Resources, Conservation and Recycling 54 (2010) 163–170

Contents lists available at ScienceDirect

Resources, Conservation and Recycling

journal homepage: www.elsevier.com/locate/resconrec

# The effects of behavior and attitudes on drop-off recycling activities

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ARTICLE INFO

*Article history:*
Received 27 April 2008
Received in revised form 19 January 2009
Accepted 22 July 2009
Available online 25 August 2009

*Keywords:*
Recycling
Drop-off programs
Drop-off sites
Curbside programs
Waste management
Recycling behavior

ABSTRACT

To reduce the amount of waste entering landfills, policymakers and governments have implemented various recycling and waste reduction programs such as source reduction, curbside recycling and drop-off recycling programs. The success of a recycling program largely depends on household participation and sorting activities. A better understanding of recycling behavior will help us aid the design and improve the effectiveness of recycling policies. This paper studies the profile of people who utilize drop-off recycling sites and analyzes the factors influencing their site usage. The results show that the usage of drop-off recycling sites is influenced by demographic factors such as age, education, income and household size. Attitudinal factors are also found to affect site usage. Recyclers tend to use the drop-off sites more when they feel that recycling is a convenient activity and when they are more familiar with the sites.



## 1. Introduction

In 2007, United States residents, businesses, and institutions produced approximately 254 million tons of municipal solid waste and more than 50% of the solid waste generated was landfilled (USEPA, 2007). To reduce the amount of waste entering landfills, local governments have implemented numerous recycling and waste reduction programs, including source reduction, variable garbage pricing, curbside recycling and drop-off recycling.

Drop-off recycling is a recycling program where designated sites are established to collect a range of recyclables and usually recyclers themselves are required to deposit the sorted recyclables in specially marked containers. Drop-off recycling centers are less costly to operate compared to curbside programs, and they are also faster to implement than take-back and deposit refund programs involving manufacturers (Saphores et al., 2006). Drop-off center operators are able to save on labor and transportation costs because these costs are transferred to the recyclers. Drop-off recycling is also considered to be a financially viable recycling option in rural areas with low population density (Tiller et al., 1997). As a result, drop-off recycling is a widely adopted recycling program by local governments. As of 1998, over 12,000 recyclable drop-off sites were operating in the United States (USEPA, 2000).

Despite wide implementation, relatively little literature analyzes drop-off recycling. Research on curbside recycling and variable garbage pricing is more popular in the field of recycling and waste management. For example, Fullerton and Kinnaman (1996), Hong and Adams (1999), Van Houtven and Morris (1999), Kinnaman and Fullerton (2000) and Jenkins et al. (2003) analyze the effect of curbside recycling, together with variable garbage pricing, on the amount of waste generation and recycling. Hong and Adams (1999) study the effect of disposal fee and household characteristics on recycling rates and waste generation using household data from Portland, Oregon and find that an increase in the price of solid waste collection increases both the demand for recycling and recycling rates. Hong (1999) reports similar results for a household sample from Korea. Kinnaman and Fullerton (2000) find that an unit fee has a negative effect on garbage weight, and curbside recycling programs have a positive effect on recycling. Other studies have estimated the consumer willingness to pay for curbside recycling services (Lake et al., 1996; Aadland and Caplan, 1999, 2003; Blaine et al., 2005).

A rare example of recycling research that is related to drop-off recycling is the stated preference study of a drop-off program conducted by Tiller et al. (1997). Their study analyzed the economic feasibility of establishing a drop-off recycling program in a rural and suburban area of Tennessee by utilizing the contingent valuation method to calculate household willingness to pay (WTP) for the program. They found that the estimated WTP depended on respondents' income, education level, age and attitudes towards the importance of recycling. However, the study was based on stated preferences of households and not on observed behavior or revealed preference. Speirs and Tucker (2001) studied the profile of recyclers utilizing drop-off recycling sites in Glasgow and

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doi:10.1016/j.resconrec.2009.07.012

across Ayrshire in south-west Scotland. They report recyclers' travel distances, the weights and types of recyclables and demographic characteristics. However, the study is mainly descriptive and does not analyze the relationship between drop-off site utilization and the profile of recyclers. Similarly, the Ohio EPA conducted a study of participation rates and usage patterns of recyclers at drop-off sites in Ohio in 2004 (Snyder et al., 2004). The primary purpose of the study was to assess the percentage of population in a waste management district with access to recycling facilities to see whether it met the set targets and the reported results are mainly descriptive statistics. Saphores et al. (2006) analysis of households' willingness to recycle at drop-off centers is limited to electronic waste.

We address this gap in the literature by studying individuals utilizing drop-off recycling. We conducted onsite interviews of recyclers using eight drop-off recycling centers around the city of Lansing in Michigan. We statistically analyze the relationship between the number of visits made to drop-off recycling sites and recycler characteristics and their attitudes towards recycling. The findings provide insights into recycling behavior that can be used to improve the design and effectiveness of drop-off recycling policies.

## 2. Literature review

The success of a drop-off recycling program is largely dependent on household participation and sorting activities which are the essential behaviors. Prior research indicates that recycling behavior is influenced by cost of recycling, convenience of available recycling infrastructure and programs, the extent of environment related awareness and knowledge, attitudes towards recycling, social norms and external pressures, and household socioeconomic status. These results are typically based on surveys of both recyclers and non-recyclers and the reported differences between these two groups (Vining and Ebreo, 1990; Oskamp et al., 1991; Ebreo and Vining, 2001).

