357

# AN ANALYSIS OF THE BENEFITS OF IMPROVING WATER QUALITY IN NARRAGANSETT BAY: AN APPLICATION OF THE CONTINGENT VALUATION METHOD

BY

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- pp 141; 154

hypothesis ($H_0$: $B_2=B_3=\ldots=B_k=0$). The likelihood ratios given by our results, 180.2 for WTP1 and 152.8 for WTP2, are both greater than the critical value for the .005 level of significance, therefore, we can reject the null hypothesis that all of the coefficients, other than the intercept, are equal to zero.

A frequently used statistic for measuring goodness-of-fit for the model is the pseudo-$R^2$ (also called the McFadden-$R^2$). The pseudo-$R^2$ is defined as

$$\rho^2 = 1 - (\ln L(\hat{\Omega})/\ln L(\hat{\omega})),$$

This measure is 1 when the model is a perfect predictor (in the sense that $P_i=F(x_iB)=1$, and 0 when $\ln L(\hat{\Omega}) = \ln L(\hat{\omega})$ (Fomby, et al., 1984). However, values of $\rho^2$ between 0.2 and 0.4 are considered extremely good fits (Hensher and Johnson, 1981). The pseudo-R2's in our results, 0.14 for WTP1 and 0.13 for WTP2, are considered reasonable.

### 7.1.2. Obtaining a Welfare Measure from the Estimated Discrete Choice Model.

The objective of this research was to obtain a utility theoretic measure of the benefits of improving water quality in Narragansett Bay, using the fitted binary response model.

From the logit results we have the response probability function. It is possible to integrate under this function to obtain a measure for the change in welfare associated with an improvement in water quality.

We asked discrete choice willingness to pay questions because individuals may not know very accurately what is the most they would be willing to pay for improved water quality, however they should know reasonably well whether it is greater than or less than BID. Nevertheless, we do actually want to estimate (or infer) the most that an individual would be willing to pay for an improvement in water quality. If the individual responds "yes" when asked if he would be willing to pay $10.00 for an improvement in water quality, then we know that $10.00 is a lower bound on his true willingness to pay. Alternatively, if the response was "no", then $10.00 would be an upper bound on the individual's true willingness to pay. We assume that the individual will be willing to pay an amount, BID, for an improvement in water quality if it is less than or equal to their maximum willingness to pay. Hanemann (1984; 1985) showed how one can derive estimates of the maximum willingness to pay for an individual with given income, Y, and characteristics t. The key to this procedure is to postulate a specific, parametric random utility model for the individual, set up the resulting response probabilities, fit the statistical model using observed responses, thereby obtaining estimates for the coefficients of the utility model, and then use the estimated utility model to calculate maximum willingness to pay. From equation (6.2.13) we know that $C = Y - m(v(0,Y;t) - w,1;t)$. Hanemann shows that two possible procedures for estimating maximum willingness to pay are to use the mean or median of the distribution of C, where C in our case is the compensating variation measure of welfare change. Both of these measures can be estimated from the fitted statistical response model. The mean is equal to the expected value of the area under the response probability function

$$C^{+} = \int_{0}^{500} (1 - G_c(BID))\, d\, BID,$$

where 500 is judged to be a maximum reasonable willingness to pay and $G_c$ is the cumulative distribution function of C (the shaded area in figure 6.2.2), and the median, $C^{\bullet}$, is the value at which the estimated response probability is 0.5.

The resulting willingness to pay amounts were summed over all individuals in the sample (the social value of improved water quaality is equal to the sum of individual's maximum willingness to pay for a given level of quality). Dividing this amount by the sample size we obtain an estimate of the average willingness to pay for water quality improvements for the average household in the sample population. Our results indicate a mean value ($C^{+}$) of $203.19 per household for water quality which is safe for swimming, and $210.22 per household for water quality such that shellfishing areas in the Upper Bay would not have to be closed due to pollution; and median values ($C^*$) of $190.84 and $170.08, respectively. These measures include option and existence values (Chapter 3). Considering the seriousness of the pollution problems in the Upper Narragansett Bay, these willingness to pay values seem reasonable. These values represent the maximum amount that people in the sample population would be willing to pay each year, until water quality projects are paid in full, to have water quality improved to swimmable/shellfishable levels.

### 7.1.3. Aggregate Benefits to the State from Improved Water Quality.

The aggregate benefits to the State of Rhode Island can be estimated by applying median income, the percentage of the population age 65 or older and the percentage of the population who have a college degree, by town, to the fitted binary response model. A weight is given to each town equal to the number of households (as occupied housing units) in the town as given in the 1980 Rhode Island Census of Population and Housing. Following the above procedure we estimate the willingness to pay for the average household in each town, by integrating under the response probability function from BID=$0 to BID=$500. The resulting willingness respondents were asked to value either shellfishing or shellfishing and swimming. WTPQ2 was equal to 1 if the respondent was asked to value shellfishing and swimming combined, and equal to 0 otherwise. WTPQ2 was found to be non-significant, which indicates that the way the second question was framed had little influence on responses to the willingness to pay question.

OLDAGE was not found to be a significant determinant of willingness to pay. However, one would expect a negative correlation between OLDAGE (specified to account for people on fixed incomes) and willingness to pay. People age 65 or older are generally on fixed incomes and would be less able to afford paying for water quality improvements. The coefficient on OLDAGE in the second model was of the expected sign.

### 7.2.3. Obtaining a Welfare Measure from the Estimated Continuous Choice Model.

Once we have our estimated model we can solve for willingness to pay to obtain a measure for the change in consumer surplus associated with an improvement in water quality. Because the functional form used in our estimated model was log-linear we can solve for willingness to pay by numerical methods.

First we estimate the maximum willingness to pay for the average household in our sample population. Using the sample data we solve for LOG(MAXWTP) then take the antilog of this result (adjusted for bias), to obtain the individual respondent's maximum willingness to pay.1 We then sum maximum willingness to pay over all respondents and divide by the sample size. This gives us the maximum willingness to pay for the average household in our sample population. Our results indicate an average willingness to pay of $47.00 and $42.00 per household for water quality which is safe for swimming and water quality such that shellfishing areas would not have to be closed due to pollution, respectively.

### 7.2.4. Aggregate Benefits to the State from Improved Water Quality Obtained from the Continuous Choice Model.

These results can be extended to obtain a measure for the aggregate benefits to the State of Rhode Island from improved water quality in Narragansett Bay. To do this we assign a weight to each town equal to the total number of occupied housing units as recorded in the 1980 Rhode Island Census of Population and Housing. We then apply median income, the percentage of the population age 65 or older, and the percentage of the population who have a college degree, by town, as recorded in the 1980 census, to the estimated model. The aggregate benefits to the State of