How Reliable are Expert Predictions of Households' Willingness-to-Pay to Preserve the Amazon Rainforest? Comparing Contingent Valuation, Delphi Surveys and Benefit Transfer

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Abstract

Avoiding deforestation of the Amazon rainforest and the resulting loss of biodiversity and ecosystem services provide benefits to both local households and households worldwide. The latter benefits seem to account for the majority of the total global benefits. As it is very time consuming and costly to assess these global non-use values in stated preference (SP) surveys in all countries worldwide, benefit transfer (BT) exercises and expert assessment in Delphi Contingent Valuation (CV) surveys have been conducted. We test the reliability of these two approaches for predicting distant beneficiaries´ willingness-to-pay (WTP) for Amazon Rainforest preservation plans by comparing these estimates to a new CV survey of 300 Norwegian households. The survey found a mean WTP of 110 € (NOK 1100) per household per year to avoid further forest and biodiversity loss.

Whereas BT in terms of unit transfer with income adjustment from a North American SP survey of similar preservation plans, resulted in transfer errors of 43-131 %; the Norwegian experts in the Delphi CV survey predicted the outcome of the population CV survey with transfer errors ranging from 2 to 31 %. Thus, the Delphi CV method could be a valid, as well as very time and cost effective, technique for assessing benefits of global public goods to distant beneficiaries.

JEL Classifications: Q51, Q57

Keywords: Amazon rainforest, Benefit transfer, Contingent valuation, Delphi survey, Expert assessment, Non-use values, Willingness-to-pay; global public goods

Abbreviations

Benefit transfer – BT, Contingent valuation – CV, Willingness-to-pay – WTP, Stated preference - SP

1. Introduction

The Amazon rainforest is the world's largest rainforest, making up as much as 40 percent of the total remaining area of tropical forest worldwide (Andersen et al., 2002, p:1). Since the 1960's, deforestation of the Amazon rainforest has grown to become a major global concern (Uhl, 1987). Today, at least 16 percent of the Amazon rainforest has disappeared (Nunes Kehl et al., 2015; Malhi et al., 2008).

Andersen et al. (2002) identify several origins of deforestation in the Brazilian Amazon rainforest. The largest contributor is cattle ranching, which previously was heavily subsidized by the Brazilian government. It accounts for about 70 percent of the deforestation of the Amazon rainforest (Malhi et al., 2008). The second largest contributor is agricultural expansion and production; contributing 10 percent. Logging, mining, insecure property rights and road building are also important driving forces for deforestation of the Amazon.

The forest provides important local, regional and global ecosystem services. Therefore, the Amazon rainforest can be defined as a global public good (Navrud and Strand, 2018; Strand et al., 2017). It provides global benefits and ecosystem services in terms of, biodiversity, carbon storage, recreational values and non-use values (Strand et al., 2017; Andersen et al., 2002, p:172).

Deforestation causes loss of ecosystem services and biodiversity (Foley et al., 2007), which reduces human well-being for both local and distant beneficiaries of the forest. Therefore, it is reasonable to assume that also distant beneficiaries are willing to pay to preserve the Amazon. Amongst distance beneficiaries, non-use values dominate as most people globally have not visited the Amazon; and thus do not have recreational use values. Non-use values represent the value of benefits people obtain by the existence of ecosystem services, the enjoyment of these services by others, and that the good is available for future generations (i.e. bequest values) (Pascual and Muradian, 2010, p:195). Even though people´s WTP per household could be small, total non-use values aggregated over the global population would be substantial. Thus, non-use values to distant beneficiaries are important to include in a global cost-benefit analysis (CBA) of preservation plans (Navrud and Strand, 2018). Existence of biodiversity, forest and tropical wildlife are examples of non-use values distant beneficiaries hold of preservation of the Amazon rainforest. Among the environmental valuation techniques, only the Stated Preference (SP) methods, i.e. Contingent Valuation (CV) and Choice Experiments (CE), are able to measure non-use values.

Only two previous SP studies have estimated distant beneficiaries' WTP to preserve the Amazon rainforest. Kramer and Mercer (1997) conducted a CV study among U.S residents to determine their WTP to preserve tropical rainforests in general. Their study showed that U.S residents, on average, were willing to pay between $21 and $31 to preserve 5 percent of tropical rainforests in addition to what was already preserved at the time. This was a one-time voluntary payment.

Horton et al. (2003) conducted a CV study in the UK and Italy to determine households' WTP to impose preservation programs of parts of the Amazon rainforest. In the first program, 5 percent of the Brazilian Amazonia were to be preserved, with an average WTP per household of

£30 as annual tax. The second program preserved 20 percent with an annual average WTP per household of £39.

In addition to these two SP-studies, Navrud and Strand (2018) conducted a Delphi CV survey for the World Bank to estimate WTP among households in the European countries to preserve the Amazon rainforest. 48 European valuation experts from different European countries were asked to guess mean and median WTP for two preservation plans among households if a CV survey was conducted in their respective country and for Europe overall (Navrud and Strand, 2018). The study was later extended by Strand et al. (2017) by including OECD countries and low-income, lower-middle income and upper-middle-income Asian countries. The experts were asked to guess the outcome of a CV survey valuing two alternative preservation plans, A and B.

In **Plan A**, there would be no further loss of forest, nor species, by 2050. Thus, 85 percent of the total area would remain in 2050, and there would be n further loss of species. **Plan B** implied some forest loss, and 75 percent of the total area would remain by 2050. 7 percent of the species would be lost. The two preservation plans were compared to a reference (business- as-usual) scenario where 60 percent of the forest would remain by 2050 and 12 percent of the species would be lost (Navrud and Strand, 2018).

Three Norwegian environmental valuation experts were surveyed in the European Delphi CV study. The mean of their mean WTP guesses for Plan A was €65 per Norwegian household as an annual tax in round 1 (Navrud and Strand, 2018). In round 2, where they were shown the distribution of the round 1 responses from all experts and asked whether they would like adjust their "guesstimates" or not, the mean of their mean WTP guesses of the Norwegian experts was $114.20 for the most ambitious preservation Plan A For the less ambitious Plan B, the mean of mean WTP guesses from the Norwegian experts was $63 and $64; in round 1 and in round 2. (Strand et al., 2014).

As a follow-up to the Delphi CV survey, a choice experiment (CE) survey of US and Canadian households was conducted to estimate their marginal WTP for avoiding forest and species loss (Siikämaki et al. 2019). They found a mean, annual WTP of North American households of $4.97 and $3.19 each percentage point of avoided forest area loss and avoided species loss, respectively.

