UC Irvine
UC Irvine Previously Published Works

Title

FINANCING ELECTRONIC WASTE RECYCLING - Californian Households' Willingness to Pay Advanced Recycling Fees

Permalink

https://escholarship.org/uc/item/19p943dz

Journal

Journal of Environmental Management, 84(4)

Authors

Nixon, Hilary
Saphores, Jean-Daniel M

Publication Date

2007

DOI

http://www.sciencedirect.com/dx.doi.org/10.1016/j.jenvman.2006.07.003

Peer reviewed

FINANCING ELECTRONIC WASTE RECYCLING
Californian Households' Willingness to Pay Advanced Recycling Fees

Hilary Nixon[a] and Jean-Daniel M. Saphores[b]

[a] Assistant Professor, Department of Urban and Regional Planning
San Jose State University, San Jose, CA 91592 USA
Phone: 408-924-5882; Hilary.Nixon@sjsu.edu

[b] Corresponding Author, Associate Professor,
Civil and Environmental Engineering, Department of Planning, Policy, & Design,
& Economics Department
University of California, Irvine, CA 92697 USA
Phone: 949-824-7334; saphores@uci.edu

Abstract

The growth of electronic waste (e-waste) is of increasing concern because of its toxic content and low recycling rates. The e-waste recycling infrastructure needs to be developed, yet little is known about people's willingness to fund its expansion. This paper examines this issue based on a 2004 mail survey of California households. Using an ordered logit model, we find that age, income, beliefs about government and business roles, proximity to existing recycling facilities, community density, education, and environmental attitudes are significant factors for explaining people's willingness to pay an advanced recycling fee (ARF) for electronics. Most respondents are willing to support a 1% ARF. Our results suggest that policymakers should target middle-aged and older adults, improve programs in communities with existing recycling centers or in rural communities, and consider public-private partnerships for e-waste recycling programs.

Keywords: recycling financing; electronic waste; principal components analysis; ordered logit.

1. INTRODUCTION

Millions of used consumer electronic items become obsolete each year, yet only a fraction is properly recycled (EPA, 2005). According to a 2005 GAO study, two reasons explain low recycling rates: consumers have few recycling options and they face substantial end-of-life fees. To boost electronic waste (e-waste) recycling, two policies are often proposed: extended producer responsibility (EPR) and advanced recycling fees (ARFs). The European Union, through its WEEE directive (2002/96/EC, 2003), chose the first approach. It transfers the burden of recycling to manufacturers by requiring them to take back and recycle waste electrical and electronic equipment. Over the long run, EPR may steer firms towards changing the design of their products to make them more environmentally friendly and easier to recycle. By contrast, there is no uniform e-waste policy in the U.S., and a number of states have proposed ARFs to defray recycling costs. Advanced recycling fees are front-end financing systems that charge consumers a fee at the point of sale which is then used to finance e-waste recovery and recycling programs.[1] In California, for example, the Electronic Waste Recycling Act of 2003 (the first such law in the U.S.) mandates ARFs ranging from $6-10 on new retail purchases of computer monitors and televisions. Little is known, however, about consumer willingness to pay for e-waste recycling programs. This paper starts filling this gap by studying the willingness to pay an ARF for consumer electronics by California households.

---

[1] ARFs offer a number of benefits: they increase recovery rates (there is no end-of-life fee); signal consumers about the potential environmental impacts of e-waste; and provide funds for developing the recycling infrastructure and for dealing with orphan waste. However, their initial set-up and ongoing administration costs may be high; funds collected may not be used for recycling; consumers may purchase electronics in one state and recycle in another (a risk if ARFs are established in a piecemeal, state-by-state fashion); and it may be politically difficult to set the fee high enough to also deal with the huge stockpile of e-waste. In addition, unlike EPR, an AFR may not stimulate innovation to make electronics environmentally friendly and easier to recycle.

1

The electronics industry has historically been perceived as fairly clean in the U.S. (perhaps because most of the manufacturing takes place in Asia), yet it is one of the most polluting industries (Darby and Obara, 2005). It seems that the public and policymakers awakened to the e-waste problem following a recent campaign by several NGOs (Basel Action Network and Silicon Valley Toxics Coalition, 2002) against exporting e-waste to developing countries; that campaign highlighted the public health and environmental damage caused by improperly processed e-waste. Indeed, typical consumer electronic products contain a variety of toxic materials including lead, cadmium, mercury, and brominated flame retardants. When improperly discarded or disposed of in leaky landfills, these materials can pose severe threats to human health and the environment (Scanlon, 2001). The effective management of e-waste is further complicated by the complex designs of consumer electronics products that mix plastics, glass, and metal components (Schoenung *et al*., 2004). Concerns about the large quantity (between 4 and 8 lbs per unit) of lead (Pb) in cathode ray tubes (CRTs) has prompted state governments, including California, Maine, Massachusetts, and Minnesota, to ban CRTs from landfills (Raymond, 2003). This means that CRTs are now considered hazardous waste in these states, but it makes the need for recycling infrastructure even more pressing.

A 2001 survey of California e-waste processors by the California Integrated Waste Management Board (CIWMB) emphasizes the presence of a gap between processing capacity and projected e-waste volume (specifically for CRTs) (see also Kang and Schoenung, 2005 for an overview of the U.S. recycling infrastructure limitations). The Electronic Waste Recycling Act of 2003 has resulted in new opportunities for recyclers, but the infrastructure still needs

considerable development.[2] Nationwide, the electronics recycling industry is rapidly growing, but its continued progress also depends on the development of cost-effective government and manufacturers' programs (IAER, 2006).

One key to new recycling infrastructure is financing. Indeed, a 2002 survey of local governments in California rated financing as their highest priority for e-waste recycling, and one option they strongly supported was advanced recycling fees (CIWMB, 2004). Prior to January 2005, most recycling programs in California imposed end-of-life fees on electronics. Survey respondents, however, voiced a strong concern regarding these fees and increased illegal dumping, particularly in rural communities. As the costs of legal disposal increase through, for example, end-of-life fees, research indicates that the frequency of illegal dumping also increases (Sigman, 1998). Policies such as ARFs should reduce this activity since the end-of-life management costs have been paid for up-front (Palmer, Sigman, & Walls, 1997).

In California, advanced recycling fees are now imposed on retail sales of televisions and monitors. Fees vary from $6-10 depending on screen size and are added to the retail invoice upon purchase. Retailers remit fees (up to 3% can be retained for costs associated with collecting the fee) to the State Board of Equalization (BOE). In order for authorized e-waste recyclers and collectors to be reimbursed for their costs by the BOE, recycling must be available at no cost to California residents, it must take place in California, recycled items must be from in-state sources, and they must be sufficiently dismantled so consumers can no longer use them. The current reimbursement rate is $0.48/lb, of which $0.20/lb is designed to cover collection costs (this amount is negotiable between recycler and collector); the rest is for recycling costs. During the first year of the program, 65 million tons of televisions and monitors were recycled in

---

[2] Personal communication, Jeff Hunts, Supervisor for Electronic Waste Management Program,

the state (CIWMB, 2006). By contrast, the EPA estimates that in 2003, only 290,000 tons of consumer electronics were recycled nationwide (EPA, 2005).

Preliminary results from Europe regarding the success of the WEEE Directive have been somewhat mixed (Huisman, *et al*., 2006; Savage, 2006). For countries without pre-existing e-waste recycling programs, it has been much more difficult to develop both the legal and operational infrastructures. Some countries, such as Sweden and Norway are collecting more than twice the WEEE Directive required e-waste per capita (>8kg/capita compared to the required 4kg/capita), but other systems (e.g. the ICT Milieu program in the Netherlands) have been less successful (Savage, 2006). Interestingly, member states with take-back programs that use an ARF or other direct "Compliance Costs" have developed their recycling infrastructure at a much faster pace and are able to realize greater economies of scale (Huisman *et al*., 2006).[3] Unfortunately, the WEEE Directive allowed member states to develop their own national legislation. This has led to a patchwork of programs and higher costs, particularly for collection, which is a major expense for e-waste recycling (Huisman *et al*., 2006).

