Using contingent valuation to measure property value impacts

Clifford Lipscomb
Greenfield Advisors, LLC, Atlanta, Georgia, USA

Received December 2010
Accepted March 2011

Abstract

Purpose – The purpose of this paper is to measure the impact of a proposed biomass facility on prospective property values using the contingent valuation method.

Design/methodology/approach – The paper uses a web-based survey approach to measure respondents' reactions to two scenarios: one that describes the study area currently and another that also mentions the proposed biomass facility.

Findings – The paper found no statistically significant difference in the respondents' WTP for a house based on whether they read about the baseline scenario (no mention of the biomass plant) or the proposed biomass plant.

Research limitations/implications – The survey sampled males, younger people, and those with higher incomes relative to the county where the facility will be built. A few respondents, who were offered very low bids (5 percent and 15 percent of their current home value), may not have understood the question or were exhibiting strategic behavior.

Originality/value – This is one of the few studies that uses contingent valuation to measure property value impacts.

Keywords Contingent valuation, Property values, Biomass, WTP, Real estate, Property management

Paper type Research paper

1. Introduction

The use of methods other than the three traditional approaches to real estate valuation (income capitalization, cost, and sales comparison) is somewhat scarce in the real estate literature. Pure reliance on one or more of these three approaches is warranted in many situations facing the typical real estate researcher or appraiser. However, for researchers working on assignments that contain unusual circumstances (such as environmental contamination or a recent natural disaster), other methods may provide evidence to inform highest and best use (H&BU), to assess the quality of market transaction data, and to understand the motivations behind certain behaviors exhibited in the real estate marketplace (e.g. why lenders choose not to lend on contaminated properties generally). This evidence often would not be known if the analyst were to rely solely on the three traditional valuation methods.

As one might expect, the suggested use of a method other than the three traditional methods of valuation has met some resistance in the real estate community. The hedonic pricing method, arguably the most common method used in real estate analyses other than the three traditional approaches to valuation (because it closely approximates the sales comparison approach), has gained general acceptance in the real estate community. Other methods, however, such as the contingent valuation method (CVM) and conjoint analysis, have not gained such widespread acceptance. The forthcoming article by Lipscomb *et al.* (forthcoming) offers an overview of CV theory and practical guidance on the use of the CVM in real estate damage estimation, including ways to mitigate the inherent biases of the CVM.

Journal of Property Investment & Finance
Vol. 29 No. 4/5, 2011
pp. 448-459

1463-578X
DOI 10.1108/14635781111150330

The rest of the paper follows. First, we discuss the assignment itself, which includes details of the web-based survey used as the source of our data. Second, we describe the data itself and the model used. Third, we discuss our results in the context of best practices in CV. Finally, we provide some conclusions for future research.

2. The assignment

Overview

Greenfield Advisors LLC was asked by an energy company to determine whether or not a proposed biomass facility would have a substantial impact on property values in a Midwest US community. The issue was more complicated than that – the local zoning ordinances allowed a 65-foot emissions stack to be constructed without obtaining a zoning variance. However, the proposed biomass facility would require a 250-foot emissions stack. Therefore, a zoning variance would be required before construction could begin. This narrows the scope of the analysis considerably to this question: will the change in the stack height have a substantial impact on property values? Our research suggests the answer to that question is "No." Below, we detail how we arrived at that answer.

Survey summary

A web-based survey of homeowners in the Midwest US (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Ohio, and Wisconsin) who do not reside in the study area was administered in July 2010. Western Wats (now renamed Opinionology) was the vendor selected to program and administer the web-based survey. Potential survey respondents were screened prior to the start of the survey. Specifically, potential respondents were accepted to complete the survey only if they were current homeowners, were not involved with market research, were not involved with real estate, or were not involved with the law (as attorneys or working for attorneys). Each of the 600 survey respondents saw one of two fact cards, each of which provided a description of the study area and includes recent pictures. Fact Card A, the baseline version, reads as follows:

> The remaining questions in this survey will refer to a community in the Midwestern United States. This town is located on a river and has a population of about 5,500 people. A city of about 40,000 people is located just a few minutes away. Residents of the town say that they feel safe and are pleased with their local government services (e.g. parks, roads, law enforcement, transportation, and libraries).
>
> The town has an industrial sector that includes an existing paper mill, coal-fired power plant, whey processing plant and other industrial facilities.
>
> While these existing plants and facilities provide employment for many nearby residents and represent a tax base for the community, they can also be obstacles to one's view of the local landscape, and each has air emissions. Photos of each plant are shown here in case you are unfamiliar with these kinds of plants.
>
> The existing paper mill has stacks and buildings that range up to 150 feet high. On site with the mill is also a company that produces lignin, a binding agent made from wood. Some believe that closure of the paper mill is likely in the future. While closure of the mill would improve air quality, it would also lead to a loss of 460 jobs in the mill and lignin plant and several hundred other supporting jobs in the community. (insert photo papermill.jpg under sentence).
>
> The coal-fired power plant produces 980 megawatts and has buildings and stacks ranging up to 500 feet high. (insert photo powerplant.jpg under sentence).

The dairy plant processes whey and lactose for use in candy, infant formula, and other items. (insert photo farms.jpg under sentence).

A train track with four to eight trains per day runs between the paper mill and residential areas of the town. Finally, there is an interstate freeway about a half of a mile away from the plants. Currently, there are approximately 16,000 vehicles per day in the area, of which about 465 are trucks.

Fact Card B, which mentions the biomass energy facility, adds the following text and pictures:

> The proposed biomass facility will use wood chips and other leftover wood products, collected mainly from local forests and the paper mill, as the fuel source to generate electricity. It will generate 50 megawatts of renewable energy and will supply steam to the mill, making the mill significantly more competitive.
>
> The photos below show the paper mill as it is now, and then an artist's rendering of what the biomass plant will add to the site when finished. The biomass facility will have buildings and stacks ranging up to 265 feet tall. (insert photo papermillnow.jpg and below it, papermillbiomass.jpg)
>
> Looking forward, the biomass facility will allow the paper mill to retire its boilers, reducing overall air emissions by about 30 percent. If built, the biomass facility would increase traffic around the paper mill by approximately 75 trucks per day. Currently, there are approximately 16,000 vehicles per day in the area, of which about 465 are trucks. Building the biomass facility will create 150 jobs to supply biomass fuel. If the facility is not built, closure of the paper mill becomes more likely. While closure of the mill would improve air quality, it would also lead to a loss of 460 jobs in the mill and lignin plant and several hundred other supporting jobs in the community.

3. Data and model

Data

Our research suggests that some respondents presented with a house price percentage in the Contingent Valuation portion of the survey may not have understood the question well enough to provide a logically coherent set of answers to Question 5. The main CV question, Question 5, states:

> Please imagine again that you are looking for a home in the area we've been discussing and you find one you like that is very similar to your current home in all aspects *except* that it is located somewhere within one-half a mile of the plants described earlier. What if, all else being equal, the home near the plants was priced at **X**% of the value of *your* current home? That is, *if* your current home is worth $100,000 this other home would cost $(100,000 times **X%)**. Would you consider this to be too high of a price, too low of a price, or about the right amount?

Each respondent is presented with a randomly generated value of **X**%. Table I shows the acceptance rates (the probability of saying "about the right amount" is the

Table I.
Acceptance rates by bid percentage

	5%	15%	33%	50%	70%	85%	100%
Fact Card A	14.2% ($n = 42$)	28.5% ($n = 35$)	56.1% ($n = 41$)	58.6% ($n = 29$)	65.1% ($n = 43$)	60.0% ($n = 40$)	17.1% ($n = 41$)
Fact Card B	37.1% ($n = 35$)	32.5% ($n = 40$)	44.4% ($n = 36$)	62.5% ($n = 48$)	64.8% ($n = 37$)	60.5% ($n = 38$)	12.9% ($n = 31$)

acceptance rate presented) for respondents who saw each fact card. Given that in follow-up questions we asked respondents to consider their maximum WTP for the same house they currently live in if it were located in the area described by the fact cards, we expect respondents to say "too low" at the lowest bid percentages and "too high" at the highest bid percentages[1]. Table I provides evidence to support those expectations.

