Alternative Policies to Increase Recycling of Plastic Water Bottles in the United States

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Introduction

Policies aimed at increasing household recycling rely primarily on two economic mechanisms: financial incentives and reduction of the time and convenience costs associated with recycling.[1] Financial incentives can be established through fees based on the volume of garbage that the household disposes, penalties for not recycling or for not separating recyclable materials, and requirements for deposits on recyclable materials such as plastic water bottles, glass bottles, and aluminum cans. The time and convenience costs associated with recycling are reduced by measures such as the provision of curbside recycling and the availability of nearby community recycling facilities. Consideration of these factors, the amount and kind of recyclable materials, as well as personal factors such as the consumer's concern for the environment, determine the extent to which the household recycles (Viscusi et al. 2010).[2]

Only a few states and local governments have enacted any type of policy aimed specifically at the recycling of plastic water bottles. However, plastic water bottle recycling has achieved greater policy prominence recently. There are two reasons for the increased focus on plastic water bottles. First, the volume of waste associated with plastic water bottles is substantial and increasing, rising from 12 billion water bottles in 2000 to 36 billion in 2006 (Container

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[1]The desirability of recycling from a policy perspective depends on the benefits of the recycled material, the costs associated with recycling and processing the recycled material, and the costs associated with disposing of the material if it is not recycled. Bohm (1981) and Kinnaman (2006) conduct broader policy assessments that consider such issues.

[2]In Viscusi et al. (2010) and in this article, the term *recycling laws* is used to refer to policies such as provision of curbside recycling, and the term *deposit policies* refers to bottle deposits and bottle return efforts.

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Recycling Institute 2008).[3] The polyethylene terephthalate bottles used for bottled water account for hundreds of millions of pounds of waste per year that is either incinerated or buried in landfills. Second, although many states have long had bottle deposit policies in place for cans and other beverage containers, such policies have emerged more recently for plastic water bottles. Six states have extended bottle deposits to include plastic water bottles, and several other states are currently considering similar measures. However, the impact of plastic water bottle deposits on recycling has yet to be evaluated. More generally, despite a great deal of effort to encourage household recycling, there has been limited analysis of and consensus on the best ways to achieve it.

This article examines the efficacy of various policy mechanisms to increase recycling of plastic water bottles.[4] Most previous studies have relied on regional data rather than national household data.[5] However, our analysis is based on an original nationally representative survey of plastic water bottle users. Because this survey was conducted at the individual household level, we are able to undertake a more refined assessment of individual recycling behavior and the impacts of state laws and financial incentives (e.g., bottle deposits) on that behavior. In particular, we evaluate the impact of the stringency of a state's recycling laws on the provision of recycling opportunities (e.g., recycling centers, curbside pickup) and on recycling rates. We also analyze the specific impact of plastic water bottle deposit laws on recycling rates and their interactions with other recycling policies. We assume rational economic behavior throughout our analysis. Thus our model of recycling decisions is based on a general framework in which the household's recycling decision is driven by a net assessment of the value of time, bottle deposits, and environmental concerns. Our principal hypothesis is that economic incentives matter and that recycling behavior will tend to be characterized by corner solutions of either nonrecycling or diligent recycling.

We begin in the next section with a discussion of the economics of the recycling decision and the key determinants of household recycling behavior. Next we provide an overview of the recycling policy landscape, which consists of recycling laws of differing stringency, plastic water bottle deposits, and bottle deposits for other bottles and cans. These regulatory and legal structures define the overall policy architecture in place, but their ultimate effectiveness depends on their impacts on the availability of recycling opportunities and on household recycling behavior. Using the results of the survey of plastic water bottles users, the next section examines the empirical evidence on the effects of different recycling policy regimes on household recycling rates. This is followed by an empirical analysis of the links between different legal regimes and the perceived availability of recycling opportunities (e.g., curbside recycling) and between these opportunities and reported levels of household recycling.[6] We then turn to the effect of bottle deposit laws, including an examination of recycling behavior in two states, Oregon and Connecticut, before and after the adoption of plastic water bottle deposits. Finally, we examine

[3]For additional data on waste, see the U.S. Environmental Protection Agency (2007).
[4]For reviews of the recycling literature more generally, see Yang and Innes (2007) and Jenkins et al. (2003).
[5]See, among others, Kinnaman and Fullerton (2000), Fullerton and Kinnaman (1996), Hong, Adams, and Love (1993), Callan and Thomas (1997), and Van Houtven and Morris (1999). Jenkins et al. (2003) consider household data for middle- to upper-income respondents with curbside recycling in twenty metropolitan statistical areas, and Sterner and Bartelings (1999) consider household recycling behavior using regional data in Sweden.
[6]In contrast, Viscusi et al. (2010) assessed the effect of laws across states but did not consider any data pertaining to how the laws were implemented at the household level, such as whether curbside recycling was available.

the role of substitution effects and whether various recycling policies compete with each other. The main findings and lessons learned from our analysis are summarized in the conclusions section. Although plastic water bottle recycling is the principal focus of our empirical investigation, our results are generally consistent with the literature on the economics of recycling.

