CONTINGENT VALUATION AND REVEALED PREFERENCE METHODOLOGIES: COMPARING THE ESTIMATES FOR QUASI-PUBLIC GOODS

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ABSTRACT

A literature search provides 83 studies from which 616 comparisons of contingent valuation (CV) to revealed preference (RP) estimates are made. Summary statistics of the CV/RP ratios are provided for the complete dataset, a 5% trimmed dataset, and a weighted dataset that gives equal weight to each study rather than each CV/RP comparison. For the complete dataset, the sample mean CV/RP ratio is 0.89 with a 95% confidence interval [0.81-0.96] and a median of 0.75. For the trimmed and weighted datasets, these summary statistics are (0.77; [0.74-0.81]; 0.75) and (0.92; [0.81-1.03]; 0.94), respectively. The Spearman rank correlation coefficients between the CV and RP estimates for the three datasets are 0.78, 0.88, and 0.92, respectively, with the Pearson correlations a bit larger. Non-parametric density estimates are provided, as well as the results of regressions of the observed CV/RP ratios on the basic RP technique used and the broad class of goods valued.

1. INTRODUCTION

Beginning with Knetsch and Davis (1966), the comparison of contingent valuation (CV) estimates for government-provided, quasi-public goods with estimates obtained from revealed preference (RP) techniques, such as travel cost analysis and hedonic pricing, has played a key role in assessing the validity and reliability of the contingent valuation method. In their assessment of the contingent valuation method twenty years later, Cummings, Brookshire and Schulze (1986) placed considerable emphasis on comparing estimates from eight studies that used both contingent valuation and revealed preference techniques for similar quasi-public goods.[1] The assemblage of studies in Cummings, Brookshire, and Schulze (1986) emphasized the shift away from treating revealed preference techniques as the "truth," toward the realization that revealed preference estimates are random variables which are sensitive to details such as commodity definition, the functional form used in estimation, and other technique-specific assumptions such as the value of time and the number of sites in a travel cost study. As a result of this shift, comparisons between contingent valuation and revealed preference estimates are generally assumed to represent tests of convergent validity rather than criterion validity.[2] Such comparisons can play a prominent role in discussions of whether there is a need to "calibrate" contingent valuation estimates up (Hoehn and Randall, 1987) or down (Diamond and Hausman,

[1]The eight studies Cummings, Brookshire, and Schulze (1986) considered were Knetsch and Davis (1966), Bishop and Heberlein (1979), Thayer (1981), Brookshire *et al.* (1982), Desvousges, Smith and McGivney (1983), Sellar, Stoll and Chavas (1985), Brookshire *et al.* (1985), and Cummings *et al.* (1986).

[2]Tests of criterion validity are possible when comparing an estimate from a technique to a value known to be the truth. Tests of convergent validity are possible when two or more measurement techniques are potentially capable of measuring the desired quantity, but both techniques do so with error. See Mitchell and Carson (1989) for a discussion.

forthcoming) and issues such as whether contingent valuation estimates systematically vary with the good being valued.

This paper seeks to summarize the available information and provide readers with the broadest possible overview of how CV estimates for quasi-public goods correspond with estimates based on revealed preference techniques. Through an extensive search of both the published and unpublished literature, we have located 83 studies that provide 616 comparisons of contingent valuation to revealed preference estimates.

2. STUDY INCLUSION CRITERIA

To help find studies that contain both CV and RP estimates, we systematically reviewed entries in the Carson *et al.* (1994) bibliography of over 1600 contingent valuation papers. To be eligible for inclusion in our sample, a study must provide at least one contingent valuation estimate and one revealed preference estimate for essentially the same quasi-public good; thus, no studies of private goods (*e.g.* Neill *et al.*, 1994) are included. The goods valued are various forms of recreation (mostly outdoor), changes in health risks, and changes in environmental amenities such as air pollution, noise pollution, water pollution, or parks. Consumers (individuals or households) had to have been interviewed to obtain contingent valuation estimates. Thus, we did not include studies where the respondents were not consumers such as Bohm's (1984) study of willingness to purchase statistical information by local governments. Furthermore, we considered only contingent valuation estimates of willingness to pay (WTP); we excluded estimates based on willingness to accept compensation or on contingent behavior responses.[3] Otherwise, we have tried to include all available study estimates.

[3]We do include CV estimates derived from willingness to drive questions if they were intended to be directly compared to a travel cost estimate. CV questions phrased in terms of willingness to give up other goods are not included. No comparisons between CV willingness to pay estimates and actual willingness to accept compensation (*e.g.*,

The studies we examined span almost thirty years, 1966-1994. The earliest study is Knetsch and Davis' (1966) well-known contingent valuation-travel cost comparison of outdoor recreation in Maine. The latest study considered is Choe, Whittington, and Donald (1994) who value the opening of a polluted urban beach in the Philippines.

Due to well-known, potential biases in relying upon only the published literature to summarize research findings, we have spent considerable effort searching the unpublished literature including theses, dissertations, conference papers, and government reports.[4] We have also drawn upon the rapidly growing non-market valuation literature from studies conducted outside the United States.[5]

Multiple estimates from a single study are provided when the study valued multiple goods. This is common, for instance, in situations where respondents were interviewed at several recreational fishing locations and travel cost and contingent valuation estimates were made for each location (*e.g.*, Duffield and Allen, 1988) or where different levels of a good were valued (*e.g.*, Shechter, 1992). Multiple estimates are also provided when a study used different analytical assumptions (*e.g.*, Smith, Desvousges, and Fisher, 1986) in making the CV and/or RP estimates. In such cases, we considered all of the possible comparisons between the CV and RP estimates for the good in question. Studies often show a clear preference for a particular

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Bishop and Heberlein, 1979) are used. However, our initial investigation suggested that CV/RP ratios in such comparisons are almost always substantially below 1.0.

[4]Berg (1994, p. 401) underscores this position based on his study of publication bias by noting "If the meta-analysis is restricted to published studies, then there is a risk that it will lead to biased conclusions. This is especially problematic in that one of the major advantages of meta-analysis is that the aggregation of data can lead to effect size estimates with very small variance, giving the impression of conclusiveness in circumstances where the summary estimate is biased. That is, the resulting inferences may not only be wrong but appear convincing."

[5]In addition to a sizeable number of non-U.S. studies available in English, we have also used several CV and RP comparisons from non-English language studies as summarized in Navrud (1992a).

estimate and provide a rationale for the choice. However, the choice of a particular estimate is subjective, and when facing the same choices, different researchers may undoubtedly make different choices. To maintain as neutral a position as possible, we considered all available comparisons made explicitly in the study or which are easily inferred.

The studies considered provide value estimates for a wide variety of quasi-public goods. We look at everything from the value of a recreational fishing day on the Blue Mesa Reservoir in Colorado to the value of a statistical life estimated from national occupational risk data. There is a substantial amount of variation between the goods considered, between the changes in the goods valued, and between the specific implementations of the valuation techniques used. There is also variation both across and within studies and in how closely the goods in different CV and RP comparisons actually match-up. This variation is both a strength and a weakness. It allows for an analysis that favors a "big-picture" view: if there is a strong signal that CV, as a general valuation approach, substantially under- or over- estimates quasi-public goods' values relative to revealed preference techniques, one is likely to see it in a sample as large as ours. Small effects and subtle interactions between particular types of goods and very specific aspects of valuation techniques used may, however, be missed.

We coded the revealed preference techniques used in the papers into five broad categories. The first of these is single site travel cost models (TC1). The second is multiple site travel cost models (TC2). The third is hedonic pricing (HP). The fourth is averting behavior (AVERT) which includes expenditure and household production function models not already included in TC2. The last category includes the creation of simulated or actual markets (ACTUAL) for the good. We excluded estimates from any technique which were not designed to capture net willingness to pay/consumer surplus such as actual trip expenditures. There are 295 TC1, 183 TC2, 62 HP, 28 AVERT, and 48 ACTUAL comparisons with CV estimates.

We have also coded the goods valued in the various studies into three broad classes. The first class, recreation (REC), includes studies that valued outdoor recreation such as sport fishing, hunting, and camping. The second class, environmental amenities (ENVAM), includes studies that valued changes in goods such as air and water quality. The third class, health risk (HEALTH), includes studies that valued small reductions in environmental or work-related health risks. There are 432 REC, 163 ENVAM and 21 HEALTH estimates. There is a considerable correspondence between the general class of good being valued and the RP technique used. This is particularly true of outdoor recreation where single (TC1) and multiple (TC2) site travel cost models are generally used.

3. COMPARISON STUDIES CONSIDERED

Table 1 displays the comparison studies used in our meta analysis. Within the table, the studies are grouped into four categories based on their revealed preference methodology: TC1, TC2, HP, AVERT, and ACTUAL. Within each revealed preference methodology, the studies are organized chronologically. A short description of each of these studies can be found in the appendix to this paper.

Table 1. Comparison Studies

Author	Good Valued	Number of Comparisons	RP Technique
Knetsch & Davis (1966)	Outdoor recreation of a forest area in northern Maine	2	TC1
Beardsley (1971)	Recreation on Cache la Pandre River, Colorado	2	TC1
Shechter, Enis & Baron (1974)	Preservation of Israel's Mt. Carmel National Park from limestone quarry expansion	2	TC1

Author	Good Valued	Number of Comparisons	RP Technique
Bishop & Heberlein (1979)	Goose hunting in Wisconsin's Horicon Zone	3	TC1
Smith (1980)	Outdoor recreation at Cullahy Lake in Oregon	1	TC1
Thayer (1981)	Prevention of geothermal development in Santa Fe National Forest	6	TC1
Haspel & Johnson (1982)	The impact of proposed surface mining to be located near Utah's Bryce Canyon National Park	8	TC1
Johnson & Haspel (1983)	The impact of proposed surface mining to be located near Utah's Bryce Canyon National Park	2	TC1
Duffield (1984)	Kootenai Falls recreation in Montana	4	TC1
Bojõ (1985)	Preservation of a nature reserve in Vaalaa Valley, Sweden from forest harvesting	1	TC1
Michaelson & Smathers (1985)	Recreation usage of public campgrounds in the Sawtooth National Recreation Area	3	TC1
O'Neil (1985)	Recreation on the West Branch of the Penobscot River and the Saco River	16	TC1
Loomis, Sorg, & Donnelly (1986)	Cold-water fishing in Idaho	1	TC1
Smith, Desvousges, & Fisher (1986)	Water quality improvements in the Monongahela River basin in Western Pennsylvania	12	TC1
Farber & Costanza (1987)	Recreation at Terrebonne Parish wetland system in South Louisiana	3	TC1
Hanley & Common (1987)	Recreational in Queen Elizabeth Forest Park in Scotland	1	TC1
Adamowicz (1988)	Bighorn sheep hunting in Alberta, Canada	72	TC1
Duffield & Allen (1988)	Trout fishing on seventeen Montana rivers	17	TC1
McCollum, Bishop, & Welsh (1988)	Wisconsin Sandhill Deer hunting permits	42	TC1
Navrud (1988)	Freshwater fishing, River Vikedalselv, Norway	4	TC1
Ralston (1988)	Recreation at Reelfoot Lake, Tennessee	1	TC1
Schelbert *et al.* (1988)	Recreation in Zurichberg forest, Switzerland	1	TC1
Bockstael, McConnell, & Strand (1989)	Chesapeake Bay water quality improvement	2	TC1

