Analysis of recycling behavior

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Abstract

Aspects of household recycling behavior and attitudes in the City of Bryan, Texas, USA, are examined using survey data obtained in 1999. Results indicate among other effects Bryan residents' preference for waste disposal is consistent with the waste management hierarchy established by the U.S. Environmental Protection Agency. The logit regression results show that respondents who are female, white, employed, have higher incomes, have children, own a house, and are self-perceived environmentalists tend to recycle more.
Keywords: recycling behavior, solid waste policies, logistic regression.

1 Introduction

Solid waste management (SWM) is an important issue facing municipalities [1]. Most SWM strategies designed and implemented by municipalities around the nation follow for the most part the waste management hierarchy developed by the U.S. EPA [2]. This hierarchy includes increasing source reduction, increasing recycling and composting, and decreasing the amount of waste disposed in landfills and through incineration. Households are being offered alternatives to conventional disposal methods, such as recycling programs, to alter their waste disposal behavior. These efforts have led to mixed results [3], partially because the marginal cost of waste disposal for many households is close to zero [4]. Moreover, most—if not all—SWM activities are centralized making it difficult for private firms to enter only the recyclable collection sector. Thus, there exists no incentive in the marketplace for households to alter their decrease waste generation, disposal or recycling behavior (for extensive discussion see Arekere [5]). It is important, however, to note that recycling is more popular now than in previous years and more people reported recycling than voting at one point [3].



Waste Management and the Environment II, V. Popov, H. Itoh, C.A. Brebbia & S. Kungolos (Editors)
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Despite the apparent lack of monetary gains to households, a large number of households do recycle (for a discussion on recycling programs and behaviour see Arekere [6]). And there are a variety of recycling programs that are being operated by communities around the nation [1]. And, more and more communities are considering expanding or establishing recycling programs. The different types of recycling programs, centralized management of waste collection, differences in recycling behaviour by region, and factors underlying recycling behaviour, several questions persist. In particular, question relating to the type of recycling program that will yield the best recycling rates is principal.

Determining the various levels of participation and recycling rates before a program is implemented is difficult if not impossible. One way to access the level of interests is to understand the attitudes and preferences of the potential population covered by the recycling program. Information thus generated can be then used to gauge recycling behavior and make informed decisions. In this paper, Bryan, Texas, USA, residents' attitudes towards waste management and recycling, and factors influencing recycling behavior are presented.

2 Methodology

A survey instrument was used to generate data to analyze the attitudes of Bryan residents. Bryan is situated in Brazos County in central Texas, USA. It is 32.3 square miles with a population of approximately 65,660 in 2000 [7]. In 1999, the survey was administered by mail to a randomly selected sample of Bryan utility household customers and using face-to-face interviews of residents using the drop-off center for non-hazardous recyclables. At the time of the survey, Bryan operated one drop-off center for non-hazardous recyclables and two for hazardous recyclables.

The survey was in a booklet form with the following format: title/cover page; general information regarding the survey and terms used on the inside cover; two questions regarding solid waste management (SWM); demographic questions; and questions related to SWM practices (with emphasis on recycling).

Data resulting from the survey, are analyzed using logit regression, a weighted regression of a dependent variable that is transformed into the unit normal deviate that generates the proportion as the area under the unit normal curve [8]. The logistic regression model is a non-linear transformation of the linear regression. The objective of logit model is to estimate the values of the coefficients, which maximize the likelihood of correctly predicting which category the binary dependent variable belongs. Logit estimation is based on maximizing the log of the likelihood function with respect to the parameters.

3 Results

3.1 Summary statistics

Two distinct samples were surveyed using three modes of survey. First, a systematic sampling technique was used to select a representative sample of



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Bryan households which were administered a mail survey. Second, recyclers using the drop-off center were either interviewed (face-to-face) or handed the survey to complete and mail back (handout). Summary statistics are provided for the pooled data using all the three modes of survey (see Appendix c in Arekere [6] for summary statistics by mode of survey). It is important to note three aspects of the data. First, because only a sub-set of the mail questionnaire was administered to those interviewed at the drop-off center, the number of observations ranges from 610 to 892 (total number of observations in the pooled data set, includes mail, face-to-face, and handout responses). Second, depending on respondents' recycling behavior, observations may not always sum up to 892. Where applicable, these discrepancies in the data are noted. Third, each question is summarized individually. Item non-responses may also cause the number of observations not to sum to 610 or 892.

