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Experience, Expectations and Hindsight:
Evidence of a Cognitive Wedge in Stated Preference Retrospectives

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This paper combines fishing trip decisions – made before observing trip outcomes – with responses to set of double-bounded dichotomous choice CV questions regarding the outcome of the trip, to explore cognitive elements of choice and their implications for decision modeling and welfare analysis. Extending the approach taken by McConnell et al. (1999), wherein the unobserved component of random utility is linked between the trip decision and the retrospective trip evaluation, we decompose the unobserved component into linked and independent elements, and make the linked component a function of cognitive factors hypothesized as affecting differences between the RP and SP responses. Results suggest that a significant "wedge" exists between the closely related trip decision and its retrospective valuation, and that this wedge is not fully explained by factors such as experience, recall, and unobserved time costs.

I. Introduction

The literature on methods to combine revealed preference (RP) and stated preference (SP) data argues that the development of these techniques can significantly improve the identification and estimation of preferences (Cameron *et al.*, 2002; Adamowicz, Louviere and Williams, 1994; Adamowicz *et al.*, 1997; Azevedo, 1999; Brownstone and Train, 2000; Cameron, 1992). However, work to date has generally focused on how such gains can be made within current models of choice, thus overlooking what is an equally compelling direction for this research: using combined preference data to examine how well current choice models capture how people make decisions and value the environment (Azevedo *et al*, 2000; Cameron *et al*, 2002; McConnell *et al*, 1999). This study takes a somewhat unconventional approach in the development of a combined RP/SP model, with the goal of improving the modeling of preferences. The model developed examines the linkages between the valuations implicit in observed Lake Michigan fishing trip decisions and those implicit in the responses to a follow-up double-bounded dichotomous-choice question regarding trip outcomes. Rather than combining RP and SP data to pursue the standard aims of improving statistical efficiency or capturing preferences for difficult-to-value goods, this work focuses on examining the consistency of individuals' valuations, made at two different points in time, of the same recreational fishing trip.

This study is in part motivated by the growing body of evidence presented in the economic psychology literature suggesting that the utility implicit in decisions can be systematically different than that derived from outcomes. Rabin (1998) provides an excellent review of the various types of phenomenon possibly generating this effect, including *hindsight bias*, *projection bias*, *status quo bias, loss aversion* and the *endowment effect* (Rabin, 1998; Conlisk, 1996; Griffen and Tversky, 1992; Tversky and Kahneman, 1974). As such, the study's primary goal is to shed light on the degree to which models that combine RP and SP data adequately account for potential underlying differences in the cognitive foundations of different types of preference data. The model extends the conceptual approach taken by McConnell *et al* (1999). Whereas McConnell et al. examined a trip occasion model, we estimate a repeated choice model of the daily fishing decision (including the anglers' decision not to fish) for an extended portion of the fishing season.

Underlying this work is the issue of how the researcher-unobserved component of random utility has been conceptually and econometrically interpreted in welfare analysis. Section II thus puts the current analysis into context by briefly summarizing how different types of combined RP/SP and discrete choice models often implicitly interpret the unobserved component, and then develops a theoretical model linking trip decisions and retrospective evaluations in a discrete choice framework. Section III details the survey data used for the analysis and presents the empirical results. The results suggest that, insofar as the empirical model reasonably characterizes the choice process of the anglers examined, *ex ante* and retrospective trip decisions indeed share common underlying elements, but that a significant and systematic "wedge" exists between the trip valuations implicit in anglers' trip decisions and those implied by retrospective trip evaluations. Furthermore, we find that variables related to experience, recall, and trip time costs do little to explain this wedge, nor does allowing the parameter on catch to differ between *ex ante* and retrospective utility. Section IV presents the results of welfare analysis, and section V concludes the paper with several remarks about future research directions.

II. A Model Linking *Ex Ante* and Retrospective Choices

Although the RP and SP data jointly examined in the recent literature often come from the same sample, much of the work examines whether, in a multinomial logit (MNL) model, differences in the Gumbel distribution scale parameter between RP and SP data can account for different parameter estimates (e.g. Haener, Boxall & Adamowicz, 2001; Hensher, Louviere & Swait, 1999; Adamowicz *et al.*, 1997). This work generally discusses these differences in terms of the "noisiness" of the data, suggesting that no link exists between the unobserved components of RP and SP utility (Hensher, Louviere & Swait, 1999; Adamowicz *et al*., 1997; Adamowicz, Louviere & Williams, 1994; Swait and Louviere, 1993). This view thus accords with interpretations of the unobserved component as capturing random phenomenon unrelated to choice utility, which include measurement error in the dependent or explanatory variables (Hiett and Worrall, 1977), random error associated with the use of instrumental variables in place of unobservable variables in the systematic portion of utility (Manski, 1973), or simply inherent "randomness" in human behavior (Hanemann, 1983).

In contrast, studies based on random utility models with normally distributed unobserved components have tended to treat the unobserved component as utility-relevant. These types of analyses have generally worked with combined RP/SP or SP/SP data sets that are related, and use the convenient functional form of the bivariate normal distribution, which allows for direct estimation of the correlation coefficient between the unobserved components of utility. Correlation implies that some aspect of the unobserved component is shared between different types of choices, and therefore could be construed to capture unobserved variables affecting the choice utilities, or shared aspects of a common underlying choice process. Examples of studies using this approach include Azevedo *et al.* (2000), Niklitschek and León (1996) and McConnell *et al.* (1999). Of particular relevance for the current study, McConnell *et al.* (1999) uses a bivariate probit model that links the fishing trip choice for individuals intercepted on site with their response to a referendum-style question asking if the respondent would have still gone fishing given a new, randomly-selected, addition to their trip cost. The authors estimate the joint probability of taking a trip and the response to the SP question, conditional on a trip having been taken, wherein the random utilities of the trip decision and the SP response share common systematic components but have potentially different unobserved components linked by correlation coefficient (ρ). They examine three cases: "transitory" preference structure (ρ = 0), "permanent" preference structure (ρ = 1) and "correlated" preference structure (ρ unrestricted). They fail to reject the hypothesis of parameter equality between the systematic components of utility for the trip decision and SP response. Not surprisingly, they find in the correlated preference model high (~0.7), but weakly significant, correlation between the unobserved components.