Author	Good Valued	Number of Comparisons	RP Technique
Brown & Henry (1989)	Viewing of elephants on wildlife safari tours in Kenya	8	TC1
Hanley (1989)	Recreation in Queen Elizabeth Forest, Scotland	8	TC1
Harley & Hanley (1989)	Recreation at three U.K. nature reserves: Island of Handa, Loch Garten, and Blacktoft Sands	6	TC1
Huppert (1989)	Salmon and striped bass fishing in California	4	TC1
Johnson (1989)	Recreational fishing at Blue Mesa Reservoir and the Poudre River, Colorado	4	TC1
White (1989)	Recreation at Belmar Beach in New Jersey	24	TC1
Navrud (1990)	Salmon and sea trout fishing, River Audna, Norway	4	TC1
Rolfsen (1990)	Salmon and sea trout fishing in the Gaula River, Norway	2	TC1
Loomis, Creel, & Park (1991)	Deer hunting in California	2	TC1
Navrud (1991a)	Brown trout fishing, Lauvann and Gjerstadskog Lakes, Norway	8	TC1
Navrud (1991b)	Salmon and sea trout fishing, River Audna, Norway	4	TC1
Sievänen, Pouta, & Ovaskainen (1991)	Recreation at a regional recreational area near Helsinki	5	TC1
Mungatana & Navrud (1993)	Wildlife viewing in Lake Nakuru National Park in Kenya	6	TC1
Choe, Whittington, & Donald (1994)	Recreation at an urban beach which had been closed, Davao, Philippines	4	TC1
Binkley & Hanemann (1978)	Beach recreation in Boston	2	TC2
Vaughan & Russell (1982b)	National freshwater fishing	4	TC2
Desvousges, Smith, & McGivney (1983)	Water quality improvements in the Monongahela River basin in Western Pennsylvania	12	TC2
Harris (1983)	Recreational fishing in Colorado	8	TC2
Sutherland (1983)	Water-based recreation in the Pacific Northwest	10	TC2

Author	Good Valued	Number of Comparisons	RP Technique
ECO Northwest (1984)	Recreational fishing of three different sites in the Swan River drainage basin	12	TC2
Devlin (1985)	Recreation associated with firewood collection in Colorado National forests	2	TC2
Donnelly *et al.* (1985)	Steelhead fishing trips in Idaho	1	TC2
Sellar, Stoll, & Chavas (1985)	Recreational boating on four lakes in East Texas	10	TC2
Walsh, Sanders, & Loomis (1985)	Recreation on eleven Colorado rivers recommended for protection under the Wild and Scenic Rivers Act and on a second group of rivers in the state	4	TC2
Wegge, Hanemann, & Strand (1985)	Marine recreational fishing in Southern California	42	TC2
Loomis, Sorg, & Donnelly (1986)	Cold-water fishing in Idaho	2	TC2
Milon (1986)	Artificial reef in South Florida	15	TC2
Mitchell and Carson (1986)	Change in national amount of fishable quality water	1	TC2
Smith, Desvousges, & Fisher (1986)	Water quality improvements in the Monongahela River basin in Western Pennsylvania	24	TC2
Sorg & Nelson (1986)	Elk hunting in Idaho	4	TC2
Young *et al.* (1987)	Small game hunting in Idaho	4	TC2
Walsh, Ward, & Olienyk (1989)	Effect of tree density on recreational demand for six recreational sites in Colorado	8	TC2
Duffield & Neher (1990)	Deer hunting in Montana	1	TC2
Richards *et al.* (1990)	Recreation at national forest campgrounds in Northern Arizona	10	TC2
Walsh, Sanders, & McKean (1990)	Pleasure driving/sightseeing along eleven rivers in the Colorado Rocky Mountains	3	TC2
Willis & Garrod (1990)	Open-access recreation on inland waterways in the United Kingdom	2	TC2
Duffield (1992)	Sportfishing in South Central Alaska	2	TC2
Darling (1973)	Amenities at three urban lakes in California	6	HP

Author	Good Valued	Number of Comparisons	RP Technique
Loehman, Boldt, & Chaikin (1981)	Changes in air quality in Los Angeles and the San Francisco Bay	7	HP
Brookshire *et al.* (1982)	Improvements in Los Angeles air quality	11	HP
Blomquist (1984)	Lake and high-rise views, Chicago	14	HP
Gegax (1984)	Job-related risk reduction	1	HP
Brookshire *et al.* (1985)	Housing locations inside and outside Los Angeles County's special earthquake study zones	1	HP
Gegax, Gerking, & Schulze (1985)	Job-related risk reduction	2	HP
Blomquist (1988)	Lake and high-rise views, Chicago	4	HP
IADB (1988)	Three types of housing structures	6	HP
Pommerehne (1988)	Road and aircraft noise in Basle, Switzerland	2	HP
d'Arge & Shogren (1989)	Water quality in the Okoboji Lakes region of Iowa	3	HP
Randall & Kriesel (1990)	25 percent reductions in both air and water pollution in the United States	1	HP
Shechter (1992)	Air pollution in the Haifa area, Israel	4	HP
Eubanks & Brookshire (1981)	Elk hunting in Wyoming	3	AVERT
Hill (1988)	Reduction of risk of breast cancer mortality	12	AVERT
John, Walsh, & Moore (1992)	Mosquito abatement program, Jefferson County, Texas	1	AVERT
Shechter (1992)	Air pollution in the Haifa area, Israel	12	AVERT
Bohm (1972)	Public television program in Sweden	10	ACTUAL
Kealy, Dovidio, & Rockel (1986)	Preventing additional damages from acid rain to the Adirondack region's aquatic system	2	ACTUAL
Hoehn & Fishelson (1988)	Visibility levels at the Hancock Tower Observatory in Chicago	3	ACTUAL
Sinden (1988)	Soil and forest conservation in Australia	17	ACTUAL
Boyce *et al.* (1989)	Preventing destruction of a Norfolk pine tree	1	ACTUAL
Bishop & Heberlein (1990)	Wisconsin Sandhill Deer hunting permits	3	ACTUAL

Author	Good Valued	Number of Comparisons	RP Technique
Hoehn (1990)	Visibility levels at the Hancock Tower Observatory in Chicago	3	ACTUAL
Duffield & Patterson (1991)	Purchasing water rights for Big and Swamp Creeks in Montana	8	ACTUAL
Essenburg (1991)	Water system in Philippine village	1	ACTUAL

4. SUMMARIZING THE CV/RP RATIOS

Table 2 summarizes the CV/RP ratios treating the dataset in three different ways. The complete sample uses each individual CV/RP ratio as an observation. The trimmed sample uses the remaining data after trimming off the smallest 5% and largest 5% of the CV/RP ratios. The weighted sample uses the mean CV/RP ratio from each study as that study's observation.[6] This weighting scheme prevents studies with multiple comparisons from having a disproportionate influence relative to studies reporting only one or a small number of comparisons. For each of the three treatments, we have provided the mean, the standard error of the mean, the maximum and minimum observations, the median (the 50th percentile), a wide range of other percentiles of the sample distribution, and finally, the sample size.

For the complete sample the estimate of the mean CV/RP ratio is 0.890 with a 95% confidence interval [0.813-0.960] and a median ratio of 0.747. For the trimmed sample, the

[6]The differences between the estimates from this treatment of the data and the complete and trimmed samples are due largely to the weighting (using the mean of each study's ratios) which reduces the influence of studies that provide multiple estimates. Adamowicz (1988) accounts for 72 comparisons; Desvousges, Smith and McGivney (1983) combined with estimates from Smith, Desvousges, and Fisher (1986) account for 48 comparisons (both use the same data); McCollum, Bishop, and Welsh (1988) and Wegge, Hanemann, and Strand (1985) both account for 42 comparisons; and White (1989) accounts for 24 comparisons. Twelve other studies provide between 10 and 17 comparisons. Because we are considering ratios which are bounded below by zero and unbounded above, averaging is understandably sensitive to large ratios within studies.

estimate of the mean CV/RP ratio is 0.774 with a 95% confidence interval [0.736-0.811][7] and a median of 0.747. For the weighted sample the mean CV/RP ratio is 0.922 with a 95% confidence interval [0.811-1.034] and a median of 0.936.[8]

Figure 1 depicts a non-parametric density estimate of the complete sample using a simple kernel density estimator first proposed by Wegman (1972; see also Silverman, 1986 and Statistical Sciences, Inc., 1993) with a width parameter of 0.5. Almost all of the density falls below a CV/RP value of 2.0 with almost 70% of the mass to the left of a CV/RP ratio of 1.0. This figure also shows a fairly long, but very shallow, right tail that would be even longer (to just past 10) if we had not cut it off at 6, which is the first time the density estimate has a relative frequency of zero. Figure 2 depicts the non-parametric density estimate for the trimmed sample. Because the maximum CV/RP ratio is slightly greater than 2.0, one can see that almost all of the density lies to the left, of 1.5 with over 80% to the left of 1.25. Figure 3 depicts the nonparametric density estimate for the weighted sample. This figure shows a very pronounced peak at about 1.0, with over half the density to the left and a thicker, but much shorter, right tail than Figure 1.

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[7]Some of the most extreme CV/RP ratios come from a small number of studies and are subject to several qualifications: Smith, Desvousges, and Fisher (1986) (4 of the 10 largest ratios and 7 of the 10 smallest ratios) whose purpose was to pick assumptions which demonstrated how an analyst's judgement plays a very important role in the development of both CV and TC estimates; Shechter (1992) (2 of the largest 10 ratios) who used an RP estimate, which was one-tenth and one-twentieth the size of two other RP estimates for the same change, to compare with different CV estimates; Sellar, Stoll, and Chavas (1985) (2 of 10 smallest ratios) who obtained two negative net willingness to pay values; and the ECO Northwest study (1984) where the two CV estimates were 5 times higher than one of the two RP estimates, but one-half the size of the other RP estimate.

