CHAPTER 3

VALUING PUBLIC GOODS: A COMPARISON OF SURVEY AND HEDONIC APPROACHES

INTRODUCTION

Although the theory of public goods has progressed rapidly since Samuelson's seminal article (1954), the empirical measurement of the value of (demand for) public goods only recently has received increased attention. Perhaps the best known and most widely accepted empirical approach has been the use of hedonic prices wherein, for example, it is assumed that either wages or housing values reflect spatial variation in public good characteristics of different communities. This indirect approach, based on theoretical work of Tiebout (1956), Lancaster (1966), Rosen (1974) and others has proven quite successful. Among public goods or bads which have been valued using the hedonic approach are climate [Hoch (1974)], air pollution [Anderson and Crocker (1971) and Harrison and Rubinfeld (1978)], social infrastructure [Cummings, et al. (1978)] and other community characteristics such as noise level [Nelson (1979)] and ethnic composition [Schnare (1976)].

An alternative approach is to directly ask households or individuals to state their willingness to pay for public goods using survey techniques. Despite arguments that strategic bias will invalidate survey results, there exists the need for an alternative to the hedonic approach. As an example, consider the case of a remote and unique scenic vista, valuable to recreators, which is threatened by air pollution from a proposed coal fired plant--a typical situation in the Western United States. Although it is possible, in principle, to impute the value of clean air and visibility from the relative decline in local visitation which might follow construction of a power plant, information on the value of visibility at the site is needed prior to construction for socially optimal decisionmaking on plant location and pollution control equipment. The hedonic approach is unavailable both because the scarcity of local population--as opposed to recreators--makes use of wage or property value data impossible and because scenic vistas may themselves be unique. For these reasons, Randall et al. (1974) first applied survey methods for valuing visibility and other environmental effects of large coal fired power plants in the Four Corners region of New Mexico. Since this initial application, the survey approach has been widely used to value environmental commodities where market data for hedonic analysis is difficult to acquire [see, for example, Brookshire, Ives and Schulze (1976), Rowe, et al. (1980), and Brookshire, et al. (1980)]. Other early attempts to value public goods using the survey approach include Davis (1963), Bohm (1972) and Hammack and Brown (1974).

Although results of using the survey approach for estimating the value of public goods appear to be internally consistent, replicable and consistent with demand theory [see Schulze et al. (forthcoming)], no external validation has been reported (i.e., a comparative analysis using another approach independent of the survey has not been conducted). Thus, the purpose of this paper is to report on an experiment designed to validate the survey approach by direct comparison to a hedonic property value study.

The Los Angeles metropolitan area was chosen for the experiment because of the well defined air pollution problem and because of the existence of detailed property value data. Twelve census tracts were chosen for sampling wherein 290 household interviews were conducted during March, 1978. Respondents were asked to provide their willingness to pay for an improvement in air quality at their current location. Air quality was defined as poor, fair, or good based both on maps of the region (the pollution gradient across the Los Angeles Metropolitan Area is both well defined and well understood by local residents) and on photographs of a distant vista representative of the differing air quality levels. Households in poor air quality areas were asked to value an improvement to fair air quality while those in fair areas were asked to value an improvement to good air quality. Households in good air quality areas were asked their willingness to pay for a region-wide improvement in air quality. The region-wide responses are reported elsewhere [Brookshire, et al. (1980)].

For comparison to the survey responses, data was obtained on 634 single family home sales which occurred between January, 1977 and March, 1978 exclusively in the twelve communities used for the survey analysis. As we show in the next section, households, in theory, will choose to locate along a pollution-rent gradient, paying more for homes in clean air areas based on income and tastes. However, ceteris paribus, we show that the annualized cost difference between homes in two different air quality areas (the rent differential for pollution) will in theory exceed the annual willingness to pay for an equivalent improvement in air quality for a household in the lower air quality area. Thus, the rent differential associated with air quality improvement from hedonic analysis of the property value data must exceed estimates of household willingness to pay for the survey responses, if the survey responses are a valid measure of the value of air quality improvements. Section 3 describes the data analysis and experimental design in more detail.

We also conjecture that the willingness to pay for air quality improvements is greater than zero for residents in our sample communities based on statewide political support for air quality regulation. The State of California, principally in response to the air pollution problem in the Los Angeles Metropolitan area, has led the nation in imposing automobile emissions standards. The automobile industry, under pressure from the California Legislature, installed the first pollution control devises on California cars in 1961. This initial step was followed nationally in 1963. Again, California imposed the first exhaust-emission control regulations in 1966, leading the nation by two years. Over the decade of the 1970's, California has had more stringent automotive emission standards than Federal levels, resulting in higher initial costs and sacrifices in both performance and fuel economy. In spite of these difficulties, political support, as reflected both in the State Legislature and in several administrations, has remained strong for auto emission controls.

In Section 4 the results of the hypotheses tests are presented. As Table 2 illustrates, results of the experiment can be summarized as follows: In the nine census tracts where air quality improvements are possible (poor and fair communities) , we cannot reject our dual hypotheses that, in each census tract, household willingness to pay for air quality improvements, as estimated by surveying households, falls below equivalent property value rent differentials and lies above zero. We view these results as a qualified verification of the survey approach for estimating the value of public goods. Further interpretation of the results is contained in the concluding remarks offered in Section 5.

A THEORETICAL BASIS

The property value and the survey approaches for valuing public goods have received considerable theoretical scrutiny. Property value studies are conceptually based on hedonic price theory as developed by Rosen (1974) and recently summarized by Freeman (1979). The survey approach has been modeled using standard concepts of consumer surplus by Randall et al. (1974), Bohm (1972), and Brookshire et al. (1976) where the latter two analyses also focus on the possibility of strategic behavior. The considerable empirical evidence now available suggests that strategic bias may be of little consequence both in survey work [See Brookshire et al. (1980) and Rowe et al. (1980)] and in experimental economics [See Grether and Plott (1979), Scherr and Babb (1975) and Smith (1977)]. However, other types of bias may still invalidate a survey approach for valuing public goods. It has even been suggested that the survey approach produces “noise” since responses are purely hypothetical and have no necessary connection to actual budgetary decisions.

In this section, a simple theoretical model is developed for comparison of survey responses to a property value study for valuing air quality improvements in the Los Angeles region in order to determine if valid public good measures can be obtained from survey data.

We use the following notation:

Let P = the level of air pollution
X = consumption of a composite commodity excluding housing
C = unit cost or price of the composite commodity X
R = rent or periodic cost of housing
Y = household income

and U(P,X) = household utility, a decreasing function of pollution $U_P < 0$ [1]
an increasing function of consumption $U_X < 0$.

Each household maximizes utility, U(P,X), subject to the budget constraint:

$$Y - CX - R(P) = 0$$

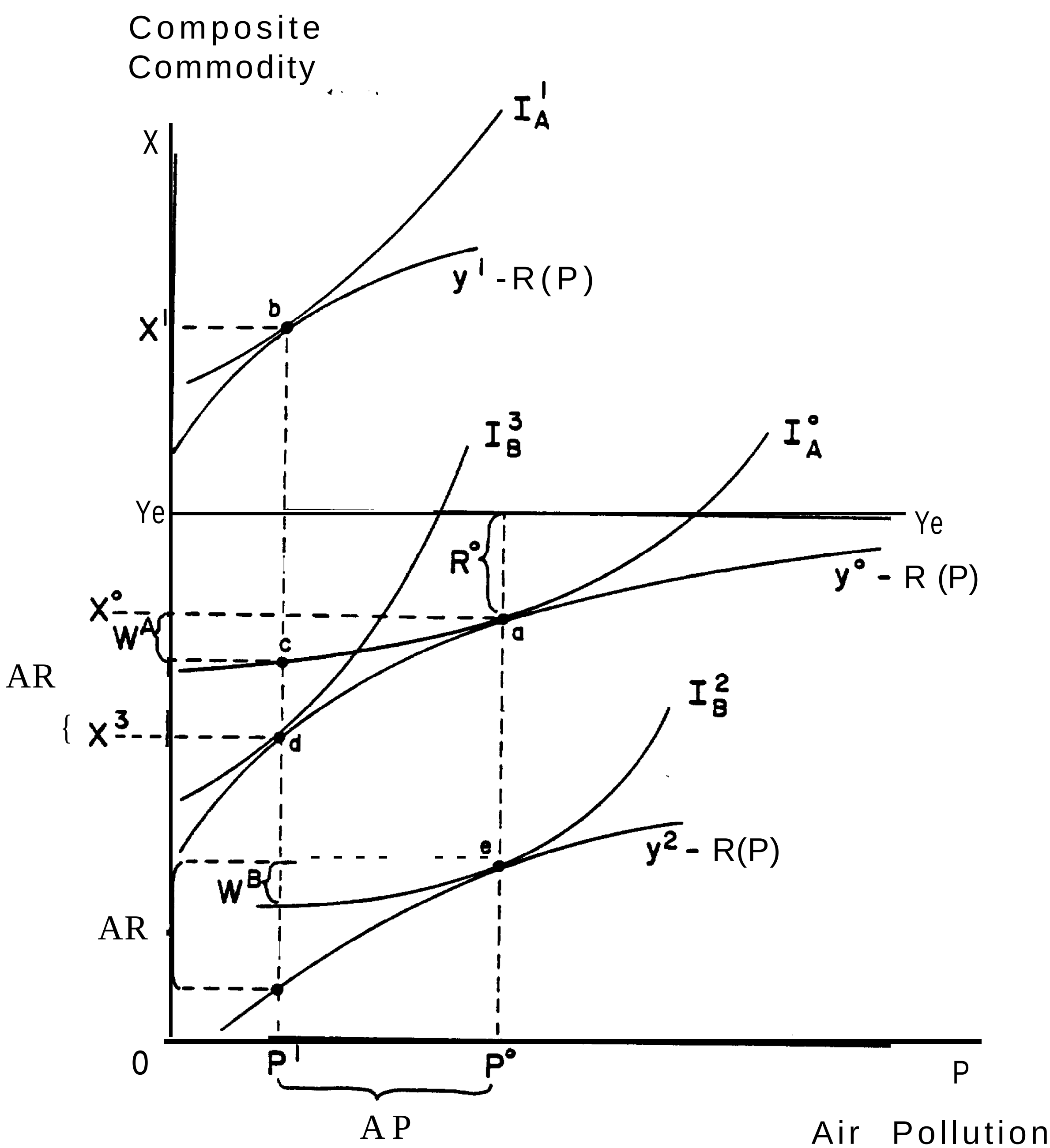
where we assume the existence of a continuous differentiable rent gradient R(P). [See Rosen (1974)] for a complete discussion of the generation and existence of rent gradients. Our model is a simple adaptation of Rosen’s, so we will not elaborate here.) Two distinct choices are modeled: consumption of the composite commodity, X, and that of housing location by pollution level, P. Presumably, lower rents will be paid for homes in more polluted areas, so $R'(P)<0$.[2] The first order conditions for choice of P and X imply that

