# Meta-analysis of nature conservation values in Asia & Oceania:

# Data heterogeneity and benefit transfer issues

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**Abstract**

We conduct a meta-analysis (MA) of around 100 studies valuing nature conservation in Asia and Oceania. Dividing our dataset into two levels of heterogeneity in terms of good characteristics (endangered species vs. nature conservation more generally) and valuation methods, we show that the degree of regularity and conformity with theory and empirical expectations is higher for the more homogenous dataset of contingent valuation of endangered species. For example, we find that willingness to pay (WTP) for preservation of mammals tends to be higher than other species and that WTP for species preservation increases with income. Increasing the degree of heterogeneity in the valuation data, however, preserves much of the regularity, and the explanatory power of some of our models is in the range of other MA studies of goods typically assumed to be more homogenous (such as water quality). Subjecting our best MA models to a simple test forecasting values for out-of-sample observations, shows median (mean) forecasting errors of 24 (46) percent for endangered species and 46 (89) percent for nature conservation more generally, approaching levels acceptable in benefit transfer for policy use. We recommend that the most prudent MA practice is to control for heterogeneity in regressions and sensitivity analysis, rather than to limit datasets by non-transparent criteria to a level of heterogeneity deemed acceptable to the individual analyst.

**Keywords:** Valuation; biodiversity; Asia; meta-analysis; meta-regression; benefit transfer. **JEL Classification**: Q26; Q51; Q57; H41

## Introduction

According to the Millennium Ecosystem Assessment, more than 60 per cent of the world's ecosystems are being degraded or used unsustainably (Millennium Ecosystem Assessment 2005). The pressure on nature is among the highest in the many rapidly growing economies of Asia and Oceania, home to four of the world's 12 megadiversity countries (Australia, China, India, Indonesia). The (neoclassical) economist's prescription to stemming this deteriorating trend is to value changes in the provision of environmental goods in economic terms, and create markets or other mechanisms to internalise their values in the billions of everyday decisions of consumers, producers and government officials. Faced with this challenge, environmental economists have produced an enormous amount of primary valuation research using stated and revealed preference methods. However, paraphrasing Glass et al. (1981: p11)[1], results of much of this work "are strewn among the scree of a hundred journals and lies in the unsightly rubble of a million dissertations." This large body of valuation research could be much better utilised to demonstrate to decision-makers the social return to nature conservation, a key area where environmental economists need to do more in the future, as pointed out by David Pearce (2005). For a range of environmental goods meta-analysis (MA) techniques has been used to synthesize valuation research, test hypotheses, and facilitate the transfer of existing welfare estimates to new, unstudied policy sites ("benefit transfer" – BT) where such information can be useful, e.g. in cost-benefit analysis (Smith and Pattanayak 2002; Navrud and Ready 2007). Responding to Pearce's challenge, we use MA to review and take stock of the literature to date on environmental valuation of a complex and somewhat heterogeneous good – (changes in) conservation of habitat, biodiversity and endangered species – in a specific geographical

[1] Original quote in Stanley and Jarrel (2005).

region; Asia and Oceania. We attempt to answer the following two research questions; (1) To what extent do welfare estimates for this complex good conform with theoretically and empirically derived expectations regarding the good characteristics, valuation methods, study quality, socio-economics and other variables?; (2) How sensitive are the meta-regression results and the value forecasts for unstudied sites to; (a) the "scope of the MA", i.e. the level of heterogeneity of the good valued and the valuation methods used; and (b) the choice of meta-regression models?

The first question investigates whether the welfare estimates display the degree of validity and regularity more typically found for less complex environmental goods with higher share of use-values, and offers a first check of the potential for using such data for BT applications (Johnston et al. 2005; Lindhjem 2007). The second question contributes to our understanding and refinement of MA methodology in environmental economics, where the meta-analyst typically is left to make a number of choices, potentially introducing various subjective biases (Hoehn 2006; Rosenberger and Johnston 2007). An important analyst choice both for the robustness of MA models and their suitability for use in BT applications, relates to the scope of the MA, i.e. the trade-off between the number of observations and the acceptable level of heterogeneity in the data, as pointed out by e.g. Engel (2002) (Question 2a above). Another, related choice is which model to choose for BT, for example how to treat insignificant variables (Question 2b)[2]. There are different practices and little is known of the empirical effects of these choices, though Lindhjem and Navrud (In press)) have shown that the precision

[2] An alternative approach to dealing with classical MA challenges, not pursued here, is to use Bayesian techniques (e.g. Moeltner et al (2007) and Moeltner and Rosenberger (2008)).

of meta-analytical BT (MA-BT) depends on the model specifications, sometimes in unexpected ways.

Previous MA studies have primarily analysed the values of more homogenous types of environmental goods (e.g. water and air quality, recreation days) often within the same country (Desvousges et al. 1998; Rosenberger and Loomis 2000a; Van Houtven et al. 2007), though there is a trend towards studying more complex goods in international settings (e.g. wetlands, coral reefs, forests) (Brander et al. 2006; Brander et al. 2007; Lindhjem 2007). Only two studies have attempted an MA for a similar good to ours; Loomis and White (1996) (endangered species in the USA), and Jacobsen and Hanley (2007) (relationship between income and willingness to pay (WTP) for biodiversity worldwide). Neither of these studies focus specifically on MA methodology or implications for BT. Compared to previous work, we add several new and interesting dimensions; (1) To investigate the effect of the MA scope, we divide our dataset into two levels of heterogeneity; endangered species (more similar good and methods used) and nature conservation more generally (more heterogeneity in good and methods used); (2) We then estimate a number of meta-regression models for these two main datasets using different cleaning procedures investigating conformity with expectations and the robustness of results, and finally; (3) We report the level of forecast (or transfer) errors for unstudied sites broken down by type of models, nature conservation habitat, geographic region and valuation method used, based on a jacknife resampling technique introduced in MA by Brander et al (2006). Using a random effects meta-regression model we find that welfare estimates show some degree of regularity, though this decreases with the increased heterogeneity of the meta-data, as expected. However, even the heterogeneous models show explanatory and predictive power at the same level or better compared with other MA studies of goods assumed to be more homogenous.

## Conceptual framework and data

*Conceptual framework*

We start by defining "nature conservation" broadly as the protection or active management of any natural terrestrial or aquatic ecosystem, resource or amenity, Q. The economic value measure for an increase in the level of nature conservation (Q) is the change in the quantity and/or quality (QUAL) of Q, or some set of services provided by Q, and is referred to as consumers' surplus (CS) or Willingness to pay (WTP). From the standard indirect utility function, the bid function for a representative individual j for this change can be given by (Bergstrom and Taylor 2006)[3]:

$$(1)\ \ \mathrm{WTP} = f(\mathrm{P}_j, \mathrm{M}_j, \mathrm{Q}_j^{\mathrm{T}} - \mathrm{Q}_j^{\mathrm{R}}, \mathrm{QUAL}_j^{\mathrm{T}} - \mathrm{QUAL}_j^{\mathrm{R}}, \mathrm{SUB}_j^{\mathrm{T}} - \mathrm{SUB}_j^{\mathrm{R}}, \mathrm{H}_j)$$

Where P = a price index of market goods (assumed constant), M = (individual or household) income (assumed constant), $Q^T$-$Q^R$ and $QUAL^T$-$QUAL^R$ are the changes in quantity and quality from a reference situation ("status quo") (R) to a target state-of-the-world (T), SUB = substitutes for Q available to individual j, H = non-income household or individual characteristics. Further to make (1) elastic enough for use in MA, we assume, following Bergstrom and Taylor (2006), a "weak structural utility theoretic approach" in which the underlying variables in the bid function are assumed to be derivable from some unknown utility function, but that flexibility is maintained to

[3] For simplicity and brevity we do not elaborate the details of how nature conservation may increase utility e.g. related to market goods and household production, e.g. as done by Van Houtven et al. (2007) for water quality.

introduce explanatory variables into the WTP model, such as study design and different valuation methods, that do not necessarily follow from (1). This is the most common approach in MA, where the meta-analyst records estimates of mean WTP from different studies and corresponding explanatory variables both informed by theory and empirical expectations. In this process, the empirical specification chosen for (1) needs to trade off the availability of variable information reported in valuation studies with the range of potentially relevant variables that can explain variation in welfare estimates. For example, information about substitute sites to a national park will most often not be reported, even if important for WTP. In addition, if information *is* reported, for example about the exact change in nature conservation valued, this change may not easily be comparable across sites and studies. No MA studies are free of this problem. Some try to map changes to a common unit of measurement in terms of hectares or to a water quality ladder or similar, though such simplified common units may mask differences in other dimensions of the good important to individuals (see e.g. discussion in Lindhjem (2007)). There are no easy solutions to this problem, and in our rather general case we interpret mean WTP from different studies as welfare estimates for a (small, though not marginal) change in Q and/or in one or more elements in an attribute vector of QUAL describing the quality of the nature site[4]. We then use dummy variables to detect differences in WTP depending on the type of habitat or change valued. Before discussing the empirical specification of (1), we first describe the data used for the MA.

*Meta-data from nature conservation studies*

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[4] The ecosystem services and functions and total economic value from nature and biodiversity conservation are discussed in depth elsewhere, and for sake of brevity not elaborated in detail here (see e.g. Fromm (2000)).