[8]An alternative weighting scheme which is more robust to large outliers and also avoids giving disproportionate influence to studies with multiple estimates is to use the median ratio from each study (rather than the mean). Doing this results in a N=83 dataset of CV/RP ratios with mean 0.820 with a 95% confidence interval [0.729-0.912] and a median of 0.858. There are also 7 pairs of studies which have substantial overlap in the data analyzed (*e.g.*, Desvousges, Smith, and McGivney, 1983; Smith, Desvousges, and Fisher, 1986). Treating these pairs as individual studies (N=76) results in only a small change in the summary statistics for the weighted sample (a mean CV/RP ratio of 0.936 with a 95% confidence interval of [0.819 - 1.052] and a median of 0.938).

TABLE 2
CV/RP ESTIMATES FOR THREE SAMPLE TREATMENTS

Percentile	Complete Sample	Trimmed Sample	Weighted Sample
Mean	0.886	0.774	0.922
Standard Error	0.038	0.019	0.057
Maximum	10.269	2.071	3.512
99%	5.584	1.948	3.512
95%	2.071	1.593	1.780
90%	1.524	1.345	1.447
80%	1.201	1.144	1.153
75%	1.122	1.090	1.111
70%	1.037	1.007	1.066
60%	0.908	0.886	0.990
50%	0.747	0.747	0.936
40%	0.610	0.624	0.809
30%	0.467	0.502	0.640
25%	0.376	0.432	0.585
20%	0.294	0.358	0.568
10%	0.094	0.132	0.349
5%	0.043	0.092	0.201
1%	0.011	0.063	0.079
Minimum	0.005	0.054	0.079
N	616	555	83

FIGURE 1
COMPLETE DATASET: NONPARAMETRIC DENSITY ESTIMATE

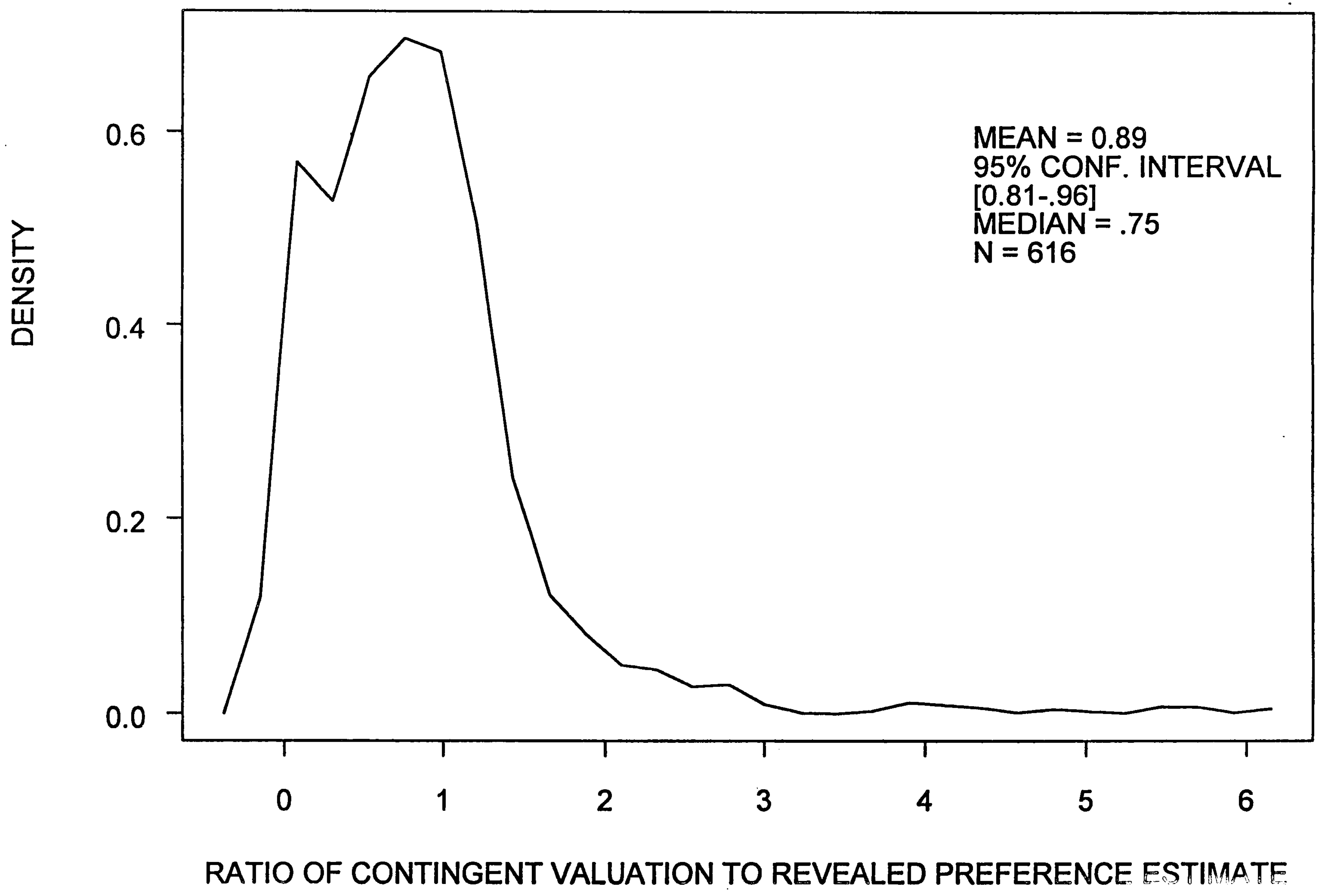


FIGURE 2
TRIMMED DATASET: NONPARAMETRIC DENSITY ESTIMATE

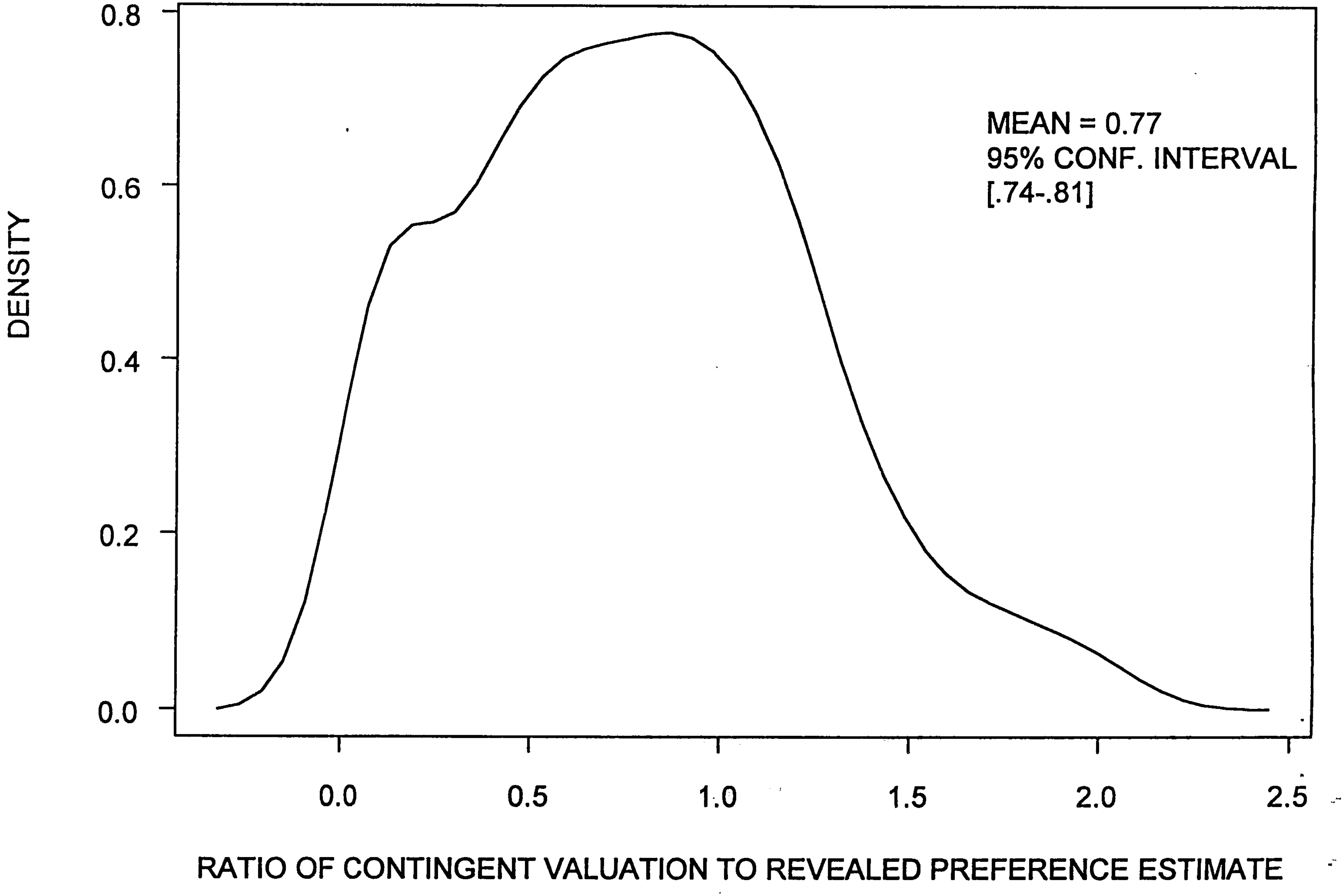
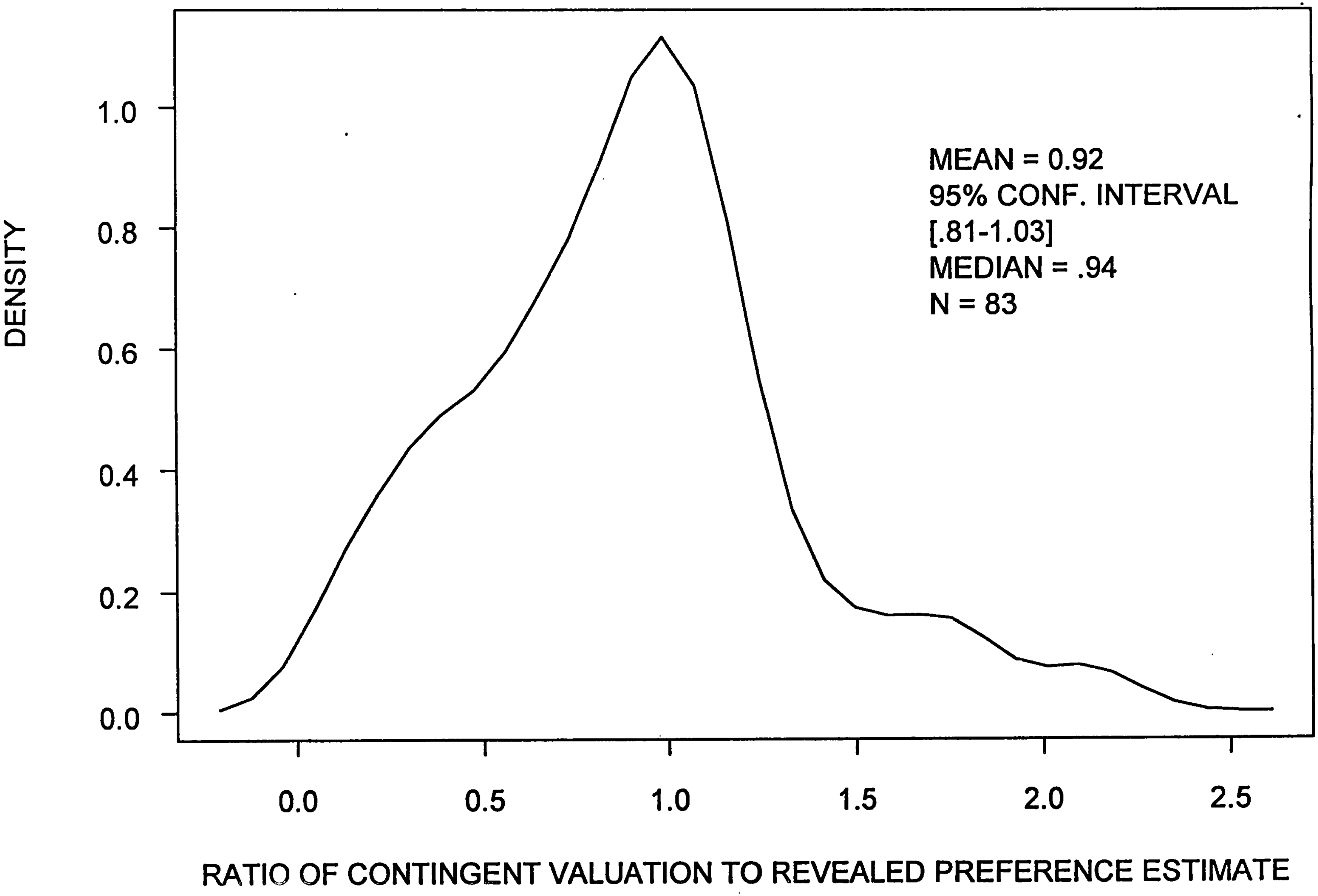


