Estimating Consumer Willingness to Supply and Willingness to Pay for Curbside Recycling

Brandon C. Koford, Glenn C. Blomquist, David M. Hardesty, and Kenneth R. Troske

ABSTRACT. *We estimate the willingness to pay for curbside recycling based on a contingent valuation survey of 600 residents of a large southeastern United States city. The best estimate of willingness to pay for curbside recycling is $2.29/month after adjustment for hypothetical bias. We also report the results of a field experiment designed to test the effectiveness of explicit monetary incentives and communication appeals to influence the decision to recycle and the quantity of materials to recycle. While households respond to the monetary cost of recycling, the effects of the token, ex ante incentives and appeals appear to be small.* (JEL D61, Q21)

I. INTRODUCTION

The number of curbside recycling programs has experienced significant growth, increasing from 1,000 programs in 1988 to about 9,000 in 2009 (Simmons et al. 2006; U.S. Environmental Protection Agency 2010). Despite growth, curbside recycling is not ubiquitous and, where it exists, participation is not 100%. Given participation below 100%, policy makers are interested in what factors influence the decision to recycle, as well as how much residents value curbside recycling. The purpose of this paper is to estimate local willingness to pay for curbside recycling and explore an experimental incentive policy designed to influence the amount of materials households recycle. Specifically, an experiment is conducted in which households receive explicit monetary incentives and communication appeals to increase curbside recycling.

On the demand side, obtaining accurate benefit estimates for public programs is important if policy makers are to allocate public funds efficiently for programs that are demanded. We explore demand for curbside recycling in two ways. First, we take advantage of unique variation in tax districts within a municipality to examine how recycling participation and knowledge differ across districts. Specifically, some tax districts are associated with city-provided refuse and recycling collection. Residents in these districts pay for refuse collection through a combination of property taxes and service fees (details are provided in Section IV); curbside recycling is provided at zero marginal cost. In other tax districts, residents must pay explicit user fees for both refuse and recycling services. As discussed in Section IV, these differences in payment structure are associated with differences in recycling behavior and knowledge.

Second, we explicitly estimate willingness to pay for curbside recycling for a city in the southeastern United States using contingent valuation methods. We calibrate stated preference responses through the use of "probably sure–definitely sure" certainty statements. Our findings indicate that willingness to pay

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The authors are, respectively, assistant professor, Department of Economics, John B. Goddard School of Business and Economics, Weber State University, Ogden, Utah; Carl F. Pollard Professor of Health Economics, and professor, Economics and Public Policy, Department of Economics and Martin School of Public Policy and Administration, Gatton College of Business and Economics, University of Kentucky, Lexington; Thomas C. Simons Endowed Professor of Marketing, School of Management, Gatton College of Business and Economics, University of Kentucky, Lexington; and William B. Sturgill Professor of Economics, and director, Center for Business and Economic Research, Department of Economics, Gatton College of Business and Economics, University of Kentucky, Lexington.

for curbside recycling for a city in the southeastern United States is similar to estimates from the western United States.

On the supply side, we consider an experiment designed to assess whether municipalities can influence the recycling behavior of households through explicit monetary incentives, communication appeals, or their interaction. Increases in curbside recycling are especially important for municipalities concerned with landfill constraints or high tipping fees. This study addresses both monetary-based and norm-based interventions to change curbside recycling behavior. In particular, we conduct a supply field experiment to estimate the impacts of offering households various dollar amounts and communication appeals on participation and quantity of materials they recycle through curbside collection. Our results indicate that it will be difficult for municipalities to influence household recycling behavior in the range of incentives we explore.

II. RELATED LITERATURE

Obtaining accurate willingness to pay information is important if public decision makers are to assess the efficiency of curbside recycling programs. Benefit estimates with respect to recycling have focused on using cheap talk and sampling strategies to mitigate hypothetical bias and thus enhance the accuracy of willingness to pay. Aadland and Caplan (1999) surveyed residents of Ogden, Utah, and elicited willingness to pay using an ordered interval format. They find that residents are willing to pay $2.65 per month for curbside recycling.[1] In a similar study of 36 Utah counties, Aadland and Caplan (2003) explicitly recognize the possibility that individuals may overstate their willingness to pay for curbside recycling in a hypothetical setting. They attempt to detect hypothetical bias using two methods related to their sampling strategy. In the first method, households who have already made the decision to participate in a real curbside recycling program are compared to households who are currently making a decision to participate in a hypothetical curbside recycling program. The second method compares the stated willingness-to-pay response from each household with the same household's decision to participate in an actual curbside recycling program. Both detection methods indicate households overstate their willingness to pay in the hypothetical setting. To mitigate the bias, they rely on survey design. Specifically, they use a short cheap-talk script to remind respondents that they are in a hypothetical setting and to exhort them to behave as if the situation were real. Their estimate of willingness to pay is $7.89, with cheap talk reducing willingness to pay to $7.22.

In a third related study, Aadland and Caplan (2006) investigated the benefits and costs of curbside recycling using a sample of households in 40 cities in the western United States. They used sampling strategies to detect and mitigate hypothetical bias. Correcting for hypothetical bias, they find an average willingness to pay of $3.42. On the cost side, Aadland and Caplan consider the explicit fixed and variable costs as well as the opportunity costs of curbside recycling programs. Combining benefit and cost information, they find net social benefits of curbside recycling almost exactly equal to zero. However, net social benefits vary among cities.

Our paper differs by estimating willingness to pay for recycling for a city in the southeastern United States, rather than western United States, and mitigating potential hypothetical bias using follow-up certainty statements, rather than cheap talk or sampling strategies. Because of differences in citizen preferences, population density, and waste practices, it is likely that benefits of curbside recycling vary across regions. For example, Simmons et al. (2006) report that, on average, the South region recycled 25.4% of the municipal solid waste stream, while the Rocky Mountain region recycled 12.5%.[2] With respect to population den-

[1] All willingness-to-pay dollar amounts are converted to 2007 dollars using the Consumer Price Index in order to match the year for our data.

[2] The South region is defined to be: Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia. The Rocky Mountain region is Arizona, Colorado, Idaho, Montana, New Mexico, Utah, and Wyoming.

sity, the U.S. Census Bureau reports that in 2010 the average population density in the South region was 160 people per square mile compared to 27 people per square mile in the Rocky Mountain region.

We also calibrate stated preference responses by counting as "yes" only respondents who say "yes" and are "definitely sure" they would pay for curbside recycling. This calibration has been found to produce a match between hypothetical and real payments in previous studies, see for example Champ and Bishop (2001) and Blumenschein et al. (2008).

On the supply side, participation in recycling can be viewed in the context of optimal policy design for solid waste. Kinnaman and Fullerton (1999) provide an extensive review of the economic literature regarding solid waste policies. Germane to the current work are policies that encourage households to recycle. One policy to increase the amount of household recycling is the unit-pricing of waste in which households pay per unit for disposal of trash. The anticipated effects are a decrease in refuse collection and increased household recycling. Fullerton and Kinnaman (1996) show that some households respond to unit pricing by "stomping" more garbage into each unit. Other studies have shown unit pricing to have a positive impact on the quantity of materials recycled. Ferrara and Missios (2005) find that user fees on garbage collection increase recycling quantities. Economic factors such as fees for waste disposal at landfills, so-called tipping fees, and population density also play a role in the quantity of materials recycled. Using data collected during the mid-1990s on 959 communities in the United States, Kinnaman and Fullerton (2000) find that a $15 increase in the tipping fee increases the likelihood of a community adopting a curbside recycling program by 7.8%. A 1,000 person per square mile increase in the population density increases the likelihood of curbside adoption by 3.9%.