Given this conceptual framework, we conducted a broad search for studies (published papers, reports, book chapters etc[5]) internationally available in English valuing nature conservation in the region drawn from various databases, including EVRI (Environmental Valuation Reference Inventory), ECONLIT, ISI Web of Science, EEPSEA's (Environment and Economy Programme for Southeast Asia), etc[6]. The first valuation studies related to nature conservation were conducted in Australia in the 1980s. In the rest of Asia, valuation started much later, but has grown in number substantially during the 1990's and 2000's. Based on the literature search we compiled a gross meta-dataset of 577 mean WTP estimates (i.e. observations) from 99 studies. A first crude screening of the studies was conducted by excluding the ones reporting negative mean WTP or very high or low estimates (2 standard deviations of the mean), leaving 550 estimates from 95 studies for detailed analysis. This reduces the influence of outlier estimates in our regression analysis. The resulting distribution of studies by region, by type of habitat or service valued, and valuation method used are given in Tables 1-3 below[7].

Most of the studies are from Southeast Asia, East Asia or Oceania (mostly Australia), with a smaller number of studies from South and Southwest Asia (Table 1). Australia

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[5] We did not include Master degree theses for practical reasons (hard to find and/or to get hold of) and because many are written in the native language.

[6] Since the Australian database ENVALUE is no longer updated, has been (partly) integrated with EVRI, and include limited study information, our main search used the EVRI database.

[7] We do not claim to have achieved to collect an exhaustive database of all studies in Asia and Oceania, but the extent of our search makes us confident that we cover the majority of such studies. Further, it is unlikely that our search has been biased in any way (except for the focus on studies in English), which means that our data will give a objective picture of the valuation literature in the region. Finally, to answer our research questions, completeness is also not strictly necessary.

has the largest number of studies (with 22 studies), followed by the Philippines with 10 studies. Raw mean annual WTP is highest for Oceania at US$ 254, as expected, though also high for South Asia (US$ 206). The lowest WTP, all at around the same level, is found in Southeast Asia (US$ 83), East Asia (US$ 76) and Southwest Asia (US$ 66).

*Table 1 Regional distribution of valuation studies*

| Region | Mean WTP (SD) | No. of obs. | No. of studies |
|---|---|---|---|
| Southeast Asia (SEA) | 83 (212) | 244 | 32 |
| Oceania (O) | 254 (914) | 116 | 23 |
| East Asia (EA) | 76 (108) | 99 | 23 |
| South Asia (SA) | 206 (286) | 70 | 11 |
| Southwest Asia (SWA) | 66 (78) | 21 | 6 |
| **Total** | | **550** | **95** |

Notes: Oceania= Australia, Micronesia, Papua New Guinea, Vanuatu; SEA= Cambodia, Indonesia, Laos, Malaysia, the Philippines, Singapore, Thailand, Vietnam; EA= China, Japan, Korea, Taiwan; SA= India, Sri Lanka; SWA= Iran, Israel, Pakistan.

*Table 2 Distribution of valuation studies by habitat types*

| Types of habitats/services | Mean WTP (SD) | No. of obs. | No. of studies |
|---|---|---|---|
| Terrestrial habitats (reserves, national parks, forests) | 116 (252) | 176 | 33 |
| Marine habitats (reefs, beaches, sea, watercourses) | 80 (97) | 162 | 27 |
| Endangered species (single or multiple) | 105 (220) | 129 | 16 |
| Wetlands (wetlands, mangroves) | 514 (1503) | 41 | 8 |
| Other habitats/services (landscapes, eco.-services) | 121 (182) | 37 | 13 |
| **Total** | | **550** | **97*** |

Note: * Some studies have more split samples asking different types of good, and thus the number of studies is more than reported in Table 1.

*Table 3 Valuation studies by methods*

| Method | Mean WTP (SD) | No. of obs | No. of studies |
|---|---|---|---|
| Contingent valuation method (CV) | 124 (505) | 417 | 77 |
| Choice modelling/experiments (CM) | 67 (41) | 50 | 8 |
| Travel cost method (TCM) | 161 (162) | 37 | 14 |
| Others (market price, hedonic pricing) | 269 (435) | 46 | 5 |
| **Total** | | **550** | **104*** |

Note: * In some studies, there are more than one method used, and thus the number of studies (as understood by the software) is more than those reported in Table 1.

The most frequently valued habitat is terrestrial habitats (including forests, nature reserves and national parks), grouped together here for ease of exposition (Table 2). Marine and freshwater habitats (i.e. coral reefs, beaches, sea, rivers, watercourses) for simplicity termed "marine habitats", follow second. Wetlands have the highest value at US$ 514, mostly due to the market price methods often used to value such habitats (see next paragraph). Studies that value named and endangered (often iconic or charismatic) species or groups of species are categorised as "endangered species". Marine habitats provide the lowest value (US$ 80) compared to other types of habitats, while terrestrial habitats (US$ 116), endangered species (US$ 105), and other habitats (US$ 121) have values that are around 40-50 percent higher.

The by far most frequently used method of valuation is CV, with 77 studies, while the TCM comes second with only 14 studies (Table 3). CV generally yields lower WTP than TCM, which is commonly found in the literature (e.g. Carson et al (1996)). A small number of studies (5) use other methods, such as the hedonic pricing method or calculating the value of wetlands and forests using the market price approach. These methods frequently calculate a different welfare measure than CV, CM and TCM studies, and also yield twice as high estimates as the other methods. Details of the individual studies (including reference) are given in the Appendix.

Information from the studies was then coded in a spreadsheet originally containing 30 variables, with between 1 and 36 observations drawn from each study (average 5.8). The same study typically has several sub-samples varying the methods used, scope and other aspects of the good being valued. The two first columns in Table 4 below give the variable names and definitions. Since there is no standardised way of reporting welfare estimates in the literature, a wide variety of units are typically used, e.g. WTP per individual or household, per unit of area[8], per visitor, for different time periods (e.g. per month, per visit, per year, one-time amount etc.), and in different currencies and reporting years. To deal with this, we standardized the values to a common metric, i.e. WTP (US$ in 2006 prices) per household per year as a default, and coded WTP per individual, WTP per month etc., using dummies. For WTP per visit from CV or TCM studies, we calculated per visit WTP per year (if the study had information about how many trips a person would make per year, we converted to WTP per year). Values from different years were converted to 2006 prices using GDP deflators from the World Bank World Development Indicators. Purchase Power Parity (PPP) corrected exchange rates were used to correct for differences in price levels between countries, which is the common procedure in international BT and MA (Ready and Navrud 2006). Some theoretical models predict that WTP given per household is higher than individual WTP (e.g. Strand 2007), though empirical evidence is mixed (Lindhjem 2007; Lindhjem and Navrud 2008a). It can also be expected that WTP given per month multiplied by 12 to convert to an annual amount is higher than WTP originally stated on an annual basis (a well-known bias).

We also included other methodological variables that are often used in MA studies: whether the study used personal interviews, if the CV method applied a dichotomous choice (DC) WTP question format (i.e. the respondent says yes or no to a given bid, rather than stating max WTP), and whether the CV data were analysed using non-parametric statistical methods. DC formats are often found to give higher mean WTP (a main reason is so-called yea-saying), while non-parametric methods typically give a lower bound on WTP. There is no clear prior for use of interviews vs. other modes,

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[8] Studies that reported results with per unit of area were excluded, as there total size typically was not given.

though type of survey mode is known to influence results (Boyle 2003; Lindhjem and Navrud 2008b). Further, we include a set of geographic and good characteristics variables to control for differences in welfare estimates between types of species (mammals, turtles) and habitat types, between regions and countries, and between primarily non-use vs. use value. Larger and more charismatic or iconized species (for example elephants or pandas) are likely to yield higher welfare estimates than non-charismatic species or biodiversity/nature conservation in general (e.g. as found in Jacobsen et al (2008)), though it is uncertain a priori if our MA will be able to detect such a pattern across several studies. Studies that primarily estimate non-use values are likely to give lower value estimates. There are no strong priors regarding other habitat types or regional/country dummies, though it is expected that these dimensions may influence WTP[9]. We considered including a dummy for the season of the study (e.g. rainy-dry season) similar to Lindhjem (2007), however in most cases such information was not reported.

The only socio-economic variable generally reported is income of the sample, which we include in our analysis. Around 78 percent of the studies report this. For those which don't, we follow common practice from other MA studies to use a proxy for income from other sources instead (we use GDP/capita for the country). It is expected that income will positively influence WTP, an often-found result in the literature for single studies. However, in MA studies WTP is often relatively insensitive to income levels (see e.g. Johnston et al. 2005; Jacobsen and Hanley 2007). One reason for this is the low variation in income levels in MA studies conducted within the same country or in

[9] We also considered using population density of the country of study as a variable, for example as done by Brander et al (2006) for wetlands. However, we think link between nature conservation and population density may be overly speculative, and excluded this variable in our analysis.

Western countries with similar income levels. In our case we have a fairly large variation in income levels, so may expect that nature conservation will turn out to be a normal good.

