-0.0456
Education	298	0.1506****	0.1760**	0.0740
Residence	308	0.0410	0.0187	0.0658
Frequency of forest visits	303	0.0787*	-0.0017	-0.0519

Significant at: ****p<0.0001; ***p<0.001; **p<0.01; *p<0.1.
Source: Own research.

4. Discussion

All attributes are significant determinants of choice. Absolute WTP values are similar to those found by RAJMIS et al. (2010), which argues for the transferability and the robustness of our results with respect to temporal preference stability.

From the respondents' point of view, the protection against insect pests and storms has the highest priority of all the three offered protection measures, followed by the protection against unknown environmental risks. Consequently, when addressing forest-related environmental issues, local decision makers should bear in mind that potentially there are environmental risks more important to the public than the risk of climate change.

Most of the socio-demographic variables observed are close to national level. However, female respondents and respondents with lower levels of education were somewhat underrepresented in our survey. Consequently, an extrapolation of the study results beyond the limits of the investigated sample has to be handled with care.

In the overall models, only the three variables net income, education and age remain as important predictors of WTP. However, whereas net income and education show a positive effect on WTP, age has a negative influence, i.e. the older the respondents are, the less inclined they are to pay for the protection from unknown environmental risks. Possibly, older respondents are less receptive to topics such as ecological risk prevention, especially when considering unknown risks.

Income, age, education and gender are socio-demographics known to potentially influence preferences for (environmental) goods (e.g. ACHTNICHT, 2012; BATEMAN et al., 2002, 320f). Yet, in our study especially preferences for unknown environmental risks are mainly unaffected by socio-demographic factors. It is especially interesting that net income, the variable with the highest influence on the other two attributes, has no impact on preferences for forest resistance against unknown environmental risks. It seems that the otherwise highly important monetary restrictions do not play a crucial role for respondents when valuing protection from unknown environmental risks.

Instead of socio-demographics, in many cases attitudes could be the primary driver of stated preferences (BATEMAN et al., 2002, 330). In a related study, we found that preferences for ecosystem insurance services were among other things influenced by respondents' general beliefs about the environment and that especially respondents' perception of unknown environmental risks had an effect on preferences for protection against these risks (SCHRÖDER, 2012). Further research is necessary to investigate the relationship between attitudinal variables such as risk perception and WTP for protection from environmental risks in detail.

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