THESIS

PECUNIARY AND NON-PECUNIARY DETERMINANTS OF HOUSEHOLD RECYCLING BEHAVIOR

Submitted by

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ABSTRACT

PECUNIARY AND NON-PECUNIARY DETERMINANTS OF HOUSEHOLD RECYCLING BEHAVIOR

This article examines the effects of both the pecuniary variables (such as prices) traditionally favored by economists and the non-pecuniary variables (such as attitudes and beliefs) preferred by psychologists on household recycling behavior. In order to better explore what decisions households are actually making when they recycle, three dependent variables are examined: recycling rate, waste disposal container size, and time spent recycling. The recycling rate decision is well-explained by a combination of pecuniary and non-pecuniary variables, especially price, difficulty of recycling, and perceived social pressure to recycle. Non-pecuniary variables have the least influence on the how much time respondents spent recycling, which depends primarily on household size. Calculated consumer surplus from recycling activity is $386 per year.

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1. INTRODUCTION

1.1 Importance of recycling

Recycling programs are rising in both popularity and relevance. As people continue to consume, this consumption continues to create waste, and the problem of effectively disposing of that waste becomes more pressing. The ideal waste reduction strategy is actually to reduce consumption and therefore waste generation, but large-scale buy-in for this solution is difficult to achieve without a significant change in incentives. Given that consumption will likely continue at similar levels, viable waste disposal options for the household become disposing of waste in landfills via traditional (typically municipal) garbage pick-up programs; disposing of waste through illegal burning or dumping, which is undesirable because of the negative environmental and aesthetic externalities it causes; and recycling a proportion of that waste (Fullerton and Kinnaman 1996). Recycling reduces the overall waste stream by turning materials back into consumable goods an additional time before they must ultimately be disposed of. It also slows extraction of virgin resources by providing an alternate source of production materials. Both of these functions create positive net environmental externalities as long as the benefits are greater than the environmental costs of processing recycled materials into a (re)useable form. Those costs are beyond the scope of the current analysis.

The most recent available data from the United States Environmental Protection Agency (EPA) allow us to characterize the scale of waste generation in the country: In

2008, Americans generated 250 million tons of municipal solid waste, or about 4.5 pounds per person per day (EPA 2009). Note that municipal solid waste does not include industrial, hazardous, or construction waste (EPA 2009). Residential waste (including waste from multi-family dwellings, such as apartments) accounts for 55-65 percent of the total municipal solid waste generated in the United States; the rest is commercial and institutional waste from places such as businesses and hospitals (EPA 2009). Recycling programs are a significant part of the residential waste disposal equation in this country, and examinations of optimal program design are therefore warranted.

Many communities in the United States now have municipal recycling programs. As such programs become more widespread, the focus for both researchers and operators turns toward ways to fine-tune these programs to maximize net social benefit from recycling. Incentives for households to recycle may be direct, through the recycling opportunities themselves, indirect, through the design of waste disposal programs, or a combination of the two. Understanding how people make recycling and disposal decisions allows policymakers to target their programs to achieve the desired results of cost effective disposal and minimized negative environmental impact.

1.2 Benefits of Combining Academic Perspectives

To date, however, much of the relevant recycling research remains segregated within distinct academic disciplines. While economists focus on the pecuniary costs and benefits of various recycling options (see, e.g., Reschovsky and Stone 1994; Fullerton and Kinnaman 1995, 1996; Kinnaman and Fullerton 2000; Jenkins *et al* 2003; Fererra and Missios 2005; Kipperberg 2007), psychologists study non-pecuniary factors that cause people to decide to recycle (see, e.g., Oskamp *et al* 1991; Vining and Ebreo 1990, 1992; Thøgersen 1996; Cheung *et al* 1999; do Valle *et al* 2004). Van den Bergh (2008) concludes that studies using traditional variables from economics (price, income) or psychology (attitudes, knowledge, motivations and perceptions) but not both only present part of the story and therefore create results that are of limited application; both types of variables must be systematically combined in order to generate truly policy-relevant analyses. Combining knowledge across disciplines should result in a more complete understanding of what influences recycling behavior, which in turn will allow policymakers to comprehensively address these influences when designing recycling programs. For instance, utility-maximizing households will participate in recycling only when it benefits them. One way for recycling to be utility-enhancing is if the program reduces household costs, either because it is actually the less expensive waste disposal option or because recycling activity is incentivized (subsidized). This cost-reduction option is a very familiar household motivation in the economic literature. Another way for recycling to enhance utility is by affecting the utility function itself. Recycling may increase utility directly through the contribution of altruism or by giving people an enhanced sense of belongingness from following social expectations. How well recycling programs do in terms of waste diversion or cost effectiveness depends critically on households' participation; including both pecuniary and non-pecuniary variables that may influence household behavior provides decision-makers with better information with which to design recycling programs that get sufficient household participation to accomplish waste diversion and cost minimization goals. Some researchers (such as Aadland and Caplan 2006; Halvorsen 2008; Hage *et al* 2009) have begun to combine these discipline-specific contributions into an overarching understanding, but much opportunity for further study remains.

1.3 Objectives of This Study

This work can contribute to the existing literature both by combining disciplinary perspectives and by examining the relevance of three decisions that result in recycling output. The purpose of this paper is to compare the pecuniary and non-pecuniary factors that influence recycling decisions as represented by recycling rate, waste disposal amount, and time spent recycling. This problem is examined by developing a utility framework for the recycling decision, then performing regression analyses for recycling rate, waste disposal, and recycling time that include determinants from both the economics and psychology literatures. This thesis focuses on the recycling component of household waste management, but will also present theoretical and empirical discussion of waste disposal and recycling time that contextualizes the recycling rate models by exploring other possible conceptualizations of the recycling decision. All three sets of models use an activity demand framework. Variables from both disciplines are significant in this analysis, but play into different models in different ways. Of the three, the recycling rate decision model is best supported by the data in this application.

2. FRAMING THE RECYCLING PROBLEM

2.1 RECYCLING AND PUBLIC GOODS

Recycling is a desirable activity because it contributes to the public good of environmental quality by, for instance, reducing landfill externalities and preserving natural resources (Kinnaman 2006; Hage *et al* 2009). Returning for a moment to basic theory, recall that public goods are nonrival – one person's consumption of the good does not detract from other people's consumption – and nonexclusive – excluding people from consuming the good is either impossible or prohibitively expensive (Nicholson 1998). Public goods are often underproduced by private markets because the benefits are distributed across users but costs are subject to free riding, where one person may benefit from the good provided by another (because that good is nonexclusive) without contributing to provision of the good themselves (Varian 2006). Public goods are interesting because everyone in society must consume the same amount – once the good is made available, it is available in the same way to everyone, regardless of differences in individual valuation of that good (Varian 2006). Therefore, governments often step in to ensure that the public good is provided at a socially efficient level (Nicholson 1998). Figure I illustrates the difference between optimal public good provision for private provision (Q_1) and public provision (Q^*). A private individual would provide where their demand curve (D_1) intersects marginal cost (MC) at Q_1, but socially optimal provision demands provision at the level where market demand (the vertical summation of all individual demand, D above) equals marginal cost at Q*. The good would be privately underprovided compared to the social optimum. Environmental quality from waste

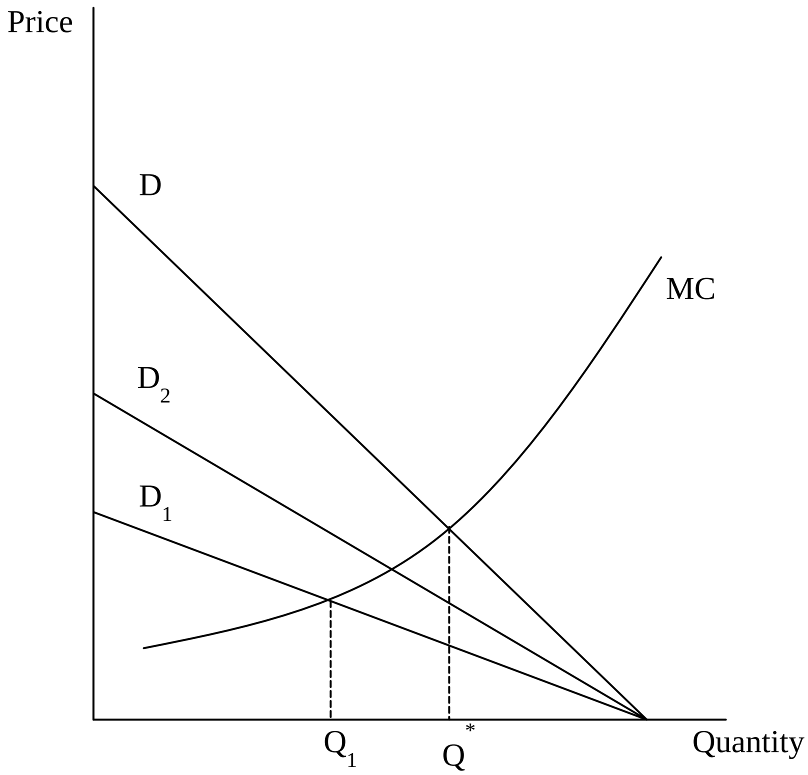

Figure I: Efficient public good provision. Figure based on Varian (2006).

reduction activities (of which recycling is a subcategory) is such a public good: each person’s efforts to reduce the amount of waste they create contribute to an increase in environmental quality, but that person cannot exclude their neighbors from enjoying the benefit provided by their waste reduction activity, whether or not those neighbors bear any waste reduction cost. An individual would not have an incentive to provide environmental quality at the socially optimal level.

Furthermore, the public good of environmental quality provides positive externalities, wherein choices made by one agent have an effect on the utility of others but the agent has no incentive to consider these effects in her decision framework (Freeman 2003). Environmental quality provides a flow of services to people, and changes in agents' actions can create changes in the flow of these services, thereby imposing either benefits or costs on others; these benefits or costs are positive or negative externalities, respectively (Freeman 2003; Varian 2006). Because environmental quality is nonexclusive, people benefit from that quality whether or not they contribute to its creation. Negative externalities, which harm rather than benefit others, are often corrected by assigning property rights or using a tax to incentivize the agent to include the detrimental effects on others in her own decision framework (Varian 2006). Positive externalities, such as that examined here, are less frequently corrected. Unless the agent is altruistic – and derives satisfaction from others' experience of environmental quality – this benefit to others is not included in her utility function.

2.2 Waste Disposal Options

There are two ways to reduce the amount of residential waste deposited in the environment: reduce the amount of consumption that creates waste or reduce the amount of waste discarded (Choe and Fraser 1998). The literature focuses on the second of these options. Households generate waste from consumption that may be disposed of in three possible ways: "traditional" solid waste disposal, such as depositing waste in a landfill; recycling; and illegal dumping or burning (Fullerton and Kinnaman 1996). Of these three options, both recycling and illegal dumping divert waste from landfills, but only recycling prevents that waste from being deposited in the environment and therefore provides the public good of increased environmental quality (assuming, of course, that the emissions created in the recycling process are less environmentally harmful than the emissions resulting from that waste decomposing in landfills or ditches where it has been dumped). Recycling also reduces greenhouse gas emissions, air pollution, and water pollution generated by making new products from raw materials (EPA 2009). It has therefore become one of the preferred waste reductions solutions. In 2008, Americans recycled 61 million tons of municipal solid waste, a recycling rate of about 33%, while "traditional" disposal of municipal solid waste in landfills accounted for 135 million tons of waste, or about 54% of the total (EPA 2009).

Municipal governments tend to bear the responsibility for providing residents with programs for waste disposal, including garbage pickup and recycling programs, and much of the literature is therefore focused on informing policymaking at the municipal level. Government provision of this good most likely results from economies of scale in recycling provision that make it more efficient to have a single provider rather than multiple competitive providers – that is, governments tend to provide recycling services because those services will be underprovided in a private market and there are natural monopolies in recycling service provision. Natural monopolies occur when there are large fixed costs and small marginal costs (Varian 2006), meaning that it is efficient for a single large supplier (such as a municipality) to take advantage of the economies of scale that occur when these large fixed costs can be spread over a great number of customers. Indeed, Reschovsky and Stone (1994) indicate that natural monopolies in waste disposal may make it efficient for municipalities, rather than private companies, to run waste disposal programs, especially when the revenues from waste disposal fees are used to fund recycling programs. Natural monopolies tend to be either regulated or provided by governments because of their cost structure (Varian 2006). Natural monopolies are characterized by decreasing average cost curves over the relevant output levels, which means that marginal cost remains below average cost as long as the average cost curve is

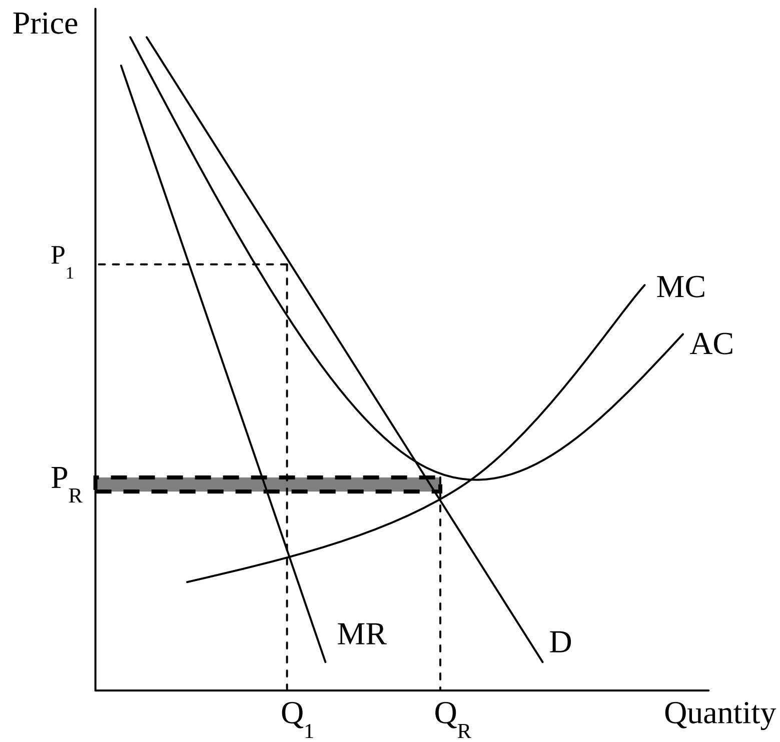

Figure II: Natural monopoly. Figure based on Nicholson (1998).

decreasing (Nicholson 1998). Figure II provides a qualitative illustration of good provision from a natural monopoly. In the figure, the natural monopolist would prefer to price where marginal revenue (MR) equals marginal cost (MC) at P_1, but this results in underprovision of the good relative to the socially optimal level Q_R (Nicholson 1998). Regulators (such as the municipality) would prefer that the monopolist set the price equal to marginal cost at P_R so that the good is provided at the socially optimal level Q_R, but this results in an operating loss for the monopolist equal to the shaded area (Nicholson 1998). Regulators can require that price be set equal to marginal cost so that the socially optimal level of recycling is supplied and use subsidies to make this possible for the monopolist, or the municipality itself may assume responsibility for recycling provision. That is in fact what is observed in the case of municipal solid waste recycling programs. Callan and Thomas (2004) find product-specific economies of scale for recycling that support the characterization of recycling services as a natural monopoly.

Rather than exploring who provides recycling services, however, the economic literature has generally taken the existence of a recycling program as given and focused instead on creating a cost-efficient recycling program by asking which type of program (curbside vs. drop-off, bag/tag vs. subscription, et cetera) induces people to recycle the most, and how much it costs to accomplish. One might expect these questions to be explored at the firm/municipality level and to therefore examine the municipality's problem. In a situation devoid of natural monopoly, the firm's problem would be maximizing profit given costs. In the situation of natural monopoly, the municipality's problem becomes trickier to characterize. Rather than maximize profit, the municipality's objective is to remedy the market failure that results in sub-optimal good provision while minimizing costs. However, rather than explore the municipality's problem, the literature instead focuses on the household problem, even for recycling program design analyses, because "households are the decision-making units that are the target of recycling policies" (Jenkins *et al* 2003, 296) and understanding how they decide to recycle indicates what traits are important in recycling program design. Consequently, the discussion now turns to exploration of the various ways that household recycling may be characterized.

2.3 The Household Problem in Recycling

The household's problem is to maximize utility subject to a budget constraint (Nicholson 1998, Varian 2006). Utility depends on the amount of goods consumed, organized according to the individual/household's preference ranking (Nicholson 1998). The conceptualization of the utility function can be shifted to highlight variables of interest for a particular line of questioning. In the case of recycling, utility can be understood to be a function of the household's consumption of activities, their household maintenance activities, the amount of recyclable household waste (generated by consumption) that the household actually recycles, and the amount of the public good of environmental quality. The resulting utility function is $U = U(\boldsymbol{X}, \boldsymbol{h}, r, Z)$, where $\boldsymbol{X}$ is the vector of consumption activities, $\boldsymbol{h}$ is the vector of household maintenance activities, r is the recycling rate, and Z is the public good. This model will be discussed in greater depth in Section 6.1. Formulating utility this way allows the researcher to focus on the decision of interest, the disposal decision, as part of the broader utility framework. Utility maximization is always subject to a budget constraint. This budget constraint, too, can be conceptualized in multiple ways according to the question of interest. In the case of recycling, both the money budget and the time budget are potentially important. When the budget constraint is constructed in terms of the money budget, it takes the general form $M = \boldsymbol{PX}$, where M is the household's income, P is the vector of prices corresponding to each good consumed, and $\boldsymbol{X}$ is the vector of consumption goods (Nicholson 1998; Varian 2006). For the present application, the money budget takes the form $M = \boldsymbol{P_X} \cdot \boldsymbol{X} + \boldsymbol{P_h} \cdot \boldsymbol{h} + P_d \cdot (1 - r \cdot \theta(\boldsymbol{X}))$, which includes corresponding prices for the variables discussed above (assuming that costs involved with contributing to the public good, Z, are subsumed in the costs of recycling – the way households make that contribution – and costs for consuming the public good are zero). The household spends its full income on these activities (Nicholson 1998). Examination of the time budget hypothesizes that households actually decide how much time to allocate to recycling activity vs. work and leisure. In this case, there are actually two time budgets to allow different time values on recycling and household maintenance activity vs. consumption activity. The price vectors are measured in time rather than money for these budgets; basically, they are the opportunity cost of consuming a particular good. Those time budgets take the forms $T_1 = \boldsymbol{t_X} \cdot \boldsymbol{X}$ and $T_2 = \boldsymbol{t_h} \cdot \boldsymbol{h} + t_r \cdot r$ where the variables t_i are the time costs corresponding to each activity. It is appropriate to examine these time budgets rather than the money budget when the choice variable of interest is time spent recycling rather than recycling rate. The utility and budgeting decisions for this study will be examined in more detail in the theoretical model section.

