UNIVERSITY OF CALIFORNIA

Santa Barbara

Essays in Environmental Economics

A Dissertation submitted in partial satisfaction of the requirements for the degree

Doctor of Philosophy in Economics

By

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March 2006

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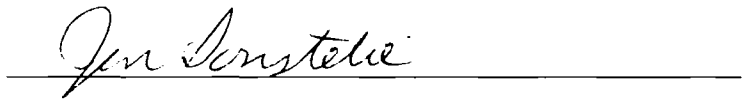

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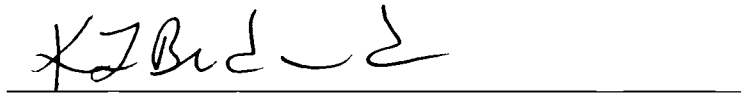

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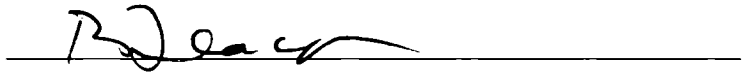

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ACKNOWLEDGEMENTS

I am grateful to Kelly Bedard, Bob Deacon and Jon Sonstelie for their support throughout this process. I want to thank my husband, Josh Ashenmiller, for his unconditional support and ability to make me laugh, even in the most aggravating and painful moments. In addition I thank both my parents for their guidance and understanding, and my two sons for reminding me to always remember the big picture.

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ABSTRACT

Essays in Environmental Economics

by

Bevin Ashenmiller

The three essays included consider unintended consequences of state bottle laws on labor markets. Eleven U.S. states have enacted "bottle laws" that encourage household recycling of beverage container materials through a deposit-refund program.

The first paper focuses on answering the question: who are the people collecting recyclable materials? Using survey data from recycling centers in California I investigate the demographics of all cash recyclers. I find the image of the homeless recycler is incomplete. In addition to the homeless recyclers, a surprising number of professional and work recyclers use trucks and vans to recycle both as a full-time job and as a second job as well as household recyclers. While there are many descriptive articles about cash recyclers this is the first study that looks empirically at people recycling for cash. Using survey data I draw a picture of the recyclers, estimate a recycling wage, and analyze what determines that wage.

The second paper uses the individual level data that I have collected on observed cash recycling behavior to show that an unintended consequence of bottle laws is that they have the potential to increase the incomes of very low

wage workers. If states set the bottle deposit high enough, harvesting recyclables becomes viable employment. The use of a price system as an environmental remedy is often criticized on the grounds that it leads to lower incomes for the poor. In this case deposit-refund recycling laws may provide a way to improve resource allocation using the appropriate Pigouvian tax, and simultaneously provide a way to increase the income of low wage workers. The data show the surprising result that recycling income does indeed provide a substantial supplemental income to a certain group of low-income cash recyclers.

The third paper examines the degree to which using bottle laws to subsidize recycling programs improves labor market opportunities and has a negative effect on petty crime rates. Using a simple choice theory model of crime participation and labor supply this paper examines the decision by individuals to engage in illegal activities. When the legal wage increases, recycling bottles and cans, we expect to see people substituting their time and effort away from the illegal activity to the legal activity. In a natural experiment this paper exploits the variation in the year of implementation of the bottle laws to measure the reduction in crime rates of improved job market opportunities. This paper shows that the opportunity effect, that is a result of state bottle laws, results in about a 10% decrease in average reported larceny rates. In this way the primary positive benefits of these labor market changes go to low-income individuals, but secondary benefits trickle up to higher wage earners.

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Abstract

While there are many descriptive articles about cash recyclers this is the first empirical study of people recycling for cash. A new survey shows that cash recycling is an important part of the income of the working poor and that an astonishing twenty percent of the income of professional scavengers comes from recycling. At the same time professional and workplace recyclers are responsible for a large amount of new recycling. A rough estimate of the amount of new recycling generated by the recycling redemption centers in Santa Barbara, CA lies between 36% and 51% of all cash recycling. Based on the evidence presented here it is important for policy makers to consider structuring new bottle laws in ways that encourage professional recycling.

* Thanks are due to my advisors, Robert T. Deacon, Kelly Bedard, and Jon Sonstelie.

1. Introduction

The discussion about recycling programs most often revolves around voluntary participation in municipal curbside and drop-off recycling programs. This paper focuses not on these voluntary recyclers, but people who are earning income by collecting recyclable materials. In many major cities recycling for cash brings to mind the image of a homeless man pulling a shopping cart full of discarded soft drink bottles. Are other people recycling for cash? Is the image of the homeless man capturing the entire story? How much recycling income do people earn?

Recycling bottles and cans is a flexible way to earn income. Grab a shopping cart from the local grocer and you're off. It doesn't require a firm time commitment, a large capital investment, or a regular schedule. Sociologist Teresa Gowan finds that recent immigrants and homeless men are often active recyclers. She surveyed homeless men in San Francisco and recorded their stories about how they adopted this profession.[1] In "Homeless in America" Ronald Paul Hill and Mark Stamey describe recycling bottles and cans as "probably the first choice of homeless persons seeking money." Their research takes place in a large northeastern city and they find that the most commonly

[1] Gowan, Teresa, "American Untouchables: Homeless Scavengers in San Francisco's Underground Economy", *The International Journal of Sociology and Social Policy*, 17: 3-4 (1997), 159-190.

reported estimate of daily recycling income is $6.[2] A study of the homeless in Los Angeles by the Rand Institute found that about 20% of homeless persons who reported earning any income earned recycling income. The average value of this recycling income was $65 a month.[3] In this paper I use survey data from recycling centers in California to investigate the demographics of all cash recyclers. Is it reasonable to characterize cash recyclers as often being homeless, or are the homeless just a highly visible subset of the recyclers? I find that while the image of the homeless recycler that comes to mind is useful it is incomplete. In addition to the homeless recyclers, a surprising number of professional and work recyclers use trucks and vans to recycle both as a full-time job and as a second job. These innovative recyclers have found a way to recycle bottles and cans in areas where curbside recycling programs have failed, in particular in areas with lots of apartment buildings and small businesses.

Why is California a good place to start when studying cash recycling? In most states the total value of recycling is based on the value of the scrap metal. In California, along with the other ten states that have bottle bills[4], state law sets the value of beverage containers above the scrap value by the amount of a deposit paid by the consumer. So the same pound of aluminum that in 2002 was

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[2] Hill, Ronald Paul and Stamey, Mark, "The Homeless in America: An Examination of Possessions and Consumption Behaviors", *The Journal of Consumer Research*, Vol. 17, No. 3 (Dec. 1990), 303-321.

[3] Conroy, Stephen John, "Income Choices and Earnings of Homeless Persons", dissertation University of Southern California Department of Economics, December 1998, 111.

[4] The eleven states with bottle bills are: California, Connecticut, Delaware, Hawaii, Iowa, Maine, Massachusetts, Michigan, New York, Oregon, and Vermont.

worth $0.23 in Nevada was worth about a $1.00 in California. While deposit-refund programs are designed to encourage household recycling, there are still a large number of people who don't recycle for money. Recyclable containers that end up in either garbage or curbside recycling bins[5] become fair game for people collecting recyclable materials. I define cash recyclers as people who are specifically and consciously recycling bottles and cans they did not buy.

Who are the cash recyclers? In general they fall into two categories: 1) workers who are currently unemployed or outside of formal labor markets, and 2) low-wage workers. I use a labor supply model and a moonlighting model to explain this behavior. For the workers who are recycling as a second job, I find that the wage they earn recycling can either be higher or lower than their primary wage. Workers who face a binding constraint on the number of hours that they work at their primary job or who receive some utility from their recycling – say a nice walk on the beach – might recycle even if their recycling wage was less than their primary wage. People collecting recycling from garbage, litter, and recycling containers I call "professional recyclers." Another type of recycler is a moonlighter whose primary job enables them to recycle from their workplace, a restaurant or hotel. I call these people "workplace recyclers."

[5] For a study focusing on the efficiency of a deposit-refund program it is extremely important to know the source of the recyclable materials collected – garbage cans, litter, or recycling bins. In this paper I only focus on the income earned by the recyclers and not the value of their labor to society. For this reason it is not important whether or not the recycled materials are pulled from the garbage or curbside recycling bins.

While there are many descriptive articles[6] about cash recyclers this is the first study that looks empirically at people recycling for cash. Using survey data I draw a picture of the professional recyclers, estimate a recycling wage, and analyze what determines that wage. I also examine how the loss of this wage would affect the income distribution in the area surveyed. In other words, my research determines how socially useful recycling is as a tool for distributing income to the homeless men and other people recycling, without considering the source of the materials.

In order to formalize the role of the cash recycler I need to develop a theory of cash recycling. The theoretical literature that is the most relevant focuses on deposit-refund programs. A deposit-refund program is a consumption tax combined with a disposal rebate that is the equivalent of a Pigouvian tax. A Pigouvian tax charges the consumer a disposal fee that is equal to the marginal damage caused by the disposal. This covers the cost of disposal, but encourages illegal disposal by individuals trying to avoid paying the fee. Because of the possibility for illegal disposal the deposit-refund program is the most efficient way of internalizing the external costs of waste disposal. One of the most general models of a deposit-refund program is described in Fullerton and Wolverton (2000)[7]. This general equilibrium model loosens many of the

[6] For example an article in the Los Angeles Times in February, 2001 which tells the story of Rogelia and Yolanda Garcia who were putting two children through college by collecting bottles and cans in Venice (Cardenas).
[7] See also Sigman 1995, Fullerton and Kinnaman 1995, Palmer and Walls 1997.

assumptions of earlier theoretical models, in particular the assumption that the consumption tax is equal to the refund.

One assumption that has not been relaxed by Fullerton and Wolverton is the representative agent assumption.[8] In these models the agents have identical characteristics and as a result they all respond to the deposit-refund program in the same manner. People either all return the recycling that they purchase for the refund or they don't. The problem with using a representative agent model of a deposit-refund program is that people do not respond identically. This creates a situation in which the behavior of professional recyclers is prohibited by the assumptions of the model. In other words in these models there is nobody willing to dig through someone else's garbage looking for bottles and cans. If professional recyclers do receive a significant amount of income, or if their recycling adds up to a significant amount of the recycling returned, then it may be important for policy makers to structure new bottle laws in ways that encourage professional recycling. This paper specifically examines the income earned by professional and workplace recyclers.

2. The Model

The supply of professional recyclers may include people who recycle part-time or full-time. Full time recyclers are those for whom the wage that they receive recycling is higher than any market wage that they could earn. This

[8] In Fullerton and West 2002 the authors use heterogeneous consumers in their model, but because this paper deals with car pollution and not solid waste, it would be impossible for the recycling behavior discussed in this paper to occur.

would include people who are unemployable, people who are on some form of government aid that restricts their ability to work in the conventional labor force, or people with very poor job market opportunities, such as addicts or the homeless.[9] Part-time recyclers are under-employed, meaning they face a restriction on the number of hours that they can work at their labor market job. The model that I use to describe this behavior is a moonlighting model. In this model people can only work a fixed amount of time for their wage, but they might prefer to work longer. If the constraint on their wage labor is binding they would accept a second job at a lower wage and this will increase their utility.

I start with a utility maximization problem, where utility is a function of leisure (ℓ), and consumption (x). It is assumed that people value their time recycling in the same way that they value their time working at their labor market job.

There is a constraint on time such that: $T = R + L + \ell$ where

T is total hours that can be worked

R is the number of hours recycling

L is total hours of wage labor

ℓ is total hours of leisure

The budget constraint for the model is: $wL + sR = x$ where

s is the hourly recycling wage

[9] This paper focuses on professional recyclers and workplace recyclers, but also includes some information about households recycling their own bottles and cans.

x is a composite consumption good with a price of 1

w is the hourly wage in the labor market

$\overline{H}$ is the maximum number of wage hours that can be worked at the labor market job

The maximization problem is:

$$\underset{L,R,x}{Max} \quad U(T-R-L,x)$$

$$s.t. \quad wL+sR=x$$

$$\overline{H} \geq L$$

$$L \geq 0$$

$$R \geq 0$$

The Lagrangian for this problem, under the Kuhn-Tucker first order conditions is:

$$\mathcal{L}=U(T-R-L,x)+\lambda_1(wL+sR-x)+\lambda_2(\overline{H}-L)+\lambda_3 L+\lambda_4 R$$

The first order conditions follow:

$$U_L+\lambda_1 w-\lambda_2+\lambda_3 \leq 0 \qquad \frac{\partial}{\partial L}\cdot L=0$$

$$U_R+\lambda_1 s+\lambda_4 \leq 0 \qquad \frac{\partial}{\partial R}\cdot R=0$$

$$U_x-\lambda_1 \leq 0 \qquad \frac{\partial}{\partial x}\cdot x=0$$

$$wL+sR-x \geq 0 \qquad \frac{\partial}{\partial \lambda_1}\cdot \lambda_1=0$$

$$\overline{H} - L \geq 0 \qquad \frac{\partial}{\partial \lambda_2} \cdot \lambda_2 = 0$$

$$L \geq 0 \qquad \frac{\partial}{\partial \lambda_3} \cdot \lambda_3 = 0$$

$$R \geq 0 \qquad \frac{\partial}{\partial \lambda_4} \cdot \lambda_4 = 0$$

For workers who choose only to recycle the first-order conditions yield the condition:

$$\frac{U_R}{s} - \frac{\lambda_3}{w} = \frac{U_L}{w}$$

This model assumes that people value their time recycling in the same way that they value their time working at their labor market job so that $U_R = U_L$. Because the assumption is that these workers spend no time doing paid labor, λ_3 is positive. So in other words a worker will choose only to recycle when $s > w$.

For workers who choose both to recycle and work at a wage job, the conditions depend on whether the worker faces a binding restriction on the number of hours worked. If the restriction on number of hours worked is not binding then the first order conditions yield the simple equality $s = w$. However if the worker faces a binding restriction on the number of hours worked then the first order conditions yield the following inequality $s < w$. The binding restriction on hours worked in the labor market means that these workers are

willing to recycle even though their recycling wage is less than their market wage.[10]

3. The Survey Instrument

When reading the literature on cash recycling one thing became clear quickly: there was no data currently available that looked at all cash recyclers. The papers either focused on surveys of homeless people, or used case studies to illustrate their point. The unique dataset used for this analysis was created specifically to address the questions surrounding cash recycling empirically. In particular I was interested in how much money cash recyclers earned, how much of the total material recycled they had collected, and where the material came from. The survey instrument grew from these questions. The dataset is the result of a one month survey of all people returning bottles and cans for cash at several recycling centers.

The survey instrument was designed and then tested during a weeklong preliminary survey done at one of the main Santa Barbara area recycling centers. The data collected from this survey were used to understand how the system worked at the recycling center. The analysis of the preliminary data allowed me to redesign the survey: refining the original questions and adding new ones. Because of Santa Barbara area demographics the survey was administered in

[10] An alternative model would be to assume diminishing marginal returns to recycling. In this situation you could also find recyclers who were willing to work both at recycling and at their labor market wage. They would recycle until the value of the marginal product of their recycling wage was equal to their labor market wage or their other non-market wages. This might fit the homeless recyclers who are often doing multiple activities for cash: recycling, panhandling, etc...

both Spanish and English. According to survey methodology the survey was translated into Spanish by one translator and then translated back into English by a second translator. The two English versions were then compared to test for inconsistencies. In addition the translations were done by people familiar with the Mexican idioms of Spanish.