Hong, Adams, and Love (1993), Hong and Adams (1999), and Hong (1999) find that the volume of a household's recycling level is more responsive to price than is the volume of nonrecyclables. Abbot, Nandeibam, and O'Shea (2011) find that decreasing the frequency of waste collection increases the recycling rate. Interestingly, ordinances aimed at making recycling mandatory have little significant impact on recycling or garbage quantities, according to some studies (Kinnaman and Fullerton 2000; Jenkins et al. 2003). Other studies consider time and convenience costs, social norms, and state recycling laws with somewhat different results. Halvorsen (2008) finds that the opportunity cost of time has a negative effect on recycling and that warm glow, social norms, and moral norms increase recycling. Gonzalez-Torre, Adenso-Diaz, and Ruiz-Torres (2003) cite lower time costs to recycle in Europe compared to the United States as a reason for greater recycling. Viscusi, Huber, and Bell (2011) find that personal norms matter, social norms have little additional effect, and state recycling laws that reduce time costs and/or require refundable deposits increase recycling of plastic water bottles.

Overall, the literature suggests that there are many economic forces that can influence the decision to recycle. While the literature indicates that monetary factors change recycling behavior, this study is the first to examine the effects of offering households explicit dollar incentives. Additionally, the literature suggests that nonmonetary factors, such as norms and convenience, may influence recycling. This study complements other research on nonmonetary incentives by analyzing the effects of various types of communication appeals on recycling behavior. On the demand side, the literature suggests that it is important to take into consideration hypothetical bias when estimating the benefits of recycling.

III. SURVEY AND SAMPLE

In order to examine household recycling behavior, a survey was administered to a representative sample of households in Lexington, Kentucky. The sample was divided into two subsamples based on whether the participating household was to receive incentives to encourage recycling (the experimental supply sample) or the household was to be part of the assessment of willingness to pay for curbside recycling (the demand sample). The experimental supply sample consisted of 1,000

households in a representative neighborhood in Lexington. Residents in the experimental sample are part of a city tax district in which residents receive city-provided refuse and recycling collection services. The experimental sample was chosen in conjunction with the solid waste manager for Lexington to correspond with a single garbage collection route. This feature of the sample facilitated household-level data collection.

The demand sample was drawn from a local property value assessment database and consisted of 600 additional households. Five hundred were randomly selected from households in tax/service districts that did not receive city-provided refuse and recycling collection. Households in this portion of the sample contracted with private firms for curbside collection services. The remaining 100 were households in tax/service districts receiving city-provided collection services. Sampling in this fashion allows for a comparison of the recycling behavior across service types as well as experimental treatments.

The survey instrument was designed to be administered by mail to the sample of Lexington households. It consisted of three main sections. In the first section, respondents were asked about their knowledge of current recycling programs and their use of recycling services throughout the city. The second section provided a description of a hypothetical curbside recycling service. Households were then asked to indicate their willingness to pay for the service. The willingness-to-pay question used a dichotomous choice format and was followed by a question asking respondents to indicate their certainty of willingness to pay on a "probably sure–definitely sure" scale. The final section collected standard demographic information along with information on recycling behavior with respect to specific materials such as aluminum, newspaper, and plastics.

Three professionally moderated focus groups were conducted to ensure understanding of the questionnaire by respondents. The first two groups consisted of eight university faculty and staff members. These groups were distinguished by their self-reported recycling behavior, with one group being recyclers and the other group being nonrecyclers. The third focus group of seven individuals consisted of members of a local neighborhood association in the Lexington area, with no distinction made for recycler status.

The survey was sent out in June–August 2007. Following Dillman (2007), implementation included up to five separate mail contacts. The contacts included an introductory letter, the survey itself with a $1 token of (anticipated) appreciation for completing the survey, a reminder postcard, a second mailing of the survey instrument, and final mailing of the survey sent by Priority Mail. A total of 1,600 surveys were sent, with 31 surveys being returned as undeliverable. Nine hundred ninety seven surveys were returned, for a response rate of 64% (997/1,569).

IV. RESULTS OF WILLINGNESS TO PAY

As described above, the sample contained individuals in different tax districts. Lexington is unique in that residents of a street can choose, through an established democratic process, the level of city services provided to them. Residents who choose to receive city service (approximately 85% of households) pay for refuse collection through a combination of property taxes and monthly fees levied through residents' water bills. In Lexington, the 2007 tax rate associated with refuse collection was $0.16 per $100 paid in assessed property value. For the average household in our sample, the attributable amount is approximately $21 per month. In addition, the city charges each household $4.50 per month for each 90 gallon container it uses. In contrast to garbage collection, there is no cost specifically attributed to recycling. Residents desiring to recycle are not required to pay additional taxes or fees for curbside recycling containers or service. From the perspective of the household, the marginal monetary cost of using the city-provided curbside recycling service is zero. Similarly, residents on city service cannot save money by opting out of participation in the curbside recycling service. There is one possible monetary component to curbside recycling. If a household is on the margin of ordering another garbage can from the city, rather than incurring the additional $4.50 per month, the household could order a

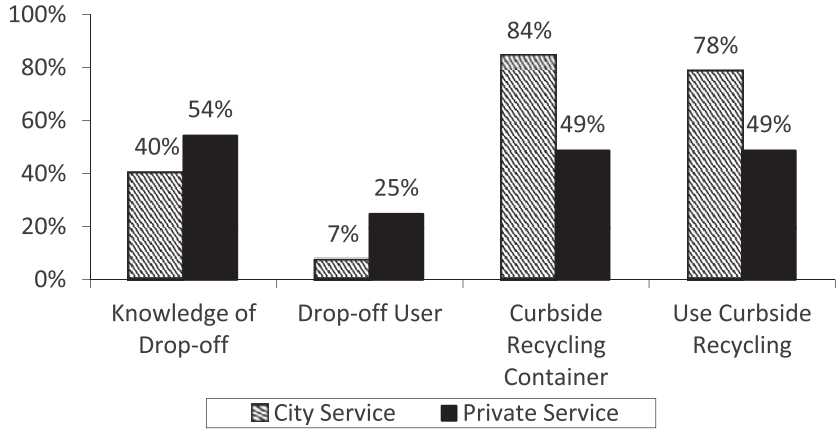

FIGURE 1
Drop-off and Curbside Recycling Use by Service Type

recycling container and alleviate the garbage capacity constraint. Of course, time costs are not zero.

Households on streets who have chosen private service (approximately 15% of households), in contrast, face an explicit monetary cost related to their curbside recycling behavior. In 2007, the primary private provider in Lexington charged $6 per month to provide curbside recycling. This monthly charge appeared as a line item on the collection bill and could be discontinued at any time at the choosing of the resident. The differences in the cost structure of recycling for private and city service households are associated with differences in the observed recycling behavior. As shown in Figure 1, households in tax/service districts that do not receive city service are more likely to know about alternatives to curbside recycling and less likely to use curbside recycling services. Households in tax districts that receive city service are more likely to have a recycling container and are more likely to use curbside recycling. They are less likely to know about substitutes to curbside recycling, such as drop-off recycling centers. Specifically related to participation, 78% of households on city service use curbside recycling at no additional cost, while only 49% of households use curbside recycling if they must pay extra to private collection services. Those on private service face a higher marginal cost for curbside recycling and thus have an incentive to look for other ways to recycle. These results provide initial evidence that the monetary price is an important component of the decision to recycle.