As discussed above, the literature tends to examine recycling program construction in terms of determinants of the household recycling decision. Researchers include various program design options as potential determinants of recycling behavior in the household equation, and then make program design recommendations based on the relative effectiveness of each design option in increasing (typically) the amount of materials recycled. Important variables in these models include those characterizing the type of program, the cost per unit of waste disposal, and the socio-demographics of potential recyclers. Studies may be broadly categorized into those that examine the waste disposal decision – i.e., disposing of all municipal solid waste in a landfill vs. recycling a percentage of waste – and those that examine the waste disposal program attributes that influence the recycling decision – i.e., the type of recycling program design that maximizes the recycling percentage in a given area. Studies in the first category are the province of Fullerton and Kinnaman (1995, 1996) and Kinnaman and Fullerton (2000). Studies in the latter category include Reschovsky and Stone (1994); Jenkins *et al* (2003); Kipperberg (2007); and Fererra and Missios (2005). Socio-demographic variables in these studies include household income, whether the respondent owns their home, the highest level of education obtained by the respondent, household size, the age of the head of the household, whether the respondent is married, and whether the respondent is retired. Not all studies include all of these variables, and they will be discussed in more detail in the results section below.

3. PECUNIARY MOTIVATIONS TO RECYCLE

3.1 Household Decisions about Disposal Method

The first class of studies is those that examine the waste disposal decision: what makes households decide to recycle a given item of trash rather than dispose of it in a landfill? Fullerton and Kinnaman dominate this category of inquiry, and their research focuses on variables consistent with the economic paradigm: the disposal options that are available, and the relative costs of each (Fullerton and Kinnaman 1995, 1996; Kinnaman and Fullerton 2000). This study characterizes such variables that capture economists' concerns as pecuniary variables. Prior to the work of Kinnaman and Fullerton, the literature tended to look at recycling and disposal as substitutes and the only choices for getting rid of waste, but these authors explicitly model the third option: illegal dumping or burning, which is often overlooked in waste disposal models because of the difficulty of data collection (Fullerton and Kinnaman 1995, 1996). Including this variable more fully characterizes the disposal decision, and leads the authors to conclude that a combination of curbside recycling pickup and a unit-based fee for garbage disposal successfully induces people to recycle, but the benefits from this program combination may not outweigh the administrative costs, especially if illegal disposal methods are not successfully tracked and punished (Fullerton and Kinnaman 1996). The existence of a curbside recycling program is more important in increasing recycling probability than is the existence of a disposal fee (Kinnaman and Fullerton 2000). When these disposal decisions are modeled as a series of endogenous policy choices (whether or not to create a curbside recycling program, what disposal fee to charge) with illegal dumping as a third choice, it may actually be optimal to subsidize disposal rather than charge for it – for example, though a deposit refund program that provides refunds if a person engages in either legal disposal or recycling – in order to indirectly penalize illegal dumping (Kinnaman and Fullerton 2000). Increases in garbage prices have little effect on solid waste disposal demand, but garbage price hikes increase demand for recycling and, probably but not provably, illegal dumping (Fullerton and Kinnaman 1996). Allowing for endogeneity of policy choices (i.e., the user fees for garbage collection are set according to the amount of waste a city expects to have to dispose of) reinforces rather than counteracts these effects (Fullerton and Kinnaman 2000). They do mention that social pressure – a non-pecuniary variable – may influence the recycling decision, but do not pursue this hypothesis empirically (Fullerton and Kinnaman 2000).

3.2 Household Decisions about Recycling

The next group of studies examines variables that influence the household's recycling decision specifically: what makes a household choose to recycle more? The first recycling decision variable is most definitely pecuniary: the relative cost of recycling vs. disposal. Municipalities may encourage recycling (and other forms of waste reduction, such as illegal dumping or composting) by charging a fee for garbage collection (coupled with a reduced or zero fee for curbside recycling, or the opportunity for residents to utilize drop-off recycling facilities). There are three different types of disposal fee programs: subscription programs, where residents choose a particular size of container for their waste and may completely or incompletely fill this container in any given week but are charged by container size regardless; bag/tag programs, where residents purchase either designated garbage bags or tags to affix to the garbage container of their choice but may dispose of as much trash as they like in a given week in these approved containers; and weight-based programs where the municipality weighs the amount of waste collected each week (typically with scales installed on the garbage trucks) and charges accordingly (Kinnaman 2006). Seattle, the application in the current study, uses a subscription program. Generally, results indicate that disposal fees have a significant and positive effect on recycling intensity (Fererra and Missios 2005; Kipperberg 2007). Jenkins *et al* (2003) do not find disposal price to be significant, but this may be due to disposal fees being too low to create a reaction in their particular application or such fees providing only an indirect signal to recycle. Importantly, Reschovsky and Stone (1994) point out that full waste disposal costs are probably not reflected in households' marginal decision-making, even when externalities are fully internalized, in cases where households pay collectors in flat payments (such as in a subscription program) because payment decisions are made on a monthly or annual basis – when the household decides to subscribe to a particular size of container – but disposal decisions are made on a weekly basis when households generate an amount of waste that may or may not completely fill their container. Because there is zero marginal cost to generate extra waste until the container is completely filled, the incentive is to generate enough waste to fill the container completely rather than to reduce waste without utilizing all of the container space for which they have paid (Reschovsky and Stone 1994). Furthermore, a meta-analysis of recycling studies across several disciplines – economics, environmental psychology, sociology, law, and engineering – found that "external incentives," which included financial incentives and perceived social influence, were the second most influential in promoting recycling activity (Hornik *et al* 1995). Interestingly, the researchers concluded that monetary incentives were effective at initiating recycling behavior but the behavior ceased when the incentives ceased; to promote long-term recycling behavior, personal satisfaction from recycling activity and ecological concern were the important variables (Hornik *et al* 1995). If prices can only incentivize recycling for so long, it is important to explore other factors, both pecuniary and non-pecuniary, that contribute to increased recycling behavior. Additionally, the temporary effect discovered by Hornik *et al* (1995) may be explained by Jenkins *et al* (2003): waste disposal cost affects recycling only indirectly, but directly affects the disposal decision itself. Perhaps, when faced with increased disposal costs, households reduce costs by recycling in the short run but in the long run change consumption behavior instead to reduce the amount of garbage produced (Jenkins *et al* 2003) – that is, decrease $\boldsymbol{X}$ and therefore also $G(\boldsymbol{X})$.

Another household decision variable is recycling program design. Recycling programs are typically either curbside pickup programs, in which recycling material is collected at the curb weekly or biweekly (just as garbage is collected) or drop-off programs, in which residents must transport their recycling to centralized collection points. Both types of program require space to store recyclables until they are picked up or dropped off, which may be inconvenient, and drop-off programs require participants to expend time and potentially gas money to travel to the drop-off site. Much of the literature to date has focused on optimal program design, but because a given municipality is likely to implement only one type of recycling program, opportunities for direct comparison have been more limited. Results indicate that curbside recycling programs are most effective at promoting recycling behavior (Reschovsky and Stone 1994; Jenkins *et al* 2003; Kipperberg 2007; Halvorsen 2008). Similarly, curbside recycling programs reduce household recycling costs by increasing convenience and reducing storage costs relative to drop-off programs (Jenkins *et al* 2003).

Other determinants of the household recycling decision are modeled less consistently. These include convenience, information about available recycling programs, and visibility. Convenience was explored in two studies. Jenkins *et al* (2003) indicate that convenience may help explain the popularity of curbside recycling, but use program design as a proxy for convenience rather than including a variable to capture this attribute directly (on the assumption that curbside programs were more convenient than drop-off programs). In that curbside programs had more effect on recycling behavior than drop-off programs (Jenkins *et al* 2003), results indicate that increased convenience increases recycling intensity. Hage *et al* (2009) did explicitly test convenience using the proximity of recycling collection points to the respondent's property and found that this was positively and significantly related to every material except plastic. Vining and Ebreo (1990) found that convenience was more influential on non-recyclers than on recyclers: those who did not recycle highlighted inconvenience as a motivation.

Information about the available recycling programs could include fliers about the recycling program in an area, block leaders who personally informed their neighbors about the program (Hopper and Nielsen 1991), or knowledge attained through observation of existing curbside programs. Both fliers and block leaders positively influenced recycling behavior in Hopper and Nielsen (1991), but block leaders were especially effective. Recycling knowledge increased both actual and self-reported recycling behavior for Gamba and Oskamp (1994). "Internal facilitators," which included recycling knowledge, were the most influential variables on recycling activity in the Hornik *et al* (1995) meta-analysis. Whether or not an information variable is tested, better knowledge about available programs may be an attribute of more active recyclers, especially for programs that are less visible than curbside recycling (Jenkins *et al* 2003). Knowledge about the recycling programs available to respondents was important for Thøgersen (1996), but general environmental knowledge was not. Note that van den Bergh (2008) categorizes information as a variable characteristic of the non-pecuniary/psychological literature rather than one characteristic of the pecuniary/economic literature.

Finally, a survey of the literature by Schultz *et al* (1995) found that variables related to socially visible activities were likely to influence recycling behavior. Vining and Ebreo (1992) indicate that the visibility of curbside recycling programs both increases the perception of social pressure to recycle (because others can see how much a person is or is not contributing to the public good) and serve as a reminder to recycle. Again, visibility may not be tested directly, but may contribute to the importance of other variables.

Reschovsky and Stone (1994) indicate that recycling rates were not fully explained by recycling program attributes in their study and implicate both time costs and "intrinsic returns to recycling" as other important variables. In other words, pecuniary variables provide only an incomplete explanation of recycling behavior because they are not the only influential motivations that people have, and non-pecuniary factors should also be examined. This may be especially true in the case of public goods provision, where a household may have reason to be more concerned with the effects of their actions on others (altruism) or particularly sensitive to social or moral judgments about their actions in regard to that good. Consequently, the analysis now shifts to exploration of the non-pecuniary variables that have been used to examine recycling behavior. These variables are found predominantly in the psychology literature, although they are gaining ground in the economics literature as well with studies such as Halvorsen (2008), Aadland and Caplan (2006), and van den Bergh (2008). Indeed, Halvorsen ties non-pecuniary variables to the utility framework as follows:

> "Household utility is likely to be influenced by social and moral norms, since how we live up to these norms determine[s] our sense of self-respect and the respect we gain, or sanctions we receive, from the community. Furthermore, if a norm is not followed, the person may have [a] guilty conscience for not complying with the norm. These feelings will in turn affect a person's utility from recycling [sic]" (Halvorsen 2008, 502).

Part of the reason these variables have not previously been included in economic models of household recycling decisions is that it is difficult to verify that the questions respondents are answering are actually those that researchers think they are asking; however, a long history of refinement in the psychology literature should mitigate that issue. Additionally, economists often use the "act as if" argument and a preference for model parsimony to argue that as long as a model's results are consistent with people's behavior (they act as if they are making the decisions modeled), there is no need to clutter the analysis with additional variables. However, studies such as Halvorsen (2008) and Hage *et al* (2009) that find significant results for both categories of variables when they are jointly modeled provide empirical evidence that our understanding can indeed be made richer by considering "non-traditional" variables.

4. NON-PECUNIARY MOTIVATIONS TO RECYCLE

4.1 Altruism

The non-pecuniary variable with which economists are probably most familiar is altruism, or the possibility that an individual may gain utility from contributing to the public good as well as from directly consuming the public good itself. Works such as Andreoni (1990) and McConnell (1997) have examined the various ways to incorporate altruism into the utility framework and determined that certain types of altruism do affect equilibrium outcomes. Andreoni considered warm glow altruism, where utility is dependent on private consumption by the individual, public good provision, and the satisfaction that the individual receives from contributing to the public good – the so-called "warm glow" (Andreoni 1990). A collection of articles in the recycling literature (Brekke *et al* 2003; Bruvoll and Nyborg 2004) explored the concept of warm glow altruism and how it might be expanded to more fully explain recycling behavior. Brekke *et al* (2003) used a theoretical model and a recycling-based thought experiment to explore how increased recycling efficiency (through, for instance, a new recycling program that requires less time to recycle the same amount of goods) may decrease, rather than increase, participation in public good provision because people will use the "extra" time gained through the added efficiency to do something other than recycle but will maintain the same level of moral satisfaction because they continue to recycle the same amount. Bruvoll and Nyborg (2004) added a self-image function to a model with warm glow altruism to explore how appeals to the public to recycle may actually decrease recycling activity by raising the perceived expectations about recycling, which makes it more likely that people will feel like they are not meeting expectations (the authors term this the "cold shiver of not giving enough" – it is essentially disutility from contributing to the public good).

Alternately, McConnell defined altruism in relation to environmental quality as "the desire to preserve natural resources because they provide services that enhance the well-being of others" (McConnell 1997, 22); this definition focuses specifically on altruism as an element of existence value. Several of the statements used to elicit norms in the psychology literature could be categorized as examining this type of altruism. Examples include the statements "I recycle because it is a good way to contribute to environmental quality," "I recycle because it is a good way to contribute to conserving scarce natural resources," and "My personal actions can greatly improve the well-being of people I don't know," all of which were used in the current study. Respondents used a scale to indicate their level of agreement with these statements. Agreement with the first two statements indicated that the respondent explicitly linked recycling with public good provision and is consistent with McConnell's paternalistic altruism, where the individual's utility depends on the amount of public goods available for others to use (McConnell 1997). Agreement with the third statement obviously indicates altruistic intentions in the respondent, and is probably most consistent with McConnell's individualistic/non-paternalistic altruism, where the altruist gets utility from the general well-being of others (McConnell 1997).

4.2 Psychological Theories of Behavior

Apart from altruism, the preponderance of the non-pecuniary variables used in the psychology literature come from one of three theories that categorize people's attitudes and beliefs: Ajzen's Theory of Planned Behavior (Ajzen 1991), Schwartz's norm activation model (Schwartz 1977; Schwartz and Howard 1980), and the New Environmental Paradigm of Dunlap and Van Liere (Dunlap and Van Liere 1978; Dunlap *et al* 2000). Broadly, these theories examine how a person's attitude toward a behavior influences their performance of the behavior. In the context of recycling, the basic hypothesis is that people who see themselves as green or responsible consumers, believe that environmental conservation is desirable, and think that their environmentally-related behavior influences others will be more avid recyclers. These theories are relevant to the current research because one of the contributions of this study is the combination of the pecuniary variables that economists traditionally examine and the non-pecuniary variables that have been shown to influence the household recycling decision in the psychology literature but are not yet common in the economic literature. Indeed, van den Berg (2008) notes in his review of empirical studies of household environmental activity that, although such non-pecuniary variables have slowly been gaining the attention of economists, there is still a dearth of studies that effectively and systematically integrate variables from both fields, even though focusing exclusively on one or the other omits important information. This section briefly outlines the three main theories from the psychology literature and explores the research that has been done to date applying attitude and behavior considerations to recycling activity.

4.2.1 THEORY OF PLANNED BEHAVIOR

The Theory of Planned Behavior (Ajzen 1991) stems from the Theory of Reasoned Action (Ajzen and Fishbein 1977), which traces the influences of beliefs, evaluations, and motivations to comply on attitudes and social norms that in turn influence behavior (Thøgersen 1996). The Theory of Reasoned Action is based on the notion of consistency, wherein favorable attitudes toward a topic are assumed to result in favorable behaviors related to that topic, and unfavorable attitudes should result in unfavorable behaviors. If the action, target, context and time are consistent between the attitude and the behavior, then attitude will be a good predictor of the behavior (Ajzen and Fishbein 1977). These fundamental beliefs about a behavior are both practical, concerning the ease of performing and the consequences of not performing the behavior, and social, concerning the expectations of important others in the household or peer group regarding the performance of the behavior (Thøgersen 1996; Cheung *et al* 1999). The Theory of Planned Behavior expands on the Theory of Reasoned Action with the addition of perceived behavioral control – how difficult the person thinks it will be to perform the behavior given their available resources and opportunities (Ajzen 1991). Therefore, the Theory of Planned Behavior posits that a person's intention about a behavior is determined by the attitude towards the behavior (the person's normative assessment of the behavior, subjective norms (the perceived social pressures surrounding the behavior), and perceived behavioral control (the perceived difficulty of completing the behavior) (Ajzen 1991). Those intentions, tempered by a person's actual resources and capabilities, then result in the behavior itself (Ajzen 1991). The social pressures portion of this model has found the most application in subsequent studies of recycling behavior (Berk *et al* 1980; Sadalla and Krull 1995; Cheung *et al* 1999; Lam 1999), although attitudes about the environment in general and recycling in particular have also been studied (see, e.g., Oskamp *et al* 1991).