The data was collected using face-to-face surveys administered at the recycling centers. The recycling centers are located in Santa Barbara and Goleta, California. In July 2002 this area had three main recycling centers and five small buyback centers in supermarket parking lots. The final survey included results from one week spent at each of the high volume recycling centers as well as one week at one of the grocery store buyback centers. All people recycling for cash at a redemption center were approached while they were waiting to check out and asked to participate in the survey. The final question of the survey was a card on which the surveyor recorded the actual cash payment or the weight of each load brought to recycling center by the survey participant. This was reported individually for each material that was recycled: aluminum, glass, and plastic. In addition, because the surveys were face-to-face interviews, the surveyors were able to visually verify the answers to some of the survey questions. For example, household recyclers are quite easy to distinguish from professional recyclers both because of the volume and types of recycling that they bring. Many of the professional recyclers come to the recycling center several times a week. People

who visited the redemption center multiple times during the survey period were only asked to complete the survey once.

There are three main sections in the survey. In the first part of the survey the questions are about the recycled material and recycling activities of the respondent. These include where the recycled materials are from, how much time it takes to recycle, and how far out of their way did he or she have to travel to come to the redemption center. The second part of the survey questions the individual about his age, where he was born, his educational attainment, his household income, etc. The question about household income was asked using a separate card. This card categorized income levels as A: less than $10,000, B: $10,000 to $25,000, C: $25,000 to $50,000, D: $50,000 to $75,000 and E: more than $75,000. The respondent was asked to name the letter which corresponded most closely to their household income. The third part of the survey was a card filled out by the surveyor recording either the weight by material of the recycling brought into the center or in some cases the amount paid by the recycling center for each material recycled.

Six hundred and sixty participants completed the survey and about one third of them took the survey in Spanish. The refusal rate for the survey was 10%. In the survey the respondent was asked to identify from where the material they are recycling came. The answers include my home, my workplace, and all over. Then each person is asked what percentage of each material came from

their home. Because there were many people who brought recycling from more than one of these places the individual's recycling type was determined by the location from which the majority of their bottle and cans came. So, for example, if more than 50% of a person's recycling was from collecting bottles and cans from all over, I considered him a professional recycler. If more than 50% of her items came from her workplace, then I considered her a workplace recycler. The sample includes 102 professional recyclers, 65 workplace recyclers, and 527 household recyclers.

4. The Data

How much recycling does a community like the Santa Barbara area collect in a month? Table 1 reports estimates of the total amounts of California Cash Redemption Value materials (CRV) recycling in the Santa Barbara South Coast region[11] for the month of July, 2002. The weights are reported both by the type of recycler returning the material and by the type of material. From the survey data I calculate the percentages of each material brought by each recycler type; household, workplace and professional, to each of the redemption centers surveyed. I assume that these proportions are constant throughout the month of July. In addition, while the survey included all three of the high volume redemption centers in the region, it only included one of the supermarket

[11] The Santa Barbara South Coast is defined as the city of Santa Barbara, Goleta CDP and Isla Vista CDP. For the rest of the paper the community will be referred to as the Santa Barbara South Coast. A census-designated place (CDP) is an area identified by the United States Census for separate statistical reporting.

Table 1: July 2002 Total CRV[1] Recycling for the Santa Barbara South Coast from Redemption Centers[2] and Curbside Recycling Collection

Source of Recyclable Materials	Aluminum (lbs)	Total (%)	Glass (lbs)	Total (%)	Plastic (lbs)	Total (%)	All Materials (lbs)	Total (%)
Household Recyclers (Redemption Center)	43,433	49.5%	106,756	15.2%	13,021	18.6%	163,210	18.9%
Workplace Recyclers (Redemption Center)	6,420	7.3%	154,614	22.0%	3,320	4.7%	164,354	19.1%
Professional Recyclers (Redemption Center)	21,247	24.2%	214,360	30.4%	12,584	17.9%	248,191	28.8%
Curbside Aggregate for South Coast[3]	16,711	19.0%	228,333*	32.4%	41,228	58.8%	286,272	33.2%
Total CRV Recycling for South Coast	87,811		704,063		70,153		862,027	

Notes: In order to report these estimates I assume that the proportion of the recycling brought to each of the recycling centers is the same for the month of July as it was for the week the center was surveyed. In addition I assume that all of the grocery store parking lot recycling centers have the same proportions as the one that was in the survey. [1] CRV are bottles and cans that are included in the California Cash Redemption program. [2] Redemption centers are recycling supplied by the Santa Barbara County Department of Public Works, Solid Waste and Utilities Divison. * The number for centers which buy CRV materials and then receive payments from the State for these materials. [3] This information was supplied by the Santa Barbara County Department of Public Works, Solid Waste and Utilities Divison. * The number for glass reported in this chart is the estimated amount of CRV glass captured by the curbside recycling program for all of Santa Barbara County and was supplied by the California Department of Conservation, Division of Recycling. This number is an upper bound because it was not possible to secure the amount of CRV glass in the South Coast recycling region.

buyback centers[12]. In order to overcome this I assume that the recycling proportions are the same at each of the supermarket buyback centers. I then apply these proportions to the total amount of recycling collected by each recycling center[13] during the month of July. It is clear that the different recycler types return different materials for recycling. Households bring in about 50% of the aluminum being recycled. Workplace recyclers disproportionately recycle glass accounting for 22% of the total glass recycled. Professional recyclers bring everything and account for about 29% of the total weight of materials being recycled. The curbside recycling program accounts for about one third of all the CRV materials recycled on the Santa Barbara South Coast.

Table 2 gives the breakdown of the reported household income levels by the type of recycler. Professional recyclers come from the lowest income brackets in the community, 56% of them live in households with an annual income less than $10,000. In the surrounding community only 9% of households fell in that income bracket. The income distribution for the surrounding community is based on the 2000 Census information for the Santa Barbara South Coast. The household income question is included on the census long form and the distribution is estimated from the sample of households which answers this

[12] The disaggregated data is proprietary, but to give you an example the average amount of Aluminum for the larger centers was over 9.5 tons and for the supermarket buybacks the average was about 1.5 tons, for glass the averages are approximately 75 tons and 2 tons and for plastic they are about 3.5 tons and 1.5 tons.

[13] The total amount of recycling collected by each recycling center was supplied by the California Department of Conservation, Division of Recycling.

Table 2: The Breakdown of Household Income Level by Recycler Type

Household Income Level	Sample		Household		Workplace		Professional		Community	
	Obs.	Percent	Obs.	Percent	Obs.	Percent	Obs.	Percent	Obs.	Percent
Less than $10,000	108	19%	63	14%	3	5%	42	56%	5,414	9%
$10,000 to $24,999	165	29%	127	29%	16	28%	22	29%	9,702	16%
$25,000 to $49,999	156	27%	126	29%	22	39%	8	11%	16,036	26%
$50,000 to $75,000	74	13%	65	15%	7	12%	2	3%	11,521	19%
Over $75,000	69	12%	59	13%	9	16%	1	1%	18,171	30%
Responses	572		440		57		75			
No Response	122		87		8		27			
Response Rate for Income Question	82%		83%		88%		74%			

Notes: The Community observations and percentages are based on the 2000 Census information for Santa Barbara city, Goleta CDP and Isla Vista CDP. The income question is on the Census long form and therefore is estimated from a sample (1 in 6 households).

form. This information is therefore only an estimate and should be treated as such.

Among the household and workplace recyclers the lower income brackets are disproportionately represented at the recycling centers. Fifty eight percent of the household recyclers and sixty seven percent of the workplace recyclers fall into the $10,000 to $49,999 income brackets. The representation of the higher income brackets is sparse. This may be because higher income recyclers were less likely to answer the question, but it is also consistent with the recycling model in the paper. The income distribution of the sample is consistent with the idea that there is a transaction cost associated with returning recycling to the centers even for households returning bottles and cans that they purchased. They may spend very little time collecting and organizing their recycling, so for them the largest part of the transaction cost of recycling is the time that it takes. Higher income households face a higher market wage, which makes the opportunity cost of their time high. For lower income households the value of the bottles and cans are more likely to outweigh the cost in time of cashing it in.

There are many variables that may factor into a household's decision to return their recycling to a redemption center; including the quantity of CRV materials used on a regular basis by the household, space to store the bottles and cans as they collect, and the presence of children (who have a very low value on

their time) in the household.[14] Additionally, it seems that the decision to return the bottles and cans may be made at the time of purchase. For example, suppose when I buy a case of water I decide that I won't return the bottles. If that is the case then I will consider the CRV deposit as part of the price of the water, and adjust my purchase of the bottles accordingly. Alternatively, I may decide that I will return the bottles for the deposit and so I do not include the deposit as part of the bottle price when I choose how many bottles to consume. In the second scenario, I may find when I actually prepare to return the bottles to a redemption center that this is not the best use of my time. However, because I decided at the time of purchase to get my refund, I may stick to that decision even if the transaction cost of returning the bottles is higher than the refund that I receive. This type of model would allow consumers, for whom the transaction cost of returning their bottles is higher than their refund, to return their recycling to a redemption center, without violating the model.

Table 3 reports the means and standard deviations of the descriptive variables for Santa Barbara South Coast community, for the entire sample, and for each recycler type. The means for the community characteristics are taken from the 2000 Census fact sheets for these areas and are as close to the question asked in the recycling survey as possible. For each of the community

[14] I can not formally test these assertions because I only have households in my dataset who have chosen to recycle at redemption centers. However, Table 4 does compare the demographic characteristics of the households in the dataset to the average community characteristics.

Table 3: Recycler Characteristics

	Community	Sample	Household	Workplace	Professional
Variable	Mean	Mean	Mean	Mean	Mean
Survey in Spanish[B]	0.125[1]	0.305	0.270	0.323	0.479
		(0.461)	(0.445)	(0.471)	(0.502)
born-US[B]	0.767	0.593	0.634	0.516	0.426
		(0.492)	(0.482)	(0.504)	(0.497)
born-Mexico[B]	0.138[2]	0.328	0.304	0.355	0.436
		(.470)	(0.461)	(0.482)	(0.499)
married[3B]	0.463	0.563	0.575	0.627	0.453
		(0.496)	(0.495)	(0.488)	(0.501)
child < 18 in house[A]	0.28	0.355	0.373	0.458	0.186
		(0.479)	(0.484)	(0.502)	(0.391)
household size[A]	2.59	3.53	3.56	3.32	3.44
		(1.965)	(1.929)	(1.795)	(2.315)
age		46.2	45.3	43.5	53.1
		(16.02)	(15.93)	(13.20)	(16.44)
student		0.138	0.142	0.119	0.108
		(0.345)	(0.349)	(0.326)	(0.313)
"retired"		0.216	0.202	0.100	0.349
		(0.411)	(0.402)	(0.303)	(0.480)
female[A]	0.506	0.277	0.315	0.167	0.144
		(0.448)	(0.464)	(0.376)	(0.354)
no high school[4B]	0.079	0.240	0.202	0.218	0.458
		(0.428)	(0.402)	(0.417)	(0.501)
high school[4B]	0.246	0.261	0.255	0.327	0.253
		(0.440)	(0.436)	(0.474)	(0.437)
college[4B]	0.675	0.498	0.544	0.455	0.289
		(0.500)	(0.499)	(0.503)	(0.456)
income[5B]	$47,790	$34,598	$36,801	$39,298	$18,100
		(22,347)	(22,375)	(21,494)	(14,750)

Notes: Standard deviations are in parentheses. Community means are based on the 2000 Census information for Santa Barbara city, Goleta CDP and Isla Vista CDP. Variables marked with an A are calculated from the Census short form (100% data). Variables marked with a B are calculated from the Census long form (1 in 6 households). [1]This mean is taken from Spanish speakers who report speaking English less than "very well". [2]This is reported in the Census as born in Latin America. [3]This variable is for a population age of 15+. [4]The educational attainment variables are for a population age of 25+. [5]These incomes are reported in brackets. For the analysis the incomes are coded at midpoints except for the highest and lowest brackets which are coded as $10,000 and $75,000.

characteristics the information is either from the short form, which is a census or from the long form, which is a sample. The community variables which are taken from the Census short form are: whether there is a child under the age of 18 in the household (kid<18 in house), household size and female. The community variables which are taken from the Census long form are: survey Spanish, born-US, born-Mexico, married, no high school, high school, college, and income.

Survey Spanish is a dummy variable for if the survey was given in Spanish. For the community variable I used the proportion of Spanish speakers who report speaking English less than "very well". Born-US and born-Mexico are dummy variables for the country of the respondent's birth. For born-Mexico the community data I use the number of people born in Latin America, which is an upper-bound for people born in Mexico. Married is a dummy variable for marital status. The educational attainment variables are restricted to respondents over the age of 25. No high school is for respondents without any high school education. High school includes students who attended any high school, graduated from high school, or earned a GED. College is a dummy variable which includes some college as well as college graduates. Income is household income aggregated into the same income brackets as the survey results and it is coded at midpoints, the minimum ($10,000) and the maximum ($75,000). For

the community variable the Census income brackets are recoded to be consistent with the survey income brackets.

Table 4 reports the results of t-tests comparing the means for the sample as a whole and the means for each recycler type to the means of the community characteristics. Only the means and the t-statistics for the variables that are statistically significantly different are reported. For the variables taken from the census long form, and are therefore estimated from a sample, I am unable to obtain the standard deviations or the raw data for the Santa Barbara South Coast. For this reason I assume that the estimated census mean is the true population mean.

People returning recycling to the redemption center are not representative of the surrounding community. People who recycle are more likely to be primarily Spanish speaking, less likely to be born in the United States and more likely to have been born in Mexico. People in the sample have larger households, are more likely to have a child under the age of 18 in the household, and more likely to be married. The recyclers are more likely to have no formal high school education, less likely to have attended college, and their mean income is lower. Surprisingly they are also less likely to be women. It is also true that these differences are true across the board, no matter whether this is a household, workplace, or professional recycler. The only exception is that only household and workplace recyclers are more likely to be married and to have a

Table 4: T-test Comparing the Sample and Recycler Types to the Community Characteristics

Variable	Community Mean	Sample vs. Community	Household vs. Community	Work vs. Community	Professional vs. Community
Spanish Survey[B]	0.1251	0.305	0.27	0.323	0.479
		(10.029)	(7.334)	(3.301)	(6.829)
born-US[B]	0.767	0.593	0.634	0.516	0.426
		(9.07)	(6.178)	(3.921)	(6.66)
born-Mexico[B]	0.1382	0.328	0.304	0.355	0.436
		(10.370)	(8.093)	(3.540)	(5.798)
married[3B]	0.463	0.563	0.575	0.627	
		(5.044)	(4.955)	(2.585)	
kid < 18 in house[A]	0.28	0.355	0.373	0.458	0.186
		(3.967)	(4.244)	(2.715)	(2.226)
household size[A]	2.59	3.53	3.56	3.32	3.44
		(11.892)	(11.168)	(3.133)	(3.180)
female[A]	0.506	0.277	0.315	0.167	0.144
		(13.001)	(9.197)	(6.994)	(9.703)
no high school[4B]	0.079	0.240	0.202	0.218	0.458
		(9.041)	(6.383)	(2.476)	(6.886)
college[4B]	0.675	0.498	0.544	0.455	0.289
		(8.462)	(5.503)	(3.254)	(7.707)
income[5B]	$47,790	$34,598	$36,801	$39,298	$18,100
		(14.12)	(10.30)	(2.98)	(17.66)

Notes: The T-statistic for a two-sided test that the mean is equal to the community mean is in parentheses. Community means are based on the 2000 Census information for Santa Barbara city, Goleta CDP and Isla Vista CDP. Variables marked with an A are calculated from the Census short form (100% data). Variables marked with a B are calculated from the Census long form (1 in 6 households). [1]This mean is taken from Spanish speakers who report speaking English less than very well. [2]This is reported in the Census as born in Latin America. [3]This variable is for a population age of 15+. [4]The educational attainment variables are for a population age of 25+. [5]These incomes are reported in brackets. For the analysis the incomes are coded at midpoints except for the highest and lowest brackets which are coded as $10,000 and $75,000.

child under the age of 18 in the household than people in the surrounding community. Professional recyclers are actually less likely than the community to have a child in the household.