Figure 2[3] provides additional evidence of money being an influential factor in the recycling decision. The figure contains a summary of results on the self-reported factors that would most encourage people to recycle. Respondents were asked to select among three options: (1) ethical duty to help the environment, (2) saving money, and (3) being paid to recycle. Most households (63%) see recycling as an ethical duty; however, money is a motivating factor for recycling behavior. Thirty-seven percent of households indicate either saving or earning money would encourage them to recycle.

Willingness to Pay

Individuals in the demand sample were asked if they would be willing to pay a specific dollar amount for curbside recycling services. Table 1 summarizes demographic in-

[3] The results in the figure pool observations across tax districts. Self-reported factors encouraging recycling are similar across both city-service and private-service districts. For city-service districts 65%, 13%, and 22% indicate Ethical Duty, Saving Money, and Being Paid, respectively, as the primary motivation for recycling, while percentages for private-service districts are 67, 13, and 20, respectively.

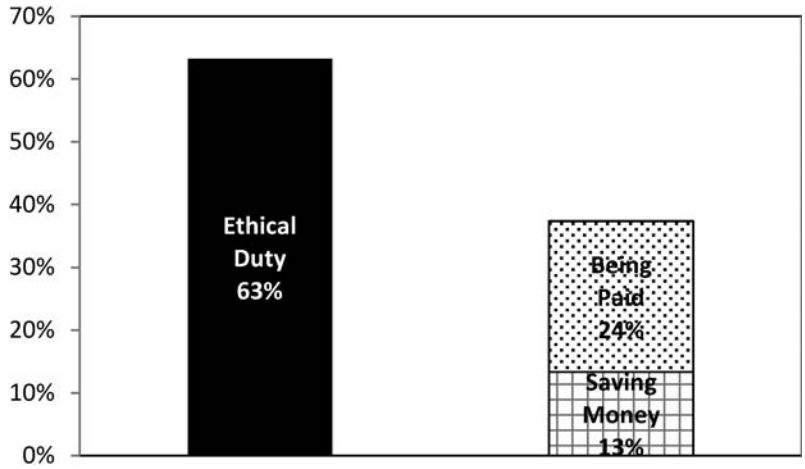

FIGURE 2
Self-Reported Factors Encouraging Recycling

formation from survey respondents and corresponding information for the Fayette County portion of the Census Bureau's American Community Survey (ACS) 2007. Overall, respondents to the recycling survey are fairly representative. They tend to be more educated but have income closer to the middle of the distribution.

Table 2 presents the proportion of households willing to pay for curbside recycling at various dollar amounts. The table is divided into two sections based on the definition of yes. "All yes" includes all yes responses regardless of respondent certainty. Definitely Sure separates yes responses based on respondent certainty.[4] Respondents indicating a yes to the willingness-to-pay question and who were Definitely Sure of their response were treated as yes, while all remaining responses were treated as no.[5] The proportion of yes responses tends to decline as the amount the respondent is asked to pay increases, as expected. For example, under the All Yes definition of yes, a high of 84% of respondents were willing to pay $1 per month for curbside recycling, while only 37% were willing to pay $7 per month. Fewer survey participants were Definitely Sure of their willingness-to-pay response; 61% were willing to pay $1 per month, with 20% willing at a price of $7 per month.

[4] Certainty on a probably sure/definitely sure and a 0 to 10 scale was elicited in the survey. In the literature, each scale has been shown to work well; however, the 0 to 10 scale has the disadvantage that the researcher has to choose a cut-off level of certainty that will best represent real purchase behavior. However, with probably sure/definitely sure certainty statements, estimating the cut-off is not necessary. The number of respondents saying yes with certainty of 8 or above was 115. Definitely sure yeses were most similar to those who expressed a certainty of 9 or higher, with 94 respondents represented.

[5] For each specification, the final sample has been adjusted for respondents identified as protestors. The term *protester* refers to someone who rejects the survey valuation scenario and therefore does not give responses that reflect his or her true preference for curbside recycling. To identify protesters, those individuals answering no to the willingness-to-pay question were asked to identify the reason. Individuals responding, "My household should not have to pay for curbside recycling," were considered protesters, as this response indicates a rejection of the hypothetical market rather than a low or nonexistent value of curbside recycling. Individuals who answered that they could not afford to pay, that curbside recycling had no value to their household, that there were suitable alternatives to curbside recycling, or that drop-off recycling is adequate were not considered protesters. Out of 200 no responses, 97 were identified as protesters. Running a logistic regression with a protester indicator as the dependent variable and the variables in Table 4 as independent variables yields only one significant predictor, Ethical Duty. The variable is positive and significant at the 5% level.

TABLE 1
Demographics of Recycling Survey vs. American Community Survey 2007 for Fayette County, Kentucky (Percent)

	Demand Sample ($n = 225$)	City Service ($n = 577$)	No City Service ($n = 207$)	Experimental Supply Sample ($n = 517$)	Overall ($n = 859$)	American Community Survey 2007
Gender						
Female	58.93	60.83	59.42	62.48	59.37	53.09
Age						
18–29	4.46	25.48	5.31	26.69	18.86	19.13
30–39	16.96	33.10	12.56	34.04	26.78	20.42
40–49	22.32	19.58	20.29	18.96	19.91	21.82
50–64	35.71	14.04	37.20	13.35	20.84	24.45
65 or over	20.54	6.93	23.67	6.00	12.69	14.18
Race						
White	97.32	79.55	98.55	77.95	85.68	83.07
Education						
Less than high school diploma	0.45	2.77	0.48	2.90	2.33	11.40
High school diploma or equivalent	4.91	6.24	6.28	6.77	6.75	21.06
Some college	16.07	16.12	14.98	15.86	16.76	21.83
Associate's degree	8.04	9.71	8.21	10.44	9.55	6.17
Bachelor's degree	35.27	37.09	30.43	36.17	34.11	22.49
Master's degree or beyond	31.25	23.92	34.30	23.21	26.08	17.06
Household income						
Under $15,000	3.13	2.25	4.35	2.51	2.56	8.32
$15,000–$39,999	14.29	19.58	14.49	20.50	18.04	24.14
$40,000–$59,999	20.98	24.09	21.26	23.98	23.17	18.21
$60,000–$99,999	31.25	38.99	31.88	39.46	37.60	24.49
$100,000 or more	30.36	15.08	28.02	13.54	18.63	24.84

Note: Both the Recycling Survey statistics and the American Community Survey statistics are for those individuals 18 years old or over living in a single family dwelling. The difference in the number of returned surveys ($n = 997$) and number represented in the Overall column ($n = 859$) is due to item nonresponse. Also note that the samples listed above are not mutually exclusive. Specifically, those in the demand sample can both receive city service or not receive city service; those in the experimental sample are on city service; Overall includes the Demand Sample and the Experimental Supply Sample.