$$C \frac{U_P}{U_X} = R'(P)$$

or that the marginal rate of substitution between pollution, P, and the composite commodity, X, valued at the cost of the composite commodity, C, equals the slope of the rent gradient R’(P) at equilibrium location and consumption levels.

Figure 1 illustrates the solution graphically and allows us to structure hypotheses for testing the validity of survey results in comparison to the property value approach. The vertical axis measures the quantity of the composite commodity, X, where we assume that the cost, C, of the composite

Figure 3.1



With identical housing attributes the identical rent differential, AR, exceeds individual willingness to pay, WA and wB.

commodity is unity; i.e., the vertical axis measures dollars as well. Pollution is on the horizontal axis. Given household income Y^0, the budget constraint, shown as $Y^0 - R(P)$ in Figure 1, is obtained by vertically subtracting the rent gradient, R(P). Thus, household A with preferences shown by indifference curve I^0_A would maximize utility at point "a", choosing to locate at pollution level P^0, consume X^0 and pay rent R^0. If household A's income were to increase to Y^1, the budget constraint would shift vertically to Y^1 - R(P) and the same household would relocate, choosing point "b", at a lower pollution level P^1 with higher consumption, X^1, given tastes as represented by indifference curve I^1_A. Alternatively, another household, B, with income Y^0, but tastes as shown by I^3_B would choose point "d", locating at P^1 as well, but choosing lower consumption X^3. Thus, both tastes and income enter location decisions over pollution levels.

The survey approach used in the Los Angeles metropolitan area to obtain an estimate of the value of air quality asked households how much, at most, they would be willing to pay for an improvement in air quality at the site where they presently live. Thus, the household in equilibrium at point "a" in Figure 1 was asked how much X it would forego to experience P^1 rather than P^0 while maintaining the same utility level. Presumably, household A would be indifferent between points "a" and "c" and be willing to pay W^A dollars (or units of X) to achieve a reduction in air pollution of AP. Unfortunately, as is illustrated in Figure 1, the budget constraint, Y^0 - R(P), obtainable by estimating the rent gradient function, R(P), does not provide information on the bid for improved air quality, W^A. Rather, the change in rent between locations with air quality levels P^0 and P^1, AR in Figure 1, must, for any household located at "a", equal or exceed the bid, W^A, if the second order conditions for the household optimization problem are generally satisfied. Thus, we can establish an upper bound on the willingness to pay for air quality improvement by examining the rent gradient. For example, if household B had a lower income, Y^2, it would locate at point "e". Even though household B is now located at pollution level P^0 like household A, its bid for an air quality improvement AP would be W^B, smaller than W^A yet still less than AR. Thus, if survey bids are a valid measure of willingness to pay for air quality improvements then AR > W.

This hypothesis holds for each household even if we consider the case of multiple housing attributes. Including other attributes such as square footage of the home, bathrooms, fireplaces, neighborhood characteristics, etc., denoted by the vector $\vec{Z}$, the model is revised as follows:

$$\max U(\vec{Z}, P, x)$$

$$\text{St. } Y - Cx - R(\vec{Z}, P) = 0$$

with first order conditions [3]

$$\frac{U_P}{U_X} = R_P(\vec{Z},P)$$

and

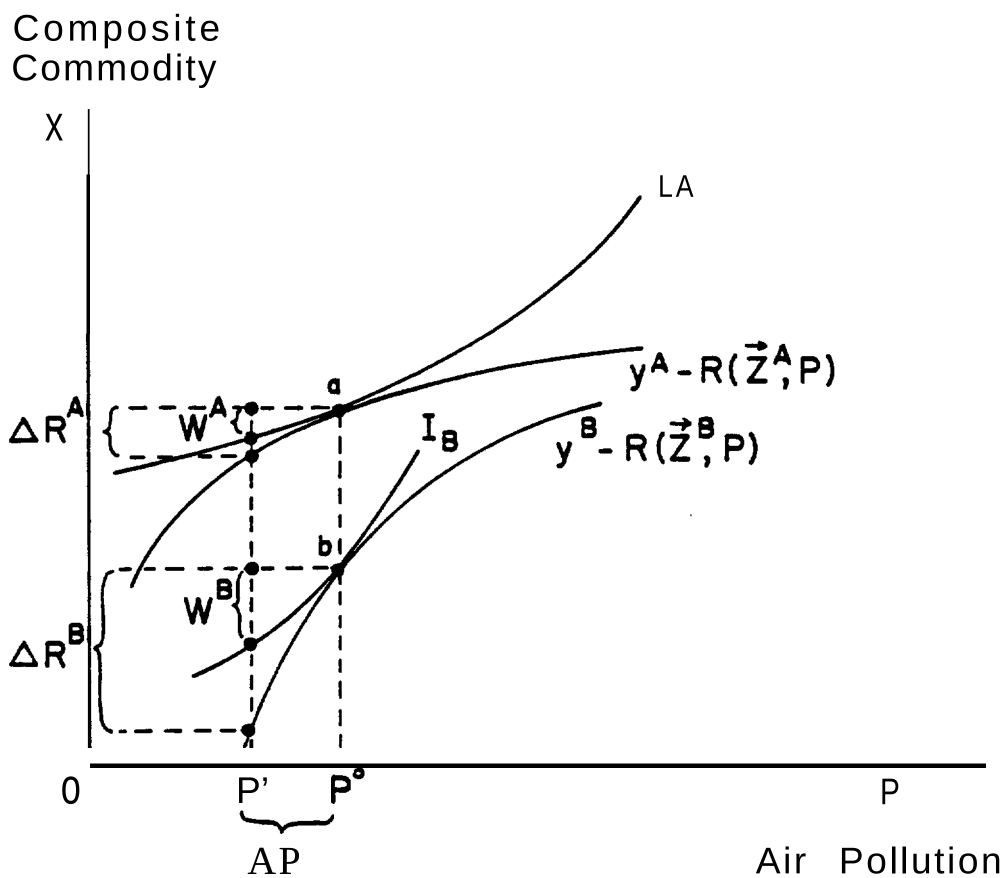
$$\frac{U_{\vec{Z}}}{U_X} = R_{\vec{Z}}(\vec{Z},P).$$

These first order conditions constitute, along with frequency distributions for housing characteristics and household preferences, a system of partial differential equations which solve for $R(\vec{Z},P)$.[4] Thus, a hedonic rent gradient is defined for pollution, P, and other household characteristics, $\vec{Z}$, as well.

As is illustrated in Figure 1, in which housing characteristics other than pollution are not incorporated, budget constraints for different households are obtained by vertically shifting the same rent gradient. Thus, all households face the same rent differential ΔR for a change in pollution level ΔP even though willingness to pay for that change may differ, i.e., $W^A \neq W^B$. However, turning to Figure 2, household A, located at $P°$, may occupy a house with attributes $\vec{Z}^A$ while household B also located at $P°$ may occupy a house with a different set of attributes $\vec{Z}^B$. Household A, with income Y^A, would then face a rent gradient like that shown in Figure 2 defined by $R(\vec{Z}^A, P)$ and choose point "a", but household B with income Y^B, would now face a different rent gradient of $R(\vec{Z}^B, P)$ and choose to locate at point "b". Therefore, households. with different housing characteristics may face different rent gradients over pollution when projected in the (X, P) plane. In general, ΔR, unlike the case shown in Figure 1, will no longer be constant across households at the same location. However, for each household i (i = A, B in Figure 2), it is still true that the rent differential, ΔR^i, for a change in pollution ΔP, calculated for the fixed vector of housing characteristics $\vec{Z}^i$, will exceed that household's willingness to pay, W^i, for the same change in pollution level at the same location. Note that households were asked their willingness to pay with the specific assumption that they remained in the same house and location. Thus, $\vec{Z}^i$, for a particular household was truly fixed - allowing the simple analysis in the (X,P) plane as shown in Figure 2.

The first hypothesis for testing the validity of the survey approach can be constructed as follows: for each household i in a community, $\Delta R^i \geq W^i$. It then follows that in each community the average rent differential across households, $\overline{\Delta R}$, must equal or exceed the average willingness to pay $\bar{W}$ for an improvement in air quality. In other words, if survey bids are a valid measure of willingness to pay, then for each community in our sample, $\overline{\Delta R} \geq \bar{W}$, i.e., average willingness to pay cannot exceed the average rent differential. Our second hypothesis is that, given the political history of air pollution control in the State of California as described in the introduction, mean bids

Figure 3.2



With differing housing attributes across households each individual rent differential exceeds that households willingness to pay.

in each community are nonnegative, $W > 0$.