In Table 5 the recyclers are compared against one another. This Table reports the means and t-statistics for the variables for which the mean value is statistically significantly different across recycler types. The first column compares the household recyclers to the workplace recyclers, the second column compares the workplace recyclers to the professional recyclers and the third column compares the household recyclers to the professional recyclers. The clearest differentiation here is between the professional and household recyclers. The professional recycler is more likely to have been born in Mexico and more likely to take the survey in Spanish. Professional recyclers are older and more likely to be retired. They are less likely to be married or to have children under the age of 18 and they are more likely to be men. They have less education and lower incomes than the household recyclers.

Professional and workplace recyclers are also significantly different. The workplace recyclers are younger, by almost 10 years, and are more likely to be married. In addition they have higher levels of education. Household and workplace recyclers are for the most part indistinguishable. Workplace recyclers are less likely than household recyclers to be retired; this is essentially true by definition. Workplace recyclers are also more likely to be male. The fact that

Table 5: 2-Sample T-test of the Means with Unequal Variances by Recycler

Variable	Household vs. Work		Work vs. Professional		Household vs. Professional	
Spanish Survey			0.323	0.479	0.27	0.479
			(1.97)		(3.756)	
born-US	0.634	0.516			0.634	0.426
	(1.749)				(3.753)	
born-Mexico					0.304	0.436
					(2.384)	
age			43.5	53.6	45	53.6
			(4.092)		(4.465)	
retired	0.203	0.102	0.102	0.365	0.203	0.365
	(2.318)		(3.995)		(2.913)	
female	0.315	0.167			0.315	0.144
	(2.803)				(3.988)	
married[1]			0.627	0.453	0.575	0.453
			(2.083)		(2.071)	
kid <18 in house			0.458	0.186	0.373	0.186
			(3.488)		(3.928)	
no high school[2]			0.218	0.458	0.202	0.458
			(3.047)		(4.392)	
college[2]			0.455	0.289	0.544	0.289
			(1.963)		(4.587)	
income[3]			$39,298	$18,100	$36,801	$18,100
			(6.412)		(9.393)	

Notes: T-statistics are in parentheses. [1]This variable is for a population age of 15+. [2]The educational attainment variables are for a population age of 25+. [3]These incomes are reported in brackets. For the analysis the incomes are coded at midpoints except for the highest and lowest brackets which are coded as $10,000 and $75,000.

the workplace recyclers resemble household recyclers is consistent with the idea that recycling is an informal part of their wage. They see the recycling payment as a weekly or monthly bonus.

4. The Results

A. Hourly Wage

What do people earn per hour or per year recycling? Using information from the survey about the frequency and length of time that recyclers devote to collection I estimate an hourly wage for professional recyclers. The hourly recycling wage is simply the exact value of the recycling returned to the recycling center by an individual divided by the time that he reported it took him to collect that load. The summary statistics for the hourly wage are reported in Table 6 for professional recyclers and workplace recyclers. Also included in Table 6 is the average wage estimated by the professional recyclers. The average wage for professional recyclers was $6.33. This is just a bit below the California minimum wage, which was raised from $6.25 to $6.75 on January 1, 2002. The median recycling wage is $2.31. There are four observations at the right-side tail of the wage distribution that are pulling this mean up, but I have no reason to believe that they do not belong in the sample. The estimated wage is the wage that they recyclers themselves believe that they are earning. The mean value of the estimated wage is $3.74 and the median is $3.00. The recyclers

themselves are clearly aware that the wage they earn is likely below the minimum wage.

Workplace recyclers are defined as people bringing material primarily from their place of work and who keep the money they earn. It turns out that about half of the workplace recyclers are on the clock while they are recycling, reinforcing the notion that this income is really just a bonus from their employer. Table 6 reports both the calculated mean wage for this kind of recycling and also the mean value of the recycling cashed in. The mean workplace recyclers wage is $65.85 and the median is $31.49. As with the professional recycling wage there are four observations at the right-side of the distribution pulling this mean up. The work wage is calculated using the cash amount paid to the recycler for the material from their workplace divided by the time that they reported it took them to collect and bring in the recycling.

The error in the mean wages calculated comes entirely from the estimate of the time it took to collect the load of bottles and cans. It is important to keep in mind that a high recycling wage can reflect a small amount of time worked. This is particularly problematic with the workplace recyclers. The workplace recyclers came to the redemption center less frequently and appeared to be less sure about the amount of time that they spent recycling. In many cases when asked how long it took them to collect the recycling they would answer "Oh, no time at all". They were then prompted to give an exact time. It seemed like the

Table 6: Estimated Recycling Wages for Professional and Workplace Recyclers

	Mean	Median	Standard Deviation	Observations
Professional Wage	6.33	2.31	12.68	77
Professional's Estimated Wage	3.74	3.00	3.62	60
Work Wage	65.85	31.49	102.54	48
Work Total	27.90	12.91	40.92	55

Notes: The Professional's estimated wage is the amount that the individual recycler believed that he was earning by recycling. The work total is the total amount of recycling the work recycler was paid for during this visit to the recycling center.

amounts of time were so short on a daily basis that they were likely to underestimate the time that it took them to recycle. If these workers are consistently underestimating the time that it takes them to recycle this would result in an overestimated wage for these workers. For this reason Table 6 includes the actual value of the load of recycling brought to the center. The mean value of the recycling brought by the workplace recyclers is $27.90. If it takes about half an hour to bring the recycling from work and unload it and head back you end up with a mean wage of $55.80, not too far from the estimated average wage of $65.85. The average distance that the recyclers travel to the recycling center is 5 miles.

B. Annual Income

How much income does recycling amount to annually? Table 7 gives the annual mean recycling income for both workplace and professional recyclers. The standard deviation and median recycling income are also reported. In order to find these values I aggregate the value of the recycling returned during the survey based on how often the person reports that they recycle. For this estimate the only assumptions that I make are that each person recycling in the sample is bringing roughly his normal load to the recycling center and that he was accurately able to report how frequently he recycles. The payment that each person received is then inflated based on the frequency of their visits to the recycling center. I do this for household, workplace and professional recyclers.

Table 7: Annual Mean Recycling Income for Professional and Workplace Recyclers

	Mean	Standard Deviation	Median	Mean Percentage of Total Income
Professional	$2,789	$5,244	$667	22.10%
Workplace	$1,185	$3,353	$211	3.30%
Households	$161	$392	$65	0.67%

Notes: For households this is the amount of the deposits that they paid on the bottles and cans that they purchased that they claimed from redemption centers.

For the household recyclers this is not an income transfer, it is a refund of money that they paid in deposit when they purchased the bottles and cans. It may be useful to think of this as a tax on disposal that the households are choosing not to pay.

The mean annual recycling income is $2,789 for the professional recyclers, $1,185 for the workplace recyclers, and $161 for household recyclers. In addition I create a new variable, the mean percentage of household income represented by the recycling income. This variable is the ratio of the annual recycling income to reported household income for each recycler. The mean of this variable is reported for household, workplace and professional recyclers. What is remarkable is that for the professional recyclers $2,789 represents about twenty two percent of their annual household income. For the workplace recyclers their recycling income represents, on average, just over three percent of their household income. For both professional and workplace recyclers this does not include the recycling that comes from their own household. For the household recycler the $161 mean annual refund amounts to less than one percent of household income.

Because the annual income variable depends on the assumption that the recycler is bringing his normal load to the recycling center, someone having a good day or a bad day will increase the variation. Dropping the four highest professional recycler observations lowers the mean percentage of total household

income to about fifteen percent, still a significant percentage. The income from recycling appears to be extremely important to the professional recyclers.

C: Determinates of the Recycling Wage and Hours Spent Recycling

Most of the data collected in the survey is demographic along with some behavioral information. In Table 8 I use some of the average characteristics of the recyclers to try and identify characteristics that determine the recycling wage of professional recyclers (s), and the number of hours that they choose to work. The variables may reflect the recycler's productivity and therefore explaining the recycler's wage. The variables in the regression include educational attainment dummy variables: whether the recycler has no high school education or attended college. A high level of educational attainment may make a recycler more productive than a lower level of educational attainment. Or high educational attainment might pick up the less productive homeless recyclers and others with low job prospects. In this case someone with a higher level of education working in such a low-skill job is likely a signal that there may be some other problem preventing him from participating in the formal labor market. The regression also includes individual characteristics including whether the survey was administered in Spanish, the recycler's gender, age, and marital status. A recycler taking the survey in Spanish might be more productive than a recycler taking the survey in English since language and possibly citizenship constraints may keep her out of the formal labor market.

Table 8: Determinants of Professional Recycler's Hourly Wage and Hours Worked

	Log of Recycling Wage	Hours Recycling	Log of Hours Recycling
No High School	0.343	213.213	-0.017
	(0.554)	(226.108)	(0.601)
Some College plus	-0.273	160.674	0.235
	(0.533)	(164.974)	(0.452)
Spanish language survey	0.194	268.606	-0.371
	(0.555)	(230.432)	(0.686)
Female	-0.305	-173.777	-0.010
	(0.559)	(290.203)	(0.667)
Age	-0.002	13.167	0.047***
	(0.017)	(6.815)	(0.016)
Married	0.062	-398.617	-0.158
	(0.480)	(287.371)	(0.560)
Child under 18 in house	-0.001	359.781	0.442
	(0.709)	(348.782)	(0.689)
Miles to Recycling Center	-0.048	-8.252	0.014
	(0.052)	(23.454)	(0.052)
Curbside Service at Home	-0.171	30.270	-0.027
	(0.353)	(205.692)	(0.459)
Obs.	66	67	67
R2	0.083	0.127	0.174

Notes: Robust standard errors are in parentheses. Regression includes a constant term. ***, **, and * are significance at the 1%, 5% and 10% level, respectively.

Finally household characteristics like whether or not there is a child under the age of 18 in the household, how far the recycler had to travel to the recycling center, and whether they have curbside recycling service at their home are also included in the regression. Families with small children may have a low value of time spent while acting as the primary caregiver. If the recycling center is far away the costs of recycling may be higher, resulting in a lower recycling wage. The presence of curbside recycling bins may make recyclers more aware of the income they can earn, and it should be easier to collect recycling if it is already sorted out of the garbage for you, resulting in a higher wage. Of course this may lead to more competition between recyclers, which could result in a lower wage. As shown in Table 8 it turns out that none of the explanatory variables are significant in explaining the wage or hours spent recycling.

D: Determinates of Taking Materials From Curbside Recycling Bins, Recycling as Only Paid Labor, and Recycling Aluminum

Another interesting question to investigate is whether or not the same set of recycler characteristics, adding only whether they describe themselves as retired, determines some of the other behavioral choices of the recyclers. In particular I look at whether or not the recycler reports that they take recycling from curbside recycling bins, whether recycling is the only paid labor that they perform, and finally whether or not they choose to recycle aluminum.

Table 9 reports the results (probit marginal effects and the standard errors) for each of the behavioral traits examined as a function of the demographic, human capital and household characteristics previously defined adding only whether the respondent identifies themselves as retired. Recyclers with no high school education were 36.2 percentage points more likely to take materials from curbside recycling bins while recyclers who took the survey in Spanish were 52.6 percentage points less likely to do so. Recyclers who are married are 24.2 percentage points more likely to take from curbside recycling while those who have curbside recycling service at their residence are 18.8 percentage points less likely to do so.

Whether a recycler takes bottles and cans from the curbside bins is self-reported. It may be that the recyclers with less formal education were more likely to respond honestly to this question, perhaps because they may be less aware of when it is legal and when it is illegal to remove materials from curbside containers. In fact, these rules not transparent. In the city of Santa Barbara it is illegal to remove recycling from a curbside recycling container "without the express consent of the property owner of the property (or the owner's tenant) upon which the recyclable material or container is located."[15] The Santa Barbara County Code allows only the owner or business who generated the recycling to

[15] Santa Barbara Municipal Code 7.16.305

Table 9: Determinants of Taking from Curbside, Recycling as Only Paid Labor and Recycling Aluminum

(Probit Marginal Effects and Standard Errors)

	Take from Curbside Bins	Recycling Only Paid Labor	Recycle Aluminum
No High School	0.362**	0.345	0.027*
	(0.147)	(0.201)	(0.026)
Some College plus	0.001	-0.322	-0.005
	(0.121)	(0.223)	(0.011)
Spanish language survey	-0.526***	-0.602**	-0.008
	(0.129)	(0.186)	(0.016)
Female	-0.150	0.528***	-0.164**
	(0.070)	(0.081)	(0.150)
Age	-0.004	0.018**	0.001*
	(0.004)	(0.008)	(0.001)
Retired	0.171	0.471**	0.119***
	(0.147)	(0.155)	(0.070)
Married	0.242*	-0.334	0.002
	(0.131)	(0.202)	(0.009)
Child under 18 in house	0.030	0.114	0.001
	(0.150)	(0.220)	(0.007)
Miles to Recycling Center	-0.011	0.023	-0.001***
	(0.011)	(0.022)	(0.001)
Curbside Service at Home	-0.188*	0.083	-0.081***
	(0.093)	(0.084)	(0.060)
Obs.	69	63	69
Pseudo R^2	0.241	0.429	0.417

Notes: Robust standard errors are in parentheses. Regression includes a constant term. ***, **, and * are significance at the 1%, 5% and 10% level, respectively.

remove recycling or the "authorized recycling contractor"[16] who has an exclusive franchise negotiated with the County. The penalty for a first offense is a fine of no more than $100 according to both the Municipal and the County Codes.[17] According to the Santa Barbara Police Department and the University of California, Santa Barbara Police Department, complaints are extremely infrequent and generally not prosecuted. There is not a lot of support for arresting recyclers in Santa Barbara County. In fact in the Isla Vista CPD, next to the University of California, Santa Barbara campus, the officers generally feel that the recyclers are doing an extremely valuable community service by cleaning up after the students.[18]

When recyclers were asked about removing materials from curbside recycling bins during the pre-test of the survey, at a large redemption center in Goleta, they did not seem to find the question incriminating. Forty eight percent of the professional recyclers reported that they took some material from curbside recycling bins. During the actual survey only twenty one percent of the recyclers admitted to taking materials from the curbside bins. The recycling center from the pre-test of the survey was surveyed a second time during the final survey. It is possible that, having been asked this question previously, the recyclers were more aware that the removal of recycling from curbside containers was not legal,

[16] Santa Barbara County Code 17.29
[17] Santa Barbara Municipal Code, 1.28.030, Santa Barbara County Code 17.82
[18] USCB Officer Mark Larson, telephone interview June 3, 2003

and less likely to respond honestly. In addition there were very few homeless recyclers in the pre-test because most of the homeless collect bottles and cans in the denser downtown Santa Barbara area. The homeless recyclers that I met were very aware of the legality of taking recycling from the curbside bins and they generally denied ever doing that.