It is likely that respondents who said that 5 percent and 15 percent was too high might have had an alternative agenda by the way they answered the questions. In this situation, of respondents who saw Fact Card A (with no mention of the proposed biomass facility), 5 percent of those presented with a 5 per cent house price percentage (meaning they are answering whether or not $5,000 is "too high," "too low," or "about right" for a house in the situation described by the fact card) said that the percentage was "too high," essentially suggesting a 100 per cent discount on the house described (that the house is worthless). Of respondents who saw Fact Card B (which did mention the proposed biomass facility), 7 percent of those presented with a 5 percent house price percentage said that percentage was "too high." In addition, we found similar responses of "too high" for the 15 percent house price percentage in both versions of the survey. These extreme responses are not representative of the entire sample. In fact, a few recent economic studies have shown that survey respondents may respond unusually at the lower extreme of the bid distribution in hopes of their decisions having a favorable impact on policy outcomes (Farmer and Lipscomb, 2008; Lipscomb and Koford, 2011). Following the guidance of these studies, we omitted the 171 observations that randomly received bids of 5 percent and 15 percent (86 respondents saw Fact Card A, 85 respondents saw Fact Card B) from the WTP estimation procedure described below[2]. While this increases the mean WTP by truncating the bid percentage distribution from below, the important result remains the difference in mean WTP between the respondents who saw the two different fact cards. No statistically significant difference in mean WTP suggests that respondents do not view the proposed biomass facility as a detriment to local property values over and beyond the decrease that already has occurred as a result of other industries in the area.

Theoretical model

Theory suggests that the WTP for a house, the good of interest in our CV study, is non-negative. Hanemann (1989) provides a standard formula for the mean of a distribution as a function of the cumulative density function (cdf), G(A), for non-negative variables:

$$\int_{D}^{\infty} [1 - G(A)]dA. \tag{1}$$

Then, if we assume a linear utility function ($v = \alpha + \beta y$) and a logistic distribution, Equation 1 yields the following WTP formula (from Hanemann, 1989, p. 1,059):

$$-\frac{1}{\beta}[\ln(1 + e^{a})] \tag{2}$$

Hanemann (1989) is very clear that the use of Equation 2 is incorrect when the model to be estimated allows negative WTP values. Even though this analysis considers the

purchase of a private good (housing), we make sure that our WTP calculations are valid by following the minimum criteria established by Haab and McConnell (1998) and discuss this in a subsequent section.

Empirical model

To estimate WTP, we use a logistic regression model. A logistic regression model is a nonlinear regression model that uses data collected from the survey to estimate the mean WTP for each group of respondents based on which fact card was viewed. This model includes a dependent variable (the variable to explain) and a series of independent variables used to explain variation in the dependent variable. To define the dependent variable, we take the responses from Question 5 and re-categorize them. We define the dependent variable ACCEPT to be equal to 0 if the respondent said "too high" or "too low"; or to be equal to 1 if the respondent said "about the right amount." "Don't know" responses were offered to respondents in accordance with the National Oceanic and Atmospheric Administration (NOAA) Blue Ribbon Panel on Contingent Valuation report recommendation (Arrow *et al.*, 1993). The conservative approach in situations like this is to treat "Don't Know" responses as a "No" response, which will tend to underestimate WTP (Carson *et al.*, 1998). Since our focus is on the difference between mean WTP for different sets of respondents, we test for the impact of the 19 "Don't Know" responses by omitting them from the analysis in one regression model and coding them as a "No" response in a separate analysis. Omitting these observations in one analysis is "equivalent to allocating them proportionate to the favor/nonfavor response pattern" (Carson and Hanemann, 2005, p. 891). Treating the "Don't Know" responses as "No" responses responds to the concerns of Groothuis and Whitehead (2002) and Caudill and Groothuis (2005). The results are virtually identical when we omit the 19 observations versus when we code the "Don't Know" responses as "No" responses.

Next, we define the following independent (or explanatory) variables: BID, FACTCARDA, MALE, INCOME, and CERTAINTY. BID is the random house percentage value presented to each respondent (5 percent, 15 percent, 33 percent, 50 percent, 70 percent, 85 percent, and 100 percent); different bid values were presented to different respondents randomly so that the value of the status-quo house could be estimated. FACTCARDA is another discrete variable, taking on the value of 0 if the respondent was presented Fact Card B and the value of 1 if the respondent was presented Fact Card A. MALE indicates whether the respondent is male (MALE = 1) or female (MALE = 0). INCOME is a variable defined as the midpoint of the ranges of household income presented in survey Question DEMO4. For example, if a respondent chose the $75,000 to $99,999 income range, that response was recoded in the dataset as $87,500. This is a standard practice in social science research. Finally, we use two different measures of certainty. CERTAINTY_1 is constructed directly from Question 5d in the survey and provides a measure of how certain the respondent is that she would pay the house price percentage randomly presented to her. Also, CERTAINTY_2 is constructed directly from Question 5e and takes on values 0 to 10, with 10 indicating that the respondent is very certain of her answer.