Our dual test of the validity of survey measures must remain somewhat imprecise because hedonic rent gradients themselves only provide point estimates of the marginal rates of substitution (slopes of indifference tunes) between pollution and other goods (money) for individuals with possible differing tastes and income. One does not have information necessary to estimate, for example, the shape of 1°_{A} in Figure 1 solely on the basis of the slope of the budget constraint, $R'(P^{\circ})^{A}$, at point "a". Attempts to estimate individual willingness to pay (W^{A} in Figure 1) from hedonic rent gradients must thus introduce strong assumptions about the nature of preferences. (See, for an example of an hedonic approach which derives willingness to pay by making such assumptions, Harrison and Rubinfeld [1978].

SAMPLING AND DATA ANALYSIS

The previous section has presented a theoretical framework for a comparison between the survey technique and the property value approach for valuing public goods. In order to empirically implement the comparison, the two approaches require a consistent sampling procedure. This section describes the sampling procedure and results of the separate studies.

Sampling was restricted to households within the Los Angeles metropolitan area. The first concern was air pollution data. Air monitoring stations are located throughout the Los Angeles area providing readings on nitrogen dioxide (NO_2), total suspended particulate matter (TSP) and other pollutants. The objective was to relate as closely as possible the readings of two constituents of air pollution (NO_2 and TSP) to census tracts used both for the property value and survey studies. The air shed was divided into the following air quality regions: "good" (NO_2 < 9 pphm) (TSP < 90 $\mu g/m^3$); "fair" (NO_2 911 pphm) (TSP 9110 $\mu g/m^3$); and "poor" (NO_2 > 11 pphm) TSP > 110 $\mu g/m^3$). Improvements from poor to fair and fair to good across the region are each associated with about a 30% reduction in ambient pollution levels. Consideration was given to wind patterns and topography of the area in making these distinctions.

Many variables may affect the value households place on air quality. To control for as many of these as possible in advance of the actual experiment, the sample plan identified six community pairs where each pair was relatively homogeneous with respect to socioeconomic, housing and community characteristics, yet allowed for a significant variation in air quality.[5]

The property value analysis attempts to provide external validation for the survey approach. The absence of such validation explains in our view, the lack of general acceptance of survey techniques. The objective, then, is to estimate the hedonic rent gradient $R(\vec{Z}, P)$ and calculate rent differentials associated with the poor-fair and fair-good air quality improvements for sample census tracts. These results are then utilized for comparison to the survey results.

A hedonic rent gradient was estimated in accordance with literature as recently summarized by Freeman (1979).[6] Housing sale price is assumed to be a function of housing structure variables (living area, bathrooms, fireplaces, etc.), neighborhood variables (crime rate, school quality, population density, etc.), accessibility variables (distance employment to centers and beach) and air quality as measured by total suspended particulate (TSP) or nitrogen dioxide (NO_2).[7] The primary assumption of the analysis is that variations in air pollution levels as well as other household, neighborhood and accessibility attributes are capitalized into home sale price. Implicit or hedonic prices for each attribute are then determined by examining housing prices and attribute levels.

The property value analysis was conducted at the household level in order to provide an appropriate comparison to the survey instrument. Thus, the household data used were at the micro level of aggregation and include a large number of characteristics.[8] Data was obtained for 634 sales of single family homes which occurred between January, 1977 and March, 1978 in the communities used for the survey analysis. In addition to the immediate attributes of the household, variables which reflected the neighborhood and community were included to isolate the independent influence of air quality differentials on home sale price.

As indicated by Maler (1977) even under the presumption of correct model specification, estimation of a single equation hedonic rent gradient may be hindered by severe empirical difficulties, primarily multi-collinearity. With respect to this problem, in each of three data categories--household, neighborhood, and air quality--multicollinearity forced the exclusion of variables and the usage of proxy variables. For instance, collinearity between number of rooms, number of bedrooms and living area as quantitative measures of house size allowed the use only one--living area which serves as a proxy for all. Further, since housing density and population density measure essentially the same phenomenon, only the former is used in the estimated equations. The estimation procedure was not able to separate out the independent influence of each air pollutant. Thus, only one pollution measure, either NO_2 or TSP, was utilized to describe the level of air quality. In order to provide information concerning the sensitivity of our analysis, results are presented for each of these pollutants. Finally, contrary to expectation a collinearity problem did not exist between distance from beach and air pollution. This can be attributed, in part, to the success of the sample plan in isolating the effects of air quality.

Two alternative nonlinear specifications are presented in Table 1 alternatively using NO_2 or TSP to represent pollution level.[9] A number of aspects of the equations are worth noting.

First, approximately 90% of the variation in home sale price is explained by the variation in the independent variable set. Second, with only a minor exception, all coefficients possess the expected relationship to the dependent variable and are statistically significant at the one percent level. The exception is the crime rate in both the NO_2 and TSP equations. Third, in their respective equations, the log form of the pollution variables have the expected negative influence on sale price and are highly significant. The estimated relationship between house sale price and pollution is therefore consistent with the graphical analysis of Section 2; that is, the rent gradient is convex from below in the pollution/dollars plane. Finally, the stability or relative insensitivity of the regression coefficients to the particular pollution variable indicates that individuals have an aversion to pollution in general rather than to any one pollutant.

Estimation of the rent gradient was also completed using other forms of the pollution variables (linear, squared, cubic). Whereas the squared and cubic terms did not demonstrate statistical significance, the first order terms performed only marginally worse than the log formulation. Rent differentials have also been calculated for these and other forms with results nearly identical to those presented here.

The next step was to estimate the rent differential ΔR_i for each individual household for each census tract. The rent differential specifies the premium an individual household would have to pay to obtain an identical home in the next cleaner air region (poor to fair for six communities, fair to good for three communities). Due to the estimated functional form of the rent gradient, the calculated rent differential is dependent upon the value of all other variables.[10] The average home sale price change based on individual data in each census tract associated with an improvement in air quality, *ceteris paribus,* is shown in column two of Table 2 of the next section. Column one of Table 2 lists communities by air quality level. The table only shows for the log-linear NO_2 equation since, as noted above, other specifications give nearly identical results. The figures shown are derived by evaluating the hedonic housing expression, given the household's characteristics, for a pollution change from poor to fair or fair to good as the case may be. The resulting sale price differential is then converted to an equivalent monthly payment through the standard annualization procedure and

Table 3.1

Estimated Hedonic Rent Gradient Equations[a]

Dependent Variable = Log (Home Sale Price in $1,000)

Independent Variable	NO_2 Equation	TSP Equation
Housing Structure Variables		
Sale Date . . .	.018591 (9.7577)	.018654 (9.7727)
Age	-.018171 (2.3385)	-.021411 (-2.8147)
Living Area	.00017568 (12.126)	.00017507 (12.069)
Bathrooms	.15602 (9.609)	.15703 (9.6636)
Pool	.058063 (4.6301)	.058397 (4.6518)'
Fireplaces	.099577 (7.1705)	.099927 (7.1866)
Neighborhood Variables		
Log (Crime)	-.08381 (-.5766)	-.10401 (-1.9974)
School Quality	.0019826 (3.9450)	.001771 (3.5769)
Ethnic Composition -(Percent White)	.027031 (4.3915)	.043472 (6.2583)
Housing Density	-.000066926 (9.1277)	-.000067613 (-9.2359)
Public Safety Expenditures	.00026192 (4.7602)	.00026143 (4.7418)
Accessibility Variables		
Distance to Beach	-.011586 (-7.8321)	-.011612 (7.7822)
Distance to Employment	-.28514 (-14.786)	-.26232 (14.158)
Air Pollution Variables		
log (TSP)		-.22183 (-3.8324)
log (NO_2)	-.22407 (4.0324)	
Constant	2.2325 (2.9296)	1.0527 (1.4537)
R^2	.89	.89
Sum of Squared Residuals	18.92	18.97
Degrees of Freedom	619	619

[a] t - Statistics in Parentheses

Table 3.2

Tests of Hypotheses

Community	Property Value Results[a]		Survey Results		Tests of Hypotheses	
	$\overline{\Delta R}$ (Standard Deviation)	Number of Observations	$\overline{W}$ (Standard Deviation)	Number of Observations	t-statistics $\mu_{\overline{W}} > 0$[b]	t-statistics $\mu_{\overline{\Delta R}} \geq \mu_{\overline{W}}$[c]
Poor - Fair						
El Monte	15.44 (2.88)	22	11.10 (13.13)	20	3.78	1.51
Montebello	30.62 (7.26)	49	11.42 (15.15)	19	3.28	7.07
La Cañada	73.78 (48.25)	51	22.06 (33.24)	17	2.74	4.10
Sample Population	45.92 (36.69)	122	14.54 (21.93)	56	4.96	5.54
Fair - Good						
Canoga Park	33.17 (3.88)	22	16.08 (15.46)	34	6.07	5.07
Huntington Beach	47.26 (10.66)	44	24.34 (25.46)	38	5.92.	5.47
Irvine	48.22 (8.90)	196	22.37 (19.13)	27	6.08	5.08
Culver City	54.44 (16.09)	64	28.18 (34.17)	30	5.42	11..85
Encino	128.46 (51.95)	45	16.51 (13.38)	37	7.51	12.75
Newport Beach	77.02 (41.25)	22	5.55 (6.83)	20	3.63	7.65
Sample Population	59.09 (34.28)	393	20.31 (23.0)	186	12.02	14.00

[a]Rent differentials for the hedonic housing equation in which log (NO_2) is the relevant pollution variable are presented here. Essentially identical results are obtained using NO_2, TSP or log (TSP).