As recycling requires investment of time, space, money and effort, making recycling convenient should increase household participation. Domina and Koch (2002) in their study of textile recycling behavior report that convenience is an important driver of recycling behavior. Vining and Ebreo (1990) examine the differences between recyclers and non-recyclers and conclude that non-recyclers were deterred by the inconvenience and the costs associated with recycling. Saphores et al. (2006) study households' willingness to recycle electronic waste at drop-off centers and find that convenience factors such as proximity to the drop-off center increased recycling. Hornik et al. (1995), based on a meta-analysis, conclude that frequency of recyclables collection was a strong predictor of recycling behavior. Gonzalez-Torre et al. (2003) examine selective waste collection systems that are frequently used in Europe and America and conclude that a system that requires less time and effort to dispose and separate waste will result in a higher recycling rate.

Concern for the environment is perceived to be important in encouraging recycling participation, but empirical studies have shown mixed results. Domina and Koch (2002) find that people who have great concern for the environment are more likely to recycle. Meneses and Palacio (2005) study the distribution of recycling tasks within the household, and report that household members with positive attitudes towards ecology and who are motivated to protect the environment shared a greater burden of the recycling. However, Vining and Ebreo (1990) find that concern for the environment was indiscriminately expressed by both recyclers and non-recyclers. Similarly, Oskamp et al. (1991) did not find significant differences between recyclers and non-recyclers in their general pro-ecological attitudes and beliefs in the seriousness of environmental problems.

Knowledge about the availability of recycling programs and facilities is necessary for effective participation in recycling. Studies have found that knowledge about recycling programs is a strong predictor of recycling involvement (Gamba and Oskamp, 1994; Hornik et al., 1995). Vining and Ebreo (1990) find that recyclers were more aware of the publicity associated with recycling and more knowledgeable about the recycling facilities in the local area. Other studies have tried to analyze the role of knowledge about the environment in recycling behavior. Oskamp et al. (1991) report that the level of knowledge about conservation is a good predictor of participation in recycling. Studies have also investigated the effect social influence has on recycling behavior. Social influence in this context is defined as an individual's concern about the perception of others, such as family and neighbors if they do not recycle (Vining and Ebreo, 1990). Oskamp et al. (1991) and Do Valle et al. (2004) report that social influence is an important driver of recycling behavior, but Vining and Ebreo (1990) do not find social influence to be significant in explaining recycling behavior.

Apart from behavioral aspects, numerous studies have also looked at the relationship between demographic and socioeconomic variables and recycling involvement. The most commonly examined variables are gender, age, education and income (Saphores et al., 2006). Meneses and Palacio (2005) argue that women bore a greater burden of recycling tasks than men in a household, while Arcury et al. (1987) suggest that women are usually associated with recycling tasks because they traditionally have played a greater role in domestic tasks. Saphores et al. (2006) find that women are more willing to recycle electronic waste at drop-off centers. However, other studies find no link between gender and recycling (Gamba and Oskamp, 1994; Werner and Makela, 1998).

Some studies find age to be a significant factor influencing recycling involvement (Vining and Ebreo, 1990; Gamba and Oskamp, 1994; Margai, 1997; Scott, 1999; Saphores et al., 2006), while some other studies do not (Werner and Makela, 1998; Meneses and Palacio, 2005). Contrary to common expectation that younger people are likely to be more involved in recycling, some researchers conclude that middle aged and older people are more likely to recycle (Vining and Ebreo, 1990; Meneses and Palacio, 2005; Saphores et al., 2006).

The relationship between education and recycling is ambiguous. Saphores et al. (2006) find that higher education increases the willingness to recycle, but several other studies report that education has no significant effect on recycling behavior (Vining and Ebreo, 1990; Oskamp et al., 1991; Gamba and Oskamp, 1994; Meneses and Palacio, 2005). Some studies find a positive relationship between income level and recycling involvement (Vining and Ebreo, 1990; Oskamp et al., 1991; Gamba and Oskamp, 1994), but a study by Scott (1999) finds no statistically significant relationship.

## 3. Research objectives and hypotheses

The above review suggests that there are mixed findings about the drivers of recycling behavior. One likely reason for such mixed results is the lack of correspondence between the attitudinal and behavioral entities. Ajzen and Fishbein (1977) conclude from a review of a number of attitude–behavior studies that when elements (i.e. target, action, context and time) of the attitudinal entity corresponded to elements of the behavioral entity, attitude–behavior correlations were quite high and significant, and when correspondence was either partial or lacking, attitude–behavior correlations were insignificant. Generalizing on Ajzen and Fishbein (1977) findings, we conjecture that these mixed findings about drivers of recycling behavior are because of lack of correspondence between the specific elements of recycling behavior and presumed drivers of such behavior. For example, in many of these studies, measures of attitudes towards the environment and environmental knowledge were very broad and general, while the behavioral entity (i.e. recycling behavior) being measured was

very specific. In other words there was no correspondence between the target and action elements of the entities. Similarly, in household surveys of recycling behavior, the time and context elements of the recycling behavior are not specific; the respondent may not be the actual recycler, and reported behavior may be different from actual behavior depending on the context. Further because of the different action, context and timing elements of drop-off recycling compared to other forms of recycling, the findings from other recycling behavior studies may not be directly applicable to drop-off recycling.