4.2.2 Norm Activation Model

Schwartz's norm activation model examines internalized, or personal, and non-internalized, or social, norms and their influence on behavior (Schwartz 1977; Schwartz and Howard 1980; Thøgersen 1996). When a behavioral situation is introduced, an individual first responds to it using relevant social norms that "represent the values and attitudes of significant others" but are too general to prompt people to action; over time, however, social norms may be internalized and therefore become personal norms related to the situation (Hopper and Nielsen 1991, 200; Thøgersen 1996). Personal norms are capable of prompting behavior because they are actually related to a person's self-concept; behaving in a way consistent with the personal norm makes an individual feel good about himself, while behaving in a way that violates that norm makes the individual feel guilty (Hopper and Nielsen 1991). Furthermore, personal norms require two further conditions to be met before they lead to performance of a behavior: the individual must recognize that his actions have consequences – Schwartz calls this Awareness of Consequences – and that he is personally responsible for creating these consequences – called Ascription of Responsibility (Hopper and Nielsen 1991; Vining and Ebreo 1992). When both conditions are in place, an individual's behavior will be in accordance with personal (and therefore also social) norms (Hopper and Nielsen 1991). Figure III presents a visual representation of this model. Schwartz created the norm activation model as an exploration of altruistic behavior, a situation where approval of a behavior (the social norm) does not necessarily translate into participation in that behavior (Hopper

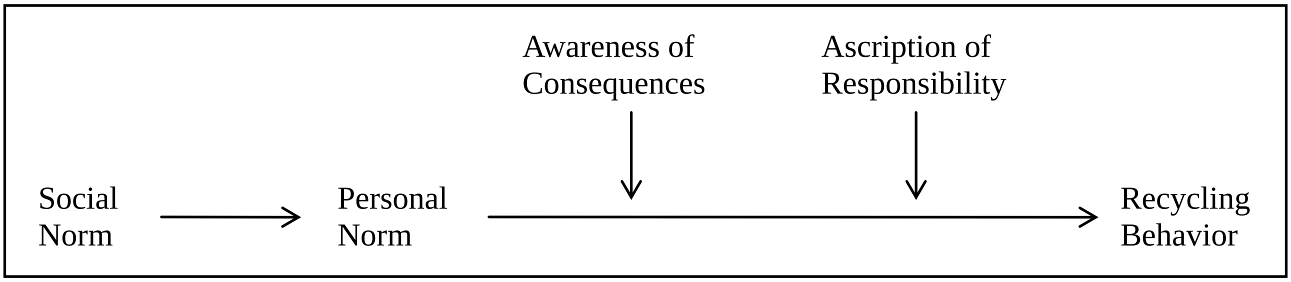

Figure III: Schwarz norm activation model. Source: Hopper and Nielsen (1991).

and Nielsen 1991). Recycling is an example of such an altruistic behavior that finds widespread approval but more limited participation (Vining and Ebreo 1990, 1992; Hopper and Nielsen 1991). Studies that specifically apply the norm activation model to recycling behavior include Vining and Ebreo (1990, 1992); Hopper and Nielsen (1991); and Hage *et al* (2009).

4.2.3 New Ecological Paradigm

The New Environmental Paradigm (NEP) examines a set of values, attitudes, and beliefs which comprise an ecological worldview that is more pro-environmental than the dominant social paradigm (Dunlap and Van Liere 1978; Dunlap *et al* 2000). The NEP consists of twelve statements along three dimensions: people's ability to interfere with the balance of nature, limits to growth created by the scarcity of natural resources, and humanity's right to dominate over nature (Dunlap and Van Liere 1978; Vining and Ebreo 1992). Dunlap *et al* (2000) updated the original study to include fifteen statements and renamed it the New Ecological Paradigm (which is also abbreviated NEP); both versions are still used in the literature. The updated scale includes statements that capture the concepts of humans' fundamental difference from other animals and the possibility of environmental crises (Dunlap *et al* 2000). As noted in Dunlap *et al* (2000), these statements do not tend to divide into five distinct factors when subjected to factor analysis in individual studies; instead, the results tend to be sample-specific. Both versions of the NEP examine the pro-environmental attitudes of research subjects, with the general premise that the stronger the subjects' agreement with scale items, the higher their pro-environmental attitudes, and the stronger their recycling behavior (Dunlap *et al* 2000). Environmental concern, or a pro-environmental attitude, has been shown to be an important motive for recycling behavior in studies such as Vining and Ebreo (1990, 1992).

4.2.4 Psychological Theories in Practice

However, the three psychology models above are hardly ever used in their complete forms by any researcher looking at recycling behavior. In practice, questions from these theories are often combined into a set of questions that the researcher believes to be most relevant to people's recycling behavior in the situation under question. The theoretical justification for this practice is unclear. Empirical support for the influence of non-pecuniary variables derived from these models is tested in the following studies: Oskamp *et al* (1991) found that social pressure provided by friends and neighbors' recycling behavior, acknowledgement of environmental problems, and acknowledgement of intrinsic motivations to recycle all had positive and significant influence on whether a person recycled, but that performing environmentally responsible behaviors other than recycling and having general pro-ecology attitudes both had a negative relationship with recycling. Attitudinal variables concerning recycling behavior were significant predictors of self-reported recycling behavior but did not predict actual recycling behavior in Gamba and Oskamp (1994). The meta-analysis by Hornik *et al* (1995) found evidence that perceived social influence affected recycling behavior. Vining and Ebreo (1992) found that social norms and an interaction variable for personal norms and awareness of consequences had positive and significant relationships with recycling behavior in a curbside recycling program, while awareness of consequences was negatively and significantly related. These results contrast with those in an earlier study by the same authors that found that social influences were not important to recycling behavior, but may not be inconsistent because the only type of recycling program available to participants in the earlier study was drop-off recycling, which does not expose a person's recycling behavior to public scrutiny in the same way that curbside recycling does (Vining and Ebreo 1990). Hopper and Nielsen (1991) found that awareness of the consequences of recycling and personal norms about recycling both increased recycling frequency. Aadland and Caplan (2006) found that those who believe they have an ethical duty to help the environment and belong to an environmental organization have the highest willingness to pay for curbside recycling. Strong moral norms (people's desire to be considered socially responsible by themselves and others) increased recycling effort in Halvorsen (2008). Hage *et al* (2009) found that social norms, as measured by agreement with the statement "Important persons close to me want me to recycle," did not have a statistically significant effect on recycling behavior but moral norms, measured by agreement with the statement "I recognize a moral obligation to recycle," were positive and significant for recycling paper, plastic, glass and metal. Finally, the meta-analysis by Schultz *et al* (1995) found that variables related to socially visible activities were likely to influence recycling behavior. Schultz *et al* (1995) also make the excellent point that studies of social norms should include characteristics of the community, although none apparently do.

In summary, the recycling literature in economics has historically focused on external motivations for recycling such as the relative costs of recycling vs. traditional waste disposal, how the recycling program is designed, and whether that design is incentive-compatible. Altruism has been addressed by both economics and psychology literatures, but is applied to recycling primarily in the psychology literature. Non-pecuniary determinants of recycling tend to fall in the domain of psychology, which is more comfortable exploring internal motivations for recycling behavior. Such variables include the attitudes a person holds about recycling and other environmental activity, social expectations set by the person's community or peer group, and environmental values. Various researchers have found all of these different motivations to be significant determinants of recycling behavior, although the relative absence of studies combining pecuniary and non-pecuniary variables means that the relative importance of each type of variable for recycling behavior is still unknown. By examining all of these motivations in the same model, this study can directly compare how influential each type of variable is while handily reducing omitted variable bias.

5. EMPIRICAL CONSIDERATIONS

5.1 Stated vs. Revealed Information

Before progressing to the analysis portion of this study, there are a few more concepts that affect interpretation of the results. Although "revealed preference variables" and "stated preference variables" technically refer to methods of eliciting preferences in non-market valuation studies, there are sufficient parallels to the types of variables used in this study to make a brief discussion of the relative merits of stated vs. revealed worthwhile here. In non-market valuation, revealed preference uses purchasing habits (such as the amount spent on travel to a location) to determine how a respondent values a set of attributes that currently exist in the world. Stated preference questions, on the other hand, ask respondents how much they would be willing to pay for attributes that do not currently exist. The parallel here is that a handful of studies (Gamba and Oskamp 1994; Fullerton and Kinnaman 1996) have actually obtained measurements of how much people recycled – this is akin to a revealed preference – while most others rely on respondents to self-report their recycling behavior – which is more like a stated preference. Although not exactly preferences per se, these variables do measure actual (or revealed) behaviors and reported (or stated) behaviors and some of the considerations relevant to preference questions are relevant. Furthermore, many non-pecuniary variables must be stated rather than revealed. The problems associated with revealed and stated preference questions can then be kept in mind when interpreting results in this application.

Revealed preference variables are based on actual behavior and can often be independently measured by the researcher. The main problem with revealed preference data is that it may be limited and difficult to obtain. Because revealed preference data is based on actual behavior, it can only cover those situations which are currently present in the real world; other scenarios must be elicited using stated preferences (Boyle 2003). The benefit to revealed preference data is that it has high content validity: it actually measures the construct the researcher intends it to measure because it is directly observable and can be accurately described (Boyle 2003). Possible revealed preference variables in the recycling literature include the amount of waste actually recycled, the types of recycling programs that exist in a municipality, and whether the respondent has received information about a particular program.

Stated preference variables provide information about hypothetical, rather than actual, situations and must be reported by the respondent (Brown 2003). The two concerns with this type of data are hypothetical bias and validity. Hypothetical bias is the concern that the respondent might react differently in the imaginary situations given in a survey than they would actually react in those same situations in real life (basically, researchers do not trust that the respondents are answering carefully) (Brown 2003). It can be mitigated through careful survey design and use of focus groups. Concerns about validity – that the stated preference question is actually asking what it is intended to ask – can be addressed in a number of ways. Criterion validity may be evaluated by comparing the stated preference measure with another measure that is known to be close to the thing the researcher intends to measure (Brown 2003). Construct validity evaluates whether the concept under consideration relates to other concepts as predicted by theory and can be assessed by comparing the variable of interest to other variables that should give similar results as indicated by theory and by looking at the relationship between the variable of interest and other variables that the theory says should influence it (Brown 2003). The benefit of stated preference variables is that they are useful in measuring intangible concepts. Problems with bias and validity could conceivably affect the stated behaviors of interest in this study, especially if the survey designers' intent differs from the respondent's understanding of a question. Van den Bergh (2008) encourages researchers to use stated preference psychological variables rather than not collect this information at all, even though the reliability of stated preference responses may be questioned, in order to inform truly optimal policy and notes (amusingly) that "economists have perhaps been more concerned with efficiency than effectiveness" (Van den Bergh 2008, 569).

One interesting contrast of stated and revealed variables in the recycling literature, as mentioned above, is in the dependent variables themselves. Most studies use stated variables for the dependent variable; these typically take the form of self-reported recycling behavior. For instance, the respondent indicates what percentage of a recyclable material their household actually recycles (as in Kipperberg 2007). This is done for ease of data collection, but leaves open the possibility that the response is not entirely accurate. Perhaps, when faced with a survey about recycling, the respondent feels pressured to present the best version of their actual behavior or incorrectly recalls this behavior. On the other hand, a few studies use actual recycling behavior as the dependent variable. In one instance, the researchers actually manually weighed the garbage and recycling materials that were placed on the curb each week (Fullerton and Kinnaman 1996). This method has the advantage of providing accurate information on how much is actually recycled, but is more expensive and time-consuming for the researcher. Gamba and Oskamp (1994) made the interesting decision to directly compare stated and revealed information about household recycling behavior. Accordingly, they obtained self-reported recycling behavior from respondents (stated) and determined actual recycling behavior (revealed) by visually evaluating the amount of material in respondents' recycling containers for two months, starting a week before survey mailing (Gamba and Oskamp 1994). They found that household size, income, and recycling knowledge predicted actual recycling behavior, but no attitudinal variables were statistically significant; self-reported recycling behavior, on the other hand, depended on recycling knowledge and attitudinal variables but not really on socio-demographic variables (Gamba and Oskamp 1994). It is worth keeping this difference in determinants for stated and revealed variables in mind when evaluating other studies. Might those results change as well if the other type of dependent variable were used? This is potentially important for future survey design and policy analysis.

5.2 Principal Component Analysis

Principal component analysis (PCA) is a way of reducing a collection of variables to a smaller collection of linear functions of those variables while retaining as much variation as possible from the original data (Darlington 1997; Jolliffe 2002). This method is well-established in the psychological literature and has been widely used (along with its cousin, factor analysis) to study recycling behavior, especially when the researcher includes attitude statements from the New Ecological Paradigm, Theory of Planned Behavior, or Schwartz's norm activation model (see, e.g., Vining and Ebreo 1990; Oskamp *et al* 1991; Gamba and Oskamp 1994; do Valle *et al* 2004, Barr and Gilg 2006).

Principal component analysis is often conflated with factor analysis and the terms are often used interchangeably, but each method answers a distinct question: principal component analysis uses a smaller set of variables to summarize a larger set as explained above, while factor analysis looks for underlying unobserved (latent) variables that explain a larger set of observed variables (Darlington 1997; Fabrigar *et al* 1999). Principal component analysis does not distinguish between the proportions of all the variables that are explained by the component (common variance) and the proportions that are not (unique variance), while factor analysis does distinguish between the two (Darlington 1997; Fabrigar *et al* 1999). This assumed lack of random variance is a primary criticism of principal component analysis (Fabrigar *et al* 1999).

This analysis will follow Jolliffe (2002) closely for a mathematical explanation of principal component analysis. Note that the letters used to denote variables here have no relation to the notation used in the theoretical model below. In this instance, suppose that x is a matrix of p random variables. The purpose of principal component analysis is to find $m < p$ derived variables that preserve most of the information provided by the correlations and variances in x. The idea is to find a linear function $\alpha_1'x$ of x that has maximum variance and where α_1 is a vector of p constants:

$$\alpha_1'x = \alpha_{11}x_1 + \alpha_{12}x_2 + \ldots + \alpha_{1p}x_p = \sum_{j=1 \text{ to } p} \alpha_{1j}x_j.$$

This function maximizes variance on a line, but some variance remains. It is then necessary to find another linear function that maximizes the remaining variance on another line: a linear function $\alpha_2'x$ of x that is uncorrelated with $\alpha_1'x$ and has maximum variance. Again, some variance remains, so this process is continued until there are $\alpha_k'x$ linear functions. Each linear function is a principal component. It is possible to have $k = p$ principal components, but the goal is to find $k = m$, $m < p$, principal components such that the first m principal components account for most of the variance in x. The vector of random variables x has a known covariance matrix Σ whose (i, j)th element is the known covariance between the ith and jth elements of x for all $i \neq j$ and is the variance of the jth element of x for all $i = j$:

$$\Sigma = \begin{bmatrix} var\ x_1 & covar\ x_1x_2 & covar\ x_1x_3 \\ covar\ x_2x_1 & var\ x_2 & covar\ x_2x_3 \\ covar\ x_3x_1 & covar\ x_3x_2 & var\ x_3 \end{bmatrix}.$$

For $k = 1, 2,\ldots, p$, the kth principal component is $z_k = \alpha_k'x$ where α_k is an eigenvector of Σ corresponding to its kth largest eigenvalue, λ_k. If α_k is chosen to have unit length ($\alpha_k'\alpha_k = 1$), then $var(z_k) = \lambda_k$. Remember that α_k is the vector of coefficients or loadings for the kth principal component, z_k. This gives $z = A'x$, where A is the orthogonal matrix whose kth column, α_k, is the kth eigenvector of Σ.

This analysis actually finds the principal components using a correlation matrix rather than a covariance matrix; this allows for better informal comparison of the results of different analyses because the sizes of the variances of the principal components have the same implications for different correlation matrices of the same dimension (Jolliffe 2002). The principal components created from correlation matrices (rather than covariance matrices) depend on the ratios of the correlations rather than their absolute values (Jolliffe 2002). This changes the math just slightly: rather than working with the covariance matrix, it uses a correlation matrix that really gives $z = A'x^*$. A now has columns consisting of the eigenvectors of the correlation matrix and x^* is the standardized version of x. Furthermore, x^* has jth element $x_j/\sigma_{jj}^{1/2}$, $j = 1, 2,\ldots, p$, x_j is the jth element of x, and σ_{jj} is the variance of x_j. So the covariance matrix for x^* is the correlation matrix of x. Because x^* is not an orthogonal transformation of x (although it is a simple transformation of x), the principal components found for x^* are not the same principal components found for x (Jolliffe 2002).

There are infinitely many linear functions z_k (principal components) of the original variables that summarize those variables, so the choice of the "best" function is based on three criteria: "First, the *m* derived linear functions must be mutually uncorrelated. Second, any set of *m* linear functions must include the functions of a smaller set…. Third, the squared weights defining each linear function must sum to 1" (Darlington 1997, 13). One way to choose the number of principal components is by rotating the matrix of principal components in multidimensional space to reorganize the loadings and make the factors easier to interpret (Darlington 1997). Rotation redistributes the maximized total variance more evenly over the rotated components than would have otherwise been the case (Jolliffe 2002). Using the concept of simple structure, the matrix is rotated until each principal component is "defined by a subset of measured variables that ha[ve] large loadings relative to the other measured variables (i.e., high within-factor variability in loadings) and in which each measured variable loaded highly on only a subset of the common factors (i.e., low factorial complexity in defining variables)" (Fabrigar *et al* 1999, 281). This method chooses the simplest set of principal components, where simple means that the number of predictor variables is minimized (Darlington 1997). The first several principal components will then retain most of the variation from the entire original set of variables (Jolliffe 2002). Orthogonal rotation specifies that the principal components remain uncorrelated with each other; varimax rotation is the type of orthogonal rotation that is most popular in psychological research (Darlington 1997; Fabrigar *et al* 1999). This smaller set of variables can then be used in place of the original variables without much loss of information in subsequent analysis.

Performing this process on the set of 25 attitude statements for this study yielded seven principal components with eigenvalues greater than or equal to 1, and those principal components were then named according to which statements loaded into each principal component at 0.500 or above. Each of the statements shown loads into every principal component according to the loading value shown in the table, but the principal components are conceptualized according to the statements that load most heavily in each respective component. Five statements did not load significantly into any principal component and are dropped from further analyses. Table I presents the twenty remaining attitude statements and the resulting principal components. Together, these principal components cumulatively explain 56% of the total variance.