[b]The hypotheses to be tested were $H_0: \mu_{\overline{W}} = 0; H_1: \mu_{\overline{W}} > 0$. All test statistics indicate rejection of the null hypothesis at the 1% significance level.

[c]The hypotheses to be tested were $H_0: \mu_{\overline{\Delta R}} \geq \mu_{\overline{W}}; H_1: \mu_{\overline{\Delta R}} < \mu_{\overline{W}}$. All Test statistics indicate that the null hypothesis could not be rejected even at the 10% significance level.

division by twelve.[11] Since our hypothesis test is posed in terms of the average rent differential in the relevant communities, then a community mean and standard deviation are calculated. Column three of Table 2 shows the number of homes for which data was available to calculate average rent differentials and standard deviations for each community. Monthly rent differentials ranged from $15.44 to $45.92 for an improvement from poor to fair air quality and $33.17" to $128.46 for an improvement from fair to good air quality. The higher figures in each case are associated with higher income communities. Again, these average differentials should provide an upper bound for the survey results.

The survey approach followed the work of Davis (1963) and Bohm (1972) in gathering the information necessary for estimating a Bradford (1972) bid curve. The approach involves the establishment of a hypothetical market via a survey instrument. Through the work of Randall, et al., (1974) and Brookshire, et al., (1976), the necessary structure for constructing a hypothetical market for the direct determination of economic values within the Hicksian consumer surplus framework has been developed. The survey reported here is consistent with this previous literature.

The hypothetical market was defined and described both in technical and institutional detail. The public good (air quality) was described by the survey instrument to the respondent in terms of easily perceived levels of provision such as visual range through photographs[12] and maps depicting good, fair and poor air quality levels over the region. Respondents had little difficulty understanding the levels of air quality represented to them because of the sharp pollution gradient across the region.

Payment mechanisms[13] were specified within the survey instrument and the respondent was asked to react to alternative price levels posited for different air quality levels. In every case the basis for the bid for better air quality was the existing pollution situation as determined by location of their home shown on a map of the Log Angeles metropolitan area which depicted regional air quality levels. Various starting points for the bidding prices and differing information structures were included in the survey format. Biases from alternative starting points and information structures were not present in the results [See Brookshire, et al. (1980)].[14]

The survey was conducted over the period of March, 1978. A total of 290 completed surveys were obtained for the above mentioned areas. Sampling was random within each paired area.[15]

Table 2 in the next section presents the mean bids and standard deviations and number of observations in Columns four and five respectively for each community for an improvement in air quality. Two types of bids are presented: proposed improvements from poor to fair air quality and from fair to good air quality. In poor communities--El Monte, Montebello and La Canada--the mean bids ranged from $11.00 to $22.06 per month. For the fair communities--Canoga Park, Huntington Beach, Irvine, Culver City, Encino and Newport Beach communities--the mean monthly amounts range from $5.55 to $28.18 to obtain good air quality.

TEST OF HYPOTHESES

The previous sections have described a theoretical structure and two different empirical estimation techniques for determining the value of urban air quality improvements in the Los Angeles metropolitan area. The theoretical relationship between the valuation procedures ($\overline{AR} \geq \overline{W}$) and the hypothesis that survey bids are non-zero ($\overline{W} > 0$) are tested in this section.

Table 2 presents the community average survey bids (column four) and corresponding rent differentials (column two). As is indicated, in each community the sample survey bids are non-zero and less than the calculated rent differentials in absolute magnitude. This establishes that the survey bid bounds are consistent with our theoretical arguments but does not indicate statistical significance, which is provided below.

With respect to the test of equality of mean survey bids to zero, Table 2 (column six) presents the experimental results. The calculated t-statistics indicate rejection of the null hypothesis (that the population mean, $\mu_{\overline{Y}}$ equals zero at the one percent level in every community sampled.) These results are in accordance with the political situation of the region and indicate that individual households are willing to pay amounts significantly greater than zero for an approximate 30% improvement in air quality.

The comparison of the survey bids to the estimated rent differentials is presented in Table 2 (column seven). In this instance the compound hypothesis that population average rent differential ($\mu_{\overline{WR}}$) equals or exceeds the population average survey bid ($\mu_{\overline{\Delta}}$) is again tested using the t-statistic. Rejection of the null hypothesis requires that the calculated t-statistics be negative and of sufficient magnitude.[16] The standard t-test calculations (column seven, Table 2) imply that the hypothesis $\mu_{\overline{\Delta R}} \geq \mu_{\overline{W}}$ cannot be rejected for the population means $\mu_{\overline{R}}$ and $\mu_{\overline{W}}$ even at the 10% critical level. Although we present only the results for the hedonic housing equation in which log (NO_2) is the pollution measure, these results remain essentially unchanged for all communities, for all estimated hedonic rent gradients, regardless of the variable (NO_2 or TSP) utilized as a proxy for the general state of air quality. The results then are quite insensitive to the particular hedonic model specification, providing a degree of generality to the results.

The hypotheses tests indicate that the empirical analysis is entirely consistent with the theoretical structure outlined above. This conclusion, when combined with the absence of any identified biases [see Brookshire, et al. (1980)] suggests that survey responses yield estimates of willingness to pay for environmental improvements in an urban context consistent with a hedonic- market analysis. A further implication is that individual households demonstrated a non-zero willingness to pay for air quality improvements rather than free riding. This conforms to the previous survey resuits of Brookshire, et al. (1976) and Rowe, et al. (1980) as well as the experimental work of Scherr and Babb (1975), Smith (1977) and Grether and Plott (1979) concerning the role of strategic behavior. This seems to indicate that the substantive effort to devise a payment mechanism free of strategic incentives for consumers [see Groves and Ledyard (1977)] has been directed towards solving a problem not yet empirically observed. However, the conclusions of this experiment are not without qualifications. In the next section possible limitations of survey analysis and conclusions concerning the efficacy of employing surveys to value a wide range of non-market commodities are discussed.

CONCLUSION

There are a number of limitations in generalizing our results to all survey work. First, this experiment was conducted in the South Coast Air Basin where individuals have both an exceptionally well-defined regional pollution situation and a well-developed housing value market for clean air. The effect of clean air on housing values appears to be exceptionally well understood in the Los Angeles metropolitan area. Thus, the Los Angeles experiment may be a special case in which an informed populace with market experience for a particular public good allowed the successful application of the survey approach. In particular, situations where no well-developed hedonic market exists may not be amenable to survey valuation. Biases due to lack of experience must then be considered a possibility. However, existing studies by Randall et al. (1974) and Brookshire et al. (1976) and Rowe et al. (1980) of remote recreation areas certainly suggest that survey approaches provide replicable estimates of consumer's willingness to pay to prevent environmental deterioration, without prior valuation experience.

In summary, this paper set out to both theoretically and empirically examine the survey approach and to provide external validation for survey analysis. The theoretical model described in Section 2 predicts that survey responses will be bounded below by zero and above by rent differentials derived from the estimated hedonic rent gradient. In order to test the dual hypotheses a survey and a traditional analysis of the housing market were undertaken. Each was based upon a consistent but random sampling procedure in the Los Angeles Metropolitan area. The empirical results do not allow the rejection of either of the two hypotheses, thereby providing evidence towards the validity of survey methods as a means of determining the value of public goods .

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1. Alternatively we could define the utility function U(-P, X) which would be an increasing quasi-concave function of both arguments.

2. Primes or subscripts denote derivatives or partial derivatives respectively throughout the paper.

3. The second expression is, of course, a vector of conditions, one for each attribute.

4. For a continuous model one could specify a taste parameter in the utility function and specify a distribution of households over that parameter. To complete a closed model one also needs the distribution of housing units over characteristics.

5. The paired areas with associated census tract marker and air quality level are respectively (1) Canoga Park - #1345 - fair/El Monte - #4334 poor, (2) Culver City - #2026 - fair/Montebello - #4301.02 and part of #5300.02 - poor, (3) Newport Beach - central #630.00 - fair/Pacific - northeast portion of //2627.02 and southwest intersection good; (4) Irvine - part of #525 - fair/Pales Verdes - portion of good; (5) Encino - portion of #1326 - fair/La Canada - south-central portion of #4607 - poor; (6) Huntington Beach central portion of #993.03 poor/Redondo Beach - eastern portion of #6205.01 and #6205.02 - good. For a map showing the monitoring station locations in relation to the paired sample areas and the air quality isopleths see Brookshire, et al. (1980).

6. The estimation of a hedonic rent gradient requires that rather restrictive assumptions are satisfied. For Example, Maler (1977), has raised a number of objections to the hedonic property value approach for valuing environmental goods. These include the possibility that transaction costs (moving expenses and real estate commissions) might restrict transactions leaving real estate markets in near constant disequilibrium; and that markets other than those for property alone might capture part of the value of an environmental commodity. The first

of these criticisms is mitigated by the extremely fluid and mobile real estate market of the late 1970's in Los Angeles, where rapidly escalating real property values increased homeowner equity so quickly that "house jumping" became financially feasible. The second of Maler's concerns, that other prices, e.g., golf club fees and wages capture part of the willingness to pay can be addressed empirically. For example, attempts to test if wages from our survey data across the Los Angeles area reflected differences in pollution level produced negative results.

7. Note that we use sale price or the discounted present value of the flow of rents rather than actual rent as the dependent variable. Given the appropriate discount rate the two are interchangeable.

8. Housing characteristic data was obtained from the Market Data Center, a computerized appraisal service with central headquarters in Los Angeles, California.

9. Although the nonlinear equations provide large t values on the air pollution coefficients, the coefficients on the pollution variables in the linear equations possessed the expected relationship and were significant at the 1% level. Also, the calculated rent differentials associated with the linear specifications were larger than those from the nonlinear equations.