The main objective of this study is to analyze the influence of socioeconomic, demographic and behavioral factors on drop-off site visits. The behavioral aspects examined are environmental affiliation, perception and attitudes towards drop-off recycling and implications of such recycling on the environment. This study also analyzes the effect of drop-off site distance from home on site visits. To address the limitations of other studies, we specifically target recyclers recycling at drop-off centers. Our measure of recycling behavior is the number of such visits to the drop-off centers, and our interviews were aimed at measuring attitudes specifically towards recycling activities and knowledge about drop-off recycling, along with other demographic and socioeconomic variables. By establishing such a correspondence, we expect our results to be more robust compared to earlier findings.

Drawing on the findings in earlier literature, we propose the following hypotheses and then test them empirically:

**H1.** Longer distance to recycling sites from home reduces the number of recycling visits.

**H2.** Increase in the number of different types of recyclables brought to a site increases the number of site visits.

**H3.** Higher time required to sort recyclables reduces the number of site visits.

**H4.** Access to curbside recycling reduces the number of site visits.

**H5.** Demographic factors such as age, gender, marital status, education and employment status influences the number of site visits.

**H6.** Affiliation with an environmental organization increases the number of site visits.

Since attitudes towards recycling and awareness about recycling of the respondents cannot be directly observed, a scale was developed to measure attitudes towards recycling consisting of 18 Likert-scale items covering various aspects of recycling, such as convenience, attitude, social pressure and awareness or familiarity. The assumption is that such a specific recycling attitude scale provides a better correspondence with recycling behavior being measured than commonly used general environmental attitude measures such as the New Ecological Paradigm (NEP) scale (Dunlap et al., 2000). We hypothesize that increased convenience, positive attitude towards recycling, positive social pressure and higher familiarity will be positively associated with the number of visits to the recycling center.

## 4. Methods

Since we sought to analyze the effects of recycler characteristics on the number of drop-off site visits, we conducted a survey of drop-off site visitors. This section describes the survey design and data collection process. This section also reports the descriptive statistics of the variables of interest. We also conducted factor analysis to reduce the number of our attitudinal variables into a few interpretable factors that were later operationalized as explanatory variables in our statistical model of drop-off site visits.

### 4.1. Questionnaire design and data collection

The data for this study was collected through in-person interviews conducted at eight drop-off recycling sites around the Lansing area in Michigan. The interviews included questions on the frequency of visits to drop-off sites in the past three months and one year. Respondents' home address was elicited to enable calculation of respondents' travel distances to the recycling site. The survey also contained questions soliciting demographic information of the respondent such as gender, education, employment status income and marital status. Questions were asked about the respondents' other recycling options as such curbside recycling at their residence, the types of recyclables they brought onsite, and the time they took to sort the recyclables they had brought during the visit. A question asked if the respondents were affiliated with any environmental organization (government or non-governmental environmental organizations included). The survey also included a set of questions assessing the respondent's attitudes towards recycling. In answering these questions, respondents were read statements and asked to indicate the extent to which they agree or disagree with the statements on a five-point Likert-scale ranging from strongly agree to strongly disagree.

The questionnaire was pretested and improved before conducting the actual survey. The questionnaire pretest was conducted by interviewing several recyclers at one of the drop-off sites. The pretest resulted in some wording refinements and rearrangement of questions in the instrument. The final survey was conducted for four weeks, from the last week of October 2006 to the last week of November 2006. Interviews were conducted at each site four times, during 3 h intervals each time throughout the four-week period. The survey dates chosen for all the sites were randomly selected to avoid any potential bias. During the survey, recyclers visiting the sites were approached for interviews. At the end of the survey, we approached 527 recyclers and managed to complete 356 interviews for a 68% response rate.

### 4.2. Variables description

Table 1 lists and defines the demographic and other related variables that were utilized in our analysis. The variables *THREEMTHS* and *ONEYEAR* are the number of visits to the drop-off site where the respondent was interviewed in the past three months and one year. The variable *DISTANCE* represents the roundtrip distance from the respondent's home to the recycling site where the respondent was interviewed. The roundtrip distance was computed using MapQuest (www.mapquest.com). The variable *CURBSIDE* is a dummy variable indicating if the respondents had access to curbside recycling pickup at their home. The recyclers came from several townships and curbside recycling service was offered only in some

**Table 1**
Definition of variables.

| Variable | Definition |
|---|---|
| *THREEMTHS* | Total number of site visits in the last three months |
| *ONEYEAR* | Total number of site visits in the last one year |
| *DISTANCE* | Total round-trip distance from home to site |
| *NUMREC* | Number of different types of recyclables brought onsite |
| *SORTIME* | Time taken (in minutes) to sort recyclables brought |
| *CURBSIDE* | Access to curbside recycling (yes = 1, no = 0) |
| *CDEGREE* | Educated with a bachelor's degree or higher (yes = 1, no = 0) |
| *INCOME* | Annual household income ($1000's) |
| *HSIZE* | Household size |
| *AGE* | Age (years) |
| *MALE* | Male (yes = 1, no = 0) |
| *MARRIED* | Married (yes = 1, no = 0) |
| *FULLEMP* | Employed full-time (yes = 1, no = 0) |
| *ENVAFF* | Affiliated with an environmental organization (yes = 1, no = 0) |