3.1.1 Demographics

A total of nine demographics related questions were asked. Detailed tables and discussion of the survey data can be found in Arekere [6]. Slightly more males (54 percent) responded than females (46 percent). The majority of the respondents are white (79 percent), followed by Blacks (8 percent), and Hispanics (6 percent). The mean age of the respondents is 49 years. The youngest respondent was 17 years old and the oldest 96. A substantial number of respondents, 90 percent, belonged to households with either one (59 percent) or two (31 percent) individuals. More than half, 53 percent of the respondents have post-secondary education, having completed a bachelor/associate degree or a graduate degree. A majority of the respondents, 46 percent, are employed full-time. Approximately, 8 percent of the respondents reported are students. A majority of the respondents, 71 percent, earned more than $25,000 annually. Approximately 76 percent of the respondents owned the property at which they resided. Over 61 percent of the respondents reported being environmentalists.

The gender, age, household size, and income levels of the respondents are reflective of the general Bryan population. But, the racial make-up, employment status, and education levels are not necessarily representative. Whites are over-represented. Black, Hispanic and student populations are under-represented in the sample. In addition, the highly educated and retired are over-represented.

3.1.2 Solid waste and recycling attitudes

A majority, 88 percent of the respondents, indicated that SWM was as either more (41 percent) or equally important (47 percent) as other environmental issues in Bryan. Only a fraction, 3 percent of the respondents, felt that SWM issues were "less" or "not important". In general, respondents ranked the five SWM alternatives consistent with the [2] SWM hierarchy (table 1). A majority of the respondents, nearly 70 percent, identified recycling as the alternative that should be given more emphasis in future SWM policies, followed by source reduction (47 percent) and composting (46 percent).

Seventy-eight percent of the respondents recycle (table 2). It is important to note that the high proportion of recyclers is a consequence of pooling the data from the three sub-samples. The overall recycling rates manifested by the data



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are high because all the respondents using the drop-off recycling center sub-sample recycle. If only the mail sample is considered, only about 37 percent of the respondents recycle.

Table 1: Preference for solid waste management alternative.

	Source Reduction		Recycling		Composting		Landfilling		Incineration	
Category	No.	%	No.	%	No.	%	No.	%%	No.	%
More emphasis	333	46.64	513	69.99	325	45.84	160	22.41	164	23.30
Equal emphasis	275	38.52	181	24.69	312	44.01	309	43.28	257	36.51
Less emphasis	44	6.16	25	3.41	46	6.49	200	28.01	190	26.99
Undecided	62	8.68	14	1.91	26	3.67	45	6.30	93	13.21
Total	714	100	733	100	709	100	714	100	704	100

Recyclers identified the following factors, in descending order of importance, as best describing their motivations for recycling, good for the environment, conserves landfill space, benefits future generations, and conserves resources (table 3). These factors are consistent with earlier research findings. In contrast to previous research, peer pressure (most people I know recycle) appeared to have little to do with recycling behavior among Bryan residents. Earning money through the sales of recyclables was identified only 12 percent of the respondents as the reason for recycling. Recyclers consistently identified benefits to society over personal ones (table 3). Coupled with the apparent unimportance of economic incentives and the lack of social confirmation, the motivation to classify recycling activities as an altruistic activity is strengthened.

Table 2: Respondents' recycling behavior.