FIGURE 3
WEIGHTED DATASET: NONPARAMETRIC DENSITY ESTIMATE



The analysis provided is not invariant to whether the CV estimate is chosen as the numerator of the ratio (as above) or as the denominator. One could instead look at the ratio of the RP to CV estimates. For the complete dataset, one gets a mean value of 5.671 with a 95% confidence interval of [4.189-7.153] and a median estimate of 1.338. This estimate, which suggests that the RP estimates are on average over five times the CV estimates, is driven by the several large outliers noted earlier. Using the trimmed dataset, we estimate a smaller, but still large, mean RP/CV ratio of 2.626 with a 95% confidence interval [2.351-2.902]. For the weighted sample, the mean RP/CV ratio is 3.542 with a 95% confidence interval of [2.029-5.057] and a median of 1.416. Thus, looking at the RP/CV ratios suggests that RP estimates are on average considerably larger than their CV counterparts. Drawing a CV/RP comparison at random from any of the three datasets summarized in Table 2, there is almost a 70% chance of getting a CV/RP ratio less than 1.0. Very small CV/RP ratios imply very large RP/CV ratios.

We can also directly test whether the quantity (CV - RP) is different from zero. Doing so results in t-statistics of -7.31, -6.19, and -2.58, respectively, for the complete, trimmed, and weighted datasets. Non-parametric, signed rank tests even more strongly reject the null hypothesis of no difference in favor of the alternative that CV estimates are on average smaller than their RP counterparts.

5. VARIATION WITH RP TECHNIQUE AND CLASS OF GOOD

We regressed the CV/RP ratios from the trimmed dataset on a set of dummy variables representing the RP technique used with the single site travel cost models (TC1) as the omitted category. These results are shown in Table 3 with the t-statistics reported based on the White (1980) heteroskedasticity-consistent covariance matrix. They suggest the CV estimates run about

20% lower than the TC1 counterparts, about 30% lower than their TC2 counterparts, a little less than 40% lower than their HP counterparts, about 20% lower than their AVERT counterparts, and are, on average, indistinguishable from their ACTUAL counterparts.[9] We also regressed the CV/RP ratios from the trimmed dataset on a set of dummy variables for the broad class of goods valued. These results are shown in Table 4 with the t-statistics similarly calculated. They suggest that the HEALTH goods may have CV/RP ratios closer to 1.0 relative to the other two categories of goods, although this conclusion should be tempered by the smaller number of CV/RP estimates in the HEALTH category and the marginally significant t-statistic.[10]

An obvious next step is to conduct a more detailed analysis of this data using additional variables which show the specific details of the contingent valuation implementation, a finer partitioning of the RP techniques, and potential indicators of reliability such as sample size and standard errors. Our efforts to conduct this analysis, however, have been greatly hindered by the curse suffered by other meta-analyses of non-market data (*e.g.*, Smith and Kaoru, 1990): incomplete reporting of the necessary details. With rapidly declining sample sizes due to missing data and a large set of dummy variables, we found we were soon identifying individual

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[9]It is possible to use the parameters in Tables 3 and 4 to assess the influence of the inclusion or exclusion of a particular RP technique or type of good. This can be done by noting that the mean CV/RP estimate is simply the sum of the intercept and the weighted parameter estimates where the weights are the percent of the sample in each category. To recalculate the weights from dropping one or more categories the only additional information needed is the original number of observations in each category (*i.e.*, TC1=272, TC2=152, HP=62, AVERT=23, ACTUAL=46; REC=400, ENVAM=134, HEALTH=21). For instance, one may want to drop the comparisons with HP studies because the assumptions necessary to identify consumer surplus in hedonic models are often questionable (doing so changes the original mean CV/RP estimate from .775 to .795), or to drop the ACTUAL comparisons because some of these RP estimates came from situations which had strong incentives for free-riding (mean CV/RP ratio goes from .775 to .752), or to drop the health studies because of frequent difficulties with either perceived or conveyed health impacts (mean CV/RP goes from .775 to .770).

[10]Results based on the complete dataset are quite similar in both relative and absolute magnitude for the various RP techniques with the exceptions: TC1 has an intercept term of 0.9392, AVERT has a significant positive coefficient, and ACTUAL has an insignificant positive coefficient. Neither the HEALTH nor ENVAM dummies are even marginally significant in the regression equation using the complete dataset.

TABLE 3
REGRESSION OF CV/RP on RP TECHNIQUE USED

Parameter	Estimate	T-Statistic
Intercept	0.8014	28.55
TC2	-0.1039	-2.21
HP	-0.1813	-3.18
AVERT	0.0335	0.51
ACTUAL	0.2348	3.91
N=555	R^2=.05	

TABLE 4
REGRESSION OF CV/RP on TYPE OF GOOD VALUED

Parameter	Estimate	T-Statistic
Intercept	0.7706	34.06
ENVAM	-0.0107	-0.23
HEALTH	0.1450	1.64
N=555	R^2=.01	

studies with particularly large or small CV/RP ratios. However, some general observations may be warranted which are along the lines of the meta-analyses of contingent valuation, travel cost analysis, and hedonic pricing which have previously been performed (Smith and Kaoru, 1990; Walsh, Johnson, and McKean, 1992; Smith and Huang, 1993; Smith and Osborne, 1994). The single-site travel cost models produce higher CV/RP ratios on average than do the multiple-site models. This is largely because many TC1 models do not include any value of travel time while most TC2 models make some allowance for travel time cost. TC2 models also tend to be more elaborate with some visitors coming from long distances to one or more of the sites examined. Estimates from the TC2 models are often presented using different functional forms, some of which produce quite large RP numbers. Hedonic pricing and averting/household production models are quite sensitive to the particular functional form and attributes used, and can generate a wide range of RP estimates from the same dataset. The CV estimates vary with the treatment of outliers and protest responses, the functional form used with discrete choice CV data, and the payment mechanism used. CV estimates are undoubtedly sensitive to how well the good is described and whether the respondents believe the good can be provided (Mitchell and Carson, 1989). RP estimates are undoubtedly sensitive to the researcher's assumptions about a good's input costs (Randall, 1994) and characteristics (Freeman, 1993).[11]

6. CORRELATION BETWEEN CV AND RP ESTIMATES

The average CV/RP ratio does not directly address whether CV and RP estimates tend to move together. The convergent validity of the two measurement techniques is closely tied to the presence of a significant correlation between the estimates derived using the different

[11]For instance, recreationists' costs of travel may differ greatly from the researcher's assigned costs or lake users may be unaware of an invisible toxin known to the researcher. In both cases, there is a divergence between the researchers's assumptions and the consumer's perceptions.

techniques, although how large such a correlation should be is an open question. A correlation framework in this case can also be linked to a measurement error model where neither of two available measurements is error free and the two techniques may measure the desired quantity in different units such as gallons and liters.[12]

We provide two measures of correlation, the Pearson correlation coefficient and the Spearman rank-order correlation coefficient. The Pearson correlation coefficient is the ratio of covariance of the two measures to the square root of the product of the variances of the two measures. The Spearman correlation coefficient is a non-parametric measure which first individually rank orders the values obtained from the two measurement approaches and then calculates the Pearson measure using the ranks as the data. It tends to be less sensitive to outliers and differences in scale than the Pearson measure.[13]

For the complete sample, the Pearson coefficient is 0.83 and the Spearman coefficient is 0.78. For the trimmed sample, these two measures are 0.91 and 0.88, respectively, while for the weighted sample they are .98 and .92, respectively. As expected, both of these datasets show higher correlation than the complete dataset since in the trimmed dataset, the most divergent observations have been dropped and in the weighted data set, CV and RP estimates which were divergent in one direction have often been averaged with those divergent in the opposite direction. In all three datasets, both the Pearson and Spearman correlation coefficient are significantly different from zero ($p < 0.001$).