**Table 2**
Summary statistics of variables.

| Variable | Obs. | Mean | SD |
|---|---|---|---|
| *THREEMTHS* | 348 | 4.330 | 3.455 |
| *ONEYEAR* | 348 | 14.652 | 13.804 |
| *DISTANCE* | 333 | 19.712 | 10.287 |
| *NUMREC* | 348 | 6.322 | 3.474 |
| *SORTIME* | 344 | 16.166 | 27.337 |
| *CURBSIDE* | 345 | 0.252 | 0.435 |
| *CDEGREE* | 348 | 0.718 | 0.450 |
| *INCOME* | 348 | 77,935 | 52.791 |
| *HSIZE* | 346 | 2.520 | 1.265 |
| *AGE* | 345 | 48.542 | 15.181 |
| *MALE* | 347 | 0.556 | 0.498 |
| *MARRIED* | 348 | 0.704 | 0.457 |
| *FULLEMP* | 348 | 0.641 | 0.480 |
| *ENVAFF* | 346 | 0.263 | 0.441 |

areas and for selected materials. Similarly, some large apartment buildings provided onsite recycling facilities. We use access to curbside recycling as a summary indicator of a variety of such services. Our interviews suggested that drop-off centers were usually used for recycling materials that were not collected at the curbside. Hence, we hypothesize that respondents without curbside recycling service at their residences would tend to recycle more at drop-off centers than respondents with curbside recycling.

The summary statistics of the variables (Table 2) indicate that the average number of visits to a drop-off site in the past three months and one year were approximately 4 and 15 times respectively. The average roundtrip distance traveled by the respondents to a drop-off site was around 19 miles. The respondents recycled, on average, 6 different materials each time they visited a drop-off recycling site, and they spent approximately 16 min sorting out the recyclables that they brought. Twenty-five percent of the respondents reported that they had curbside recycling service at their residence.

The majority of the respondents (72%) had at least four years of college education. Sixty-four percent of our respondents were fully employed and the mean household income was $77,935. Our sample comprised of 56% male respondents indicating rough gender balance in recycling participation. Seventy percent of the respondents were married, and the average household size was 2.5. Only 26% of the respondents indicated that they were affiliated with one or more environmental organizations.

Table 3 shows the statements that were used in our survey to elicit the respondents experience, knowledge and attitude towards recycling along with the respective distribution of Likert-scale responses and descriptive statistics. The scale was defined as (1) strongly agree, (2) agree, (3) neither agree nor disagree, (4) disagree and (5) strongly disagree. Based on the mean score we can see that drop-off recyclers disagree that recycling is a difficult task ($M = 4.174$, SD = 0.825). They also disagree to both the statements of not having enough sorting time ($M = 4.285$, SD = 0.711) and storage space ($M = 3.797$, SD = 1.038). The recyclers also disagree that recyclables stored may attract pests ($M = 4.026$, SD = 0.825). Most of the recyclers agree that they are familiar with the recycling facilities ($M = 1.947$, SD = 0.847) and the materials accepted for recycling in the facilities in their area ($M = 1.724$, SD = 0.595).

The recyclers also agree that their family expects them to recycle ($M = 2.312$, $M = 1.012$). However, the recyclers are quite indiffer-

**Table 3**
Definition, distribution and descriptive statistics of Likert-scale variables.

| Variable | Survey statement | Percentage distribution of response | | | | | Descriptive statistics | |
|---|---|---|---|---|---|---|---|---|
| | | Strongly agree | Agree | Neither agree nor disagree | Disagree | Strongly disagree | Mean | SD |
| *DIFFIC* | For me, household recycling is a difficult task | 2.1% | 2.9% | 5.6% | 54.4% | 35.0% | 4.174 | 0.825 |
| *TIME* | I do not have enough time to sort the materials for recycling | 0.6% | 3.5% | 0.9% | 56.8% | 38.2% | 4.285 | 0.711 |
| *SPACE* | I do not have enough space to store the materials for recycling | 2.6% | 14.7% | 5.9% | 53.8% | 22.9% | 3.797 | 1.038 |
| *PEST* | The recyclables that I store attract pests | 0.0% | 10.0% | 2.6% | 62.1% | 25.3% | 4.026 | 0.825 |
| *FACILI* | I am familiar with the recycling facilities in my area | 28.8% | 57.1% | 5.0% | 8.8% | 0.3% | 1.947 | 0.847 |
| *MATERI* | I am familiar with the materials accepted for recycling in the recycling facilities in my area | 33.2% | 63.2% | 1.5% | 2.1% | 0.0% | 1.724 | 0.595 |
| *NEIGHB* | My neighbors expect me to recycle household materials | 2.9% | 7.4% | 55.3% | 25.3% | 9.1% | 3.303 | 0.848 |
| *FRIEND* | My friends expect me to recycle household materials | 9.1% | 23.5% | 39.4% | 22.9% | 5.0% | 2.912 | 1.012 |
| *FAMILY* | My family expects me to recycle household materials | 21.2% | 46.2% | 16.5% | 12.6% | 3.5% | 2.312 | 1.052 |
| *GOOD* | I feel good about myself when I recycle | 48.5% | 47.1% | 4.4% | 0.0% | 0.0% | 1.559 | 0.579 |
| *REDPOL* | Recycling is a major way to reduce pollution | 45.7% | 48.7% | 4.1% | 1.2% | 0.3% | 1.617 | 0.653 |
| *REDLAND* | Recycling is a major way to reduce wasteful use of landfills | 48.4% | 49.9% | 0.6% | 0.9% | 0.3% | 1.549 | 0.591 |
| *NATRES* | Recycling is a major way to conserve natural resources | 49.0% | 47.5% | 2.1% | 1.2% | 0.3% | 1.563 | 0.628 |
| *ENVQ* | Recycling will improve environmental quality | 46.3% | 51.3% | 1.2% | 0.9% | 0.3% | 1.575 | 0.598 |
| *BREDPOL* | I believe that my recycling activities will help reduce pollution | 44.7% | 49.7% | 3.5% | 1.5% | 0.6% | 1.635 | 0.680 |
| *BREDLAND* | I believe that my recycling activities will help reduce wasteful use of landfills. | 47.9% | 50.0% | 1.2% | 0.6% | 0.3% | 1.553 | 0.585 |
| *BNATRES* | I believe that my recycling activities will help conserve natural resources | 48.5% | 47.9% | 1.8% | 1.5% | 0.3% | 1.571 | 0.636 |
| *BENVQ* | I believe that my recycling activities will help improve environmental quality | 46.8% | 50.9% | 0.9% | 0.9% | 0.6% | 1.576 | 0.622 |