Finally, we include a proxy variable for study quality; whether a study is a published or unpublished paper (i.e. a journal article or research report/working paper). Though published studies may be expected to apply more stringent and perhaps conservative methods, it is not clear if this would result in lower WTP. There may also be publication bias with unknown influence on WTP (Rosenberger and Stanley 2007). To capture trends in WTP values over time not captured by income (or other coded variables), we include a trend variable for the year of the study (rather than publication year). MA studies generally find WTP to increase over time, reflecting, perhaps, both increased nature scarcity and "greener" preferences. Since a portion of our studies is funded by the same institution and may share similarities we have not otherwise coded, we include a dummy (EEPSEA) to control for that. This procedure is similar to Bateman and Jones (2003), which find indications of similarities in WTP estimates from the same authors.

*Table 4 Definition of meta-analysis variables and descriptive statistics*

| Variables | Description | Mean (SD) Level 1 data | Mean (SD) Level 2 data |
|---|---|---|---|
| ***Dependent variable*** | | | |
| WTP 2006 | WTP in 2006 prices (US$) | 73 (105) | 133 (461) |
| ***Methodological variables*** | | | |
| SP | 1 if stated preference, 0 otherwise | - | .84 (.35) |
| DC | 1 if dichotomous choice, 0 otherwise | .95 (.22) | .51 (.50) |
| Hhldpay | 1 if household's WTP, 0 if individual | .87 (.33) | .67 (.46) |
| Month | 1 if payment is a monthly payment, 0 if otherwise | .79 (.40) | .35 (.47) |
| Nonpara | 1 if estimate is non-parametric (Turnbull), 0 otherwise | .20 (.40) | .07 (.25) |
| Interview | 1 if it is an in-person interview, 0 otherwise | .16 (.31) | .60 (.48) |
| ***Good characteristics variables*** | | | |
| Mammal | 1 if it is a mammal, 0 otherwise | .15 (.36) | .04 (.20) |
| Turtle | 1 for sea turtle, 0 otherwise | .27 (.44) | .06 (.24) |
| Otherspecies | 1 for other species, 0 for turtle and mammal | .56 (.49) | .13 (.30) |
| Terrestrial | 1 for terrestrial habitats, 0 otherwise | - | .32 (.47) |
| Marine | 1 if marine habitat (beach, sea, watercourse, lake, river), 0 otherwise | - | .29 (.45) |
| Wetland | 1 for wetlands, 0 otherwise | - | .07 (.26) |
| Otherhabitats | 1 for other habitats/services, 0 for terrestrial & marine habitats, endangered species, wetlands | - | .06 (.25) |
| Nonuse | 1 for primarily non-use, 0 otherwise | - | .77 (.41) |
| ***Socio-economic variables*** | | | |
| Income | Household income (PPP adjustment, 2006) | 11,700 (11,815) | 14,318 (17,258) |
| ***Geographic characteristics*** | | | |
| Australia | 1 if the study in Australia, 0 otherwise | .12 (.33) | .19 (.39) |
| Philippin | 1 if a study in the Philippines, 0 otherwise | .33 (.47) | .22 (.42) |
| Oceania | 1 if a study in Oceanic countries, 0 otherwise | .12 (.33) | .21 (.40) |
| East | 1 if a study in East Asian countries, 0 otherwise | .23 (.42) | .18 (.38) |
| Southeast | 1 if a study in Southeast Asia, 0 otherwise | .56 (.50) | .44 (.48) |
| South | 1 if a study in South Asia, 0 otherwise | .09 (.29) | .13 (.33) |
| Southwest | 1 if a study in Southwest Asia, 0 otherwise | - | .04 (.19) |
| ***Other variables*** | | | |
| EEPSEA | 1 if the study is funded by EEPSEA, 0 otherwise | .76 (.42) | .39 (.48) |
| Journal | 1 if it is a published article, 0 otherwise | .23 (.42) | .47 (.49) |
| Year | Continuous: ranging from 1 (1979, year of first survey) to 28 (2006) | 2.11 (2.04) | 6.36 (4.07) |
| **No. of obs. (N)** | | **124** | **550** |
| **No. of studies** | | **16** | **95** |

Notes: EEPSEA = Environment and Economy Program for Southeast Asia

For our meta-regressions, we divided the dataset into two primary levels of scope, according to level of homogeneity of the good and methods used: Level 1: Endangered species; and Level 2: Biodiversity and nature conservation more generally. The endangered species data include WTP estimates from 16 studies using the CV method to value the preservation of single or multiple species. These CV studies typically ask how much local/domestic populations are willing to pay for various conservation programs for endangered species (e.g. WTP to conserve a viable population of sea turtles)[10]. 10 of the studies are funded by EEPSEA (hence the importance of the control variable discussed above). The species valued in these studies include sea turtles (several countries), black-faced spoonbill (Macau), rhinos (Vietnam), eagles and whale shark (Phillipines), and various species such as dugong dugong, elephants, rhinos, dolphins and tigers (Thailand). In addition we found six non-EEPSEA funded studies in the region using CV to value the preservation of the possum (a marsupial species native to Australia) and glider (the Mahogany Glider**:** a type of endangered possum), giant panda (China), and elephants (India, Sri Lanka)[11]. The 16 studies provide 124 estimates that will be used in meta-regression analysis. Although the species are different, we consider the preservation of them as a good with many similar attributes in valuation (i.e. a larger degree of homogeneity of the good), as compared to nature and biodiversity conservation more generally. In addition, methodological heterogeneity is reduced since all the studies in this level use CV.

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[10] A small number of studies survey foreign populations, e.g. Bandara and Tisdell (2005) study OECD citizens' WTP for the preservation of the Giant Panda in China.

[11] We found another valuation study on endangered species in Asia. Adhikari et al. (2005) use CM to investigate rhino conservation in Nepal, but was excluded since it does not provide welfare measures.

The second level of the data, include the studies from Level 1 and all the rest of the studies that value nature conservation more generally, with different types of methods (though the majority also use CV here). This dataset includes welfare estimates for a fairly heterogeneous good, however, not more so, it can be argued, than many other complex environmental goods studied in MA. Further, as almost all non-textbook goods in general (and environmental goods in particular) are heterogeneous to some degree, except perhaps Big Mac and the iPod[12], it is unclear from theory where to draw the line in practice. All in all the Level 2 dataset contains between 67 to 95 studies and 390 to 550 estimates, depending on the cleaning procedures used in the meta-regressions (see section on results below). The details of the Level 1 and 2 datasets are given in Tables A and B, respectively, in the appendix (reference, country, year, species/habitat/service types, method, survey mode, payment vehicle and format, number of values in the MA and WTP range). We will conduct several meta-regressions models based on these two levels of our data, to investigate the effects of heterogeneity.

**Meta-regression model**

We estimate meta-regression models to explain the variation in welfare estimates for conservation of species, biodiversity and nature more generally across studies in the literature. As most studies provide more than one WTP estimate, the data should most prudently be treated as a panel to account for the correlation between the errors of estimates from the same study[13]. Thus we used the procedure proposed by Rosenberger

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[12] Though it can be argued that the Big Mac (or the iPod) can be a very different good when consumed in different cultural and socio-economic contexts, and hence are not strictly homogenous in a wider sense.

[13] We also tested two other stratifications of the data: by-survey and by-author. Results show that in many model specifications of these two stratifications equal effects (and random effects) cannot be rejected.

and Loomis (2000b) to check for panel structures in the data. The panel structure model, our empirical specification of equation (1) above, can be written as:

$$(2)\ WTP_{ij} = \alpha + \sum_{i=1}^{n} \beta_i x_{ij} + \mu_{ij} + \varepsilon_i$$

where WTP is the *i*'th observation from the *j*'th study, $\alpha$ is a constant, $x_{ij}$ is a vector of explanatory variables (as defined in Table 4), with a panel effect $\mu_{ij}$ and an error $\varepsilon_i \sim N(0, \sigma_\varepsilon^2)$. We chose a double-log specification of (2), common in the MA literature, which fitted our data better than linear or other specifications. A Breusch and Pagan's Lagrange multiplier statistic test of whether panel effects are significant was conducted. The null hypothesis is that an equal effects model is correct ($H_0 : \mu_{ij} = 0$), and the alternative hypothesis that a panel effects model is correct $(H_1 : \mu_{ij} \neq 0)$. For a model with income as the only explanatory variable[14], this test showed that a model with equal effects ($H_0 : \mu_{ij} = 0$) was rejected, confirming the appropriateness of a panel estimation model ($\chi^2$ = 274.90, p=0.000 with N=550 and j=95). In order to test whether a random effects specification (which has a panel specific error component) is outperformed by a fixed effects model (which keeps the panel specific error component constant), a Hausman $\chi^2$ test was performed for the whole dataset. The results in Table 5 show that the random effects model (B) cannot be rejected, and thus, it is used in the next sections

[14] A comprehensive test would have included other explanatory variables with different model specifications, but for sake of simplicity and brevity, we only present the model with the income variable here

*Table 5 Test of random vs fixed effects panel structure ( N=550, j=95)*

| | b Fixed effects model | B Random effects model | b-B | S.E. |
|---|---|---|---|---|
| Income variable | .0305127 | -.0494427 | .0799554 | .2193994 |
| p> $\chi^2$: 0.7155 | | | | |

We also performed the Hausman test for all the models used in this study (see next section for results), i.e. for different subsets of the data and different explanatory variables included, and find that a random effects model is the best estimation approach for Level 1 and 2 of our data.