As described later, we estimate a repeated choice model in which, on a daily basis, anglers choose from among five alternatives: no fishing trip, a trip to one of three Lake Michigan sites, or a trip to a non-Lake Michigan site. Here we present the details of the linkage between angler trip decisions and responses to a double-bounded dichotomous-choice question regarding the outcome of each Lake Michigan trip. Specifically, after eliciting from respondents the details of a particular Lake Michigan fishing trip, the following question (CV^1) was asked:

CV^1: "*Given the way the trip turned out in terms of the fish catch, weather and other aspects, was the trip worth what it cost you?*"

The follow-up question then altered either fish catch or trip cost. If respondents answered "yes" to CV^1, then either fish catch was reduced or cost increased for the second question, and vice versa if the respondent answered "no" to CV^1. The trip cost ($CV^{2\text{-COST}}$) and catch ($CV^{2\text{-CATCH}}$) questions are as follows:

$CV^{2\text{-COST}}$: *"Adding up the total you told us you (...and members of your household...) spent on gas, boat fuel and oil, daily ramp or launch fees, food and beverages, charter boat fees, derby fees, other costs for your fishing trip, you spent about* ______[sum of trip expenses and contest fees, excluding lures and fishing equipment]. *Now suppose for a moment that your expenses had been higher/lower. If the costs I just mentioned had in fact been a total of* _______, *would this trip have been worth what it cost you?"*

$CV^{2\text{-CATCH}}$: *"Now if the catch was the same, except that instead of catching* ______ [the number and name of a specific species actually caught … either Steelhead, Chinook, Coho or Brown Trout, randomly selected from the actual the fish catch), *you in fact caught*_________, *would the trip have been worth what it cost you?"*

The wording of all three questions was designed to introduce minimal bias into angler responses, and the instrument was coded to alternate systematically between $CV^{2\text{-COST}}$ and $CV^{2\text{-CATCH}}$.[1] A total of 251 paired RP-SP trip observations for Lake Michigan daytrips were collected. Of these, anglers indicated that the trip was "worth the cost" 85% of the time. Of those that responded yes to CV^1, 17% changed their response in CV^2. Of those that responded "no" to CV^1, 59% changed their response in CV^2.

The trip decision is a function of *expected* trip outcomes – a characterization implicit in standard travel cost models – whereas the retrospective evaluation is a function of *realized* trip outcomes. To signify this, retrospective and trip-decision utilities will be labeled with

[1] If $CV^{2\text{-COST}}$ was asked, the new trip cost was randomly selected to be 10%, 25% or 50% of reported trip cost for a "no" response to CV^1, and 150%, 175% or 200% of reported trip cost for a "yes" response to CV^1. Extra weight was put on the probability of drawing 200% of trip cost for $CV^{2\text{-COST}}$ given a "yes" response to CV^1. Trip cost was calculated as the sum of all variable trip costs, and so does not include fixed costs such as expenditures for lures or fishing equipment. If $CV^{2\text{-CATCH}}$ was asked, and respondents answered "yes" to CV^1, then random selection was limited to only those species that had actually been caught, with the maximum reduction limited to min{catch of selected species,3}. If a respondent had answered "no" to CV^1, then any of the four species above (either Steelhead, Chinook or Coho salmon or Brown trout) could be randomly selected, with a maximum random increase in catch of 3 fish.

superscripts XP (for *ex post*) and XA (for *ex ante*), respectively. Utility on choice occasion t for CV question $\mathrm{q} \in \{1,2\}$ regarding Lake Michigan site i is thus

$$\begin{aligned} U_{it}^{XPq} &= V_{it}^{\mathrm{XP}q} + \varepsilon_{it}^{\mathrm{XP}} \\ &= \mathbf{z}_t{}'\tilde{\boldsymbol{\gamma}}_z + \mathbf{x}_{it}{}'\tilde{\boldsymbol{\gamma}}_x + catch_{it}^q \cdot \tilde{\gamma}_{catch} - cost_{it}^q \cdot \gamma_{income} + \varepsilon_{it}^{\mathrm{XP}} \end{aligned}, \qquad (1)$$

where $V_{it}^{\mathrm{XP}q}$ is the systematic component of utility, and is a function of angler characteristics, $\mathbf{z}_t$, site or trip characteristics that are observed by the angler both before and after taking trips, $\mathbf{x}_{it}$, trip salmonid catch ($catch_{it}^{\mathrm{q}}$) and cost ($cost_{it}^q$) per person, preference parameters $\tilde{\boldsymbol{\gamma}} \equiv [\ \tilde{\boldsymbol{\gamma}}_{\mathbf{z}}\ \ \tilde{\boldsymbol{\gamma}}_{\mathbf{x}}\ \ \tilde{\gamma}_{catch}\ ]$, and constant marginal utility of income, γ_{income}; and $\varepsilon_{it}^{\mathrm{XP}}$ is known by the angler but treated by the analyst as a random variable. Note that since the first CV question is based on trip outcomes, $catch_{it}^1$ and $cost_{it}^1$ represent actual trip catch and cost, whereas $catch_{it}^2$ and $cost_{it}^2$ represent hypothetical trip catch and cost asked of respondents in the second question.

Because $catch_{it}$ and $cost_{it}$ are not observed at the time of the trip decision, the trip decision is based on the expected utility for the trip,

$$\begin{aligned} U_{it}^{XA} &= V_{it}^{\mathrm{XA}} + \varepsilon_{it}^{\mathrm{XA}} \\ &= \mathbf{x}_{it}{}'\boldsymbol{\gamma}_x + \mathbf{z}_t{}'\boldsymbol{\gamma}_z + e\_catch_{it} \cdot \gamma_{catch} - e\_cost_i \cdot \gamma_{income} + \varepsilon_{it}^{\mathrm{XA}} \end{aligned}, \qquad (2)$$

where V_{it}^{XA} denotes the systematic component of *ex ante* utility, e_catch_{it} and e_cost_i are researcher-constructed proxies for angler-expected catch and cost, and other terms are ex-ante counterparts to those defined above for (1).

Decision Rules

The angler will choose to go on a trip to a particular site if the net utility for that choice is at lease as great as that for any other choice. The probabilities that the angler will not take a trip ($Trip_t = 0$) or will choose site *i* ($Trip_t = i$) on choice occasion *t* are thus

$$P(Trip_t = 0) \quad = \quad P\left(U_t^0 > \max_{j \in C}\left\{U_{jt}^{\mathrm{XA}}\right\}\right), \tag{3}$$

$$P(Trip_t = i) \quad = \quad P\left(U_{it}^{\mathrm{XA}} \geq \max\left\{U_t^0, \max_{j \in C} U_{jt}^{\mathrm{XA}}\right\}\right), \tag{4}$$

where *C* is the choice set of fishing sites.