Designing effective policies to address e-waste recycling requires understanding the consumers' willingness to pay for those policies. In California, for example, there are concerns that the state's ARF is considerably lower than the current actual cost to recycle the covered items (approximately $15 to $20 per item).[4] In that context, our paper makes two contributions to the existing literature. First, although a few papers study the financing of recycling programs, we found no published academic paper on financing e-waste recycling. This issue is of

---

CIWMB, March 21, 2005.
[3] The WEEE Directive allows manufacturers to charge a "visible fee" to pay for recycling costs of historical waste during a transitional period of 8 to 10 years.
[4] Personal communication with Jeff Hunts, Supervisor for Electronic Waste Management Program, CIWMB, March 21, 2005.

significant concern and our study provides the first look at willingness to pay for financing consumer electronics recycling. Second, we extend the existing interdisciplinary literature on pro-environmental behavior by analyzing the joint impact of psychological and economic variables on stated support for ARFs for consumer electronics.

We find that most people are willing to pay at least a 1% ARF but few are willing to pay a 5% ARF. In addition, statistically significant predictors of willingness to pay an ARF include: age; education; income; proximity to existing recycling centers; whether an individual lives in a rural or suburban/urban community; ideological position regarding the role of government and business in protecting the environment; and attitude toward the environment as well as involvement with environmental activities.

Our results suggest that: 1) middle-aged and older adults will require more encouragement in order to support ARFs; 2) initially, collected funds should be use to improve recycling programs in communities with an existing recycling facility and in rural communities (where support for ARFs appears higher); and 3) since ideological positions regarding the role of government and business in protecting the environment are important, public-private partnership to administer e-waste recycling programs should be considered.

This paper is organized as follows. In the next section, we briefly review selected papers from the economics and environmental psychology literatures that are relevant to our project, in addition to a few existing studies on financing recycling. In Section 3, we present information about our survey and the data we collected. This is followed by a summary of our modeling methodology and a discussion of our results. Finally, we present our conclusions and make some policy recommendations.

2. LITERATURE REVIEW

In order to design effective policies to solve environmental problems, it is important to understand what motivates people to engage in pro-environmental behavior (PEB). Most investigations to explain PEB are characterized by single-discipline studies (typically psychology or economics). In their attempts to explain PEB, economists tend to emphasize external variables such as income, price, or other socio-economic and demographic characteristics. Psychologists, on the other hand, focus instead on internal characteristics such as personal values, beliefs, or attitudes.

For economists, PEB represents an individual's attempt to provide a public good that would otherwise be under-provided due to market failure. The underlying reason is the public good nature of recycling: it benefits society at large through improved environmental quality but only recyclers bear its cost.[5] Olson's (1965) seminal contribution on the voluntary provision of public goods (here environmental quality) was followed by a number of important papers including (but not limited to) McGuire (1974), Young (1982), Warr (1983), or Cornes and Sandler (1984).

Economic theory suggests that individuals have a strong temptation to "free-ride," yet several empirical studies suggest that this problem may not as severe as predicted (e.g., see Bohm, 1972; Sweeney, 1973; or Smith, 1979). For Kim and Walker (1984), however, studies that find little supporting evidence for free-riding usually suffer from one or more invalidating factors (for example, lack of anonymity within the group, small group size, or not a "pure" public good). Others, on the other hand, suggest that the discrepancy between theory and

---

[5] Alternatively, individuals who do not recycle impose externalities on others.

empirical observations is due to altruistic motivations not captured by current economic theory (Andreoni, 1990).

The relationship between internal variables and PEB has been extensively studied by psychologists (see Fransson and Garling, 1999, for a review of this literature). The theory of planned behavior (TPB) has been postulated as a possible explanation for PEB (Ajzen, 1985; 1991). TPB suggests that intentions to perform a behavior can be accurately predicted from individual attitudes toward this behavior and from subjective norms. Chan (1998) applies this theory to the specific case of recycling in Hong Kong. According to Schwartz's norm-activation model (1970), two conditions must hold for personal beliefs to impact behavior. First, an individual must believe that her actions have consequences for another person's welfare. Second, she must feel some control over her actions and their consequences.

Environmental concerns and its influence on PEB is another area of interest for social-psychologists. Dunlap and Van Liere (1978) developed the New Environmental Paradigm (NEP) scale, which has been widely used to measure environmental attitudes, beliefs, and values, but also to predict self-reported and actual PEB (e.g., see Ebreo, Hershey, and Vining, 1999; Schultz and Oskamp, 1996; Stern, Dietz, and Guagnano, 1995). The NEP was updated in 2000 and renamed the New Ecological Paradigm Scale. Chung and Poon (2001) use the NEP in a comparison of recycling attitudes in rural and urban China.

To bridge this disciplinary divide between environmental economists and psychologists, a few researchers have proposed to combine internal and external variables in order to understand PEB and develop more effective environmental policies. Van Liere and Dunlap (1980) argue that a better understanding of environmental concerns and their relationship to PEB will require an integrated approach that combines socio-psychological and socio-economic

7

characteristics. Guagnano, Stern, and Dietz (1995) develop an "A-B-C" model of behavior that combines *attitudes* and external *conditions* to predict *behavior* (in this case, household recycling). The integration of psychology and economics is also emphasized by Clark, Kotchen, and Moore (2003), who study participation in a green electricity program. They combine internal influences based on Schwartz's norm-activation model and the New Ecological Paradigm with socio-economic and demographic characteristics and find both internal and external factors to be statistically significant.

Previous research on financing options for recycling programs also provides valuable background information for this paper. Recycling rates for conventional household recyclables (e.g. newspaper, plastics, aluminum, and glass) grew dramatically during the 1990s and researchers began to pay increased attention to the economics of recycling. Folz (1999) identifies several criteria that influence the economic viability of household recycling programs: successful programs rely on high participation levels which can be achieved through improving recycling convenience, establishing "recycling goals," assigning neighborhood leaders to encourage participation, and improving public education.

Jordi (1995) examines financing for battery recycling in Switzerland. He reports that, although there have been some problems with free-riders, the use of an ARF has been successful. Since 1994, Switzerland has used an ARF to finance the recycling of used electronics equipment from various sectors including, for example, office electronics, telecommunications, or dental practices (SWICO, 2005). Consumer electronics were added in 2002. From 1994 to 2001, ARF revenue exceeded recycling costs. However, in recent years, sales of new equipment have not kept pace with disposal rates so ARF revenues have not been sufficient to cover recycling costs. Individual ARF rates will be reviewed in 2006 (SWICO, 2005).

A few studies also examine willingness to pay for household recycling (see, e.g., Blaine, Lichtkoppler, Jones, & Zondag, 2005; Caplan, Grijalva, & Jakus, 2002; Lake, Bateman, & Parfitt, 1996)). Blaine *et al*. (2005) find that while a majority of respondents are willing to pay for curbside recycling, support does not reach the "break-even" level to finance the program. Caplan *et al*. (2002) use contingent ranking to estimate willingness to pay for curbside recycling in Ogden, UT. Two-thirds of respondents supported expansion of curbside services although men, residents older than 45 years, and long-time residents were more likely to prefer a "garbage-only" service as opposed to recycling. Curbside recycling is also the focus for Lake *et al*.'s (1996) study. Similar to the previous studies mentioned, a majority of respondents support paying for curbside recycling. Interestingly, although socio-economic characteristics influence people's decision to pay, there were not as important for determining the level of payment.

Although this condition is often overlooked, the availability of end markets is an essential condition for the economic viability of a recycling program. Recycling is costly and material revenues rarely exceed program expenses (Folz, 1999). This is of particular concern for e-waste. After examining various e-waste recycling options Dillon (1994) argues that, while extended producer responsibility programs can help develop the recycling infrastructure, it may not be cost-effective to recycle all consumer electronics; according to the CIWMB (2004), for example, cathode ray tube (CRT) recycling costs greatly exceed their current commodity value.

Another concern is the additional cost associated with residential e-waste recycling programs compared to business e-waste recycling. Compared to the commercial sector, it is significantly more expensive to collect and transport e-waste from residences (CIWMB, 2004).

Based on the insights provided by previous research in both economics and psychology, we combine standard socio-economic and demographic characteristics with variables that

capture environmental attitudes and beliefs to model Californian's willingness to pay an advanced recycling fee for consumer electronics.