Recyclers who took the survey in Spanish were 60.2 percentage points less likely to have recycling as their only form of paid labor than recyclers who were comfortable taking the survey in English. Women were 52.8 percentage points more likely than men to have recycling be their only form of paid labor, which may be because women are more likely to perform unpaid labor in the household anyway. Retired recyclers were 47.1 percentage points more likely more likely to have recycling be their only source of wage income.

Aluminum is the most desirable material to recycle for two reasons; it is the most valuable per pound (in July 2002 it was worth from $0.77 to $1.00 a pound) and is easy to crush, so that it takes up less volume per pound and can be stored and transported more easily than any of the other materials. Because of these traits however, aluminum is also the most sought after material and there is more competition for the material available. There are in fact some recyclers who choose to recycle only aluminum. Recyclers who are retired are 11.9 percentage points more likely to recycle aluminum than recyclers who are not retired. This may be because of the ease with which aluminum can be

transported. Women and people who have curbside recycling at their residence are less likely to recycle aluminum, by 16.4 and 8.1 percentage points respectively.

5. Conclusions

Workplace recyclers are people in low-wage service jobs. They work in bars, restaurants and hotels, and earn a bonus recycling bottles and cans. These recyclers are not easy to distinguish from households that return their recyclable materials for cash. They are likely to be married men and women with children under the age of 18 living in their household.

Professional recyclers are different. They are more likely to be Spanish speaking and less likely to be born in the United States. They are older, more likely to be retired, and less likely to be female, married and to have small children. They have less education and a lower mean income. And their recycling income is an important part of their income.

Recyclers for profit receive a meaningful economic benefit from their recycling activities. Professional scavengers have chosen this profession and they rely on the income that they earn. How a bottle law is designed has a large effect on whether or not a significant amount of scavenging will occur. Scavenging can be effectively limited by specific rules about returning bottles and cans. In many states, like New York, retailers are only required to accept the particular bottles and cans of the products that that they sell. In Oregon retailers

may refuse to accept more than 144 containers per day from a single individual. These policies reduce the recycling wage and decrease the number of professional recyclers.

What are the benefits provided by recycling for profit? Recycling provides otherwise unemployed people with a wage to fall back on, a temporary buffer when they are in between jobs or during periods when they are able to work. It allows underemployed people to supplement their income at will. From the analysis in this paper recycling increases the annual income of the professional recyclers by fifteen to twenty two percentage points. Recycling for profit also increases the amount of materials recycled, thus decreasing the amount of waste headed to landfills. Beverage container litter is decreased. Designing a deposit-refund program that encourages recycling for profit will allow states to reach higher redemption rates than states with programs that discourage recycling for profit.

What is one of the main costs of a bottle bill in the presence of curbside recycling programs? Recycling companies complain about the loss of valuable materials from the curbside recycling bins, in particular aluminum. Often this pilfering of the recycling bins is blamed on professional recyclers. A study in the San Francisco area estimated that scavengers were diverting 25% of glass, 30% of PET plastic, and 50% of aluminum from curbside recycling programs.[19] This

[19] Berck, p.33

is in San Francisco, a population dense county, estimated to have curbside recycling programs that cover 75-100% of the population of the county.

Santa Barbara County is less dense than San Francisco and in 2002 it was estimated that curbside recycling programs covered only 25-50% of the county's population. These differences will mean that pilfering from curbside is less likely to be a problem; there are fewer curbside bins, and the less populated areas are less conducive to scavenging. Comparing the results of the pre-survey to the final survey I not only found a difference in the amount of recyclers who admitted to taking bottles and cans from the curbside containers discussed earlier in the paper, but also a difference in how much recycling they admitted to removing from the bins. In the pre-survey, when the recyclers seem less cautious about answering this question, recyclers reported taking about 21% of their materials from curbside bins. In the final survey the recyclers reported taking on average 9% of their materials from curbside bins. For the purpose of this paper I use 50% as an estimate of the amount of professional recyclers' materials that comes from the curbside recycling bins a number closer to the San Francisco numbers, but I believe this is an upper bound.

Table 10 reports the figures originally in Table 1, the total CRV recycling for the Santa Barbara south coast from redemption centers and curbside recycling collection by recycler type for July 2002. However, in table 10 the amount of recycling for each recycler trip is divided by whether or not the household,

Table 10: July 2002 Total Recycling for the Santa Barbara South Coast from Redemption Centers[1] and Curbside Recycling Collection sorted by Access to Curbside Recycling Service

Source of Recyclable Materials	Aluminum (lbs)	Total (%)	Glass (lbs)	Total (%)	Plastic (lbs)	Total (%)	All Materials (lbs)	Total (%)
Household Recyclers with Curbside (Redemption Center)	31,428	36%	74,701	11%	8,816	13%	114,945	13%
Household Recyclers without Curbside (Redemption Center)	12,054	14%	28,513	4%	4,198	6%	44,765	5%
Workplace Recyclers with Curbside (Redemption Center)	1,635	2%	21,817	3%	854	1%	24,306	3%
Workplace Recyclers without Curbside (Redemption Center)	4,667	5%	134,442	19%	2,220	3%	141,330	16%
Professional Recyclers from Curbside[1] (Redemption Center)	10,658	12%	108,128	15%	6,418	9%	125,204	15%
Professional Recyclers from Trash[1] (Redemption Center)	10,658	12%	108,128	15%	6,418	9%	125,204	15%
Curbside Aggregate for South Coast[2]	16,711	19%	228,333*	32%	41,228	59%	286,272	33%
Total Recycling for South Coast	87,811		704,063		70,152		862,026	

Notes: In order to report these estimates I assume that the proportion of the recycling brought to each of the recycling centers is the same for the month of July as it was for the week the center was surveyed. In addition I assume that all of the grocery store parking lot recycling centers have the same proportions as the one that was in the survey. [1]This assumes that half of the recycling collected by the Professional recyclers is from trash and litter. [2]This information was supplied by the Santa Barbara County Department of Public Works, Solid Waste and Utilities Divison. * The number for glass reported in this chart is the estimated amount of CRV glass captured by the curbside recycling program for all of Santa Barbara County and was supplied by the California Department of Conservation, Division of Recycling. This number is an upper bound because it was not possible to secure the amount of CRV glass in the South Coast recycling region.

workplace, or professional removed the materials from curbside collection. In fact my survey of the recycling received at the redemption centers shows that as much material is pulled from the curbside recycling containers by the household recyclers themselves as by professional recyclers.

In fact, because professional and workplace recyclers do not stay away from plastic and glass they are responsible for a large amount of new recycling generated by the bottle bill. I define new recycling as recycling that would not have been captured by pre-existing curbside recycling programs. Table 11 reports that assuming that all the materials collected by professional recyclers is new recycling then 51% of the total weight of the recycling collected through redemption centers, and as a result of the bottle bill, is new recycling. Assuming that half of the material collected by professional recyclers is taken from curbside recycling the amount of new recycling generated by the redemption centers is still 36%. The true value lies somewhere in the middle.

Table 11: New Recycling

Assuming all Professional Recycling is from Trash	Weight (lbs)	Percent of Total CRV Recycling
Total materials that could be captured by existing curbside programs	425,523	49%
Total materials that could not be captured by existing curbside programs	436,503	51%
Assuming 50% of Professional Recycling is from Curbside Bins	**Weight (lbs)**	**Percent of Total CRV Recycling**
Total materials that could be captured by existing curbside programs	550,727	64%
Total materials that could not be captured by existing curbside programs	311,299	36%

This paper does not attempt to answer the question; should curbside recycling programs and bottle bills co-exist? The answer depends as much on the geographic and demographic characteristics of the state, as on the design of the bottle bill that is enacted. Bottle bills do generate increased recycling rates over areas that exclusive recycle through curbside recycling programs. In addition much of this recycling is through the work of professional recyclers, and these recyclers gain significant financial gains from their recycling activity. Future research should examine the conditions under which bottle bills are complementary to curbside recycling programs within a state and when they are only in competition.

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Appendix A: English Language Survey

Question 35 CARD

A Less than $10,000

B $10,000-$25,000

C $25,000-$50,000

D $50,000-$75,000

E More than $75,000

Question 36 CARD

Survey Number_____

Please write the weight or the cash refund you received for each material that you recycled. Thank you very much.

Glass	**Aluminum**	**Plastic**
_____ **lbs**	_____ **lbs**	_____ **lbs**
OR	**OR**	**OR**
_____ **$**	_____ **$**	_____ **$**

Recycling Survey Number _____

Date _____

Surveyor _____

1. **I am a student at UC Santa Barbara and I am doing an anonymous survey of people who are returning their recycling for refund for a school project. Are you willing to answer a few questions about your recycling and yourself? Y N (If no ask 3,14,17,19, 21)**

First I am going to ask you some questions about your recycling.

2. **How many miles out of your way did you travel to come to the Recycling center today? _____ miles**

3. **Where is your recycling from?** ***circle all that apply***

   my own household my workplace all over

Ask only workplace recyclers questions 4,5, 6, and 7

4. ***Do you have curbside recycling pickup at your workplace? Y***

   N

5. ***How much time, between trips to the recycling center, do you spend on recycling at your workplace?*** _____ ***hours*** ***OR*** _____ ***minutes.***

6. ***Are you recycling during work hours?*** ***Y*** ***N***

7. ***What happens to the refund?*** ***Keep it*** ***Goes to Work*** ***Petty Cash*** ***Other*** _____

Ask only the people who bring recycling from all over questions 19-23

8. On average, how often do you go out to collect materials for recycling?

_____ X a day _____ X a week _____ X a month _____ X a year Other _____

9. About how long do you spend collecting each time you go out? _____ hours OR _____ minutes

10. When do you collect recycling? All year long Summer Fall Winter Spring Other

11. About how much do you think you earn per hour recycling?

_____

12. How do you travel when collecting recycling? On foot By bike

In a car In a truck or van

13. Is recycling the principal use of your vehicle? Y N

14. Do you have curbside recycling pickup at your home? Y N

15. Did you bring something today that your curbside program doesn't accept? Y N

16. Did you bring recycling today for which you did not receive a refund? Y N

17. Did you bring aluminum for a refund today? Y N

18. If yes, how much of the aluminum comes from your own household?_____

19. Did you bring glass for a refund today? Y N

20. If yes, how much of the glass comes from your own household?_____

21. Did you bring plastic for a refund today? Y N

22. How much of the plastic comes from your own household? _____

23. How often do you bring materials to the recycling center?

_____ X a day _____ X a week _____ X a month _____ X a year Other _____

24. How do you usually come to the recycling center?

On foot By bike In a car In a truck or van

Now I would like to ask you a few questions about yourself.

25. Where were you born? (Country) _____

26. How old are you? _____

27. Are you retired? Y N

28. Circle the interviewees gender M F

29. Are you married? Y N

30. Do you have any children? Y N

31. ***If yes ask*** **How many of your children are under the age of eighteen and live with you? _____**

32. How many people live in your house? _____

33. Are you a student? Y N

34. Did you go to high school? Y N

If yes ask **Did you graduate from high school? Y N**

If yes ask **Did you go to college? Y N**

If yes ask **Did you graduate from college? Y N**

Ask only the people who bring recycling from all over questions 30-37

35. In the past twelve months have you had another job other than recycling?

Y N

36. How many hours a week do/did you work?

37. What is/was your hourly wage?

38. Have you been looking for a job, or to change jobs in the past twelve months? Y N

39. How much of the material that you recycle comes from curbside or neighborhood recycling containers?

None about a quarter about half about three quarters All Other

_____

40. What types of material does that include? Aluminum Glass Plastic

41. What is your approximate annual family income?

A B C D E

42. We are trying to figure out what fraction of recycling comes from different types of people. Would you please fill out the weight of your recycling, or the amount you are refunded on this card and hand it back to us when you are finished. Or you can ask the cashier for a receipt. Thank you very much!

Appendix B: Spanish Language survey

TARJETA de la pregunta 35

A Menos de $10,000

B $10,000-$25,000

C $25,000-$50,000

D $50,000-$75,000

E Más de $75,000

TARJETA de la pregunta 36 CARD

Encuesta Número_____

Sea tan amable de anotar el peso o el reembolso en efectivo que recibió por cada material que recicló. Muchas gracias.

Vidrio	**Aluminio**	**Plástico**
_____ libras	**_____ libras**	**_____ libras**
Ó	**Ó**	**Ó**
_____ $	**_____ $**	**_____ $**

Encuesta de Reciclaje Número _____

Fecha _____

Encuestador(a) _____

1. **Soy un(a) estudiante de la Universidad de California en Santa Bárbara y estoy haciendo una encuesta anónima sobre las personas que reciclan materiales a cambio de un reembolso para un proyecto escolar. ¿Está dispuesto(a) a contestar unas cuantas preguntas sobre lo que recicla y sobre usted? Sí No (Si su respuesta fue negativa, haga las preguntas 3,14, 17,19 y 21)**

Primero voy a hacerle algunas preguntas sobre su reciclaje.

2. **¿Cuántas millas se desvió de su camino para venir hoy al centro de reciclaje?** _____ **millas**

3. **¿De dónde proviene su material de reciclaje?:** ***indique con un círculo todo lo que corresponda***

   de mi propia casa de mi trabajo de todas partes

Haga las preguntas 4,5, 6 y 7 sólo a las personas que reciclan materiales de su trabajo

4. ***Donde usted trabaja, ¿tienen servicio de recolección de reciclaje en la acera?*** ***Sí*** ***No***

5. ***¿Cuánto tiempo, entre los viajes al centro de reciclaje, se pasa reciclando en su trabajo?*** _____ ***horas*** ***Ó*** _____ ***minutos.***

6. ***¿Está reciclando en horas de trabajo?*** ***Sí*** ***No***

7. ***¿Qué hace con el reembolso?*** ***Me quedo con él*** ***Lo entrego en mi trabajo*** ***Gastos menores*** ***Otro*** _____

Haga las preguntas 19-23 sólo a las personas que traen reciclaje de todas partes

8. En promedio, ¿con qué frecuencia sale a recolectar materiales para reciclarlos?

_____ veces al día _____ veces a la semana _____ veces al mes

_____ veces al año otro _____

9. ¿Aproximadamente cuánto tiempo pasa recolectando cada vez que sale?

_____ horas O ____ minutos

10. ¿Cuándo recolecta material de reciclaje? Todo el año Verano Otoño Invierno Primavera Otro

11. ¿Aproximadamente cuánto cree que gana por hora al reciclar?

_____

12. ¿Cómo viaja cuando recolecta material de reciclaje? A pie Bicicleta Carro Camión o camioneta

13. ¿El uso principal de su vehículo es para reciclar? Sí No

14. Donde Ud. vive, ¿tiene servício de recolección de reciclaje en la acera?

Sí No

15. ¿Trajo algo hoy al centro de reciclaje que el programa de reciclaje en la acera no acepta? Sí No

16. ¿Trajo algo hoy al reciclaje que no le reembolsaron? Sí No

17. ¿Trajo aluminio hoy para un reembolso? Sí No

18. Si es así, ¿qué cantidad del aluminio proviene de su propia casa? _____

19. ¿Trajo vidrio hoy para un reembolso? Sí No

20. Si es así, ¿qué cantidad del vidrio proviene de su propia casa?_____

21. ¿Trajo plástico hoy para un reembolso? Sí No

22. Si es así, ¿qué cantidad del vidrio proviene de su propia casa?_____

23. ¿Con qué frecuencia trae materiales al centro de reciclaje?