## Meta-regression results and discussion

Results of four random-effects GLS regression models for the Level 1 data (species) are reported in Table 6. Moving from Model 1 to Model 4, we include more explanatory variables in the models. Model 1 contains methodological variables only, Model 2 adds good characteristics, Model 3 adds country variables, and Model 4 includes socio-economic (income) and other variables (survey year). For all models we present both a full and reduced version, in which variables not significant at the 20 per cent level are taken out[15]. This reduced form is often used in MA-BT applications (see for example Rosenberger and Loomis 2000a, Lindhjem and Navrud (In press)), demonstrated in the next section. Going from Model 1 to 4, the models gradually explain more of the variation in WTP for species preservation. The methodological variables in Model 1 explain around 40 percent of the variation ($R^2$ = 0.398), while adding characteristics of the species explain another 14 percent of the variation ($R^2$ = 0.536). Adding country

[15] A range of models was tried using combinations of variables in Table 4. Models presented here were chosen to avoid collinearity (excluding e.g. the EEPSEA variable), to include dummies reflecting a significant share of the data (i.e. excluding region dummies for Level 1 data), to obtain best fit with the data and to enhance comparison between models and between Level 1 and Level 2 data.

specifics and income and year in Models 3 and 4 help explain another 22-27 percentage points of the variation. Model 4, the best fitting of the models, obtains an overall $R^2$ of 0.81, which is very high compared to other MA studies. It is comforting for our belief in the validity of the data and for the potential use of such value estimates for BT that around half of the explained variation in the best model is due to non-study specific, observable characteristics related to the good, geographical area, year of study and income level of the population surveyed. Note that the models are directly comparable since they all include the same observations.

Individual parameter estimates in the fully specified and best Model 4 confirm well with expectations, where such priors exist. The DC format tends to provide higher estimates than other formats, as expected. Monthly payment is significantly higher than other vehicles of payment, as expected. Non-parametric estimates are significantly lower than estimates using parametric methods, also as expected. Household payment is significantly higher than WTP from individual payment, though theoretical and empirical expectations here are not clear. Personal interview is not significantly different than other survey modes in the fully specified Model 4 (but significantly higher in the reduced model). Not controlling for good characteristics and other variables make interviews significantly lower, in Model 1. Valuation of turtle preservation is significantly lower than for other species (though insignificant in Model 2), while mammals are valued significantly higher[16]. Higher values for mammals can be explained by their higher degree of "charisma" than for other, lower-profile species. The result for sea turtles, on the other hand, is somewhat puzzling. Australian studies

[16] We also tried other groupings or specifications of types of species, such as size, degree of "charisma" across types of species etc, but found that using the biological classification "mammal" worked best in our models. Adding dummies for each species is not feasible due to the limited number of observations for each.

provide higher values than studies in other countries in Model 3, but when controlling for income level, this parameter becomes negative and significant. Studies conducted in the Philippines are likely to give lower values (though only significant in Model 3) than studies conducted in other countries. The income parameter, i.e. the income elasticity of WTP in our double-log formulation, is 0.85 and highly significant. Income elasticity of WTP in the 0-1 range is commonly found in the CV literature (e.g. Kriström and Riera 1996). In Model 4 more recent studies yield significantly higher WTP estimates, reflecting perhaps increased scarcity or greening of preferences over time.

*Table 6 Meta-regression models for Level I: Endangered species studies*

| Variables | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| | **Full** | **Reduced** | **Full** | **Reduced** | **Full** | **Reduced** | **Full** | **Reduced** |
| Constant | 1.298* (.095) | 1.779*** (.010) | 2.413*** (.002) | 3.347*** (.000) | 1.493 (.156) | 2.488*** (.000) | -9.365*** (.001) | -9.867*** (.000) |
| DC | 1.517* (.064) | 1.992*** (.004) | .695 (.374) | | 1.187 (.102) | 1.797*** (.004) | 1.555*** (.002) | 1.567*** (.000) |
| Hholdpay | .855 (.295) | | .038 (.961) | | .563 (.438) | | 1.722*** (.003) | 1.775*** (.000) |
| Month | .168 (.810) | | .657 (.274) | | 1.116* (.092) | .785 (.101) | .140 (.788) | |
| Nonpara. | -.259** (.032) | -.264** (.028) | -.278** (.022) | -.265** (.027) | -.273** (.016) | -.300*** (.010) | -.281*** (.010) | -.286*** (.009) |
| Interview | 1.525*** (.004) | 1.419*** (.004) | .113 (.873) | | .729 (.375) | | -.972 (.192) | -1.105** (.025) |
| Turtle | | | -.363 (.470) | | -.675 (.151) | -1.347*** (.001) | -.954*** (.001) | -.919*** (.000) |
| Mammal | | | 1.740** (.035) | 2.038*** (.000) | .856 (.277) | | 1.569*** (.004) | 1.678*** (.000) |
| Australia | | | | | .698 (.415) | | -2.048** (.019) | -2.221*** (.000) |
| Philippin. | | | | | -.982*** (.000) | -1.143*** (.000) | -.126 (.699) | |
| LnIncome | | | | | | | .854*** (001) | .895*** (.000) |
| LnYear | | | | | | | 2.189*** (.000) | 2.309*** (.000) |
| *Summary statistics*: | | | | | | | | |
| $R^2$: within | 0.044 | 0.044 | 0.044 | 0.044 | 0.157 | 0.157 | 0.231 | 0.230 |
| $R^2$: betw. | 0.604 | 0.541 | 0.785 | 0.673 | 0.879 | 0.690 | 0.961 | 0.961 |
| **$R^2$: overa.** | **0.398** | **0.391** | **0.536** | **0.438** | **0.757** | **0.548** | **0.810** | **0.810** |
| Sigma_u | .841 | .867 | .674 | .701 | .614 | .611 | .330 | .248 |
| Sigma_e | .470 | .470 | .470 | .470 | .444 | .444 | .425 | .423 |
| Rho | .761 | .772 | .672 | .689 | .656 | .654 | .376 | .255 |
| N | 124 | 124 | 124 | 124 | 124 | 124 | 124 | 124 |
| # studies | 16 | 16 | 16 | 16 | 16 | 16 | 16 | 16 |

Note: *p < 0.10, **p < 0.05, ***p < 0.01. STATA Version 9.2 used. # Red. models exclude variables with p>0.20.

In Table 7 we present results of four random-effects GLS regression models using the more heterogeneous Level 2 data (nature and biodiversity conservation), in this case with the fuller range of explanatory variables, but using different subsets of the data. We keep the same methodological variables (except we include the dummy for stated preference values) for the sake of comparing the robustness of the results with Level 1. Further, we include the habitat/good characteristics variables that are significant across at least one of our four models. Finally, geographic region dummies were included if significant or if data from these regions dominate our dataset. Model 1 investigates the full dataset of 550 observations (27 obs. <0 or outside 2 std. dev. of the mean range were screened out initially as described in a previous section). This full dataset is contained in Table A and B in the Appendix. Model 2 excludes observations from studies that did not report income information, a procedure sometimes used in MA. In Model 1 GDP/capita was substituted for the missing income information. Model 3 contains the Model 2 observations, excluding values estimated using other methods than CV, CM, and TCM (i.e. market price and hedonic pricing methods), as these methods typically estimate conceptually different (and typically higher) welfare measures. Model 4 contains studies of endangered species only (the same observations as in Model 4 from Level 1), for sake of comparison. As for the Level 1 data we use both full and reduced forms of the models. For the most heterogeneous version of the data in Model 1 $R^2$ (overall) is 16 percent, which is somewhat lower but comparable to the 25-26 percent obtained in two national level MA studies of an apparently more homogenous good; recreation activity days in the USA (see Rosenberger and Loomis (2000a) and Shresta and Loomis (2003))[17]. Our $R^2$ for the full dataset is generally higher than Jacobsen and Hanley's (2007) random-effects MA models of international biodiversity studies. Excluding the studies from Model 1 for which a crude GDP/Capita measure was substituted for missing income information, more than doubles the explained variation (Model 2, $R^2 = 0.34$). This is an indication that mean WTP is more sensitive to reported sample income than GDP/capita, as expected (though Jacobsen and Hanley (2007) somewhat surprisingly finds the opposite result).

[17] Since $R^2$ obtained from random-effects models is not directly comparable to standard $R^2$ OLS, the comparison should be interpreted with caution.