Less straightforward is the appropriate decision rule for responses to the CV questions, since it is unknown what comparisons underlie anglers' responses to questions of "was the trip worth what it cost you?" For example, anglers might only care that the trip generated more utility than baseline utility, so that an angler would answer yes to question *q* if $U_{it}^{\mathrm{XP}q} \geq U_t^0$. To make the retrospective decision rule consistent with the formulated trip decision rule (3)-(4), we assume that anglers answer yes to question *q* if $U_{it}^{\mathrm{XP}q} \geq \max\limits_{\substack{j \neq i \\ j \in C}}\left\{U_t^0, U_{jt}^{\mathrm{XA}}\right\}$. The probability that the angler will answer "yes" to question q is thus,

$$P\left(\mathrm{CV}_t^{\mathrm{q}} = \mathbf{Yes}\right) = P\left(U_{it}^{\mathrm{XPq}} \geq \max\left\{U_t^0, \max_{\substack{j \neq i \\ j \in C}} U_{jt}^{\mathrm{XA}}\right\}\right). \tag{5}$$

The joint probabilities of taking a trip to Lake Michigan site *i* and responding to the two CV questions are therefore (for $j \in C$),

$$P\left(trip_t = i, \mathrm{CV}_t^1 = \mathbf{Yes}, \mathrm{CV}_t^2 = \mathbf{Yes}\right) = P\left(\min\left\{U_{it}^{\mathrm{XA}}, U_{it}^{\mathrm{XP2}}\right\} \geq \max\left\{U_t^0, \max_{j \neq i} U_{jt}^{\mathrm{XA}}\right\}\right), \tag{6}$$

$$P\left(trip_t = i, \mathrm{CV}_t^1 = \mathbf{Yes}, \mathrm{CV}_t^2 = \mathbf{No}\right) = P\left(\min\left\{U_{it}^{\mathrm{XA}}, U_{it}^{\mathrm{XP1}}\right\} \geq \max\left\{U_t^0, \max_{j \neq i} U_{jt}^{\mathrm{XA}}, U_{it}^{\mathrm{XP2}}\right\}\right), \tag{7}$$

$$P\left(trip_t = i, \mathrm{CV}_t^1 = \mathbf{No}, \mathrm{CV}_t^2 = \mathbf{Yes}\right) = P\left(\min\left\{U_{it}^{\mathrm{XA}}, U_{it}^{\mathrm{XP2}}\right\} \geq \max\left\{U_t^0, \max_{j \neq i} U_{jt}^{\mathrm{XA}}, U_{it}^{\mathrm{XP1}}\right\}\right) \tag{8}$$

$$P\left(trip_t = i, \mathrm{CV}_t^1 = \mathbf{No}, \mathrm{CV}_t^2 = \mathbf{No}\right) = P\left(U_{it}^{\mathrm{XA}} \geq \max\left\{U_t^0, \max_{j \neq i} U_{jt}^{\mathrm{XA}}\right\} > U_{it}^{\mathrm{XP2}}\right), \qquad (9)$$

where $\mathrm{CV}_t^{\mathrm{q}}$ is the response to CV question $q \in \{1, 2\}$ on choice occasion *t*.

Linkages Between the Unobserved Components of Random Utility

Although the linkages between unobserved components could be characterized purely in terms of an *ex ante* → *ex post* expectational relationship, so that $\varepsilon_{it}^{\mathrm{XA}} = E_t\left[\varepsilon_{it}^{\mathrm{XP}}\right]$ for the angler, $\varepsilon_{it}^{\mathrm{XP}}$ likely also captures retrospective aspects of the *ex post* evaluation, such as memory.[2] Consequently, it is desirable to characterize the linkages between $\varepsilon_{it}^{\mathrm{XA}}$ and $\varepsilon_{it}^{\mathrm{XP}}$ in a general enough way to capture these various possible types of linkages. To this end, we define

$$\varepsilon_{it}^{\mathrm{XP}} \equiv g\left(\mathbf{w}_{it} \middle| \boldsymbol{\theta}\right) \cdot \varepsilon_{\mathrm{it}}^{\mathrm{XA}} + \tilde{\omega}_{it} . \qquad (10)$$

where the $\varepsilon_{it}^{\mathrm{XA}}$ are ~ i.i.d. Gumbel with mode 0 and scale 1, the $\tilde{\omega}_{it}$ are distributed i.i.d. Normal with mean 0 and variance σ_ω^2, and $\mathbf{w}_{it}$ is a vector of researcher-observable angler and trip characteristics conditioning the relationship between $\varepsilon_{\mathrm{it}}^{\mathrm{XA}}$ and $\varepsilon_{\mathrm{it}}^{\mathrm{XP}}$. This characterization allows differences between the unobserved components of *ex ante* and retrospective utility to be articulated in two distinct ways. First, researcher-unobserved aspects of the retrospective decision process could contain additional variability that is independent of unobserved aspects of the *ex ante* decision process. This is captured by $\tilde{\omega}_{it}$. Such added variability could be the result of, among other things, aspects of realized trip utility not anticipated by the angler *ex ante*.

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[2] At first glance it may seem incorrect to cast a random variable as the expectation of another random variable. But it should be remembered that $\varepsilon_{it}^{\mathrm{XA}}$ is observed by the angler but not by the analyst – that is, it is **not** random from the perspective of the angler. Thus, the statement $\varepsilon_{it}^{\mathrm{XA}} = E_t\left[\varepsilon_{it}^{\mathrm{XP}}\right]$ merely recognizes that from the perspective of the angler, $\varepsilon_{it}^{\mathrm{XP}}$ is not observed when the trip decision is made.

Conversely, it could be interpreted as "randomness" or cognitive dissonance present in the retrospective choice process, which Hanemann (1982, 1983) has suggested is part of human decision-making.

Second, the conditioning term $\mathrm{g}(\mathbf{w}_{it}|\boldsymbol{\theta})$ serves to rescale the retrospective linked component. Specifically, $\mathrm{g}(\mathbf{w}_{it}|\boldsymbol{\theta})$ is analogous (but not identical) to the ratio of MNL model scale parameters used in recent work to explain differences between RP and SP choices (Swait and Louviere, 1993; Adamowicz *et al.*, 1994; Adamowicz *et al.*, 1997; Hensher, Louviere and Swait, 1999; Swait and Bernardino, 2000).