____ veces al día ____ veces a la semana____ veces al mes

____ veces al año Otro _____

24. Habitualmente, ¿cómo se transporta/llega al centro de reciclaje?

A pie En bicicleta En carro En camión o camioneta

Ahora quisiera hacerle algunas preguntas sobre usted.

25. ¿En dónde nació? (País) _____

26. ¿Qué edad tiene?_____

27. ¿Está jubilado(a)? Sí No

28. Indique con un círculo el sexo del (la) entrevistado(da) M F

29. ¿Está casado? Sí No

30. ¿Tiene hijos? Sí No

31. *Si respondió afirmativamente* ¿Cuántos hijos menores de deiciocho años tiene y viven con usted?_____

32. ¿Cuántas personas viven en su casa? _____

33. ¿Es estudiante? Sí No

34. ¿Estudió preparatoria (bachillerato)? Sí No

***Si dijo que sí, pregunte* ¿Terminó la preparatoria? Sí No**

***Si dijo que sí, pregunte* ¿Estudió en la universidad? Sí No**

Si dijo que sí, pregunte **¿Terminó la universidad? Sí No**

Haga las preguntas 30-37 sólo a las personas que traen sus materiales de reciclaje de todas partes

35. En los últimos doce meses, ¿ha tenido otro trabajo que no sea el de reciclar?

Sí No

36. ¿Cuántas horas a la semana trabaja/trabajó?

37. ¿Cuánto gana/ganaba por hora?

38. ¿Ha estado buscando empleo o ha tratado de cambiar de empleo en los últimos doce meses? Sí No

39. ¿Qué cantidad del material que recicla proviene de los contenedores de reciclado de los vecindarios o de la calle?

Ninguna una cuarta parte alrededor de la mitad unas tres cuartas partes todo otro _____

40. ¿Qué tipo de materiales incluye? Aluminio Vidrio Plástico

41. ¿Cuáles son los ingresos anuales aproximados de su familia?

A B C D E

42. Estamos tratando de calcular qué fracción del reciclaje proviene de diferentes tipos de personas. ¿Quiere ser tan amable de anotar en esta tarjeta el peso de sus materiales de reciclaje o la cantidad de dinero que recibe como reembolso y entregárnosla cuando haya terminado de llenarla? Ó pida al cajero que le de una copia del recibo. ¡Muchas gracias!

II. The Effect of Income on Recycling Behavior in the Presence of a Bottle Law: New Empirical Results

* Thanks are due to my advisors, Robert T. Deacon, Kelly Bedard, and Jon Sonstelie.

Abstract

Eleven U.S. states have enacted "bottle laws" and they are one of the few examples of a policy that takes advantage of the price system to ameliorate environmental damage. A deposit-refund program on beverage containers is a consumption tax combined with a disposal rebate that is the equivalent of a Pigouvian tax. Using individual level data I have collected on observed cash recycling behavior, this paper shows that an unintended consequence of bottle laws is that they have the potential to increase the incomes of very low wage workers. If states set the bottle deposit high enough, harvesting recyclables becomes viable employment. The use of a price system as an environmental remedy is often criticized on the grounds that it leads to lower incomes for the poor. In this case deposit-refund recycling laws may provide a way to improve resource allocation using the appropriate Pigouvian tax, and simultaneously provide a way to increase the income of low wage workers. The first section of this paper I estimate the determinants of recycling behavior in the presence of a bottle law. This provides some insights into the characteristics of those who cash recycle. In particular I find that low income households are much more likely to recycle for cash than are high income households. The second section of this paper uses the dataset of recyclers to examine the importance of recycling income to low income households. The data show the surprising result that

recycling income does indeed provide a substantial supplemental income to a certain group of low-income cash recyclers.

1. Introduction

This paper reports the results of an empirical study of an unintended consequence, the transfer of income to low income households, of the use of bottle deposit laws to promote consumer recycling. Eleven U.S. states have enacted "bottle laws" which apply a deposit-refund system to the purchase of beverage containers. A bottle law is one of the few examples of an environmental protection policy that takes advantage of the price system.[20] A deposit-refund program on beverage containers is a consumption tax combined with a disposal rebate that is the equivalent of a Pigouvian tax. Under a Pigouvian tax a consumer would pay a disposal fee equal to the marginal damage caused by the disposal. A deposit-refund is preferable to a Pigouvian tax because while a Pigouvian tax encourages illegal disposal by individuals trying to avoid paying the fee, a deposit-refund encourages correct disposal, in this case recycling. In the presence of illegal disposal a deposit-refund program is the most efficient way of internalizing the external costs of waste disposal. One of the most general models of a deposit-refund program is described in Fullerton and Wolverton (2000).[21] Because deposit-refund programs encourage recycling, the deposit-refund literature is a small subset of the literature on recycling.

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[20] The eleven states with bottle bills are: Oregon (1972), Vermont (1973), Maine (1978), Michigan (1978), Iowa (1979), Connecticut (1980), Delaware (1983), Massachusetts (1983), New York (1983), California (1987), and Hawaii (2002).

[21] See also Sigman (1995), Fullerton and Kinnaman (1995), Palmer and Walls (1997).

Within the recycling literature various studies have examined the effect of income level and education level on voluntary and curbside recycling. The general effect of income on recycling is not well understood. There is more agreement on the affect of education level. Callan and Thomas (1997) use community level data that exploit differences in community characteristics. They find that income and education both increase recycling quantities. Duggal et al. (1991) also find that higher income and education levels increase recycling. Hong et al. (1993) use self-reported survey data to find that income does not affect recycling rates, but that education does increase recycling. Hong et al. (1999) use actual recycling and garbage weights to find that increases in income lead to a higher recycling rate and that education is not significant. Ferrara and Missios (2004) use individual level survey data. The proportions of the materials recycled are self-reported in their survey. They find that income decreases newspaper and plastic recycling and that post-graduate education increases recycling of newspaper, glass, and aluminum. Jenkins et al. (2003) also use individual level survey data in which the proportions of the materials recycled are self-reported. They find that income increases newspaper recycling and education level increases newspaper, glass and aluminum recycling.[22]

This paper uses a unique dataset I have collected specifically for the purpose of examining the effects of income and education on cash recycling. The important

[22] Reschovsky and Stone (1994) and Judge and Becker (1993) also find that education increases recycling.

features of this dataset are that the data is defined at the individual level and that the recycling behavior of the individuals is observed, not self-reported. While both Fullerton and Kinnaman (1996) and Hong and Adams (1999) combine a household survey with periodic weighing of garbage and recycling bins, their studies are concerned primarily with curbside and drop-off recycling programs. This study is different because it focuses on people who are recycling specifically for a cash payment, not just leaving their recyclables on the curb. The subjects of this study may also participate in curbside recycling programs at their home and other voluntary drop-off recycling programs. In fact sixty-nine percent of the study participants reported having curbside recycling at their home, a number that matches curbside recycling availability for the Santa Barbara south coast.[23]

Although most studies show that environmental taxes are mildly regressive, this paper shows that bottle laws have the potential to increase the incomes of very low wage workers.[24] If states set their bottle deposit high enough, harvesting recyclables becomes viable employment for low income households. The use of the price system as an environmental remedy is often criticized on the grounds that it leads to lower incomes for the poor because environmental taxes are

[23] The California Beverage Container Recycling and Litter Reduction Study reported that in 1999 curbside recycling programs covered 50% of the population of Santa Barbara County. In 2001 curbside programs in California covered 72% of single family dwellings, 58% of multi-family dwellings (2 to 4 households) and 28% of apartment units.

[24] D.B Suits (1977) finds that sales taxes and motor vehicle taxes. There is also current literature examining the distributional effects of a tax on gasoline, which has also been found to be a regressive tax. See Sipes and Mendelsohn (2001) and West and Williams (2004) for this discussion.

regressive. Deposit-refund recycling laws may provide a way to improve resource allocation using the appropriate Pigouvian tax and simultaneously to increase the income of low wage workers.[25] This paper provides the first evidence that this happens in practice.

The rest of the paper is laid out as two sections. The first section describes the data on cash recyclers and non-recyclers and the construction of a combined dataset. The dataset of recyclers is from a July, 2002 empirical field study of recyclers and their characteristics in Santa Barbara, California. These data are the first information of their kind ever collected. Using choice-based sampling the recycling survey data are merged with Census 2000 data. The dataset provides the basis for the estimation of a discrete choice model of the decision to recycle for cash. In particular this model permits the estimation of the effects of other demographic variables on the demand for cash recycling while holding income constant. This estimation provides some insights into the characteristics of those who cash recycle. There is a strong the negative relationship between recycling and income. The result that recycling for cash is far greater among low income households than among high income households leads to the second section of the paper.

The second section of the paper seeks to answer the question, how important is recycling income to low income households? The data are used to determine the

[25] In this paper the amount of beverage container materials purchased by the each household is ignored. In a second paper I find the value of the collected (not purchased) beverage containers returned by cash recyclers.

total amount recyclable materials returned to recycling centers by income level and by income level and English language proficiency and the value of that material. If bottle deposit laws provide a strong incentive for low wage consumers to recycle because they provide a relatively high recycling then what effect does this incentive have on the income distribution? The data show that recycling income provides a substantial supplemental income to a certain group of low-income cash recyclers. The final section of the paper provides a summary and conclusions.

2. The Determinants of Recycling for Cash

2.1. The Model

The question to begin with is what are the attributes of people who are recycling for cash? To begin thinking about a recycling wage let's start with a very simple assumption. Suppose that there is a fixed amount of recycling available, and the wage is simply the value of the recycling divided by the number of people who choose to recycle. Because the wage is very low, only the lowest wage people will recycle, perhaps only the homeless. In this case the only people recycling for cash would be those whose recycling wage is higher than their labor market wage.

In practice, however, we observe other people recycling. The wage then may be high enough to encourage other people to recycle. In this case we might expect to see people recycling whose market wage is higher than their recycling

wage, but they have a constraint on the number of hours that they work. Alternatively they may work in a place where they have access to large amounts of recycling, such as a restaurant or hotel.

In the first two cases the decision to recycle for cash is based entirely on a person's market and recycling wages. A third case would be that perhaps people do not value their time recycling in the same way that they value their time spent in the labor market. People may actually like recycling for cash. People who receive some utility from their recycling – say a nice walk on the beach – might choose to recycle even if their recycling wage was less than their market wage.[26] In order to examine the decision to recycle for cash I use data on cash recyclers to build a unique dataset. I use this dataset to assess income as a predictor of cash recycling behavior and to examine what other characteristics, besides income, predict cash recycling behavior.

2.2. Data

2.2.1. The Survey of Recyclers

In the economic literature on recycling there is no data currently available that explain recycling behavior in the presence of a bottle law. The unique dataset used for this analysis was created specifically to address empirically the questions surrounding bottle law recycling. In particular I was interested in the characteristics of cash recyclers. How much money do they earn? How much of

[26] Formal models of each of these cases are available upon request.

the total material recycled do they collect? From where does that material come? The survey instrument grew from these questions. The dataset is the result of one month of face-to-face surveys administered to all people returning bottles and cans for cash at four recycling centers. The survey was administered in Spanish and English.

The recycling centers are located in Santa Barbara and Goleta, California. In July 2002 this area had three main recycling centers and five small buyback centers in supermarket parking lots. The final survey included results from one week spent at each of the high volume recycling centers as well as one week at one of the grocery store buyback centers. All people recycling for cash at each redemption center were approached while they were waiting to check out and asked to participate in the survey. The final question of the survey was a card on which the surveyor recorded the actual cash payment or the weight of each load brought to recycling center by the survey participant. This was reported individually for each material that was recycled: aluminum, glass, and plastic.

There are three main sections in the survey. The first part of the survey asks about the recycled material and recycling activities of the respondent. The survey asks where the recycled materials are from, how much time it takes to recycle, and how far out of their way they had to travel to come to the redemption center. The second part of the survey questions the individual about his age, place if birth, educational attainment, household income, etc. The

question about household income was asked using a separate card. This card categorized income levels as A: less than $10,000, B: $10,000 to $25,000, C: $25,000 to $50,000, D: $50,000 to $75,000 and E: more than $75,000. The respondent was asked to name the letter which corresponded most closely to her household income. The third part of the survey was a card filled out by the surveyor recording either the weight by material of the recycling brought into the center, or in some cases the amount paid by the recycling center for each material recycled. Six hundred and sixty participants completed the survey and about one third of them took the survey in Spanish. The refusal rate for the survey was ten percent.

The recycling survey data is a sample of the total population that recycles for cash in the Santa Barbara South Coast. The sample was then weighted to approximate the total number of people who recycle for cash in the course of a year. Because only one month was spent surveying at the recycling centers, a week at each of five centers, I do not have an accurate count of the total number of people who recycle over the course of a year. In order to estimate this number I need to weight each of the cash recyclers in the sample based on the frequency with which they recycle.[27] To do this I assume that the week I surveyed at each recycling center was a typical week. Each observation is weighted based on the probability that, during the week I was there, I sampled all of the recyclers who

[27] Manski and Lerman (1977) explain this technique thoroughly.

visited the recycling center with the same frequency that they did. So, for example, if a person recycled once a week or more then his weight is 1. A person who reported that they recycled once a month has a weight of 52/12. A person who reported that they recycled once a year has a sample weight of 52. Overall, I estimate that about eight percent of the people in the Santa Barbara South Coast recycle at the redemption centers for cash at least once per year.

2.2.2. Choice Based Sample

If eight percent of the people in the Santa Barbara south coast area recycle for cash, this leaves us with ninety-two percent of the population not recycling for cash. The survey data described above contains detailed information on the people who are recycling for cash. It does not, however, contain any information about people who do not choose to recycle for cash. In order to examine the determinants of this recycling decision it is necessary to have individual level data on both recyclers and non-recyclers. To overcome this problem I use data from the 2000 census 5% sample to gather information on non-recyclers.[28] Both the recycling data and the census data are weighted samples. In order to merge these datasets the samples need to be re-weighted. The new weights will

[28] I use the 2000 Census 5% sample of the smallest census area that surrounds the Santa Barbara south coast. This is the Census Public Use Micro Area (PUMA) which includes part of Santa Barbara county including Santa Barbara, Goleta CPD, Isle Vista CPD, Carpinteria, Montecito CDP, Mission Canyon CDP, Summerland CDP and Toro Canyon CDP.

correct the fact that the cash recyclers in the recycling survey are also accounted for in the census sample. In other words I want to be sure that the survey respondents are not counted twice in the combined dataset. The first step involves matching each observation from the recycling survey sample to an observation from the census. In order to determine which of the observations from the census data most closely match the observations from the recycling survey data, I use propensity score matching.[29] Matching on the propensity score is matching on the probability of recycling conditional on the covariates. This probability is an index of all the covariates and a way of compressing the vector of covariates into a simple scalar. The identifying assumption is that the treatment, in this case recycling, is associated only with observable variables.[30] I implement the propensity score matching and re-weight the samples in two steps. First the propensity score is obtained by estimating a probit model for recycling using the explanatory variables in the sample. Second, using the nearest-neighbor method, I match census observations to recycling observations. Then I re-weight the census data by subtracting from the original census weight the frequency that each census observation was matched to a recycling survey observation. In every case the resulting weight remained positive. In other words I never had an observation in the census that was matched to more recycling observations than the value of the observation's original weight.