From the logistic regression analysis, several parameters are estimated. These parameters tell us the marginal influences of each independent variable on the dependent variable ACCEPT. Following the studies of Hanemann (1989) and more

recently Johansson (1995, p. 113), mean WTP for a status-quo house is estimated using Equation 2. In this calculation, β is the estimated parameter for the variable BID from the logistic regression equation, ln refers to the natural logarithmic function, e is the exponential function, and *a* is the constant from the logistic regression equation added to the effects of all other independent variables. This formula restricts willingness to pay to be nonnegative, which is appropriate for a private good such as the house described in the survey (Blumenschein *et al.*, 2008).

4. Results

Descriptive statistics of the sample by fact card viewed are presented in Table II. We see that the sample is very similarly distributed by fact card. For example, for those who viewed Fact Card A, 42 percent accepted the bid percentage presented to them; for those who viewed Fact Card B, 46 percent accepted the bid percentage presented to them. According to a difference of proportions test, these differences are not statistically significant. The rest of the statistical tests suggest no statistical difference between the respondents who viewed a particular fact card. These similarities assure us that results are comparable between the groups.

Next, we present the results of the logistic regression model in Table III, where ACCEPT is the dependent variable. Notice that only 181 observations are used in this regression model. These 181 observations are those respondents who faced an initial bid percentage greater than 15 percent and who responded with a CERTAINTY_2 level greater than or equal to 7. This conforms to one level of certainty below that level determined by Blomquist *et al.* (2009) to be equivalent to a "definitely sure" and "real" acceptance. The primary reason for using certainty level 7 instead of 8 in the model is the significant drop in the number of observations (181 to 120) if we use certainty level 8 as the cutoff for "definitely sure" and "real" acceptances.

We can see that the estimated parameter on BID (β) has the expected negative sign and is significant, indicating that higher bid percentages correlate to a lower probability of accepting the bid. Interestingly, none of the other independent variables is a significant predictor of ACCEPT. Yet, the likelihood ratio statistic is significant at the 98 percent level, suggesting that the model as a whole significantly explains variation in the dependent variable. Next, using these logistic regression model parameters, we calculate mean WTP using Equation 2 above. The primary result is that the description of the proposed biomass facility in Fact Card B did not result in a mean WTP that was statistically different from the mean WTP for those who were presented Fact Card A. Using CERTAINTY_2 as our measure of certainty, we can test the sensitivity of our results based on difference levels of certainty. Table IV summarizes these results.

This table says that, on average, respondents who were presented Fact Card A and reported a certainty level greater than or equal to 7 have an estimated mean WTP of 86.2 percent; the corresponding mean WTP for those respondents presented Fact Card B is 83.1 percent. To estimate whether or not the proposed biomass facility is likely to exert a negative impact on property values, we used a difference of means test to see if the mean WTP for the status-quo house for those respondents presented Fact Card A is statistically different from the mean WTP for those respondents presented Fact Card B. [Essentially, by row, we are testing whether or not the percentages listed in the Fact Card A column are statistically different from the percentages listed in the Fact Card B

Table II.
Descriptive statistics

	Description	Fact Card A (n = 300) Mean	Fact Card A (n = 300) Standard deviation	Fact Card B (n = 300) Mean	Fact Card B (n = 300) Standard deviation	Statistically significant difference?
ACCEPT	1 = Respondent accepted the bid presented to him/her; 0 = Respondent said "too high" or "too low" or "don't know" to bid presented	0.42	0.49	0.46	0.49	No (prob. = 0.32)
BID	Expressed in percentages; randomly assigned to respondents	51.96	33.75	50.47	32.47	No (prob. = 0.58)
MALE	1 = Male; 0 = Female	0.56	0.49	0.53	0.49	No (prob. = 0.46)
INCOME	Household income for last 12 months	63,420	36,270	62,758	33,724	No (prob. = 0.81)
AGE	Respondent's age	41.13	14.54	41.33	14.67	No (prob. = 0.86)
CHILDREN	1 = Respondent has at least one child living with him/her presently; 0 = No children in the home	0.41	0.49	0.40	0.49	No (prob. = 0.80)
CERTAINTY_2	Degree of certainty that respondent would actually pay the amount stated in Question 5 (range is 0 to 10)	5.98	2.40	6.15	2.31	No (prob. = 0.37)