Economics of the Recycling Decision: Theory and Empirical Hypotheses

This section examines the economics of the recycling decision, both within households and across households. Economic analyses of recycling generally take as given the individual's consumption decisions, and they analyze whether the consumer will choose to recycle the materials conditional on these purchase decisions.[7] Such an approach is reasonable since prior decisions can be treated as fixed when analyzing subsequent recycling behavior. However, it should be noted that recycling policies of various kinds may also affect the initial purchase decision and the kinds of materials available to be recycled.[8] For example, beverage container deposits raise the purchase cost of the product and the overall monetary cost that the consumer incurs if the container is not recycled, but they also impose time costs if the container is returned for its deposit. Unless the prospect of recycling is of sufficient value based on the deposit amount and the consumer's assessment of the environmental benefits, the presence of a deposit policy will reduce the demand for the affected goods relative to substitute products that have no such costs. Thus, independent of the recycling decision, recycling policies generally reduce the waste associated with the covered products by reducing the demand for those goods. However, whether *overall* waste is reduced hinges on the consumer's substitution decision and the waste generated by those other purchases. Although these issues associated with the endogeneity of the purchase decision may be relevant in some contexts, we assume they are negligible for the analysis of the household recycling decision here.

The Household's Recycling Decision

The economics of the consumer's recycling decision concerning a given product, such as a bottle or a can, is straightforward. Consider a bottle for which the consumer has paid a deposit. Discarding the bottle in the trash has a relatively low time cost. This time cost includes the fixed cost associated with putting out the garbage, which will generally not be affected by the incremental bottle that is tossed, as well as the marginal time and effort costs of disposal. Returning the bottle for deposit offers a financial reward equal to the amount of the deposit plus any "warm glow" environmental benefit (or utility) that the consumer derives from taking this pro-environmental action.[9] On the cost side, returning the bottle for deposit incurs the fixed time and incremental transportation expense of traveling to a location

[7]Kinnaman and Fullerton (2000), Jenkins et al. (2003), Beatty et al. (2007), and Viscusi et al. (2010), among others, include models that follow this approach.
[8]Bohm (1981) presents an economic model of this initial purchase decision.
[9]The existence of such a warm glow benefit generally is borne out by studies indicating that many people are willing to pay for the provision of recycling services. Kinnaman (2006) reviews these studies.

where deposits can be redeemed plus any per bottle time cost of saving and returning the bottle for deposit.[10]

Although bottle deposits are the only financial incentive mechanism considered in this article, other studies of household behavior suggest that incentives created by household waste disposal policies have behavioral consequences. For example, for a household sample in Charlottesville, Virginia, Fullerton and Kinnaman (1996) found that charging people per bag of garbage led them to compress their garbage to reduce their costs, with only a modest reduction in the weight. Similarly, a subsequent study by Kinnaman and Fullerton (2000) estimated that a fee of $1 per bag reduced household garbage by 412 pounds per person-year but had only a modest effect on recycling, which increased by 30 pounds per year.[11] Kinnaman's (2006) review of studies of unit-based pricing approaches found that the policy structures differ in their relative efficacy, but that the behavioral responses follow economic predictions and potentially can be effective. However, the ultimate efficacy of a policy hinges on the structure of economic incentives created. For example, if a household facing a unit pricing system per bag of garbage contracts for two cans of garbage per week and would normally generate between one and two cans of garbage, then there will be no marginal restraining effect from the pricing policy. Waste disposal will respond to economic incentives, but the incentives need to be tailored to generate genuine waste reductions.

Unlike waste disposal policies generally, bottle deposit systems are particularly well suited to promoting recycling because the financial reward is explicitly linked to whether or not the bottle is returned for recycling. As with other recycling policies, how the bottle deposit will influence behavior depends critically on the economic incentives the policy creates.

Within households, fixed costs play a prominent role in the discrete decisions to return bottles for deposit, use curbside recycling, or put bottles in the garbage. Viscusi et al. (2010) theorize that consumers will tend to gravitate to corner solutions where they adopt consistent modes of behavior.[12] That is, they tend to recycle most or all of their bottles or none of their bottles once they have chosen a particular disposal mode. This hypothesis in turn predicts not that the effect of recycling policies on households will be incremental but rather that if a person formerly did not recycle and as a result of a bottle deposit policy begins to do so, the extent of the change in behavior will likely involve a discontinuous jump. As discussed later, empirical evidence supports this hypothesis, with people who formerly recycled zero out of ten plastic bottles becoming diligent recyclers in response to the policy intervention.