The main aim of this paper is to test the validity of both Delphi CV[1] and benefit transfer method, by comparing their results to the outcome of a new CV survey of a representative sample of 300 Norwegian households valuing the same Amazon rainforest preservation plans. As CV and other SP techniques do not measure households´ actual WTP, this comparison of estimates from different valuation approaches will be a criterion validity test (Bishop and Boyle, 2019).

In the benefit transfer exercise, we perform unit value transfer with income adjustment from a CE survey of a representative sample of US and Canadian households (Siikämaki et al., 2019). Equivalence tests (Kristófersson and Navrud 2005, 2007), t-tests and estimated transfer

[1] Delphi CV surveys could also be classified as a benefit transfer technique, as all benefit transfer techniques depend on experts' opinions and assessment of how previous studies can be used to estimate benefits or costs in new policy contexts (León et al., 2003; Navrud and Strand, 2018; Strand et al., 2017).

errors (TE) are used to evaluate equivalence or difference between transferred mean WTP estimates and mean WTP estimates from our Norwegian CV survey. As only three Norwegian valuation experts were asked in the Delphi CV survey, only transfer errors from using the mean of their mean WTP guesses to predict the outcome of the Norwegian CV survey will be calculated (as conventional testing with only 3 observations in one sample does not make sense). Results show that experts in Delphi CV studies outperform traditional benefit transfer by having lower transfer errors and can thus provide valid estimates for non-use values among distant beneficiaries to global public goods. However, further comparative studies for other global public goods, contexts and countries should be performed to see whether, and under what conditions, these results can be generalized.

2. Data and methods

As the main aim of this paper is to compare the outcome of an actual population Contingent Valuation (CV) survey with an earlier expert assessment of the outcome of such a CV survey (in term of a Delphi CV survey), and with a benefit transfer exercise; we will in the following describe the methodology of these three valuation approaches

2.1. Norwegian CV survey

The CV survey conducted in Norway was constructed to be as identical as possible to the Delphi CV survey used by Navrud and Strand (2018), in order to make the CV survey directly comparable to the Delphi CV survey. An internet survey of 300 members of the NORSTAT internet panel was conducted. The respondents were randomly selected from the panel to be representative of the Norwegian population in terms of age, gender and education level. The survey was sent to 1451 individuals, which gives a response rate of 20 percent. This might seem low but note that in this and many other internet panel surveys, invitations are sent to members of large panels without follow-up reminders, and the survey is then closed when the number of respondents aimed for is reached.

In the CV survey, respondents are first asked questions regarding their preferences for public spending on a range of public services. The questions make the respondents consider their preferences regarding public spending for different public goods, avoid a focus effect on the Amazon rainforest, and train respondents for the WTP elicitation questions (Siikämaki et al., 2019). Respondents are also asked if they have ever visited a tropical rainforest in general, and the Amazon rainforest specifically.

Next, respondents are provided a definition and information about tropical rainforests in general, and the Amazon rainforest in particular. Maps are presented to show where the world's tropical rainforests are located (see figure 1); and the size of Norway and other European countries relative to the Amazon rainforest (see figure 2).

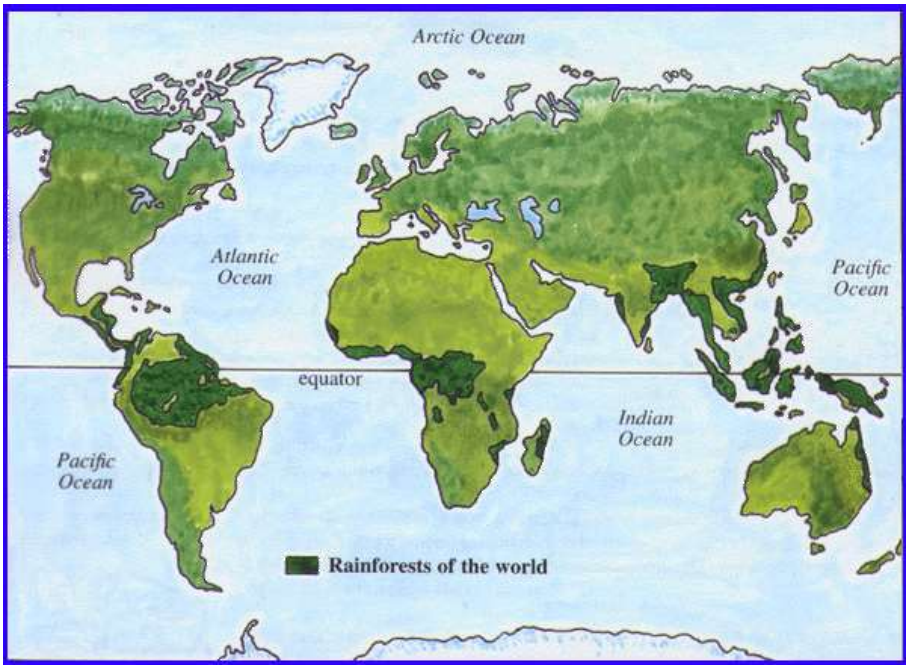

Figure 1. Rainforest of the world; as shown in the Norwegian Contingent Valuation (CV) survey and the European Delphi CV survey.