Independent variable	Parameter estimate (standard error)
BID	−0.0198 * (0.0067)
FACTCARDA	0.0751 (0.3096)
MALE	0.4379 (0.3239)
INCOME	0.000005 (0.000004)
CHILDREN	0.4089 (0.3242)
CONSTANT	0.5855 (0.6091)
Likelihood ratio χ^2 statistic	14.28
(Probability)	(0.0139)
McFadden Pseudo R^2	0.06
Number of observations	181

Notes: AGE was excluded from the final model due to its insignificance in explaining variation in the dependent variable ACCEPT; * $p < 0.01$

Table III.
Logistic regression results

CERTAINTY_2 Level	No. of observations	WTP – Fact Card A (%)	WTP – Fact Card B (%)	χ^2 test statistic	Probability
All levels	384	101.0	99.5	0.02	0.88
≥ 5	297	95.9	98.3	0.05	0.81
≥ 6	226	96.5	97.8	0.01	0.91
≥ 7	181	86.2	83.1	0.06	0.80
≥ 8	120	86.2	72.5	0.91	0.34
≥ 9	59	108.0	81.5	2.01	0.15
≥ 10	29	197.7	141.1	1.66	0.19

Table IV.
Sensitivity analysis for observations facing bids > 15 percent

column.] The far right columns present the χ^2 test statistic and associated probability that come from a difference of means test. More specifically, the difference of means test statistic is the Chi-square (χ^2) statistic. Any Chi-square statistic above the critical threshold of approximately 3.87 indicates a significant difference in the two estimates of mean WTP.

This sensitivity analysis suggests that there is no statistically significant difference between the mean WTP of those who were told about the proposed biomass facility regardless of certainty level reported by survey respondents[3]. We have even included the estimated mean WTP for all observations regardless of the certainty level expressed in Question 5e. Note, however, that these results cannot be interpreted strictly to indicate that respondents believe property value diminution to be calculated as 100 percent minus the mean WTP estimate. For the mean WTP results in the last

two rows of Table IV, this misinterpretation would lead to incorrect conclusions, namely that respondents are willing to pay a premium to live within one-half mile of the area described. While this may be true for a small number of observations (if the employment effect outweighs the disamenity effect), paying a premium to live closer to the areas described is not representative of the majority of survey respondents.

5. Discussion

Our results suggest that there is no significant different in the WTP amounts based on the information presented in the fact cards. To provide further confidence in our results, we interpret our results in terms of the minimum criteria for a valid WTP model established by Haab and McConnell (1998), who provide a list of criteria to address perceived inconsistencies between the estimation stage and the calculation stage of WTP. Their minimum criteria for a valid model of WTP are that:

- WTP should have a non-negative lower bound and an upper bound not greater than income;
- estimation and calculation should be accomplished with no arbitrary truncation; and
- there should be consistency between randomness for estimation and randomness for calculation.

In the research presented here, the contingent valuation question focuses on a private good with which each respondent has sufficient knowledge (a house purchase). The data suggest there is no strategic behavior being exhibited whereby respondents are trying to "game" the system. Also, related to the upper bound of WTP, private goods like houses are different than public goods in that income is spent not only on houses but also on other goods like groceries and utilities. Respondents' data suggest that they are not overstating WTP, likely due to the description of the good in the fact cards. Therefore, the first criterion is satisfied.

Related to the second criterion for a valid WTP model, we did not employ arbitrary truncation in the estimation and calculation of WTP. First, the inclusion and then elimination of the 5 percent and 15 percent bids is consistent with the literature related to strategic behavior and respondents who are sometimes confused with bids so much lower than the price they actually pay for goods. Second, the sensitivity analysis in Table IV shows how the WTP results differ based on the inclusion of all respondents and then respondents with varying degrees of certainty in their answers. So, in this sense, we have weighted the responses that reflect more certainty to increase the reliability of our results.

For their third criterion, we have used the restriction that WTP is non-negative in both the calculations and the estimation. This provides us with consistent estimates that are most likely efficient as well.