[10]More generally, there also may be situations in which there is a pricing policy for garbage that is used to create economic incentives for recycling. See Fullerton and Kinnaman (1996), Hong and Adams (1999), and Suwa and Usui (2007). For a discussion of economic incentives and household waste disposal generally, see Reschovsky and Stone (1994) and Nestor and Podolsky (1998).

[11]Based on a 1994 demonstration project in Marietta, Georgia, Van Houtven and Morris (1999) found that a nonreusable trash bag program involving a fee per bag reduced solid waste more than did a fee per reusable trash can program. However, both financial incentive programs were found to reduce waste consistent with economic theory.

[12]Kinnaman and Fullerton (1995) developed a similar model in which they hypothesized that corner solutions would characterize the behavioral response to unit garbage fees and found that people tend to allocate all recyclable materials to separate bins, such as those for newspapers.

Determinants of Recycling Behavior across Households

Various personal characteristics account for heterogeneity in the recycling decision across households.

Role of Private Values

The warm glow environmental benefit that a person receives from recycling will be greater for those who place a higher value on the environment. Empirical evidence is consistent with such behavior because greater recycling rates are observed for those who consider themselves to be environmentalists or those who belong to prominent environmental organizations.[13] These private values appear to be more influential in the decision to recycle than social norms such as concern with how others might view individuals if they did not recycle (Viscusi, Huber, and Bell 2011).

Role of Income

Individual income levels can be expected to have competing effects on the recycling decision. Higher income increases the time opportunity costs of recycling, which tends to reduce recycling rates. However, communities with high income levels have greater resources and may address such costs by making recycling more convenient through measures such as the availability of curbside recycling. In addition, if there is positive income elasticity with respect to the valuation of the environment, then boosting income raises the warm glow benefit from recycling. On balance, past research has indicated that income has a positive effect on recycling rates.[14]

Nevertheless, how income affects recycling behavior depends on the features of the recycling regime. For example, empirical evidence suggests that recycling plays a nontrivial financial role among those in very low-income groups in states that have bottle deposits. Ashenmiller (2006, 2009, 2010) provides substantial evidence that bottle deposit redemptions are an important income supplement for scavengers, including the homeless, and that they are associated with the added benefit of reducing criminal behavior.[15] To the extent that scavengers remove bottles from curbside bins to return them for the deposit, the net recycling rate will not increase. However, there may be social benefits apart from the environmental effects.

Bottle deposit incentives also interact with income for those in upper-income levels. One might expect bottle deposits to be less effective in inducing additional recycling behavior among the more affluent because their higher opportunity costs of time will make them less motivated by the modest financial rewards. This relationship is borne out empirically in the case of recycling of plastic water bottles (Viscusi et al. 2010). Moreover, Ashenmiller (2006) finds that deposit refund programs generally are more effective in promoting recycling among those with low-income levels than among households with high income.

[13]Supporting evidence for such an effect can be found in Halvorsen (2008), who considers the share of paper, cardboard, plastic, metal, glass, and organic waste recycled by households, and Viscusi et al. (2010), who consider plastic water bottles.

[14]Positive income effects were found by Viscusi et al. (2010) for plastic water bottle recycling in the United States and by Collins, O'Doherty, and Snell (2006) for recycling in Scotland. Saltzman, Duggal, and Williams (1993) also examined the role of income.

[15]In particular, bottle recycling laws appear to have reduced larceny rates by 10 percent.

Role of Education

Individual education levels have two types of effects. In addition to being correlated with lifetime wealth, which will tend to generate effects that are similar to those of income levels, education may augment knowledge of both the environmental benefits of recycling and the recycling opportunities that are available, such as the location of recycling centers. Thus higher education levels are expected to raise recycling rates even after accounting for income.

Role of Residential Location

Perhaps the most important residential determinant of recycling behavior is whether one lives in an urban or rural area. State laws that impose recycling requirements often have separate provisions for areas that are not densely populated, since curbside pickup and convenient recycling locations are generally not cost effective in such areas. Moreover, given the possibility of substantial time and transportation costs, including the pollution associated with driving to a recycling facility, it may not be desirable from a social efficiency standpoint to encourage such recycling.