10. It should be noted that the nonlinear estimated equations will give biased but consistent forecasts of rent differentials. However, the linear estimated equations in all cases forecast larger rent differentials than the nonlinear estimated equations presented here.

11. A capital recovery factor equal to .0995 which corresponds to the prevailing .0925 mortgage rate in the January, 1979 - March, 1978 period is used.

12. In developing photographs, two observational paths from Griffith Observatory in Los Angeles were chosen: (1) toward downtown Los Angeles, and (2) looking down Western Avenue. The approximate visibility (discernible objects in the distance, not visual range) for poor visibility was 2 miles, for fair visibility 12 miles, and for good visibility 28 miles.

13. Payment mechanisms are either of the lump sum variety, or well specified schemes such as tax increments or utility bill additions. The choice in the experimental setting varies according to the

structure of the contingent market.

14 Questions have been raised as to problems of biases in the survey approach. Strategic bias (i.e., free rider problems), hypothetical bias, instrument bias all have been explored. Generally speaking, problems of bias within the survey approach have not been prevalent. For a general review of the definition of various biases and results of different experiments see Schulze et al. (forthcoming) and for investigations of strategic bias utilizing other demand revealing techniques see Scherr and Babb (1975) and Smith (1979).

15. Interviewer bias was not present. No records were kept that would enable the testing for non-respondent bias.

16. For instance, rejection of the null hypothesis ($\mu_{\overline{A-R}} \geq \mu_{\overline{W}}$) at the one percent level would require a calculated t-statistic less than -2.326 given a large number of observations. Since none of the calculated t-statistics are negative the null hypothesis cannot be rejected [See Guenther (1973)].

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CHAPTER 4

THE ADVANTAGES OF CONTINGENT VALUATION METHODS FOR BENEFIT-COST ANALYSIS

INTRODUCTION

Historically, policy decisions regarding the alteration or manipulation of natural systems have relied to some extent upon the methods of benefit-cost analysis to provide information about the efficiency attributes of selected alternatives. Construction programs of the Army Corps of Engineers and the Bureau of Reclamation are probably the best examples. These programs have usually had explicit market price information on the value of additional water or electricity that could be used to analyze the benefits and costs. When non-marketed goods, such as loss of wildlife habitat, were to be influenced by the project, they were not formally incorporated into the benefit- cost analysis.

A developing emphasis, however, on valuing non-marketed goods and incorporating these values into formal benefit-cost analyses can be traced in part to recent Federal and State legislation oriented toward environmental quality regulation and preservation. Quantification of non-market benefits to establish the economic efficiency of regulatory decisions is required, for example, under the Occupational Safety and Health Act of 1970, the Safe Drinking Water Act, the Clean Air Act Amendments of 1977, the Toxic Substances Control Act, the Endangered American Wilderness Act, and others.

The implications of this requirement for policy and for benefit-cost analysis are severe. First, many of the key components of the benefits are several steps removed from a direct relation with a marketed good. When considering potential degradation of a Class I visibility area such as the Grand Canyon National Park, how is value to be placed on the scenic beauty of the colors and the pristine visibility? What is the value of being able to see 120 miles versus 90 miles? Additionally, what are the benefits of permanently preserving ancestral habitat for bighorn sheep versus utilization of the area for a natural resource development when both preservation and development can benefit current and future generations? What are the benefits of reduced risk to life? What are three less years of life worth, or 20 illness days per year? These types of questions either implicitly or explicitly are raised by today's legislative mandate. Thus, recent legislative history asks of benefit-cost analysis to assess various trade-offs for which many of the key value components of the tradeoff process are not readily observable in the market place. Further, many of the valuations necessary do not have readily observable market surrogates available to impute the value of non-market commodities. For instance, property value studies have been proposed as a manner to impute the value of air quality in urban regions. How could such an approach possibly work in the Four Comers region of the sparsely populated Southwest? How could travel cost methodologies possibly impute the value of critical habitat preservation? The answer, of course, is that they cannot.

An additional issue in valuing non-market environmental goods is that the policy alternatives frequently involve the provision of some quantity of the good or the restructuring of property claims on the good in a fashion outside the realm of recent historical experience. If behavior and valuations are sensitive to these institutional and quantity perturbations, retrospective observations have little to offer to the benefit-cost analyst. For example, the development of a massive synthetic fuel industry in the Rocky Mountain area could, if atmospheric emissions are uncontrolled, cause major deteriorations in the area's atmospheric visibility. However, because there has historically been little degradation of visibility in the area, that record which could allow the economic value of any change to be empirically determined does not exist. To acquire the record, one must either develop the synthetic fuels industry, hoping that the development can be reversed if the value of atmospheric degradation proves excessive, or undertake small scale experiments that generate data by artificially perturbing the essential features of the problem. On the presumption that the former course can be exceedingly expensive., we present heuristic arguments for the use of experiments. Our attention is focused upon contingent valuation studies of complex natural processes rather than upon carefully controlled laboratory studies. Plott (1979) has recently written a valuable review and defense of laboratory studies.

Contingent valuation studies are distinguished from traditional benefits assessment practices by their use of survey questionnaires to acquire the data for analysis. Despite a paucity of empirical evidence to support or deny its significance, the systematic misrepresentation of preferences is widely recognized among economists as being potentially a serious disadvantage of using survey questionnaires for valuation purposes. Our purpose is to raise the possibility that economists, by their near-exclusive devotion to the strategic behavior problem, may, at their own apparently unrecognized cost, have neglected many of the analytical and empirical advantages to be reaped through the use of survey instruments to acquire valuation information. We will examine these advantages in terms of the contribution survey questionnaires can make to filling the informational void the policymaker now often faces, and in terms of the conformity of their data-generating process with the economic-theoretic foundations of benefit-cost analysis. Any thorough assessment of the relative reliabilities and validities of data generated by survey questionnaires'and by observed behavior must weigh these advantages.

CONTINGENT VALUATION APPROACHES

The key to contingent valuation approaches to valuing a non-marketed good is the construction of a hypothetical market for that good. The procedure is as follows:

a. The non-market commodity is described in quantity, quality, location and time dimensions. Various types of supplementary information including maps and photo graphs are introduced when appropriate.

b. The rules of operation of the hypothetical market are established. Then a representation of the available quantity of the environmental good is perturbed and the respondent is asked to state willingness-to-pay or required compensation, or the activity substitutions and expenditure adjustments he would make. Both a status quo quantity of the good and price are explicitly stated by the interviewer prior to any respondent statements. The first is a direct approach, while the second provides infor mation for using the indirect techniques commonly employed with data on actual observed behavior.

c. The market rules of operation, bidding vehicles, and status quo prices and quantities may differ across respondents. Each respondent is presented a status quo price and/or quantity of the non-marketed good; the price and/or quantity of the good is then altered by the interviewer until a combination is reached to which the respondent is indifferent.

Thus, a series of contingent markets are established with a mechanism of payment suggested for the alternative levels of the non-market good in question. For instance, a proposed power plant of 1000 kilowatt capacity located ten miles from a site is said to result in a 25 mile reduction in the visual range, and the respondent is asked whether he would be willing to pay perhaps fifty dollars over some specific time period to prevent the reduction.

An important element in the process is clearly defining the non- marketed good in a manner that establishes a clear linkage to physical parameters. For atmospheric visibility, this would include linking power plant emissions to ambient concentrations, and ambient concentrations to the representation of ambient concentrations used in the interview.

Bradford (197?)) has set forth the analytical basis of the direct version (bidding games) of the contingent valuation technique. Davis (1963) and Randall, et al. (1974), made the first empirical applications to environmental goods. Instruments that collect information on time and budget adjustments and then employ this information to infer valuations of a non-marketed good, have the bulk of their analytical foundations presented in Hori (1975) and Freeman (1979).

Published papers employing these contingent claims games to acquire information have valued non-marketed goods as diverse as public television programming [Bohm (1972)]; atmospheric visibility [Randall, et al. (1974, Brookshire, et al. (1976), and Rowe, et al. (forthcoming)]; land-form alterations due to strip mining [Randall, et al. (1978)]; air pollution-induced health effects [Loehman, et al. (forthcoming), and Brookshire, et al. (forthcoming (a))]; wildlife [Hammock and Brown (1974) and Brookshire, et al. (forthcoming (b))]; water pollution [Gramlich (1977)]; preservation of river headwaters [O'Hanlon and Sinden (1978), and Sinden and Wyckoff (1976)]; urban infrastructure allocations for expenditures and taxes [Strauss and Hughes (1976)]; and airplane safety [Jones-Lee (1976)]. In addition, there are a number of as yet unpublished reports and papers that have used the technique to value atmospheric visibility [Horst and Crocker (1978)1; power plant cooling towers [Curry, et al. (1979)]; boomtown infrastructure [Cummings and Schulze (1978), Brookshire and d'Arge (1979)]; urban public parks [Vaughn (1974)]; odors [Loehman, et al. (1978)]; and geothermal steam development in wilderness areas [Ben-David, et al. (1977)].

One might reasonably conclude from this listing that in spite of the persistently held belief that valuations established through contingent (hypothetical) claims games are systematically biased, there have nevertheless been some economists who have overcome their skepticism.[1] However, they have not yet offered a coherent presentation of the advantages of their technique. In succeeding sections, we present some of the elements on which advantages might stem.

CONTINGENT VALUATIONS AND THE CONSUMER SURPLUS FRAMEWORK

Buchanan (1969) distinguishes between *ex ante* and *ex post* costs. He argues that it is the former that is relevant to choice. We employ the distinction to establish the place of contingent valuations in a consumer surplus framework. Contingent valuations are seen as providing a means for the potentially affected individual to participate in the choice of the provision The choice to be used for valuation purposes is based upon "what could be," rather than upon "what might have been."