ent on the statements on whether their neighbors ($M = 3.303$, SD = 0.848) and friends ($M = 2.912$, SD = 1.012) expect them to recycle. Nevertheless, most of the recyclers feel good about themselves when they recycle ($M = 1.559$, SD = 0.579). The mean scores also show that the recyclers strongly feel that recycling is generally beneficial to the environment. The recyclers strongly agree that recycling is a major way to reduce pollution ($M = 1.617$, SD = 0.653), to reduce landfill use ($M = 1.549$, SD = 0.591), to conserve natural resources ($M = 1.563$, SD = 0.628) and to improve environmental quality ($M = 1.575$, SD = 0.598). Additionally, these general perceptions on the benefits of recycling are strengthened by what the recyclers believe about the contributions of their activities. The recyclers strongly believe that their recycling activities will actually contribute to reducing pollution ($M = 1.635$, SD = 0.680), reducing landfill use ($M = 1.553$, SD = 0.585), conserve natural resources ($M = 1.571$, SD = 0.636) and improve environmental quality ($M = 1.576$, SD = 0.622).

### 4.3. Factor analysis

We use factor analysis with principal component analysis to group the Likert-scale variables into a small number of interpretable underlying factors. Factor analysis will group the variables that are measuring the same construct. This method is commonly used in social science research. We use the Kaiser eigenvalue criterion and the scree test, as suggested by Nunnally and Bernstein (1997), to decide on how many factors to retain before proceeding with further analysis. According to the eigenvalue criterion, factors with eigenvalues greater than one are retained and factors with eigenvalues less than one are considered insignificant and therefore excluded. Table 4 reports the initial factor extraction with the eigenvalues and percentage of variances for each successive factor. Using the eigenvalue criterion method, four factors were retained for further analysis.

The scree test, on the other hand, is a graphical method of determining the number of appropriate factors to retain. The scree test involves plotting the eigenvalue magnitudes on the vertical axis against the component numbers on the horizontal axis and noting the point at which the plot becomes fairly horizontal. The number of factors corresponding to the fairly horizontal point indicates the appropriate number to retain. In Fig. 1, the point where the line becomes fairly horizontal starts at about factor 4. Thus, the scree test indicates that we should also retain four factors, similar to the result of the eigenvalue criterion method.

We also assess the suitability of our data for factor analysis using the Kaiser–Mayer–Olkin's (KMO) measure of sampling adequacy and Bartlett's test of sphericity (Hair et al., 1998). The sampling adequacy test predicts if data are likely to factor well, based on correlation and partial correlation, and a KMO measure value greater than 0.6 is considered acceptable. Bartlett's test of sphericity is used to test the null hypothesis that the variables in the population correlation matrix are uncorrelated. The results are reported in Table 5, which show that the data meet the requirements for factor analysis.

We use the Varimax rotation method (Kaiser, 1958) to rotate the four retained factors in our solution. The rotated factor matrix with its factor loadings is presented in Table 6.

**Table 4**
Total variance explained.

| Factor | Initial eigenvalues | | |
|---|---|---|---|
| | Total | % of variance | Cumulative % |
| 1 | 7.6666 | 42.59% | 42.59% |
| 2 | 2.0989 | 11.66% | 54.25% |
| 3 | 1.6771 | 9.32% | 63.57% |
| 4 | 1.1681 | 6.49% | 70.06% |

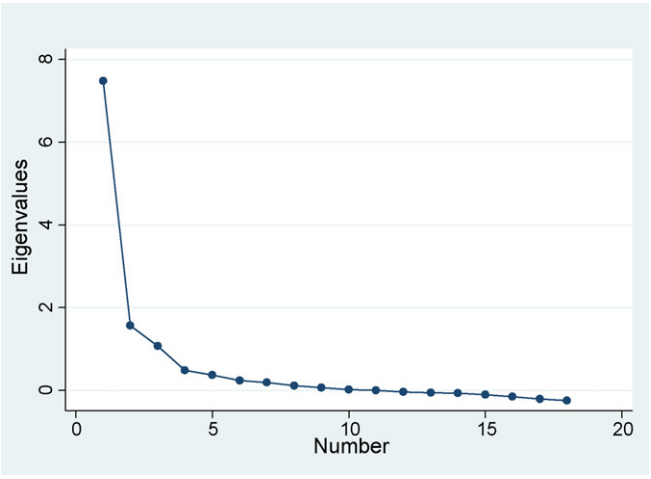


**Fig. 1.** Scree plot of eigenvalues and factors.

**Table 5**
KMO and Bartlett's test.

| | | |
|---|---|---|
| Kaiser–Meyer–Olkin measure of sampling adequacy | | 0.841 |
| Bartlett's test of sphericity | Approx. $\chi^2$ | 5075 |
| | Df | 153 |
| | Significance | $p < 0.001$ |