The seven principal components in this analysis are internal motivation, difficulty, individualistic orientation, environmental orientation, external motivation, resourcefulness, and social concern. The internal motivation component describes a

Table I: Factor Loadings on the Orthogonal Principal Components for the Attitude Statements

	Factor						
Statement	*Internal Motivation*	*Difficulty*	*Individualistic Orientation*	*Environmental Orientation*	*External Motivation*	*Resource-fulness*	*Social Concern*
I recycle because it is a good way to contribute to preserving environmental quality.	0.863	-0.135	-0.026	0.091	0.056	-0.021	-0.055
I recycle because it is a good way to contribute to conserving scarce natural resources.	0.827	-0.138	-0.061	0.166	0.090	-0.011	-0.073
I recycle because I want to be a socially responsible person.	0.766	-0.088	-0.125	0.078	0.146	-0.131	0.084
I recycle because, regardless of what other people might think, I feel it is my ethical duty.	0.755	-0.098	-0.157	0.132	0.171	-0.058	0.084
My personal actions can greatly improve the well-being of people I don't know.	0.512	0.021	-0.394	0.149	-0.110	0.314	0.072
It [recycling] takes too much time.	-0.103	0.731	0.008	-0.027	-0.004	0.148	-0.137
It is difficult to find room/space for temporarily storing recyclable items.	-0.154	0.675	0.007	-0.013	0.008	-0.009	-0.091
It is often difficult to know what items can or cannot be recycled.	0.107	0.663	0.026	0.023	0.043	-0.090	-0.030
I don't have enough recyclables.	-0.136	0.623	0.027	-0.119	0.183	0.018	0.190
My responsibility is to provide only for my family and myself.	-0.097	0.014	0.757	-0.174	0.088	-0.017	-0.117
Contributions to community organizations rarely improve the lives of others.	-0.129	0.116	0.688	0.099	-0.126	0.104	0.046
The individual alone is responsible for his or her well-being in life.	-0.068	-0.010	0.634	-0.171	0.002	0.177	0.147
The earth has very limited room and resources.	0.123	0.100	-0.123	0.739	0.061	0.209	0.086
Plants and animals have as much right as humans to exist.	0.127	-0.199	0.022	0.638	0.030	-0.037	-0.131
The balance of nature is strong enough to cope with the impacts of industrial nations.	-0.230	0.049	0.276	-0.565	0.085	0.283	-0.148
I recycle because I want other people to think of me as a responsible person.	0.060	0.155	-0.054	0.016	0.759	0.053	-0.009
I recycle because I feel it is expected of me.	0.146	-0.045	-0.208	0.046	0.642	0.015	-0.122
I recycle because it saves me money since I am able to use a smaller garbage container.	0.088	0.056	0.254	-0.034	0.536	-0.104	0.145
Human resourcefulness will insure that we do not make the earth unlivable.	-0.070	-0.076	0.105	0.018	0.125	0.730	-0.038
Other people are not doing enough.	0.060	-0.087	-0.003	0.025	0.050	-0.029	0.835

person who cares about their impact on the environment and being the kind of "good person" that chooses environmentally responsible actions. Notice that all three altruistic statements discussed in the altruism section above are included in this factor. The difficulty component describes a person who finds practical excuses not to recycle, such as lack of storage space for recyclables and lack of knowledge about what items are eligible for recycling. Compare this to the individualistic orientation component, which describes a person who finds theoretical excuses not to recycle; they do not believe that recycling is a worthwhile activity. Next, the environmental orientation component describes an individual who strongly values the environment and acts to conserve it. The statements that load most strongly in this component are all from the New Ecological Paradigm (Dunlap *et al* 2000). The external motivation component describes an individual who is concerned with the tangible and social benefits they receive from recycling activity. Two of the highest loading statements have to do with feeling pressure from others: "I recycle because I want other people to think of me as a responsible person" and "I recycle because I feel it is expected of me." The third statement with a high loading, "I recycle because it saves me money since I am able to use a smaller garbage container," indicates a pecuniary motivation and is a strange fit with the other two, although all three statements come from the same section of the questionnaire that asked what motivates people to recycle. The resourcefulness component loads on a single statement that describes a person who believes that human ingenuity will allow society to escape from the consequences of human wastefulness. This statement is also from the NEP (Dunlap *et al* 2000). Finally, the social concern principal component also loads on a single statement: that "[o]ther people are not doing enough." For subsequent analysis, these principal components were formed into seven variables by weighting each component according to the factor loadings given in Table I. These variables are added as independent variables in the second iteration of each equation (8) – (10).

With these empirical considerations in mind, proceed to the next section, which explores the theoretical and empirical methodology used in this analysis.

6. METHODS

6.1 THEORETICAL MODEL

As discussed earlier, decisions about recycling behavior are components of the larger utility-maximizing decisions being made by an individual. For the purposes of this study, utility can be conceptualized as consisting of a vector, $\boldsymbol{X}$, of consumption and the resulting waste generated, G, which is a function $G(\boldsymbol{X})$ of that consumption. Of the waste generated, $G(\boldsymbol{X})$, a fraction, θ, is recyclable and the remainder, $(1 – \theta)$, is not recyclable. A household will actually recycle a fraction, r, of the total recyclable waste, θ, that they create. Figure IV presents a visual representation of the amounts of waste recycled and recyclable as a portion of total waste generated; relative proportions of the areas in the

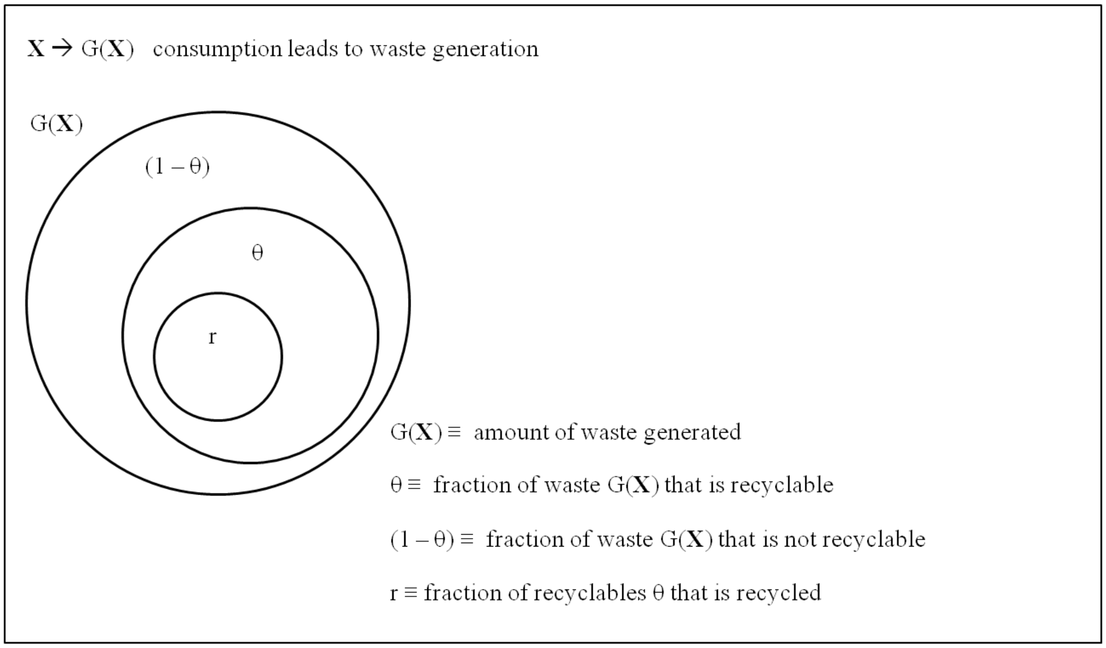

Figure IV: Recycling as a portion of waste generated

figure are arbitrary. Thus, the amounts of waste recycled, R, and disposed of, D, by a household are given by $R = r \cdot \theta \cdot G(\boldsymbol{X})$ and $D = (1 - r \cdot \theta) \cdot G(\boldsymbol{X})$, which are governed by the mass balance equation $G \equiv R + D$. Waste generated is $G = G(\boldsymbol{X})$, where $\boldsymbol{X}$ is chosen simultaneously with r. It is possible to assume that θ depends on what types of goods are consumed, X, because some the characteristics of those goods determine whether they can be recycled (for instance, cardboard packaging is recyclable, but cellophane packaging is not) and the household does not have direct control over these characteristics. The household may choose "brands" within the consumption vector in order to, for instance, reduce waste generated and/or increase its recycling potential, meaning that both $G(\boldsymbol{X})$ and $\theta(\boldsymbol{X})$ are endogenous – that is, implicit – choices. However, it is likely that most households do not really consider waste reduction potential when making consumption choices. Instead, their choices are driven by household income (wealth), the size and composition of the household, and tastes and preferences about the consumption options. By this interpretation, it is reasonable to assume that θ is exogenous. In the empirical application in this study, G and θ are not known; otherwise, the volumes R and D could be recovered.

There are several possible ways to conceptualize household utility in relation to recycling: First, if households only recycle to reduce disposal expenditures, then $U = U(\boldsymbol{X})$. This would mean a corner solution for recycling, $r = 0$, if the disposal fee $P_D = 0$ (or if P_D is fixed, invariant with D). Second, households may actually get utility from recycling, r (or, equivalently, R), giving $U = U(\boldsymbol{X}, r)$, $U_r > 0$. This would be akin to the egoistic altruism formation from Andreoni (1990), where the household receives utility solely from their own contribution to the public good. If the household's utility comes from both the warm glow of their own contribution, r, and from the aggregate amount of the public good of environmental quality, Z, then the utility formulation would be $U = U(\boldsymbol{X}_i, r_i, Z)$ as in Andreoni's (1990) impure altruism formulation (the subscript i denotes a particular household). In this case, overall recycling in society reduces waste disposal (ceteris paribus), resulting in conservation of resources, fewer landfills, and fewer externalities from virgin material extraction and production, et cetera. The public good will be a function of the recycling decisions, r, of each household $Z = Z(r_1, r_2, \ldots, r_J)$ where J is the number of contributing households. Here, $\partial Z/\partial r > 0$, albeit very small. A third possibility is that households receive disutility (i.e. guilt) from disposal, D (or, equivalently, $d = 1 - r \cdot \theta)$, so that $U = U(\boldsymbol{X}, d)$, $U_d < 0$. This is a simplification of the models used in Brekke *et al* (2003) and Bruvoll and Nyborg (2004) that show disutility arising from a disconnect between a household's actions and perceived moral and social obligations. In these models, $S = S(r, r^{MORAL}, r^{OTHERS})$ represents an identity or self-image function, where r^{MORAL} is the perception of what the "morally correct" household recycling rate would be and r^{OTHERS} is the perception of the average recycling rate of other households. Note that $\partial S/\partial r > 0$, $\partial S/\partial r^{MORAL} < 0$, and $\partial S/\partial r^{OTHERS} < 0$. The implied utility function is therefore $U = U(\boldsymbol{X}, d, S, Z)$, with $U_S > 0$. This model is a generalization of the Andreoni (1990) model as well. It is equivalent to that model when r^{MORAL} and r^{OTHERS} are absent from the self-image function. Finally, utility could be a combination of the warm glow utility formulation and the disutility formulation above. Note that $r = (1 - d) / \theta$, so r can represent both utility and disutility from recycling.

This study will utilize the final option of allowing a household's recycling activity to cause both utility and disutility. Household chore activities will be separated out into a second activity vector, $\boldsymbol{h}$, to allow for better conceptualization of the time budgets below. With this set-up, household chore activities are chosen exogenously and are separate from other labor and leisure choices (which are included in $\boldsymbol{X}$). Therefore, the utility function is:

$$U = U(\boldsymbol{X}, \boldsymbol{h}, r, Z) \tag{1}$$

where U_r captures the utility or disutility of recycling.

Households are constrained by both money and time budgets. For the money budget, assume that exogenous labor market choices (both primary and secondary) yield money budget M. Assume a stylized continuous fee on waste disposal, P_d, and no fee on recycling so that $P_r = 0$. The assumption about the recycling fee fits this specific empirical application. The strictly binding money budget constraint for the household can then be expressed as:

$$M = \boldsymbol{P_X} \cdot \boldsymbol{X} + \boldsymbol{P_h} \cdot \boldsymbol{h} + P_d \cdot d = \boldsymbol{P_X} \cdot \boldsymbol{X} + \boldsymbol{P_h} \cdot \boldsymbol{h} + P_d \cdot (1 - r \cdot \theta). \tag{2}$$

There are two time budgets arising from exogenous labor market and leisure choices. The first time budget, T_1, covers “ordinary” consumption activities. The strictly binding form of this budget is:

$$T_1 = \boldsymbol{t_X} \cdot \boldsymbol{X} \tag{3}$$

where $\boldsymbol{t_X}$ is the time price of consumption activity. Households are likely to have their time divided into blocks with their own unique constraints because some kinds of time simply aren’t fully interchangeable (Eom and Larson 2006). Some activities are only available on certain days or at certain times, like working during the normal workweek, commuting at the beginning and end of the day, and not being able to sleep during the workday. These different blocks of time allow for multiple values of time, so that, for instance, labor time is valued at the wage rate while leisure time is valued at some fraction of that rate. Separating out a strictly binding time budget for household chores and recycling gives:

$$T_2 = \boldsymbol{t_h} \cdot \boldsymbol{h} + t_r \cdot r \qquad (4)$$

where $\boldsymbol{t_h}$ is the time price of household chore activities and t_r is the time price of recycling. The exogenous time price of recycling, t_r, is interpreted as the number of hours it takes to recycle one percent of household recyclables within a time period (say, a year) relative to disposing of this waste. Specifying two time budgets in this way assumes inflexibility between time spent on household chores and recycling and household time spent on other consumption activities; this specification is based on the model in Eom and Larson (2006). This disconnect between wage rate and the value of time allows the marginal money value of time to be small if recycling yields little utility. Furthermore, the time budget T_2 corresponds to the empirical variable HHTIME, where respondents stated the amount of time they spent on household maintenance activities, including recycling.

Given the above utility and budget formulations, the household's choice problem is to maximize:

$$U = U(\boldsymbol{X}, \boldsymbol{h}, r, Z)$$

subject to:

$$M = \boldsymbol{P_X} \cdot \boldsymbol{X} + \boldsymbol{P_h} \cdot \boldsymbol{h} + P_d \cdot (1 - r \cdot \theta)$$

$$T_1 = \boldsymbol{t_X} \cdot \boldsymbol{X}$$

$$T_2 = \boldsymbol{t_h} \cdot \boldsymbol{h} + t_r \cdot r.$$

Let V represent the resulting indirect utility function of the above. Then:

$$V = max\{U(\boldsymbol{X}, \boldsymbol{h}, r, Z(r)) + \lambda[M - \boldsymbol{P_X} \cdot \boldsymbol{X} - \boldsymbol{P_h} \cdot \boldsymbol{h} - P_d \cdot (1 - r \cdot \theta)] + \mu_1[T_1 - \boldsymbol{t_X} \cdot \boldsymbol{X}] + \mu_2[T_2 - \boldsymbol{t_h} \cdot \boldsymbol{h} - t_r \cdot r]\}. \quad (5)$$

The first order necessary condition (FONC) with respect to household chore activities of a representative household ($\boldsymbol{h}_j$), assuming an interior solution, is:

$$\partial U/\partial \boldsymbol{h} - \lambda \cdot \boldsymbol{P_{hj}} - \mu_2 \cdot \boldsymbol{t_{hj}} = 0.$$

This FONC can be rearranged to show marginal benefits (MB) and marginal costs (MC) of household chores:

$$(\partial U/\partial \boldsymbol{h})/\lambda = \boldsymbol{P_{hj}} + (\mu_2/\lambda) \cdot \boldsymbol{t_{hj}}.$$

The left hand side (LHS) of this equation gives the marginal benefit of household chores (the marginal utility of chore activities), while the right hand side (RHS) gives the marginal costs. Note that the ratio $(\mu_2/\lambda) \equiv (\partial V/\partial T_2)/(\partial V/\partial M) = MRTS_{T2,M}$ is the marginal money value of time for household chores and recycling. The term $((\mu_2/\lambda) \cdot \boldsymbol{t_{hj}})$ therefore gives the monetized time price of household chores. Similarly, (μ_1/λ) will be the marginal money value of time for household consumption activity. The FONC with respect to consumption of a representative household ($\boldsymbol{X}_j$), assuming an interior solution, is:

$$\partial U/\partial \boldsymbol{X}_j - \lambda \cdot \boldsymbol{P}_{\boldsymbol{X}j} - \mu_1 \cdot \boldsymbol{t}_{\boldsymbol{X}j} = 0.$$

Rearranging this to get a MB = MC interpretation gives:

$$(\partial U/\partial \boldsymbol{X}_j)/\lambda = \boldsymbol{P}_{\boldsymbol{X}j} + (\mu_1/\lambda) \cdot \boldsymbol{t}_{\boldsymbol{X}j}$$

Again, the LHS gives marginal benefits (the marginal utility of consumption) while the RHS shows marginal costs and the time cost term is monetized through multiplication by the marginal money value of time. Finally, the FONC with respect to recycling percentage, again assuming an interior solution, is:

$$\partial U/\partial r + (\partial U/\partial Z) \cdot (\partial Z/\partial r) + \lambda \cdot P_d \cdot \theta - \mu_2 \cdot t_r = 0.$$

Rearranging slightly gives:

$$(\partial U/\partial r)/\lambda + (\partial U/\partial Z) \cdot (\partial Z/\partial r) \cdot 1/\lambda = -P_d \cdot \theta + (\mu_2/\lambda) \cdot t_r. \quad (6)$$

The LHS of this equation (6) represents the non-pecuniary aspects of the recycling decision, while the RHS represents the pecuniary aspects. The marginal benefit from recycling is the marginal utility of recycling itself $((\partial U/\partial r)/\lambda)$, plus the marginal utility received from the household contribution to the public good, plus the amount saved by recycling rather than disposing the recyclable fraction of waste $(P_d \cdot \theta)$. The marginal cost is the time price of recycling, t_r, monetized by the marginal money value of time spent on chores and recycling (μ_2/λ). Per the earlier discussion of utility formulations, the marginal utility from recycling could encompass either utility or disutility; in the case of disutility, the marginal benefit would be only the savings from recycling. The FONCs yield a Marshallian recycling rate function:

$$r = r(\boldsymbol{P_x}, \boldsymbol{P_h}, P_d, \boldsymbol{t_x}, \boldsymbol{t_h}, t_r, M, T_1, T_2) \quad (7)$$

The time price for recycling can be inferred from survey questions about total recycling time expenditures. In this particular empirical context, the price of waste disposal P_d is not continuous; instead, households choose the size of the waste disposal container and therefore the corresponding monthly collection fee. In other words, container size (or disposal amount, D, and therefore disposal fee, P_d) and recycling amount, R, are selected jointly. Choosing the can size is the same as choosing the disposal expenditures ($P_d \cdot D$ rather than D). Can size is a long-run decision; people tend not to switch, so recycling intensity can be thought of as being conditional on can size. Hence, this paper explores the determinants of the following variables:

1) households' reported recycling rate (r, or REC in the empirical model),
2) households' reported can size (D, or CANSZ), and
3) households' reported recycling time expenditures (RECT in the empirical model).