*Table 7 Meta-regression models for Level 2: Biodiversity and nature conservation*

| Variables | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| | **Full** | **Reduced#** | **Full** | **Reduced** | **Full** | **Reduced** | **Full** | **Reduced** |
| Constant | 3.455** | 3.672*** | 4.058*** | 4.854*** | 3.448*** | 4.798*** | (dropped) | (dropped) |
| | (.022) | (.000) | (.001) | (.000) | (.002) | (.000) | | |
| SP | -.450 | -.448* | -1.713*** | -1.828*** | -1.769*** | -1.779*** | (dropped) | -5.837*** |
| | (.149) | (.092) | (.000) | (.000) | (.000) | (.000) | | (.000) |
| DC | .580*** | .473** | .0114 | | -.065 | | -1.856 | |
| | (.007) | (.022) | (.950) | | (.642) | | (.163) | |
| Hhldpay | .335 | | .025 | | .008 | | -2.270** | |
| | (.248) | | (.923) | | (.976) | | (.032) | |
| Month | .606 | .549* | 1.377*** | 1.188*** | 1.448*** | 1.253*** | 2.893*** | 1.776*** |
| | (.108) | (.066) | (.000) | (.000) | (.000) | (.000) | (.000) | (.000) |
| Nonpara | -.252 | | -.209 | | -.220* | -.227* | -.307*** | -.315*** |
| | (.300) | | (.229) | | (.078) | (.068) | (.006) | (.005) |
| Interview | .080 | | -.009 | | .176 | | 1.749** | |
| | (.778) | | (.970) | | (.442) | | (.049) | |
| Turtle | -.026 | | -.117 | | -.275 | | -.912** | -.878*** |
| | (.968) | | (.811) | | (.579) | | (.014) | (.002) |
| Mammal | 1.666*** | 1.838*** | 1.885*** | 1.715*** | 1.715*** | 1.745*** | 1.710*** | 2.185*** |
| | (.007) | (.001) | (.000) | (.000) | (.001) | (.000) | (.002) | (.000) |
| | 0** | | | | | | | |
| Marine | .888*** | .963*** | .562** | .532** | .554** | .717*** | (dropped) | (dropped) |
| | (.004) | (.001) | (.035) | (.017) | (.042) | (.001) | | |
| Wetland | -.991** | -.822** | 1.258 | 1.282*** | 1.218*** | 1.307*** | (dropped) | (dropped) |
| | (.021) | (.036) | (.003)*** | (.001) | (.003) | (.000) | | |
| Nonuse | .057 | | -.240 | | -.084 | | (dropped) | (dropped) |
| | (.809) | | (.269) | | (.639) | | | |
| Oceania | .755* | .910*** | .677 * | .755*** | .588 | .720*** | (dropped) | (dropped) |
| | (.099) | (.003) | (.095) | (.006) | (.146) | (.006) | | |
| East | -.204 | | .180 | | -.105 | | -3.825 | |
| | (.622) | | (.612) | | (.776) | | (.108) | |
| Southeast | -.766* | -.758*** | -.323 | | -.841** | -.801*** | -3.997* | |
| | (.063) | (.004) | (.364) | | (.028) | (.000) | (.080) | |
| Eepsea | -.449** | | -.561* | -.695*** | .188 | | (dropped) | -.680*** |
| | (.024) | | (.070) | (.001) | (.609) | | | (.010) |
| Journal | -.318 | | -.263 | | -.017 | | -5.309 | |
| | (.351) | | (.387) | | (.956) | | (.373) | |
| LnIncome | -.022 | | .062 | | .103 | | .867*** | .873*** |
| | (.863) | | (.558) | | (.260) | | (.000) | (.000) |
| LnYear | .281 | | .213 | | .180 | | .791 | |
| | (.234) | | (.270) | | (.342) | | (.818) | |
| *Summary statistics* | | | | | | | | |
| $R^2$ within | 0.124 | 0.101 | 0.124 | 0.109 | 0.212 | 0.203 | 0.227 | 0.222 |
| $R^2$:betwen | 0.172 | 0.169 | 0.550 | 0.530 | 0.572 | 0.564 | 0.953 | 0.924 |
| **$R^2$:overall** | **0.159** | **0.145** | **0.337** | **0.311** | **0.459** | **0.448** | **0.790** | **0.779** |
| Sigma_u | .955 | .909 | .708 | .669 | .764 | .710 | .396 | .325 |
| Sigma_e | 1.083 | 1.111 | .809 | .811 | .582 | .583 | .440 | .439 |
| Rho | .437 | .401 | .434 | .404 | .632 | .596 | .447 | .354 |
| N | 550 | 550 | 431 | 431 | 390 | 390 | 124 | 124 |
| # studies | 95 | 95 | 70 | 70 | 67 | 67 | 15 | 15 |

Notes: *p < 0.10, **p < 0.05, ***p < 0.01. STATA Version 9.2 used. # Red. models exclude variables with p>0.20.

Enhancing methodological homogeneity in Model 3 increases the explained variation further to 46 percent, the same level as for example found in Brander et al's (2006) MA of international wetland valuation studies. Finally, in Model 4, using the Level 1 dataset, with the more complete range of explanatory variables does not change $R^2$ much compared to Model 4 in Table 6 (though the signs of the DC and Hhldpay parameters are not preserved). Despite a higher degree of heterogeneity than for the Level 1 dataset, the data show some degree of regularity, and many of the parameters have the expected signs. Stated preference (SP) methods tend to give lower estimates than revealed preference (RP) methods, as expected. It is also as expected that monthly payments yield higher estimates than other payment vehicles and that non-parametric estimates are lower than parametric ones, like for the Level 1 dataset. The other methodological parameter estimates (i.e. household WTP, personal interview) are not robust across models and there are no strong priors for their signs. The signs and significance of the turtle and mammal parameters are preserved from the Level 1 models. Marine habitats are valued significantly higher than other habitats across Models 1-3, while the wetland parameter is not robust. Estimates with primarily non-use values are only lower in Models 2 and 3 (not significant). Studies conducted in Oceania (mostly Australia) tend to yield significantly higher values (most significant in reduced model versions), after controlling for the higher income level, which may be an indication of "greener" preferences. Studies from Southeast Asia (significant) and East Asia (not significant) give lower values, compared to other regions. Interestingly, studies funded by EEPSEA give lower values than studies funded by other institutions. Published papers seem to yield lower estimates (not significant), a possible indication of the more conservative valuation methods and reported values in the published literature. The income parameter is positive for studies that have reported income information from their samples, but only significantly so in Model 4 for the endangered species data. Year is positive but not significant in any models.

Increasing the degree of homogeneity of our data in terms of good characteristics and methods, then, generally increases the explanatory power of the models, as expected. For the more homogenous Level 1 data, observable characteristics of the type of species, region and other variables (income, year) add significantly to the explanatory power of the models. Even with the fairly heterogeneous Level 2 dataset, the models are still able to explain a significant part of the variation giving some credibility to pooling valuation estimates drawn from a varied base of studies for MA. Many of the parameter signs (and significance) are preserved when going from Level 1 to Level 2. The explanatory power of our Level 2 models is comparable and our Level 1 models in the high range, compared to other MA studies in environmental economics. For example, the $R^2$ for our Level 2 Model 3 is only about 10-15 percentage points lower than Van Houtven et al's (2007) MA of water quality valuation studies in the USA. They screened 300 publications related to water quality valuation and found only 11 studies (96 observations) they considered "sufficiently comparable" to include in an MA, a highly subjective and not very transparent choice. In contrast, we chose to follow the recommendation to "err on the side of inclusion" (Stanley and Jarrel 2005: p137) and exclude studies only by clear criteria. Given the degree of confirmed validity of our data, the next, and directly policy relevant question, is how the MA models will perform forecasting values for unstudied sites, i.e. used for BT. This is the question we turn to in the next section.

**A check of the transferability of nature conservation values**

MA-BT involves transferring one or more estimated meta-regression equations (2) to an unstudied policy site, and insert values from this site for the geographic, socio-economic, good characteristics variables and relevant year, and predict or forecast annual WTP per household. The values of methodological variables would typically be set at some best practice level, at the average sample value or drawn from the MA sample (Johnston et al. 2006), since there is no such information for an unstudied policy site. To the extent that observable characteristics of the habitats/good valued and the population, and not only the methodological differences between the studies, explain a significant portion of the variation in WTP, it gives us confidence that MA-BT may be a credible alternative to a new valuation study or other BT techniques as input for example in cost-benefit analysis. The performance of MA-BT can only be accurately assessed if we knew the "true value", or an estimate of this, for a range of sites, and then used the MA models to predict the value at those sites, and calculate so-called transfer errors (TE)[18]. Lindhjem and Navrud (In press) and a few other studies referenced therein, use different "benchmark" values from within their sample or from new studies to "simulate" the true value to assess TE performance. We will not conduct a full such investigation, but only carry out a first check on how our MA models forecast nature conservation values for our two datasets. We use a jacknife data splitting technique, introduced in BT by Loomis (1992) and used in MA e.g. by Santos (1998) and Brander et al (2006), where we estimate n-1 separate meta-regression equations to predict (or forecast) the value of the omitted observation in each case (i.e. "the site" we predict). We then calculate the percentage difference between observed and predicted values, the TE in our simple exercise, and the overall median and mean TE for all observations[19]. This measure gives a first indication of how far off our MA models would be in a real

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[18] $TE = \frac{|WTP_T - WTP_B|}{WTP_B}$ , where T = Transferred (predicted) value from study site(s), B = Estimated true value ("benchmark") at policy site.

[19] The mean prediction error is often termed Mean Absolute Percentage Error (MAPE).

BT exercise. We start by reporting the results for the four models using the Level 1 and Level 2 data (Table 8 and 9 below, respectively)[20].