We consider variables with loadings greater than 0.4 to be 'highly loaded' and salient to the interpretation of a factor. Using this criterion, the variables are grouped together in the appropriate factor categories (refer to highlighted cells in Table 6). Each factor is described based on these variables and assigned descriptive names. We also compute the Cronbach's coefficient alpha for each factor to test the reliability of scales of the item variables. While there is no standard cut-off point for the alpha coefficient, a generally acceptable lower limit is 0.7 (Hair et al., 1998) although values higher than 0.5 are acceptable in exploratory research (Nunnally, 1978). We then use the factor loadings to compute the factor scores.

The variables that load highly on factor 1 are, *GOOD*, *REDPOL*, *REDLAND*, *NATRES*, *ENVQ*, *BREDLAND*, *BNATRES* and *BENVQ*. This factor is labeled as "Attitude" and can be best described as attitude and belief that recycling activities benefit the environment. A low score for this factor indicates that the respondents have positive attitude and belief that their recycling activities lead to environmental benefits such as reduced pollution and landfill use, conserving natural

**Table 6**
Rotated factor matrix.

| Variable | Factor 1 | Factor 2 | Factor 3 | Factor 4 |
|---|---|---|---|---|
| *DIFFIC* | −0.109 | 0.811 | −0.138 | −0.115 |
| *TIME* | −0.205 | 0.842 | −0.002 | −0.036 |
| *SPACE* | −0.145 | 0.679 | −0.118 | −0.015 |
| *PEST* | −0.231 | 0.410 | 0.104 | −0.286 |
| *FACILI* | 0.168 | −0.003 | 0.027 | 0.853 |
| *MATERI* | 0.224 | −0.198 | 0.129 | 0.747 |
| *NEIGHB* | 0.042 | −0.005 | 0.820 | 0.086 |
| *FRIEND* | 0.126 | −0.092 | 0.799 | 0.020 |
| *FAMILY* | 0.112 | −0.122 | 0.720 | 0.042 |
| *GOOD* | 0.482 | −0.351 | −0.041 | 0.190 |
| *REDPOL* | 0.873 | −0.050 | 0.067 | 0.105 |
| *REDLAND* | 0.893 | −0.106 | 0.015 | 0.101 |
| *NATRES* | 0.927 | −0.112 | 0.007 | 0.089 |
| *ENVQ* | 0.877 | −0.113 | 0.048 | 0.116 |
| *BREDPOL* | 0.877 | −0.065 | 0.103 | 0.057 |
| *BREDLAND* | 0.917 | −0.130 | 0.074 | 0.108 |
| *BNATRES* | 0.924 | −0.075 | 0.016 | 0.079 |
| *BENVQ* | 0.895 | −0.144 | 0.106 | 0.064 |

resources and improving environmental quality. The Cronbachs's alpha for these items is 0.96.

The item variables with high loadings on factor 2 are *DIFFIC*, *TIME*, *SPACE* and *PEST*. We label this factor as 'Convenience' as it relates to recycling being a convenient activity to undertake. A high score for this factor signifies that the respondents regard recycling as something that is convenient to them as they have no issue with it being difficult, time consuming, space consuming, or attracting pests. The Cronbach's alpha for these variable items is 0.6964.

We label factor 3 as 'Social Pressure' because the variables that load highly on factor 3 concern social pressures on the recycler. The variables in this factor are *NEIGHB*, *FRIEND* and *FAMILY*. A low score for this factor indicates that the respondent feels that neighbors, friends and family expectations are important elements in encouraging him/her to recycle. The Cronbach's alpha for factor 3 is 0.7015.

The variables that load highly on factor 4 are *FACILI* and *MATERI*. We label this factor as 'Familiar' as it relates to the familiarity of recycling facilities. A low score for this factor demonstrates that respondents are highly familiar with the recycling facilities and the materials accepted in the recycling facilities in their area. The Cronbachs's alpha for factor 4 is 0.579.

Table 7 outlines the factors, their respective variables as extracted by the factor analysis, and their Cronbach's alpha coefficient. The factors condense the experience, knowledge and attitude towards recycling of our survey respondents into four new interpretable variables; namely Attitude, Convenience, Social Pressure and Familiarity. We use the factor scores of these four new variables and analyze the effects of these on the number of recycling visits to drop-off centers.

## 5. Estimation model and results

The main purpose of the article is to analyze the variables that influence visits to drop-off recycling sites. This section develops a visitation model to analyze the effects of demographics, environmental affiliation, and the attitude and knowledge variables derived from the factor analysis, on the number of trips taken to a drop-off site. The visitation model is developed using the Poisson regression method. Poisson regression is utilized because the data for our dependent variable, the trips an individual takes to a recycling site $y_i$, is classified as a count variable where $y_i$ can only take discrete values ($y_i = 1, 2, 3, \ldots$). More specifically, we will use the endogenous stratified and truncated Poisson regression since we do not observe zero trips for any of the sample members as our sample is obtained via the onsite sampling method. Following Haab and McConnell (2002) the Poisson probability with onsite endogeneity and truncation is expressed as follows:

$$Pr(y_i \mid y_i > 0) = \frac{e^{-\lambda_i}\lambda_i^{y_i-1}}{y_i - 1!} \quad (1)$$