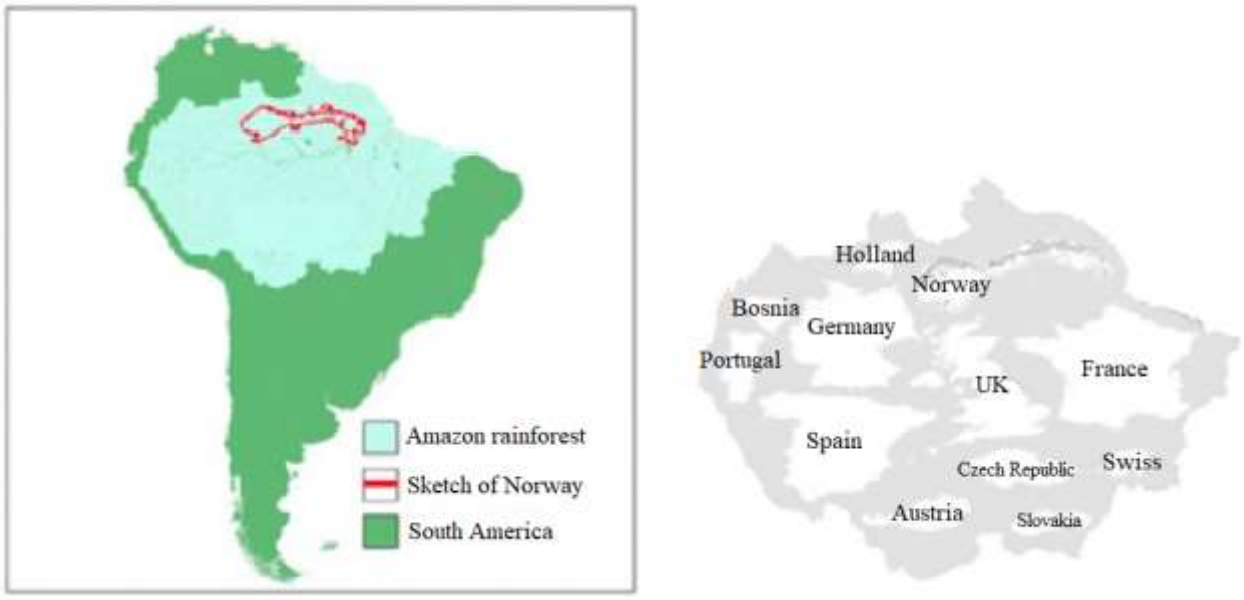

Figure 2. The Amazon rainforest compared to the size of Norway and other European countries; as shown in the Norwegian Contingent Valuation (CV) survey and the European Delphi CV survey (but the size of Norway was not shown in the Delphi CV survey).

Respondents are then asked questions to reveal their knowledge about the Amazon rainforest. Then, the two different preservation plans A and B are presented. Respondents are informed that if no preservation plan for the Amazon is implemented, 24 percent of existing species and 25 percent of the current forest areas of the Amazon will be lost within 2050. This is defined as the **reference scenario**.

Just like in the Delphi CV survey; a slide depicting mammals in the Amazon facing potential extinction (see figure 3) as well as maps showing the forested area with preservation plans A, B and the reference scenario are shown to the respondents; reproduced in figures 4, 5 and 6, respectively. Respondents are informed that the Brazilian government, by collaborating with NGOs, have constructed the two preservation plans A and B. However, without international funding the costs of the preservation plans are too high for implementation. **Plan A** is more extensive than Plan B, and implies no further forest nor species loss within 2050. **Plan B** implies 15 percent forest loss and 7 percent species loss within 2050 compared to current levels. The respondents are also reminded that 15 percent of the original Amazon rainforest has already disappeared since the 1970s, and will not be recovered by any of the preservation plans. Thus, even with the most ambitious preservation Plan A, 85 % (and not 100%) of the original Amazon rainforest is preserved (This was stated in the upper right corner of the map shown to respondents; see figure 4).

Figure 3. Mammal species in the Amazon rainforest at risk of extinction. Slide shown in in the Norwegian Contingent Valuation (CV) survey and Delphi CV survey.

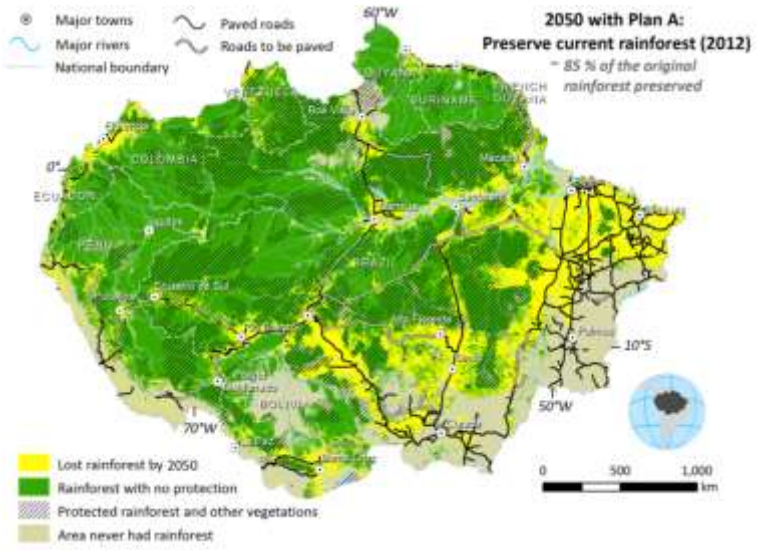

Figure 4. Preservation Plan A, as shown in the Norwegian Contingent Valuation (CV) survey and the European Delphi CV survey.

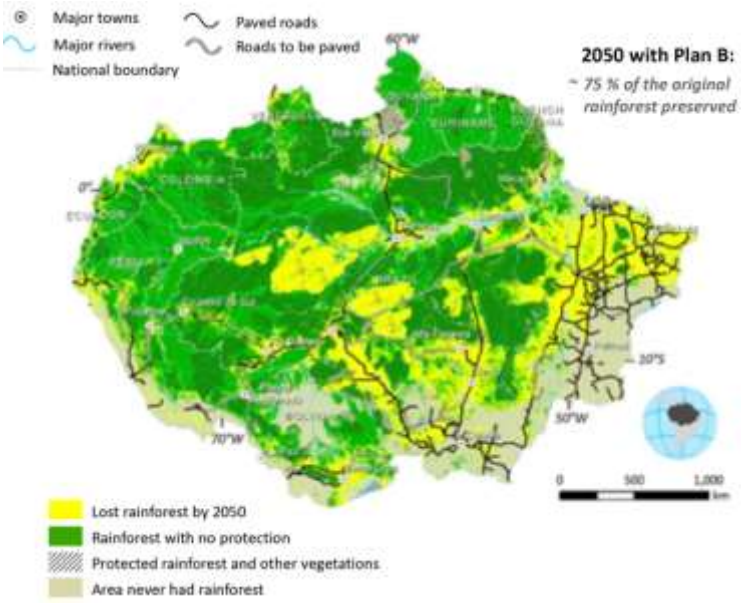

Figure 5. Preservation Plan B, as shown in the Norwegian Contingent Valuation (CV) survey and the European Delphi CV survey.