TABLE 2
Percent Yes Responses to Willingness to Pay for Two Definitions of Yes

	All		Definitely Sure	
Price	Yes/Total	Percent	Yes/Total	Percent
$1	32/38	84%	23/38	61%
$2	35/47	74%	26/47	55%
$3	33/44	75%	22/44	50%
$5	28/46	61%	10/46	22%
$7	13/35	37%	7/35	20%
$9	3/9	33%	1/9	11%
$12	1/6	17%	1/6	17%
Overall	145/225	64%	90/225	40%
Turnbull mean willingness to pay	$5.46		$2.76	
95% confidence interval	($4.28, $6.65)		($2.13, $3.38)	

Turnbull Estimate

Two methods are used for calculating willingness to pay for curbside recycling based on survey responses. The first is the Turnbull nonparametric estimator. The advantage of the Turnbull estimator is that it makes no assumptions about the shape of the underlying willingness-to-pay distribution. Instead, the fraction of the empirical distribution falling into each price interval is used to calculate mean willingness to pay for the sample. Figure 3 displays the plots of the empirical distribution of willingness to pay for curbside recycling in Lexington. The Turnbull estimate of willingness to pay using the All Yes definition of yes is $5.46 per household per month (95% confidence interval of [$4.28, $6.65]). Using the Definitely Sure definition of yes produces a Turnbull estimate of willingness to pay of $2.76 (95% confidence interval of [$2.13, $3.38]). We have more confidence in this second estimate because, as noted above, Definitely Sure yes responses have matched well with real responses in previous field experiments (Champ and Bishop 2001; Blumenschein et al. 2008).

Parametric Estimate

While the Turnbull estimator makes no assumption about the underlying distribution of willingness to pay, its main disadvantage is its inability to control for household characteristics that may influence willingness to pay. To control for influential household characteristics, a parametric approach is used. The parametric approach follows Cameron (1988) and uses logistic regression to control for observable respondent characteristics. The logistic regression takes the following form:

$$\Pr(\text{Yes}) = 1/(1+e^{(-X\beta)}), \qquad [1]$$

where the dependent variable is a household's yes or no response to the willingness-to-pay question. Table 3 presents the definitions of X, the control variables used in the regression analysis, along with their descriptive statistics. The main variables of interest can be divided into two groups. The first group relates to standard demographic characteristics of the household, things such as income, education, gender, and race. The second group is related to current recycling behavior and personal motivations for recycling. For example, individuals who are currently using or are aware of drop-off recycling centers might be willing to pay less for curbside recycling because of drop-off being an adequate substitute for them. On the other hand, individuals motivated by an ethical duty may be willing to pay more for curbside recycling.

Table 4 presents the results of the logistic regression with controls for household characteristics. The two specifications presented are distinguished by the dependent variable used. The dependent variable for the All Yes specification is the yes/no response to the willingness-to-pay question. For the Definitely Sure specification, the dependent variable is the response to the willingness-to-pay question after adjusting for respondents who were definitely sure of their willingness-to-pay response.

The regression results indicate those facing a lower price, those having higher income, and those that feel an ethical duty to recycle are most likely to respond affirmatively to the willingness-to-pay question. For respondents who are definitely sure that they would participate, the estimated marginal effect of a $1,000 increase in income is an increase in the probability of saying yes to the willingness to pay question by 0.0014. Indicating an ethical duty to recycle increases the probability of saying yes by 0.24. Table 4 also shows the mean willingness to pay for the willingness-to-pay sample estimated using the formula $-(1/b_{\text{Price}})\cdot z$, where b_{Price} is the coefficient of the price variable and z represents the effects of all the other covariates evaluated at their means, including the constant. Accounting for certainty, the best estimate of mean willingness to pay is $2.29 per household per month, with a 95% confidence interval of $1.27–$3.31.[6] The similarity of the

[6] The ratio of uncalibrated mean willingness to pay to mean willingness to pay calibrated by certainty statements in our study is (6.18/2.29), or 2.7. The ratio reported by Aadland and Caplan (2006) calibrated by revealed participation in voluntary recycling programs is (6.47/3.42), or 1.9. List and Gallet (2001) perform a meta-analysis of contingent valuation studies having both a real and hypothetical conditions. The ratio for the field experiments they review is 3.2.

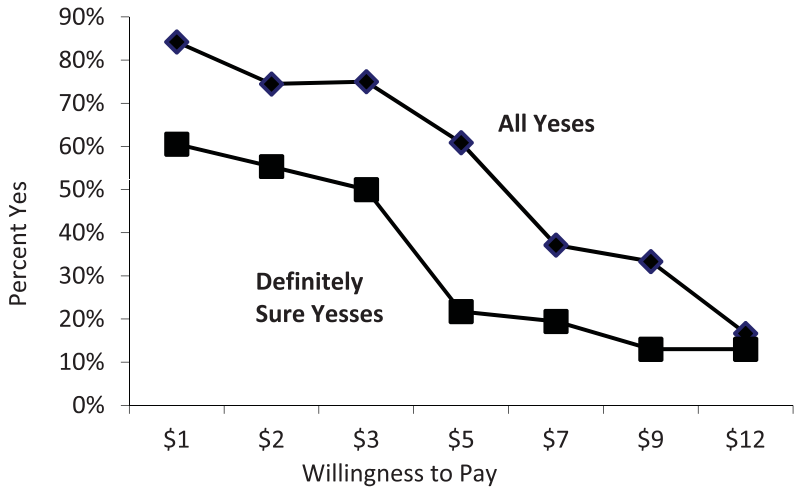

FIGURE 3
Nonparametric Demand Curves for Two Definitions of Yes

TABLE 3
Definitions of Variables and Summary Statistics

Variable	Mean	Description
Price	3.96 [2.63]	Dollar amount individual would pay for curbside recycling service in 2007 dollars; amounts were one of the following: 1 (17%), 2 (21%), 3 (20%), 5 (20%), 7 (16%), 9 (4%), 12 (3%)
Income	86.42 [54.07]	Household income in thousands of dollars
Employed	0.59	1 if employed full time, 0 otherwise
College Graduate	0.74	1 if received bachelor's degree or higher, 0 otherwise
Age	52.41 [14.83]	Age of respondent
Female	0.59	1 if respondent if female, 0 otherwise
White	0.97	1 if respondent is white, 0 otherwise
Number in Household	2.51 [1.16]	Number of individuals living in the household
City Service	0.18	1 if respondent receives city-provided trash collection, 0 otherwise
Drop-off Know	0.48	1 if respondent knows of drop-off recycling center in the city, 0 otherwise
Drop-off User	0.20	1 if respondent uses drop-off recycling, 0 otherwise
Recycle at Work	0.45	1 if respondent recycles at work, 0 otherwise
Ethical Duty	0.83	1 if respondent feels an ethical duty to recycle, 0 otherwise
Money Motive	0.32	1 if saving money motivates respondent to recycle, 0 otherwise
Primary Ethics	0.66	1 if ethical duty would *most* encourage household to recycle, 0 otherwise
Primary Saving Money	0.16	1 if saving money would *most* encourage household to recycle, 0 otherwise
Member Envir. Org.	0.10	1 if someone in household is a member of an environmental organization, 0 otherwise

Note: Standard deviations for noncategorical variables are in brackets. Means calculated using estimation sample, $n = 225$.