The equation for reported recycling rate answers the question "what makes people recycle as much as they do?", while the reported can size equation answers the question "what makes people choose a garbage can size?" with the understanding that the choice of can size determines how much material they will have left to recycle. The recycling time expenditures equation answers the question "what determines how much time people spend recycling?" Keep in mind that, by definition from the conceptual model, $RECT = t_r \cdot r$. It is an outcome resulting from the choice of r given t_r, not a choice on its own per se. Both time spent recycling (RECT) and recycling rate, r (or REC in the empirical model), are elicited in the survey. Of course, in reality, we cannot know whether households actually choose recycling time expenditure, RECT, or the recycling rate, REC. The empirical results give some intuition as to which one is the actual choice variable.

6.2 DATA

The data for this study come from a 2005 recycling survey of Seattle residents. Survey packets were mailed to a random sample of 2,012 (primarily single-family) households to examine their current recycling activities, willingness to pay for recycling, recycling program preferences, and socio-demographic information. The survey was conducted by researchers at Seattle Public Utilities and the University of California, Davis according to the Dillman Tailored Design Method over the course of October 2004 to January 2005 (Larson *et al* 2005). The survey instrument development process included two focus groups of 8-10 participants each, personal interviews with 10 individuals to hone question wording and content, and a pilot survey sent to a random sample of 300 Seattle residents (Larson *et al* 2005). Apartment-dwellers were excluded from sampling for the finalized survey because they did not pay explicitly for waste disposal. A total of 1,172 households completed the questionnaire, yielding a response rate of approximately 60%. Surveys with critical item non-response were eliminated, leaving a sample of 1,036 useable responses. This application uses only respondents who filled out survey versions 16-30, yielding 569 responses. Analysis was limited to these survey versions because they also elicited contingent valuation questions about people's willingness to pay (in both money and time) for improvements in Seattle's overall recycling rate. Responses to these questions allow an analysis of the money-time tradeoff, from which values of time can be identified, allowing a monetary value to be placed on t_r.

There is potential for self-selection bias if the non-responders were also non-recyclers. However, Seattle instituted a recycling requirement in January 2005 for all materials except plastics (SPU 2006) and actual participation in Seattle's curbside recycling program is close to 100% for single family residences and duplexes. Excluding apartment-dwellers also creates potential bias. One would typically expect apartment residents to be lower income, have less education, and potentially be older than the general population. Then again, in Seattle, it is also possible that urban apartment dwellers would be younger and relatively wealthy. More information is necessary to be able to confidently characterize the direction of this bias.

The majority of respondents (98%) indicated that they disposed of recyclable paper, cardboard, plastics, metals and glass through the curbside program. According to Seattle Public Utilities, materials eligible for recycling in 2005 include: newspaper, mixed paper, glass, aluminum, tin, PET and HDPE bottles, ferrous metals, plastic bags, plastic containers, milk cartons and juice boxes (SPU 2006); the materials listed in the survey reflect these options. At the time of the survey, Seattle's recycling program consisted of weekly curbside garbage collection (with a monthly fee based on the size and number of trash cans to which the household subscribed) and biweekly curbside collection of recyclables with a separate container for glass. Putting yard waste into garbage cans was prohibited, but the option existed to subscribe to curbside yard waste collection. The Curbside Recycling Report for Seattle indicates that, on average, Seattle households created 70.1 pounds of recyclables per eligible household per month during

2005 (SPU 2006), which allows us to conceptualize the volume of materials in question. The cumulative average cost to the city of Seattle of collecting and sorting recyclables was $81.72 per ton of recyclable material; the city paid contactors to conduct this work (SPU 2006). Descriptive statistics for the relevant variables are presented in Table II.

Table II: Descriptive Statistics

Variable Name	Variable Desccription	Mean	Std. Dev.	Min.	Max.
REC	HH recycling percentage	89.00	13.86	5.5	98
RECT	HH recycling time (min/wk)	15.13	10.80	0	60
CANSZ	HH waste disposal collection service level	2.64	0.81	1	5
MALE	0/1 Indicator for male respondent	0.47	0.50	0	1
AGE	Age of respondent in years	50.29	15.50	18	92
EDU	Respondent years in school	16.69	2.75	6	22
HHSIZE	Number of people in hh	2.30	1.14	1	7
KIDS1	0/1 Indicator for presence of kids 0-5 years old	0.09	0.28	0	1
KIDS2	0/1 Indicator for presence of kids 6-18 years old	0.12	0.33	0	1
OWN	0/1 Indicator for residence ownership	0.92	0.27	0	1
HHINC	HH annual gross income ($1,000)	83.93	39.33	12.5	150
HHTIME	HH annual hours for hh chores (hr/yr)	908.55	722.58	52.17	4,747.47
OTHREC	Perception of other hhs' recycling rate	74.85	21.19	0	98
RTPRICE	Hours per year to recycle 1% (imputed)	0.18	0.15	0	1.69

The dependent variables used in this series of models are the self-reported household recycling rate (REC), the trash can size to which the household subscribes for traditional garbage disposal (CANSZ), and household time spent recycling (RECT). Recycling rate is a categorical variable; the respondent reported what percentage of recyclable materials their household actually recycled by choosing a category such as 41-50%. The data were entered using midpoints from each category to allow coefficients to be interpreted continuously. The average recycling rate was 89.0%, with 37% of the respondents indicating that they fell into the 96-100% category. The next most common response was the 91-95% category, reported by 27% of respondents. Only 3% of respondents reported a household recycling rate of less than 50%. The second dependent variable used is waste disposal amount (CANZ), which is proxied by the size of trash can to which the household subscribes. Figure V illustrates the available trash can subscription choices. The average subscription level was imputed to respondents who

Micro (12 gallon)	Mini (20-gallon)	1-Can (32-gallon)	2-Can (64-gallon)	3-Can (96-gallon)	Other subscription	Don’t Know
						
$10.05/month	$12.35/month	$16.10/month	$32.20/month	$48.30/month		

Figure V: Trash can size choices and corresponding monthly subscription prices

chose “other subscription” or “don’t know” or did not respond. This variable is not continuous. Fifty-three percent of households subscribed to the 32 gallon can; the next most popular choice was the 20 gallon can selected by 30% of respondents. Subscription payments are made monthly (and subscription decisions at most monthly, but often for multiple years at a time) while recycling decisions are made weekly, which may create an incentive for households to fill their allotted can with garbage before recycling the remainder rather than choosing recycling activity directly. The final dependent variable, recycling time, asked how many extra minutes per week the respondent’s household spent recycling instead of throwing items away and gave categorical response choices. Again, data were entered using the midpoints of the categories to allow for continuous interpretation; the more than 60 minutes per week choice was entered as 60 minutes per week, which underestimates recycling time for some respondents. The average time spent recycling was 15.13 minutes per week, with the most common response categories being 6-10 minutes per week (26% of respondents) and 11-15 minutes per week (24% of respondents).

The next several variables collected socio-demographic information about the respondents. The gender variable (MALE) is a dummy variable coded 1 if the respondent is male and 0 if female. Respondents were equally divided, with 50% being male and 50% female. Age of respondent (AGE) was a continuous variable measured in years; 50% of respondents were between 35 and 54 years old. Similarly, education (EDU) was also a continuous variable giving the number of years of schooling completed by the respondent. The sample was highly educated, with 45% of respondents reporting post-graduate work and 47% of respondents being college graduates. Household size (HHSIZE) indicates how many people including the respondent are in the household; the most common response was two people, with 46% giving this response. Respondents also indicated how many children age 0-5 years old (KIDS1) and 6-18 years old (KIDS2) were in the household. Home ownership (OWN) was a dummy variable coded 1 if the respondent owned their home and 0 if not; the majority of respondents (91%) were home owners. Household income (HHINC) was presented as a categorical variable to increase the likelihood that people would respond; the data were entered as category midpoints to

Table III: Responses to HHINC, OTHREC

Annual HH Income			Perceived Peer Recylcing		
Response Category	**Frequency**	**Percent**	**Response Category**	**Frequency**	**Percent**
Under $25,000	31	5%	0%	2	0%
$25,000 - 34,999	26	5%	1 - 20%	14	2%
$35,000 - 44,999	36	6%	21 - 40%	27	5%
$45,000 - 54,999	34	6%	41 - 60%	75	13%
$55,000 - 64,999	102	18%	61 - 70%	73	13%
$65,000 - 74,999	85	15%	71 - 80%	81	14%
$75,000 - 94,999	75	13%	81 - 85%	58	10%
$95,000 - 119,999	57	10%	86 - 90%	82	14%
$120,000 - 149,999	42	7%	91 - 95%	97	17%
$150,000 or More	81	14%	96 - 100%	60	11%
n=569			n=569		

allow for continuous interpretation of the variable. Table III presents the responses to both HHINC and OTHREC (explained below) by response category. The variable

HHTIME asked respondents to estimate how many hours per week they spent on household maintenance activities or chores including recycling but excluding recreational time. Responses were converted to hours per year. The variable OTHREC asked respondents to estimate the categorical recycling rates of other people they knew personally. These categories were again entered using midpoints to allow for continuous interpretation. The most common response was that others recycled 91-95% of their potentially recyclable material (17% of responses); this is less than the 96-100% category commonly reported for respondents' own recycling behavior, indicating that people seem to think themselves more comprehensive recyclers than their peers.

In order to assess respondents' attitudes towards the environment, altruism, and recycling, they were asked to respond to a series of statements similar to those used in previous psychological studies (see, e.g., Oskamp *et al* 1991; Vining and Ebreo 1992; Gamba and Oskamp 1994; Ebreo *et al* 1999; do Valle *et al* 2004; Hage *et al* 2009). These attitude statements capture non-pecuniary motivations for recycling behavior that should be able to flesh out the portrait of a recycler and help policymakers fine-tune recycling program presentation to achieve maximum participation. See Table IV for a breakdown of these attitude statements. The attitude statements fell into three groups: environmental and altruistic attitude statements (five of which correspond to the New Ecological Paradigm measures), factors motivating personal recycling, and factors discouraging personal recycling. Responses for all attitude statements took the form of a five point scale ranging from strongly disagree (1) to strongly agree (5). Notice the tendency for respondents to agree with the statements that motivate own recycling and disagree with statements that discourage recycling. Also notice that all of the attitude statements in the first two groups are non-pecuniary except “It saves me money since I am able to use a smaller garbage container,” which reflects the traditional economic

Table IV: Attitude statements

Agreement with Environmental/Altrusitic Statement:	**Disagree**	**Neutral**	**Agree**
The ecological crisis facing humankind has been greatly exaggerated	70%	16%	13%
Plants and animals have as much right as humans to exist	13%	20%	67%
Human resourcefulness will insure that we do not make the earth unlivable	31%	21%	49%
The earth has very limited room and resources	10%	14%	76%
The balance of nature is strong enough to cope with the impacts of industrial nations	82%	10%	9%
Contributions to community organizations rarely improve the lives of others	74%	16%	11%
The individual alone is responsible for his or he well-being in life	47%	22%	31%
It is my ethical duty to help other people when they are unable to help themselves	7%	22%	72%
My responsibility is to provide only for my family and myself	71%	16%	13%
My personal actions can greatly improve the well-being of people I don't know	6%	18%	75%
Agreement with Motivating Recycling Statement "I Recycle because…"	**Disagree**	**Neutral**	**Agree**
It saves me money since I am able to use a smaller garbage container	31%	28%	41%
I want to be a socially responsible person	2%	9%	89%
I want other people to think of me as a responsible person	24%	41%	35%
Regardless of what other people might think, I feel it is my ethical duty	4%	11%	86%
I find it to be a pleasant activity in itself, compared to other "everyday" chores	26%	46%	28%
It is a good way to contribute to preserving environmental quality	2%	6%	93%
It is a good way to contribute to conserving scarce natural resources	2%	6%	92%
I feel it is expected of me	5%	9%	31%
Agreement with Discouraging Recycling Statement "I hesitate to recycle because…"	**Disagree**	**Neutral**	**Agree**
I don't think recycling benefits me personally	82%	13%	5%
I don't think recycling provides benefits to the community/society	91%	5%	4%
It is often difficult to know what items can or cannot be recycled	43%	24%	34%
It takes too much time	78%	16%	6%
I don't have enough recyclables	85%	11%	4%
It is difficult to find room/space for temporarily storing recyclable items	64%	14%	21%
Other people are not doing enough	31%	37%	32%

understanding of what motivates recycling behavior. The third, fourth, and sixth statements from the discouraging recycling statement section are also motivations that receive attention from economists (information about the program, opportunity cost, and convenience, respectively).

6.3 Empirical models

Having explored both the theoretical model and the available data, it is time to discuss the empirical models. In accordance with the objective of comparing pecuniary and non-pecuniary factors that influence recycling decisions, equations are constructed for three potential recycling decisions that can then be qualitatively compared. Each model is run with and without the principal component variables derived from the attitude statements to see how inclusion of those variables changes the fit and significance of the overall model. The first set of models examines the household's choice of recycling rate, in keeping with the rich recycling literature that examines how much people recycle (see, e.g., Hong *et al* 1992; Jenkins *et al* 2003; Fererra and Missios 2005; Kipperberg 2007; Hage *et al* 2009). It answers the question "what makes people recycle as much as they do?" The model is:

$$REC_i = \boldsymbol{X}_i\beta_{REC} + \varepsilon_{REC\,i} \qquad (8)$$

where $\boldsymbol{X}_i$ includes socio-demographic variables and perceptions of others' recycling in the first version and adds the principal component variables in the second version, β_{REC} is a conformable parameter vector, and $\varepsilon_{REC\,i}$ is the error term. There is no explicit cost of recycling in this model; consequently, a third version of the recycling rate decision is also calculated that includes the variables CANSZ and RTPRICE in $\boldsymbol{X}_i$. Recall that subscribing to a trash can size for waste disposal is the same as choosing disposal expenditures in Seattle because each can size has an associated subscription rate (that is, Seattle residents choose $P_D \cdot D$ rather than D). This choice of can size is made at most monthly (people tend not to switch). Switching can size is most likely to be done with changes in consumption patterns that come from structural changes in life situation, such as moving or a change in the number of household members from a birth, divorce, child moving out, et cetera. It is likely that people do not even change their subscriptions as often as annually. Switching is thus a long-run decision compared to the short-run (weekly) decision of how much to recycle. Therefore, recycling intensity can be thought of as being conditional on can size. CANSZ is essentially the substitute activity for recycling. Additionally, the time price of recycling, t_r (or RTPRICE), can be recovered under the assumptions of the theoretical model because recycling time (RECT) is equal to $t_r \cdot r$ and both recycling time and recycling rate, r, are elicited in the survey. RTPRICE is essentially the own price of recycling. In Section 7.4, this time price is monetized under various assumptions for the money value of time to compute welfare measures. Note that this version of the model has potential endogeneity issues because CANSZ could be correlated with the error term in REC. This set of models does not lend itself well to an instrumental variables approach to address the potential endogeneity because all of the variables in the CANSZ model (explained below) also appear in the REC model and no other variable in this dataset proxies CANSZ well enough to serve as a suitable instrument. Despite being linked in theory, the correlation between the variables REC and CANSZ is only -0.1526. Furthermore, running the REC model that includes CANSZ, saving the residuals, and testing them for correlation with CANSZ yields a correlation of 0.0000. This indicates that endogeneity is less of a concern for this particular empirical application. Results for this set of recycling rate models are presented in Section 7.1 below.

The next set of models examines the household's choice of can size and therefore disposal amount D, disposal expenditures P_D and recycling rate r. In that this set of models examines the waste disposal decision directly, they follow the questions explored by Fullerton and Kinnaman (1995, 1996; Kinnaman and Fullerton 2000). However, they are also another way to characterize the recycling decision because choice of disposal container implies choice of recycling rate from two possible sides: either the chosen container is too small and people must recycle any remaining materials, or the container is the correct size on average but too large some weeks, in which case residents have less incentive to recycle because they can simply dispose of otherwise recyclable materials. Under a volume-based pricing program, the relationship between recycling and disposal is not necessarily one-to-one because of the "Seattle Stomp" where residents "cheat" on recycling by standing on their garbage in order to compact more waste into the disposal container rather than recycle those materials. The basic model used is:

$$CANSZ_i = \boldsymbol{X}_i \beta_{CANSZ} + \varepsilon_{CANSZ\,i} \tag{9}$$

where $\boldsymbol{X}_i$ contains socio-demographic variables and perception of others' recycling in the first iteration and includes the principal component variables in the second iteration, β_{CANSZ} is again a conformable parameter vector, and $\varepsilon_{CANSZ\,i}$ is the error term. Can size choice (and waste disposal) is essentially a substitute for recycling. Results for this set of models are presented in Section 7.2 below.

The final set of models examines households' potential choice of time spent recycling. It may be that people would be targeting an amount of time that they are willing to spend on recycling activity rather than an amount to recycle because the former choice is easier to conceptualize. Or, rather than being a direct choice, recycling time may instead be an outcome of the recycling rate decision (REC) because choosing to recycle any amount means that a household must spend time actually performing this recycling activity. Consequently, the model

$$RECT_i = \boldsymbol{X}_i\beta_{RECT} + \varepsilon_{RECT\,i} \tag{10}$$

explores the question "what determines how much time people spend recycling?" Again, $\boldsymbol{X}_i$ contains socio-demographic variables and perception of others' recycling in the first iteration and adds the principal component variables in the second iteration, β_{RECT} is a conformable parameter vector, and $\varepsilon_{RECT\,i}$ is the error term. Results for this set of models are presented in Section 7.3 below. All models for equations (8), (9), and (10) were estimated with ordinary least squares (OLS) in STATA 8 using White's heteroskedasticity-consistent standard errors. Results were not qualitatively different when the models were estimated using seemingly unrelated regression or with an ordered probit for equation (9). The next section examines the hypotheses tested using these models.