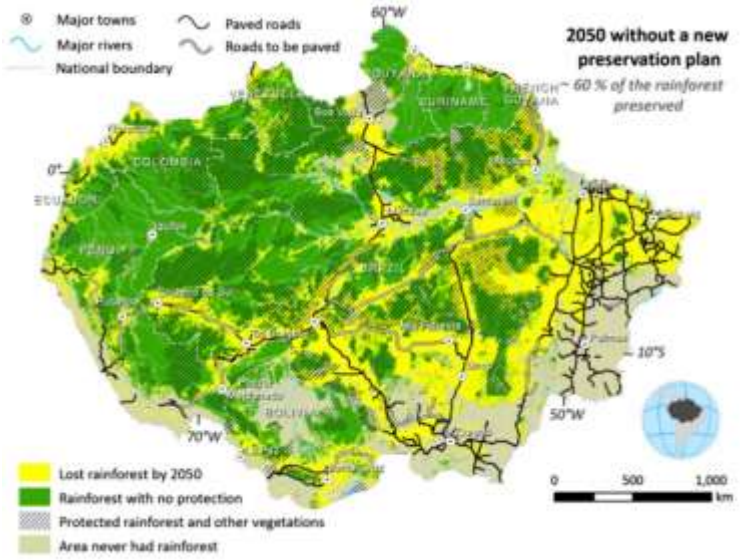

Figure 6. Reference scenario (i.e. no preservation plan), as shown in the Norwegian Contingent Valuation (CV) survey and the European Delphi CV survey.

Respondents are then asked what the most, if anything, their household would certainly be willing to pay annually for preservation Plans A and B, respectively; by indicating an amount on a payment card (PC), shown as a horizontal list of amounts from zero to 12,000 NOK (about 1,200 euro). The payment vehicle (PV) is an extra annual national tax, where the tax payments are transferred to the eight Amazon rainforest countries which have agreed to implement the preservation plan(s). The choice of PV is realistic, as recommended by Johnston et al. (2017), because Norway has already set aside money to pay Brazil to reduce deforestation. Additionally, respondents might be less sceptic to a tax which is earmarked for this specific purpose than a general increase in the income tax (Lindhjem and Navrud, 2009). Respondents reporting positive WTP are asked an open-ended question (i.e. no reply options provided) on *why* they are willing to pay, in order to evaluate and group their WTP response by the motivation for paying.

A follow-up question is also asked respondents stating zero WTP. They are asked to choose the most important reason for stating zero WTP, among a pre-specified set of reasons. This is used to distinguish “true zeros” from “protest zeros”: The latter group of respondents have positive WTP, but answer zero because they protest some part of the CV scenario. As their answer do not reflect their true WTP, they are excluded from the sample that is used to calculate mean WTP (Thus, we implicitly assume that the protest zeros have a WTP equal to the mean WTP of this remaining sample of respondents). If zero WTP respondents chose "Amazonian countries should pay themselves", "The Norwegian government should pay", or "Norway has already paid enough to reduce deforestation in Brazil and other countries", we identified them as protest zero responses, and excluded them from further analysis.

Respondents are then asked: i) if they think the preservation plans will be implemented, ii) if they believe they really have to pay the amounts they state, and iii) whether the results from the

survey will be used as decision support for policies aiming to reduce deforestation of the Amazon rainforest. These questions are used to test the level of payment and policy consequentiality; and thus assess the truthfulness and reliability of the responses (Johnston et al., 2017). Data on age, gender, education and other socioeconomic variables are also collected.

2.2. Delphi CV survey

The Delphi method is used to determine information on a specified subject by surveying experts about their respective opinion (Dalkey and Helmer, 1963). It was initially applied to forecast science and technology by Dalkey and Helmer (1963), and has later been applied in several different contexts (Hsu and A. Sandford, 2007; Sackman, 1974, p:1).

In the context of valuing environmental goods and ecosystem services, the Delphi method is used to ask valuation practitioners/experts how they expect households, in a population of interest, to value specified changes in an environmental good. Experts accumulate experience and valuation information when conducting primary valuation studies and conducting BT exercises. Correspondingly, conducting a Delphi CV survey to value changes in environmental goods and ecosystem services could also be viewed as a BT technique, considering that experts utilize accumulated valuation information in a Delphi CV survey when stating their respective opinions on behalf of a population of interest (Navrud and Strand, 2018).

A Delphi survey usually consists of several rounds. In the first round, experts fill in a questionnaire and state their opinion about the specified subject, without communicating with other experts. In the later rounds, the experts are shown what the other experts answered (without knowing the identity of the other experts), and are then allowed to revise their own answers. Generally, it is believed that predictions are more accurate in the later rounds (Navrud and Strand, 2018). A Delphi CV survey has the potential of providing quick and cheap WTP estimates, but the question is how they compare to a population CV survey; which is what we would like to test here.

We are comparing our population CV survey in Norway with the Norwegian part of the European Delphi CV survey reported by Navrud and Strand (2018); Delphi CV survey which was also included in the extension of the Delphi CV survey to other parts of the world (see Strand et al 2017).

2.3. Benefit transfer

The fundamental purpose of benefit transfer is to transfer valuation information from previous study sites to a new policy site. There are three main benefit transfer techniques for results from existing SP studies; i) unit transfer (i.e. transferring mean WTP/household/year estimates) without or with adjustments for different incomes at the study and policy site; ii) value function transfer (i.e. transferring the WTP function from a policy in terms of e.g. WTP as a function of the

characteristics of the environmental good valued and characteristics of the respondents), and iii) meta-analysis (i.e. transferring a WTP function estimated as a meta-regression function of data from a number of previous valuation studies valuing the same type of environmental good; including also the characteristics of the valuation studies in the value function to be used for benefit transfer) (Navrud, 2004).

2.4. Econometric Approach

In order to estimate mean WTP and WTP functions for the two preservation plans, ordinary leased squares (OLS) and interval censored regression models were applied. In the OLS models we assume that the respondents´ "true" WTP is the midpoint of their chosen amount and the next amount on the PC. However, OLS models might yield biased estimates, as they do not consider the uncertainty in the stated WTP amounts, and that their WTP might be different from the midpoint between the amounts on the PC (Cameron and Huppert, 1989; Yang et al., 2012).