Using this formulation, the covariance between *ex ante* and retrospective unobserved components of utility is

$$\sigma_{\varepsilon^{XA}\varepsilon^{XP}} = \mathrm{g}(\bar{\mathbf{z}}_{it}|\boldsymbol{\theta})\cdot\sigma_{\varepsilon}^{2}, \tag{11}$$

and the correlation coefficient is,

$$\rho_{\varepsilon^{XA}\varepsilon^{XP}} = \frac{\mathrm{g}(\bar{\mathbf{z}}_{it}|\boldsymbol{\theta})\cdot\sigma_{\varepsilon}}{\left(\left(\mathrm{g}(\bar{\mathbf{z}}_{it}|\boldsymbol{\theta})\cdot\sigma_{\varepsilon}\right)^{2}+\sigma_{\omega}^{2}\right)^{1/2}}. \tag{12}$$

Expression (12) is straightforward: the greater the level of unlinked variability present in the retrospective trip valuation ($\sigma_{\omega}^{2} \to \infty$), the weaker the connection between unobserved aspects of the RP and SP decisions ($\rho_{\varepsilon^{XA}\varepsilon^{XP}} \to 0$, which is analogous to the case that McConnell *et al.* (1999) terms "transient" preferences). The lower the level of unlinked variability present ($\sigma_{\omega}^{2} \to 0$), the stronger the connection between unobserved aspects of the RP and SP decisions ($\rho_{\varepsilon^{XA}\varepsilon^{XP}} \to 1$, which is analogous to the case that McConnell *et al* terms "permanent" preferences).

Form of the Likelihood Function Used in Estimation

Anglers were not asked CV questions for sites other than Lake Michigan, and so the probabilities for no trip and for a trip to a site not on Lake Michigan take standard multinomial logit forms,

$$P\left(Trip_t = 0\right) \quad = \quad \frac{1}{1 + \sum_{j \in C} e^{V_{jt}^{\mathrm{XA}}}}, \tag{13}$$

$$P\left(Trip_t = i \,\middle|\, i \in C^{Other}\right) \quad = \quad \frac{e^{V_{it}^{\mathrm{XA}}}}{1 + \sum_{j \in C} e^{V_{jt}^{\mathrm{XA}}}}, \tag{14}$$

where C^{Other} is the choice set of fishing alternatives other than Lake Michigan sites. The general form of the log-likelihood function for the sample of *N* anglers over all *T* choice occasions in the season is

$$\ln L\left(\boldsymbol{\gamma}, \tilde{\boldsymbol{\gamma}}, \boldsymbol{\theta}, \sigma_{\omega}^2\right) \quad = \quad \sum_{n=1}^{N} \sum_{t=1}^{T} \left[\begin{array}{l} \left(1 - \sum_{i} d_{nit}\right) \cdot \ln P\left(Trip_{nt} = 0\right) \\ + \sum_{i \in C_n^{LMich}} d_{nit} \cdot \ln P\left(Trip_{nt} = i, CV_{nt}^1, CV_{nt}^2\right) \\ + \sum_{i \in C_n^{Other}} d_{nit} \cdot \ln P\left(Trip_{nt} = i\right) \end{array} \right], \tag{15}$$

where C_n^{LMich} is angler *n*'s choice set of Lake Michigan sites (so that $C_n = C_n^{LMich} \cup C_n^{Other}$), and d_{nit} is an indicator variable equal to 1 if angler *n* takes a trip to site *i* on choice occasion *t,* and 0 otherwise. Analytical forms for the joint choice probabilities (6)-(9) are quite extensive and complex, and are not presented here; they are in an appendix available from the authors.

III. Application of the Model

We estimate a repeated choice model in which anglers make a daily decision to either not fish, or fish at one of several sites. Study participants were randomly drawn from the list of Wisconsin residents who had purchased a Great Lakes trout and salmon stamp as of May 15, 1999. Trip-specific data for the study was collected via a telephone survey that tracked the recreational fishing trips taken by participants from June 1st to October 15th, 1999. Questions included site location, itemized expenses, travel time, type of fishing, and fish catch.[3] Data on the demographic characteristics of participants, their years of experience fishing and 1998-1999 purchases of fishing and boating equipment were collected via mail survey sent after the telephone interviews were completed. Of a starting sample of 440 anglers, 255 participants completed all phone interviews and the mail survey, for a response rate of 59%. A sub-sample of 140 angers was selected for the empirical work. This sub-sample consisted of all anglers who recalled all trip dates, took at least one daytrip during the season, and took at least one trip between June 15 and September 24, 1999 – the part of the season for which reasonable Lake Michigan catch rates could be derived. The data set used for the analysis thus consists of 14,280 choice occasions (140 anglers x 106 days).

Table 1 below presents the characteristics of this sub-sample. The group took, on average, 4.48 daytrips between June 15 and September 24, 1999, with these divided almost equally between inland/Lake Superior trips and Lake Michigan trips.

[3] To meet the combined goals of i) minimizing respondent burden while maximizing trip information collected and ii) meeting survey budget limits, detailed trip information was collected for only the four most recent trips since the last telephone call, with priority placed on Lake Michigan trips. Specifically, respondents were asked about 1) all Lake Michigan trips first, then 2) all trips to inland sites, then 3) all Lake Superior trips, and finally 4) all trips to other locations. For trips other than the four most recent, respondents were only asked the trip date, the general location of the trip (Lake Michigan, Lake Superior, an inland site or another location), the specific location for Lake Michigan trips, and whether the respondent left from and returned home on the same day.

Table 1: Angler Characteristics (N = 140).