[29] Rosenbaum and Rubin (1983) lays out this approach in detail.
[30] Heckman and Robb (1985) explains this thoroughly.

2.3. A Probit Model

What are the attributes of people recycling for cash? In order to answer this question I use the dataset described above to estimate a probit model of the decision to cash recycle. The probability of recycling is assumed to be given by:

$$\text{Pr (Recycling)} = \text{Pr}(R_i = 1) = \text{Pr}(\alpha \ln y_i + \beta X_i + v_i > 0) = \Phi(\alpha \ln y_i + \beta X_i) \quad (1)$$

where Φ is the standard normal cumulative density function. The model includes household income (y_i) and a vector (X_i) of demographic, household and other characteristics that may reflect the individuals' preferences and costs associated with recycling at the recycling center and may therefore explain their recycling behavior.

The variables in the regression include the natural log of income, which should represent the opportunity cost of the time spent collecting and bringing the materials to the recycling center for payment, as opposed to placing them in curbside garbage or recycling bins. The other variables may reflect the recycler's preference for recycling at the recycling center for payment as opposed to another method. The variables include educational attainment dummy variables: whether the recycler has some high school education or attended college. A high level of educational attainment may lead to a higher preference for recycling. But remember the recycling in this study is specifically recycling for cash, not using a curbside program or drop-off program.

The regression also includes individual characteristics including whether the survey was administered in Spanish, the recycler's gender, age, and marital status. A recycler taking the survey in Spanish may be more likely to live in a multi-unit dwelling. Apartment buildings are less likely to have curbside recycling and this may make it easier to gather additional recycling, increasing the benefit of making the trip to the recycling center. Finally, household characteristics like household size and children under the age of 18 are also included in the regression. Families with children and larger households may have difficulty coordinating a visit to the recycling center with other errands and the use of the family vehicles, since the recycling centers are not easily accessible on foot.

2.4. Results

Table 1 reports the results of a probit model to identify characteristics that determine whether or not a person will choose to recycle for cash. The first two columns report the results from the combined census and recycling survey dataset. The second two columns report the results from the dataset using the corrected choice-based sampling weights.

In the first and third columns the income variable used is the natural log of income. In the second and fourth columns the income variable is the error term from an ordinary least squares regression of income on the demographic characteristics. The residual here represents the portion of income not explained

Table 1: The Determinants of Recycling
(Probit Marginal Effects and Standard Errors)

	Census and Sample Weights		Choice Based Sample Weights	
	Recycle	Recycle	Recycle	Recycle
Natural log of Inc	-0.443***		-0.447***	
	(0.045)		(0.045)	
Residuals of Income Equation[1]		-0.443*** (0.045)		-0.447*** (0.045)
Born in US	0.208**	0.123	0.213**	0.127
	(0.086)	(0.086)	(0.087)	(0.086)
No High School	-0.025	-0.007	-0.025	-0.007
	(0.112)	(0.112)	(0.112)	(0.112)
Some College or More	-0.028	-0.092	-0.054	-0.093
	(0.091)	(0.113)	(0.113)	(0.113)
Spanish language survey	0.753***	0.892***	0.769***	0.907***
	(0.127)	(0.127)	(0.127)	(0.128)
Female	-0.481***	-0.463***	-0.486***	-0.467***
	(0.070)	(0.070)	(0.070)	(0.070)
Married	0.355***	0.239***	0.360***	0.242***
	(0.075)	(0.074)	(0.075)	(0.074)
Age	0.005***	0.004**	0.005***	0.004**
	(0.002)	(0.002)	(0.002)	(0.002)
Child under 18 in house	-0.162*	-0.216**	-0.163*	-0.217**
	(0.088)	(0.087)	(0.088)	(0.088)
Household Size	-0.005	-0.036**	-0.006	-0.037**
	(0.018)	(0.018)	(0.018)	(0.018)
Obs.	9395	9395	9395	9395
Pseudo R^2	0.125	0.125	0.127	0.127

Notes: Robust standard errors are in parentheses. Regression includes a constant term. ***, **, and * are significance at the 1%, 5% and 10% level respectively. [1]These are residuals from an OLS regression of the natural log of income on the demographic variables.

by the demographic characteristics in the dataset. This allows us to interpret the significance of the impact of the demographic variables on the recycling choice, separate from their impact on the recycling choice through income.

Table 1 shows that income is negatively correlated to recycling for cash. The higher income you have, the more costly the time spent going to the recycling center, and the more likely you are to recycle in other, less time-consuming ways. The education variables are not significant, which is consistent with the idea that while education might increase your preference for recycling there is no reason to believe that it should increase one's need to get paid for that recycling.

The primarily Spanish speakers are more likely to recycle for cash, which may reflect the fact that they may have less disutility from collecting extra recycling, which increases the pay-off of going to the recycling center. Women are less likely to recycle for cash. This may be related to the resource constraints that cause larger households and households with children to be less likely to recycle. Women are generally much more likely to be the care-givers in these situations. Married people and older people are more likely to recycle for cash. This is may be because the costs of recycling also include storage costs. Many families save up their recycling, especially aluminum, for long periods of time because it is compact and the most valuable per pound. More established, married couples are likely to have the space to do this cheaply and this may lead them to recycle for cash.

The most compelling result of the probit model is that income has a strong negative effect on the decision to recycle for cash. This suggests that low income people are much more likely to participate in the cash recycling program than high income people. In fact bottle deposit laws provide a very strong incentive for low wage consumers to recycle because they provide a relatively high wage to low income workers who recycle. As this is the case the question, becomes how important is the recycling income for these low income recyclers? Is there a significant effect on the income distribution?

3. The Value of Recycling Income to Households and the Effect on the Income Distribution

Under a bottle law consumers pay a deposit when they purchase a beverage container and receive a refund when they return the container to a recycling center. When a consumer chooses not to participate in the cash recycling program, the effective result is that the deposit becomes a tax. The probit model on the decision to participate in the cash recycling program shows that low-income households are more likely to participate than high-income households. In fact data from the recycling survey shows that low-income households actually recycle more material than they purchase. What additional data are necessary to examine the size of the income redistribution?

3.1. Data on the Total Weight of Recycling for 2002

In order to determine the importance of recycling income I need to find the annual value of the recycling income to people participating in the California Cash Redemption Program. The recycling survey data reports the total amount of materials redeemed for cash at each of four recycling centers for a period of one week each. To find the annual value of recycling income I combine the data from the survey with the total amount of recycled materials for the Santa Barbara South Coast.[31]

I use the following method to aggregate the numbers from the survey up to the total weight of recycled materials for the year. From the survey data I calculate the proportions of aluminum, glass, and plastic materials brought to the redemption centers by the recyclers of each income level. I do this a second time by income level and language proficiency. I assume that the proportions of materials brought by recyclers to each recycling center throughout the month of July are constant. In addition, while the survey included all three of the high volume redemption centers in the region, it only included one of the supermarket buyback centers.[32] Therefore I make the assumption that the proportion of

[31] The Santa Barbara South Coast is defined as the city of Santa Barbara, Goleta CDP and Isla Vista CDP. A census-designated place (CDP) is an area identified by the United States Census for separate statistical reporting. The household income question is included on the census long form and the distribution is estimated from the sample of households which answers this form. This information is therefore only an estimate and should be treated as such.

[32] The disaggregated data is proprietary, but to give you an example the average amount of Aluminum for the larger centers was over 9.5 tons and for the supermarket buybacks the average was about 1.5 tons, for glass the averages are approximately 75 tons and 2 tons. For plastic they are about 3.5 tons and 1.5 tons.

recyclables brought by recyclers of each income level is the same at each of the supermarket buyback centers. I then apply these proportions to the total amount of material collected by each recycling center during the 2002 calendar year.[33] Using the proportion of materials recycled by recycling center limits the total amount of recycling to the actual amount of material recycled in 2002. This is important because the next step is to calculate the value of the total amount of materials recycled in 2002. To determine the total amount of cash paid for recycled materials I use the per pound redemption value paid by the State of California in the year 2002. The redemption values were $0.77 for a pound of aluminum, $0.05 for a pound of glass, and $0.41 for a pound of plastic.[34]

3.2. Results

Table 2 reports the breakdown of participation in the California Cash Redemption Program (CRV recycling) and the weight of the total materials recycled by income level for the year 2002. The participation rate in the program is skewed toward the lower income levels. Twelve percent of the people who earn less than $10,000 a year and thirteen percent of the people who earn between $10,000 and $24,999 recycle, compared to nine percent of people who earn between $25,000 and $49,999, five percent of the people who earn between $50,000 and $75,000 and four percent of the people who earn over $75,000.

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[33] The total amount of recycling collected by each recycling center was supplied by the California Department of Conservation, Division of Recycling.

[34] This is slightly underestimated since the redemption centers pay a slightly elevated price for larger loads of aluminum. For example, all the redemption centers pay $1.00 a pound for a load of aluminum of 100 lbs or more.

Table 2: The 2002 Breakdown of CRV[1] Recycling Participation and Weight by Income Level

Household Income Level		Less than $10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $75,000	Over $75,000
Recyclers[2]	Obs.	623	1,257	1,523	555	779
	Percent	12%	13%	9%	5%	4%
Non-Recyclers[3]	Obs.	4,791	8,445	14,513	10,966	17,392
	Percent	88%	87%	91%	95%	96%
Aluminum Recycled[4]	Lbs.	184,313	289,934	195,133	78,523	104,336
	Percent	22%	34%	23%	9%	12%
Glass Recycled[4]	Lbs.	650,840	2,091,391	847,102	904,147	83,834
	Percent	14%	46%	19%	20%	2%
Plastic Recycled[4]	Lbs.	91,016	168,414	65,777	36,250	28,522
	Percent	23%	43%	17%	9%	7%
Total Recycled Materials	Lbs.	926,170	2,549,739	1,108,012	1,018,920	216,692
	Percent	16%	44%	19%	18%	4%

Notes: [1]CRV are bottles and cans that are included in the California Cash Redemption program. [2]These are the corrected sample weights from the recycling survey which estimate the total number of recyclers in a year from each income level. [3]This is the total number of households reported for each of these income levels in the 2000 Census for Santa Barbara city, Goleta CDP and Isla Vista CDP (income is estimated from the Census long form which is a sample of 1 out of 6 households), minus the recycling households. [4]In order to report these estimates I assume that the proportion of the recycling brought by each income level to each of the recycling centers is the same for the month of July as it was for the week the center was surveyed. In addition I assume that all of the grocery store parking lot recycling center have the same proportions as the one that was in the survey. These proportions are then applied to total recycling weights supplied by the Santa Barbara County Department of Public Works, Solid Waste and Utilities Divison. The number for glass reported in this chart is the estimated amount of CRV glass captured by the curbside recycling program for all of Santa Barbara County and was supplied by the California Department of Conservation, Division of Recycling. This number is an upper bound because it was not possible to secure the amount of CRV glass in the South Coast recycling region.

Recyclers with incomes less than $25,000 are responsible for fifty-six percent of the aluminum recycled, sixty percent of the glass recycled, sixty-six percent of the plastic recycled, and sixty percent of all recycled materials by weight.

Table 3 reports the cash value of the CRV recycling returned by income level. The recyclers with incomes less than $25,000 received $608,649 during 2002, which was fifty-eight percent of the value of all of the recycling brought to the redemption centers. The average cash payment per household is the total value of the recyclable materials returned by household in each income bracket divided by the total number of households. The payments to households that earn less than $25,000 is about $40, while for the higher income levels the annual payments drop to $14, $10, and $5. The average cash paid to all recycling households is the total value of the recyclable materials returned by household in each income bracket divided by the total number of recycling households. The payment to households that earn less than $10,000 is about $340 while for households that earn between $10,000 and $24,999 it is about $315. For the three higher income levels the payments drop to $144, $217, and $124.
Table 4 reports the breakdown of 2002 participation in the California Cash Redemption Program and the weight of the total materials recycled by income level and whether the primary language of the recycler is Spanish. For primarily English speakers four percent of the people who earn less than $10,000 a year and three percent of the people who earn between $10,000 and $24,999, and

Table 3: 2002 Cash Value of CRV[1] Recycling by Income Level

Household Income Level		Less than $10,000	$10,000 to $24,999	$25,000 to $49,999	$50,000 to $75,000	Over $75,000
Total Cash Paid for Recycling[2]	$	$211,780	$396,869	$219,576	$120,532	$96,224
	Percent	20%	38%	21%	12%	9%
Average Cash Paid to Household[3]	$	$39.12	$40.91	$13.69	$10.46	$5.30
Average Cash Paid to Recycling Households[4]	$	$340.03	$315.65	$144.13	$217.05	$123.54
Total Households	Obs.	5,414	9,702	16,036	11,521	18,171
Households that CRV Recycle[5]	Obs.	623	1,257	1,523	555	779
	Percent	12%	13%	9%	5%	4%

Notes: [1]CRV are bottles and cans that are included in the California Cash Redemption program. [2]The total cash paid for recycling is the value of the total amount of recycling for the South Coast in Table 1. [3]The average cash paid to each household is the total value of all the cash recycling divided by the number of people in each income bracket based on the 2000 Census information for Santa Barbara city, Goleta CDP and Isla Vista CDP. The income question is on the Census long form and therefore is estimated from a sample (1 in 6 households). [4]The average cash paid to recycling households is the total value of the recycling returned divided by the estimated number of households that participates in the CRV recycling program. [5]The estimate of the number of households that participate in CRV recycling is based on the frequency that recyclers reported they came to the recycling center.

Table 4: The 2002 Breakdown of CRV[1] Recycling Participation and Weight by Income Level and Language Proficiency

Household Income Level		Less than $10,000		$10,000 to $24,999		$25,000 to $49,999		$50,000 to $75,000		Over $75,000	
Language[2]		English	Spanish	English	Spanish	English	Spanish	English	Spanish	English	Spanish
Recyclers[3]	Obs.	364	259	607	650	1,228	295	540	15	770	9
	Percent	4%	26%	3%	25%	3%	6%	2%	1%	1%	0.3%
Non-Recyclers[3]	Obs.	9,252	739	17,838	1,907	36,706	4,428	31,167	2,353	65,816	2,672
	Percent	96%	74%	97%	75%	97%	94%	98%	99%	99%	99.7%
Aluminum Recycled[4]	Lbs.	81,414	102,899	71,760	218,174	131,920	63,213	74,437	4,085	103,646	690
	Percent	9.6%	12.1%	8.4%	25.6%	15.5%	7.4%	8.7%	0.5%	12.2%	0.1%
Glass Recycled[4]	Lbs.	414,903	235,937	829,021	1,262,370	424,799	422,302	890,372	13,775	83,834	0
	Percent	9.1%	5.2%	18.1%	27.6%	9.3%	9.2%	19.5%	0.3%	1.8%	0%
Plastic Recycled[4]	Lbs.	43,048	47,969	60,899	107,515	45,924	19,853	36,108	142	28,522	0
	Percent	11.0%	12.3%	15.6%	27.6%	11.8%	5.1%	9.3%	0.04%	7.3%	0%
Total Recycled Materials	Lbs.	539,365	386,805	961,681	1,588,058	602,644	505,369	1,000,918	18,002	216,002	690
	Percent	9%	7%	17%	27%	10%	9%	17%	0.3%	4%	0.01%

Notes: [1]CRV are bottles and cans that are included in the California Cash Redemption program. [2]The language assigned to each household is based on the whether they reported that their first or most spoken language was Spanish and they spoke English "not well" or "not at all". These are people who took the recycling survey in Spanish. [3]These numbers are based on the corrected sample weights from the US Census and the recycling survey. [4]To find these values I assume that the proportion of the recycling brought by each income level to each of the recycling centers is the same for the month of July as it was for the week the center was surveyed. In addition I assume that all of the grocery store parking lot recycling center have the same proportions as the one that was in the survey. These proportions are then applied to total recycling weights supplied by the Santa Barbara County Department of Public Works, Solid Waste and Utilities Divison. The number for glass reported in this chart is the estimated amount of CRV glass captured by the curbside recycling program for all of Santa Barbara County and was supplied by the California Department of Conservation, Division of Recycling. This number is an upper bound because it was not possible to secure the amount of CRV glass in the South Coast recycling region.

between $25,000 and $49,999, recycle. This is compared to two percent of English speakers who earn between $50,000 and $75,000 and one percent of those who earn over $75,000.