Interval censored regression models take this uncertainty into account, and assumes normality. Interval regression models utilize the maximum likelihood estimator (MLE), but yield biased estimates if assumptions regarding normality and homoscedasticity are not met (Wooldridge, 2013, p: 603). The log likelihood function of *n* independent observations can be defined as (Cameron and Trivedi, 2005, p:534)):

$$\ell(\beta,\sigma) = \sum_{i=1}^{n} \ln\left[\frac{1}{\sqrt{2\pi\sigma^2}}\exp\left\{-\frac{(y-\boldsymbol{x_i\beta})^2}{2\sigma^2}\right\} + \Phi\left(\frac{a_{j+1}-\boldsymbol{x_i\beta}}{\sigma}\right) - \Phi\left(\frac{a_j-\boldsymbol{x_i\beta}}{\sigma}\right)\right] \quad (1)$$

where y are observed point data of WTP, $\boldsymbol{x_i}$ is a vector of independent variables, $\boldsymbol{\beta}$ is a vector of coefficients which explains how independent variables affect WTP, a_j is the respondent i's chosen amount on the PC and a_{j+1} is the next (and higher) amount on the PC.

3. Results and Discussion

3.1 Delphi CV survey

As the Norwegian valuation experts (as well as experts from other European countries) were asked to state WTP in euros using the market exchange rate we need to convert these amounts to NOK using the exchange rate at the time the Norwegian experts were surveyed. We then used the Norwegian consumer price index (CPI) to convert 2012-NOK to 2018-NOK, as the Delphi CV survey was conducted in 2012 and the population CV survey in early 2018.[2] Table 1 reports the

[2] The Norwegian experts in the Delphi CV were surveyed in April (Round 1) and June (Round 2) 2012, and they were asked to state the amount in euro using the market exchange rate. The average exchange rate for these two months of 2012 was 1 euro= 7,55 NOK.https://www.norges-bank.no/Statistikk/Valutakurser/valuta/EUR. The Norwegian Consumer Price Index (CPI) from May 2012 to February 2018, which increased by 13,6 %, was used to convert these amounts to 2018-NOK, and make the comparable to the population CV survey results.

initial expected mean WTP values among Norwegian households for Plan A and B in round 1 and 2 from the Delphi CV study. As the experts were shown the results from the other experts (without knowing their names) in Round 2 and were asked whether they would to like to keep or adjust their results, we consider Round 2 replies as the best representation of expert opinion (in line with other Delphi exercises e.g. Carson et al 2013). Among the three Norwegian experts, one kept his/her answer, one adjusted WTP upwards and one adjusted WTP downwards in Round 2.

Table 1: Delphi CV survey results for Norway. Mean WTP per household (hh) / year (y) for Preservation Plans A and B in Round 1 and 2.

Plan/Round	Mean WTP/hh/y from Delphi CV Survey (2012-euro)	Mean WTP/hh/y (2012-NOK)	Mean WTP/hh/y (2018-NOK)
Plan A/Round 1	€65	NOK 491	NOK 557
Plan A/Round 2	€98	NOK 740	NOK 841
Plan B/Round 1	€58	NOK 438	NOK 497
Plan B/Round 2	€64	NOK 483	NOK 549

3.2. Benefit transfer

We also tested international BT of WTP estimates from a North American Choice Experiment (CE) survey of the same preservation plans for the Amazon rainforest. A representative sample of North American households (i.e. USA and Canada) were on average willing to pay US $4.97 and $3.19 for avoiding one percent point loss in forest area and number of species, respectively (Siikämaki et al., 2019). Multiplying these marginal WTP estimates with the avoided percentage loss of forest area and species for preservation Plans A and B, we obtain estimates of mean WTP for the respective preservation plans among North American households. Unit transfer with income adjustment can then be applied to determine mean WTP among Norwegian households for Plans A and B (Ready and Navrud, 2006; Navrud and Ready, 2007). We use a Purchase Power Parity (PPP) adjusted exchange rate to convert US dollars to NOK in the time of the survey[3], and use the Norwegian Consumer Price Index (CPI) to convert to 2018-NOK.. Correspondingly, mean WTP among Norwegian households is NOK 2187 for Plan A and NOK 1137 for Plan B (again assuming an income elasticity of WTP equal to one).

3.2. CV survey

Table 2 reports the characteristics of the 300 respondents in the national sample of Norwegian household in the CV survey, and the corresponding statistics for the overall Norwegian population. While the sample seems representative in terms of gender, age and distribution on different geographical regions; households with high education and high income seem to be overrepresented.

[3]The North American survey was conducted in 2015, where the 1 USD = NOK 9.733 using the PPP-adjusted exchange rate.

Table 2: CV survey sample vs Population Characteristics

		Sample	Norwegian Population
Gender			
	Male	50.33%	50.39%
	Female	49.67%	49.61%
Income			
	Mean household income	NOK 773 171	NOK 518 313
Education			
	Below upper secondary education ((< 11 years)	5%	26.5%
	Upper secondary education (11-13 years	29.33%	37.8%
	Tertiary vocational education	12%	2.8%
	Higher education, short (Bachelor degree)	34%	23.4%
	Higher education, long (Master or PhD degree)	19.66%	9.5%
Age categories	Classification A:		
	15-24	11%	12.7%
	25-49	39.33%	34.4%
	50-64	19%	18.4%
	65-79	30%	12.4%
	≥80	0.67%	4.2%
	Classification B:		
	15-49	50.33%	47.7%
	50 or above	49.67%	52.9%
Geographical regions			
	Mid-Norway	12.33%	8.6%
	Northern Norway	9%	9.3%
	Southern Norway	8.67%	5.7%
	Western Norway	19.33%	26%
	Eastern Norway	50.66%	50.4%

Sources: SSB (2017c), SSB (2017d), SSB (2017a), Kommuneprofilen (2018a), Kommuneprofilen (2018b) and Kommuneprofilen (ND).

Out of the 300 respondents, 44 and 50 respondents stated zero WTP for Plan A and Plan B, respectively. 36 and 37 respondents replied 'don't know' to the WTP question for Plan A and Plan B, respectively. Mean WTP for Plans A and B were estimated excluding 'Don't know' answers and protest zeros; see table 3. Overall, 220 respondents have positive WTP for Plan A, while 213 respondents have positive WTP for Plan B.

Using the midpoints (between the stated amount, and the next higher amount on the PC), except for zero (where the "true" zeros (i.e. not protests) were recorded as zeros) mean WTP/household/year is NOK 945 and NOK 677 for Plans A and B, respectively. Using the unconditional interval censored means, WTP was NOK 1136 and 796 for Plans A and B, respectively. A scope test was performed to test whether households´ WTP for the more extensive preservation Plan A was significantly higher than for Plan B. The bootstrapped distribution of the difference in WTP between Plan A and B was estimated using 1000 replications. Further, we

estimated the percentile-t 95% confidence interval of the difference (143.43, 432.05).[4] As zero is not present, we can reject the null hypothesis of equality.[5] This confirms that there is scope, which is consistent with economic theory, as preserving larger forest areas and a higher number of species should be valued higher (see also Veisten et al., 2004).