Variable	Mean	Std Dev	Min.	Max
Age	46.30	12.89	19	73
Years of experience fishing the Great Lakes	16.94	14.03	0	65
Years of experience fishing inland locations	28.36	16.04	0	65
Level of Education *(1 = Less than highschool, 2 = high school graduate, 3 = some college or technical school, 4 = technical or trade school, 5 = college graduate, 6 = advanced degree).*	3.59	1.37	1	6
Works full-time? *(1 = yes, 0 = no)*	0.71	0.46	0	1
Annual Income *(1 = under 10,000, 2 = 10,000-19,999, 3 = 20,000-29,999, 4 = 30,000-39,999, 5 = 40,000-49,999, 6 =50,000-59,999, 7 = 60,000-69,999, 8 = 70,000-79,999, 9 = 80,000-89,999*	6.00	2.18	2	10
Total number of day trips between June 15 and September 24, 1999.	4.48	4.19	1	23
Number of trips to inland sites or Lake Superior.	2.19	3.24	0	23
Number of trips to Lake Michigan.	2.29	3.66	0	18
Number of trips to "North" Lake Michigan.*	1.24	2.95	0	18
Number of trips to "Central" Lake Michigan.	0.64	1.88	0	15
Number of trips to "South" Lake Michigan.	0.41	2.02	0	16

* "North" Lake Michigan encompasses all locations north of and including Sheboygan. "Central" Lake Michigan encompasses all locations between and including South Milwaukee and Port Washington. "South" Lake Michigan encompasses all locations south of and including Racine.

Wisconsin's tremendous freshwater resources – including 487 miles of Lake Michigan shoreline and more than 15,000 inland lakes – made it impractical to define narrowly a fishing site. In the estimated model the choice set contains three aggregated Lake Michigan sites and a single, representative, non-Lake Michigan fishing alternative. The Lake Michigan sites partition the Wisconsin shoreline into 1) North, consisting of all locations including and north of Sheboygan, 2) Central, consisting of all sites between and including Port Washington and Milwaukee, and 3) South, consisting of all sites including and south of Racine. This partition is based on distance and highway accessibility, and informed by the trip behavior observed in the sample. It is constructed to capture location-specific differences in catch rates that, along with distance, are hypothesized to affect trip decisions. Creel data for inland sites and Lake Superior was unavailable or insufficiently detailed to differentiate these locations by attributes other than travel cost and weather (which varied little across regions during the time period examined). Thus, given the available information, a single representative alternative – modeled as the closest of the observed choices for each angler – is used as an approximation of the trade-off between Lake Michigan and non-Lake Michigan fishing,

The model is applied to explain single-day recreational fishing trips, since such trips are more comparable across anglers and choice occasions than overnight and multi-day trips.[4] Table 2 lists the variables that comprise angler attributes $\mathbf{z}_t$ and site/trip attributes $\mathbf{x}_{it}$. Angler attributes include two dummy variables indicating whether, as of June 1999, an angler had purchased or applied for other non- hunting/trapping/fishing permits (*lic_oth1*), such as a state parks permit, or other hunting/trapping/fishing (*lic_oth2*) permits, such as a hunting license. These two variables are included as proxies representing discrete differences in underlying preferences for outdoor recreational activities in general. To account for time constraints affecting trip decisions, $\mathbf{z}_t$ includes dummy variables indicating whether the angler works fulltime (*fulltime*) and if the day in question was a workday ($workday_t$) for the angler.

Included in the vector of site/trip attributes are different intercepts for Lake Michigan and non-Lake Michigan trips to capture systematic differences in the characteristics of the fishing trips at these types of sites, and to account for the lack of a catch variable for the non-Lake-Michigan alternative. Similar to Provencher and Bishop (1997), a variable is included that measures the number of days that have elapsed since the last daytrip ($triplag_t$).[5] In the context of

[4] Our sample took 117 multi-day trips The average length of such trips in the sample was just under 4 days, and more than half of the trips with listed locations were to counties in Wisconsin that had at least a third of their housing units in 1990 classifiable as recreational (Marcouiller *et al*, 1996). This suggests that the majority of these trips were for multiple recreational activities in addition to fishing.

[5] If no trips were recorded for an angler before June 15, then $triplag_t$ was set to 30 for June 15, the first day of the period analyzed.

the current analysis, this variable is added to pick up dynamic aspects of trip utility not captured in the static representation of the trip decision embodied in the model.

Two variables in $\mathbf{x}_{it}$ require some discussion. Trip cost ($cost_{it}$) is defined as total variable trip expenditures reported by anglers in the telephone interview, which consist of expenditures for gas for the car, boat oil and fuel, daily ramp or launch fees, food and beverages, bait, charter boat fees, guided trip fees, contest or derby fees and other expenditures not including lures and fishing equipment. Expected trip cost, e_cost_i, is the estimated angler-specific seasonal average trip cost for site *i*. For Lake Michigan trips, this was calculated using the average of the observed round-trip travel times to each site. For non-Lake Michigan trips, this was calculated using observed travel time to the closest of the observed choices. If an angler never visited a particular Lake Michigan site, travel time was calculated to the closest major city for the angler within the "site." This was done using Microsoft Streets and Trips©, based on Microsoft MapPoint© Technology, which maps the shortest route in terms of travel time and accounts for average daily congestion. If an angler made no inland or Lake Superior trips, expected cost was calculated using angler-specific average cost per unit time multiplied by the travel time to a hypothetical "proximate" non-Lake Michigan alternative. This was constructed as the average – across the sub-sample of anglers who took non-Lake Michigan trips – of the closest observed non-Lake Michigan choices.

Trip catch ($catch_{it}$) is defined as the combined catch *per person* (rather than per boat) of trout and salmon species. A common practice in the analysis of recreational fishing is to use some measure of site-wide average catch as the expected catch for a trip (Provencher and Bishop, 1997; Adamowicz, Louviere and Williams, 1994; Chen *et al*, 1999; Chen and Coslett, 1998; Morey *et al*, 1993). For our analysis, the expected catch for a Lake Michigan site

(e_catch_{it}) is the predicted value from a seemingly unrelated regression model that explains each site's 12-day moving average of site-wide catch per person with the lagged catch rates of the other sites. The model was developed to approximate both spatial and intertemporal relationships among the catch rates of the three sites and to account for linked unobserved factors that affect the catch rates of all sites.

Table 2: Constant Site and Trip Attributes and Angler Characteristics Used in Estimation.