For primarily Spanish speakers the percentage of households that recycle is significantly higher. Twenty-six percent of primarily Spanish speakers earning less than $10,000 a year and twenty-five percent of Spanish speakers earning between $10,000 and $24,999 recycle. The participation rate for Spanish speakers then drastically drops and only six percent of those who earn between $25,000 and $49,999, one percent of those who earn between $50,000 and $75,000 and less than one percent of those who earn over $75,000 recycle. Primarily English speaking recyclers with incomes less than $25,000 are responsible for eighteen percent of the aluminum recycled, twenty-seven percent of the glass recycled, twenty-seven percent of the plastic recycled, and twenty-six percent of all recycled materials by weight. Primarily Spanish speaking recyclers with incomes less than $25,000 are responsible for thirty-eight percent of the aluminum recycled, thirty-three percent of the glass recycled, forty percent of the plastic recycled, and thirty-four percent of all recycled materials by weight.

Table 5 reports the cash value for the year 2002 of the CRV recycling returned by income level and whether the primary language of the recycler is Spanish. The primarily English speaking recyclers with incomes less than $25,000 received $222,759 during 2002, which was twenty-two percent of the

Table 5: 2002 Cash Value of CRV[1] Recycling by Income Level and Language

Household Income Level		Less than $10,000		$10,000 to $24,999		$25,000 to $49,999		$50,000 to $75,000		Over $75,000	
Language[2]		English	Spanish	English	Spanish	English	Spanish	English	Spanish	English	Spanish
Total Cash Paid for Recycling[3]	$	$101,084	$110,696	$121,675	$275,193	$141,647	$77,929	$116,640	$3,892	$95,693	$531
	Percent	10%	11%	12%	26%	14%	7%	11%	0.37%	9%	0.05%
Average Cash Paid to Household[5]	$	$10.51	$110.95	$6.60	$107.61	$3.73	$16.50	$3.68	$1.64	$1.44	$0.20
Average Cash Paid to Recycling Households[6]	$	$278	$428	$200	$423	$115	$264	$216	$257	$124	$61
Total Households	Obs.	9,616	998	18,445	2,557	37,934	4,723	31,707	2,368	66,586	2,681
Households that CRV Recycle[4]	Obs.	364	259	607	650	1,228	295	540	15	770	9
	Percent	4%	26%	3%	25%	3%	6%	2%	1%	1%	0.3%

Notes: [1]CRV are bottles and cans that are included in the California Cash Redemption program. [2]The language assigned to each household is based on the whether they reported that their first or most spoken language was Spanish and they spoke English "not well" or "not at all". These are people who took the recycling survey in Spanish. [3]The total cash paid for recycling is the value of the total amount of recycling for the South Coast in Table 3. [4]The estimate of the number of households that participate in CRV recycling is based on the frequency that recyclers reported they came to the recycling center.[5]The average cash paid to each household is the total value of all the cash recycling divided by the number of people in each income bracket based on the corrected sample weights from the 2000 US Census and the recycling survey. [6]The average cash paid to recycling households is the total value of the recycling returned divided by the estimated number of households that participates in the CRV recycling program. [7]The average cash amount paid to recycling households in the survey is the average of their project annual recycling income based on the total payment they received the day of the survey and the frequency that they report recycling.

value of all of the recycling brought to the redemption centers. The primarily Spanish speaking recyclers with incomes less than $25,000 received $385,889 during 2002, which was thirty-seven percent of the value of all of the recycling brought to the redemption centers.

The average cash payment per household is the total value of the recyclable materials returned by households in each income bracket divided by the total number of households in that income bracket, based on the primary language. The payments to primarily English speaking households that earn less than $10,000 is $10.51, while the payments to primarily Spanish speaking households that earn less than $10,000 is $110.95. The payment to primarily English speaking households that earn between $10,000 and $24,999 is $6.60, while the payment to primarily Spanish speaking households that earn between $10,000 and $24,999 is $107.61. The payments to primarily English speaking households for the higher income levels continue to drop to $3.73, $3.68, and $1.44. Primarily Spanish speaking households face a much larger drop at higher income levels to $16.50, $1.64, and $0.20.

The average cash paid to all recycling households is the total value of the recyclable materials returned by household in each income and language bracket divided by the total number of recycling households in that bracket. At income levels below $50,000 the average paid to primarily Spanish speaking recycling households is approximately twice the income paid to primarily English speaking

households. The payment to households that earn less than $10,000 is $278 for English speaking households and $428 for Spanish speaking households. For households that earn between $10,000 and $24,999, it is $200 for English speaking households and $423 for Spanish speaking households. For households that earn between $25,000 and $49,999, it is $115 for English speaking households and $264 for Spanish speaking households. For households with income between $50,000 and $74,999 the payments are about equal at $216 for English speaking households and $257 for Spanish speaking households. For households with incomes over $75,000, the payment to English speaking households is twice the payment to Spanish speaking households, $124 as compared to $61.

4. Conclusions

Does income explain recycling behavior in the presence of a deposit-refund program? While it is clear that there is a strongly negative correlation between income and participating in a deposit-refund program, it is not the only significant determinant. Storage costs may play a considerable factor, but other determinants such as gender, age, language, and the presence of children are also significant. This would argue against using the simplest model to describe cash recycling. Even in the case of cash recycling it seems that people may not value their time recycling in the same way as they value time in their labor market job.

So while income level has a strong negative influence on the participation in the California Cash Redemption Program, it does not explain everything.

Does the strong negative correlation between income and recycling lead to a significant income redistribution? Lower income households certainly recycle more than households with higher incomes. Is the recycling income significant? In order to answer this I suggest that we look at the lowest income groups. Twelve percent of households with an income less than $10,000 participate in the California Cash Redemption Program. These households comprise about one percent of the total households in the Santa Barbara South Coast and yet they receive about twenty percent of the total cash value of recycling in 2002. Suppose that we assume that the average household income for these households is $5,000. This would mean that the $340 annual transfer represents 6.8 percent of their annual income. When we narrow our focus to primarily Spanish speaking the transfer is even greater. Twenty-six percent of primarily Spanish speaking households earning less than $10,000 receive about $428 a year from cash recycling. Assume that the average household income for these households is $5,000. This would mean that the $428 annual transfer represents 8.6 percent of their annual income. So while the overall effect of the deposit refund for many income levels may be very small, for the people falling into the lowest income bracket it is quite meaningful. The Santa Barbara area has a very large number of primarily Spanish speaking families. Recyclers are not required to

show any form of identification. In other words, your legal working status can not prevent you from recycling. This program indeed seems to provide a significant income transfer to a small number of households that are difficult to support.

The key to the income redistribution is that the low income families are more likely to recycle, and in fact are recycling more materials than they have purchased.[35] This behavior does create a situation in which deposit-refund recycling laws improve resource allocation using the appropriate Pigouvian tax and simultaneously increase the income of very low wage workers.

[35] From the survey of recyclers low income households return materials collected from outside of their own household.

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III. The Labor Market Consequences of State Bottle Laws:

Evidence from Petty Crime Rates*

* Thanks are due to my advisors, Robert T. Deacon, Kelly Bedard, and Jon Sonstelie.

Abstract

This paper examines the degree to which using bottle laws to subsidize recycling programs improves labor market opportunities and has a negative effect on petty crime rates. Using a simple choice theory model of crime participation and labor supply this paper examines the decision by individuals to engage in illegal activities by comparing the expected wage from their illegal activity to the certain wage from their legal activity. When the legal wage increases we expect to see people substituting their time and effort away from the illegal activity to the legal activity. The legal wage is the wage earned recycling bottles and cans at recycling centers. Between 1973 and 2001 eleven states and one city enacted bottle laws. In a natural experiment this paper exploits the variation in the year of implementation of the bottle laws to measure the reduction in crime rates of improved job market opportunities. This paper shows that the opportunity effect, that is a result of state bottle laws, results in about a 10% decrease in average reported larceny rates. In this way the primary positive benefits of these labor market changes go to low-income individuals, but secondary benefits trickle up to higher wage earners.

1. Introduction

This paper examines the degree to which using bottle laws to subsidize recycling programs improves labor market opportunities and has a negative effect on petty crime rates. Using a simple choice theory model of crime participation and labor supply this paper examines the decision by individuals to engage in illegal activities by comparing the expected wage from their illegal activity to the certain wage from their legal activity. When the legal wage increases we expect to see people substituting their time and effort away from the illegal activity to the legal activity. The legal wage is the wage earned recycling bottles and cans at recycling centers. In a natural experiment this paper uses crime and police data along with demographic, government spending and economic variables to take advantage of the variation in the year of implementation of the bottle law to measure the opportunity effect of improved recycling jobs on petty crime rates.

A "Bottle Law" is legislation that applies a deposit-refund to the purchase of beverage containers in order to encourage consumer recycling. A deposit-refund program is a consumption tax (paid at the time of purchase)

combined with a disposal rebate (paid at the time of disposal).[36] An unintended consequence of state bottle deposit laws that promote consumer recycling is the potential increase in the incomes of very low wage workers. When states set a deposit on bottles and cans, harvesting recyclables becomes viable employment for low-income households. In this way bottle laws subsidize recycling markets. Between 1973 and 2001 eleven states and one city enacted bottle laws.

Is there evidence that unskilled workers recycle? While deposit-refund programs are designed to encourage household recycling, there are still a large number of people who discard beverage containers. Many recyclable containers end up as litter, in garbage cans, or in curbside recycling bins. Recyclable containers are then collected by people who are recycling for cash. Professional recyclers are people who recycle bottles and cans that they did not purchase.

Sociologist Teresa Gowan finds that recent immigrants and homeless men are often active recyclers. She surveyed homeless men in San Francisco and recorded their stories about how they adopted this profession.[37] In "Homeless in America" Ronald Paul Hill and Mark Stamey describe recycling bottles and cans as "probably the first choice of homeless persons seeking money." Their research takes place in a large northeastern city and they find that the most

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[36] A deposit-refund program is the equivalent of a Pigouvian tax. Under a Pigouvian tax a consumer would pay a disposal fee equal to the marginal damage caused by the disposal. A deposit-refund is preferable to a Pigouvian tax because while a Pigouvian tax encourages illegal disposal by individuals trying to avoid paying the fee, a deposit-refund encourages correct disposal, in this case recycling. One of the most general models of a deposit-refund program is described in Fullerton and Wolverton (2000).

[37] Gowan (1997)

commonly reported estimate of daily recycling income is $6.[38] A study of the homeless in Los Angeles by the RAND Corporation found that about 20% of homeless persons who reported earning any income earned recycling income. The average value of this recycling income was $65 a month.[39]

Ashenmiller (2005) uses unique survey data to show that cash recycling is an important part of the income of the working poor. The paper finds that that twelve percent of all households and twenty-six percent of primarily Spanish speaking households, with an income less than $10,000, recycle beverage containers for cash. The recycling income earned represents seven and nine percent of their annual income respectively.

A second paper finds that an astonishing twenty-two percent of the income of professional scavengers comes from recycling. At the same time professional and workplace recyclers are responsible for a large amount of new recycling. Roughly thirty-six to fifty-one percent of the recycling generated by the bottle law would not have been captured by other existing recycling programs. This paper shows that deposit-refund recycling laws improve resource allocation using the appropriate Pigouvian tax and simultaneously increase the income of very low-wage workers.

[38] Hill and Stamey (1990)
[39] Conroy (1998)

2. Crime Rates and Wages

While bottle laws have been shown to increase the income of low-wage workers, a number of papers have argued that declining wages and employment opportunities contribute to the involvement of unskilled workers in criminal activity. Phillips, Votey, and Maxwell (1972) use the FBI's Uniform Crime Reports (UCR) urban crime rates from 1953-1970 to estimate an empirical model. They conclude that changing labor market opportunities for youth in this time period are sufficient to explain the increase in youth crime rates. Freeman (1996) uses the (UCR) and the National Crime Victimization Survey (NCVS) to compare the predicted number of crimes, based on high incarceration rates, to the actual number of crimes reported. He argues that the propensity to commit crime has increased between the years 1977 and 1992. He suggests that the economic incentives for crime may be sufficiently large to play a role in the rise in criminal propensity. Grogger (1998) uses data from the National Longitudinal Survey of Youth (NLSY) to estimate a time-allocation model in which consumers face parametric wages and diminishing marginal returns to crime. The author's estimates suggest that youth behavior is responsive to price incentives and that falling real wages may have been an important determinant of rising youth crime during the 1970s and 1980s.

Raphael and Winter-Ebmer (2001) use the (UCR) to estimate the effect of unemployment rates on crime rates using a panel of state-level data from 1971 to

1997. They find that 82 percent of the decline in the larceny rate and slightly more than 40 percent of the decline in the overall property crime rate, can be attributed to the decline in unemployment. Gould, Weinberg, and Mustard (2002) use county-level panel data, ten-year changes from Census data, and individual level data from the NLSY to examine the relationship between crime and labor market conditions for men with low education levels. They find that wage trends explained more than 50% of the increase in both property and violent crime indices over their sample period, 1979 to 1997. Machin and Meghir (2004) use regional panel of police data from England and Wales to investigate how changes in wages at the bottom end of the wage distribution affect crime rates. They find that increased wages reduce crimes.

The question remains then, do bottle laws reduce crime by raising the effective wage for low skill individuals? The following section addresses the mechanism through which a deposit-refund program raises wages and what evidence exists that low-wage and low-skill workers participate in the subsidized recycling market.

3. A Model of the Supply of Professional Recycling

The supply of professional recyclers includes people who recycle part-time or full-time. Full time recyclers are people for whom the recycling wage is higher than any market wage they could earn. This would include people who

are unemployable, people who are on some form of government aid that restricts their ability to work in the conventional labor force, or people with very poor job market opportunities, such as addicts or the homeless. Part-time recyclers are under-employed, meaning they face a restriction on the number of hours that they can work at their labor market job. A moonlighting model can be used to describe this decision. In this model people can only work a fixed amount of time even though they might prefer to work longer. If the constraint on their wage labor is binding they can accept a second job at a lower wage to increase their utility.