The Policy Landscape: State Recycling Laws[16]

Various kinds of government support are needed to provide households with the opportunity to recycle. There are two general types of state laws concerning the recycling of bottles and cans: (a) recycling laws that influence the state's recycling environment, such as the provision of recycling centers; and (b) deposit laws that provide a direct incentive to recycle. Typically, recycling laws aim to reduce the time and convenience costs associated with recycling, although in some instances there also may be financial penalties for failing to recycle. Deposit laws provide a direct monetary incentive to recycle. However, the initial deposit paid by the consumer at the time of purchase increases the cost of the good if it is not recycled. Thus deposits can reduce the primary demand for the good, whereas laws increasing the convenience of recycling might offset that reduction through lower recycling costs.

Recycling Laws

State recycling laws exhibit substantial heterogeneity and often have multiple components, such as specifying a recycling plan and imposing mandatory recycling. For the purpose of our empirical analysis, we categorize them based on their most stringent component. These legal regimes are listed in increasing order of stringency in Table 1 and summarized here.[17]

[16]Viscusi et al. (2010) document the statutory basis for the categorization of current recycling laws in each state. For further discussion of the legal context of recycling laws, see Tchobanoglous and Kreith (2002) and Gaba and Stever (2008). The study of municipality recycling behavior by Kinnaman (2005) uses a different characterization of recycling laws than the study by Kaufman et al. (2004).

[17]A detailed review of these laws is included in Viscusi et al. (2010), which documents the statutory citations on which this discussion is based. Here we discuss the status of laws at the end of 2009.

Table 1 Recycling laws and deposit regimes by state in 2009

Legal regimes	
Least stringent	
No law	Alaska, Colorado, Delaware, Georgia, Idaho, Indiana, Kansas, Kentucky, Massachusetts, Missouri, North Dakota, Oklahoma, Utah, Vermont, Wyoming
State requires a recycling goal	Louisiana, Mississippi, Montana, New Hampshire, Rhode Island, South Dakota
State requires recycling plan	Alabama, California, Hawaii, Illinois, Iowa, Maine, Maryland, Michigan, Nebraska, New Mexico, North Carolina, Ohio, Tennessee, Texas, Virginia
Opportunity to recycle	Arizona, Arkansas, Florida, Minnesota, Nevada, Oregon, South Carolina, Washington
Most stringent	
Mandatory recycling	Connecticut, District of Columbia, New Jersey, New York, Pennsylvania, West Virginia, Wisconsin
Deposit regimes	
Deposit law does not cover water bottles	California, Hawaii, Maine, Vermont
Deposit law covering water bottles	Connecticut, Delaware, Iowa, Massachusetts, Michigan, New York, Oregon

Source: Statutory documentation for the legal regimes is provided in Tables A4, A5, and A6 of Viscusi et al. (2010). Connecticut and Oregon adopted plastic water bottle recycling policies that took effect in 2009. No residents of North Dakota or Vermont participated in the survey. Vermont's laws addressing recycling (10 V.S.A. § 6604 and § 6622, 24 V.S.A. § 2202a) were not considered stringent enough to qualify it as a plan law state. New York passed a deposit law covering plastic bottles, but it had not been implemented when the survey was administered.

Less Stringent Legal Regimes for Recycling

At one extreme are the fifteen states that have no recycling law. Six states have enacted the least stringent form of recycling law, which specifies only that the state have a recycling or waste reduction goal. New Hampshire, for example, specifies a goal of 4 percent waste reduction. Laws that are restricted to specifying goals do not include any concrete policy measures that could alter the time or financial costs associated with recycling. In terms of recycling behavior, we would expect states with exhortatory laws such as those announcing recycling goals to resemble states with no laws because both lack explicit economic incentives.

The next level of stringency consists of recycling laws that require the establishment of regional waste management plans that include recycling considerations. For the most part, these recycling planning laws also specify a recycling goal in terms of reduction of total solid waste. What distinguishes them from laws that only specify goals is a requirement that the state or municipalities establish concrete policies to increase recycling.[18] Fifteen states, including California, have such regional planning laws.

More Stringent Legal Regimes for Recycling

The next category of recycling laws includes laws requiring that households be provided the opportunity to recycle. Eight states have laws requiring municipalities to provide such recycling

[18]To qualify as a planning state, there must be a statewide management plan that mentions the importance of recycling and state requirements for counties, cities, and municipalities to implement plans that include recycling. Vermont fell just short based on this criterion.

opportunities. Although such laws often require the establishment of curbside recycling or convenient recycling centers, they typically include exemptions for sparsely populated rural areas. For example, Oregon's law requires convenient disposal sites, and, for cities with at least 4,000 residents, the collection of separated recyclable material at least once a month.

The most stringent laws are those that impose mandatory recycling requirements, which usually also require separation of the different kinds of recyclable materials. Six states and the District of Columbia have such requirements.