Variable	Description
Constant Site or Trip Attributes ($\mathbf{x}_{it}$)	
Inland_d	Inland/Lake Superior site intercept.
Lmich_d	Lake Michigan site intercept.
$Temp_{it}$	Average daily temperature (degrees Fahrenheit) at site *i* on day *t*.
$Wind_{it}$	The maximum wind speed at site *i* on day *t* (0.1 Knots).
Fog_{it}	Dummy variable indicating if there was fog or thunderstorms at site *i* on day *t*. *(1 = yes, 0 = no)*
$Weekend_{t}$	Dummy variable indicating if day *t* is a Saturday or Sunday. *(1 = yes, 0 = no)*
Angler Characteristics ($\mathbf{z}_{it}$)	
Age	Age
Glyrs	Years of experience fishing the Great Lakes.
Lic_oth1	Dummy variable indicating if the angler had purchased or applied for other non-hunting/fishing permits or stamps as of June, 1999. *(1 = yes, 0 = no)*
Lic_oth2	Dummy vairable indicating if the angler had purchased other hunting/fishing permits or stamps as of June, 1999? *(1 = yes, 0 = no)*
Fulltime	Dummy variable, indicating if the angler works full-time. *(1 = yes, 0 = no)*
$Workday_{t}$	Dummy variable indicating if day *t is* a workday for the angler. *(1 = yes, 0 = no)*
$Triplag_{t}$	Number of days that have elapsed since the last trip *(set to 30 for the first trip of the season)*.
Trip Catch & Cost	
$cost_{it}$	Observed variable trip cost to site *i* on day *t*, defined as total expenditures for gas for the car, boat oil and fuel, daily ramp or launch fees, food and beverages, bait, charter boat fees, guided trip fees, contest or derby fees and other expenditures not including lures and fishing equipment.
e_cost_{i}	Proxy for angler-specific average cost for trips to site *i.*
$catch_{it}$	Observed catch per person of Steelhead, Chinook and Coho Salmon and Brown Trout at site *i* on day *t*.
e_catch_{it}	Proxy for site-wide average catch per person of Steelhead, Chinook and Coho Salmon and Brown Trout at site *i* on day t.

Results and Hypothesis Tests

Table 3 presents the results for three models, all estimated via maximum likelihood using Gauss's Maxlik module with numerical integration and gradients. In the first model, $\theta = 0$, which, recalling that the unobserved component of retrospective utility takes the form $\theta \cdot \varepsilon_{it} + \tilde{\omega}_{it}$, assumes that *ex ante* and retrospective utility have unobserved components that are independently distributed. The second model assumes that *ex ante* and retrospective random utility share a common unobserved component that behaves identically between the *ex ante* and retrospective decisions, so that $\theta = 1$. The unrestricted model includes θ in the set of parameters estimated. Overall, parameter estimates for the systematic component of utility were, in most cases, of the expected signs and highly significant. Where necessary, the parameter on catch was restricted to have a log-Normal distribution, and so parameter values reported are from bootstrapping.[6] It is only significant in the unrestricted model. The Lake Michigan and the inland/Lake Superior fixed effects were both negative and significant. They are negative because they are relative to the alternative not to fish, which was chosen in the vast majority of choice occasions in the sample. That the Inland/Lake Superior effect is the smaller of the two in magnitude, despite observed trips being roughly equal between the two types of alternatives, is likely because it is also picking up the unobserved (positive) effect of catch, a variable not included in inland/Lake Superior random utility.

[6] The parameter σ_{ω} was restricted in all cases to have a log-Normal distribution.

Table 3: Model Results

Parameters		No Linkages (θ = 0)			No Cognitive Effects (θ = 1)			θ Unrestricted		
		Estimate		Std. Error	Estimate		Std. Error	Estimate		Std. Error
Constant Trip Characteristics	*Lake Mich. Intercept*	-5.9233	***	0.3334	-6.6062	***	0.3313	-3.2937	***	0.4593
	Inland/L. Sup. Intercept	-2.0854	***	0.3382	-2.8321	***	0.3346	-2.0850	***	0.4626
	Temp	0.0076		0.0039	0.0134	***	0.0040	0.0012		0.0059
	Wind	-0.0608	***	0.0083	-0.0307	**	0.0102	-0.0996	***	0.0158
	Fog	-0.2132	*	0.0841	-0.1559		0.0921	-0.3035		0.1578
	Weekend	0.5098	***	0.0883	0.5382	***	0.0896	0.5914	***	0.1004
Angler Characteristics	*Age*	-0.0176	***	0.0036	-0.0113	**	0.0036	-0.0151	***	0.0041
	Glyrs	0.0124	***	0.0026	0.0083	**	0.0026	0.0121	***	0.0031
	Lic_oth1	-0.4660	**	0.1495	-0.1729		0.1203	-0.4501	*	0.1887
	Lic_oth2	0.0899		0.0772	-0.0967		0.0889	0.0144		0.0984
	Fulltime	-0.2391	*	0.0966	-0.2093	*	0.0985	-0.2524	*	0.1114
	Worktime	-0.2880	***	0.0873	-0.3167	***	0.0911	-0.3187	**	0.1099
	Triplag	-0.0199	***	0.0018	-0.0252	***	0.0020	-0.0278	***	0.0023
Cost and Catch	*Cost*	-0.0014	*	0.0006	-0.0008	*	0.0004	-0.0013	**	0.0004
	Catch [a]	0.0914		0.0130	0.0266		0.0136	0.0471	***	0.1150
Un-observed Utility	σ_{ω} [b]	10.2276	***	0.9710	0.0587	***	0.0320	0.1062	***	0.0260
	θ	0		--	1		--	1.5164	***	0.1360
Log-Likelihood Value		-6143.66			-6051.22			-5573.04		
Likelihood Ratio *(Result)*		1141.24 *(H_0: θ = 0 rejected)*			956.36 *(H_0: θ = 1 Rejected)*			--		
Estimated Correlation of Unobserved Components		0.000			0.999			0.997		

* Significant at the 5% level (two-tailed test). ** Significant at the 1% level. *** Significant at the 0.1% level.

a Catch was restricted to be non-negative via a lognormal distribution for (θ = 0) and (θ unrestricted), and so for these cases its mean and std. error are bootstrapped, and significance levels are with regard to the underlying parameter.

b Sigma is restricted to be non-negative via the log-normal distribution, and so its mean and variance are bootstrapped and significance levels are with regard to the underlying parameter.