3. SURVEY INSTRUMENT AND DATA

Data for this study were collected through a mail survey administered between January and April 2004 to 3,000 randomly selected California households. We stratified our sample by county in order to better capture the diversity of the state's population. Our sample includes 500 households in each of six counties (three northern counties: Alameda, Contra Costa (both urban) and Mono (rural); and three southern counties: Orange and San Diego (both urban), and Kern (rural)). Household addresses were bought from a commercial database (Fox's Data Services). At the time of the survey, California had just passed the Electronic Waste Recycling Act of 2003, but it had not been implemented.

Our survey instrument was designed to capture consumer preferences for e-waste recycling options, to inquire about e-waste recycling financing preferences, and to quantify the total amount of e-waste currently stored by California households. In addition to asking respondents about their willingness to pay advanced recycling fees for consumer electronics, we also asked about willingness to pay higher retail prices for environmentally friendly desktop computers and cell phones that would not be subject to any disposal regulations. We also collect socio-economic data on our respondents and information to develop a better understanding of general environmental attitudes and beliefs. More details about our survey instrument are available in Saphores *et al*. (2006).

For our purposes, a mail survey offered several key advantages. First, it allowed us to contact a widely dispersed population at a lower cost than in-person or telephone interviews and

it eliminated interviewer bias. Second, we could present detailed scenarios, ask longer questions, and give respondents time to provide thoughtful answers. Disadvantages with mail surveys, however, include low response rates as well as strong literacy skills required by respondents, both of which could introduce bias in the sample. To increase response rates, we followed Alreck and Settle (1995) and Fowler Jr. (1993): all households received a follow-up reminder postcard two weeks after mailing the initial survey package. This was followed by another mailing of a complete survey package to non-respondents shortly thereafter. To ensure questionnaire clarity and comprehension, we conducted a pretest on a small sample of potential respondents and used this information to improve survey instructions, question wording, and overall design.

From the original 3,000 household sample, 357 completed surveys were returned. Taking into account that 132 addresses were invalid, this represents a 12.4% response rate, which is at the low end of response rates for general population mail surveys (Alreck and Settle, 1995).[6] Our survey was rather long (12 pages), it was administered only in English due to a limited budget, and we did not target a specific group or location which may have had a personal interest in responding to the survey so this result is not unexpected. Non-response bias can be a particular concern for mail surveys (Fowler Jr., 1993), so we used contingency table analysis to compare our sample respondents' characteristics to 2000 Census data in order to identify some potential sample biases. In general, our respondents are older, better educated, and are more

---

[6] Charnley and Engelbert (2005) get response rates between 19% and 44% for the different phases of their study of EPA's community involvement program at Superfund sites. In their mail survey to farmers around Riding Mountain National Park, Brook and McLachlan (2006) obtain a 25% response rate; they focus on concerns regarding bovine tuberculosis in wildlife and livestock. Likewise, Lansana Margai (1995) gets 25% of questionnaires back to her mail survey of 450 households on Staten Island, New York; she is interested in manmade environmental hazards at a waste disposal site. Also note these mail surveys target specific groups with a direct interest in the survey questions. On the other hand, some mail surveys achieve much higher response rates (e.g., see Noe, et al., 1997).

likely to live in and own a single-family house; they also have a higher income, and they are less

ethnically diverse. Given these differences, care needs to be taken when generalizing from our

results to the California population. Our survey results are discussed more in-depth in Saphores

et al. (2006).

4. MODELING HOUSEHOLDS' WILLINGNESS TO PAY AN ARF

Our survey respondents were given four options to indicate their willingness to pay an advanced

recycling fee (ARF) when buying new electronics: 1) Not willing to pay an ARF; 2) Willing to

pay a 1% ARF; 3) Willing to pay a 5% ARF; and 4) Willing to pay a 10% ARF. Very few

respondents chose a 10% ARF so we combined the 5% and 10% categories. Respondents were

told that the fee would be used to finance e-waste recycling in California and would be based on

the retail price of the product. Just over half of respondents indicate a willingness to pay an ARF

of 1%; the others are fairly equally divided between not willing to pay and willing to pay a 5%

ARF. Our range of categories is consistent with previous research that suggests consumers are

willing to pay up to 10% extra for environmentally friendly products (De Pelsmacker *et al*.,

2005; Harris *et al*., 2000).[7]

     For consistency with the microeconomics of discrete choices, we assume that respondents

maximize an unobserved utility function when selecting among these alternatives (Train, 2003).

This utility function depends both on the attributes of the specific alternatives and on unique

characteristics of the respondent. More specifically, we decompose the unobserved utility $y*$ of

---

[7] Chung and Poon (1996) ask similar questions to examine recycling attitudes in Hong Kong. In
their research on salmon recovery in Oregon, Montgomery and Helvoigt (2006) also use broad
categories. This approach provide a framework for evaluating attitudes and support for an issue;
it is better than Likert scale responses (e.g. strongly agree, agree, disagree) because it allows
survey responses to be mapped to a cardinal scale.

respondent i ($i=1,\ldots,N$) into two parts: 1) a deterministic portion that depends on a vector of observations x_i of explanatory variables and a vector β of unknown parameters; and 2) a random error component ε_i that reflects the difference between true utility and what we actually observe (the ε_i are identically and independently distributed.) This can be written:

$$y_i^* = x_i'\beta + \varepsilon_i. \tag{1}$$

The actual choice of category k by respondent i (i.e., $y_i = k$) is then related to his utility y_i^* by:

$$y_i = k, \quad \text{if } \tau_{k-1} \leq y_i^* < \tau_k, \tag{2}$$

with $\tau_0 = -\infty < \tau_1 < \tau_2 < \tau_3 = +\infty$; the $\tau_i s$ are unknown thresholds that need to be jointly estimated with β. The probability of a given outcome is then given by (Long, 1997)

$$\Pr(y_i = k) = F(\tau_k - x_i'\beta) - F(\tau_{k-1} - x_i'\beta), \tag{3}$$

where $F(.)$ is the cumulative distribution function of the error term ε. Unlike correlation or contingency table analyses, this multivariate approach enables us to examine the joint impact of several explanatory variables on our dependent variable.

To estimate our model, we use an ordered logit, which assumes that the error term ε has a logistic distribution with a mean of 0 and a variance of $\pi^2/3$. An advantage of this choice is the availability of extensive specification tests to assess the robustness of our results.

As a preliminary step, we sequentially regress each of them on the others and check that the corresponding R^2 is not too high to avoid problems linked to multicollinearity between our independent variables (Stewart, 1991). After estimating our model, we add second and third order powers of our continuous variables to assess linearity (Hosmer and Lemeshow, 2000), and experiment with interaction terms; we then check for their statistical significance using likelihood ratio (LR) tests. To test the parallel regression assumption (i.e., the slope of the

13

regression line does not vary across the different categories of our dependent variable), we use the Wald test proposed by Brant (1990). Another possible specification error we examine is a link error. Here, we check whether a transformation of the dependent variable is required to properly link it to the independent variables (Pregibon, 1980). Following Long and Freese (2005), we also test for influential observations using Pregibon's Delta-Beta influential statistic, a counterpart to Cook's distance, which is commonly used in linear regression models.

To condense information on environmental attitudes and behaviors into a small number of factors, we perform a Principal Components Analysis (PCA) with varimax rotation. We use Bartlett's test for sphericity to check for the appropriate level of intercorrelation between our variables. Intercorrelations need to be high enough to limit the number of factors, but not too high to avoid multicollinearity (we rely on the Kaiser-Meyer-Olkin (KMO) statistic to detect this problem.) Finally, we use Cronbach's alpha to measure the reliability of our factors.

5. RESULTS

5.1 Principal Components Analysis

We develop two factors, normalized between 0 and 1, to summarize answers to ten survey questions on environmental activism and attitudes (see Table 1).

<Insert Table 1 approximately here>

The first factor (PC1) reflects personal involvement in environmental activities, with higher values indicating *less* support for the environment, so we create a neologism and call it "environmental inactivism." This factor is based on four survey questions with fairly high intercorrelations (Cronbach's alpha = 0.695), and it accounts for 80.1% of their variance.

The second factor (PC2) is based on six survey questions that ask respondents to rate environmental quality at the local, state, and national levels; to prioritize the environment over the economy; and to assess the adequacy of current spending on environmental protection. A higher value for PC2 indicates a belief that environmental quality has improved in recent years and a tendency to prioritize economic over environmental concerns, hence its name "Environmental quality & economic priorities." This factor accounts for 29.2% of the variance between the original variables (Cronbach's alpha = 0.782).