TABLE 4
Logistic Regression for Two Definitions of Yes

	Baseline	Baseline Marginal Effects	Definitely Sure	Definitely Sure Marginal Effects
Price	−0.4048*** [0.0762]	−0.0833*** [0.0157]	−0.3387*** [0.0742]	−0.0782*** [0.0165]
Income	0.0101** [0.0043]	0.0021** [0.0009]	0.0062** [0.0032]	0.0014** [0.0007]
Employed	0.1913 [0.4904]	0.0396 [0.1023]	−0.1272 [0.4288]	−0.0295 [0.0996]
College Graduate	0.6413 [0.4166]	0.1394 [0.0945]	−0.06 [0.3864]	−0.0139 [0.0899]
Age	−0.0425*** [0.0164]	−0.0087*** [0.0033]	−0.0204 [0.0138]	−0.0047 [0.0032]
Female	0.6299 [0.4008]	0.1321 [0.0845]	0.2753 [0.3538]	0.0631 [0.0802]
White	0.9722 [1.1777]	0.228 [0.2931]	1.0693 [1.2118]	0.2016 [0.1709]
Number in Household	−0.0811 [0.1777]	−0.0167 [0.0365]	0.0615 [0.1487]	0.0142 [0.0343]
City Service	−0.687 [0.4859]	−0.1524 [0.1132]	−0.393 [0.4361]	−0.0872 [0.0923]
Drop-off Know	−0.3574 [0.4259]	−0.0736 [0.0876]	−0.3445 [0.3767]	−0.0793 [0.0862]
Drop-off User	0.3809 [0.5689]	0.0744 [0.1048]	0.7746* [0.4698]	0.1862 [0.1146]
Recycle at Work	−0.3012 [0.4341]	−0.0623 [0.0902]	−0.1042 [0.3641]	−0.024 [0.0838]
Ethical Duty	2.1964*** [0.5760]	0.4968*** [0.1137]	1.2089** [0.5393]	0.2388*** [0.0855]
Money Motive	−0.9106** [0.4028]	−0.1972** [0.0891]	−0.103 [0.3485]	−0.0237 [0.0796]
Primary Ethics	0.8905* [0.5165]	0.1916* [0.1135]	0.5155 [0.4615]	0.1158 [0.1003]
Primary Saving Money	0.3203 [0.6141]	0.0627 [0.1138]	0.4412 [0.5784]	0.1053 [0.1413]
Member Envir. Org.	1.4539* [0.7933]	0.2208*** [0.0794]	0.5569 [0.5695]	0.1344 [0.1410]
Constant	0.2143 [1.8096]		−1.2322 [1.6919]	
n	225		225	
Pseudo *R*-squared	0.334		0.177	
Proportion yes	64%		40%	
Mean willingness to pay	$6.18 [0.5631]		$2.29 [0.5196]	
95% confidence interval	(5.08, 7.28)		(1.27, 3.31)	

Note: Standard errors are in brackets.
* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

point estimates for the parametric ($2.29) and nonparametric ($2.76) methods is reassuring.

V. PAID TO RECYCLE: A FIELD EXPERIMENT IN CURBSIDE RECYCLING SUPPLY

Willingness to pay is an important component when analyzing the net benefits of a recycling program. Solid waste administrators may also be interested in knowing how to influence recycling behavior. The purpose of the supply experiment is to understand how households respond to different incentives to increase their level of household recycling. In particular, the experiment is designed to assess the impact of monetary incentives and communication appeals given to households over a period of time. The field experiment is a 3 monetary incentive ($0, $1, $2) by 4 communication appeal (none, informational, guilt, or feel good) between subjects design; it encompasses 12 experimental conditions.

All communication appeals consisted of a flier sent to households at the beginning of each month. The Informational Appeal stated several specific facts about recycling. The Guilt Appeal contained the statement, "Not Recycling Destroys Kentucky," along with a photo of Iron Eyes Cody from the Keep America Beautiful Campaign in the 1970s. The text below the photo included a statement that Kentucky recycles 30% less than the national average and ends with the question, "When will we wake up and see what we have done?" The Feel Good Appeal described a program in which proceeds from recycled aluminum cans fund construction of homes through Habitat for Humanity. The appeal contains a photograph of a home being built and individuals who received a home through the program.

To test the effects of the communication appeals along with the monetary incentives, the weight of household recycled materials was recorded once a week for five weeks be-

fore experimental conditions began. Experimental conditions then proceeded for six months. The price incentives and communication appeals were offered at the beginning of each month. Each household received the incentive payments and appeals each month regardless of its measured recycling behavior. The timing of incentives as well as the relatively small dollar amounts were generated in consultation with the local solid waste administrators for the city to ensure that it would be structured in a way that could be implemented on a broad basis and in other municipalities. Additionally, whole dollar values were chosen as $1 bills were to be sent as incentives. The communication appeals were chosen to represent three types of messages households commonly receive regarding recycling. The appeals were developed and revised after feedback from two focus groups.

In order to understand the behavior of households under a recycling incentive program, data were collected on participation and weight of materials that households recycle on a weekly basis. To this end a garbage truck in Lexington was retrofitted with a scale and radio frequency identification (RFID) reader. Additionally, household recycling containers in a selected neighborhood were fitted with RFID tags. A total of 462 households in the experimental neighborhood had tags placed on their recycling container. The tags along with the scale and reader allowed the weight of household recyclable material to be automatically measured for each household at each pickup.

Table 5 shows the overall demographic characteristics for the final estimation sample of the experimental route, for each experimental cell (group), and for the entire Lexington area as given by the 2007 ACS. Compared to the Lexington population, households in the experimental supply sample tend to have a higher proportion of females, be individuals in the 18–39 age group, be more educated, and have a higher share of households in middle income groups.

Experimental Supply Results

Our main variables of interest in the field experiment are household participation and household recycling weight. Table 6 presents the mean recycling weight for each experimental condition in both the control and treatment time periods. The period of November 6 through December 4, 2008, represents the control weeks in which household recycling weight was measured without administration of experimental treatments. The lowest average recycling weight during control conditions was 6.50 pounds and occurred for the Guilt Appeal, $0 group. The highest during control conditions was 11.03 pounds and occurred for the Information Appeal, $2 group. The No Communication Appeal, $0 group was between these two at 7.13 pounds on average.

Treatment conditions began December 11, 2008, and continued through July 30, 2009. As Table 6 indicates, recycling in treatment months was lower for each of the experimental conditions and control group. This is likely due to the control time period occurring at a time of the year with high levels of trash and recyclable materials related to the holiday season. Consistently lower averages in the treatment period highlight the importance of controlling for time series changes in recycling weight, which is done in the empirical model below. The greatest amount of recyclable materials during treatment was collected for the No Communication Appeal, $1 group at 8.57 pounds. The low of 4.20 pounds occurred for Information Appeal, $1 with the No Communication Appeal, $0 group again in the middle at 5.47 pounds.

Table 7 presents the proportion of households that ever set out their recycling container divided into control and treatment time periods. Out of 11 possible changes due to money or communication appeals, six point estimates indicate an increase in the proportion of households that ever set out their recycling container during treatment conditions. None of the point estimates indicate a decrease in the proportion of households ever setting out their container.

Parametric Analysis

Two regression frameworks provide additional insight to the effect of the monetary incentives and communication appeals on re-

TABLE 5
Demographics of Experimental Route vs. American Community Survey 2007 for Fayette County, Kentucky (Percent)