*Table 8 Median and mean transfer error for full and reduced models Level 1: Endangered species*

| | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| | Full | Reduced | Full | Reduced | Full | Reduced | Full | Reduced |
| Median | 61 | 69 | 59 | 44 | 33 | 68 | 24 | 25 |
| Mean | 108 | 108 | 85 | 77 | 58 | 103 | 46 | 44 |
| N | 124 | 124 | 124 | 124 | 124 | 124 | 123 | 123 |

*Table 9 Median and mean transfer error (percent) for full and reduced models Level 2: Biodiversity and nature conservation*

| | Model 1 | | Model 2 | | Model 3 | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| | Full | Reduced | Full | Reduced | Full | Reduced | Full | Reduced |
| Median | 68 | 67 | 52 | 58 | 46 | 46 | 22 | 26 |
| Mean | 7344 | 10449 | 377 | 279 | 89 | 86 | 45 | 44 |
| N | 547 | 547 | 428 | 428 | 387 | 387 | 121 | 121 |

Introducing variables other than study-specific methodological variables in the Level 1 models, reduces median TE from 61 percent (full Model 1) to 24 percent for the best-fitting Model 4 (Table 8). Mean TE for Model 4 is 46 percent. This is fairly low compared to other studies performing this check, e.g. Lindhjem and Navrud (In press) (62-266 percent), and Brander et al (2006; 2007) (74-186 percent), indicating a level of precision that could be acceptable for policy use. Such levels would have to be determined on a case-by-case basis, but a general level of 20-40 percent has been suggested (Kristofersson and Navrud 2007). Precision increases with the more fully

[20] To account for econometric error in transforming ln(WTP) to WTP using antilog, we add standard deviation ($s^2/2$), which estimate varies when the sample changes, prior to transformation of ln(WTP) (see e.g. Johnston et al. 2006). Some of the observations were dropped by STATA performing the TE estimations in Tables 8-9 as compared to Tables 7-8..

specified models. There is no clear relationship between mean and median TE and the reduced vs. full models[21].

For the Level 2 data median TE is comparable to the Level 1 results across all models, but the Level 2 data produce more high TE values (i.e. the mean is much higher than the median) (Table 9). Reducing methodological heterogeneity for the Level 2 data from Model 2 to 3 reduces median TE from around 52 percent to 46, while mean TE comes down from an unacceptably high level of 279-377 percent to a more reasonable 86-89 percent. For both Level 1 and 2 models there is an inverse relationship between the level of explained variation and TE, as expected. Hence, increasing degree of homogeneity of the data in terms of good characteristics (biodiversity and nature conservation in general to endangered species) increases the precision, as does the enhanced homogeneity of valuation methods used within Level 2. However, even with a heterogeneous dataset, TE may approach acceptable levels for policy use. The plot of observed WTP values (estimates sorted in ascending order, lnwtp06) vs. predicted (zig-zag line, wtp_p) for Model 4 (Level 1 data) is illustrated in Figure 1. The forecasts follow the observed values well except at the extremities of the data, a characteristic of forecasting models. For comparison, Model 1 (the whole dataset, 550 observations) for Level 2 is plotted in Figure 2. This plot shows a lower level of precision than for Level 1 in Figure 1 (though the scale is different).

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[21] We also ran the same TE simulations using a rule-of-thumb of $p>0.1$ instead of $p>0.2$ for the reduced models, detecting no clear(er) relationship with TE.

*Figure 1   Plot of predicted vs observed WTP, Model 4 full form (Level 1)*

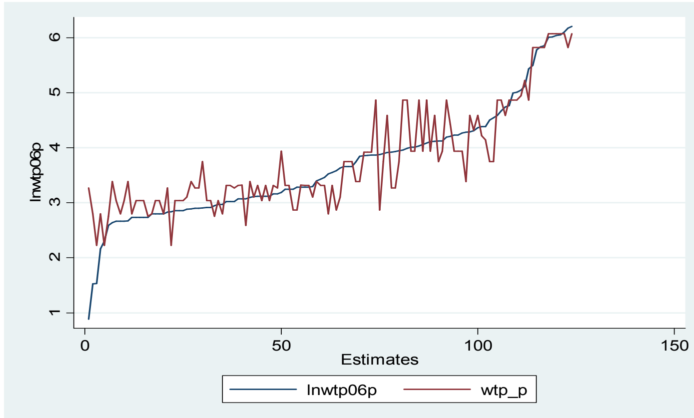
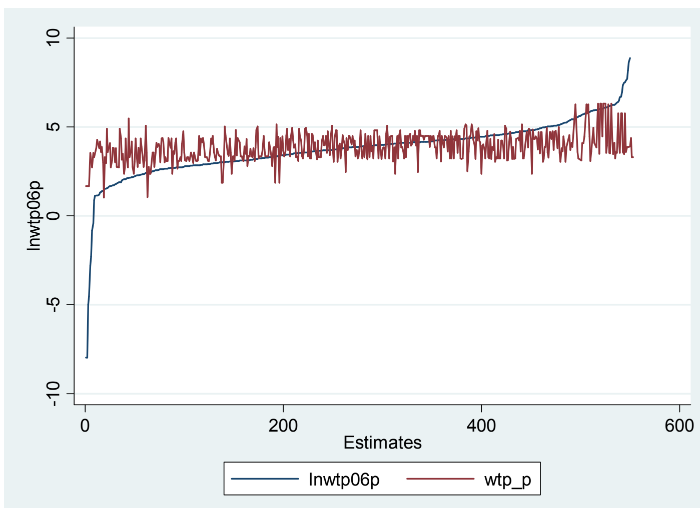



*Figure 2   Plot of predicted vs observed WTP, Model 1 full form (Level 2)*




We also break down estimated median and mean TE from Tables 8 and 9 for the full models only, for different subsets of the Level 1 and 2 data, i.e. by different characteristics of the good (Levels 1 and 2), valuation methods and geographical region (Level 2). First, TE for the four Level 1 models predicting values for preservation of turtles, mammals and other species, are given in Table 10. Precision increases from Model 1 through to 4 for all species types. WTP for mammal preservation is predicted with a median (mean) precision of 16 (17), percent, while for other species median TE doubles.

*Table 10 Median (mean) transfer error in percent for full models for types of species, Level 1: Endangered species data*

| | Turtle | Mammal | Other species |
|---|---|---|---|
| Model 1 | 45 (169) | 50 (120) | 67 (75) |
| Model 2 | 52 (114) | 43 (86) | 65 (71) |
| Model 3 | 32 (97) | 36 (61) | 33 (39) |
| Model 4 | 24 (69) | 16 (17) | 32 (43) |
| **# of obs.** | **34** | **19/20** | **70** |

In Table 11 we split the estimated TE for species and different types of habitats for the Level 2 data. The precision is generally higher for the endangered species (median TE of 36 percent in Model 3 and 22 percent in Model 3). Model 3 predicts WTP for terrestrial and marine habitats with the same median error of 40-46 percent (means around 100 percent), while wetlands and other habitats have higher median errors. The mean TEs, however, show a different pattern (species have lowest TE). To the extent endangered species can be argued to be a more homogenous good than the habitat types specified here, this may be a reason why WTP for their preservation are predicted with less noise. Santos (1998) argues that the prediction errors he obtains in a MA of CV studies of landscape conservation are higher than those estimated in Loomis' (1992) study of rivers within the same US state, due to landscapes being a more heterogeneous good.

*Table 11 Median (mean) transfer error for full models for endangered species and types of habitat, Level 2 data*

| | Terrestrial habitats | Marine habitats | Endangered species | Wetlands | Other habitats |
|---|---|---|---|---|---|
| Model 1 | 86 (545) | 63 (605) | 47 (85) | 71 (92838) | 77 (184) |
| Model 2 | 62 (1134) | 44 (105) | 36 (60) | 77 (116) | 78 (79) |
| Model 3 | 46 (104) | 40 (106) | 36 (57) | 71 (119) | 81 (75) |
| Model 4 | - | - | 22 (45) | - | - |

| # obs. | 81- 173 | 129-162 | 121-129 | 31-41 | 17-37 |
|---|---|---|---|---|---|

Enhancing methodological homogeneity from Model 2 to 3 (i.e. removing estimates using market price or hedonic methods) reduces TE especially for terrestrial habitats, while TE for the other habitats are around the same level. This is an indication that other valuation methods introduce substantial noise for terrestrial habitat valuation in the MA. In Table 12 we break down TE by valuation methods used. WTP estimates derived by CV has a median (mean) TE of 41 (71) percent in the most homogenous Model 3. CM has lower median TE than this, but double mean TE. Estimates derived by TCM or other valuation methods generally have higher TE than stated preference methods.

*Table 12 Median (mean) transfer error for full models for different valuation methods, Level 2 data*

| | CV | CM | TCM | Others |
|---|---|---|---|---|
| Model 1 | 64 (157) | 70 (159) | 73 (104785) | 93 (1776) |
| Model 2 | 41 (81) | 78 (167) | 101 (141) | 84 (3882) |
| Model 3 | 41 (71) | 26 (149) | 105 (145) | - |
| Model 4 | 22 (45) | - | - | - |
| # of obs. | 121-423 | 50 | 17-37 | 37 |

Finally, breaking the TE estimates down by region shows that using the model to predict values in Southeast Asia produces the lowest TE, which is partly due to the larger number of estimates from this region. Except for some very high TE estimates pulling up the mean, median TE for transfers to all regions is below 80 percent and approaching acceptable levels for policy use.