5.2 Willingness to Pay an Advanced Recycling Fee

We insert the two factors described above along with a number of demographic and socio-economic variables (see Table 2 for descriptive statistics) in an ordered logit model that explains our respondents' willingness to pay an ARF, and we estimate this model using Stata. We find that our respondents tend not to be actively involved with environmental organizations and activities (PC1 = 0.77) and they fall somewhat in the middle when it comes to prioritizing environmental quality versus economic growth (PC2 = 0.44). Interestingly, respondents have high mean values for their expectation that both government and business play a major role in protecting the environment (0.79 and 0.81, respectively). This suggests that these institutions could do a better job and need to take on greater responsibilities. Approximately one-third of respondents live in rural communities which is consistent with our survey stratification methodology in which one-third of the counties surveyed were predominantly rural. Almost all of our respondents are college-educated with household incomes greater than $40,000. This is not unexpected since our surveyed counties include some of the highest income areas of the state.

<Insert Table 2 approximately here>

A check for multicollinearity between our independent variables reveals no problems. We fail to reject the parallel regression assumption, and likelihood ratio (LR) tests do not yield any significant polynomial contrasts, but several interaction terms turn out to play important roles. A link test indicates that the relationship between the dependent and independent variables is not inappropriate. Pregibon's Delta-Beta influence statistic suggests examining seven observations more in-depth, so we estimate our model again without these observations and re-run a full set of specification tests. The least significant variable in our model, *role of business in protecting the environment*, becomes non-significant at the 10% level, but the coefficients of the other independent variables do not change significantly. As a result, we opt to keep our original model presented in Table 3. Other variables considered include gender, ethnicity, and political affiliation but they are not statistically significant. The non-significance of gender contrasts with consistent findings in the environmental psychology literature (see, e.g., Brown, 2003; Lockie, Lyons, Lawrence, & Grice, 2004; Loureiro & Hine, 2002; Steel, 1996) and even our own analysis of people's willingness to recycle e-waste at drop-off centers based on the same survey (see Saphores *et al*., 2006). However, the literature reports mixed results on this issue (see, e.g., Chung & Poon, 1996; Montgomery & Helvoigt, 2006), so it clearly warrants more research.

<Insert Table 3 approximately here>

5.2.1 Sensitivity analysis

Interpreting ordered models is somewhat more involved than interpreting linear regressions. To examine the impact of our two factors (PC1 and PC2), we follow Long (1997) and plot the predicted probabilities of being in any of the three categories characterizing willingness to pay an

16

ARF as a function of each factor. After analyzing the likely preferences of a baseline respondent characterized by mean values of our independent variables, we change one binary variable at a time, holding other variables at their baseline values. Our baseline respondent is over 35 years old, college–educated, enjoys an annual household income in excess of $40,000, and lives in a suburban or in an urban community less than 5 miles from the nearest drop-off recycling center. The base respondent scores 0.77 on PC1, 0.44 on PC2, and believes that both business and government have a major role to play in protecting the environment.

5.2.1.1 *Continuous variables*

Figure 1 graphs the predicted probability that a respondent is willing to pay a 5% ARF as a function of PC1. We begin with our baseline respondent and systematically change each of our binary variables from their baseline value to their alternate value, holding all other variables constant, and plot the change in predicted probabilities. We observe that predicted probabilities decrease over the whole range of PC1 (from a baseline high of 20.7% to a baseline low of 12.5%); as expected, a higher level of environmental activism corresponds to a higher willingness to pay for environmental issues.

<Insert Figure 1 approximately here>

Our baseline respondent is over 35 years old. When we change this category to 18 to 35 year old respondents, holding all other variables constant, we see that young adults are consistently more willing than our baseline person to support a 5% ARF. We know that this age group tends to be a major consumer of electronics products (Mintel USA, 2005), so our results suggest they may be more receptive to the environmental consequences of e-waste mismanagement.

Respondents who indicate that business does not play a major role in protecting the environment ("no business role") are also more likely to support a 5% ARF, holding all other variables at the baseline. These respondents may feel that the responsibility for recycling lies with other institutions, such as government, and that taxation (in the form of ARF) is an adequate way of financing recycling.

We suggest two possible reasons for rural respondents' higher interest in a 5% ARF. First, rural communities do not enjoy economies of scale for recycling and they are increasingly vulnerable to illegal dumping (CIWMB, 2004); rural residents also need to drive further to drop-off recyclables. Since the stated purpose of an ARF in our survey is to increase opportunities for e-waste recycling, rural respondents may be willing to boost recycling convenience in their communities. Second, these results may reflect the presence in our stratified random sample of Mono County, which has a long history of environmental activism.

Figure 1 also shows that respondents living more than five miles from the nearest recycling facility have consistently lower predicted probabilities than our baseline. This may seem surprising since they may benefit from additional recycling centers. Their lack of interest, however, may simply reflect NIMBYism: they just don't want a recycling facility in their backyard. Their possible lack of experience with recycling may also motivate them to refuse funding an activity they believe they will not engage in.

Income enters our model through an interaction with a binary variable that indicates whether or not the government has an important role to play in environmental protection (not shown on Figure 1; predicted probabilities are very similar to "rural"). Surprisingly, households earning less than $40,000 annually are more likely to support a 5% ARF, holding all other variable constant. A possible explanation is the higher likelihood of lower income households to

18

indicate that their local environmental quality is "poor" or "fair," so they may be willing to pay

more to protect or improve the environment (for details, see Saphores *et al*., 2006).

Respondents' attitudes toward the role of government also come into play through an

interaction with PC1: indicating that government does not play a major role in protecting the

environment leads to a lower willingness to pay a 5% ARF. Someone who believes that

recycling is best left to individuals or businesses may reject an ARF as an unwanted tax.

The other variable that intervenes through interactions, both with PC1 and PC2, is the

level of education ("No college"). From Figure 1, we see that respondents with no college

education are more likely than our baseline to support a 5% ARF at high levels of environmental

activism. But as their level of involvement decreases, the reverse becomes true.

Figure 2 illustrates how the predicted probability that a respondent is unwilling to pay an

ARF varies with PC1. As expected, predicted probabilities increase with PC1 for all cases, so

people less directly involved with environmental activities are less likely to support advanced

recycling fees for electronics. Compared to our base respondent, young adults, rural residents,

lower income households (not shown), and those stating that business does not play a major role

in protecting the environment are all less likely to oppose an ARF. By contrast, respondents who

believe in a weaker environmental role for the government and those without a nearby recycling

center are more likely to oppose an ARF. In addition, just as for Figure 1, the impact of

education depends on the level of environmental involvement.

<center><Insert Figure 2 approximately here></center>

Figure 3 depicts the change in the predicted probability for the willingness to pay a 1%

ARF for consumer electronics as a function of PC2 ("Environmental quality & Economic

priorities"). It nicely illustrates the transitions that occur between different levels of willingness

to pay an ARF. PC2 intervenes in our model only through its interaction with "college"; this interaction disappears when we change its baseline value (which equals one), so "college" does not appear on Figure 3.

<center><Insert Figure 3 approximately here></center>

First, we observe that most probabilities of Figure 3 range between 30% and 60%, so our respondents are generally willing to support at least a 1% ARF. At low values of PC2, younger adults, rural residents, lower income households (not shown but similar to rural ones), and those stating that business does not play a major role in environmental protection are less likely than our baseline to support a 1% ARF (because they are more likely to support a 5% ARF). When PC2 is high enough (i.e., when respondents believe the environment is doing well or the economy should have priority), however, they are more likely to support a 1% ARF.

Conversely, respondents living more than five miles from the nearest drop-off recycling facility or who see a limited role in environmental protection for the government (not shown) tend to support a 1% ARF for low values of PC2; as it increases, they increasingly oppose an ARF. The rest of our sensitivity analysis supports the same conclusions, so it is omitted.

5.2.1.2 *Discrete variables*

To examine the specific influence of our binary dependent variables on a respondent's probable level of support for ARFs to finance e-waste recycling, we examine discrete changes by switching the value of one binary variable at a time while holding all the others at their baseline value (Long, 1997). Our results are summarized in Table 4.