6.4 Hypotheses tested

Hypothesis statements will be presented by variable (for all models), starting with the socio-demographic variables, followed by pecuniary variables and finally non-pecuniary variables.

6.4.1 Hypotheses for Socio-demographic Variables

The literature shows conflicting results for the influence of socio-demographic variables on recycling behavior. Partly, this is due to the specifics of the variables and models used, no two of which are exactly alike. However, qualitative examination of previous results can help guide expectations for the importance of those variables in the models tested in this study. Furthermore, socio-demographic variables that are theoretically appropriate should be included in the models to avoid omitted variable bias regardless of prior empirical results.

The perception that women are more likely to recycle than men is supported by Aadland and Caplan (2006), who report higher willingness to pay for curbside recycling in women. The meta-analysis by Schultz *et al* (1995) indicated that gender is generally insignificant for recycling behavior. Because the gender dummy (MALE) is coded 1 for male and 0 for female, a negative relationship with REC and RECT and a positive relationship with CANSZ would be consistent with the results of Aadland and Caplan (2006). Formally:

Null hypothesis (H_0): $\beta_{MALE} \geq 0$

Alternative hypothesis (H_A): $\beta_{MALE} < 0$

for equations (8) and (10) and

H_0: $\beta_{MALE} \leq 0$

H_A: $\beta_{MALE} > 0$

for equation (9). The next socio-demographic variable of interest is the age of the respondent (AGE). Many studies do not include this variable, and the results are mixed for those that do. Some found a positive linear relationship (Hage *et al* 2009), some found youth positively related to recycling (Aadland and Caplan 2006), some early middle age (Reschovsky and Stone 1994), and others found age insignificant (Fererra and Missios 2005). The current hypothesis is that age enters non-linearly into both recycling and disposal decisions:

H_0: $\beta_{AGE} = 0$ and $\beta_{AGE^{\wedge}2} = 0$

H_A: $\beta_{AGE} \neq 0$ and $\beta_{AGE^{\wedge}2} \neq 0$

for all models (equations (8)-(10)). More highly educated people tend to recycle more (Kinnaman and Fullerton 2000; Reschovsky and Stone 1994; Fererra and Missios 2005) and are willing to pay more for curbside recycling (Aadland and Caplan 2006), although the variable was insignificant in two studies (Fullerton and Kinnaman 1996, Kinnaman 2005). Hypothesize that education (EDU), like age, will have a nonlinear relationship with recycling activity, giving:

H_0: $\beta_{EDU} \leq 0$ and $\beta_{EDU^{\wedge}2} = 0$

H_A: $\beta_{EDU} > 0$ and $\beta_{EDU^{\wedge}2} \neq 0$

for models (8) and (10) and

H_0: $\beta_{EDU} = 0$ and $\beta_{EDU^{\wedge}2} = 0$

H_A: $\beta_{EDU} \neq 0$ and $\beta_{EDU^{\wedge}2} \neq 0$

for model (9). Household size (HHSIZE), the number of people in the household, could potentially affect recycling behavior in a variety of ways. More people in the household mean more overall waste to be dealt with, and therefore more work to recycle that waste. However, there are also more people who could technically participate in that recycling behavior. If one household member has strong beliefs about recycling, this could influence the behavior of others in the household. No strong trend for the relationship of household size to recycling behavior exists in the literature; it was significant in Gamba and Oskamp (1994), insignificant in Fererra and Missios (1995), had mixed results in Reschovsky and Stone (1994), and was not included in other studies. The expectation here is that household size will have a relationship with recycling behavior, but the direction of that relationship cannot be confidently anticipated. Therefore, hypothesize the following:

H_0: $\beta_{HHSIZE} = 0$

H_A: $\beta_{HHSIZE} \neq 0$

for all equations (8), (9), and (10). The number of children in the household has arguments similar to those for household size. More children may create more waste but leave households with less time available to deal with that waste; recycling programs in schools may make younger people more aware of recycling activities in their own households and contribute positively to recycling behavior. The present survey allows separation of the number of children in a household into two groups: young children 0-5 years old (KIDS1) and children 6-18 years old (KIDS2). Use the following hypotheses:

H_0: $\beta_{KIDS1} = 0$ and $\beta_{KIDS2} = 0$

H_A: $\beta_{KIDS1} \neq 0$ and $\beta_{KIDS2} \neq 0$

for all models (8) – (10). Home ownership (OWN) has been found to increase recycling intensity (Fererra and Missios 2005; Kinnaman and Fullerton 2000; Oskamp *et al* 1991). Ferrara and Missios (2005) speculate that this may be because homeowners value their communities and the opinions of their neighbors more highly than non-homeowners. Consequently, home ownership is expected to enter positively into the recycling activity equations and negatively into the waste disposal equation:

H_0: $\beta_{OWN} \leq 0$

H_A: $\beta_{OWN} > 0$

for equations (8) and (10) and

H_0: $\beta_{OWN} \geq 0$

H_A: $\beta_{OWN} < 0$

for equation (9). The persistently inconsistent performance of demographic variables as predictors of recycling behavior in previous literature may simply indicate that there is no single, overarching demographic profile of a recycler – perhaps the common aspect is something else, such as a set of beliefs. The next subsection presents hypotheses for the pecuniary variables.

6.4.2 Hypotheses for Pecuniary Variables

There are differing arguments for the effects of income (HHINC) on recycling behavior. As income increases, people may be able to afford someone to do this type of household maintenance for them, and their own recycling behavior could therefore decrease. Alternately, higher-income people may have more to spend on recycling programs. Ultimately, the most obvious choice is to look at recycling as a normal good, the demand for which increases as income increases. Disposal should also increase as income increases. This yields the following hypotheses:

H_0: $\beta_{HHINC} \leq 0$

H_A: $\beta_{HHINC} > 0$

for all models (8) – (10). Results for this variable were mixed in the literature: income had a positive impact on the probability of recycling glass and plastic in Reschovsky and Stone (1994) and on recycling rate in (Kinnaman 2005), indicating that people recycle more as their income increases. However, Fererra and Missios (2005) found the opposite result: at least one income level (different income ranges were included as different variables here) was negative and significant for newspaper, plastic bottles, and toxic chemicals, meaning that having a given income level decreased the recycling intensity for these materials. Income was insignificant for all other materials in this study (Fererra and Missios 2005) and in Kinnaman and Fullerton (2000). Interestingly, income predicted actual but not self-reported recycling behavior in Gamba and Oskamp (1994). Next comes the time the household spends on maintenance activities (HHTIME). The hypothesis is that households that spend more time on these types of activities in general will spend more time on recycling activity:

H_0: $\beta_{HHTIME} \leq 0$

H_A: $\beta_{HHTIME} > 0$

for equations (8) and (10) and

H_0: $\beta_{HHTIME} = 0$

H_A: $\beta_{HHTIME} \neq 0$

for equation (9) because either households invest more in disposal activity, period, or they invest more in recycling and less in its substitute, throwing things away. The recycling rate (REC) equation (8) has two additional variables not included in the other equations (although disposal price is implicit in the can size equation). As explained in Section 6.3, RTPRICE is the own price of recycling and CANSZ is the substitute for recycling. As the price of recycling activity increases, the quantity of recycling activity is expected to decrease:

H_0: $\beta_{RTPRICE} \geq 0$

H_A: $\beta_{RTPRICE} < 0$

for equation (8). As the cost of substitute disposal activities increases, people are expected to shift to recycling, the alternative activity. However, that shift may not occur immediately if households use the aforementioned “Seattle Stomp” to fit more garbage into their disposal container rather than recycling it. This effect may also be confounded because people implicitly choose the amount they have to recycle when they choose a waste disposal container size. This gives the following hypotheses for CANSZ:

H_0: $\beta_{CANSZ} = 0$

H_A: $\beta_{CANSZ} \neq 0$

in equation (8). Various ways of conceptualizing trash disposal cost in the literature came up with the result that increases in trash disposal cost lead to increased recycling behavior (Fullerton and Kinnaman 1996; Fererra and Missios 2005; Kipperberg 2007), although it was not significant in Jenkins *et al* (2003).

6.4.3 Hypotheses for Non-pecuniary Variables

The variable OTHREC, the percentage of total recyclable material respondents think is recycled by other people that they know personally, is intended in these models to capture social pressure. The expectation is that respondents who think their peers recycle will feel pressure to conform and will therefore also recycle. An increase in OTHREC should be positive in both the recycling rate (REC) and recycling time (RECT) equations, and negative in the waste disposal amount (CANSZ) equation because traditional waste disposal and recycling are substitutes. Formally, that gives:

H_0: $\beta_{OTHREC} \leq 0$

H_A: $\beta_{OTHREC} > 0$

for equations (8) and (10) and

H_0: $\beta_{OTHREC} \geq 0$

H_A: $\beta_{OTHREC} < 0$

for equation (9). Examination of the descriptive statistics in Section 6.2 above did reveal that, in general, respondents reported that they thought they personally recycled a higher percentage of their recyclable material than their peers recycled (that is, the most common response for REC is larger than the most common response for OTHREC).

Because people seem to think they are already doing a better job of recycling than their peers, the effect of this variable may be somewhat mitigated. However, it is still expected to be important. The perceived recycling behavior of others had positive and significant effects on recycling behavior in Oskamp *et al* (1991) and Hage *et al* (2009). Similarly, block leader programs where neighbors had responsibility for encouraging recycling behavior in their peers resulted in more recycling in Hopper and Nielsen (1991).

Attitudes such as those captured in the internal motivation component were found to positively influence recycling behavior in Oskamp *et al* 1991 and the Hornik *et al* (1995) meta-analysis. The internal motivation component is expected to be positively related to both recycling rate (REC) and recycling time (RECT). Formal hypotheses here are:

H_0: $\beta_{INTERNAL\_MOTIVATION} \leq 0$

H_A: $\beta_{INTERNAL\_MOTIVATION} > 0$

for equations (8) and (10). Concern for environmental impact and social responsibility should have a negative impact on disposal amount, enticing people to select a smaller waste disposal container:

H_0: $\beta_{INTERNAL\_MOTIVATION} \geq 0$

H_A: $\beta_{INTERNAL\_MOTIVATION} < 0$

for equation (9). Next, the difficulty component describes a person who finds practical excuses not to recycle. These sorts of practical considerations have been considered both as attitude statements and as independent variables in previous studies and been found to be significant (Hopper and Nielsen 1991; Gamba and Oskamp 1994; Hornik *et al* 1995; Jenkins *et al* 2003; Hage *et al* 2009). Because agreement with the statements in this principal component indicates negative opinions (such as “recycling takes too much time”), a negative relationship is expected with recycling rate and a positive relationship with its substitute, waste disposal behavior. A positive relationship is also expected with time spent recycling (RECT) because respondents who find recycling difficult are likely to spend more time accomplishing recycling. This gives the hypotheses:

H_0: $\beta_{DIFFICULTY} \geq 0$

H_A: $\beta_{DIFFICULTY} < 0$

for equation (8) and

H_0: $\beta_{DIFFICULTY} \leq 0$

H_A: $\beta_{DIFFICULTY} > 0$

for equations (9) and (10). In contrast, the individualistic orientation component describes a person who finds theoretical excuses not to recycle. This component is expected to be negatively related to recycling rate (REC) and time spent recycling (RECT):

H_0: $\beta_{INDIVIDUALISTIC\_ORIENTATION} \geq 0$

H_A: $\beta_{INDIVIDUALISTIC\_ORIENTATION} < 0$

and positively related to waste disposal amount (CANSZ):

H_0: $\beta_{INDIVIDUALISTIC\_ORIENTATION} \leq 0$

H_A: $\beta_{INDIVIDUALISTIC\_ORIENTATION} > 0$.

The environmental orientation component describes an individual who values and conserves the environment. Both acknowledgment of environmental problems (Oskamp *et al* 1991) and respondents' attitudes towards the environment (do Valle *et al* 2004) influenced recycling behavior in previous studies. This component is expected to have a positive relationship with recycling rate and time spent recycling and a negative relationship with can size:

H_0: $\beta_{ENVIRONMENTAL\_ORIENTATION} \leq 0$

H_A: $\beta_{ENVIRONMENTAL\_ORIENTATION} > 0$

for equations (8) and (10) and

H_0: $\beta_{ENVIRONMENTAL\_ORIENTATION} \geq 0$

H_A: $\beta_{ENVIRONMENTAL\_ORIENTATION} < 0$

for equation (9). The external motivation component describes an individual who is concerned with the tangible and social benefits they receive from recycling activity. This component is expected to be positively related with recycling activities:

H_0: $\beta_{EXTERNAL\_MOTIVATION} \leq 0$

H_A: $\beta_{EXTERNAL\_MOTIVATION} > 0$

for equations (8) and (10) and have a negative relationship with CANSZ:

H_0: $\beta_{EXTERNAL\_MOTIVATION} \geq 0$

H_A: $\beta_{EXTERNAL\_MOTIVATION} < 0$

in equation (9). The resourcefulness component loads on a single statement that describes a person who believes that humans will be able to develop solutions to the damage caused by their wasteful actions. Agreement with this component should have a negative impact on the recycling rate and time spent recycling:

H_0: $\beta_{RESOURCEFULNESS} \geq 0$

H_A: $\beta_{RESOURCEFULNESS} < 0$.

Although agreement with this statement should not give pause to those who prefer to dispose of their waste in landfills, there is not necessarily a strong reason to expect a positive relationship. Therefore, hypothesize:

H_0: $\beta_{RESOURCEFULNESS} = 0$

H_A: $\beta_{RESOURCEFULNESS} \neq 0$

for equation (9). And finally, the social concern factor describes a person who believes that "[o]ther people are not doing enough." It is possible that a perceived lack of effort on the part of others makes the respondent feel like he or she does not need to contribute either, or it could make them feel like they need to do more to pick up the slack. Therefore, the hypothesis is:

H_0: $\beta_{SOCIAL\_CONCERN} = 0$

H_A: $\beta_{SOCIAL\_CONCERN} \neq 0$

for all three equations. These principal component variables embody the non-pecuniary aspects of recycling in this study.

This chapter developed a theoretical model of waste disposal choices under a utility maximizing framework. There are three possible related decisions a household could be making that result in recycling: choosing a rate of recycling activity; choosing its substitute, the amount of disposal space available; or choosing an amount of time to spend recycling. The data that will be used to test which of these decisions most accurately reflects behavior were then introduced. Seattle Public Utilities chose to make recycling "free" by rolling the costs of the recycling program into the prices charged for waste disposal bins, which are tiered according to bin size; this affects the construction of the empirical models and introduces possible endogeneity issues. Empirical models were then constructed which will be tested with and without the principal component variables derived from the group of twenty-five attitude statements, and hypotheses were specified for the variables tested. The hypotheses were essentially the same for both the recycling rate (REC) and recycling time (RECT) equations, because the influences on recycling activity should be similar whether that activity is chosen directly or selected indirectly through an allocation of time to that chore. However, differences are expected in the degree to which these variables are influential in one model vs. another. Accordingly, it is time to examine the results of this study.

7. RESULTS

7.1 RECYCLING RATE MODELS

Begin with the set of models examining recycling rate. Results of the recycling rate models are presented in Table V, and all of the final models for sections 7.1-7.3 are presented again in Section 8 for ease of cross-model comparison. Note that because these models use cross-sectional data, it was necessary to test for the presence of heteroskedasticity in the models; White's general heteroskedasticity test indicated heteroskedasticity for each of these model iterations (with test values 76.086 (degrees of freedom = 71, *p*-value = 0.3182), 276.094 (d.f. = 203, *p*-value = 0.0005), and 478.245 (d.f. = 206, *p*-value = 0.0000) for iterations one through three, respectively). Heteroskedasticity, or unequal variance of the disturbance terms, violates the homoskedasticity assumption of the Classical Linear Regression Model and means that the resulting estimates, although still unbiased, will no longer be BLUE, or minimum variance (Gujarati 1995). Therefore, conclusions drawn from *t*- and *F*- tests become unreliable if OLS is still used without correction (Gujarati 1995). Given that the data are a sample rather than the population and the true sample variance cannot be known, using Weighted Least Squares is impractical and the correction must instead take the form of White's heteroskedasticity-consistent standard errors (Gujarati 1995). Each iteration was therefore run and reported in Table V with these corrected standard errors to allow for reliable hypothesis testing.