Two sets of results are of particular interest. First, the marginal value of an additional salmonid caught per angler varies significantly across models, from a maximum of \$65 in the model with no linkages between unobserved components of utility (θ = 0), to around \$33 in the model with no cognitive effects (θ = 1) and \$36 in the unrestricted model. Second, both the hypothesis of no link between the unobserved components of *ex ante* and retrospective utility

(H_{01}: θ = 0), and the hypothesis that unobservable utility ex ante is the expected value of unobservable utility ex post (and H_{02}: θ = 1), are rejected. The point estimate of θ is highly significant in the unrestricted model and equal to 1.52. This suggests, among other things, that valuations implicit in the retrospective responses are systematically larger than those implied by *ex ante* trip decisions. In monetary terms, *ceteris paribus*, these results indicate that the expected valuations implicit in retrospective decisions are, on average, almost $229 larger than those implicit in trip decisions.[7]

Alternative Models

This section examines two different extensions of the above model. The first makes θ a function of cognitive and cost-related variables, $g(\bar{\mathbf{z}}_{it}|\boldsymbol{\theta})$. The second allows the catch parameter to vary between the systematic portions of *ex ante* and retrospective utility. The first extension characterizes $g(\bar{\mathbf{z}}_{it}|\boldsymbol{\theta})$ for chosen Lake Michigan site *i* on choice occasion *t* as,

$$g(\bar{\mathbf{z}}_{it}|\boldsymbol{\theta}) = \theta_0 + \theta_1 \cdot Glyrs + \theta_2 \cdot Callag_t + \theta_3 \cdot Travtime_{it} \qquad (16)$$

where *Glyrs* is respondent years of experience fishing on the Great Lakes, *Callag* is the number of days that have elapsed between trip date and respondent interview, and *Travtime* is the round-trip travel time to the site in question. *Glyrs* is included to examine the effects of fishing experience on the systematic difference found between *ex ante* and retrospective utility. Viewed in a Bayesian framework, one would expect that with increased fishing experience anglers update their priors regarding fishing trip outcomes, so that expected outcomes are on average closer to realized outcomes for more experienced anglers. Under such a scenario, *Glyrs* would

[7] This is the difference between the expected values of unobserved *ex ante* and retrospective random utility, divided by the marginal utility of income.

reduce differences between *ex ante* and retrospective utility captured in $g\left(\overline{\mathbf{z}}_{it} \middle| \boldsymbol{\theta}\right)$. *Callag* is included as an imperfect measure of anglers' ability to recall trip details, to test whether memory has an effect on differences in valuations. Since time costs were not included in the trip costs for the SP questions, it is possible that anglers fail to adequately consider such costs when answering questions of whether the trip was "worth the cost." As such, *Travtime* is included as a proxy for time costs, to test whether or not anglers are cognizant of these costs when responding to the CV questions.

Table 4 below presents model results for the model with θ as a constant, and with θ as a function of cognitive and time cost variables. In the new model the marginal value of fish catch per person is lower, at around $29, than for any other specification. The results indicate that experience, recall and time costs indeed play a role in, but do not entirely remove, the "wedge" between *ex ante* and retrospective trip utility. The variables *Glyrs* and *Callag* are highly significant. Furthermore, the parameter values in the systematic component of utility are significantly smaller – in money-metric terms – in the $\theta \equiv g\left(\overline{\mathbf{z}}_{it} \middle| \boldsymbol{\theta}\right)$ specification. Overall, the results indicated that, at trip-weighted averages of *Glyrs, Callag* and *Travtime*, trip valuations implicit in retrospective choices are, on average, around $124 larger than those implied by the trip decisions. However, this overlooks a significant degree of variability implied by the parameter estimates.

Table 4: Examining the Effects of Experience, Memory and Time Costs on Differences Between *Ex Ante* and Retrospective Random Utility.

Parameters		θ Constant			$\theta = f$(Cognitive Effects, Time Cost)		
		Estimate		Std. Error	Estimate		Std. Error
Constant Trip Characteristics	Lake Mich. Intercept	-3.2937	***	0.4593	-3.2422	***	0.4298
	Inland Intercept	-2.0850	***	0.4626	-2.1149	***	0.4317
	Temp	0.0012		0.0059	0.0008		0.0053
	Wind	-0.0996	***	0.0158	-0.0975	***	0.0158
	Fog	-0.3035		0.1578	-0.2792		0.1555
	Weekend	0.5914	***	0.1004	0.6051	***	0.1002
Angler Characteristics	Age	-0.0151	***	0.0041	-0.0155	***	0.0041
	Glyrs	0.0121	***	0.0031	0.0133	***	0.0031
	Lic_oth1	-0.4501	*	0.1887	-0.5189	*	0.2025
	Lic_oth2	0.0144		0.0984	0.0413		0.0959
	Fulltime	-0.2524	*	0.1114	-0.2457	*	0.1114
	Worktime	-0.3187	**	0.1099	-0.3083	**	0.1077
	Triplag	-0.0278	***	0.0023	-0.0273	***	0.0022
Cost and Catch	Cost	-0.0013	***	0.0004	-0.0019	***	0.0004
	Catch [a]	0.0471	***	0.1151	0.0549	***	0.0105
Unobserved Utility	σ_ω [b]	0.1062	***	0.0260	0.1346	***	0.2510
	θ_0 *(Constant)*	1.5164	***	0.1360	1.3458	***	0.0939
	θ_1 *(Glyrs)*	--		--	0.0090	***	0.0022
	θ_2 *(Callag)*	--		--	-0.0047	***	0.0015
	θ_3 *(Travtime)*	--		--	-0.0007		0.0005
Log-Likelihood Value		-5573.04			-5566.89		

* Significant at the 5% level (two-tailed test). ** Significant at the 1% level. *** Significant at the 0.1% level.

a Catch was restricted to be non-negative via a lognormal distribution, and so its mean and std. error are bootstrapped, and significance levels are with regard to the underlying parameter.

b Sigma is restricted to be non-negative via the log-normal distribution, and so its mean and variance are bootstrapped and significance levels are with regard to the underlying parameter.

Regarding the individual components of $g(\bar{\mathbf{z}}_{it}|\boldsymbol{\theta})$, the fixed effect (i.e. θ_0), by itself, represents an expected difference between retrospective and *ex ante* random utility of almost

$105.[8] Suggesting that anglers are cognizant of time costs, the effect on *Travtime* is negative, and indicates that retrospective trip utility is reduced by $0.37 per minute of round-trip travel time, or by around $21 for an average trip. The positive sign on *Glyrs* indicates that each year of Great Lakes fishing experience increases average retrospective utility by $2.73, or by about $48 for the average angler in the sample. The negative sign on *Callag* indicates that each day elapsed between the trip and the interview about the trip reduces retrospective utility by $1.42.