[12]It is possible to have an average CV/RP ratio of 0.5 or 2.0 and to have the correlation between the two estimates equal 1.0. It is also possible to have an average CV/RP ratio of 1.0 and a correlation coefficient of zero.

[13]Note that the CV/RP ratios are not sensitive to the scale of the data. For the purpose of calculating the CV/RP ratio it does not matter whether the CV estimate is in 1972 dollars or 1994 dollars, or for that matter, pounds or kroner, as long as the RP estimate is in the same units. Similarly, it does not matter whether individual or aggregate estimates are used.

In any finite sample, estimated correlation coefficients maybe sensitive to the scale of the data.[14] The largest estimate in the sample is now an RP estimate of 5920 (CV estimate 4650) from the Brookshire *et al.* study (1982) on the increased value of a house due to being outside rather than inside an earthquake zone in the greater Los Angeles area. There are six comparisons with CV or RP estimates above 2000, four valuing housing characteristics and two valuing big game hunting. Dropping these comparisons reduces the correlations a small amount, dropping the much larger number of comparisons (N=53) with CV or RP estimates above 1000 reduces them a bit further (*i.e.*, Pearson [.81, .85, .92] and Spearman [.77, .85, .91], for the three samples, respectively). Dropping the 106 comparisons with a CV or RP estimate above 500 results in a sizeable reduction in the Pearson correlation coefficients for the full and trimmed samples, but not for the weighted sample (.60, .64, .90). The Spearman correlation coefficients, which are less sensitive to scale, remain largely unchanged (.72, .81, .90). All of these Pearson and Spearman correlation estimates are significantly different from zero ($p < 0.001$).

One can also regress the RP estimate on the CV estimate. Depending on the sample used, the coefficient on the CV estimate to ranges from .9 to 1.4 and to always be highly significant. The intercept term is always positive and tends to be reasonably large and quite significant for treatments where the coefficient on the CV estimate is near or below 1.0. One

[14]In an earlier version of this paper, we reported Pearson correlation coefficients in the .4 to .7 range. While there has been a substantial increase in the number of comparisons since that version, the principal change has been placing all of the estimates at the individual consumer level rather than the aggregate level. Originally, aggregate CV and RP estimates had been entered into our database for a small number of studies, because it was not immediately obvious how to obtain the preferred consumer level estimate from the aggregate estimate in those studies. The CV/RP ratios from these studies tend to be quite erratic relative to the studies with more complete reporting. These large and highly variable aggregate estimates had a very large influence on the magnitude of the estimated Pearson correlation coefficient. We have devoted considerable effort to extracting the appropriate individual agent level estimate from the aggregate estimate in these studies. In only one instance, the early Darling (1973) CV/HP comparison, is it impossible to determine the exact rule, or a close approximation, for going from the aggregate to the individual level estimate. As the Darling estimates are in millions of dollars, we divided these estimates by 1 million dollars to make them consistent with the scale of most of the other estimates.

of the more interesting and best fitting regression models was found by taking the average RP and CV estimates from the 83 studies as the observations when the averaging is performed using the trimmed data set rather than complete data set.[15] The resulting regression equation is given by:

$$\text{RP\_ESTIMATE} = \underset{(0.117)}{0.8995} + \underset{(64.609)}{1.2652}{*}\text{CV\_ESTIMATE},$$

where the White t-statistics are in parentheses and the adjusted R^2 is .98. The high R^2 suggests that after eliminating *a fraction* of the *between* studies variance by trimming off the overall smallest and largest 5% of the CV/RP ratios and eliminating *all within* study variance by averaging, the CV and RP estimates are very closely linked. Furthermore, the reciprocal of the coefficient on the CV estimate (.79) is almost identical to the mean CV/RP ratio (.78) from the trimmed data.

7. OTHER COMPARISON APPROACHES

Comparing WTP estimates from contingent valuation to estimates from RP methodologies is certainly the most popular way of comparing the two approaches, but it is not the only one. Another approach is to compare estimates of the fraction of a particular population who say that they will undertake a given activity with the fraction who actually undertake the activity. For example, Carson, Hanemann, and Mitchell (1987) look at the correspondence between the estimate of the percent who say in a survey that they will vote for a water quality bond issue (70-75%) and the percent actually voting in favor of it (73%). Kealy, Montgomery and Dovidio (1990) find that 72% of those who said they would donate money to the New York Department of Environmental Conservation to reduce acid rain in the Adirondacks actually did so several

[15]This procedure still results in one observations per study because no study has CV/RP comparisons where all of the study ratios are in the largest or smallest 5% of the 612 ratios contained in the complete data set.

weeks later. This percentage increased to 92% in a subsample in which they strongly stressed the future payment obligation.[16] In contrast, Seip and Strand (1992), using members of a Norwegian environmental group as interviewers, found that only 10% of respondents who indicated they would be willing to pay a specified membership fee for the group actually did so when solicited a month later. Navrud (1992b) conducted a similar exercise, but this time sampling people who had sent in a reply coupon from a full page World Wildlife Federation (WWF) newspaper ad in Norway "contributing their vote as a WWF friend." While Navrud's study showed the percentage joining the environmental group as several times that of Seip and Strand's study, Navrud emphasizes the difficulty in drawing a close correspondence between a vague initial request which potentially includes ideological support for the environmental group's public goals and the actual private good purchase of membership in the group.[17]

Analysts may also be interested in price and substitution elasticities. For example, Cummings *et al.* (1986) estimated the elasticity of substitution between wages and municipal infrastructures in western boomtowns to be -0.35 using a hedonic wage equation estimated on data from 29 towns and -0.037 to -0.042 using CV surveys done in three boomtowns. Thomas and Syme (1988) used a contingent valuation study in Perth, Australia to estimate the residential water demand price elasticity since there had been little prior variation in water rates. The authors estimated the price elasticity to be -0.20 using the data from their CV study, whereas econometric models estimated from actual demand observed after water rate changes had been put in place resulted in price elasticity estimates ranging from -0.10 to -0.43. In the public

[16]The number of subjects who declined to donate after earlier saying they would was only slightly larger than the number of subjects who said they would not donate but who actually did so.

[17]It can also be shown that the incentive structure of the two-step mechanism used in Seip and Strand (1992) and Navrud (1992b) should lead to over-pledging in the survey market and free-riding in the actual market.

finance literature, tax price elasticities for a particular good estimated from survey data tend to be similar to those estimated from aggregate voting data and governmental provision decisions (Bergstrom, Rubinfeld, and Shapiro, 1982; Gramlich and Rubinfeld, 1982).

A different approach is to compare the utility of different choices from stated preference (SP) and RP models using the suggestions of Louviere and Timmermans (1990) for recreational modeling.[18] In some instances, it may also be possible to compare parameters estimated from different models. Hensher *et al.* (1989) use this approach to show the similarity of the value of travel time estimates from the two types of models in the transportation literature. With adequate and similar information on the variables underlying the choice process, one can directly test for the statistical equivalence of the estimated contingent valuation and revealed preference choice models. Mu (1988) shows this for the choice problem of where to obtain household water in Brazil.[19] A less structured approach based on the non-parametric consumer preference framework of Varian (1983) has been applied to contingent valuation and travel cost data for big horn sheep hunting in Canada by Adamowicz and Graham-Tomasi (1991). They show that most of their data from both approaches is consistent with the basic set of theoretical restrictions on demand, with the contingent valuation data showing fewer violations.

If one is prepared to say that neither CV nor RP data is inherently superior to the other, an obvious thing to do is combine them in some fashion. This approach has recently been

[18] Utilities from choice models estimated from RP and SP data cannot be directly compared unless one takes account of the possibility of different latent scale parameters underlying the choice models (Morikawa, 1989). A number of comparisons in the literature which were previously thought to be divergent have been shown to be consistent once differences in scale (which is related to reliability) are taken into account.

[19] It is difficult to test whether the CV and RP data were generated by the same utility function without making strong structural assumptions about the choice process. It is particularly difficult unless one has obtained the key variables underlying that process for both the RP and CV samples. See Larson (1990) for an application and discussion of problems with this approach.

applied in the marketing and transportation literatures (Ben-Akiva and Morikawa, 1990; Hensher and Bradley, 1993; Swait and Louviere, 1993), and has seen some initial applications (Adamowicz, Louviere, and Williams, 1994; Cameron, 1992; Hanemann, Chapman and Kanninen, 1993) in the recreational demand literature. Cameron (1992) proposes a procedure for jointly estimating a recreational demand equation and a CV valuation function in a utility-consistent framework.

8. CONCLUDING REMARKS

Our examination of 83 studies containing 616 CV/RP comparisons for quasi-public goods finds that CV estimates are smaller, but not grossly smaller, than their RP counterparts. For the complete dataset, 1.0 is just outside the upper-end of the 95% confidence interval [0.81-0.96] for the mean CV/RP ratio (0.89).[20] For the trimmed dataset, one can clearly reject the hypothesis that the mean CV/RP ratio (0.77) is 1.0 in favor of the alternate hypothesis that it is less than one. For the weighted dataset, the mean CV/RP ratio (.92) is not significantly different from 1.0 using a 5% two-sided t-test. The median CV/RP ratios range between 0.75 and 0.94 depending upon the treatment of the sample. Most of the density lies in the range of CV/RP ratios of 0.25 to 1.25. The Pearson correlation coefficient between the CV and RP estimates varies between .60 and .98, depending on the sample considered; the Spearman rank correlation coefficient varies between 0.72 and 0.92. In every case, the correlation coefficient estimates are significant at $p > .001$, thus providing support for the convergent validity of the two basic approaches to non-market valuation of quasi-public goods.

[20]By carefully selecting a small subset of study estimates, one could argue either that the CV/RP ratio was almost always 1.0 or that it was almost always substantially larger or smaller than 1.0. Any such selection should be carefully justified.

Some CV estimates clearly exceed their revealed preference counterparts, and therefore one should not conclude that CV estimates are always smaller than revealed preference estimates. Nonetheless, based on the available CV/RP comparisons, discounting CV estimates by a factor of two or more, as some have proposed, appears to be unwarranted given that CV/RP ratios of greater than 2.0 comprise only 5% of our complete sample and only 3% of our weighted sample. Indeed, applying a discount factor of 2.0 or greater to the CV estimates used in our analysis would result in "adjusted" CV estimates that, in almost all cases, *diverge* from the estimates obtained from observable behavior, rather than *converge*.