6. Conclusion

The key question in this research is whether or not the difference in stack height of this proposed biomass facility is perceived to have a statistically significant difference in respondents' WTP for their homes. The simple answer is no. Beneath this simple answer lies a litany of theoretical possibilities (strategic behavior, distribution of the

WTP function) and econometric issues that must be tested (differences in BID acceptance rates, calculation of WTP estimates, results by levels of certainty). In the end, the results suggest no statistically significant difference in the WTP for a home situated near the proposed biomass facility. The results suggest that the industries already in the area have been capitalized into house prices and that the proposed biomass facility does not impact those house prices any further.

One limitation of our research is that respondents presented the 5 percent and 15 percent house price percentages may not have understood the question fully. However, this only occurred with five respondents out of 600. So, we are confident that the results reflect the large majority of respondents. Second, a general criticism of contingent valuation studies is that the survey creates a constructed market. Through the use of an artist's rendering of the proposed biomass facility, coupled with a detailed explanation of the existing industries within the local community, we are confident that we have overcome any hypothetical bias in the survey instrument. Plus, the good being valued is the respondents current home, which also mitigates hypothetical bias. Third, based on respondents' incomes, we might expect higher-income earners to have a higher percentage of "yes" votes at higher bid values than lower-income earners. Our results suggest that there is no clear pattern that lower-income earners say "too low" more often to the higher house price percentages. So, the presence of an income effect is unlikely.

In future research, we hope to explore the differences in WTP using the same instrument with web-based samples (having an unequal probability of inclusion in the survey) and random digit dialing samples (having an equal probability of inclusion in the survey). In this research, we do not expect any significant difference in the outcomes. As Table III suggests, there are no significant WTP differences that can be attributed to gender, income, and the number of children in the household. So, the fact that our Web sample (relative to the study area) over samples males, younger people, and those with higher incomes compared to the demographics of the actual study area (available from the author upon request) does not cause concern about the reliability of our results.

Notes

1. Follow-up questions to the main CV question asked respondents "What is the maximum percentage of your current home's value that you would consider to be a reasonable price for purchasing a home located within a half mile of the plants?" and "What is the smallest percentage price you think is still reasonable?" To make certain that respondents' open-ended questions were not providing significantly different information than their dichotomous choice responses, we tested for differences in their answers to these two questions. Difference of means tests suggest that there is no statistical difference in the maximum percentages stated by respondents facing different fact cards ($t = 1.31$; prob. $= 0.18$) nor in the minimum percentages stated by respondents facing different fact cards ($t = 0.25$; prob. $= 0.79$). This is additional evidence that the mention of the proposed biomass facility in Fact Card B has no impact on prospective property values. But, even if respondents accepted the initial bid offered to them, the certainty statement questions asked specifically about the initial percentage (bid) randomly offered to them.
2. Another statistically valid reason for not using bids equal to 5 percent is that this is the only bid level where a two-sample difference of proportions test (null hypothesis is that there is no difference in the acceptance rates of the 5 percent bid based on whether Fact Card A or Fact

Card B was seen by the respondents) is significant at the 99 percent level (one-tail test). In other words, at the bid level of 5 percent, Fact Card B respondents had statistically significant and higher acceptance rates than Fact Card A respondents.

3. For completeness, we regressed ACCEPT against the natural log of BID, MALE, INCOME, AGE, and CHILDREN for both Fact Card A ($n = 194$) and Fact Card B ($n = 190$) respondents. Using the Krinsky and Robb (1986) method to simulate the confidence intervals around estimated mean WTP, we found no statistical difference in the median WTP for respondents who viewed the different fact cards. Median WTP for Fact Card A respondents was 64.89 percent and 65.27 percent for Fact Card B respondents. Then, we restricted the estimation procedure to include only respondents who reported a certainty level of seven or higher. This did not change the median WTP estimates significantly. The median WTP for Fact Card A respondents ($n = 92$) is 67.79 percent and for Fact Card B ($n = 89$) respondents is 61.63 percent. The advantage of using the Krinsky and Robb (1986) method is that it establishes a confidence interval that is not symmetric about the median WTP, "as it would be if one were to calculate a confidence interval under the assumption that median WTP is normally distributed" (Haab and McConnell, 2003, p. 113).

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Corresponding author
Clifford Lipscomb can be contacted at: cliff@greenfieldadvisors.com