	Experimental Supply Sample ($n = 256$)	American Community Survey 2007	No Comm. Appeal, $0 ($n = 19$)	No Comm. Appeal, $1 ($n = 21$)	No Comm. Appeal, $2 ($n = 20$)	Info. Appeal, $0 ($n = 22$)	Info. Appeal, $1 ($n = 18$)	Info. Appeal, $2 ($n = 18$)	Guilt Appeal, $0 ($n = 23$)	Guilt Appeal, $1 ($n = 24$)	Guilt Appeal, $2 ($n = 22$)	Feel Good Appeal, $0 ($n = 24$)	Feel Good Appeal, $1 ($n = 23$)	Feel Good Appeal, $2 ($n = 22$)
Gender														
Female	60.98	53.09	63.16	57.14	50.00	72.73	66.67	66.67	56.52	58.33	45.45	66.67	52.17	63.64
Age														
18–29	24.24	19.13	42.11	4.76	10.00	31.82	33.33	27.78	30.43	16.67	31.82	12.50	26.09	22.73
30–39	34.47	20.42	26.32	38.10	45.00	40.91	33.33	27.78	39.13	37.50	13.64	54.17	34.78	36.36
40–49	21.21	21.82	26.32	42.86	5.00	18.18	16.67	11.11	17.39	16.67	18.18	20.83	26.09	31.82
50–64	13.26	24.45	5.26	4.76	35.00	4.55	11.11	27.78	8.70	20.83	18.18	12.50	13.04	0.00
65 or over	6.44	14.18	0.00	9.52	5.00	4.55	5.56	5.56	4.35	8.33	18.18	0.00	0.00	9.09
Race														
White	80.30	83.07	73.68	76.19	75.00	86.36	77.78	83.33	82.61	75.00	95.45	75.00	73.91	77.27
Education														
Less than high school diploma	3.41	11.40	5.26	9.52	0.00	0.00	5.56	5.56	0.00	12.50	0.00	4.17	0.00	0.00
High school diploma or equivalent	7.20	21.06	11.11	10.00	15.00	9.09	5.56	5.88	17.39	4.17	4.55	4.17	0.00	0.00
Some college	14.77	21.83	10.53	23.81	30.00	18.18	11.11	5.56	8.70	16.67	9.09	16.67	13.04	18.18
Associate's degree	11.74	6.17	5.26	4.76	15.00	9.09	5.56	11.11	13.04	12.50	9.09	16.67	21.74	13.64
Bachelor's degree	34.85	22.49	31.58	23.81	30.00	31.82	50.00	22.22	34.78	29.17	45.45	29.17	34.78	40.91
Master's degree or beyond	24.24	17.06	21.05	19.05	10.00	18.18	22.22	44.44	26.09	16.67	27.27	29.17	30.43	27.27
Household income														
Under $15,000	3.41	8.32	5.26	4.76	10.00	4.55	5.56	5.56	0.00	0.00	0.00	0.00	4.35	4.55
$15,000–$39,999	20.83	24.14	21.05	14.29	30.00	13.64	11.11	5.56	8.70	33.33	18.18	29.17	26.09	36.36
$40,000–$59,999	24.62	18.21	26.32	33.33	20.00	31.82	22.22	16.67	30.43	29.17	27.27	12.50	8.70	22.73
$60,000–$99,999	38.26	24.49	36.84	38.10	20.00	36.36	44.44	66.67	39.13	37.50	40.91	41.67	39.13	27.27
$100,000 or more	12.88	24.84	10.53	9.52	20.00	13.64	16.67	5.56	21.74	0.00	13.64	16.67	21.74	9.09

Note: Both the Recycling Survey statistics and the American Community Survey statistics are for those individuals 18 years old or over living in a single family dwelling. The difference between the 462 total tagged bins on the experimental route and the 256 reported in this table is due to item nonresponse.

TABLE 6
Average Weight by Experimental Condition

	Control	Treatment	Difference	Cell Difference from No Comm. Appeal, $0 during Control	Cell Difference from No Comm. Appeal, $0 during Treatment
No Comm. Appeal, $0	7.13 [9.25]	5.47 [7.90]	−1.66	—	—
No Comm. Appeal, $1	9.38 [9.62]	8.57 [10.40]	−0.81	2.25	3.10
No Comm. Appeal, $2	7.67 [9.00]	6.01 [8.61]	−1.66	0.54	0.54
Info. Appeal, $0	7.20 [8.43]	5.91 [8.34]	−1.29	0.07	0.44
Info. Appeal, $1	7.68 [10.30]	4.20 [7.55]	−3.48	0.55	−1.27
Info. Appeal, $2	11.03 [16.41]	6.53 [8.82]	−4.50	3.90	1.06
Guilt Appeal, $0	6.50 [8.00]	5.05 [8.07]	−1.45	−0.63	−0.42
Guilt Appeal, $1	6.61 [9.16]	5.40 [9.16]	−1.21	−0.52	−0.07
Guilt Appeal, $2	6.51 [10.19]	5.21 [9.87]	−1.30	−0.62	−0.26
Feel Good Appeal, $0	9.23 [10.31]	6.84 [10.18]	−2.38	2.10	1.37
Feel Good Appeal, $1	9.19 [11.48]	7.51 [10.33]	−1.68	2.06	2.04
Feel Good Appeal, $2	7.71 [9.23]	5.60 [8.30]	−2.11	0.58	0.13

Note: Standard deviations are in brackets.

TABLE 7
Proportion of Households That Ever Set Out Recycling Container

	Control	Treatment
No Comm. Appeal, $0	1.00	1.00
No Comm. Appeal, $1	0.95	1.00
No Comm. Appeal, $2	0.75	0.90
Info. Appeal, $0	0.86	1.00
Info. Appeal, $1	0.94	0.94
Info. Appeal, $2	0.94	1.00
Guilt Appeal, $0	0.91	0.91
Guilt Appeal, $1	0.88	0.88
Guilt Appeal, $2	0.77	0.86
Feel Good Appeal, $0	0.88	0.92
Feel Good Appeal, $1	0.91	0.91
Feel Good Appeal, $2	1.00	1.00

cycling weight. The following equation shows the basic model.

$$RW_{it} = \alpha + \sum_{j=1}^{2} \beta_j DolInc_i + \sum_{k=2}^{4} \delta_k ComApp_i + \sum_{j=1}^{2} \sum_{k=2}^{4} \gamma_{jk} DolInc_i \cdot ComApp_i + \omega X_i + \varphi_t + \varepsilon_{it}. \quad [2]$$

The dependent variable RW_{it} is the measured recycling weight for each household (i), each week (t). *DolInc* is a group of dummy variables that identify which of the monetary incentives the household received, $0, $1, or $2, with $0 being the omitted category. Similarly, *ComApp* is a group of dummy variables that identify the communication appeal the household received, None, Informational, Guilt, or Feel Good, with None being the omitted category. In addition to standard demographic variables, X includes several attitudinal questions regarding recycling and also information on whether each household uses drop-off recycling centers or recycling at work programs. φ represents week fixed effects, and ε is the error term.

Table 8 presents coefficient estimates associated with equation [2] along with robust standard errors clustered at the household level. The table is divided into two time periods. In the left column, coefficients are estimated for the control weeks only. On the right, the coefficients are estimated during the experimental weeks. The comparison of the coefficients in these two broad time periods is to ensure similarity of recycling behavior between experimental groups before treatment conditions began. During the control weeks, the main predictors of recycling weight were not related to the experimental conditions. Instead, age, race, number of people in a household, knowledge and use of drop-off recycling centers, recycling at work, and membership in an environmental organization are the significant predictors.

The right column in Table 8 presents coefficient estimates during the treatment weeks.