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APPENDIX: STUDY SUMMARIES BY CATEGORY

3.1 Comparisons of Contingent Valuation with Single Site Travel Cost Models

Knetsch and Davis (1966) valued outdoor recreation at a forest recreation area in northern Maine using a single-site travel cost model and two variants of the contingent valuation approach. The data was obtained from on-site interviews of recreation area users. Both willingness to pay and willingness to drive additional distances were elicited from the respondents. *(2 comparison ratios)*

Beardsley (1971) conducted a study to value recreation on the Cache la Pandre River in Colorado using both travel cost and contingent valuation methodologies. The study data was obtained from an in-person survey of river visitors conducted in 1966. The authors present two different benefit estimates using a simple single-site, zonal travel cost model, different participation predictions, and a comparable contingent valuation estimates. *(2 comparison ratios)*

Shechter, Enis and Baron (1974) valued the preservation of Israel's Mt. Carmel National Park from the expansion of an adjacent Limestone quarry. The quarry expansion threatened one of the Park's nicest recreational areas. Two contingent valuation estimates and a travel cost estimate are provided based on a 1971-1972 survey of 2,000 Israeli urban households and 900 individuals/groups visiting the Park. The travel cost estimate is based on an implicit price that is based on variable costs and a value of time equal the mean hourly wage rate of surveyed visitors. One CV estimate is based on an entrance fee payment vehicle and the other is based on willingness to drive additional miles to visit the park; both survey versions used a bidding game elicitation. *(2 comparison ratios)*

In a study best known for its innovative elicitation of willingness to accept compensation in a simulated market, Bishop and Heberlein (1979) also used the contingent valuation and travel cost methodologies to value willingness to pay for goose hunting in the Horicon Zone of Wisconsin. The study data was obtained from a mail questionnaire administered to a random sample of hunters who had applied for early season permits. Under different assumptions for the value of time, the authors present three travel cost estimates and one contingent valuation estimate. *(3 comparison ratios)*

Smith (1980) used both travel cost and contingent valuation methodologies to estimate the recreational value at Oregon's Cullahy Lake in her Master's Thesis. The study data was obtained from on-site interviews of lake visitors conducted in 1979. The author presents one travel cost and one contingent valuation estimate. *(1 comparison ratio)*

Thayer (1981) used contingent valuation and a site-substitution travel cost model to estimate willingness to pay for the preservation of the Santa Fe National Forest (located in the Jemez Mountain Area of New Mexico) in its original state (*i.e.*, to prevent geothermal activity which was scheduled to begin in the early 1980's). The study data was obtained from interviews of recreationists conducted in the fall of 1976 and the spring of 1977. The authors present contingent valuation and travel cost estimates for daytrippers, campers, and the visitor population as a whole under different travel cost modeling assumptions. *(6 comparison ratios)*

Haspel and Johnson (1982) conducted a study to assess the impact of proposed surface mining to be located near Utah's Bryce Canyon National Park. A survey was administered to different samples of the park's visitors in the summer of 1980. One section of the survey was designed to generate data to allow for a comparison of travel cost and contingent valuation estimation techniques. Under alternate assumptions regarding model specification and the value of time, eight travel cost estimates are presented. Two contingent valuation estimates are provided that were calculated using the maximum additional distance visitors were willing to drive to visit Bryce Canyon. Johnson and Haspel (1983) used two additional survey samples to derive new travel cost estimates which were then compared to one of the CV estimates from Haspel and Johnson (1982). *(8, 2 comparison ratios)*

Duffield (1984) conducted a study to estimate recreational values of the Kootenai Falls in northwestern Montana using the both travel cost and contingent valuation methodologies. On site, in-person interviews were conducted in the summers of 1981 and 1982. Two travel cost estimates are presented under alternate assumptions regarding model specifications and contingent valuation estimates for two different payment vehicles. *(4 comparison ratios)*

Bojö (1985) undertook a study for Sweden's Environmental Protection Agency to estimate the benefits of protecting an area (called a Nature Reserve) from forest harvesting in the Vaalaa Valley in Northern Sweden. Bojö interviewed Vaalaa Valley visitors to gather information to estimate an average willingness to pay per visitor using both a travel cost and a contingent valuation model. *(1 comparison ratio)*

Michaelson and Smathers (1985) conducted a study to value the recreational usage of public campgrounds in the Sawtooth National Recreation Area using the travel cost and contingent valuation methodologies. The study data was obtained from on-site interviews of tourists and local users. The authors present a travel cost estimate and, using different payment vehicles, three contingent valuation estimates. *(3 comparison ratios)*

O'Neil (1985) estimated consumer surplus for recreation associated with two sites in Maine, the West Branch of the Penobscot River and an area of the Saco River. A contingent valuation and single-site travel cost analysis were conducted using information gathered from in-person interviews of site visitors conducted during the summer of 1984. Under different assumptions regarding functional form, the authors present travel cost estimates for each site and, using two different elicitation methods, contingent valuation estimates for each site. *(16 comparison ratios)*

Loomis, Sorg and Donnelly (1986) estimated per-trip consumer surplus for cold-water fishing in Idaho. The authors used a multiple-site travel cost model and the contingent valuation method in estimation. The data was gathered in 1983 from a survey of anglers that elicited information about the anglers' fishing activity in 1982. Fifty-one sites were included in the study area. Travel cost estimates are provided using the full fifty-one sight model, a three site model, and a one-site model. A per-trip contingent valuation estimate is also provided. *(3 comparison ratios: 1 single site TC and 2 multiple site TC)*

Smith, Desvousges and Fisher (1986) See the Desvousges, Smith, and McGivney (1983) summary in the multiple site travel cost section.

Farber and Costanza (1987) conducted a study to estimate the social value of the Terrebonne Parish wetland system in South Louisiana. The social value of the wetland system was divided into three primary components: commercial fishing and trapping, recreation, and storm wind damage protection. The value of the wetlands area for one of these three components of value, recreation, was estimated using both travel cost and contingent valuation methodologies. The study data was obtained from a mail survey of Terrebonne wetland users that was administered July, 1984 through July, 1985. Under various assumptions regarding the value of travel time, three different travel cost estimates are compared to the contingent valuation estimate. *(3 comparison ratios)*

Hanley and Common (1987) used a zonal travel cost model and a contingent valuation model to estimate the recreational benefits derived by visitors to a part of the Queen Elizabeth Forest Park in Central Scotland. This study was the pilot for Hanley (1989). *(1 comparison ratio)*

Adamowicz (1988) valued consumer surplus per day for hunting big horn sheep in six Alberta, Canada hunting zones. Twelve travel cost estimates and one contingent valuation estimate is provided for each hunting zone. The travel cost estimates are based on four different functional forms combined with three different time values. *(72 comparison ratios)*

Duffield and Allen (1988) used travel cost and contingent valuation methodologies to compare site-specific per-trip values for trout fishing on seventeen Montana rivers. The travel cost estimates are based on a 1985 survey while the contingent valuation estimates are based on the 1986 Angler Preference Survey administered by the Montana Department of Fish, Wildlife and Parks. The authors present site-specific estimates for each river derived from a multiple-site travel cost model and a contingent valuation model. *(17 comparison ratios)*

McCollum, Bishop and Welsh (1988) used traditional travel cost, probabilistic travel cost, and contingent valuation methodologies to estimate the value of a Wisconsin Sandhill Deer hunting permit. The study data was collected as part of a 1983 Sandhill Deer hunting experiment which is also examined in Bishop and Heberlein (1990). The probabilistic travel cost model was set in a discrete choice framework. Seven estimates of both simple and probabilistic travel cost are presented using seven different values of travel time. *(42 comparison ratios)*

Navrud (1988, 1990, 1991a, 1991b) conducted four studies that all had a similar focus — estimating the recreational value per angling day using both travel cost and contingent valuation methodologies. Navrud's 1988 study valued freshwater fishing for salmon and sea trout at Norway's River Vikedalselv; the 1990 study valued salmon and sea trout on the River Audna; and the 1991a study valued brown trout at Lake Lauvann and Gjerstadskog Lakes (separate estimates are provided for each lake). Navrud's 1991b study valued saltwater fishing for salmon and sea trout at a sea area near River Audna. *(4, 4, 8, 4 comparison ratios)*

Ralston (1988) valued annual recreation benefits from Reelfoot Lake in Tennessee using the contingent valuation and travel cost methodologies. The data for both analyses was obtained in a mail-survey sent to lake visitors. A single-site, zonal travel cost model, with an internally generated value of time, provided one estimate. The contingent valuation estimate was based on an open-ended question for an annual pass to the lake. *(1 comparison ratio)*

Schelbert *et al.* (1988) valued recreation in a specific part of the Zurichberg forest in Switzerland. Using data from an on-site survey, the authors estimated a simple single site travel cost model. They also used contingent valuation to value several aspects of the forest, one of which was designed to be directly comparable to the travel cost estimates. *(1 comparison)*

Brown and Henry (1989) examined the viewing of elephants on wildlife safari tours in Kenya. They estimate both the contingent valuation and a single-site travel cost model using several different assumptions. The contingent valuation data and travel cost data was obtained from an on-site survey of tour participants. Most participants were from the United State or Europe. *(8 comparison ratios)*

Bockstael, McConnell and Strand (1989) used the contingent valuation method and two variants of the travel cost method to estimate an improvement in the water quality of the Chesapeake Bay from current levels to an improved condition, one which the respondent considers acceptable for swimming. The study data was obtained from a random sample of residents in the Baltimore-Washington SMSA. *(2 comparison ratios)*

Hanley (1989) conducted a study to value recreation benefits derived by visitors to a part of the Queen Elizabeth Forest park in Central Scotland using both travel cost and contingent valuation methodologies. The study data was obtained in the summer of 1987 from in-person interviews and self-administered questionnaires of park visitors. Four travel cost estimates, based on different functional forms, are provided along with two contingent valuation estimates, one obtained from a close-ended format and another from an open-ended format. *(8 comparison ratios)*

Harley and Hanley (1989) conducted a study to value visits to three nature reserves in Great Britain using a contingent valuation model and a travel cost model employing two different functional forms. Of the three reserves, contingent valuation and travel cost estimates were provided for only two sites, the Loch Garten bird reserve in the Scottish Highlands and Blacktoft Sands in Humberside, England. The study data was obtained from on-site interviews of visitors to the reserve. *(6 comparison ratio)*

Huppert (1989) used both the travel cost and contingent valuation methodologies to estimate the economic value associated with recreational fishing for chinook salmon and striped bass in Central California. The study data was obtained from the Bay Area Sportfish Economic Survey which was carried out during 1985-86. Willingness to pay values were estimated using both the complete sample and a subsample in which respondents not catching any fish were dropped. *(4 comparison ratios)*