Bottle Deposit Regimes

Bottle deposit regimes are much less prevalent than recycling laws. As the bottom panel of Table 1 indicates, eleven states have bottle deposit laws, affecting 29 percent of the U.S. population.[19] However, at the end of 2009, only seven of these states had bottle deposit laws that included plastic water bottles. New York had passed a deposit law that includes plastic water bottles, but due to court challenges it had not been implemented. Thus we do not include New York as a plastic water bottle deposit state in our empirical analysis.

Empirical Analysis of the Effects of Recycling Laws on Recycling Rates

Using a 2009 nationally representative survey of households, we examined the effects of different recycling regimes on the recycling rates for plastic water bottles.[20] The survey sample consists of 605 households that use bottled water, a subset of a national sample of 1,065 households, which included households that do not drink bottled water. We focus on the difference in the proportion of bottles recycled across recycling policy regimes rather than on the total number of bottles recycled. We measure recycling propensity as the number of bottles that households indicate they recycle out of every ten plastic water bottles purchased.

Overall Recycling Rates

The overall reported level of recycling was 6.4 bottles out of 10, which exceeds reported national recycling rates for bottles overall. Although the 64 percent reported rate of recycling is high, it is not implausible given the national focus on recycling at the household level and the demographic characteristics of purchasers of bottled water. The U.S. Government Accountability Office (GAO 2009) estimated the national recycling rate in 2006 to be 24 percent. However, this estimate is not comparable because it is not limited to recycling at the household level. More specifically, the GAO estimate includes plastic water bottle use in all locations, such as restaurants and sporting events, rather than focusing on the 31 percent of plastic bottles that are used at

[19]The deposit laws by state are summarized in the Bottle Bill Resource Guide (see http://www.bottlebill.org/ [accessed June 6, 2012]). The standard bottle deposit amount is five cents. The exception is Michigan, where the deposit is ten cents. However, Michigan's deposit policy does not include plastic water bottles.

[20]The survey was administered to a web-based panel by Knowledge Networks and had a response rate of 69 percent. Recycling questions accounted for about ten minutes of a twenty-five minute survey addressing various aspects of drinking water use. Respondents were asked to answer all questions in terms of the behavior of their entire household.

the household level.[21] Furthermore, the plastic water bottle recycling rates from our survey are similar to those found by Jenkins et al. (2003) for areas with curbside recycling.[22]

Recycling Rates under Different Policy Regimes

To determine which policy interventions have the greatest effect, Table 2 presents reported recycling rates as a function of the legal regimes of the states in which respondents reside.[23] Although the analysis relies on a cross section and is consistent with the hypothesis that policies change behavior, it does not provide a conclusive comparison of behavior before and after the implementation of recycling laws because these legal regimes did not change over the period for which we have data. As discussed later, such a comparison is feasible for bottle deposit laws.

The first column in the top panel of Table 2 displays the reported number of bottles recycled out of every ten plastic water bottles purchased. These statistics show average rates of recycling under different policy regimes rather than the marginal effects of the policies.[24] The results indicate that states with recycling goals that are largely symbolic, and states with no recycling laws at all have the lowest levels of recycling. The recycling rate is 50 percent higher when a state has laws that require a recycling plan. The highest recycling rates are achieved through more stringent laws, those requiring either an opportunity for the household to recycle or mandatory recycling. Among households in our sample, those in states with mandatory recycling laws have more than double the recycling rates of those in states with recycling goals or no recycling laws.

Types of Recyclers

The subsequent columns in Table 2 divide households into nonrecyclers, moderate recyclers, and diligent recyclers,[25] indicating the fraction of households that recycle 0, 1 to 7, and 8 to 10 bottles, respectively. The most striking result in Table 2 is the small number of households in the moderate recycling category, highlighting the discontinuous shifts in behavior that result from stringent recycling laws.[26] Moving from the least to the most stringent legal regimes is not associated with a shift in nonrecyclers to the moderate recycling group. Rather, there is a very small fraction of the households in the nonrecycling group and a dominant representation in the diligent recycling group. For states with no recycling laws or laws that simply specify a recycling goal, about half of all households engage in no recycling and only about a third of

[21]The GAO estimate is not based on a survey or a comprehensive determination of household recycling behavior. Rather, it is based on various data from environmental and industry organizations using a methodology that is not disclosed. Updates by the private groups relied on by the GAO estimate an overall recycling rate of 27 percent in 2008.

[22]Jenkins et al. (2003) found that 54 percent of households in areas with curbside recycling recycled more than 95 percent of all plastic bottles, with 28 percent recycling 11 to 95 percent of their bottles and 18 percent recycling 0 to 10 percent of their bottles. Vermont reports a bottle redemption rate of 85 percent (see http://www.bottlebill.org/ [accessed June 6, 2012]).

[23]We examine the specific impacts of bottle deposit laws later.