TABLE 8
Effect of Recycling Incentives on Recycling Weight

	Control Weeks	Treatment Weeks
Info. Appeal	− 0.031 [1.290]	0.247 [0.870]
Guilt Appeal	− 0.887 [1.386]	− 0.513 [0.858]
Feel Good Appeal	1.388 [1.601]	0.843 [0.907]
$1	0.628 [1.595]	2.526* [1.315]
$2	− 0.915 [1.420]	0.281 [1.119]
Info. Appeal, $1	0.103 [2.165]	− 4.281*** [1.602]
Info. Appeal, $2	3.639 [2.373]	− 0.134 [1.558]
Guilt Appeal, $1	− 1.202 [2.151]	− 2.299 [1.608]
Guilt Appeal, $2	0.373 [2.140]	− 0.508 [1.561]
Feel Good Appeal, $1	− 0.907 [2.405]	− 1.673 [1.745]
Feel Good Appeal, $2	0.13 [2.242]	− 0.784 [1.544]
Income	0.016 [0.011]	0.010 [0.008]
Employed	− 1.337 [1.020]	− 1.020 [0.722]
College Graduate	0.383 [0.797]	0.361 [0.557]
Age	0.131*** [0.030]	0.053*** [0.020]
Female	− 0.135 [0.709]	0.594 [0.487]
White	2.356*** [0.892]	1.664*** [0.621]
Number in Household	0.914*** [0.346]	0.341* [0.225]
Drop-off Know	1.520** [0.763]	0.088 [0.522]
Drop-off User	− 2.671** [1.205]	− 0.369 [0.868]
Recycle at Work	1.510* [0.769]	1.355** [0.544]
Ethical Duty	0.559 [1.252]	0.420 [0.752]
Money Motive	0.997 [0.786]	− 0.318 [0.542]
Primary Ethics	− 0.831 [0.968]	0.216 [0.535]
Primary Saving Money	− 1.364 [1.367]	− 0.315 [0.843]
Member Envir. Org.	3.221* [1.927]	0.829 [1.065]
Constant	− 3.243 [2.716]	0.927 [2.014]
Week fixed effects	Yes	Yes
Standard error adjustment	Cluster	Cluster
n	1,280	3,584
R-squared	0.096	0.093

Standard errors are in brackets.
* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

The table shows that the informational and feel good appeals had positive impacts on recycling weight, while the Guilt Appeal had a negative impact, but none of the communication appeals are statistically significant.

The $1 incentive had a positive impact on household recycling weight. The $1 incentive increased recycling by 2.53 pounds on average, a 31% increase over the control period average for those receiving the $1 incentive. The coefficient is statistically significant and arguably economically significant. However, the $2 incentive did not have as large an impact, and it is not significantly different from zero.

The interaction effects of dollar incentives and communication appeals are uniformly negative. The coefficient that is largest in magnitude is for the combination of the Informational Appeal and the $1 incentive; it *reduces* recycling weight by 4.28 pounds compared to the No Communication Appeal, $0 incentive group. The Guilt Appeal combination with $1 is also large, but not statistically significant.

Once again, several demographic characteristics were significant predictors of recycling weight. Those who are older, white, have more people in their household, and recycle at work, tend to recycle more on average.

It is also possible to analyze the recycling behavior in the experimental neighborhood by combining data collected under control and treatment conditions and using an untreated control group design with pretest and posttest (Meyer 1995). This can be accomplished by

estimating a difference-in-difference equation of the following form:

$$RW_{it} = \alpha + \sum_{j=1}^{2} \beta_j DolInc_{it} + \sum_{k=2}^{4} \delta_k ComApp_{it} + \sum_{j=1}^{2}\sum_{k=2}^{4} \gamma_{jk} DolInc_{it} \cdot ComApp_{it} + \psi After + \sum_{j=1}^{2} \theta_j After \cdot DolInc_{it} + \sum_{k=2}^{4} \eta_k After \cdot ComApp_{it} + \sum_{j=1}^{2}\sum_{k=2}^{4} \lambda_{jk} After \cdot DolInc_{it} \cdot ComApp_{it} + \omega X_i + \varphi_t + \varepsilon_{it}. \quad [3]$$

RW, X, φ, and ε again represent recycling weight, demographic variables, week fixed effects, and the error term, respectively, as in equation [2]. *After* is a variable that equals one during the treatment period, and zero otherwise. In this framework, θ_j represents the difference-in-difference estimate of the average treatment effect of dollar incentive j on recycling weight. Similarly, η_k represents the difference-in-difference estimate of the effect of communication appeal k, and λ_{jk} is the estimate of the interaction effect between dollar incentive j and communication appeal k. Changes in the recycling weight of households in treatment groups represent the possible effect of the experimental incentives but could be contaminated by other unobserved factors that changed over the same time period. The average change in the control group reflects the unobserved determinants of recycling that changed over the study period. The difference in these changes separates the effects of recycling incentives from other unobserved determinants that were also changing at the same time the experiment took place. The difference-in-difference estimates capture the variation in recycling weight specific to the treatments (relative to control) in the time period after treatment began (relative to before treatment).

Table 9 presents estimates of the difference-in-difference coefficients from equation [3]. The coefficients in Table 9 are estimated

TABLE 9
Difference-in-Difference Estimate of the Average Treatment Effect

	Net Weight
After, Info. Appeal	0.365 [1.278]
After, Guilt Appeal	0.195 [1.133]
After, Feel Good Appeal	−0.730 [1.369]
After, $1	0.843 [1.247]
After, $2	−0.003 [1.346]
After, Info. Appeal, $1	−3.031* [1.818]
After, Info. Appeal, $2	−3.211 [2.516]
After, Guilt Appeal, $1	−0.598 [1.793]
After, Guilt Appeal, $2	0.163 [1.811]
After, Feel Good Appeal, $1	−0.139 [1.793]
After, Feel Good Appeal, $2	0.281 [1.838]
Controls	
Week fixed effects	Yes
Demographic controls	Yes
Standard error adjustment	Cluster
n	4,864
R-squared	0.095

Note: Standard errors are in brackets.
* $p < 0.10$.

while controlling for demographic characteristics of the recycler as well as time series changes in recycling weight. The largest point estimate of an increase in recycling weight occurred for the No Communication Appeal, $1 group with a 0.84 pound increase, but it is not statistically significant. The largest decrease in recycling weight occurred for the Informational Appeal $1 and $2 cells. The Informational Appeal, $1 cell showed a statistically significant 3.03 pound decrease in recycling weight, while the Informational Appeal, $2 cell showed a statistically insignificant 3.21 pound decrease in recycling weight. Combining the Informational Appeal with the monetary incentives appears to have caused a large decline in recycling.

Finally, experimental treatments could have influenced the frequency with which households set out their recyclable materials. To that end, we use a Probit model by changing the dependent variable in equation [2] so that it equals one if the household placed their container out for recycling in a particular week, and zero otherwise. Table 10 shows the estimated coefficients along with the marginal effects for the control and treatment time period. The marginal effects of the interactions are calculated as the discrete double differ-