Johnson (1989) valued recreational fishing at two Colorado locations, Blue Mesa Reservoir and the Poudre River, using the travel cost and contingent valuation methodologies. The data for both analyses was obtained from a survey of visitors. For each location, two pairs of contingent valuation/travel cost estimates are provided. One pair is based on the maximum willingness to pay rather than forgo the recreational experience and the other is based on a change in catch. *(4 comparison ratios)*

White (1989) valued recreation at Belmar Beach in New Jersey using the contingent valuation and travel cost approaches. The data for both analyses was taken from a 1985 U.S. Army Corp of Engineers on-site survey of beach users. Two different single-site travel cost estimates are provided as well as three different CV estimates for four different sub-samples: season pass holders, day pass holders, season pass holders with summer residents excluded, and day pass holders with summer residents excluded. *(24 comparison ratios)*

Rolfsen (1990) estimated the recreational value per angling day for salmon and sea trout in Norway's freshwater Gaula River using the travel cost and contingent valuation methodologies. The author provides a contingent valuation estimate and a range of travel cost estimates. We used the high and low estimates from this range. *(2 comparison ratios)*

Loomis, Creel and Park (1991) valued deer hunting in California using the contingent valuation and travel cost methodologies. The data was obtained from a mail survey of California residents and nonresidents who had purchased a deer hunting license for the 1987 season. Under different assumptions regarding functional form, the authors present two travel cost estimates and compare those to a contingent valuation estimate. *(2 comparison ratios)*

Sievänen, Pouta and Ovaskainen (1991) valued recreation at a regional recreational area near Helsinki using a single-site travel cost model and two variants of the contingent valuation approach. The study data was obtained from on-site interviews of visitors to the recreational area. Willingness to pay and willingness to travel additional distances responses were elicited. *(5 comparison ratios)*

Mungatana and Navrud (1993) conducted a study to estimate the recreational value of wildlife viewing in Lake Nakuru National Park in Kenya using travel cost and contingent valuation approaches. The data was obtained from on-site interviews of park visitors in 1991. The authors present travel cost and contingent valuation estimates under different assumptions regarding functional form. Separate estimates were derived for flamingo viewing. *(6 comparison ratios)*

Choe, Whittington and Donald (1994) valued recreational benefits at an urban beach, which had been closed due to pollution, near Davao, Philippines using the contingent valuation and travel cost approaches. The data for both analyses was collected in an in-person survey in late 1992. One travel cost estimate is presented as well as four different CV estimates based on different forms of the valuation function. *(4 comparison ratios)*

3.2 Comparisons of Contingent Valuation with Multiple Site Travel Cost Models

Binkley and Hanemann (1978) examined beach usage in Boston using both travel cost and contingent valuation methodologies. The study data was obtained from in-person interviews of beach users. Using a multi-site travel cost model, the authors estimate a range of average values per day that can be compared to a contingent valuation estimate for the same. *(2 comparison ratios)*

Vaughan and Russell (1982b) valued a day of freshwater trout fishing and another day of freshwater catfish fishing using the travel cost method and contingent valuation method. The study data was obtained from the 1975 National Survey of Hunting, Fishing and Wildlife Associated Recreation. Some of the parameters in the travel cost model were derived using data from a 1979 mail survey of recreational fee-fishing sites in the United States. The travel cost analysis used a varying-parameter model with multiple sites. For trout and catfish, the authors calculated two travel cost estimates, one without inclusion of time costs and one with time valued at the median wage by zone. A contingent valuation estimate was also provided for the two types of fish. *(4 comparison ratios)*

Desvousges, Smith and McGivney (1983) valued water quality improvements in the Monongahela river basin in Western Pennsylvania. The study data was obtained from in-person interviews administered to a sample of area households. Three different scenarios were valued: avoiding a loss of water quality, an improvement from boatable to fishable water quality, and an improvement from fishable to swimmable water quality. One travel cost estimate for each scenario is presented along with four different contingent valuation estimates obtained from different elicitation methods. Smith, Desvousges and Fisher (1986) used the same CV data but present three new travel cost estimates for each scenario using different model specifications. *(12, 36 comparison ratios: 12 single site TC and 24 multiple site TC)*

Harris (1983) used both travel cost and contingent valuation methodologies to estimate the benefits from Colorado's fisheries in his Ph.D. dissertation. The study data was obtained from a mail questionnaire sent to a sample of Colorado fishing licensees. Both travel cost and contingent valuation estimates are presented for the full-sample and a single-purpose trip subsample by four fishery types (wild, basic yield, plains and combined). *(8 comparison ratios)*

Sutherland (1983) used a regional travel cost model and a contingent valuation model to value water-based outdoor recreation in the Pacific Northwest. The travel cost model varied by the functional form, the assumptions about demand at zero cost, and the manner in which origin zones were defined. The household survey for both approaches was conducted during the summer of 1980 in Washington State. One contingent valuation estimate and nine travel cost estimates are presented. *(10 comparison ratios)*

ECO Northwest (1984) used simple travel cost, hedonic travel cost, and two contingent valuation approaches to estimate the value of recreational fishing of three different sites in the Swan River drainage. The data was obtained from on-site interviews and a creel census administered to users at sites along the Swan River, Swan Lake, and their tributaries. *(12 comparison ratios)*

Devlin (1985) estimated the benefits from firewood collection in Northern Colorado National forests in his Ph.D. dissertation. A mail survey was used to collect the data. The author presents a travel cost estimate derived from an individual-observation model and two contingent valuation estimates, one based on willingness to pay and the other based on willingness to drive. *(2 comparison ratios)*

Donnelly, Loomis, Sorg and Nelson (1985) conducted a study in 1982 that estimated the average net willingness to pay for steelhead fishing trips in Idaho using both travel cost and contingent valuation methodologies. The data was obtained from a random sample of anglers purchasing Idaho steelhead fishing tags. The authors present per trip estimates derived from a multiple-site travel cost model and a contingent valuation model. *(1 comparison ratio)*

Sellar, Stoll and Chavas (1985) used a regional travel cost model and two different contingent valuation elicitation approaches to estimate the value of recreational boating on four lakes in East Texas. The study data was collected using a questionnaire mailed to a sample of registered pleasure-boat owners in a 23-county area of East Texas. The authors present travel cost estimates for each of the four lakes, three contingent valuation estimates for three of the four lakes, and one contingent valuation estimate for the fourth lake. Net willingness to pay was calculated by subtracting average boat launch fees from estimates of gross consumer surplus. This procedure resulted in negative CV willingness to pay estimates in two instances. To avoid numeric complications, we set these CV/RP values equal to the smallest positive CV/RP ratio in the sample. *(10 comparison ratios)*

Walsh, Sanders and Loomis (1985) used a multi-site travel cost model and a contingent valuation model to value visits to a group of eleven Colorado rivers recommended for protection under the Wild and Scenic Rivers Act and to a second group of other rivers in the state. The data was obtained from a mail survey administered to a random sample of Colorado residents in 1983. *(4 comparison ratios)*

Wegge, Hanemann and Strand (1985) valued marine recreational fishing in Southern California using the contingent valuation methodology and multiple-site travel cost analysis. Their data was obtained from a 1984 mail survey of anglers. Separate estimates were derived for several modes of fishing: shore fishing, party/charter boat fishing, rental boat fishing and private boat fishing. The authors present both travel cost and contingent valuation estimates under different assumptions regarding functional form. *(42 comparison ratios)*

Loomis, Sorg and Donnelly (1986) See the Loomis, Sorg and Donnelly summary in the single site section.

Milon (1986) valued the construction of an artificial reef in Southern Florida. He estimated several different multi-site travel cost models that differed in the functional form used and the assumptions made about possible site-substitution. Using three subsamples with different elicitation methods, he obtained comparable contingent valuation data from a large mail survey. (*15 comparison ratios*).

Mitchell and Carson (1986) valued water pollution control using the contingent valuation methodology. The data was obtained from a large, national, in-person survey administered in 1983. The authors provide a comparison of their contingent valuation estimate for a small change in the quantity of fishable water with a travel cost estimate for a similar change from Vaughan and Russell (1982a). (*1 comparison ratio*)

Sorg and Nelson (1986) conducted a study to value elk hunting in Idaho using both travel cost and contingent valuation methodologies. A telephone survey was administered to resident and nonresident elk hunters holding a general elk hunting license in January and February of 1983 and 1984 to gather data on the 1982 and 1983 elk hunting seasons. Using standard and reported costs per mile, the authors present two travel cost estimates and two contingent valuation estimates. (*4 comparison ratios*)

Young, Donnelly, Sorg, Loomis and Nelson (1987) estimated the consumer surplus from small game hunting in Idaho. The authors provide an estimate for all upland game species and a separate estimate for pheasant hunting. Travel cost and willingness to pay information was gathered from a mail survey followed by a telephone survey of residents and nonresident licensed hunters. Travel cost estimates are reported using two different assumptions about the cost per mile. The authors provide four multiple-site travel cost model estimates and two contingent valuation estimates. (*4 comparison ratios*)

Walsh, Ward and Olienyk (1989) valued the effect of tree density on recreational demand for six recreational sites in Colorado. In the summer of 1980, in-person interviews were conducted to gather travel cost and contingent valuation data from site visitors. Contingent valuation estimates were derived using the complete sample and a multiple-site travel cost model was estimated using a subsample of respondents. (*8 comparison ratios*)

Duffield and Neher (1990) estimated the consumer surplus associated with deer hunting in Montana using the contingent valuation method. The study data was collected in a 1988 survey of hunters. The authors offer a comparison of their contingent valuation estimate with a travel cost estimate obtained from a companion study by Brooks (1988). (*1 comparison ratio*)

Richards, King, Daniel and Brown (1990) used both the travel cost and contingent valuation methodologies to estimate recreational consumer surplus for national forest campgrounds in northern Arizona. The study data for the contingent valuation analysis was obtained from an on-site survey of recreationists at several national forest campgrounds in northern Arizona during the summer of 1985. The data for the travel cost analysis was compiled from fee envelopes collected by the U.S. Forest Service in 1985. The authors compare contingent valuation estimates with estimates derived from a multiple-site travel cost model for 10 campgrounds. (*10 comparison ratios*)

Walsh, Sanders and McKean (1990) used both travel cost and contingent valuation approaches to estimate a demand function for the recreation activity of pleasure driving/sightseeing by car along sections of eleven rivers in the Colorado Rocky Mountains. The data was obtained from a 1983 mail survey of Colorado's resident population. For per day consumer surplus, the authors present one travel cost and two contingent valuation estimates (one is obtained from a related study by Johnson and Walsh (1987)); for total trips, the authors present one travel cost and one contingent valuation estimate. (*3 comparison ratios*)