where $\lambda_i$ is both the mean and the variance of the distribution. Since it is necessary for $\lambda_i > 0$, it is commonly specified as an exponential function:

$$\lambda_i = \exp(x_i\beta) \quad (2)$$

**Table 7**
Factors, item variables and Cronbach's alpha.

| Factor | Item variables | Cronbach's α |
|---|---|---|
| (1) Attitude | *GOOD*, *REDPOL*, *REDLAND*, *NATRES*, *ENVQ*, *BREDLAND*, *BNATRES*, *BENVQ* | 0.960 |
| (2) Convenience | *DIFFIC*, *TIME*, *SPACE*, *PEST* | 0.696 |
| (3) Social pressure | *NEIGHB*, *FRIEND*, *FAMILY* | 0.702 |
| (4) Familiarity | *FACILI*, *MATERI* | 0.579 |

where $x_i$ is a vector of explanatory variables. Eq. (1) can be simplified by re-writing it as:

$$Pr(y_i \mid y_i > 0) = \frac{e^{-\lambda_i}\lambda_i^{y_i'}}{y_i'!} \quad (3)$$

where $y_i' = y_i - 1$. Using Eq. (3), we obtain the log-likelihood of a Poisson function

$$\ln\left(\beta \mid X, y\right) = \sum_{i=1}^{T}[-e^{X_i\beta} + X_i\beta y_i - \ln(y_i'!)] \quad (4)$$

and thus, the onsite endogenous and truncated Possion can be estimated by simply running a standard Poisson regression of $y_i - 1$ on all $X_i$'s.

The time invested in sorting the recyclables prior to visiting a drop-off center is a household decision which may affect the number of visits and in turn may be affected by the number of visits, which gives rise to a potential endogeniety problem in our estimation model. We conduct the omitted-variable version of the Hausman test to examine whether there is an endogeneity bias in our estimates using a two-stage instrumental variable method. Our instrumental variable was the fitted values obtained by regressing the likely endogenous variable, *SORTTIME*, as a function of all the other independent variables in the regressions and additional dummy variables for materials recycled. Our tests failed to reject the hypothesis of no endogeniety bias. Hence we report the results corrected for endoegeniety with the instrumental variable for *SORTTIME* in Table 8.

Table 8 presents the results of the Poisson regression models predicting the number of trips taken to a recycling drop-off site in the last one year. There are two models in this analysis. Model 1 is the basic model that uses distance, number of recyclables, sorting time, access to curbside recycling and demographic variables as dependent variables. Model 2 is the extended model that includes all four Likert-scale variables derived from the previous factor analysis along with all of the basic variables in Model 1. The purpose of two models is to see the incremental effects of attitude and familiar-

**Table 8**
Poisson regression.

| Dependent variable: *ONEYEAR* i.e. number of visits in the past year | | | | |
|---|---|---|---|---|
| Variable | Model 1 | | Model 2 | |
| | Coeff. | Std. error | Coeff. | Std. error |
| *DISTANCE* | −0.01 | 0.001*** | −0.01 | 0.002*** |
| *NUMREC* | 0.035 | 0.007*** | 0.036 | 0.007*** |
| *SORTIME* | −0.039 | 0.011*** | −0.037 | 0.012*** |
| *CURBSIDE* | 0.013 | 0.046 | −0.013 | 0.047 |
| *CDEGREE* | −0.025 | 0.045 | −0.004 | 0.047 |
| *INCOME* | 0.002 | 0.001*** | 0.002 | 0.001*** |
| *HSIZE* | 0.031 | 0.018* | 0.048 | 0.019*** |
| *AGE* | 0.01 | 0.001*** | 0.008 | 0.001*** |
| *MALE* | 0.03 | 0.032 | 0.059 | 0.033* |
| *MARRIED* | 0.086 | 0.042** | 0.018 | 0.044 |
| *FULLEMP* | −0.303 | 0.038*** | −0.331 | 0.04*** |
| *ENVAFF* | 0.114 | 0.038*** | 0.036 | 0.041 |
| *CONVENIENCE* | | | 0.046 | 0.016*** |
| *FAMILIAR* | | | −0.148 | 0.017*** |
| *SOCIAL* | | | −0.084 | 0.016*** |
| *ATTITUDE* | | | 0.021 | 0.017 |
| *CONSTANT* | 2.483 | 0.146*** | 2.561 | 0.152*** |
| Observations | 329 | | 322 | |
| Log-likelihood | −2343.06 | | −2195.48 | |
| $-2\ln(L_R/L_U)$ | 424.33 | | 516.83 | |
| Pseudo $R^2$ | 0.08 | | 0.11 | |

* Statistically significant at the 10% level.
** Statistically significant at the 5% level.
*** Statistically significant at the 1% level.

ity variables over demographic and distance variables. The results show that both Models 1 and 2 are statistically significant with likelihood ratio test statistics of 424.33 and 516.83 respectively.