TABLE 10
Effect of Treatment on the Probability of Recycling

	Control Weeks	Marginal Effects: Control Weeks	Treatment Weeks	Marginal Effects: Treatment Weeks
Info. Appeal	− 0.148 [0.223]	0.026 [0.057]	− 0.006 [0.187]	− 0.035 [0.045]
Guilt Appeal	0.041 [0.222]	− 0.044 [0.053]	0.029 [0.212]	− 0.064 [0.045]
Feel Good Appeal	0.072 [0.247]	0.018 [0.053]	− 0.031 [0.190]	0.008 [0.043]
$1	0.166 [0.238]	0.007 [0.045]	0.278 [0.206]	− 0.004 [0.037]
$2	− 0.156 [0.274]	− 0.002 [0.048]	− 0.123 [0.213]	− 0.005 [0.039]
Info. Appeal, $1	0.155 [0.357]	0.061 [0.135]	− 0.542* [0.277]	− 0.213** [0.108]
Info. Appeal, $2	0.529 [0.397]	0.204 [0.152]	0.281 [0.308]	0.111 [0.122]
Guilt Appeal, $1	− 0.44 [0.343]	− 0.171 [0.132]	− 0.477 [0.301]	− 0.189 [0.119]
Guilt Appeal, $2	− 0.04 [0.357]	− 0.016 [0.141]	− 0.151 [0.306]	− 0.058 [0.120]
Feel Good Appeal, $1	− 0.226 [0.337]	− 0.086 [0.128]	− 0.138 [0.270]	− 0.054 [0.107]
Feel Good Appeal, $2	0.155 [0.373]	0.061 [0.145]	0.313 [0.283]	0.124 [0.111]
Income	0.002 [0.002]	0.001 [0.001]	0.003* [0.001]	0.001* [0.000]
Employed	− 0.187 [0.153]	− 0.068 [0.055]	− 0.223* [0.129]	− 0.080* [0.046]
College Graduate	− 0.072 [0.130]	− 0.026 [0.047]	− 0.079 [0.099]	− 0.028 [0.035]
Age	0.004 [0.004]	0.001 [0.002]	0.002 [0.004]	0.001 [0.001]
Female	0.033 [0.109]	0.012 [0.039]	0.043 [0.089]	0.015 [0.032]
White	0.395*** [0.138]	0.143*** [0.049]	0.273** [0.107]	0.097** [0.038]
Number in Household	0.175*** [0.047]	0.063*** [0.017]	0.108*** [0.034]	0.039*** [0.012]
Drop-off Know	0.252** [0.115]	0.091** [0.041]	0.066 [0.094]	0.024 [0.034]
Drop-off User	− 0.286 [0.228]	–0.103 [0.082]	–0.137 [0.159]	–0.049 [0.057]
Recycle at Work	0.257*** [0.124]	0.093** [0.044]	0.232** [0.104]	0.083** [0.037]
Ethical Duty	0.149 [0.186]	0.054 [0.067]	0.154 [0.143]	0.055 [0.051]
Money Motive	0.002 [0.113]	0.001 [0.041]	–0.102 [0.092]	–0.037 [0.033]
Primary Ethics	0.004 [0.142]	0.001 [0.051]	–0.037 [0.111]	–0.013 [0.040]
Primary Saving Money	− 0.159 [0.205]	–0.057 [0.074]	–0.077 [0.175]	–0.028 [0.063]
Member Envir. Org.	0.264 [0.199]	0.095 [0.072]	0.028 [0.222]	0.01 [0.079]
Constant	− 0.874*** [0.423]		− 0.656** [0.344]	
Week fixed effects	Yes		Yes	
Standard error adjustment	Cluster		Cluster	
n	1,280		3,584	
Pseudo *R*-squared	0.066		0.096	

Note: Standard errors are in brackets.
* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

ence as recommend by Ai and Norton (2003) for nonlinear models.

The left-hand columns of Table 10 again represent the control weeks and show that the main predictors of setting out the recycling container are related to demographic characteristics and not experimental treatments. During the treatment period, the results indicate that the Informational Appeal, $1 treatment condition significantly reduced the probability of setting out recycling for collection. The Informational Appeal and the $1 incentive combine to reduce the probability of recycling by 0.21. The $1 incentive also interacted with the Guilt Appeal to reduce the probability of setting out the recycling container by 0.19. Beyond experimental treatments, certain demographic characteristics appear to be important predictors of the decision to recycle. The largest predictor appears to be a person's race. Being white increases the probability of setting out the container by 0.10 compared to nonwhites. Another significant predictor is whether a person recycles at work. Doing so increases the probability of setting out the recycling container by 0.08 on average. The more people in a particular household, the more likely that recycling will occur. Income is also statistically significant. Employment reduces the probability of recycling by 0.08. The recycle at work and employment variables tend to influ-

ence the probability of setting out the recycling container in the opposite directions. Someone who recycles is more likely to take that behavior with them from place to place. However, employment itself lowers the probability of setting out the recycling container, perhaps because of increased demands on time.

VI. DISCUSSION AND POLICY IMPLICATIONS

Viscusi, Huber, and Bell (2011) and Viscusi et al. (forthcoming) provide possible reasons why some of our experimental conditions had little impact. They give theoretical and empirical evidence that households either recycle diligently or do not recycle. Reschovsky and Stone (1994) find that recycling levels tend to increase modestly the longer a recycling program has been in place, making marginal additions to recycling levels more difficult the longer a program has been in place. Specifically related to the monetary incentives, Seabright (2009) suggests that some socially desirable activities are subject to crowding-out effects in which individuals' willingness to participate in the activities decreases when explicit monetary rewards are involved. While $1 appears to be a threshold for the effectiveness of monetary incentives in this experiment, incentives greater than $2 were not investigated. Additionally the monetary incentives for this experiment were paid to households monthly regardless of their recycling behavior and were small. With respect to incentives, certain types may be more effective than others. Ferraro, Miranda, and Price (2011) find that only prosocial appeals that include a social comparison with the behaviors of others have a long-run impact. Future research should assess whether appeals that contain comparisons to other's recycling behavior are capable of influencing recycling behavior. Overall, the empirical estimates presented in this paper along with these points suggest that it will be difficult to marginally increase the recycling levels of households living in an area with an established recycling program.

While the experiment shows that paying households a small nominal amount has some effect on increasing recycling behavior, it is unlikely that cities would choose to fund incentives at a level that would substantially impact recycling behavior. The results suggest that municipalities would likely have to spend a substantial amount of money on incentives or on an effort to change norms if they want to increase recycling behavior. Given the estimates of willingness to pay for curbside recycling in this paper and in the literature, it does not appear that the benefit of trying to change recycling behavior in neighborhoods with an established recycling program exceeds the amount of incentive payments necessary to induce additional recycling.

The modest increase in recycling weight seems to question whether it is efficient to administer the experimental treatments; however, the recycling program itself may still be economically beneficial if households' willingness to pay for the program, along with reduced municipal waste disposal expenditures, covered the cost of administering the program. Aadland and Caplan (2006) report per month, per household cost estimates of curbside recycling programs in 11 different cities. The average cost reported was $3.38 with a low of $1.87 and a high of $5.88. Based on the city budget for Lexington in 2007 and the number of households receiving city recycling services, the cost to administer the curbside recycling program in Lexington is $2.40 per household per month. This estimate represents a lower bound of the cost of running the curbside recycling program, as the program takes advantage of city facilities that have their own line item in the city budget. The $2.29 estimate of willingness to pay for curbside recycling is lower than the cost to run the program.

VII. CONCLUSION

In seeking to understand household recycling behavior, this research examines both the demand and supply of household curbside recycling. On the demand side, we use contingent valuation techniques to estimate the average willingness to pay for curbside recycling programs. Using both nonparametric and parametric estimates, and adjusting for hypothetical bias, we find that households are

willing to pay $2.29 per month to participate in their curbside recycling program. This estimate is similar to estimates from the western region of the United States.

To estimate the supply of household recyclable materials, an experiment was designed in which households were offered various incentives to change their recycling behavior. Households were given explicit monetary incentives in the form of $1 or $2 each month. Households were also given communication appeals in the form of informative, guilt, and feel good appeals to recycle. Based on experimental results, it appears that the $1 monetary incentive had the greatest impact on household recycling. Another emerging result is that the monetary incentives interact negatively with communication appeals. The communication appeals by themselves had little impact overall.

APPENDIX

Would your household be willing to pay $X per month out of its own household budget for curbside recycling, in addition to the current monthly garbage collection fee?

a. Yes

b. No → Go to question ##

Are you "probably sure" or "definitely sure" that your household would be willing to pay an additional $X per month for a curbside recycling service?

c. Probably sure

d. Definitely sure

On a scale from 0 to 10, how certain are you that your household would be willing to pay $X per month to participate in the curbside recycling service?

0 1 2 3 4 5 6 7 8 9 10

Very uncertain Very certain

FIGURE A1
Willingness to Pay Question and Certainty Elicitation

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