Another possible explanation of the estimated divergence between *ex ante* and *ex post* valuations estimated by the model is that it is picking up bias associated with the misspecification of the *ex ante* expected catch variable. To test for this, the parameter catch is allowed to vary between *ex ante* and retrospective random utility, where the effects of such misspecification would most directly manifest itself. In this new model, the ex ante coefficient on expected catch is 0.1250 (with a standard error of 1.748), and is insignificant. The retrospective coefficient is 0.076 (with a standard error of 0.021), and is significant at the 1% level; all other parameters are very close to their values in the restricted model. The log-likelihood values of the unrestricted and restricted models are –5557.65 and –5566.89, respectively, and so the restricted model is rejected. This result is consistent with the perspective that the researcher-constructed value for angler expectations of catch, e_catch_{it}, is not adequately capturing how anglers evaluate fish catch in their *ex ante* decisions, and that augmenting SP data with RP responses can help to identify preferences for important environmental variables in the analysis. In the present case, examining how actual catch affects retrospective trip evaluations helps to inform estimation of preferences for catch.

[8] This is calculated as $(\theta_0 - 1) \times \eta \div \gamma_{income}$, where η is the Euler constant ($\approx$ 0.577).

IV. Welfare Results: Seasonal Value of Lake Michigan Fishing

The measure of an angler's WTP for Lake Michigan fishing trips on a given day is the amount of money that will make the angler indifferent between going fishing at his or her most preferred Lake Michigan site of that day and not being able to fish at any Lake Michigan site. Let C^h, $h \in \{0,1\}$, denote the relevant choice sets for a welfare analysis of Lake Michigan fishing, where C^0 contains all choices and C^1 excludes Lake Michigan sites. To construct a measure of expected WTP based on the *ex ante* valuations of trips, model expressions of *ex ante* random utility and of the unobserved component presented above are used to derive the following expression of the maximum utility on choice occasion *t* given choice set C^h, $h \in \{0,1\}$,

$$\begin{aligned} \mathrm{U}_t^{\max h} &= \max_{i \in C^h}\left(V_{it}^{XA} + \varepsilon_{it}\right) \\ &= V_t^{XAh} + \eta_t^{XAh} \end{aligned}$$

where $V_t^{XAh} = \ln\left(\sum_{i \in C^h} e^{V_{it}^{XA}}\right)$ and η_t^{XAh} is a Gumbel – distributed random variable with mode 0 and scale 1. The value of Lake Michigan fishing on day *t* is then

$$\frac{V_t^{XA0} - V_t^{XA1}}{\gamma_{income}}. \tag{17}$$

Seasonal welfare estimates are merely the sum of V_t^{XAh} across all trip occasions, but must be simulated to reflect that the variable $Triplag_t$ depends on past trip decisions. Letting *R* denote the number of iterations in the simulation, and indexing the expression (19) with *r* to indicate the WTP calculation on day *t* of iteration *r*, the expected seasonal WTP for Lake Michigan for a given angler is

$$\frac{1}{R}\sum_R\sum_T\left[\frac{V_t^{XA0} - V_t^{XA1}}{\gamma_{income}}\right]_r . \tag{18}$$

Table 5 presents estimates of expected seasonal WTP per angler for Lake Michigan fishing based on *R*=1000 for each of the anglers in the study, where each draw involved a T-length draw from the random component of utility; note, then, that these estimates of seasonal WTP are conditional on the point estimates of model parameters. Point estimates of the seasonal value of Lake Michigan fishing ranges from a low of $210 for the model in which retrospective valuations are treated as conditionally independent of the trip decision, to $1368 for the model in which the unobserved component of the retrospective valuation is a linear function of the unobserved component of trip utility.

Table 5: Estimated Seasonal WTP per Angler for Lake Michigan Fishing

Characterization of θ	*2.5% Quantile*		**Mean**		*97.5% Quantile*
Model 1: $\theta = 0$	*$77.89*	<	**$209.86**	<	*$380.83*
Model 2 :$\theta = 1$	*$165.28*	<	**$362.71**	<	*$631.00*
Model 3: θ *Unrestricted, Constant*	*$413.82*	<	**$1,367.58**	<	*$2,564.25*
Model 4: θ = *f(Cognitive Effects, Time Costs)*	*$258.70*	<	**$983.66**	<	*$1,935.27*

V. Conclusions

The current analysis finds evidence of a systematic wedge between the valuations implicit in trip decisions, made before observing trip outcomes, and the retrospective evaluations of those outcomes. Furthermore, proxies for cognitive phenomenon such as memory and experience do not fully explain this wedge, nor apparently do underlying differences between ex ante and retrospective preferences over catch.

This work suggests that an individual's valuation of environmental goods and services can vary significantly depending on the context and timing of the observed choice or elicited response. As such, it raises the question of what constitutes the "correct" estimate of willingness-to-pay in particular settings. For several good reasons economists are predisposed to favor welfare estimates based on revealed preference data, and in the welfare analysis above we proceed from this perspective; we allow trip retrospectives to contribute to the identification of utility parameters (under different error specifications), but we hew to the standard model that welfare is best revealed by actual behavior.

But it assumes too much to claim, as revealed preference models implicitly do, that in their decisions over recreational activities individuals adequately consider the stream of *ex post* benefits they obtain from such goods and services. That individuals often bring cameras on leisure trips is evidence of the existence of such benefits, but surely is not evidence that individuals *correctly* consider these benefits at the time of the trip decision. Retrospective surveys present the opportunity to explore the magnitude of such benefits, and to examine whether and to what extent these benefits influence the trip decision. More fundamentally, of course, retrospective surveys can help in the identification of economic models of behavior.

In this study, the retrospective valuation of Lake Michigan fishing is higher than indicated by revealed preference data alone. Possibly this an artifact of the research and survey design. For instance, perhaps the wedge between ex ante and retrospective valuations of trips would have been much smaller if, before asking the contingent valuation questions, the survey instrument were to remind respondents of the opportunity cost of their time by querying them about how they would have spent their time were they to have chosen not to take a trip. Such refinements are of course the province of future research. But it seems entirely plausible that the wedge is something "real", reflecting a real failure of individuals to fully account for the *ex post* benefits of a trip in their trip decision-making, with attendant (and confounding) implications for welfare analysis: if cognitive elements cause systematic differences in *ex ante* and *ex post* trip valuations, which valuation is correct for welfare analysis?

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