<center><Insert Table 4 approximately here></center>

Our baseline respondent's highest predicted probability is for a 1% ARF (64.8%), which

shows support for a modest ARF for electronics recycling. Not unexpectedly, we find that

young adults are far more likely to support a 5% ARF than our baseline respondent (+21.9%).

Others more likely to support a 5% ARF include rural residents (+10.9%), respondents who

believe business does not play a major role in protecting the environment (+7.4%), and lower

income households (+10.1%). Respondents more likely to support no ARF include those living

more than five miles from the nearest recycling facility (+9.8%) and those who believe

government does not play an important role in protecting the environment (+11.6%). Holding all

other variables constant, the net effect of no college experience increases the probability of

supporting no ARF at all by 15.1%. However, as shown in Figures 1 and 2, support for ARFs

depends on the interaction between college and our factors. The predicted probabilities for being

in any one of the three categories depend both on the level of education and on a respondent's

attitudes toward the environment.

6. POLICY CONSIDERATIONS AND CONCLUSIONS

Policies to address e-waste management are currently being debated by many states, counties,

and cities all around the nation (Council of State Governments, 2006). This paper contributes to

this debate by analyzing the combined role of both internal and external variables to explain

household support for an ARF for e-waste. By contrast, most of the published research on

recycling focuses either on internal or on external variables, and we found no paper that focused

specifically on how to finance e-waste recycling.

First, our findings underscore the importance of educational programs that address the

environmental impacts of improper e-waste management, a point already made in the literature

(Chan, 1998; Sharma, 2004). Indeed, one-quarter of our survey respondents did not know that

consumer electronics contain toxic materials and more than half were unaware of the landfill ban on CRTs in California. Public information campaigns could increase awareness of relevant laws and of adverse environmental consequences of improperly disposing of e-waste, which may increase support for ARFs. In order to maximize their impact, education programs should target middle-aged and older adults, as well as wealthier households, as these groups were less likely in our survey to indicate support for ARFs. Education, or simply providing objective information, also plays a role in shaping people's attitudes towards the environment, which according to our results, have a statistically significant impact on their level of support for an ARF.

Opinions about the role different organizations and institutions should play in protecting the environment appear to impact people's stated support for ARFs. To span this ideological divide and make e-waste recycling more acceptable, it may therefore be useful to implement ARF programs as public-private partnerships. This approach has proven effective in increasing used oil recycling rates in Canada (e.g., see Nixon and Saphores, 2001).

Our research also suggests that proximity to an existing recycling center influences support for advanced recycling fees. Individuals living more than five miles from the nearest facility are less likely to support ARFs designed to expand the recycling infrastructure. While this may be due to a lack of familiarity with recycling, the role of NIMBYism cannot be discounted. As a result, it may be more palatable politically to initially use ARFs to improve the recycling infrastructure in areas where facilities already exists.

Our survey results indicate that a majority of California households seems willing to support a modest ARF (1%) for consumer electronics, which is comparable to current ARF rates in California, so California households seem to be supportive of the current state policy. Unfortunately, a 1% ARF is insufficient to cover the current recycling cost for a CRT (which

varies depending on its weight according to the CIWMB).[8] To deal with this problem, one possibility would be to expand the ARF program to business and institutional purchases, in addition to consumer retail sales, in order to take advantage of economies of scale. Research in the State of Washington (Cascadia Consulting Group, 2005) indicates that ARFs on computers, monitors, and televisions ranging from $6-10 (which roughly corresponds to a 1% ARF) would be appropriate if business purchases were included in the program. However, this does not account for the funds needed to deal with the accumulated e-waste stored by households. General tax money may be necessary to process the accumulated e-waste stockpile before a steady state can be reached.

Moreover, it is important to note that ARFs should ideally be established based on the average weight and ease of recycling of a class of electronics products, rather than as a percentage of retail cost. Although price and recycling cost are correlated (for example, larger televisions are typically more expensive to purchase and recycle), this is not always the case (some very compact and expensive electronics products could be easy to recycle). For our survey, we chose a percentage-based ARF in order to get an indication of willingness to support ARFs for a wide range of consumer electronics products because asking households' preferences for detailed recycling fee schedules would have been overly complex. In practice, when setting ARF rates, policymakers should also account for estimated sales revenue, program and recycling costs, as well as estimated recovery rates (Cascadia Consulting Group, 2005).

Finally, a word of caution: our results should be extrapolated with care to the whole state due to specific biases in our sample so they should be confirmed by additional research.

---

[8] Personal communication, Jeff Hunts, Supervisor for Electronic Waste Management Program, CIWMB, March 21, 2005.

The growing volume of e-waste is an increasing concern in today's technology-driven society. Securing appropriate financial resources is essential to develop the recycling infrastructure and to ensure the sustainability of recycling. Advanced recycling fees are only one possible solution, but their effective implementation requires an understanding of consumer willingness to support such programs.

REFERENCES

Alreck, P. L., Settle, R. B., 1995. The Survey Research Handbook (2nd ed.). Boston, MA: Irwin McGraw-Hill.

Andreoni, J., 1990. Impure altruism and donations to public goods: A theory of warm-glow giving. The Economic Journal, 100, 464-477.

Ajzen, I., 1985. From intentions to actions: A theory of planned behavior. In J. Kuhl and J. Beckman (eds.), Action-control: From Cognition to Behavior (pp. 11-39). New York: Springer.

Ajzen, I., 1991. The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50, 179-211.

Basel Action Network & Silicon Valley Toxics Coalition, 2002. Exporting Harm: The High-tech Trashing of Asia. Seattle, WA; San Jose, CA.

Blaine, T. W., Lichtkoppler, F. R., Jones, K. R., Zondag, R. H., (2005). An assessment of household willingness to pay for curbside recycling; A comparison of payment care and referendum approaches. Journal of Environmental Management, 76(1), 15-22.

Bohm, P., 1972. Estimating demand for public goods: An experiment. European Economics Review, 3, 111-130.

Brant, R., 1990. Assessing proportionality in the proportional odds model for ordinal logistic regression. Biometrics, 46, 1171-1178.

Brook, R.K., McLachlan, S. M., 2006, Factors influencing farmers' concerns regarding bovine tuberculosis in wildlife and livestock around Riding Mountain National Park. Journal of Environmental Management, 80(2), 156-166.

Brown, C. (2003). Consumers' preferences for locally produced food: A study in southeast Missouri. *American Journal of Alternative Agriculture*, *18*, 213-224.

Caplan, A. J., Grijalva, T. C., Jakus, P. M., 2002. Waste not or want not? A contingent ranking analysis of curbside waste disposal options. Ecological Economic*s*, 43, 185-197.

Cascadia Consulting Group, 2005. Will they cover costs over time? An assessment of the advanced recovery fees needed to sustain recycling of covered electronics products under ESHB 2488. Draft Report, Washington.

Chan, K., 1998. Mass communication and pro-environmental behavior: waste recycling in Hong Kong. Journal of Environmental Management, 52(4), 317-325.

Charnley, S., Engelbert, B., 2005. Evaluating public participation in environmental decision-making: EPA's superfund community involvement program, Journal of Environmental Management, 77(3), 165-182.

Chung, S.-S., Poon, C.-S., 1996. The attitudinal differences in source separation and waste reduction between the general public and housewives in Hong Kong. Journal of Environmental Management, 48(3), 215-227.

Chung, S.-S., Poon, C.-S., 2001. A comparison of waste-reduction practices and new environmental paradigm of rural and urban Chinese citizens. Journal of Environmental Management, 62, 3-19.

CIWMB, 2001. Selected E-waste Diversion in California: A Baseline Study (Publication #610-01-008). Sacramento, CA: California Integrated Waste Management Board.

CIWMB, 2004. Statewide Waste Characterization Study (Publication #340-04-005). Sacramento, CA: California Integrated Waste Management Board.

CIWMB, 2006. Electronic product management news. Sacramento, CA: California Integrated Waste Management Board. Accessed June 22, 2006 from http://www.ciwmb.ca.gov/electronics/News/

Clark, C. F., Kotchen, M. J., Moore, M. R., 2003. Internal and external influences on pro-environmental behavior: Participation in a green electricity program. Journal of Environmental Psychology, 23, 237-246.