Table 3: Mean and Median Willingness-to-Pay (WTP) from the Norwegian CV survey

	Mean WTP Plan A	Mean WTP Plan B	95% CI Plan A		95% CI Plan B	
PC Value	730	525	572	889	413	637
Midpoint value	945	677	746	1145	531	823
Interval censored value	1136	796	994	1279	697	895
	Median WTP Plan A	Median WTP Plan B	95% CI Plan A		95% CI Plan B	
PC Value	300	200	134	466	89	311
Midpoint Value	550	250	345	755	95	405

Note: the confidence interval for the interval censored means are obtained by the Delta-method.

A sensitivity analysis was performed to evaluate the reliability of the midpoint means of WTP for Plan A and B, referred to as baseline estimates. Firstly, observations inconsistent with economic theory, i.e. stating WTP for Plan B greater or equal to WTP for Plan A, were removed. Mean WTP for Plan A, estimated from the midpoints, then increased from NOK 945 to 1074. In total, 134 observations were removed. Thus, a substantial part of the sample responded inconsistently with economic theory. This could be due to the fact that households found Plan B to be more realistic than A, and thus stated their WTP as an expected value in terms of their "true" WTP multiplied with a probability lower than 1 that Plan A would be implemented. This is supported by the results from a follow-up question, showing that 37 percent of the respondents find Plan B to be "very realistic", while the corresponding number for Plan A was only 15 percent. Diminishing marginal utility of increased preservation could also explain why several respondents value Plan B equally to Plan A.

Respondents were asked an open-ended question about their reason for being willing to pay something for Plan A and/or Plan B. The reason for keeping this an open-ended question was that we would like to avoid influencing the respondents by providing a list of possible motives for their WTP (which was done in Siikamaki et al 2019). This is particularly important here, as we did not want the respondents to include the carbon storage benefits of forests in their WTP estimate. This provides a "cleaner" comparison with the Delphi CV survey, where the valuation experts were explicitly told *not* to include the carbon storage benefits.

Five motivational categories (WTP categories) were identified based on their responses: i) existence value, ii) bequest value, iii) CO2 capture (Carbon), iv) social responsibility, v) don't

[4] In comparison with the percentile method, the percentile-t method has asymptotic refinement (Cameron and Trivedi, 2005, p:364)

[5] In addition, a paired t-test and a non-parametric sign test of two dependent samples were estimated. The null hypothesis of equality was rejected in each scope test.

know. As we only asked one question why they were willing to pay something for Plan A and/or B, respondents who had positive WTP for Plan A only, most likely found it difficult to answer the open question. Thus, several respondents just stated that they prefer Plan A. Thus, we added a sixth WTP category; "vi) Prefer Plan A".

Table 4: Percentage of Zero WTP responses (excluding protest zeros), and the percentage (of the total sample) of respondents with positive Willingness to Pay (WTP) distributed on their main motive (WTP Categories) for being willing to pay something for Amazon rainforest preservation

			WTP Categories				
Zero WTP	Existence	Bequest	Carbon	Social Resp.	Don't know	Prefer Plan A	Total
9,01	41.32	7.85	8.68	11.57	16.12	5.37	100

Existence values seem to dominate the motivation for positive WTP, and non-use values (in terms of existence, bequest and social responsibility values) make up 2/3 of the positive WTP. Note that less than 9% seem to include the carbon storage values in their WTP. To assess whether these respondents have higher mean WTP for Plans A and B than the other respondents with positive WTP, a Welch's t-test of mean difference between two independent samples were performed. Mean WTP for Plans A and B among the "Carbon respondents" is NOK 2141 and NOK 1297 for Plans A and B, respectively. However, among the other respondents with positive WTP, the corresponding mean WTP is NOK 885 and NOK 657. Test results confirm a statistically significant difference in mean WTP for Plans A and B between "Carbon respondents" and other respondents with positive WTP. The WTP regression models of only respondents with positive WTP, see Appendix 1, confirms that the "Carbon respondents" have significantly higher WTP than the other, also when corrected for other characteristics of the respondents. However, the "Carbon respondents" make up less than 9 % of the respondents, the mean WTP estimates should not be influenced much by these respondents. We do, however, also test the effect of excluding the "Carbon respondents" in order to get a "cleaner" comparison of the population and Delphi CV surveys.

Tables 5 and 6 report the descriptive statistics of the independent variables and results from the WTP regression models, respectively, where the dependent variable is defined as ln(wtp+1). Results are as expected; both from economic theory and from results from previous CV surveys of forest preservation. WTP for both preservation plans increase significantly with household income, with an income elasticity of WTP of 0.35 and 0.49 for Plans A and B, respectively. Respondents that have significantly higher WTP are males (*male*), from the city of Oslo (*oslo*), using more than 10 minutes to complete the internet surveys (*hightime*) (and thus probably have a greater interest in the topic), stating that environmental conservations is fairly or very important (*envlist*), and believe we must spend much more or a little more public money on environmental

conservation in South America (*moremoneySA*). Those that believe the preservation plans to be unrealistic (*unrealplans*) have significantly lower WTP than those that don´t.

Appendix 1 reports the regression models when regressing only respondents with positive WTP on the variables in table 5; some of which are only recorded for respondents with positive WTP (e.g. the variables motivating positive WTP "co2" and "bequest"). Results show that, in addition to the same variables that were significantly positive when we included true zeros (table 6), the following variables significantly increased respondents positive WTP: i) member of an environmental organization (*envmember*), ii) believe results from the survey will be used in policy decisions (*UsedForPolicy*), iii) believe they have to pay the tax to reduce deforestation in the Amazon rainforest (*TaxPaymentDeforestation*), iv) their main motive for paying is bequest value (*bequest*), and v) their main motive for paying is carbon storage benefits (*co2*). These results confirms the validity of the CV survey; as a strong interest in environmental preservation (expressed by being a paying member of an environmental organization), policy and payment consequentiality, recreational use of the good in question, as well as including bequest values and carbon storage benefits in their stated amounts are all factors that are expected to increase WTP.