*Table 12 Median (mean) transfer error for full models for different valuation methods, Level 2 data*

| | Southeast Asia | Oceania | East Asia | South Asia | Southwest Asia |
|---|---|---|---|---|---|
| Model 1 | 59 (16000) | 80 (209) | 66 (163) | 80 (1605) | 45 (76) |
| Model 2 | 42 (102) | 61 (81) | 68 (304) | 67 (3184) | 44 (43) |
| Model 3 | 37 (90) | 59 (76) | 68 (110) | 21 (27) | 36 (36) |
| Model 4 | 23 (44) | 31 (50) | 28 (57) | 15 (17) | - |
| # of obs. | 69-244 | 16-116 | 26-99 | 10-41 | 12-21 |

## Concluding remarks

Pushing the boundaries of meta-analysis (MA) in environmental economics, we have taken stock of studies estimating willingness to pay for conservation of endangered species, biodiversity and nature more generally in Asia and Oceania. Our literature review shows that nature conservation is highly valued, probably more so in many cases than the opportunity costs of increasing conservation efforts in the region, though such a comparison is beyond the scope of our study. Dividing our dataset into two levels of heterogeneity in terms of good characteristics and valuation methods, we show that the degree of regularity and conformity with theory and empirical expectations as well as the explanatory power of our MA models is higher for the more homogenous dataset of endangered species values, as expected. In fact, though the species are different, the values to preserve them generally follow predictable patterns. For example, we find that mammals are generally valued higher than other species, likely due to the "charismatic" nature of this family. Further, WTP increases significantly with income (elasticity equals 0.85). The analysis of the endangered species data show that around half of the variation in the best model is due to non-study specific observable characteristics of the good and population surveyed, boding well for use of such data in benefit transfer (BT) applications.

However, importantly, increasing the scope of the MA, i.e. gradually including more heterogeneous observations, generally preserves much of the regularity and the explanatory power of some of our models is in the range of other MA studies of goods typically assumed to be more homogenous (such as national water quality, recreation days, etc). Judging whether the relatively low variation of value estimates across types of goods and regions can be interpreted as a sign of invalid values (WTP for example an expression of “moral dump” or “purchase of moral satisfaction” (Kahneman and Knetsch 1992)), or that total values may have a large share of non-use values expected to stay more constant across social groups and environmental domains (e.g. as hypothesised in Kristofersson and Navrud (2007) and Brouwer (2000)), is an unsettled issue and beyond the scope of this study. In any case, it is generally easier to detect sensitivity of WTP to the scope of a good within individual studies than across a range of studies in a MA. However, even within single studies, it is hard to define and communicate the important dimensions of scope of complex goods such as endangered species or biodiversity to the respondent (see e.g. discussion in Carson and Hanemann (2005: p912-914) and Lindhjem (2007), and Loomis (2006) for use of such welfare estimates in cost-benefit analysis).

Subjecting both our dataset levels to a simple check of level of transfer error (TE), using the MA models to predict observations one-by-one when excluded from the datasets, show median (mean) TE of 24 (46) percent for the endangered species data and 46 (89) percent for the more heterogeneous nature and biodiversity data. This is in the low range compared to other MA studies. Results suggest that such levels of forecasting errors may approach acceptable levels for policy use. However, caution should be exercised in using values for single species for benefit transfer, as such estimates may include values of biodiversity or habitats more generally (see e.g. Veisten et al. (2004)).

The common practice in MA to exclude a large amount of valuation studies and estimates based on subjective, often arbitrary and not very transparent criteria of “acceptable level of heterogeneity”, is in any case not to be recommended (Stanley and Jarrel 2005), but our results show that the loss of explanatory and predictive power of MA models from accepting a higher level of heterogeneity may be lower than expected.

The more prudent approach we follow is first to include all value estimates in a gross dataset, and increase the degree of homogeneity by varying model specifications and data subsets to investigate sensitivity. While it is appealing to include studies of exactly the same good (if such a good exists outside the textbook) using the same valuation methods, the strength of MA is that such differences to some extent can be controlled for in a transparent way in the regression analysis. This study is, to our knowledge, one of the first attempts to systematically investigate the issue of heterogeneity in MA for environmental valuation. More research for other goods and geographical areas is needed to inform the development of a more consistent and generally applicable MA methodology, especially as MA is gradually being applied for BT to inform policy. Use of MA in economics is growing and the aim should be to move more of the methodological choices out of the black box.

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## Appendix

*Table A* *Studies of endangered species used in meta-analysis (MA)*

| Name of references | Country | Year[a] | Species | Method | Mode | Vehicle[b] | Payment format | # of values[c] | WTP (USD)[d] |
|---|---|---|---|---|---|---|---|---|---|
| Jakobsson and Dragun (2001) | Australia | 2000 | Possum | CV: DC, PC | Mail | M | Year | 12 | 14-72 |
| Tisdell et al. (2005) | Australia | 2002 | Glider | CV: OE | Mail | V | One-off | 3 | 13-19 |
| Kontoleon and Swanson (2003) | China | 1998 | Panda | CV: DC | Interview | M&V | Visit | 3 | 5-17 |
| Jianjun et al.(2006)[e] | China | 2005 | Turtles | CV: PL | Drop-off | M | Month | 5 | 5-6 |
| Jianjun (2006) | China | 2005 | Spoonbill | CV: DC | Drop-off | M&V | Month | 17 | 4-19 |
| Jianjun et al. (2006)[e] | Philippines | 2005 | Turtles | CV: DC | Drop-off | M&V | Month | 5 | 1-3 |
| Harder et al. (2006) | Philippines | 2005 | Eagles | CV: DC | Drop-off | M&V | Month | 30 | 1-3 |
| Indab (2006) | Philippines | 2005 | Shark | CV: DC | Drop-off | M | Month | 5 | 2-4 |
| Bandara and Tisdell (2004) | Sri Lanka | 2002 | Elephants | CV: DC | Drop-off | V | Month | 4 | 20-40 |
| Bandara and Tisdell (2005) | Sri Lanka | 2001 | Elephants[f] | CV: DC | Interview | V | Month | 6 | 34-41 |
| Jianjun et al. (2006)[e] | Thailand | 2005 | Turtles | CV: DC | Drop-off | M&V | Month | 5 | 3-8 |
| Nabangchang (2006) | Thailand | 2005 | Multiple[g] | CV: DC | Interview | M&V | One-off | 7 | 43-64 |
| Jianjun et al. (2006)[e] | Vietnam | 2005 | Turtles | CV: DC | Drop-off | M | Month | 4 | 0.2-4 |
| Thuy (2006) | Vietnam | 2005 | Rhino | CV: DC | Drop-off | M&V | Month | 2 | 13-14 |
| Tuan et al. (2008) | Cn,Pp,Th,Vn[h] | 2005 | Turtles | CV: DC | Drop-off | M&V | Month | 16 | 1-5 |
| Ninan and Sathyapalan (2005)* | India | 2000 | Elephants | CV:DC | Interview | M | Year | 5 | 341-1830 |
| **Total number of studies=16** | | | | | | | | **129** | |

*Notes*: *4 of 5 observations from this study were excluded by the screening criterion (2x STD of mean) for the Level 1 data, but included in the Level 2 dataset (see Table B)
[a] Year of data.
[b] Payment vehicle: mandatory (M) or voluntary (V).
[c] Number of WTP values used in MA.
[d] WTP values in US$. The WTP formats are given as reported (i.e. lump sum, per month, per year, per visit, per individual or household). WTP values in local currencies are converted to US$ using PPP adjustments; and values from different years are converted to 2006 prices using CPI.
[e] Jianjun et al. (2006) has four separate country case study components.
[f] Abundance of elephants.
[g] Multiple species: Dugong dugong, elephants, rhinos, Irawaddy dolphin, tigers.

*Table B* *Studies of nature and biodiversity conservation used in meta-analysis (MA)*