Category	Frequency	Percent
Recycles	696	78.00
Recycles at drop-off center		
Yes	487	55.53
No	390	44.47
Recycles at work		
Yes	299	38.14
No	485	61.86
Recycles at buyback center		
Yes	167	21.30
No	617	78.70
Recycles at drop-off center and work	157	42.09
Recycles at drop-off center and buyback center	83	22.25
Recycles at work and buyback center	92	24.66
Recycles at Drop-off center, work and buyback center	41	10.99

Almost an equal proportion of non-recyclers identified the lack of information (21 percent), and convenient drop-off center (20 percent) and excessive time and

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effort (21 percent) as reasons for not recycling (table 3). Slightly more than a quarter of non-recyclers (27 percent) did not know anybody that recycled. Approximately, 15 percent of the non-recyclers identified the absence of a curbside program as a reason for not recycling.

The altruistic nature of recycling may be further evidenced by the respondents' views regarding recycling benefits and costs. The benefits the general public derives from recycling are consistently ranked higher than individual costs of recycling (table 4). Revenues one can earn from selling recyclables was ranked as very important by only 9 percent of the respondents, while 62 percent ranked it as being not important. The cost of collecting, sorting and storing recyclables was ranked very important and somewhat important by 31 percent and 41 percent of the respondents. The cost of transporting recyclables to a recycling center was ranked as very important by 22 percent of those surveyed, while an equal proportion, nearly 36 percent of the respondents, identified it as somewhat or not important. To summarize, it appears concerns regarding the private cost of recycling are higher than the private revenues that a can be generated.

Table 3: Motivations underlying recycler behavior.

Category	Frequency	Percent
Recycles [a]		
Makes me feel good	366	41.03
Earn money	112	12.55
Good for the environment	569	63.78
Benefits the general public	435	48.76
Most people I know recycle	60	5.60
Conserves resources	488	54.70
Conserves energy	384	43.04
Conserves landfill space	524	58.74
Benefits future generations	488	54.70
Do Not Recycle[b]		
No information on recycling	191	21.41
No curbside recycling	136	15.24
No convenient drop-off center	182	20.40
Takes too much time & effort	184	20.62
Nobody I know recycles	241	27.01

[a] A maximum of 580 respondents (recyclers)
[b] A maximum of 312 respondents (non-recyclers)

The additional pollution that recycling related activities may contribute is of concern among critics of recycling programs, especially curbside recycling. A majority, 79 percent of those surveyed, also viewed the increased pollution from recycling to be very important or somewhat important. This suggests attention should be paid to increased pollution resulting from recycling activities when designing recycling programs.

A majority of the respondents consistently ranked recycling benefits to society as either important or somewhat important, while only a fraction ranked them as not important (table 4). Approximately 80 percent of the respondents identified benefits from avoided costs, conserving resources and energy, and



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decreased pollution, as being either important (66 percent, 63 percent, and 70 percent) or somewhat important (26 percent, 29 percent, and 26 percent). Only about 3 percent, 4 percent, and 5 percent of the respondents ranked the three benefits as not important. These responses are further indication of the altruistic nature of recycling behavior.

Table 4: Perceptions regarding benefits and costs of recycling.

	Percent				
Category	1[a]	1[a]	2[b]	3[c]	4[d]
Importance of Benefits and Costs to Individual					
Cost of					
Collecting, sorting and storing	240	30.69	40.92	21.36	7.03
Transporting recyclables	171	21.87	35.93	35.93	6.27
Benefit—earnings from recyclable sale	69	8.91	23.00	62.14	5.94
Importance of Benefits and Costs to Public					
Benefits from					
Avoided costs	521	66.45	26.28	2.55	4.72
Conserving resource and energy	493	62.96	29.12	3.96	3.96
Decreased pollution from recycling	549	70.03	21.17	5.36	3.44
Cost of increased pollution	310	40.31	39.27	11.57	8.44

[a] Most prefer; [b] Somewhat prefer; [c] Not an issue

3.2 Regression results

Two different data sets, mail and pooled data, are used to estimate logit models to examine recycling behaviour. A different number of observations are associated with each data set and dependent variable. Two reasons for this are (i) pooling the data, which adds observations and (ii) within the survey, some respondents answered some questions and not others. The number of missing observations for the dependent variable, therefore, varies. For each analysis, the most observations possible are used.