Table 5: Description of Independent Variables

Variables	Description	obs	mean	SD	min	max
lnhhinc	Natural log of annual household income (in NOK), defined as the midpoint of the income range	300	13.386	0.579	11.513	15.202
higheduc	dummy, 1 if bachelor degree or higher	300	0.523	0.500	0	1
male	dummy, 1 if male	300	0.503	0.501	0	1
lnage	Natural log of age	300	3.844	0.413	2.890	4.407
oslo	dummy, 1 if respondent lives in the city of Oslo	300	0.123	0.329	0	1
hightime	dummy, 1 if survey completion time is more than 10 minutes	300	0.300	0.459	0	1
envlist	dummy, 1 if believe environmental conservation is fairly or very important	300	0.703	0.458	0	1
moremoneySA	dummy, 1 if believe we must spend much more or a little more public money on environmental conservation in South America (SA)	300	0.277	0.448	0	1
unrealplans	dummy, 1 if believe none of the preservation plans are realistic	300	0.140	0.348	0	1
envmember	dummy, 1 if member of an environmental organization	300	0.087	0.079	0	1
visitamazon	dummy, 1 if have visited the Amazon rainforest	300	0.070	0.256	0	1
planvisitrain	dummy, 1 if quite or very sure will visit a tropical rainforest	300	0.140	0.348	0	1

Table 6: Willingness-to-Pay (WTP) regression models.

	Interval Regression		OLS Regression	
VARIABLES	Plan A	Plan B	Plan A	Plan B
lnhhinc	0.350*	0.491**	0.348*	0.491**
	(0.195)	(0.224)	(0.200)	(0.230)
higheduc	0.169	0.301	0.170	0.298
	(0.251)	(0.273)	(0.257)	(0.279)
lnage	0.268	0.426	0.266	0.421
	(0.314)	(0.323)	(0.322)	(0.331)
male	-0.503**	-0.438*	-0.507**	-0.437*
	(0.228)	(0.247)	(0.234)	(0.253)
Oslo	1.075***	0.887***	1.073***	0.884***
	(0.288)	(0.321)	(0.296)	(0.330)
hightime	0.593**	0.767***	0.593**	0.768***
	(0.242)	(0.244)	(0.248)	(0.250)
envlist	0.763**	0.869***	0.756**	0.862***
	(0.308)	(0.311)	(0.316)	(0.319)
moremoneySA	1.097***	0.815***	1.094***	0.813***
	(0.221)	(0.248)	(0.227)	(0.254)
unrealplans	-1.519***	-2.111***	-1.520***	-2.117***
	(0.514)	(0.493)	(0.528)	(0.506)
envmember	0.640	0.487	0.648	0.495
	(0.429)	(0.447)	(0.441)	(0.458)
visitamazon	0.288	0.00885	0.288	0.0134
	(0.650)	(0.630)	(0.666)	(0.646)
planvisitrain	0.412	0.375	0.408	0.372
	(0.281)	(0.347)	(0.288)	(0.355)
Constant	-1.092	-4.026	-1.028	-3.995
	(2.787)	(3.413)	(2.857)	(3.503)
Log Likelihood	-756.977	-749.010	-481.176	-495.2418
Observations	242	243	242	243
Adj. R-squared			0.259	0.266
McFadden's Adj. R2	0.036	0.038		
AIC	1541.954	1526.02	988.352	1016.484
BIC	1590.799	1574.922	1033.708	1061.893

Note: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

4. Comparison of CV, Delphi CV and Benefit Transfer

To evaluate the reliability of the transferred values we estimate the transfer errors, defined as the difference between transferred and estimated mean WTP as a percentage of the estimated mean

WTP; equation (2) (Kristófferson and Navrud 2007, p:213). TE is the transfer error, WTP_{BT} is the estimate derived using BT or Delphi CV, and WTP_E is the estimated mean WTP derived from the population CV survey.

$$TE = \frac{|WTP_{BT} - WTP_E|}{WTP_E} \quad (2)$$

Tables 7 and 8 report the transfer errors (TEs) of the Delphi CV survey and the benefit transfer exercise. Results show that the Delphi CV survey; after Round 2 gives low TEs (31 % or less), which in most cases would be acceptable for policy decisions (Ready and Navrud 2006). The unit value benefit transfer does not perform equally well, with TEs ranging from 43 to 131 %. .

Table 7. Transfer Error (TE) for the Delphi CV survey

	Midpoint Mean WTP	Unconditional Censored Mean WTP
TE Plan A Round 1	41.1%	51.0%
TE Plan A Round 2	12.2%	26.0%
TE Plan B Round 1	26.6%	37.6%
TE Plan B Round 2	18.9%	31.0%

Table 8. Transfer Error (TE) for unit value benefit transfer from the North American valuation survey

	Midpoint Mean WTP	Unconditional Censored Mean WTP
TE Plan A Unit Transfer	131.4%	92.5%
TE Plan B Unit Transfer	67.9%	42.8%

In the Delphi CV survey, the experts were asked to neglect carbon storage benefits of preserving the Amazon rainforest. The transfer errors reported in Table 7 do not exclude respondents in the CV survey that included carbon storage benefits in their WTP estimates. If we exclude these "carbon respondents", the unconditional censored mean WTP for Plans A and B are €97 (NOK 953) and €74 (NOK 727), respectively. The corresponding midpoint means are €84 (NOK 827) and €63 (NOK 614).

Table 9 shows that the transfer errors of experts' assessment when the "carbon respondents" are excluded from the population CV survey results are substantially lower. Using the midpoint mean estimate in round 2 for Plan A, the transfer error is as low as 1.8%. This strengthens the conclusion that the Delphi CV survey (after Round 2) gives low and in most cases acceptable transfer errors for policy decisions.

Additionally, expert assessment in a Delphi CV survey does not only yield substantially lower transfer errors than benefit transfer technique. The experts more accurately predict scope effect of WTP for the different preservation plans. The difference between mean WTP for the most

comprehensive Plan A and Plan B is NOK 292 in the Delphi exercise, while NOK 1050 using unit transfer. In comparison, the difference between the sample means in the population CV survey is NOK 268. Consistent with our findings, León et al. (2003) found that expert assessment was useful in predicting household´ relative valuation of national parks in Spain.