| Name of references | Country | Year[a] | Habitat/service type | Method | Mode | Vehicle | Payment format | # of values | WTP (USD) |
|---|---|---|---|---|---|---|---|---|---|
| Jakobsson and Dragun (2001) | Australia | 2000 | Flora & fauna | CV: DC, PC | Mail | M | year | 7 | 24-175 |
| Bennett et al. (1998) | Australia | 1996 | Wetlands | CV: DC | Mail | M | One-time | 2 | 122-187 |
| Bennett (1984) | Australia | 1979 | Nature reserve | CV: OE | Interview | M&V | One-time | 1 | 33 |
| Blamey et al. (1999) | Australia | 1999 | Water | CA | Interview | M | Year | 4 | 29-116 |
| Cameron and Quiggin (1994) | Australia | 1991 | Parks | CV: IB | Interview | M | | 4 | 228-664 |
| Carr and Mendelsohn (2003) | Australia | 2000 | Reefs | TCM | Interview | | Year | 1 | 391 |
| Carson et al. (1994) | Australia | 1990 | parks | CV: DBDC | Interview | M | Year | 4 | 30-129 |
| Hundloe (1990) | Australia | 1986 | Reefs | TCM | Interview | | Year | 1 | 8 |
| Kuosmanen et al. (2003) | Australia | | Parks | TCM | Mail | | Year | 6 | 54-418 |
| Lockwood and Carberry (1998 ) | Australia | 1997 | Vegetation | CM, CV | Mail | M | One-time | 8 | 35-90 |
| Lockwood and Tracy (1995) | Australia | 1993 | Parks | CV: OE | Mail | V | One-time | 1 | 21 |
| Lockwood (1999) | Australia | 1995 | Parks | CV: OE | Computer | V | | 4 | 14-450 |
| Lockwood (1996) | Australia | | Natural environm. | CV: DC | Mail | V | | 9 | 5-123 |
| Loomis et al. (1993) | Australia | | Forests | CV: OE, DC | Mail | | Year | 6 | 34-89 |
| Morrison et al. (2002) | Australia | 1997 | Wetlands | CM | Mail | M | One-time | 18 | 25-117 |
| Nillesen et al. (2005) | Australia | | Parks | TCM | Mail | | Year | 1 | 86 |
| Streever et al. (1998) | Australia | 1996 | Wetlands | CV: OE | Mail | M | | 1 | 151 |
| Greiner and Rolfe (2004) | Australia | 2000 | Parks | CV: OE | Interview | M | Visit | 3 | 23-39 |
| Campbell and Reid (2000) | Australia | 1996 | Fisheries | CV: DC | Interview | M | Year | 3 | 212-517 |
| Flatley and Bennett (1995) | Vanuatu | 1994 | Forest | CV | Interview | V | One-time | 2 | 33-36 |
| Flatley and Bennett (1996) | Vanuatu | 1994 | Forest | CV | Interview | V | One-time | 1 | 18 |
| Chen et al. (In press) | China | 1999 | Beaches | TCM | Interview | M | Visit | 1 | 64 |
| Day and Mourato (2002) | China | 1997 | Rivers | CV: DBDC | Interview | M | | 4 | 51-94 |
| Gong (2004) | China | 2002 | National reserve | CV: BG | Interview | M | | 2 | 5-16 |
| Guo et al. (2001) | China | 1997 | Ecosystem services | TCM | Interview | | Visit | 3 | 20-40 |
| Jim and Chen (2006) | China | 2003 | Urban green spaces | CV: PC | Interview | | | 1 | 15 |
| Yaping (1998) | China | 1996 | Lakes | CV:OE&<br>TCM | Interview | M | Visit<br>Year | 7 | 77-114<br>6-15 |
| Zhongmin et al. (2003) | China | 2001 | Ecosystem services | CV: PC | Interview | M&V | Year | 3 | 8-87 |
| Zhongmin et al. (2006) | China | 2003 | Watershed | CV:DC, DBDC | Interview | M&V | Year | 2 | 71 |
| Wang et al. (2007) | China | 2006 | Water | CV:DC | Interview | M | Month | 2 | |
| Xu et al. (2007) | China | 2002 | Eco-services | CM | Interview | M | Year | 7 | 51-134 |
| Gundimeda and Kathuria (2003) | India | 2003 | Water | HPM | Interview | | | 2 | 149-377 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Hadker et al.(1997) | India | 1995 | Parks | CV: DC | Interview | V | Month | 2 | 6-8 |
| Kohlin (2001) | India | 1995 | Woodlots | CV: DC, OE | Interview | | Month | 11 | 4-6 |
| Maharana et al. (2000) | India | 1998 | Lakes | CV: IB & TCM | Interview | | Year | 4 | 5-43 |
| Nallathiga (2004) | India | 1995 | Rivers | CV: PC | Interview | M | Year | 2 | 22-25 |
| Butry and Pattanayak (2001) | Indonesia | 1996 | Forests | CV:OE, PC & MP | Interview | M | Year | 3 | 23-2006 |
| Pattanayak (2001) | Indonesia | 1996 | Ecological services | CV: DC | Interview | M | Year | 1 | 20 |
| Pattanayak and Kramer (2001) | Indonesia | 1996 | Watershed | CV: DC | Interview | M | Year | 10 | 7-21 |
| Walpole et al. (2001) | Indonesia | 1995 | Parks | CV: DBDC | Interview | M | Year | 1 | 78 |
| Amirnejad et al.(2006) | Iran | 2004 | Forests | CV: DC | Interview | M | Month | 1 | 9 |
| Fleischer and Tsur (2000) | Israel | 1997 | Landscapes | TCM | Interview | | Year | 2 | 179-367 |
| Shechter et al. (1998) | Israel | 1993 | Parks | CV: OE, DC | Telephone | V | One-time | 12 | 28-57 |
| Tsgue and Washida (2003) | Japan | 1998 | Natural areas of the Sea. | CV: DC | Internet | | One-time | 6 | 132-159 |
| Nishizawa et al. (2007) | Japan | 2003 | Eco-services | CVM:DC | Mail | M | | 2 | 13-14 |
| Kwak et al. (2003) | Korea | 2001 | Forests | CV: DC | Interview | M | Year | 4 | 3-6 |
| Lee (1997) | Korea | 1996 | Nature-based tourism resources | CV: DC | Interview | M | Year | 2 | 12-13 |
| Lee and Han (2002) | Korea | 1999 | Parks | CV: DC | Interview | M | Year | 10 | 8-23 |
| Lee and Mjelde (2007) | Korea | 2005 | Eco-services | CV:DC | Interview | M | Year | 2 | 22-26 |
| Eom and Larson (2006) | Korea | 2000 | Water | CV | Interview | M | Year | 2 | 35-62 |
| Lee and Chun (1999) | Korea | 1994 | Forest recreation | CV:DC | Mail | V | Year | 3 | 445-787 |
| Othman et al.(2004) | Malaysia | 1999 | Forests | CM | Interview | | Year | 5 | 0.5-8 |
| Yeo (2002) | Malaysia | 1998 | Parks | CV: OE | Interview | | Year | 6 | 6-12 |
| Mourato (2002) | Malaysia | 1997 | Water | CV: PL | Interview | M | Month | 2 | 3 |
| Naylor and Drew (1998) | Micronesia | 1996 | Mangroves | CV | Interview | M | Month | 4 | 174-556 |
| Khan (2004) | Pakistan | 2003 | Parks | TCM | Interview | | Visit | 2 | 13-18 |
| Manoka (2001) | P.N.Guinea | 1999 | Forests | CV: OE, DC | Mail | V | Year | 10 | 11-101 |
| Arin and Kramer (2002) | Philippines | 1997 | Marine sanctuary | CV: PC | Interview | M | Year | 3 | 21-34 |
| Calderon et al. (2005) | Philippines | 2003 | Watersheds | CV: DC | Interview | M | Month | 36 | 2-6 |
| Choe et al. (1996) | Philippines | 1992 | Water | CV: DC, BG, OE | Interview | | Month | 18 | 0-13 |
| Pattanayak and Mercer (1998) | Phillippines | 1994 | Soil | MP | Interview | | Year | 2 | 195-306 |
| Subade (2005) | Philippines | 2002 | Reefs | CV: DC | Interview & drop-off | V | Year | 12 | 15-83 |
| Amponin et al. (2007) | Philippines | 2006 | Watershed | CV:DC | Interview | M | month | 9 | 3-6 |
| Wei-Shiuen and Robert (2005) | Singapore | 2002 | Beaches | TCM & CV | Interview | | Year | 14 | 0.1-485 |
| Bogahawatte (1999) | Sri Lanka | 1997 | Forests | MP | Interview | Year | Year | 30 | 1-437 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Ekanayake and Abeygunawardena (1994) | Sri Lanka | 1992 | Forests | CV: OE | Interview | | Year | 2 | 41-131 |
| Chang and Ying (2005) | Taiwan | 2001 | Agri. lands | CV: DBDC | Telephone | M | Year | 1 | 103 |
| Chen (1998) | Taiwan | | Agri. lands | CV:OE, DC | Mail | | Month | 6 | 0.3-7 |
| Hammit et al (2001) | Taiwan | 1993 | Wetlands | CV: DC, OE | Interview | V | Year | 4 | 46-173 |
| Cushman (2004) | Thailand | 2001 | Beaches | CM | Interview | M | Year | 5 | 17-526 |
| Isangkura (1998) | Thailand | 1996 | Parks | CR & CV: OE | Interview | M | Year | 9 | 2-28 |
| Seenprachawong (2002) | Thailand | 2002 | Coastal ecosystem | CM | Interview | V | Year | 5 | 9-188 |
| Seenprachawong (2001) | Thailand | 2000 | Reefs | CV:DC &TCM | Interview | V | Year | 3 | 31-555 |
| Tapvong and Kruavan (1999) | Thailand | 1998 | Rivers | CV: DC | Interview | M | Month | 2 | 9-10 |
| Pham and Tran (2000) | Vietnam | 2000 | Reefs | CV:PC & TCM | Interview | M | Year | 5 | 7-170 |
| Pham et al. (2000) | Vietnam | 2003 | Reefs | TCM<br>CV | Interview | M | Year | 4 | 17-390 |
| Phuong and Gopalakrishnan (2004) | Vietnam | 2001 | Water | CV: PC | Interview | M | Year | 7 | 4-40 |
| Do (2007) | Vietnam | 2006 | Wetlands | CM | Interview | | Year | 2 | 4-12 |
| Nam et al. (2001) | Vietnam | 1999 | Forests | CV & MP | Interview | M | Year | 9 | 24-1807 |
| **Total number of observations*** | | | | | | | | **421** | |

*Notes:* * The total number of observations using the least strict screening criterion (WTP>0 and within 2x STD of the mean), i.e. 129 (Level 1) + 429 (Level 2) = 550 observations. Blank space means that information was not reported in the study. See also notes to Table A above.

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