A test of normality of the dependent variables indicates the variables are not statistically different from normally distributed variables at an α-level of 0.15 because the skewness statistic values are less than two [6]. The tolerance statistics for the coefficients from the OLS regression are less than one and the variance inflation factors range between 1.519 and 1.023 ruling out problems with multicollinearity.

3.2.1 Recycling behavior

3.2.1.1 Mail data

Results of the logit estimation and calculated marginal effects using the mail data investigating factors underlying recycling behavior are presented in table 5. The null hypothesis that all the coefficients except the intercept are simultaneously equal to zero is rejected (Chi-square value of 183.153). The Cox and Snell and Nagelkerke R^2s are 0.246 and the 0.370. Eighty percent of the observations are

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correctly predicted by the model. The signs of the coefficient are generally as expected based on theory, previous literature, and a priori knowledge.

Four coefficients, non-whites, employed, first income category (<$25,000), and age, are not significantly different from zero at an α-level of 0.15. Coefficient signs on the insignificant coefficients indicate that non-whites, respondents with incomes less than $25,000, and older respondents are less likely to recycle than their respective reference categories. Employed respondents are more likely to recycle than students.

Table 5: Logit results with mail data.

Variable	Coefficient	Marginal Effects	Standard Error	p-value
Female	.146	0.732	.255	.120
Non-whites	-.396	-0.613	.392	.408
Employed	.325	0.765	.413	.704
Retired	-.157	0.668	.451	.000
<25K	-1.575	-0.328	.492	.436
25.1-50K	-.383	-0.616	.406	.078
50.1-75K	-.714	-0.536	.424	.018
75.1-100K	-1.002	-0.464	.007	.003
Age	-.022	-0.697	.271	.907
No Kids	.032	0.709	.285	.068
Non-Homeowner	-.521	-0.583	.243	.000
Non-Environmentalist	-1.899	-0.261	.614	.000
Mail	-3.085	0.097	.945	.000
Intercept	6.857		.225	.517
N	620			
Cox & Snell R^2	0.246			
Nagelkerke R^2	0.370			
Model χ^2	183.153			
% Correct Predications	80.60			

Signs on the significant coefficients indicate the following. Females are more likely to recycle than males. Retired respondents are less likely to recycle than students. Compared to respondents with incomes greater than $100,001, respondents in the second, third, and fourth incomes categories are less likely to recycle. Respondents without children are more likely to recycle when compared to respondents with children. Non-homeowners and non-environmentalists are less likely to recycle than homeowners and environmentalists. Mail respondents are also less likely to recycle than handout respondents. Among the coefficients that are significant, female, followed by respondents without children and those in the second income category have the highest marginal effect, most likely to recycle, on recycling behavior. Mail respondents, followed by non-environmentalists and respondents in the fourth income category are the least likely to recycle.

3.2.1.2 Pooled data

Results using the pooled data are presented in table 6. Excluding three variables and including additional observations did not change the R^2s. A test of the

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model that all coefficients except the intercept are simultaneously equal to zero is rejected (Chi-square value of 223.917). The signs of the coefficients using the pooled data are similar to those from using the mail data except in the case of females, which is now negative. The coefficient associated with non-whites and the first income category are significantly different from zero, but were insignificant in the mail data set model. While females and non-homeowners were significant in the mail data set model, they are now insignificant. Mail respondents and handout respondents are less likely to recycle than face-to-face respondents, but both coefficients are insignificant. The marginal effect indicates that non-whites are the most unlikely to recycle and non-environmentalist are most likely to recycle among the coefficients that are significant.

Table 6: Logit results with pooled data.