In making a decision about cost (either a bid in direct valuation, or reallocation of time and budget components in indirect valuation), an individual in the contingent valuation approach is setting forth his evaluation of the prospective sacrifices or gains in utility as a result of the proposed contingencies. Thus, cost is a choice-bound concept, and choices are based on prospects referenced in the type of information provided. Cost, then, in its relationship to choice must be based on expectations, not experience. This viewpoint suggests that : (1) the oft-discussed discrepancies between observed and proposed behavior [e.g., Fromm (1968) and Mills and Feenberg (1977)] are not an issue in valuing non-market commodities unless the information underlying the proposed behavior is identical to the information leading to the actual behavior; (2) for given information, the contingent valuation framework provides valuations in terms of expected value to the individual, i.e. , willingness-to-pay for the prospective outcome.

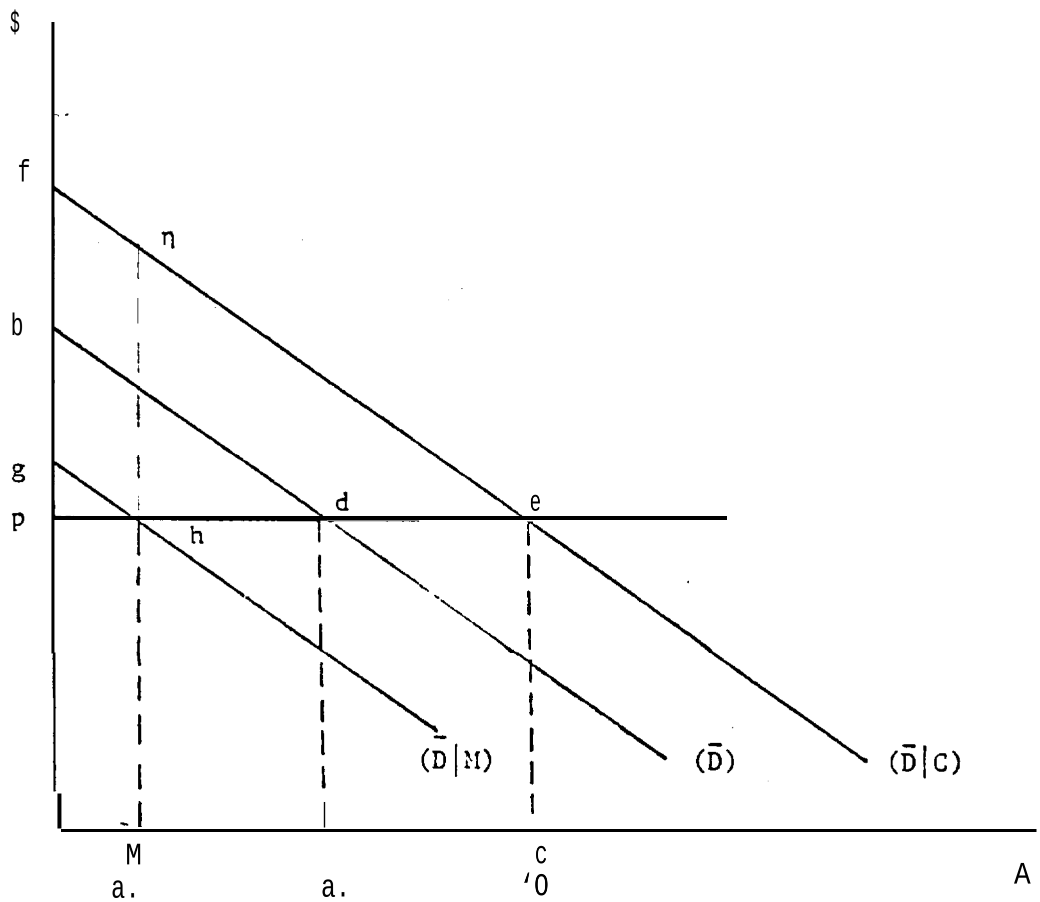
Let us consider an example that illustrates these points in the context of a contingent valuation market. Assume that a respondent's demand for a marketed activity (e.g., camping in a national park) is weakly complementary in the non-marketed commodity (e.g., visibility as measured by the distance that can be seen in and around a national park).[2] Participation in camping is assumed to have an invariant opportunity cost of P, which is independent of the level of availability of atmospheric visibility in the national park. In Figure 1, the $\bar{D}$ curve represents the individual's income-compensated demand function for the camping activity (A), averaged over all possible levels of atmospheric visibility.

The ability to observe distant mountains from the camping site enhances the utility of camping. The efficient plan for the camper with no forecast of the availability of clear vistas is to undertake the activity at activity level a_0 in Figure 1, where a_0 represents average visibility versus a pristine or murky level of visibility. The marginal value attached to an additional planned unit of camping just equals the individual's opportunity cost. The consumer surplus expected from camping, once the activity begins, is the area above the opportunity cost line and beneath the "average demand" function $\bar{D}$. The latter is the individual's mathematical expectation of the valuation attached to camping levels, once realized.

Now suppose a formal contingent market is constructed where the non-

Figure 4.1

Effect of An Improvement in Information
on Consumer's Surplus.



marketed commodity, atmospheric visibility in and around the national park, is described to the would-be camper in the requisite detail. For instance, coal fired power plants will either be installing control devices or shutting them down for maintenance. Visibility in and around the park will thus be clear (C) or murky (M) during the camping trip. The manner in which the camper will revise his estimates about the probability of clear or murky conditions can be described by Bayes' (1764) rule. If the information leads to the conclusion of clear visibility, the camper's subjective evaluation of his average compensated demand function will be (D/C), with a planned increase in camping activity to a_0^C. The area (b-d-e-f) gives the increase in expected utility if "clear" is the forecast. If the forecast is "murky," the planned activity level will be reduced to a_0^M, and the area (b-d-h-g) gives the loss in expected utility.

Now suppose that M is forecast, implying a planned activity level of a_0^M, and an expected consumer surplus of g-p-h. If, instead, C is realized and the camper is unable to adjust his activity level accordingly, he will have obtained a consumer surplus of p-h-f-n, an amount greater by g-h-n-f than the consumer surplus on the basis of which he made his decision to go to the park. This latter consumer surplus, which is established from observed behavior, has no correspondence to the basis of the camper's choices. In fact, according to the opportunity the camper has to adjust his activities, any activity level from the origin to a^C might be observed.[3] Only if clear skies had been forecast and actually realized would the camper's expected and realized consumer surpluses coincide, thus allowing the investigator to infer the utility basis of the camper's choices from his observed behavior. In contrast, contingent valuation techniques place the individual in a representation of the context in which he actually makes choices. Unless policy maker decisions about levels of provision of non-marketed goods are to be only randomly connected to the nexus the individual confronts, the appropriate state for measuring consumer surplus is that corresponding to the instant of the individual's decision.

HYPOTHETICAL BEHAVIOR AND MARKETS

If different answers can be anticipated based upon alternative information structures, what "state" is the appropriate one for measuring consumer surpluses for benefit-cost analysis? Can a contingent market be developed that is "appropriate" to the policy question at hand? What happens if informational content of an observable market is identical to that of a contingent market.

Fromm (1968) and many other economists believe that hypothetical questions generate fictional and, therefore, inaccurate responses. The dictionary defines a hypothetical proposition as a conditional proposition, i.e., an "if X, then Y" statement. A hypothetical question would then be a conditional statement in the subjunctive mood, an "if X were . . . ., then . . . ." statement. In the contingent valuation setting, a hypothetical market is constructed, perturbed and then the respondent states conditional behavior based on the specified market structure or events. Fundamentally, the problem is not hypothetical, but one of the relation between information and choice as set out for the camper in the immediately preceding section.

The individual's ultimately realized benefits and his prospective evaluations are neither jointly instantaneous nor coincidental. Frequent discrepancies should then be expected between response to contingencies embodying one form of information and eventual observable behavior carried out upon the basis of altered information. The key point is that the contingent answer is still acceptable given the well-defined circumstances that were presented to the respondent. The question of inaccuracy is then not whether, given a change in circumstance, the observable behavior pattern changes, but whether the contingent answer can be observed when the defined circumstances have not changed. Only if the answers relate to past rather than intended behavior will a simple comparison of answers with actual behavior suffice to ascertain the accuracy of the answers. Otherwise, one must explain how the individual responds to new information and circumstances in order to perform the comparison.

An empirical rebuttal of these points would require evidence that the provision of additional information about future states does not change contingent values and that contingent values and observed market values fail to coincide when the defined circumstances in the hypothetical market and the actual market are similar. In this section, we offer brief summaries of two studies that contribute to this empirical evidence.

The first study was performed in Farmington, New Mexico, where a hypothetical market for alternative levels of visibility due to additional energy development [Rowe, et al. (forthcoming)] was developed. The appropriate "states" corresponded to energy development scenarios for the Four Corners area. To investigate the role of information, after direct valuation responses had been received, a subsample of respondents was told either that others had bid a certain amount or that the bid of the subsample was so low that the proposed change in the allocation of the non-market good was impossible. In both instances, respondents were given the opportunity to revise their valuation. The results indicated that the valuation measures were affected by the structure and the information content of the contingent market. Thus, at least in this case, information about the behavior of other market participants affected valuations. This behavior is, of course, consistent with the strategic behavior predictions of the free-rider decision problem in public choice theory.