Willis and Garrod (1990) valued open-access recreation on inland waterways in the United Kingdom. Using data gathered from in-person interviews with canal users, the authors estimated recreational consumer surplus using the contingent valuation method and a multi-site travel cost model. A range of estimates is provided under different assumptions regarding functional form. (*2 comparison ratios*)

Duffield (1992) used data collected in an earlier study (Jones and Stokes, 1987) of sportfishing in Southcentral Alaska to estimate consumer surplus for sportfishing. The author estimated per trip consumer surplus using the contingent valuation method. Three contingent valuation estimates are provided: the estimated mean, an estimated truncated mean, and the estimated median. Also given is a multi-site travel cost mean estimate from Jones and Stokes (1987). Because a median travel cost estimate is not provided, we use only the estimated mean and estimated truncated mean for comparison with the travel cost estimate. (*2 comparison ratios*)

3.3 Comparisons of Contingent Valuation with Hedonic Pricing

Darling (1973) valued amenities at three urban lakes in California using the hedonic pricing and contingent valuation approaches. The CV data was obtained from interviews of residents living in the areas surrounding the water parks. The hedonic price data was obtained from sales information and tax assessment records. For each of the three lakes, the author presented one hedonic price estimate and two CV estimates for the comparable categories. The CV estimates are derived using two different functional forms. Only aggregate estimates are available from the study. (*6 comparison ratios*)

Loehman, Boldt and Chaikin (1981) valued changes in air quality in Los Angeles and the San Francisco Bay using contingent valuation and several different hedonic pricing approaches. The contingent valuation data was obtained from in-person interviews administered in areas with various air quality and socioeconomic characteristics for the two metropolitan areas in 1980. The authors provide one contingent valuation estimate for each metropolitan area; under different assumptions regarding functional form and pollution variables, they provide three hedonic price estimates for the Bay area and four hedonic price estimates for Los Angeles. (*7 comparison ratios*)

Brookshire, Thayer, Schulze and d'Arge (1982) used contingent valuation and hedonic pricing approaches to value improvements in air quality in Los Angeles. Property value information was gathered from a sample of single-family home sales that took place in late 1977 and early 1978. The contingent valuation data was obtained from in-person surveys administered in early 1978. *(11 comparison ratios)*

Gegax (1984) valued changes in risk using the contingent valuation and hedonic price methods. The study data was obtained from a large, national mail-survey during the summer of 1984. The hedonic price estimate was obtained from the regression of log wages on respondent and occupational characteristics including several job-related risk variables. The contingent valuation estimate was obtained by using a payment card elicitation approach for a specified risk change. Gegax, Gerking and Schulze (1985) examined how much workers were willing to pay for job-related risk reduction using both hedonic pricing and contingent valuation methodologies. The authors used the same mail-survey data as Gegax (1984). The authors present a range of value of life estimates from their contingent valuation results and a point estimate from their wage-risk analysis. *(1, 2 comparison ratios)*

Blomquist (1984) explored the comparability of implicit market values by using a hedonic pricing mechanism and contingent market values to estimate two-view related amenities. Residents of ten high-rise buildings along the Lake Michigan shoreline in Chicago were interviewed in 1981 to obtain estimates for the value of both the lake view and high-rise view of a dwelling unit. Blomquist (1988) used a subset of this data to presented additional hedonic pricing and contingent valuation estimates. *(14, 4 comparison ratios)*

Brookshire, Thayer, Tschirhart and Schulze (1985) used contingent valuation and a hedonic pricing approach to study the value of an equivalent house inside and outside Los Angeles County's earthquake special study zones. The contingent valuation data was obtained from a survey of homeowners inside the special study zones that asked respondents about their willingness to pay for a potential transfer of home ownership from inside to outside the zone. The hedonic pricing data was based on a comparison completed before the passage of the Alquist-Prilo Act that designated the special study zones. *(1 comparison ratio)*

Inter-American Development Bank (1988) conducted an urbanization project aimed at improving the housing situation in the "Zona de Baja Mar" of Buenaventura, Columbia. Using a hedonic pricing model and two variants of the contingent valuation method, continuous and discrete choice, the authors estimated the benefits garnered from three different types of structures. The study data was collected from household surveys conducted throughout the city. Two contingent valuation estimates and one travel cost estimate is presented for each alternative. Estimates are used in U.S. dollar form. *(6 comparison ratios)*

Pommerehne (1988) conducted a study to estimate willingness to pay for changes in road and aircraft noise using hedonic pricing and contingent valuation models. The study data was obtained from in-person interviews administered to residents of Basle, Switzerland. The authors present estimates for changes in both road and aircraft noise. *(2 comparison ratios)* d'Arge and Shogren (1989) conducted a study to value water quality in the Okoboji Lakes region of Iowa using a contingent valuation model and two variants of the hedonic pricing method. The contingent valuation study used data collected from a sample of area households in the summer and fall of 1984. One of the two hedonic price estimates is based on a standard hedonic price model and the other is based on a model derived from a survey of real estate professionals. *(3 comparison ratios)*

Randall and Kriesel (1990) valued 25 percent reductions in both air and water pollution in the United States. They used a discrete choice CV survey and a large multi-market hedonic pricing analysis. The authors present one CV estimate from a valuation function that pooled all data and included the survey mode as one of the explanatory variables. (*1 comparison ratio*)

Shechter (1992) reports value estimates for the reduction of air pollution in the Haifa area of Northern Israel. Using information obtained from a 1986-1987 household survey and other sources, consumer surplus estimates are provided for the specified reductions using the contingent valuation method, an estimated demand system for health and housing services, a consumer preference model, and the hedonic price method. Many of the same estimates are also reported earlier in Shechter (1991) and other Shechter papers using the same dataset. *(16 comparison ratios: 4 hedonic pricing, 8 household production, and 4 averting behavior)*

3.4 Comparisons of Contingent Valuation with Averting Behavior/Household Production

Eubanks and Brookshire (1981) estimated the value of elk hunting in Wyoming using a household production model and an iterative bidding model. The study data was collected from resident Wyoming hunters in 1977-78. The authors present three household production estimates and three comparable contingent valuation estimates for three different ranges of elk encounters. *(3 comparison ratios)*

Hill (1988) estimated the benefits of reducing the risk of breast cancer mortality in his PH.D. dissertation using contingent valuation and revealed preference methods. The study data was obtained from a sample of women drawn from the Cancer Prevention Clinic, University of Wisconsin, Madison. The author presents revealed preference estimates of willingness to pay for an annual physical examination using two alternate model specifications, three risk groups, and two contingent valuation estimates for comparable risk reductions. (*12 comparison ratios*)

Shechter (1992) See the Shechter (1992) summary in the hedonic pricing section.

John, Walsh and Moore (1992) valued a Jefferson County, Texas mosquito abatement program using the contingent valuation method and an expenditure function approach. The data for both analyses was collected in a 1983 mail survey of Jefferson County residents. Benefits per household are provided using the two approaches. (*1 comparison ratio*)

3.5 Comparisons of Contingent Valuation with Actual/Simulated Markets

Bohm (1972) estimated the willingness to pay for the provision of a public television program in Sweden. Five groups were asked their willingness to pay with an explicit payment schedule provided to the respondents. Two other groups were asked to state their willingness to pay with no actual payment required. The study was conducted in November of 1969. *(10 comparison ratios)*

Kealy, Dovidio and Rockel (1986) conducted a study to estimate contingent values for preventing additional damages from acid rain to the Adirondack region's aquatic system. The authors' sample of undergraduates was divided into two treatments. In the first treatment, respondents were asked to make actual payments, and in the second, respondents were asked for their willingness to pay. The two treatments were administered in two sessions held two weeks apart. Actual estimates and CV scenario estimates were presented for each of the two sessions. *(2 comparison ratios)*

Hoehn and Fishelson (1988) valued consumer surplus associated with different visibility levels at the Hancock Tower Observatory in Chicago. Using actual attendance and visibility data, the authors used a conventional demand model and two quality adjusted demand models to value per trip consumer surplus for one particular visibility level. A contingent valuation survey was administered to Hancock Tower visitors to estimate consumer surplus for the same visibility improvement. Hoehn (1990) uses the same basic dataset and provides additional conventional demand model estimates and as well as a contingent valuation estimate for a different visibility level. *(3, 3 comparison ratios)*

Sinden (1988) conducted four experiments concerning soil and forest conservation in Australia using the contingent valuation method and compared the results with actual contributions. The experiments were designed to test for potential information effects and hypothetical bias. Hypothetical willingness to pay for soil conservation and hypothetical willingness to pay for forest conservation were elicited. At the end of some of the experiments, respondents were given the opportunity to voluntarily donate into a fund marked for soil or forest conservation, thereby generating actual comparisons. *(17 comparison ratios)*

Boyce, Brown, McClelland, Peterson and Schulze (1989) conducted a study which is best known for its actual WTA and WTP experiments with Norfolk pine trees. However, one contingent valuation field study was conducted that elicited a respondent's willingness to pay for Norfolk pines under the condition that if the pine tree was not bought it would be killed. The authors compare this estimate to an estimate derived from a simulated market in which actual payments were required. *(1 comparison ratio)*

Bishop and Heberlein (1990) report on a 1983 and 1984 simulated-market, contingent-valuation field experiment in which respondents were able to purchase Wisconsin Sandhill Deer permits. The two 1983 experiments used an auction mechanism and the 1984 experiment used a discrete choice take-it-or-leave-it mechanism. The sample of individuals in each of the experiments were drawn from individuals who had expressed an interest in obtaining a permit and then randomly split into two subsamples. In the 1984 experiment one subsample was offered the opportunity to actually purchase a permit at a stated price while the other was asked, hypothetically, if they would purchase a permit at the stated price. *(3 comparison ratios)*

Duffield and Patterson (1991) conducted a field experiment in which one subsample of respondents of fishermen were asked for actual payment to help purchase water rights for Big and Swamp Creeks in Montana. Two other subsamples, which had different sponsors (*i.e.*, the University of Montana and the Montana Nature Conservancy), were asked about their willingness to pay, but no actual contribution was elicited. Comparisons were made for residents and nonresidents on a per contribution and per respondent basis. (*8 comparison ratios*)

Essenberg (1991) valued two different types of water systems in several different Philippine villages using the contingent valuation method. The contingent valuation data was obtained using in-person interviews that provided an iterative-bidding game elicitation format to respondents. One of the villages used in the contingent valuation survey was matched by characteristics with another village which had recently installed one of the described water systems. The author provides a comparison between the CV estimate and the actual payments made in the control village. (*1 comparison ratio*).