Table 9. Transfer Error (TE) for Delphi CV Survey; excluding "Carbon-Respondents" (i.e. those that stated that their WTP was motivated by carbon storage benefits; see table 4)

	Midpoint Mean WTP	Unconditional Censored Mean WTP
TE Plan A Round 1	32.6%	41.1%
TE Plan A Round 2	1.8%	11.0%
TE Plan B Round 1	19.1%	31.5%
TE Plan B Round 2	10.6%	24.4%

A mean WTP of NOK 1136 per household per year for Plan A implies an annual transfer to the Amazonian countries of NOK 2.7 billion in aggregate for the nearly 2, 4 million households in Norway. Interestingly, the Norwegian government, from 2008 to 2017, transferred a total of NOK 8.3 billion to Brazil to reduce deforestation of the Amazon rainforest. Brazil's goal is to reduce their annual deforestation rate by 80% by 2020 compared to the average annual deforestation rate from 1996 to 2005. Assuming this This could be compared to Plan A and Plan B, where in this case Norwegian politicians' WTP, on behalf of the Norwegian population, implies an annual payment of about €35 per Norwegian household over a 10 year period (For simplicity, this is the annuity at 0 % discount rate). Thus, it seems like the Norwegian valuation practitioners predict Norwegian households' WTP more accurately than the Norwegian politicians in Parliament.

5. Conclusion

The Amazon rainforest provides significant non-use values to distant beneficiaries. These values need to be included in a global cost-benefit analysis of preservation plans. However, as it is very time consuming and costly to assess these global non-use values in stated preference surveys in all countries worldwide, this study tests the reliability of benefit transfer and expert assessment to predict distant beneficiaries´ WTP for Amazon Rainforest preservation plans. We compare these benefit transfer and expert estimates for Norway to the outcome of a new CV survey of 300 Norwegian households.

The results show that Norwegian households are on average willing to pay about NOK 1100 (€110) per year to get an extensive preservation plan that implies no further forest and species loss by 2050. Thus, this study confirms the results of previous studies, that distant beneficiaries are indeed willing to pay to preserve a global public good such as the Amazon rainforest.

Aggregating mean WTP per household per year for the most extensive preservation Plan A over the total number of households in Norway implies an annual transfer of NOK 2.7 billion to the Amazonian countries that have agreed to implement the preservation plan. Norway had over

a 10-year period up until 2017 paid Brazil NOK 8.3 billion to reduce deforestation of the Amazon by 80% within 2020. This corresponds to an average annual amount that is substantially lower than what Norwegian households state they are willing to pay for such preservation plans. This clearly shows that using the implicit valuation technique of Norwegian politicians' WTP, in terms of government funds, to represent Norwegian households' WTP is an inaccurate welfare measure.

International benefit transfer seems to overestimate households' WTP for the Amazon preservation plans as well as the scope effect (measured as the difference in WTP between the two preservation plans). Unit transfer with income adjustment yields transfer errors ranging from 43 to 131 %. In one model with a transfer error of 68% the predicted difference in WTP for the two preservation plans is about four times higher than the difference found in the population CV and Delphi CV surveys.

Expert assessment in Delphi CV surveys by environmental valuation practitioners, however, seems to be a reliable technique for assessing benefits of providing global public goods to distant beneficiaries. Norwegian experts in the Delphi CV survey, taken together, predicted the outcome of the population CV survey very well, both in terms of the actual magnitude of WTP and the scope effect. Transfer errors in Round 2 of the Delphi CV survey were lower than 31 % in all models, and as low as 2% in one model. Further comparative studies for other global public goods, contexts and countries should be performed to see whether, and under what conditions, these results can be generalized.

The validity and reliability of Delphi CV studies should be further explored and tested as a method for valuing public goods when time and/or money does not allow for a new valuation study to be performed. The largest savings in time and money seems to be for valuation of global public goods, e.g. the tropical rainforests and UNESCO World Heritage sites, where distant beneficiaries are expected to hold a substantial part of the global benefits.

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Appendix 1

Table A1: Regression models; only for the respondents with positive WTP .

	Interval Regression		OLS Regression	
	Positive WTP respondents		Positive WTP respondents	
Variables	Plan A	Plan B	Plan A	Plan B
lnhhinc	0.212**	0.155	0.210**	0.154
	(0.119)	(0.122)	(0.123)	(0.131)
higheduc	0.014	0.248**	0.016	0.250**
	(0.143)	(0.146)	(0.149)	(0.139)
male	-0.296***	-0.206*	-0.304***	-0.207*
	(0.130)	(0.130)	(0.135)	(0.131)
lnage	0.284**	0.320***	0.285**	0.322**
	(0.167)	(0.167)	(0.174)	(0.173)
oslo	0.620***	0.418***	0.622***	0.417***
	(0.186)	(0.183)	(0.194)	(0.173)
hightime	0.390***	0.506***	0.392***	0.509***
	(0.139)	(0.138)	(0.144)	(0.150)
envlist	0.500***	0.443***	0.491***	0.434***
	(0.159)	(0.160)	(0.165)	(0.158)
moremoneySA	0.504***	0.346***	0.505***	0.343***
	(0.147)	(0.147)	(0.153)	(0.148)
envmember	0.672***	0.602***	0.684	0.614***
	(0.223)	(0.224)	(0.231)	(0.286)
UsedForPolicy	0.621***	0.626***	0.632***	0.628***
	(0.299)	(0.306)	(0.310)	(0.266)
visitamazon	0.673***	0.279	0.675***	0.285
	(0.276)	(0.271)	(0.287)	(0.292)
TaxPaymentDeforestation	-0.644**	-0.466*	-0.649**	-0.468
	(0.342)	(0.319)	(0.355)	(0.394
co2	0.675***	0.627***	0.674***	0.623***
	(0.225)	(0.221)	(0.235)	(0.211)
bequest	0.566***	0.912***	0.558***	0.920***
	(0.232)	(0.227)	(0.241)	(0.274)
constant	1.430	1.683	1.474	1.717
	(1.630)	(1.684)	(1.692)	(1.864)
Log likelihood	-571	-535	-476	-282
AIC	1173	1101	623	593
BIC	1228	1155	674	644
R^2	0.36	0.35	0.35	0.35
Adj. R^2			0.31	0.30
Number of obs	219	212	219	212

Note: envmeber = 1 if a respondent is a member of an environmental organization, 0 otherwise; UsedForPolicy = 1 if believe results from the survey will be used in policy decisions, 0 otherwise; TaxPaymentDeforestation = 1 if believe they have to pay the tax to reduce deforestation in the Amazon rainforest, 0 otherwise; bequest = 1 if their main motive for paying is bequest value, 0 otherwise; carbon = 1 if main motive for paying is carbon storage benefit, 0 otherwise. Please see Table 5 for description of the variables included in Table 6.

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