The second study was conducted in the South Coast Air Basin of southern California [Brookshire, et al. (forthcoming (a))]. A residential property value study based on sales of individual properties in a sample of paired communities where mcst of the variation in physical attributes within a pair was due to air pollution was performed. Similarly, during the same time period that the property sales occurred, a contingent valuation study within the same paired community sample was undertaken. The set of circumstances depicted in the contingent valuation study was those actually prevailing in the Basin at the time of the property value sales. Within a factor of less than two, the two independent studies produced similar valuations. For an approximate 30% improvement in the ambient air quality of the Basin, the property value study gave an average dollar bid per household per month of $42, while the bidding game study yielded a mean bid of $29 per household per month.

COSTLESS VERSUS COSTLY EXCHANGE

Even if the information available to participants in an everyday actual market and in a contingent valuation exercise were identical, there remains at least one reason why the two types of valuations might still diverge: the institutional structures of the contingent valuation market and the everyday market may differ. Plott (1979) reviews several empirical laboratory and field experimental studies indicating that market outcomes are highly sensitive to differences in institutional structures. Given this sensitivity, if meaningful measures of the gains and losses from the provision of a non-marketed environmental good are to be established, the measures must be derived within an institutional structure conforming to that posited in the welfare-theoretic basis of benefit-cost analysis. In this section, we argue that this conformity is often more readily achieved with the use of contingent valuation techniques.

Benefit-cost analysis is an attempt to ascertain the quantity of some numeraire (e.g., current dollars) that the gainers and losers from some proposed public investment will consider equivalent in value to their respective gains and losses. The price structure, where price is a sufficient measure of social as well as private value, represents the only terms with which the world with or without a public investment is evaluated. Prices, as generated by market exchange and adjusted in proportion to excess demand, embody all relevant information about relative economic scarcities and are a sufficient means of allocating resources to their socially most highly valued uses.[4] The benefit-cost analyst is trying to ascertain what individuals are willing to pay and/or would have to be paid for the public investment in a world where markets are pervasive.

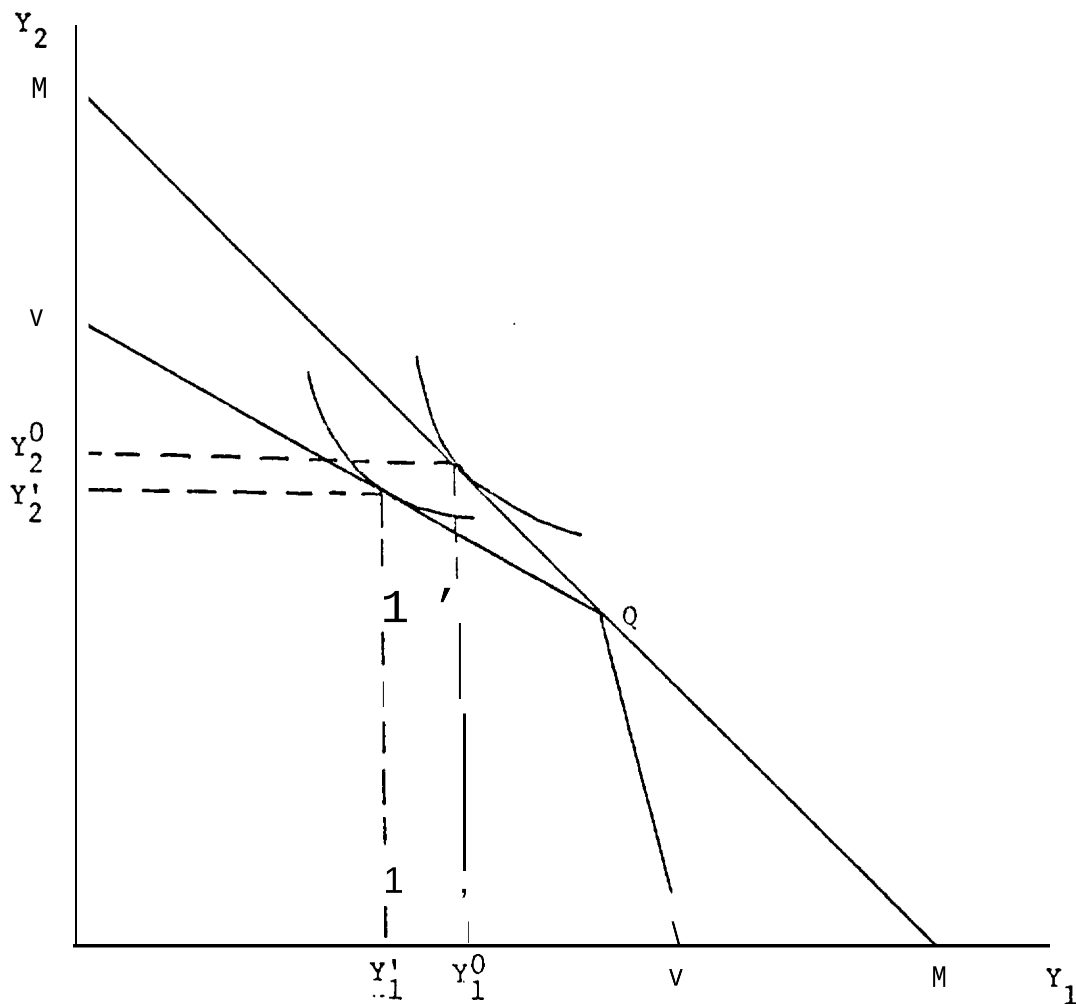
If realized market behavior is used as the data base to establish these valuations, the analyst uses propositions from economic theory for two purposes: (1) to infer what the price structure would be in a world of pervasive markets; and (2) to reason from the pervasive market price structure to the implied consumer valuations. When contingent valuation responses are employed for the data base, the first step can be avoided, if the conditions posited in the questionnaire instrument correspond to a world of pervasive markets. One might reasonably question whether the conditions corresponding to a world of pervasive markets are sufficiently close to a respondent's experiences to be meaningful to him. This justifiable doubt must be weighed however, against the difficulties of carrying through the analytical exercises necessary to construct a pervasive market price structure from initial knowledge of the price structures of a world where markets for many goods are not pervasive. The way in which this difficulty is customarily avoided when using observable, realized prices is to assume (for simplicity?) that the observed prices correspond to those in a world of pervasive markets.

It is a relatively easy task to construct examples that make apparent the difficulties of reasoning to pervasive markets from observations on non-pervasive markets. Consider costs of exchange, a phenomenon present whenever valuable resources (e.g. , time, information, legal and police services, etc.) must be expended to perform the exchange process.

In Figure 2, the individual's initial endowment of Y_1 and Y_2 is at Q. When exchange processes become costly, the individual's budget constraint will vary according to his initial endowment. This is because the costs of the act of exchanging Y_1 and Y_2 differ from the costs of exchanging Y_2 for Y_1. For example, from the perspective of a single individual, the cost of engaging in a transaction in which he is to exchange automobiles that he owns for clean ambient air may differ from these same costs in a transaction where he is exchanging clean air for automobiles. If the exchange act is costly, an initial endowment of Q implies a budget constraint of VQV, whereas if the exchange act is costless, the budget constraint is MM, the customary form which is an integral part of derivations of demand functions and their associated consumer surpluses. Then the individual completes his exchanges during the period, he will select Y_1^O and Y_2^O as an optimum if MM is operative. If VQV is the operative budget constraint, he will select Y_1' and Y_2'. If some point on MM other than Q constitutes the initial endowment, costly acts of exchange will mean that a budget constraint different from either VQV or MM may be operative because the costs of exchange acts may differ by the relative quantities of the goods in the initial endowment as well as by types of goods. Thus, the individual's budget constraint may vary according to the form in

Figure 4.2

Effect of Costly Exchange



which his initial endowment was accumulated, although the market value of this endowment may be identical for many combinations of Y_1 and Y_2. Since costs of the exchange act differ according to the original (Y_1, Y_2) combination, each combination will result in a different and generally nonlinear budget constraint. It follows that, from the individual's perspective, a dollar is not an invariant pecuniary measure. Instead, the subjective value of an additional dollar depends on the form of the income change, i.e., on the good in which the increment is embodied.[5] Moreover, it appears that realized market behavior is dependent not only on money incomes and relative market prices of goods, but also upon the combination of goods the individual starts with and the relative and absolute costs of exchange associated with those goods. These costs of exchange acts are probably neither trivial nor similar across individuals.

If realized market behavior depends on the costs of the exchange act for the bundle of goods an individual holds, if, for the same bundle of goods, these costs differ across individuals, and if individuals do not hold similar goods bundles, then the analytical effort required to infer what the price structure would be in a world of pervasive markets must clearly be greater (probably much greater) than when all individuals have no exchange act costs and when budget constraints are therefore invariant with respect to the bundle of goods held. Rather than facing these and similar analytical complexities directly in order to construct the price structure of a world of pervasive markets, or rather than simply dismissing the problem as an offensive bother, it may often be more effective to construct, using contingent valuation techniques, an artificial market for the environmental good to be valued. For the contingent valuation exercise participant, the number of goods for which markets are non-existent or incomplete is thereby reduced by one. This reduction clearly cannot remove all sources of distortion since the participant's valuation continues to depend in part upon the price structure for all remaining goods. Nevertheless, it is well known that the direct effects of a parameter change upon a variable of interest exceed the indirect effects. This suggests that the introduction of the artificial market reduces rather than enhances the impact upon valuation of the presence of incomplete markets.[6]

BENEFIT-COST ANALYSIS, PROPERTY RIGHTS, AND CONTINGENT VALUATIONS

The fact of incomplete markets says nothing about the degree of distortion in the observed price structure for marketed goods. Some recent qualitative literature [e.g., Norgaard and Hall (1974), and Smith and Krutilla (1979)] suggests that the extent of distortion could be substantial. The great bulk of goods having actual market prices are thought to be primary commodities and the goods chemically and mechanically fabricated from them.