[24]However, the estimated effects presented here are consistent with the patterns of marginal policy effects found in a multivariate analysis that is based on a 2008 survey and reported in Viscusi et al. (2010).

[25]If consumers overstate the absolute number of bottles in a consistent manner, then these categories provide an assessment of relative recycling rates, treating the reported recycling value as having ordinal rather than cardinal significance.

[26]An analysis that categorized households based on each of the eleven individual recycling possibilities yielded similar results (Viscusi et al. 2010, Table 3).

Table 2 Recycling behavior under various recycling policy regimes

	Number of bottles recycled out of 10, mean (standard deviation)	Percent who recycle at different levels			
		Nonrecyclers 0	Moderate recyclers 1–7	Diligent recyclers 8–10	*N*
Legal regimes					
No law	4.1 (4.4)	47	17	37	101
State requires a recycling goal	3.6 (4.3)	56	11	33	18
State requires recycling plan	6.4 (4.4)	28	10	62	285
Opportunity to recycle	7.0 (4.1)	21	12	67	97
Mandatory recycling	8.6 (2.9)	7	8	85	107

Source: Based on the 2009 Viscusi and Huber survey of recycling behavior administered by Knowledge Networks.

households are diligent recyclers. In contrast, in states that have laws requiring either mandatory recycling, recycling opportunities, or recycling plans, most of the recycling rate distribution is concentrated at the upper end, with 85 percent of households in mandatory recycling states recycling between 80 and 100 percent of their bottles.

These results are consistent with the economic hypothesis presented earlier, that recycling laws have a discontinuous effect on recycling behavior when there are discrete choices that have fixed costs and relatively low marginal costs associated with each mode of disposal. Once recycling laws induce people to switch away from being nonrecyclers, we find a dramatic shift in behavior such that they recycle a large proportion of their bottles. This result also implies that a program that alters behavior with respect to one category of recycling can have positive spillover effects on other categories.

Empirical Analysis of Effects of State Laws on Recycling Opportunities and Behavior

State recycling laws establish structures that in turn will have implications for how the law specifically affects the recycling opportunities. Indeed, it is only by influencing these opportunities to recycle that the laws are likely to actually affect recycling rates. Based on our survey results, this section first examines how the different legal regimes affect the components of the recycling environment by influencing the recycling opportunities available to the household and then considers how these various components or opportunities appear to affect the rate of recycling.

Mandated Separation of Recyclable Materials

As shown in Table 3, among those respondents in states with mandatory recycling, 78 percent report that they were required to separate types of recyclable materials from household trash. This coverage is below 100 percent because recycling laws generally include exemptions for certain locations such as rural areas. In addition, households may lack information on recycling

Table 3 Individuals' reported recycling opportunities by legal and deposit regimes

	Percentage reporting recycling opportunity			
	Mandated separation	**Community recycling center**	**Curbside recycling**	**Apartment with recycling**
Legal regimes				
No law	13	64	43	46
State requires a recycling goal	19	62	25	20
State requires recycling plan	29	87	64	30
Opportunity to recycle	28	68	76	63
Mandatory recycling	78	66	86	85
Deposit regimes				
No deposit law	25	70	60	92
Deposit law does not cover water bottles	57	60	79	77
Deposit law covering water bottles	54	93	80	88
Full sample	34	74	66	90

Source: Based on the 2009 Viscusi and Huber survey of recycling behavior administered by Knowledge Networks.

opportunities available in their area.[27] The reported percentage of mandated separation drops dramatically as one moves to less restrictive legal regimes. However, even in the absence of state-mandated separation requirements, some respondents reported that their households were required to separate recyclables. Any such requirements may be the result of local rather than statewide regulations. Nevertheless, it is notable that between a tenth and just over a fourth of all households in states that have no mandatory recycling or requirements to separate their recyclable materials.

Availability of Recycling Centers

The second column in Table 3 pertains to whether respondents report a community recycling center in their area. Less than two-thirds of respondents in states with no laws or with simple goals report having such centers available. About the same percentage of respondents from states with the most stringent laws report such centers. This suggests that the existence of a stringent recycling law may not increase the availability of community recycling locations because other recycling opportunities (such as curbside pickup) generated by stringent laws may be available, thus reducing the value of community recycling centers. Indeed, the highest percentage of respondents reporting community recycling centers is for states with recycling planning laws rather than states with the two more stringent forms of recycling laws.