Variable	Coefficient	Marginal Effects	Standard Error	p-value
Female	-.025	-0.682	.205	.904
Non-whites	-.499	-0.571	.233	.032
<25K	-1.307	-0.373	.404	.001
25.1-50K	-.271	-0.626	.455	.551
50.1-75K	-.633	-0.538	.358	.077
75.1-100K	-.817	-0.492	.378	.031
Non-Homeowner	-.061	-0.674	.232	.794
Non-Environmentalist	-1.688	-0.289	.210	.000
Mail	-2.199	-0.196	.391	.996
Handout	-1.507	-0.327	.139	.997
Intercept	2.786		.301	.996
N	797			
Cox & Snell R^2	0.245			
Nagelkerke R^2	0.376			
Model χ^2	223.917			
% Correct Predications	80.20			

3.3 Discussion

Recycling behavior is examined against a more comprehensive list of explanatory variables than previous studies (for a summary and discussion of previous studies see Arekere [6]). While many of the explanatory variables included in the estimation have been individually applied in different studies, they have not been considered in unison. However, two of the more common variables used in previous studies, social conformity and incentives (motivations to recycle), are not included in this study. Including explanatory variables for these factors in the models estimated here would non-trivially reduce the number of observations, therefore, the degrees of freedom. A large number of respondents did not respond to one or both of the questions addressing these factors. Of those responding to the social conformity question, only four percent of the respondents who recycled reported knowing somebody who also recycled. Likewise, monetary gains from recycling were stated to be a factor motivating

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recycling behavior by only seven percent of the respondents. Previous studies found recycling behavior to be positively correlated with females, whites, employment, income, households with children, homeowners, and environmental awareness (for a discussion see Arekere [6]). Results from the models examining recycling behavior in Bryan are similar to the previous studies for these factors. Contrary to previous findings, recycling is negatively correlated with age in the Bryan sample.

As expected, respondents in lower income categories are less likely to recycle compared to those in the highest income category. Although the opportunity cost of time is higher for people with higher income, those with higher incomes also tend to be more educated and environmentally aware. Retirees are less likely to recycle than students possibly because of the effort—collection, cleaning, storing and transportation—involved in recycling and a lack of environmental awareness among retirees. Because of its beginnings in the 1970s, the influence of the environmental movement in general and environmental education in particular may be more pronounced on younger generations than on older generations. Mail respondents are less likely to recycle than handout and face-to-face respondents. The most likely explanation is the sample population of each group. By design, respondents in the handout and face-to-face groups were recycling at the Bryan drop-off center. Mail respondents were randomly chosen from all households in Bryan.

4 Conclusion

Municipal waste recycling rates in Bryan, Texas, USA, are lower than the target rate of 40 percent set by the City when it signed-up to become part of the Clean Cities Campaign. Bryan is considering alternative policies in an attempt to increase recycling rates. However, data and / or information required to choose among alternative policies is lacking. Results from a study designed to collect necessary data and provide Bryan decision makers with additional information concerning its citizens' opinions on solid waste management (SWM) issues, and recycling behavior are presented herein. Residents of Bryan were sampled in two overlapping populations; a random sample of Bryan households were administered a mail survey and recyclers using the city's drop-off recycling center.

The combined response rate from the three modes of survey is approximately 40 percent. Respondents generally ranked the five SWM alternatives, source reduction, recycling, composting, landfilling, and incineration, consistent with the SWM hierarchy. Further, respondents reported that the focus of future SWM policies in Bryan should include recycling, source reduction, and composting (currently a major focus of Bryan's SWM policies). Most respondents who did not recycle reported either having no useful information about recycling or were unaware of the existence of the drop-off center. Approximately, 66 percent of the respondents were in favor of changes to Bryan's SWM policies.

Residents that are female, white, employed, have higher incomes, have children, own a house, and are self-perceived environmentalists tend to recycle



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more. These results are similar to previous studies, indicating a set of factors that can be used, in general, to explain recycling behavior.

Given these set of results, future SWM policies promoting recycling programs in Bryan should focus on providing recycling related information, especially associated benefits, to citizens. Specifically, Bryan should inform their citizens regarding the cost-benefits of SWM programs in general and recycling programs in particular, and recycling services available in the City. Bryan may want to focus on households with older citizens who are more likely to voice their opposition to new recycling programs, because they are more likely to be on fixed income, least likely to recycle, and least likely to support a recycling program.

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