Cornes, R., Sandler, T., 1984. Easy riders, joint production, and public goods. The Economic Journal, 94(375), 580-598.

Council of State Governments, 2006. Northeast Regional Electronics Management Project. Eastern Regional Conference. New York, NY. Available from http://www.csgeast.org/enrgwaste.asp > 01/26/06

Darby, L., Obara, L., 2005. Household recycling behaviour and attitudes towards the disposal of small electrical and electronic equipment. Resources Conservation & Recycling, 44, 17-35.

De Pelsmacker, P., Driesen, L. Rayp, G., 2005. Do consumers case about ethics? Willingness to pay for fair-trade coffee. The Journal of Consumer Affairs, 39, 363-385.

Dunlap, R. E., Van Liere, K. D., 1978. The "New Environmental Paradigm". Journal of Environmental Education, 9(4), 10-19.

Dillon, P. S., 1994. Mandated electronic equipment recycling in Europe: Implications for companies and U.S. public policy. Working Paper. Tufts University.

Ebreo, A., Hershey, J., Vining, J., 1999. Reducing solid waste: Linking recycling to environmentally responsible consumerism. Environment & Behavior, 31(10), 107-135.

EPA, 2005. Municipal Solid Waste in the United States: 2003 Facts and Figures EPA-530-F-05-003. Washington, DC: Office of Solid Waste and Emergency Response.

Euromonitor, 2006. Televisions: Retail Volume and Value 2005. Available from http://www.euromonitor.com/wcm >01/23/06.

Folz, D. H., 1999. Municipal recycling performance: A public sector environmental success story. Public Administration Review, 59(4), 336-345.

Fowler Jr., F. J., 1993. Survey Research Methods (2nd ed.). Newbury Park, CA: Sage Publications.

Fransson, N., Garling, T., 1999. Environmental concern: Conceptual definitions, measurement methods, and research findings. Journal of Environmental Psychology, 19, 369-382.

GAO [General Accounting Office], 2005. Electronic waste: Strengthening the role of the federal government in encouraging recycling and reuse. Report to Congressional Requesters, Washington, D.C.

Guagnano, G., Stern, P. C., Dietz, T., 1995. Influences on attitude-behavior relationships: A natural experiment with curbside recycling. Environment & Behavior, 27, 699-718.

Harris, R., Burress, D., Eicher, S., 2000. Demands for local and organic produce: A brief review of the literature. Institute for Public Policy and Business Research, University of Kansas.

Hosmer, D. W., Lemeshow, S., 2000. Applied Logistic Regression (2nd ed). John Wiley & Sons: New York.

Huisman, J., Stevels, A., Marinelli, T., Magalini, F., 2006. Where did WEEE go wrong in Europe? Practical and academic lessons for the US. In Proceedings of the 2006 IEEE International Symposium on Electronics & the Environment, ISBN 1-4244-0351-0, San Francisco (May).

Jordi, H., 1995. A financing system for battery recycling in Switzerland. Journal of Power Sources, 57, 51-53.

Kang, H.-Y., Schoenung, J. M., 2005. Electronic waste recycling: A review of U.S. infrastructure and technology options. Resources Conservation and Recycling, 45, 368-400.

Kim, O., Walker, M., 1984. The free rider problem: Experimental evidence. Public Choice, 43, 3-24.

IAER [International Association of Electronics Recyclers], 2006. IAER Electronics Recycling Industry Report. Portland, OR: Resources Recycling.

Lake, I. R., Bateman, I. J., Parfitt, J. P., 1996. Assessing a kerbside recycling scheme: A quantitative and willingness to pay case study. Journal of Environmental Management, 46, 239-254.

Lansana Margai, F., 1995, Evaluating the potential for environmental quality improvement in a community distressed by manmade hazards. Journal of Environmental Management, 44(2), 181-190.

Lockie, S., Lyons, K., Lawrence, G., Grice, J. (2004). Choosing organics: A path analysis of factors underlying the selection of organic food among Australian consumers. *Appetite*, *43*, 135-146.

Long, J. S., 1997. Regression Models for Categorical and Limited Dependent Variables. Thousand Oaks, CA: Sage Publications.

Long, J. S., Freese, J., 2005. Regression Models for Categorical Dependent Variables using Stata (2nd ed.). College Station, TX: Stata Press.

Loureiro, M. L., Hine, S. (2004). Preferences and willingness to pay for GM labeling policies. *Food Policy*, *29*, 467-483.

McGuire, M., 1974. Group size, group homogeneity, and the aggregate provision of pure public goods under Cournot behavior. Public Choice, 18, 107-126.

Mintel USA, 2005. Attitudes of Young Adults Towards Consumer Electronics – U.S. Mintel Reports, October.

Montgomery, C. A., Helvoigt, T. L., 2006. Changes in attitudes about important of and willingness to pay for salmon recovery in Oregon. Journal of Environmental Management, 78(4), 330-340.

Nixon, H., Saphores, J.-D., 2002. Used oil policies to protect the environment: An overview of Canadian experiences. In K. Wang, G. Xiao, L. Nie, & H. Yang (Eds.), Conference Proceedings of the Third International Conference on Traffic and Transportation Studies: Vol. 1 (pp. 73-80). Reston, VA: American Society of Civil Engineers.

Noe, F. P., Hammitt, W. E., Bixler, R. D., 1997. Park user perceptions of resource and use impacts under varied situations in three national parks. Journal of Environmental Management, 49(3), 323-336.

Olson, M., 1965. The Logic of Collective Action. Cambridge, MA: Harvard University Press.

Palmer, K., Sigman, H., Walls, M., 1997. The cost of reducing municipal solid waste. Journal of

Environmental Economics and Management, 33, 128-150.

Pregibon, D., 1980. Goodness of link tests for generalized linear models. Applied Statistics, 29, 15-24.

Raymond, M., 2003. Backgrounder: Electronic Waste. College Park, MD: Raymond Communications.

Saphores, J.-D., Nixon, H., Ogunseitan, O., Shapiro, A., 2006. Household willingness to recycle electronic waste: An application to California. Environment & Behavior, 38(2), 183-208.

Savage, M., 2006. Implementation of waste electric and electronic equipment directive in EU-25. Institute for Prospective Technological Studies, European Commission Directorate-General, Joint Research Centre. Accessed June 22, 2006 from ftp://ftp.jrc.es/pub/EURdoc/eur22231en.pdf.

Scanlon, K., 2001. Poison PCs and Toxic TVs: California's Biggest Environmental Crisis That You've Never Heard Of. Sacramento, CA: Californian Against Waste; San Francisco, CA; Materials for the Future Foundation; San Jose, CA: Silicon Valley Toxics Coalition.

Schoenung, J. M., Ogunseitan, O. A., Saphores, J.-D. M., Shapiro, A. A., 2004. Adopting lead-free electronics: Policy differences and knowledge gaps. Journal of Industrial Ecology, 8(4), 59-85.

Schultz, P. W., Oskamp, S., 1996. Effort as a moderator of the attitude-behavior relationship: General environmental concern and recycling. Social Psychology Quarterly, 59(4), 375-383.

Schwartz, S. H., 1970. Elicitation of moral obligation and self-sacrificing behavior. Journal of Personality and Social Psychology, 15, 283-293.

Sharma, M., 2004. Reverse logistics and environmental considerations in equipment leasing and asset management. Ph.D. Dissertation. Georgia Institute of Technology.

Sigman, H., 1998. Midnight dumping: Public policies and illegal disposal of used oil. RAND Journal of Economics, 29(1), 157-178.

Smith, V., 1979. An experimental comparison of three public good decision mechanisms. The Scandinavian Journal of Economics, 81(2), 198-215.

Steel, B. S., 1996. Thinking globally and acting locally? Environmental attitudes, behaviour and activism. Journal of Environmental Management, 47(1), 27-36.

Stern, P. C., Dietz, T., Guagnano, G. A., 1995. The New Ecological Paradigm in social-psychological context. Environment & Behavior, 27(6), 723-743.

Stewart, J., 1991. Econometrics. Cambridge, UK: Philip Allan.

Sweeney, J., 1973. An experimental investigation of the free rider problem. Social Science Research, 2, 277-292.

SWICO, 2005. Activity Report 2004. Swiss Association for Information, Communication and Organizational Technology: Zurich, Switzerland.