Table V: Empirical Model Results for Recycling Rate

	HH Recycling Rate (REC)								
Variable	Est.	T-Stat.	P-value	Est.	T-Stat.	P-value	Est.	T-Stat.	P-value
Constant	-6.276	-0.22	0.827	3.040	0.11	0.913	21.303	0.88	0.382
MALE	-1.339	-1.20	0.230	-0.998	-0.91	0.362	-0.746	-0.73	0.465
AGE	0.388	1.46	0.145	0.041	0.18	0.857	-0.153	-0.69	0.489
AGE^2	-0.003	-1.21	0.226	-0.001	-0.27	0.787	0.001	0.57	0.567
EDU	9.019 ***	2.71	0.007	7.026 **	2.13	0.033	6.700 **	2.34	0.020
EDU^2	-0.236 **	-2.52	0.012	-0.182 *	-1.94	0.053	-0.175 **	-2.14	0.033
HHSIZE	-0.275	-0.49	0.624	-0.304	-0.58	0.560	0.505	1.05	0.296
KIDS1	-4.875 ***	-2.63	0.009	-1.762	-1.00	0.320	-1.851	-1.12	0.264
KIDS2	1.147	0.71	0.478	-0.912	-0.60	0.551	-0.785	-0.55	0.584
OWN	2.523	1.00	0.316	3.090	1.65	0.100	2.806	1.39	0.165
HHINC	-0.016	-1.19	0.234	-0.003	-0.27	0.788	-0.006	-0.52	0.603
HHTIME	0.002 ***	3.11	0.002	0.002 ***	2.69	0.007	0.002 ***	3.21	0.001
OTHREC				0.236 ***	6.17	0.000	0.208 ***	5.92	0.000
Internal Mot.				1.631 ***	2.78	0.006	1.496 ***	2.70	0.007
Difficulty				-3.575 ***	-5.05	0.000	-3.003 ***	-4.35	0.000
Indiv. Orient.				0.728	1.41	0.159	0.807	1.57	0.117
Enviro. Orient.				0.828	1.60	0.111	0.713	1.43	0.153
External Mot.				0.611	1.38	0.169	0.309	0.71	0.481
Resourceful				-0.091	-0.12	0.905	0.092	0.13	0.896
Social Concern				1.838 ***	3.47	0.001	1.657 ***	2.97	0.003
RTPRICE							-27.990 ***	-4.44	0.000
CANSZ							-1.668 ***	-3.03	0.003
R2	0.115			0.338			0.440		
F-stat.	4.03			7.24			8.74		
Prob. F	0.000			0.000			0.000		

*** significant at the 1% level

** significant at the 5% level

* significant at the 10% level

These recycling rate models explore people's motivations in choosing how much of their possible recyclable material, θ, they actually recycle, r. Significant variables at the 5% level or better include education (EDU and EDU^2), household time spent doing chores (HHTIME), respondents' perceptions of how much other people they personally knew recycled (OTHREC), the internal motivation component, the difficulty component, and the social concern component. The third iteration of the model adds own price of recycling (RTPRICE) and the substitute price of recycling (CANSZ) without changing the significance of any other variables except the squared component of education, which goes from being significant at the 10% level in the second iteration to being significant at the 5% level in the third iteration. Additionally, three variables are significant at the ten percent level for a single-tailed hypothesis test in the final iteration: home ownership (OWN), the individualistic orientation component, and the environmental orientation component. Since choosing a level of significance, α, essentially chooses the probability of committing a Type I error – rejecting the null hypothesis when it is true – and there is a tradeoff between Type I error and Type II error – failing to reject the null when it is false – that can be avoided by instead examining *p*-values without choosing a level of significance at all (Gujarati 1995), *p*-values are also reported for all coefficients in these models so that the reader may evaluate results based on the observed levels of significance. Increasing sample size would eliminate the necessity of making this tradeoff, but that is difficult to do given the data constraints of a previously completed survey. Overall goodness of fit for these models is respectable, with an R^2 value of 44% for the final iteration. R^2 always increases as variables are added to the model, but significant results for the *F*-test confirm that the model does have explanatory power. Furthermore, additional *F*-tests of the form:

$$F = [(R^2_{new} - R^2_{old}) / (\#\ regressors\ added)] / [(1 - R^2_{new}) / (n - \#\ parameters_{new})]$$

can be used to test the marginal contribution of additional variables in nested models such as these (Gujarati 1995). The *F*-test for the change from iteration one to iteration two yields an *F-statistic = 23.10*, which is significant compared to the critical statistic of $F_{.01}(8, \infty) = 2.51$. The *F*-test for the change from iteration two to iteration three yields an *F*-statistic = 49.67 compared to a critical value of $F_{.01}(2, \infty) = 4.61$. These statistics support the addition of the non-pecuniary, own price, and substitute variables to this model.

The positive and significant relationship of EDU with recycling rate coupled with the negative and significant relationship of EDU^2 with recycling rate indicates that more educated people recycle more up to a point. HHTIME is also significant: as household time spent doing chores increases, household recycling rate increases. This is consistent with the hypothesis. Home ownership (OWN) is significant at the 10% level for a one-tailed hypothesis test; people who own their homes recycle more, as hypothesized. Notice that the coefficient on household time is small ($\beta = 0.0002$). This coefficient is sensitive to units of measurement, but the size of its effect on recycling rate is interesting in that "it takes too much time" is a frequently-cited reason for people to not recycle, but once that threshold is passed, increases in the time taken to perform the task do not have a particularly large impact on how much more a person recycles. The positive relationship of OTHREC with recycling rate indicates that the more respondents think the people they know recycle, the more the respondents recycle themselves, as hypothesized. It is possible that people recycle competitively, increasing their effort as they think those around them recycle more in order to "keep up."

Increased agreement with the internal motivation component results in an increased recycling rate, again as hypothesized. Respondents who feel strong personal responsibility to be environmentally responsible are more avid recyclers. Results for the difficulty component are consistent with the hypothesis that people who found difficulties with recycling – such as insufficient space to store recyclables or inadequate knowledge about what could be recycled – have lower recycling rates. The individualistic orientation component is significant for a one-tailed test, but the positive relationship is opposite of the hypothesized inverse relationship. The attitude statements that load most strongly in this component describe an individual who feels responsibility for their own well-being and does not see value in community organizations; one would therefore expect that this person would not be fond of contributions to the public good. However, it is possible that the positive relationship with recycling rate indicated here means that people see recycling as contributing primarily to their own well-being and therefore an acceptable action. This principal component is not significant in any of the models run on other dependent variables. The environmental orientation component is also significant at the 10% level for a one-tailed hypothesis test, and this one shows the hypothesized positive relationship with recycling rate. People who are concerned with the ability of the environment to withstand human pressures recycle a greater percentage of their waste. The social concern component is positively and significantly related to recycling rate; respondents who think that others are not doing enough recycle a higher percentage of their own recyclables, perhaps because they feel like they need to pick up the slack.

The time price of recycling (RTPRICE) has the expected negative relationship with recycling rate: as the price of recycling decreases, recycling rate increases. This is the largest coefficient by far, which is unsurprising given the theoretical importance of price. However, there are also potential endogeneity issues here because this variable was derived using *RTPRICE = RECT/REC*. This could be addressed using another price for recycling rate, which is done, but in this case there is also potential endogeneity in the other price-related variable available in the dataset, CANSZ (which is a price variable in that households choose a disposal fee at the same time that they choose a disposal container size). The substitute activity for recycling (CANSZ), however, is also negatively related to recycling rate. This indicates that this variable is actually capturing the circumstance of recycling intensity being conditional on can size. As people choose smaller disposal containers, they increase the percentage of recyclable material that they actually recycle. Again, there is a potential endogeneity problem with this variable: because choosing the recycling rate, *r*, implies choosing the disposal amount, *D*, this may be entering the same decision into the equation twice, although the recycling rate decision is short term while the disposal amount decision is essentially long term. Correlations did not indicate that endogeneity was a problem in this specific empirical application (see Section 6.3).

Viewed overall, results for the recycling rate models show both pecuniary and non-pecuniary motivations for how much people recycle. They are sensitive to the time price of and practical difficulties with recycling (RTPRICE, difficulty component), but they are also influenced by social pressures (OTHREC, social concern component) that suggest a moral or social motivation as in Brekke *et al* (2003). The importance of both pecuniary and non-pecuniary considerations echoes Halvorsen's (2008) findings that strong moral norms (a person's desire to be considered socially responsible by themselves and others) increase recycling effort and higher opportunity costs of time decrease recycling effort. There is an interesting story in the combination of OTHREC (people recycle more when they think the people they know personally are avid recyclers), the social concern component (people recycle more when they are concerned that others are not recycling enough), and the internal motivation component (I am a good person when I recycle): there seems to be a “lead by example” motivation for recycling intensity. This is consistent with Tucker’s (1999) assertion that social norms are influential when a behavior is highly visible. Curbside recycling activity is certainly visible; everyone in the neighborhood can observe how much recycling a household sets on the curb every two weeks. Next comes an examination of the waste disposal decision, which is the inverse of the recycling rate decision.

7.2 Can Size (Disposal Amount) Models

The set of models that examines the waste disposal decision uses the choice of waste disposal container size (CANSZ) as the dependent variable. Results from these models are shown in Table VI. Again, White’s test indicated the presence of heteroskedasticity in each iteration (with test values 145.864 (d.f. = 71, p-value = 0.0000) and 270.411 (d.f. = 203, p-value = 0.0011) for iterations one and two, respectively), so results were reported using White’s heteroskedasticity-consistent standard errors. Significant variables include the number of people in the household (HHSIZE), home ownership (OWN), household income (HHINC), and the external motivation component. Additionally, gender (MALE) and the difficulty component are significant for one-tailed hypothesis tests at the 10% level. Recall that the cost of waste disposal is implicit in this model because each container size is associated with a subscription price. Although the F-test statistic is significant, indicating that at least one of the variables in the model has explanatory power, the R^2 value of 15% for the final iteration is lower than we would generally like to see. This is likely a result of omitted variable bias; when Kinnaman and Fullerton (2000) modeled disposal behavior, for example, they included prices of alternate disposal methods such as deposit refunds at drop-off recycling centers and legal requirements that either barred or required alternative disposal activities such as yard waste bans or legally mandated recycling requirements. These types of consequences for

Table VI: Empirical Model Results for Can Size

	HH Waste Disposal (CANSZ)							
Variable	**Est.**		**T-Stat.**	**P-value**	**Est.**		**T-Stat.**	**P-value**
Constant	2.296	**	2.20	0.028	2.313	**	2.13	0.034
MALE	0.081		1.18	0.238	0.106		1.50	0.134
AGE	0.010		0.54	0.586	0.016		0.89	0.374
AGE^2	0.000		-0.71	0.479	0.000		-0.95	0.345
EDU	0.004		0.04	0.969	-0.019		-0.16	0.871
EDU^2	-0.001		-0.24	0.813	0.000		-0.05	0.960
HHSIZE	0.170	***	5.18	0.000	0.168	***	5.10	0.000
KIDS1	0.148		1.10	0.274	0.207		1.56	0.120
KIDS2	-0.073		-0.58	0.565	-0.095		-0.77	0.444
OWN	-0.309	**	-2.07	0.039	-0.325	**	-2.21	0.028
HHINC	0.002	**	2.13	0.034	0.002	*	1.81	0.070
HHTIME	0.000		0.57	0.568	0.000		0.97	0.331
OTHREC					0.000		-0.02	0.980
Internal Mot.					0.014		0.45	0.650
Difficulty					0.049		1.62	0.106
Indiv. Orient.					-0.004		-0.12	0.908
Enviro. Orient.					0.015		0.41	0.685
External Mot.					-0.145	***	-4.14	0.000
Resourceful					0.055		1.64	0.102
Social Concern					-0.031		-0.91	0.362
R2	0.110				0.150			
F-stat.	6.58				5.27			
Prob. F	0.000				0.000			

*** significant at the 1% level

** significant at the 5% level

* significant at the 10% level

substitute disposal behaviors were not generally relevant to Seattle at the time of the survey, but would, if pertinent, improve model specification. Another relevant variable to waste disposal container choice that was not available in this dataset is the amount of disposable waste the households actually generated. An F-test for the incremental contribution of the pecuniary variables between the first and second iterations yielded an *F*-statistic of 3.20, which is significant compared to a critical value of $F_{.01}(8, \infty) = 2.51$.

In the model as it exists, gender (MALE) is positively related to CANSZ and is significant for a single-tailed hypothesis test at the 10% level: men choose larger garbage containers and implicitly less recycling. This is consistent with results from Aadland and Caplan (2006) that suggest women are more avid recyclers than men. The more members are in a household (HHSIZE), the larger the garbage container that household selects. This makes sense, as more people typically generate more waste. The negative and significant relationship with home ownership (OWN) indicates that those who own their homes choose smaller waste disposal containers (and therefore dispose of waste through alternate methods such as recycling). It may be that home ownership induces people to make more careful long-term choices or makes them feel more invested in the environmental health of their communities. As household income (HHINC) increases, so does the size of the garbage container to which households subscribe. The combination of results from household size and income indicates that, generally, the more stuff people have, the more they throw away. The difficulty component is significant at the 10% level for a single-tailed hypothesis test. The more people agree with the sentiment that recycling is difficult, the larger waste disposal container they choose, as hypothesized. This component is the only variable that enters significantly into both the recycling rate and disposal choice decisions. The negative relationship with the external motivation component is also consistent with the hypotheses; it indicates that the more a person agrees that they think others want them to recycle and see them as a good person when they do, the smaller the waste disposal container they will choose (which implies that they will recycle more). The third component of this factor is that "I recycle because it saves me money since I am able to use a smaller garbage container" – those who see recycling as a way to save money subscribe to smaller (and cheaper) disposal containers. The combined importance in these models of income and both principal components with pecuniary aspects (difficulty and external motivation) and the absence of principal components with altruistic or environmentally concerned aspects paint a pragmatic picture of the waste disposal decision. People choose the waste disposal container that is most financially and cognitively convenient to them, although they are concerned about others' censure for recycling less.

7.3 Recycling Time Models

The final set of models examines factors that influence the amount of time people spend recycling. Table VII presents the results of these models. As with the previous models, White's test indicates heteroskedasticity (with test values 97.481 (d.f. = 71, *p*-value = 0.0203) and 248.273 (d.f. = 203, *p*-value = 0.0165) for iterations one and two, respectively) and results are reported using White's heteroskedasticity-consistent standard errors. These models had the fewest significant variables and the lowest R^2 values (7% for the second iteration): time spent recycling is not particularly well explained by the variables that were included, although the *F*-test is significant at the 5% level for both iterations, so the model does have explanatory power. The additional F-test for the marginal contribution of the non-pecuniary variables from one iteration to the next, however, yields an *F*-statistic = 0.63, which does not exceed the critical value $F_{.10}(8, \infty) = 1.67$. Variables that are significant at the 5% level include age (AGE,

Table VII: Empirical Model Results for Recycling Time

	HH Recycling Time (RECT)							
Variable	Est.		T-Stat.	P-value	Est.		T-Stat.	P-value
Constant	11.690		0.98	0.328	5.983		0.48	0.633
MALE	0.063		0.06	0.949	-0.160		-0.15	0.879
AGE	-0.698	***	-2.87	0.004	-0.636	**	-2.53	0.012
AGE^2	0.006	***	2.90	0.004	0.006	**	2.57	0.010
EDU	1.767		1.43	0.152	2.277	*	1.74	0.083
EDU^2	-0.049		-1.39	0.166	-0.061		-1.65	0.100
HHSIZE	1.400	***	2.73	0.007	1.377	***	2.65	0.008
KIDS1	-1.566		-0.92	0.359	-1.883		-1.10	0.271
KIDS2	0.727		0.46	0.645	0.756		0.47	0.637
OWN	2.297		1.09	0.274	2.190		1.06	0.291
HHINC	-0.011		-0.89	0.373	-0.011		-0.86	0.388
HHTIME	0.001		1.62	0.106	0.001	*	1.66	0.097
OTHREC					-0.010		-0.43	0.664
Internal Mot.					0.028		0.06	0.952
Difficulty					0.728		1.46	0.144
Indiv. Orient.					0.626		1.12	0.262
Enviro. Orient.					-0.141		-0.32	0.750
External Mot.					-0.133		-0.28	0.778
Resourceful					0.355		0.72	0.470
Social Concern					-0.002		0.00	0.998
R2	0.058				0.067			
F-stat.	2.36				1.81			
Prob. F	0.008				0.019			

*** significant at the 1% level

** significant at the 5% level

* significant at the 10% level

AGE^2) and the number of people in the household (HHSIZE). Variables that are significant at the 10% level include education (EDU but not EDU^2) and the amount of time the household spends on chores (HHTIME). The difficulty component is significant at the 10% level for a one-tailed hypothesis test.

AGE has a negative and significant nonlinear relationship with time spent recycling; older people spend less time recycling, up to a point. As the number of people in the household increases (HHSIZE), the household spends more time recycling. The more time the household spends on chores (HHTIME), the more time it spends recycling.

This result is consistent with the hypothesis. It could mean that these households are inefficient at doing chores, including recycling, and it takes them more time to complete these activities. It may also mean that the more time a household spends on chores, the more time they have to devote to recycling. More educated people (EDU) spend more time recycling, which is consistent with the hypothesized positive relationship. The insignificance of the corresponding squared term (EDU^2) indicates that this relationship may be linear rather than parabolic. The stronger the agreement that recycling is difficult and time consuming (difficulty component), the more time it takes people to recycle. This is consistent with the hypothesis and probably means that people who find recycling difficult are less efficient at performing the necessary activities such as washing and separating recyclables.

Overall, this model says that the bigger the household, the more time spent on chores, the younger and more educated people are, and the harder they think it is to recycle, the more time people spend recycling. None of the moral judgment variables (about oneself or others) are important in this model. We had previously speculated about whether people were choosing a recycling rate or an amount of time to spend on recycling activity; either of these decisions would imply the other. The variables tested in this analysis definitely explain the recycling rate decision better than they do the recycling time decision, and tentatively indicate that recycling rate is in fact what people choose. This provides some empirical support for the tendency of the literature to examine recycling rates rather than time spent recycling.

7.4 CONSUMER SURPLUS

These data also lend themselves to a calculation of the consumer surplus attained from recycling. Consumer surplus (CS) measures the welfare changes that people experience as a result of price changes (Nicholson 1998). It is the area under the demand curve and above price; it measures the excess utility that consumers retain when the amount they must pay for a good is less than they were willing to pay. The area underneath the demand curve measures a consumer's utility from consuming that good – this measurement is exact when there is no income effect and approximate otherwise (Varian 2006). The Marshallian demand curve is derived from utility maximization and shows both income and substitution effects of a price change. The dual expenditure minimization function produces the Hicksian demand curve, which compensates for the income effect and shows only the substitution effect of a price change. These two curves are equivalent when there is no income effect. Using the Hicksian rather than Marshallian demand curve yields the more theoretically accurate welfare measures compensating variation (CV) – which measures how much the consumer must be compensated for the price change so that he remains at the original utility level – and equivalent variation (EV) – which finds the maximum the consumer would be willing to pay to avoid the price change (Varian 2006). In practice, it is typically easier to estimate CS from real-world data than either of these other measures (because it is easier to directly observe prices and income than utility) and it can be shown that for a normal good, CV > CS > EV (Nicholson 1998).