All the coefficients in Model 1 are statistically significant at 5% except for *CURBSIDE*, *CDGREE* and *MALE*, indicating that access to curbside recycling services, gender and education level do not have statistically significant effects on the expected number of site visits. The coefficients on *NUMREC*, *INCOME*, *HSIZE*, *AGE* and *MARRIED* in Model 1 are positive indicating that increased number of recyclables, household size and income increase the number of visits. The positive coefficient for *ENVAFF* indicates that affiliation to an environmental organization increases the expected number of site visits. The coefficients on *DISTANCE*, *SORTIME*, and *FULLEMP* are negative. The significance level of the coefficients in Model 2 after adding the four attitudinal variables do not change except for *ENVAFF*, which is no longer significant, indicating that environmental affiliation was capturing the effects of the attitudinal variables. The coefficients on *NUMREC*, *INCOME*, *HSIZE* and *AGE* in the extended model remain positive. The coefficients on *DISTANCE*, *SORTIME*, *CDEGREE* and *FULLEMP* remain negative and statistically significant. Three of the four attitudinal variables: *CONVENIENCE*, *FAMILIAR* and *SOCIAL* are significant at the 1% level. *FAMILIAR* and *SOCIAL* have negative signs and *CONVENIENCE* has a positive sign.

The coefficients on *DISTANCE* imply that the expected number of visits reduces by 1% as roundtrip distance from home to site increases by a mile. This result confirms earlier findings (e.g. Saphores et al., 2006) that proximity to recycling sites encourages recycling behavior. The coefficient on *NUMREC* indicates that the number of site visits is expected to increase when a recycler recycles a larger variety of recyclables. The time taken to sort the recyclables at home was found to reduce the expected number of site visits. The *SORTTIME* coefficient in Model 2 indicates that a 1 min increase in sorting time reduces the expected number of site visits by 3.7%. Surprisingly, the coefficient for *CURBSIDE* in Model 2 suggests that the availability of curbside recycling does not significantly affect drop-off recycling. Our interviews suggested that this was mainly because of the limited number of materials accepted in curbside programs, e.g. most of the curbside programs did not accept colored glass or cardboard, which were accepted at the drop-off centers.

The negative coefficients on *FULLEMP* indicate that people who are employed full-time are likely to spend less time on recycling activities when compared to people who are employed part time or unemployed. An increase in annual household income and household size increase the number of site visits. The positive relationship is as anticipated because larger and richer households tend to consume more goods. This result also confirms the findings by Vining and Ebreo (1990), Oskamp et al. (1991), and Gamba and Oskamp (1994). The positive relationship between age and number of site visits is also consistent with previous findings that older people have a higher tendency to recycle (Vining and Ebreo, 1990; Meneses and Palacio, 2005; Saphores et al., 2006).

The positive coefficient of the variable *CONVENIENCE* in Model 2 indicates that the number of expected site visits increases when recycling is regarded as a convenient activity. This result confirms the previous findings that convenience is an important factor that encourages recycling behavior (Vining and Ebreo, 1990; Hornik et al., 1995; Domina and Koch, 2002; Gonzalez-Torre et al., 2003; Saphores et al., 2006). The coefficient for *FAMILIAR* suggests that people who are more familiar with locations and materials accepted at the drop-off center in his or her vicinity are expected to make more visits to the centers than the less familiar people. The coefficient for *SOCIAL* implies that pressure from peers and family has a positive effect on drop-off site visits. This result conforms to the findings of previous studies that indicate social pressure is an important factor motivating recycling behavior (Oskamp et al., 1991; Do Valle et al., 2004).

We also ran similar regressions with number of visits during the previous three months as the dependent variable. The fit of the overall regressions was weaker, mainly on account of lower variation in the dependent variable while all explanatory variables remained the same as the one-year visit model. All the coefficient estimates had similar signs and similar values as the one-year model. However, only coefficients on *DISTANCE*, *NUMREC*, *FULLEMP*, *FAMILIAR* and *SOCIAL* continued to be statistically significant.

## 6. Conclusions

Despite the relative popularity of drop-off recycling among local governments and policy makers, little research has empirically examined drivers of drop-off recycling. This study helps to understand the profile of people who utilize drop-off recycling sites as well the underlying factors that influence their frequency of use. Another strength of the study is that it considers economic (e.g. travel distance, sorting time, income), demographic (e.g. age, gender) and psychological (e.g. attitude, knowledge) drivers of recycling behavior in the specific context of drop-off recycling. In comparison, as discussed, many of the earlier studies lack close correspondence to drop-off recycling. Hence the findings of this study are likely to be more reliable for understanding drop-off recycling.

The study results suggest that location plays a crucial role in influencing the usage pattern of drop-off sites. Recyclers are likely to use a drop-off site more frequently if the travel distance from home to site is shorter. Thus, the decision to establish a drop-off recycling program should factor in location to encourage its use. Our results suggest that socioeconomic variables such as household size and income, which are likely highly correlated with household consumption (and hence waste generation), are good predictors of recycling behavior, compared to gender and marital status. Therefore, locating drop-off recycling centers convenient to higher income, older neighborhoods is likely to lead to higher utilization.

The results indicate that beliefs about recycling convenience, familiarity with recycling infrastructure and social pressure are significant drivers of recycling behavior. Recyclers tend to use the drop-off sites more when they feel that recycling is a convenient activity and are familiar with the available recycling facilities. Hence communication and education efforts aimed at improving awareness of recycling facilities and recycling convenience can be effective in promoting visits to recycling centers. Our results for social pressure are consistent with the growing body of research that shows how leveraging social norms can enhance conservation (Schultz, 1999; Chen et al., 2009). Interestingly, beliefs about the environmental effects of recycling were not significantly related to the number of drop-off trips. As such, our findings are consistent with research showing that communication appeals based on environmental protection are less effective that appeals that leverage social norms (Goldstein et al., 2008). Thus, the results suggest that such promotion efforts aimed at children and the community in general can also indirectly increase recycling by increasing social pressure.

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