The model starts with a utility maximization problem, where utility is a function of leisure (ℓ), and consumption (x). There is a constraint on time such that total hours that can be worked (T) must equal the sum of the number of hours spent on recycling (R), wage labor (L) and leisure (ℓ). The budget constraint for the model is: $wL + sR = x$ where s is the hourly recycling wage, x is a composite consumption good with a price of 1, w is the hourly wage in the labor market, and $\overline{H}$ is the maximum number of wage hours that can be worked at the labor market job. This model assumes that people value their time recycling in the same way that they value their time working at their labor market job so that $U_R = U_L$.

The maximization problem is:

$$\underset{L,R,x}{Max} \quad U(T-R-L,x)$$

$$s.t. \qquad wL+sR=x,\ \overline{H}\geq L,\ L\geq 0, \text{ and } R\geq 0$$

The first-order conditions yield the result that, when the hours constraint is not binding, a worker will choose only to recycle when the recycling wage is higher than the labor market wage ($s > w$) and will choose both to recycle and work at a wage job if the recycling wage is equal to his market wage ($s = w$). Alternatively, a worker may choose both to recycle and work at a wage job when the market wage is higher than the recycling wage ($s < w$) if he faces a binding restriction on the number of hours worked.[40] These workers would prefer to work more hours at their market wage, but because they are not able to do that they are willing to recycle even though their recycling wage is less than their market wage.[41] The theoretical model reveals the economic incentive for low wage workers to recycle.

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[40] Phillips and Votey (1984) look at black women's incentives to commit crime. They model the labor market participation of the women with constraints on their time. A woman is considered over employed if in order to take a job she must work more hours that she would prefer to work. A woman is considered underemployed if the jobs that she can obtain are inadequate to provide her with the income that she needs for the hours she is able to work. They find that the empirical evidence is consistent with the theoretical expectation that workers might be tempted by crime either as a solution to underemployment or overemployment.

[41] An alternative model would be to assume diminishing marginal returns to recycling. In this situation you could also find recyclers who were willing to work both at recycling and at their labor market wage. They would recycle until the value of the marginal product of their recycling wage was equal to their labor market wage or their other non-market wages. This might fit the homeless recyclers who are often doing multiple activities for cash: recycling, panhandling, etc...

4. The Data

The data used are a panel of 10,133 cities with observations running from 1970-2000. These cities represent all U.S. cities with a population over 1,000 in the year 1970.[42] The data on crime are taken from the Uniform Crime Reports issued by the Federal Bureau of Investigation (FBI). These are available annually on a city-level basis for seven types of crime: murder and non-negligent manslaughter, forcible rape, assault, robbery, burglary, larceny, and motor vehicle theft. For the purpose of this paper only the crime data for larceny is used. In particular, the property crime data for larcenies under $200 in value is used. The data includes only reported crimes, which greatly understates the true crime rate. In addition, when multiple offenses occur in the commission of a single crime, the FBI only records the most serious of these offenses. This means that all of the larcenies reported in this data involved no violence. Data on the number of sworn officers are also taken from the FBI Uniform Crime Reports. Sworn officers carry a gun and have the power of arrest; other police employees do not. The property crime rate is the annual reported crime rate per 1,000 people for larcenies under $200 in value. The police officer rate is the total number of police officers per 1,000 people.

In addition to the data on police and crime, a number of state-level demographic, government spending, and economic variables are included in the

[42] The results of the model are not sensitive to the population rule chosen.

regressions. The state-level data is from the Statistical Abstract of the United States. This data is available annually and the variables include the unemployment rate, the percent of a state's population that is black, the percent of the state's population that lives at or under the poverty line, the average income, the average state welfare payments, and the percentage of the population aged between 18-24. When this sample is restricted to cities with a population over 1,000 during the entire sample period it includes 9,771 cities.

Ideally, city-level economic and demographic variables would be included in the analysis as well. The city-level population data is available annually, but other variables are not. The U.S. Census Bureau's County and City data books are the best source of city-level data. Unfortunately the format and availability of the demographic and economic variables included changes over the time period of the sample, making them difficult to use. The city-level unemployment rate is taken from the 1967, 1972, 1977, 1983, 1988, 1994, 2000 County and City data books, and then a linear interpolation of these variables is made for the years in between. Since unemployment tends to evolve slowly this may serve as a reasonable approximation. This information is available for 1011 cities with populations of over 1,000.

Another important characteristic of crime data is the wide variation of crime rates across cities. Edward L. Glaeser et al. (1996) examine this issue in detail. They find that less than thirty percent of the variation in cross-city crime

rates can be explained by local characteristics. In this paper they argue that either the unobserved heterogeneity across cities is much higher than the observed heterogeneity, or that the decision to commit a crime in a city is highly city dependent. This is particularly true for auto theft and larceny. For this reason the model is specified using city fixed-effects combined with state-level variables, and additionally with the available city-level variables. Using city fixed-effects and state-level demographic and economic variables enables the analysis to include many more cities.

In addition to the crime, demographic, and economic data described above the data includes a dummy variable for whether or not a bottle law has been implemented in the state in which the city is located during the observation year. Bottle laws have been passed in California, Connecticut, Delaware, Hawaii, Iowa, Massachusetts, Maine, Michigan, New York, Oregon, Vermont and Columbia, Missouri. Table 1 shows the states and cities that have enacted bottles laws and the year each bottle law was implemented. None of the states that enacted bottle laws repealed them, but the city of Columbia, Missouri enacted a city bottle law in 1982 and repealed it 20 years later. Ten of the existing bottle laws were implemented during the time period covered by the sample.

While bottle laws vary in terms of the size of the deposit-refund, from an original 2.5 cents in California to 10 cents in Michigan, the dummy variable for

Table 1: States With Bottle Laws When the Laws Were Implemented

Bottle Law States	**Years Implemented**
California	1987 to present
Delaware	1983 to present
Hawaii	2002 to present
Iowa	1979 to present
Massachusetts	1983 to present
Maine	1978 to present
Michigan	1979 to present
Columbia, Missouri	1982 to 2002
New York	1983 to present
Oregon	1973 to present
Vermont	1973 to present

bottle law is not based on the value of the deposit. The reason for this is that the substitution away from crime comes as a result of the an increase in the legal recycling wage. It is helpful to think of the recycling wage as similar to a fishery. The wage is dependent on the number of cans caught per hour. When the deposit is set higher, the number of people choosing to recycle bottle, either bottles that they collect or bottles that they have purchased, will rise. This means that while each bottle may bring in a higher deposit, the effort it takes to catch each bottle will rise. In this case it is difficult to know what the resulting change in the wage will be. It could in fact be that at some point a higher deposit would result in a lower wage for people collecting recycling. In this case we only assume that the bottle subsidizes the recycling wage so that it lies above the recycling wage in the absence of the law. Table 2 reports the descriptive statistics for the sample. The descriptive statistics in part A of the table are for the sample of cities that is used when the model is specified with state demographic and economic characteristics. In part B of the table the descriptive statistics are reported for the sample which also includes city-level unemployment.

Table 2: Descriptive Statistics

A: The Sample with State Level Variables	Mean	Standard Deviation	Minimum	Maximum
Per Capita Property Crime Rate (For Larcenies under $200)	25.35	21.17	0.01	638.97
Per Capita Police Officers	1.99	1.25	0.01	91.07
City Population	20,238	115,101	1,000	8,008,278
% of Population aged 18-24	11.23	1.51	7.56	18.4
State Unemployment Rate	6.37	2.1	2	18
ln(Income per Capita)	9.49	0.58	8	18
% Black	11.1	7.46	0.2	71.7
% Below Poverty Line	12.9	3.71	2.9	33.85
City Unemployment Rate	5.9	2.59	0.7	25.5
ln(Monthly Welfare Payment)	5.57	0.44	3.85	6.62
Observations	187,929			

B: The Sample with City Level Variables	Mean	Standard Deviation	Minimum	Maximum
Per Capita Property Crime Rate (For Larcenies under $200)	37.77	17.65	0.01	331.91
Per Capita Police Officers	1.86	0.78	0.01	22.83
City Population	108,445	321,703	15,510	8,008,278
% of Population aged 18-24	11.25	1.53	7.56	18.4
State Unemployment Rate	6.4	2.04	2	18
ln(Income per Capita)	9.50	0.60	8	11
% Black	10.34	7.1	0.2	71.7
% Below Poverty Line	13.03	3.63	2.9	33.85
City Unemployment Rate	5.9	2.59	0.7	25.5
ln(Monthly Welfare Payment)	5.62	0.48	3.85	6.62
Observations	21,555			

Sample Covers 1970-2000 and includes census places with population over 1,000 in 1970.

5. Estimation and Results

The model is run as a fixed-effects model with controls for years and cities. The basic specification of the model is:

$$CrimeRate_{jt} = \beta_1 B_{jt} + \beta_2 X_{jt} + \lambda_t + \theta_j + \varepsilon_{jt},$$

where B denotes a bottle law, X includes the demographic variables described earlier, λ_t are the year dummy variables and θ_j are the city fixed-effects. The model is estimated using least squares. The model is weighted by city population. The is done to correct for the problem of heteroskedasticity because the crime rates of large cities may have a smaller variance than the crime rates of the small cities. In addition, the standard errors reported are clustered by state and the existence of a bottle law. This is done because there may be unobservable characteristics at the state-level that cause the standard errors of cities within a state to be correlated. The model measures the response of petty property crime rates to the increased recycling employment resulting from a state bottle law. Table 3 presents the estimates for three variations of the model. The dependent variable is defined as the annual reported crime rate per 1,000 people for larcenies under $200 in value. Column (1) includes only year dummies and city fixed-effects. Columns (2) and (3) add the state-level demographic, economic controls and the police officer rate, which is the total number of police officers per 1,000 people. Columns (4) and (5) add the city-level unemployment rates.

Table 3: Petty Crime Model	1	2	3	4	5
Bottle Law	-5.4742	-3.0200	-3.1303	-3.6969	-3.8709
	(1.8527)	(1.4450)	(1.5048)	(1.5578)	(1.5862)
Bottle Law 1 Year Early			-.7660		-1.1787
			(1.5603)		(1.8597)
Per Capita Police Officers		5.1032	5.0969	5.1484	5.1297
		(.9939)	(.9918)	(1.8124)	(1.8103)
% of Population aged 18-24		.9769	.9721	1.4998	1.4826
		(.7206)	(.7174)	(.8938)	(.8872)
State Unemployment Rate		.7660	.7533	.6018	.5733
		(.3217)	(.3176)	(.3725)	(.3649)
Ln(Income per Capita)		10.5954	10.5902	14.7152	14.5935
		(7.9322)	(7.9243)	(8.5985)	(8.6068)
% Black		-.5039	-.5034	-.2724	-.2725
		(.4383)	(.4376)	(.5143)	(.5119)
% Below the Poverty Line		-.4995	-.4921	-.4509	-.4389
		(.1660)	(.1568)	(.1911)	(.1794)
ln(Monthly Welfare Payment)		.2874	.3337	-2.9333	-2.8714
		(3.4988)	(3.4763)	(4.1564)	(4.1382)
City Unemployment Rate				.1519	.1696
				(.2457)	(.2466)
Year effects	Yes	Yes	Yes	Yes	Yes
City effects	Yes	Yes	Yes	Yes	Yes
Observations	187,929	187,929	187,929	21,555	21,555
Adjusted R2	0.7631	0.7788	0.7788	0.7643	0.7643

The sample covers 1970-2000 and includes 9,771 cities. The dependent variable is defined at the per capita reported property crime rate for larcenies of value $200 or less. The sample is restricted to cities that had a population of at least 1,000 in 1970. The standard errors are weighted by city population and clustered by state and bottle law.

In Table 3 the bottle law dummy variable coefficient of -3.02 in column (2) represents petty crime rates in cities in bottle law states that are about 11.9% lower than non-bottle law states. The bottle law dummy coefficient of about -3.70 in column (4), which has slightly larger cities in the sample, represents petty crime rates in those cities in bottle law states that are about 9.8% lower than the comparable cities in states without bottle laws. All of the bottle law dummy variable coefficients are significant at the 5% level.

While the focus of the paper is on the impact of a state-level bottle law on crime rates, it is also interesting to examine the impact of other law enforcement and socioeconomic variables. Several findings warrant comment. First, the per capita number of police officers is significant and has a positive coefficient. The result is examined in detail by Levitt (1996 and 1997). The problem arises because an increased police presence may be a result of more crime and it may also cause crime reporting to increase. However, the bottle law coefficient is not sensitive to the inclusion of this variable in the model. Second, the crime rates fall as the percentage of the population in poverty rises. Third, the crime rates fall as the percentage of black residents rises.[43]

Any analysis of how a law change affects behavior raises the question of endogeneity. In this case the concern would be that higher petty crime rates lead a state to pass a bottle law. Because the vast majority of the bottle laws enacted

[43] This result is found elsewhere in the literature. Among other papers see Levitt (1997) and Bedard & Helland (2004).

are at the state-level state dummy variables cannot be included. The strategy used in this paper to test for endogeneity is from Gruber and Hanratty (1995). In this case the concern is that other endogenous characteristics of the states are leading to the change in crime. The strategy then is to include a lead dummy variable for whether the law change happened in the previous year. This test is particularly suitable in the case of a bottle law because the laws are legislated on average a year before they are implemented. If the lead dummy variable for bottle law is not zero and is statistically significant, this would be evidence that endogeneity might indeed be a problem.

The regressions reported in columns 3 and 5 of Table 3 include a lead dummy variable for whether the law change happened in the previous year. While the coefficient of the lead dummy variable is not zero for either specification, it is not statistically significant. In addition the model is also run using a bottle law dummy variable for the year in which the bottle law is legislated instead of enacted. In this case the bottle law dummy variable is no longer significant and the coefficients are between .92 and .95 for all specifications. These results support the claim that the increased employment available under bottle law regimes does decrease petty crime rates. It is not the case that low petty crime rates lead a state to pass a bottle law.

6. Conclusion

Previous studies have shown that households with lower incomes are both more likely to recycle for cash and that they recycle a larger amount than households with higher incomes. This behavior results in an increase in the incomes of households with the lowest income levels. These positive labor market effects are a result of state bottle laws and they are most easily quantified for people who choose recycling as an employment activity (Ashenmiller 2005). Economic theory predicts that they will be people who have poor labor market options, the same people who may have higher incentives to commit property crime. This paper shows that the opportunity effect, that is a result of state bottle laws, results in about a 10% decrease in average reported larceny rates. In this way the primary positive benefits of these labor market changes go to low-income individuals, but secondary benefits trickle up to higher wage earners.

States often pass bottle laws when economic conditions are favorable. This paper argues that subsidizing recycling markets has positive benefits both through creating jobs for low-income households and through reduced petty crime rates as a result of the opportunity effect. This would suggest that in fact states may derive higher benefits from passing a bottle law when economic conditions are less favorable than when they are more favorable. The effect of a state bottle law on the labor market may be substantial. State-level decision makers should recognize both the intended recycling market and labor market

benefits, and their unintended consequences, as part of the decision making process.

This paper shows that subsidizing recycling markets with a deposit-refund program results in positive societal welfare effects achieved through reduced petty crime rates. While crime rates, especially for petty larcenies, are quite noisy, the effect is pronounced. It is also important to recognize that removing the refund from the labor market would have negative welfare implications not recognized by the current theoretical literature. This effect is an unintended positive consequence of the laws, in addition to the benefits of decreased litter and internalized waste disposal costs, that were the intended benefits of the legislation.

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