Because the costs of participating in direct exchanges involving the aesthetic, health and ecological support system aspects of natural environments are high, they frequently have no explicit market prices even though they are economically scarce and contribute in a non-separable fashion to the production of the fabricated goods. As a result, the market prices of fabricated goods are typically less than their opportunity costs of production. In short, those who attach high relative values to environmental goods have historically subsidized the consumers of fabricated goods. To use a price structure that has evolved at the expense of environmental goods to impart values to them has no basis in economic logic. The values must be established in a setting where the opportunity costs of environmental goods register in the plans of those who would use them.

Attempts to bring about this registration must generally involve the reassignment and/or the restructuring of claims on common property or public environmental goods. There exist analytical devices in economics allowing one to ascertain the effects upon consumer valuations of property rights reassignments for goods, whether marketed or non-marketed.[7] However, where the conditions of use, exclusion, or alienation are altered (i.e., property rights are restructured), there is no everyday behavior to observe, except insofar as one is willing to draw analogies from observed behavioral responses to changes in the property rights structures of other goods. If one knew what the availability of the non-market good would be under the property rights restructuring, it might seem one could, if one had everyday behavioral observations on consumer time and budget allocations at the same level of availability, determine the change in consumer valuation due to the property right restructuring. However, if the restructuring reduces the costs of the act of exchange this reduction can, as we argued in the previous section, alter the value the consumer attaches to a given level of availability. Furthermore, since consumer valuations will, through either the market or the political process, influence the level of availability, how is one going to reason from the level of availability to consumer valuations for the restructured property right? Economic analysis does not yet have a sufficient understanding of the reciprocal relations between costs of the act of exchange and property rights structures, nor between these costs and various demand phenomena, to permit the ready testing of detailed empirical generalizations in a wide variety of settings. Thus, the only really sound way of obtaining an estimate of whether the net benefits of a particular property rights restructuring are positive, if one insists upon employing observed everyday behavior, would be to perform the restructuring and observe the results. In some circles, this is simply known as trial and error. Trial and error can be an extremely costly way to perform research because the errors are real rather than hypothetical. In contrast, contingent valuation methods allow one to investigate the behavioral responses to a wide variety of property rights structures without involving the citizenry in the traumas of what often is euphemistically termed social experimentation.

One obviously cannot directly observe everyday behavioral responses to property rights structures that have never existed. Similarly, one cannot directly observe the everyday behavioral responses of individuals who have never participated in activities involving the non-marketed good at levels at which the good has been historically available. If some of the proposed levels of availability have not been historically available, and if some former nonparticipants would become participants at these new levels, the use of data on observed behavior to ascertain valuations would mean that the valuations of the would-be participants play no part in determining the valuation. For each proposed level of availability, the use of observed, realized behavior to establish valuation will mean that only historical participants are to count. Those who have not participated historically have no opportunity to communicate their preferences. Contingent valuation methods, because they allow the researcher to introduce ranges of availability of the non-marketed good that are broader than historical experience, permit the values of historical non-participants to become relevant.

CONTINGENT METHODS AND A PRIORI ASSUMPTIONS

Previous sections have stressed the usefulness of contingent valuation methods in traveling from prices. established within incomplete markets to value measures that are meaningful in welfare-theoretic and policy terms. In this section, we argue that these methods are useful even when the trip is unnecessary as when expected and realized utility are similar and when markets are nearly pervasive. The methods can be useful in even these cases because they assist in reducing the dimensionality of the reality the investigator must grasp.

Economists who have worked with problems of consumer analysis are thoroughly familiar with three fruitful a priori restrictions (additivity, homogeneity, and symmetry) that come from the neoclassical demand theory of Slutsky (1915) and Hicks (1934). Further reductions in dimensionality of the parameter space in which estimation is to be carried out can be achieved by judicious invocation of various separability conditions. Finally, some recent developments in the application of mathematical duality principles (the envelope theorem) to consumer theory sometimes allow one to reduce the number of parameters to be estimated without having to impose particular monotonicity and curvature properties upon the consumer's maximization problem (See Diewert, 1974).

Contingent valuation methods can provide additional restrictions by allowing the investigator to control the number and levels of different physical contexts and adaptation opportunities to which the participant must respond. Disturbances imposed by confounding variables upon the responses of interest are therefore at least partially controlled for in the data generating exercise. This contrasts with the standard practice of placing sole reliance in an ex post fashion upon the application of multi-variate parametric estimation techniques. For a given number of observations, these methods can thus increase degrees of freedom and the efficiency of estimators. For instance, in the South Coast Air Basin Experiment previously mentioned, the contingent value approach was able to obtain separate dollar valuations for aesthetic as well as acute and chronic health effects. In contrast, one can only guess what the relative magnitudes are for the property value component cross check.

The use of contingent valuation techniques to reduce the parameter space may be advantageous for reasons in addition to statistical considerations. Often, as noted above, the investigator imposes, ex post, various separability conditions upon market-generated data in order to make it more tractable. These separability conditions may imply, for example, that beer drinking at the local tavern is not a substitute for cross-country skiing. The conditions are imposed without consulting the individuals whose responses are registered in the market data. They are instead generated by what the investigator intuitively feels to be "reasonable," and what is required for analytical convenience. It is not obvious that the investigator's "feelings" and the framework he uses in accounting for what is and what is not important is to be preferred to actually providing the respondent with the opportunity to state how he would respond to alternative contingencies. The details to be abstracted from are presented to the respondent rather than being left to the investigator. In both situations, simplifications are made that will permit the investigator to work with the data. In the contingent valuation case, however, the respondent gets the opportunity to weigh the importance of these confounding variables in making his choices. In the observed behavior case, the investigator is presuming he knows as well as the respondent what, from the respondent's perspective, is and is not an irrelevant alternative. The closed questions employed to gather data with contingent valuation methods allow the domain in which the response data is generated to conform to the structures of the underlying analytical model rather than forcing, via a set of possibly tenuous assumptions (e.g. , the absence of jointness, the presence of perfect competition, etc.), the real world generated data to conform to the preconceptions of the model.[8] At the same time, the user of the methods must accept ultimate responsibility for the origin of the data, as well as the analytical model and the estimation procedures used to test hypotheses.

SUMMARY AND CONCLUSIONS

The preceding is a taxonomic discussion of some reasons why contingent market methods may often be a superior means of generating data with which to value non-market commodities. We have argued that economists have erred in viewing the situations these methods posit as necessarily fictional; that the data generated by the methods may, for non-marketed goods and the activities with which they are associated, accord more closely with the conditions of received economic theory; that the methods can make it easier to remove the difficulties of estimation and interpretation introduced by confounding variables; and that they often permit one to deal more readily with phenomena that have not been in the range of historical experience. Nevertheless, whatever the advantages, a major disadvantage remains. Until detailed analytical knowledge is acquired of the manner in which expectations are formed, there exists no way to refute empirical propositions established from contingent markets. Nevertheless, the previously mentioned South Coast Air Basin experiment (Chapter 3), where the bids obtained for clean air conformed fairly closely to the values implied in a residential property value study, suggest that contingent valuations have a basis in the real decision processes of consumers.

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1 Issues of potential bias in any mechanism that elicits preferences have long been raised (**Samuelson,** 1955). It is not our purpose to address these, as series of contingent valuation experiments suggest the problem is not significant [**Brookshire,** et al. (forthcoming (a))].

2 According to **Maler** (1974, pp. 183-189), weak complementarily exists if the quantity demanded of a marketed good is zero when the marginal utility of the non-marketed good is zero. Bradford and Hildebrandt (1977) have recently expanded the **Maler** (197,4) result to show that under weak complementarily all information required for efficient provision of the non-marketed good is imbedded in the demand functions of marketed goods .

3 Adaptive behavior, once having committed one's self and experiencing unanticipated regret or satisfaction thereby, can be treated as the acquisition of further information.

4 As used here, "social" refers solely to a world in which all voluntary gains from exchange, given the initial distribution on income, are exhausted. Only under classical conditions (an absence of **nonconvexities,** irreducible uncertainty, coordination costs leading to externalities, and less than complete contingent claims markets), does current economic knowledge demonstrate that market prices alone would be sufficient to make efficient (Pareto-optimal) allocations attainable.

5 Empirical evidence to support this is widely available. Newhouse, et al. (1974) find that the demand for health care is sensitive to modes of payment. **Keeley,** et al. (1978) obtain the same result in the demand for leisure when the form of a negative income tax is altered. In contingent valuation exercises, Rowe, et al. (forthcoming), and Brookshire, et al. (forthcoming) have found statistically significant differences in bids when utility bills, income changes, and hunting license fees are employed as bidding vehicles. Indeed, the standard undergraduate problem of whether one would prefer a housing allowance to an income subsidy of equivalent money value implies that the former is not readily converted

to the latter.

6 Consider the simple consumer's utility maximization problem of:

$$\text{maximize } U = u(X_1, X_2)$$

$$\text{subject to } M = p_1 x_1 + p_2 x_2$$

where the x_i (i=1,2) are goods, the p_i are their respective unit prices, and M is money income. An interior maximum requires that $U_{11}U_{22} - (U_{12})^2 \geq 0$, where the subscripts indicate partial derivatives taken with respect to the good in question. This says that the effects upon the utility obtained from one good due to a change in another good cannot dominate the direct utility effects of a change in either good.

7 If, for example, there is an increase in pollution, the amount the sufferer would have to be paid in order to be willing to accept the increase is consistent with the polluter being liable for the damages he causes. The amount the consumer would be willing to pay to prevent the increase implies that the polluter has zero liability for any harm he imposes upon the sufferer.

8 As Medawar (1979, p. 15) has remarked: "It is a truism that a 'good' experiment is precisely that which spares us the exertion of thinking; the better it is, the less we have to worry about its interpretation, about what it really means."

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