Some adjustments must be made to the recycling rate equation from Section 7.1 to make these data amenable to consumer surplus calculations: the annual monetized recycling price (FULLP) and full income (FULLINC) variables must be calculated in order to calculate an annual consumer surplus and a limited recycling rate (REC) model is run incorporating these new variables. The time price of recycling, RTPRICE, is monetized by three different values for the marginal money value of time (MMVT) in order to create the annual monetized recycling price (FULLP). These MMVT values are the reported hourly earnings rate for respondents, 1/3 of that rate, and 1/10 of that rate. Rather than use household income (HHINC) to monetize by the wage rate, the reported hourly earnings rate was used based on a survey question that asked respondents their wage rate per hour worked; this allows for retired people and other respondents who are not in the labor force to have positive time values. Note that this variable did have many imputed responses, and yielded n = 569. Using multiple MMVT values is consistent with the multiple time budgets (T_1 and T_2) outlined in the model in Section 6.1 that allow household chore and recycling activities to have a different value than other labor and leisure activities. The resulting annual monetized recycling price is:

$$FULLP_i = MMVT_i \cdot RTPRICE$$

where $i = 1, 2, 3$ corresponding to the full reported hourly earnings rate, 1/3 the reported hourly earnings rate, and 1/10 the hourly earnings rate, respectively. The full income variable is:

$$FULLINC_i = HHINC + (MMVT_i \cdot HHTIME)/1000.$$

The monetized time budget ($MMVT_i \cdot HHTIME$) is divided by \$1,000 to match the units on HHINC, which is in thousands of dollars. Again, $i = 1, 2, 3$ with the same corresponding values as above. The resulting limited recycling rate model is:

$$REC = FULLP_i + FULLINC_i + RECTHR + OTHREC + AGE + EDU \qquad (11)$$

where $RECTHR = RECT \cdot (52/60)$, a conversion of the recycling time variable from minutes per week to hours per year. The annual monetized price of recycling ($FULLP_i$) is the price on the demand curve in this equation. The choke price will be denoted P*; this is the intercept of the demand curve. The relevant recycling variables are applied to the steps used in Bell and Leeworthy (1990) for the following consumer surplus calculations. Combining all demand shifters in equation (11) in the above equation except price and income into a vector Ω gives the demand equation:

$$REC = \Omega + \beta\ FULLP_i + \gamma\ FULLINC_i \quad . \qquad (12)$$

The rest of the equations presented in this section will use $MMVT_2 = 1/3 \cdot$ *reported hourly earnings rate* as an example; the same steps are used for every MMVT value. To get the empirical demand function, equation (12) is calculated using the means of all variables except $FULLP_i$ and $FULLINC_i$, resulting in:

$$REC = 90.9421 - 3.1335\ FULLP_i + 0.0180\ FULLINC_i$$

where $\Omega = 90.9421$, $\beta = -3.1335$, and $\gamma = 0.0180$. Substituting in the mean value for $FULLINC_i$ and solving for $FULLP_i$ in terms of REC gives the demand curve for the recycling percentage:

$$F\hat{U}LLP_i = -29.5381 - 0.3191\ REC. \qquad (13)$$

A qualitatively similar demand curve is depicted graphically in Figure VI. Solving the demand equation (13) using the mean value of $R\bar{E}C$ gives the estimated price of recycling: $F\hat{U}LLP_i = 1.1345$. Finding the intercept of the demand curve by solving (13)

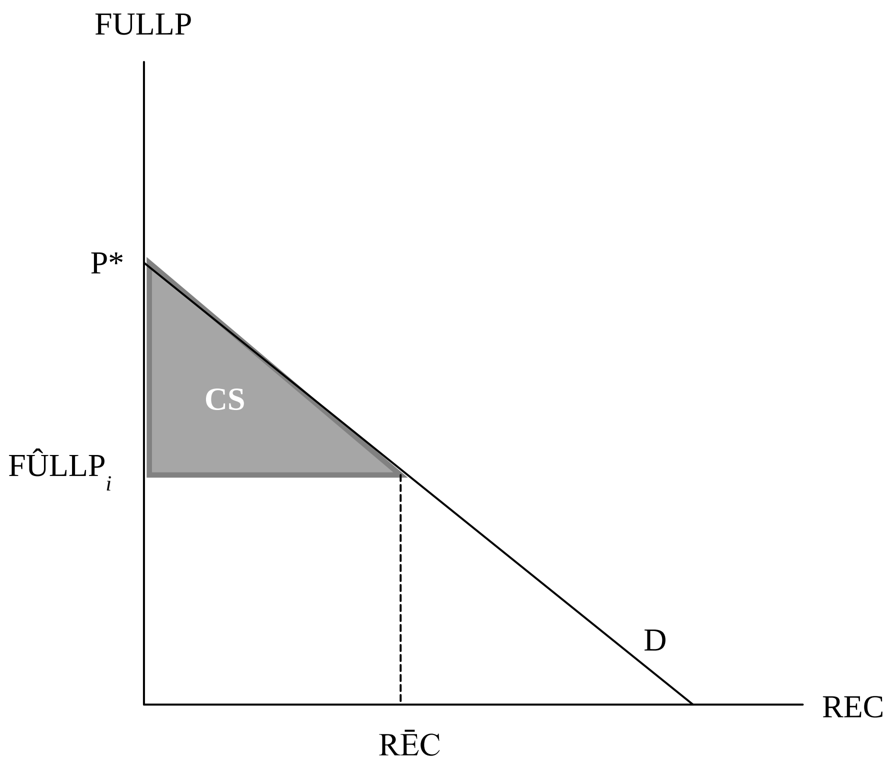

Figure VI: Consumer surplus from recycling demand function

using $REC = 0$ gives the choke price $P^* = 29.5382$. The consumer surplus equation for a linear demand curve like that here is:

$$CS = (P^* - F\hat{U}LLP_i)(R\bar{E}C)(.5) \tag{14}$$

and using the choke price, estimated value of recycling, and mean recycling percentage above results in a calculated consumer surplus of:

$$CS = (29.5382 – 1.1345)(89.0018)(.5) = 1263.9890. \tag{15}$$

The total annual consumer surplus of recycling in Seattle with a MMVT of 1/3 the reported hourly earnings rate, or the shaded area in Figure VI, is therefore a welfare gain of $1,264 per year. The consumer surplus at the full reported hourly earnings rate is

$3,580 and the consumer surplus at 1/10 the reported rate is $386 per year. These amounts and the corresponding monthly consumer surplus values are reported, along with regression results, in Table VIII.

Table VIII: Consumer Surplus Recycling Rate (REC) Models

	Reported Earnings			1/3 Reported Earnings			1/10 Reported Earnings		
Variable	**Est.**	**Std. Error**	**P-value**	**Est.**	**Std. Error**	**P-value**	**Est.**	**Std. Error**	**P-value**
Constant	55.804	3.894	0.000	56.452	3.903	0.000	56.720	3.903	0.000
$FULLP_i$	-1.106	0.153	0.000	-3.133	0.452	0.000	-10.244	1.499	0.000
$FULLINC_i$	0.029	0.012	0.017	0.018	0.013	0.182	0.012	0.014	0.376
RECTHR	0.268	0.061	0.000	0.257	0.061	0.000	0.254	0.061	0.000
OTHREC2	0.232	0.024	0.000	0.234	0.024	0.000	0.235	0.025	0.000
AGE	-0.058	0.035	0.101	-0.068	0.035	0.053	-0.072	0.035	0.041
EDU	0.965	0.194	0.000	1.021	0.194	0.000	1.045	0.194	0.000
R2	0.263			0.258			0.256		
F-stat.	33.39			32.51			32.29		
Prob. F	0.000			0.000			0.000		
Mean annual CS	$3,580			$1,264			$386		
Mean monthly CS	$298			$105			$32		

(Note that the second column presents standard errors rather than t-statistics)

The welfare value calculated at the full earnings rate (and, indeed, possibly even at 1/3 that rate) seems unrealistically high. By that measure, the welfare gains from recycling far exceed any annual disposal fee; if this were true, households would have overwhelming incentives to recycle as much as possible. Responses to the survey question for CANSZ indicate that 53% of respondents chose the 32 gallon can, which results in an annual disposal fee of $193; the next most frequent response was the 20 gallon can for 30% of respondents, resulting in an annual disposal fee of $148. The largest can choice, and correspondingly highest disposal fee, results in an annual disposal fee of $580. It is unlikely that the welfare gain from recycling is 18 times as large as the disposal fee. There is an outlying value in HHINC that may contribute to these high welfare estimates; it was included in this analysis but will be dropped in any further work with this data. These positive welfare estimates do suggest that the recycling provides marginal utility rather than marginal disutility as discussed in the theory section above.

8. GENERAL DISCUSSION

It is interesting to see which variables are consistently important and unimportant in these models. Table IX presents the last iterations of the recycling rate, waste disposal,

Table IX: Empirical Model Results for All Dependent Variables

	HH Recycling Rate (REC)			HH Waste Disposal (CANSZ)			HH Recycling Time (RECT)		
Variable	**Est.**	**T-Stat.**	**P-value**	**Est.**	**T-Stat.**	**P-value**	**Est.**	**T-Stat.**	**P-value**
Constant	21.303	0.88	0.382	2.313 **	2.13	0.034	5.983	0.48	0.633
MALE	-0.746	-0.73	0.465	0.106	1.50	0.134	-0.160	-0.15	0.879
AGE	-0.153	-0.69	0.489	0.016	0.89	0.374	-0.636 **	-2.53	0.012
AGE^2	0.001	0.57	0.567	0.000	-0.95	0.345	0.006 **	2.57	0.010
EDU	6.700 **	2.34	0.020	-0.019	-0.16	0.871	2.277 *	1.74	0.083
EDU^2	-0.175 **	-2.14	0.033	0.000	-0.05	0.960	-0.061	-1.65	0.100
HHSIZE	0.505	1.05	0.296	0.168 ***	5.10	0.000	1.377 ***	2.65	0.008
KIDS1	-1.851	-1.12	0.264	0.207	1.56	0.120	-1.883	-1.10	0.271
KIDS2	-0.785	-0.55	0.584	-0.095	-0.77	0.444	0.756	0.47	0.637
OWN	2.806	1.39	0.165	-0.325 **	-2.21	0.028	2.190	1.06	0.291
HHINC	-0.006	-0.52	0.603	0.002 *	1.81	0.070	-0.011	-0.86	0.388
HHTIME	0.002 ***	3.21	0.001	0.000	0.97	0.331	0.001 *	1.66	0.097
OTHREC	0.208 ***	5.92	0.000	0.000	-0.02	0.980	-0.010	-0.43	0.664
Internal Mot.	1.496 ***	2.70	0.007	0.014	0.45	0.650	0.028	0.06	0.952
Difficulty	-3.003 ***	-4.35	0.000	0.049	1.62	0.106	0.728	1.46	0.144
Indiv. Orient.	0.807	1.57	0.117	-0.004	-0.12	0.908	0.626	1.12	0.262
Enviro. Orient.	0.713	1.43	0.153	0.015	0.41	0.685	-0.141	-0.32	0.750
External Mot.	0.309	0.71	0.481	-0.145 ***	-4.14	0.000	-0.133	-0.28	0.778
Resourceful	0.092	0.13	0.896	0.055	1.64	0.102	0.355	0.72	0.470
Social Concern	1.657 ***	2.97	0.003	-0.031	-0.91	0.362	-0.002	0.00	0.998
RTPRICE	-27.990 ***	-4.44	0.000						
CANSZ	-1.668 ***	-3.03	0.003						
R2	0.440			0.150			0.067		
F-stat.	8.74			5.27			1.81		
Prob. F	0.000			0.000			0.019		

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

and recycling time decision models side-by-side for ease of comparison. The only variable to enter significantly into all three sets of models is the difficulty component (at the 10% level for single-tailed hypothesis tests, in the cases of CANSZ and RECT). The persistent importance of the difficulty component indicates that it would be beneficial to follow the lead of Jenkins *et al* (2003) and Hage *et al* (2009) in including measures of inconvenience and perceived inconvenience when studying recycling behavior. The number of children in the household (KIDS1, KIDS2) was not significant in these models. The resourcefulness principal component was likewise universally insignificant. Notice, however, that non-pecuniary variables (OTHREC, internal motivation component, difficulty component, individual orientation component, environmental orientation component, social concern component) are indeed important to the household's choice of recycling intensity and when traditional cost variables are included, the explanatory power of these non-pecuniary variables persists. This indicates that such combined models do, indeed, have a place in future research that refines our understanding of the household recycling problem.

Comparing the different stories told by these models, it is evident that different variables influence different aspects of recycling behavior and that both pecuniary and non-pecuniary variables provide insights into recycling behavior. The recycling rate decision depends on both pecuniary variables and non-pecuniary variables, while the decision of what size garbage container to use is heavily pecuniary. This is interesting in light of the progression of the economic literature, where waste disposal decisions were initially studied without much concern for non-pecuniary influences and these variables gained popularity when the focus shifted to the recycling decision specifically. The finding that self-reported recycling behavior depends on the cost of recycling, the ease of recycling, and other attitudes about recycling is basically consistent with Gamba and Oskamp's (1994) result that self-reported recycling behavior depends on recycling knowledge and attitudinal variables but not particularly on socio-demographic variables. This is worth noting in light of their further result that actual recycling behavior (as opposed to self-reported behavior) depends instead on household size, income, and recycling knowledge (Gamba and Oskamp 1994). There is no direct analogy in this study, as information on actual recycling behavior is not available, but this analysis found that household size and income were important in the waste disposal decision (which is a revealed variable), not in the recycling decision (a stated variable), and that attitude variables were less important to waste disposal than to recycling. Future research exploring the difference between what people say they do and what they actually do in this area could be fruitful. Furthermore, the results of this study support the hypothesis that people choose either the intensity at which to recycle or the amount to dispose and time spent recycling follows from those decisions. One of the most noteworthy results is that non-pecuniary variables play a larger part in the amount people recycle (REC) – a tangible result that is visible to those around them – than in how much time people actually spend recycling – a behavior that others do not witness. This indicates that recycling is at least partly a social behavior, and may even be used as a signal to advertise how environmentally responsible a person is: others can see the amount of recyclables you put on the curb, but they cannot see how much time you invest in getting them there.

It would be interesting to repeat this study in a community with markedly different attributes. As Schultz *et al* (1995) point out, community attributes most likely influence social norms. This is partly due to people's ability to theoretically move to communities that share their same values and partly due to becoming accustomed to a set of values through repeated exposure. Stereotypically, Seattle residents are known for having a pro-environmental mindset (which is reflected here in respondents' patterns of agreement with the attitude statements in Section 6.2, Table IV) and had a reasonably high city-wide recycling rate at the time this survey was conducted. Reproducing the findings that people's attitudes influence recycling behavior in a community that is generally less environmentally enthusiastic and has different recycling program participation rates would support the external validity of the finding that non-pecuniary considerations significantly influence recycling behavior.

Additionally, it is possible that people's attitudes towards the environment and public good contribution in general and recycling particularly relate well to how much they say they recycle but have less influence on how much they actually recycle, as was concluded by Gamba and Oskamp (1994). In the current study, there was no direct measure of quantity of material actually recycled to be able to make this comparison because such a measure is costly to obtain. However, allowing for such a measure in a subsequent study would be a valuable confirmation that people's self-reporting is a reliable measure of recycling activity and that their perceptions of themselves influence not only their perceptions of their behavior, but the behavior itself. It is possible to obliquely comment on that relationship in this study by comparing reported recycling rates to disposal behavior, which is a substitute for recycling behavior; this analysis found that different variables influence these two measures and that attitudes and beliefs were more important to the first than the second. However, it would be ideal to be able to confirm these observations with additional information on actual recycling quantities.

9. CONCLUSION

In summary, comparing the influences of the same pecuniary and non-pecuniary variables on different disposal decisions – recycling rate, disposal container size, and time spent recycling – produced two broad results. First, including non-pecuniary variables for people's attitudes towards recycling and their perceptions of their peers' behavior does allow researchers to more fully characterize these decisions. The recycling rate decision equations especially benefitted from the inclusion of such variables; the explanatory power of the model as indicated by R^2 more than doubled (from 12% to 34%) when these variables were added and the *F*-statistic went from insignificant at the 10% level to significant at the 1% level. Previous studies that have looked at either pecuniary or non-pecuniary aspects of the recycling decision but not both have presented a less complete picture of household decision making. Second, the type of information collected in this survey – and indeed in the recycling literature – explains household recycling rate decisions well but is less suited to explaining households' decisions about how much time to spend recycling or how much waste to deposit in landfills. The latter decision would probably be reasonably well-characterized with the addition of information about how much waste people generate to start with. The purpose of comparing models for these three related decisions was to try to shed light on which decision households were actually making and which decisions followed from that primary decision. Although there is no definitive test to compare these models with different dependent variables, the information available in this study indicates that households are choosing how much to recycle rather than how much time to spend recycling.

What profile of “a recycler” emerges from this study? The only socio-demographic variable that was important in both the recycling rate and recycling time models is education: more educated people recycle more and spend more time doing it. Homeowners choose smaller garbage containers and have higher recycling rates. Households who spend more time doing chores recycle more and spend more time doing so. Those who think that recycling is difficult because it takes too much time, storage space, or knowledge recycle less, take more time to do so, and dispose of more waste in landfills. Those who are concerned about how much their peers contribute to the public good of environmental quality through recycling and feel like their own contributions to this good make them more responsible people have higher recycling rates.

Policymakers, then, would benefit from seeing both pecuniary and non-pecuniary motivations for recycling, as these play into direct recycling decisions and, to a lesser degree, into the disposal decisions that indirectly influence recycling. Better understanding of the interplay of these two types of motivations allows for better ability to target program design and publicity to meet social objectives such as increasing participation in existing recycling programs or building support for new programs. Furthermore, a better understanding of what motivates household participation in municipal recycling programs can potentially lead to more efficiently designed programs that better target both household and municipal needs, and more accurate cost/benefit analysis of such programs (because the intangible benefits are more fully characterized).

Nyborg (2003) points out that, when designing recycling programs, governments already use tactics other than the traditionally expected economic incentives; this line of research could be seen as trying to bring those tactics into economic models. Once such variables are integrated into the decision-making framework, how would municipalities act on that information? The importance of the difficulty component in this research (which includes the statement, "It is often difficult to know what items can or cannot be recycled"), and of program knowledge in other work (Hopper and Nielsen 1991; Gamba and Oskamp 1994; Hornik *et al* 1995; Schultz *et al* 1995; Thøgersen 1996; Jenkins *et al* 2003), indicates that municipalities could increase recycling behavior by paying careful attention to how they explain program options, eligible materials, and necessary steps such as cleaning that must be taken to recycle those materials. The finding that people are concerned with their perceptions of others' behavior and the potential importance of the visible nature of curbside recycling activity to leveraging this concern into increased recycling behavior indicates that municipalities want to keep programs visible and could potentially increase recycling intensity by encouraging potential recyclers to interact with each other while stressing that individual effort creates positive results.

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