Availability of Curbside Recycling

The third column in Table 3 indicates the percentage of respondents reporting that curbside recycling is available to their household. The fact that under mandatory recycling regimes, 86 percent of respondents indicate the availability of curbside recycling, compared with 66 percent

[27]Respondents who claimed not to know whether they were required to separate their recyclables or whether any of the other three recycling opportunities in Table 3 were available were excluded from that part of the analysis.

indicating the availability of a community recycling center, reflects the different policy instruments used by different states. Indeed, curbside recycling could appropriately be viewed as a recycling center located at the curb of the respondent's house. States with laws requiring the opportunity to recycle also have very high rates of curbside recycling availability, with 76 percent of respondents' reporting the availability of curbside recycling. States requiring a recycling plan also provide for substantial curbside recycling, with 64 percent of respondents reporting such availability for their households. However, the states with no laws or laws specifying only that there be recycling goals provide substantially less opportunity for households to recycle.

Most of these statistics and much of the discussion in the literature concern households living in separate dwellings, where curbside recycling is a relevant policy. However, households residing in apartments are likely to experience different types of recycling opportunities. To examine the effects of these opportunities, the survey asked the 267 respondents living in apartments whether their households had a place to leave recyclable materials. As shown in Table 3, for states with mandatory recycling, 85 percent of apartment dwellers report that such a recycling opportunity is available. This high degree of coverage is similar to the result for curbside recycling in mandatory recycling states. The reported availability of recycling areas at apartments is lower in states that have weaker recycling laws.

Links between Recycling Opportunities and Recycling Behavior

We next examine how the provision of recycling opportunities for plastic water bottles affects recycling behavior. Table 4 shows, as expected, that reported recycling behavior increases in the presence of laws that increase the availability or desirability of different recycling options. In particular, curbside recycling rates are strongly correlated with the stringency of the legal regime, with a high of 76 percent for mandatory recycling regimes. Curbside recycling is a popular option for recycling even when there are plastic water bottle deposits, although households also return bottles for deposit and use community recycling centers. As shown in the bottom panel of Table 4, in states with bottle deposits for plastic water bottles the most common recycling behavior for plastic water bottles is to use curbside recycling, for which there is no deposit policy. However, over half of all households either return the bottles to the store for deposit or use a community recycling center.

The survey results also allow us to assess whether the use of a community recycling center depends on its distance from the household's residence. We would expect a decline in the rate of recycling as the time and transportation costs of using the recycling center increase. This predicted relationship between recycling rates and distance from the recycling center is supported by the data, as shown in Table 5, which indicates that the highest rate of recycling is for those households that live less than 3 miles from the recycling center. There is a steady decline in recycling rates as the distance to the recycling center increases, with the rate dropping from 80 percent when centers are within 3 miles to 59 percent when centers are 10 or more miles away.

Table 6 offers further insights into the determinants of household recycling by examining recycling activities and opportunities according to whether respondents live in relatively low population density districts or a metropolitan statistical area (MSA). Urban and rural residents do not differ significantly with respect to use of bottled water or number of servings of bottled

Table 4 Recycling behaviors by legal and deposit regimes[a]

	Percentage who report recycling behavior			
	Return for deposit	Use community center	Use curbside recycling	*N*
Legal regimes				
No law	1	15	31	101
State requires a recycling goal	0	17	11	18
State requires recycling plan	7	26	41	285
Opportunity to recycle	11	16	54	97
Mandatory recycling	3	15	76	107
Deposit regimes				
No deposit law	1	17	44	416
Deposit law does not cover water bottles	5	16	60	75
Deposit law covering water bottles	22	36	48	117
Full sample	6	20	47	608

[a]Respondents can engage in multiple recycling behaviors or none at all.
Source: Based on the 2009 Viscusi and Huber survey of recycling behavior administered by Knowledge Networks.

Table 5 Recycling behavior according to distance from community recycling center

	Number of bottles recycled out of 10	
	Mean (standard deviation)	Percentage of sample
Less than 3 miles	8.0 (3.5)	32
3–5 miles	7.4 (3.8)	34
More than 5 and less than 10 miles	7.0 (4.2)	20
More than 10 miles	5.9 (4.5)	13

Source: Based on the 2009 Viscusi and Huber survey of recycling behavior administered by Knowledge Networks.

water consumed per week, but their recycling behaviors differ, with rural respondents indicating that they recycle 25 percent fewer bottles than their urban counterparts.[28] This difference in recycling rates is likely due to differences in recycling opportunities; only 33 percent of rural respondents have curbside recycling compared to 72 percent of urban respondents. However, rural residents are about as likely as urban residents to have a recycling center available (74 percent versus 77 percent), and although such centers are on average a greater distance from rural residents than from urban residents (6.8 miles versus 5.6 miles), rural residents are more likely than urban residents to use them if available (44 percent versus 29 percent).

These results suggest that rural and urban areas should have different recycling policies. More specifically, although community recycling centers may make sense in rural areas, they appear to be less effective in urban areas, which are typically dominated by curbside collection.[29]

[28]As in Table 3, respondents who did not know the answer to a given recycling question were excluded from the analysis associated with that question.
[29]Only 13 percent of urban respondents with curbside recycling available used a recycling center.