Train, K. E., 2003. Discrete Choice Methods with Simulation. Cambridge, UK: Cambridge University Press.

Van Liere, K. D., Dunlap, R. E., 1980. The social bases of environmental concern: A review of hypotheses, explanations, and empirical evidence. Public Opinion Quarterly, 44, 181-199.

Warr, P. G., 1983. The private provision of a public good is independent of the distribution of income. Economics Letters, 13, 207-211.

Young, D., 1982. Voluntary purchase of public goods. Public Choice, 38, 73-86.

Table 1: Principal Components Analysis of Environmental Attitudes and Behaviors

Survey Items and Principal Components	Eigenvectors and scoring coefficients	% Variance explained v; Cronbach's α; KMO; Bartlett.
PC1 – "Environmental inactivism"		v = 80.1%
1. Attend meeting or sign petition to protect the environment during previous 12 months	0.611	α = 0.695
		KMO = 0.711
2. Contribute to environmental organizations during previous 12 months	0.761	Bartlett:
		p<0.001
3. Participate in local environmental activities such as Earth Day, Beach Clean-up during previous 12 months	0.295	
4. Level of volunteer involvement with environmental organizations	0.744	
PC2 – "Environmental quality & economic priorities"		v = 29.2%
1. Belief that environmental quality (land, sea, air, rivers, lakes, climate, etc.) has worsened in the past decade	0.513	α = 0.782
		KMO = 0.772
2. Rating of environmental quality in the U.S.	0.698	Bartlett:
3. Rating of environmental quality in California	0.743	p<0.001
4. Rating of local environmental quality	0.500	
5. Level of agreement with the statement "environmental protection should be a priority, even if it slows economic growth and causes some job losses"	0.643	
6. Opinion regarding current spending levels on environmental protection	0.615	

A higher value of PC1 indicates less involvement with environmental activities and organizations. A higher value of PC2 indicates less concern for the environment and a belief that environmental quality has improved recently. Cronbach's alpha indicates how well a set of variables measures a single underlying construct; it is high when inter-item correlations are high. KMO measures sampling adequacy and tests whether partial correlations between variables are small; it should be >0.5 for a satisfactory factor model. Bartlett's test of sphericity checks whether the correlation matrix of the variables differs significantly from the identity matrix; if not, the factor model is inappropriate.

Table 2: Descriptive Statistics for Key Variables

Variable	Mean	S.D.	Min.	Max.
Willingness to pay an advanced recycling fee	1.97	0.68	1	3
PC1 – "Environmental inactivism"	0.77	0.32	0	1
PC2 – "Environmental quality & economic priorities"	0.44	0.20	0	1
Age between 18 and 35 years (yes = 1)	0.13	0.33	0	1
Live in a rural community (yes = 1)	0.36	0.48	0	1
Distance to nearest drop-off recycling center (>5 miles = 1)	0.46	0.50	0	1
Role of business in protecting the environment (major role = 1)	0.79	0.40	0	1
Role of government in protecting the environment (major role = 1)	0.81	0.39	0	1
College (yes = 1)	0.89	0.31	0	1
Household income <$40,000 per year (yes = 1)	0.19	0.39	0	1
Interactions:				
PC1 * college (yes = 1)	0.68	0.38	0	1
PC2 * college (yes = 1)	0.40	0.25	0	1
PC1 * Role of government in protecting the environment (major role = 1)	0.62	0.42	0	1
Role of government in protecting the environment (major role = 1) * Household income <$40,000 per year (yes = 1)	0.15	0.36	0	1

PC1 and PC2 are both treated as a continuous index and are normalized to be between 0 and 1. The other independent variables are binary (0 or 1) indicator variables.

Table 3: Model Estimation Results

Variable	Ordered Logit Model	
	Coefficient	Robust standard error
PC1 – "Environmental inactivism"	-4.358	[0.598]
Age between 18 and 35 years (yes = 1)	1.231	[0.367]
Live in a rural community (yes = 1)	0.705	[0.300]
Distance to nearest drop-off recycling center (>5 miles = 1)	-0.514	[0.278]
Role of business in protecting the environment (major role = 1)	-0.510	[0.314]
Interactions:		
PC1 * college (yes = 1)	2.974	[0.601]
PC2 * college (yes = 1)	-3.433	[0.804]
PC1 * Role of government in protecting the environment (major role = 1)	0.780	[0.348]
Role of government in protecting the environment (major role = 1) * Household income <$40,000 per year (yes = 1)	0.667	[0.375]
τ_2	-3.826	[0.528]
τ_3	-0.703	[0.463]

[a] Number of observations = 258. OL results: Log-likelihood = -218.77. Wald Chi-Square (with 9 degrees of freedom) = 75.62; the corresponding p-value is <0.0001.

[b] The standard error in brackets is the Huber/White/sandwich estimate.

[c] The Count R^2 is 0.612 and the Adjusted Count R^2 is 0.145. The former is the proportion of correct predictions; the latter equals the proportion of correct prediction beyond what would have been guessed by simply choosing the largest marginal category (Long, 1997). Our model is best at predicting the 1% ARF category (123 correct observations out of 141), but it is clearly not very good at predicting the 0% ARF (21 correct out of 62) or the 5% ARF (only 14 correct out of 55 observations).

Table 4: Discrete Change in the Probability of the Willingness to Pay an ARF

Variable	No ARF	1%	5%
Baseline probabilities:	_0.211_	_0.648_	_0.141_
Age 18-35 years (_no_ → yes):	-0.139	-0.081	+0.219
Live in a rural community (_no_ → yes):	-0.094	-0.014	+0.109
Distance to nearest drop-off recycling center (_≤5 miles_ → >5 miles):	+0.098	-0.046	-0.052
Role of business in protecting the environment (_major role_ → minor or no role):	-0.073	-0.001	+0.074
College education (_yes_ → no):	+0.151	-0.081	-0.069
Role of government in protecting the environment (_major role_ → minor or no role):	+0.116	-0.058	-0.058
Annual household income (_>$40,000_ → ≤$40,000):	-0.090	-0.011	+0.101

To generate the results above, we change discrete variables one at a time while holding the others at their baseline value (underlined and in italics in the left-most column). Baseline probabilities are calculated for our baseline respondent, who is over 35 years old, college-educated, with an annual household income greater than $40,000, and lives in a suburban or an urban community less than 5 miles from the nearest drop-off recycling center. Our baseline respondent scores 0.77 on PC1, 0.44 on PC2, and believes that both business and government have a major role to play in protecting the environment.
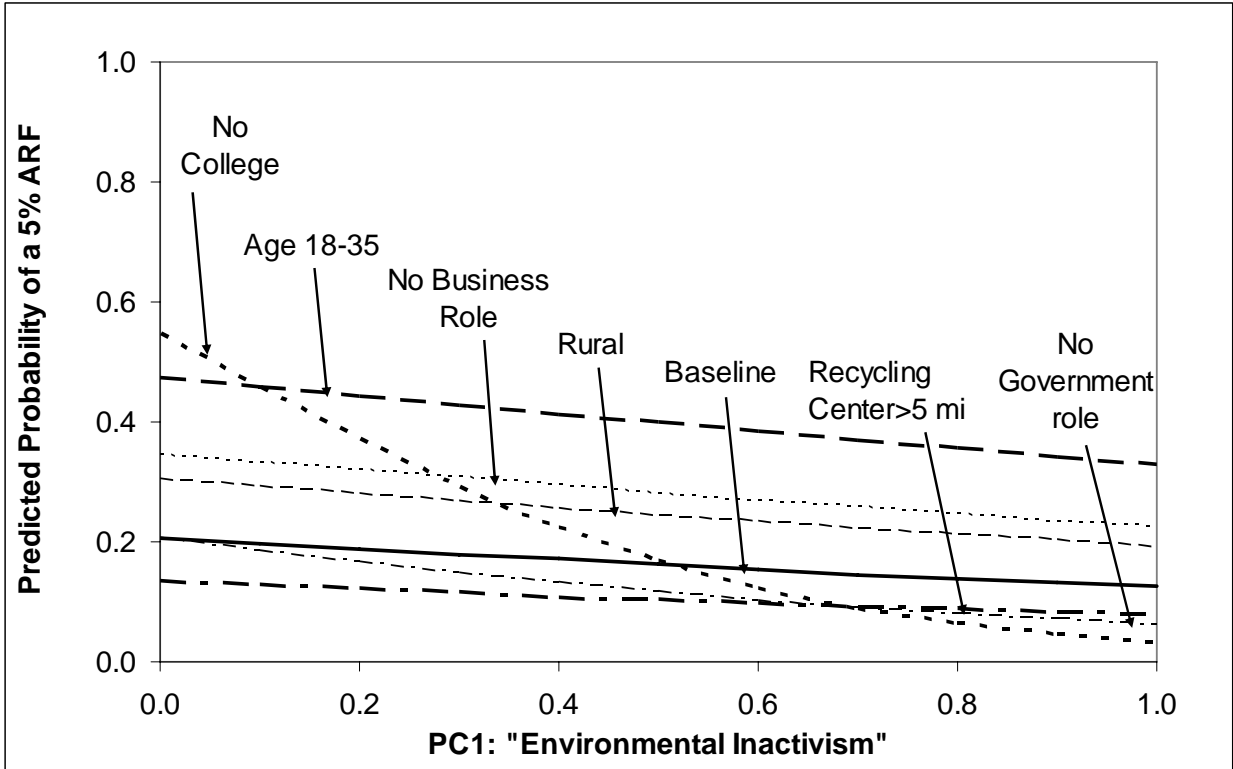
Figure 1: Predicted probability of being willing to pay a 5% ARF versus PC1

Note. PC1 reflects personal involvement in environmental activities, with higher values indicating *less* support for the environment; it is normalized to be between 0 and 1.
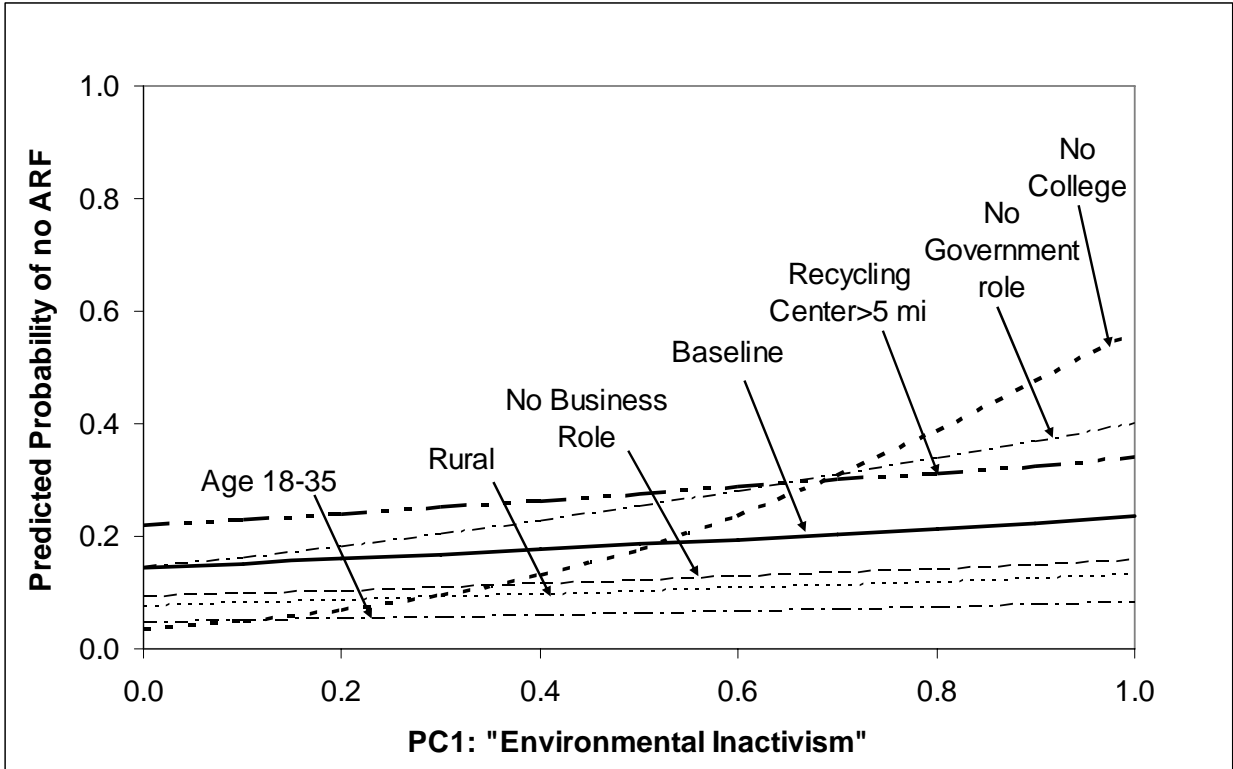
Figure 2: Predicted probability of being unwilling to pay any ARF versus PC1

Note. PC1 reflects personal involvement in environmental activities, with higher values indicating *less* support for the environment; PC1 is normalized to be between 0 and 1.
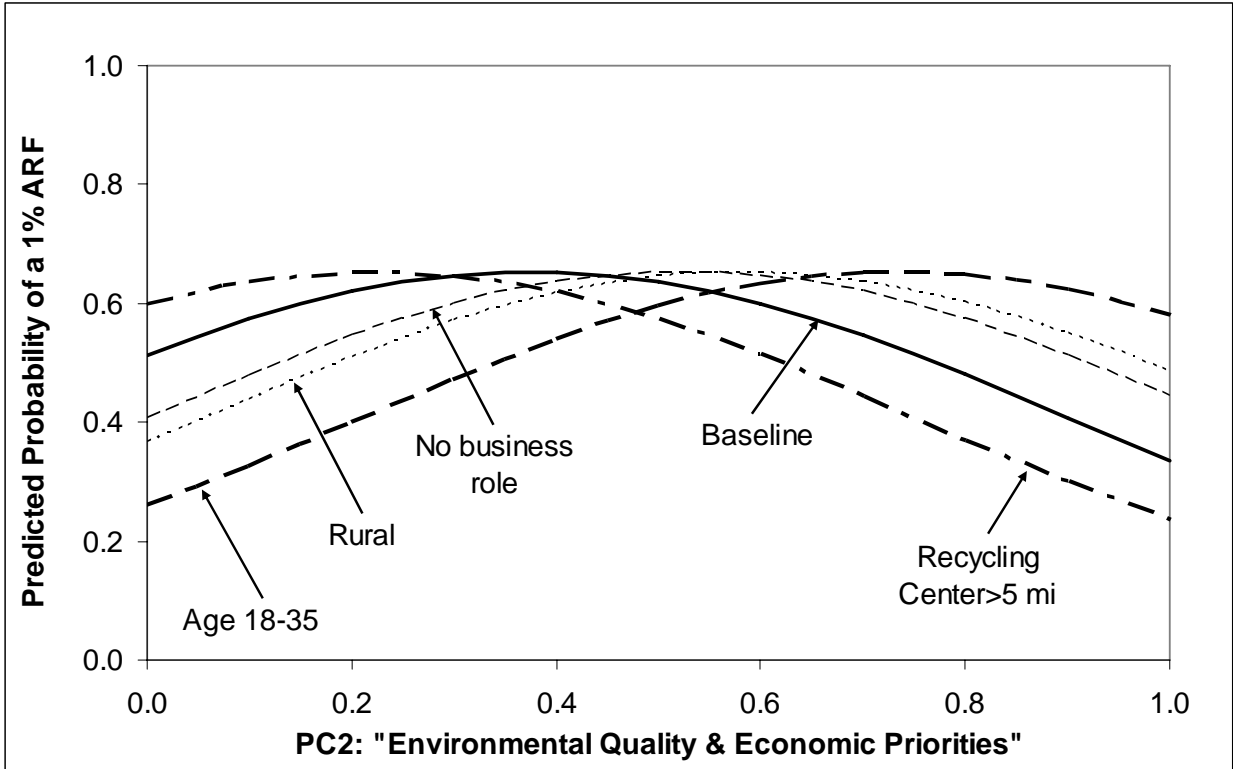
Figure 3: Predicted probability of being willing to pay a 1% ARF versus PC2.

Note: PC2 reflects personal attitudes toward current environmental quality; a higher value for PC2 indicates a general belief that environmental quality has improved in recent years and a tendency to prioritize economic over environmental concerns; PC2 is also normalized to be between 0 and 1.