Empirical Analysis of the Effects of Bottle Deposit Laws on Recycling Rates

Laws that provide explicit financial incentives to return plastic water bottles do appear to promote the recycling of such bottles. As shown in Table 7, the lowest recycling rates are in states with no bottle deposit laws. A substantially greater rate of recycling is present when there is a general bottle deposit law that does not include plastic water bottles. But the highest rate of recycling occurs when there is a deposit law that includes plastic water bottles. Thus it appears that both the financial incentives of water bottle deposits and the convenience of returning plastic water bottles along with other bottles for which there are deposits promote recycling.

Furthermore, the number of bottles recycled exhibits a remarkable upward shift in response to water bottle deposit policies, similar to the response to overall recycling laws. More than a third of the households in our sample do not recycle at all in those states that have no deposit policies; this percentage is cut in half if there is a deposit policy that does not include water bottles. In addition, the rate of diligent recycling is very high even if the deposit policy does not include water bottles. However, if there are plastic water bottle deposits, the percentage of nonrecyclers drops to 6 percent, and the percentage of diligent recyclers increases to 87 percent. These results suggest that although financial incentives to recycle water bottles appear to be consequential, the broader recycling incentives created by any deposit policy appear to be influential as well. Moreover, in general, households tend to gravitate to the recycling extremes.

Table 6 Recycling rates and opportunities according to location of respondents' residence

	Live in MSA		Not in MSA		Difference across MSA Status
	N	Mean	*N*	Mean	Significance of *t* test
Bottled water use	898	67%	167	66%	
Servings per week	799	7.5	153	5.7	
Number of bottles recycled out of 10	512	6.6	96	5.3	***
Recycle 0	512	24%	96	41%	***
Recycle 1–7	512	12%	96	9%	
Recycle 8–10	512	64%	96	50%	**
Curbside recycling available	813	72%	156	33%	***
Use curbside recycling conditional on availability	344	72%	27	59%	
Recycling center available	638	77%	137	74%	
Use recycling center conditional on availability	270	29%	55	44%	**
Distance to recycling center	475	5.6 miles	101	6.8 miles	**
Return for deposit	521	6%	98	5%	
Apartment recycling	200	52%	26	42%	
Separation of recyclables required	890	29%	165	16%	***

Difference across MSA status: **significant at the 5% level; ***significant at the 1% level.
Source: Based on the 2009 Viscusi and Huber survey of recycling behavior administered by Knowledge Networks.

Table 7 Recycling behavior under various deposit policy regimes[a]

	Number of bottles recycled out of 10, mean (standard deviation)	Percent who recycle at different levels			
		Nonrecyclers 0	Moderate recyclers 1–7	Diligent recyclers 8–10	*N*
Deposit regimes					
No deposit law	5.6 (4.5)	35	12	53	416
Deposit law does not cover water bottles	7.3 (3.9)	17	13	69	75
Deposit law covering water bottles	8.8 (2.6)	6	7	87	117
Mandatory, opportunity, or planning law; but no plastic water bottle deposit law	7.6 (3.7)	15	11	74	169
Full sample	6.4 (4.3)	27	11	62	608

[a]Recycling categories show the percentage of the subsample with that recycling behavior.
Source: Based on the 2009 Viscusi and Huber survey of recycling behavior administered by Knowledge Networks.

Distinguishing the Marginal Effects of Bottle Deposit Policies

Although the data from our survey indicate that states with deposits for plastic water bottles have higher recycling rates than states without such policies, the existence of a deposit policy is correlated with other state characteristics. In particular, every state with a plastic water bottle deposit system also has recycling laws that include either mandatory recycling, the opportunity for recycling, or specific recycling planning requirements. None of the states with plastic water bottle recycling are in the category of states that have no recycling law or a recycling law that simply specifies a recycling goal.[30]

To distinguish the marginal effect of plastic water bottle deposits from the effect of recycling laws generally, consider the recycling rates in Table 7. The recycling rates for states that have the three most stringent categories of recycling laws but do not have plastic water bottle deposits provide a reference point for assessing whether adding a water bottle deposit law has an effect. Even relative to those states with the more stringent laws, there is a remarkable shift in the distribution of recycling behavior because bottle deposits substantially transform nonrecyclers into diligent recyclers, with the percentage of those who recycle eight to ten bottles increasing by about 13 percentage points.

Effects of Changes in Bottle Deposit Laws

The previous discussion indicates that different legal and deposit regimes are associated with different levels of recycling. However, the *direction* of causality cannot be resolved with these data because a community's desire to recycle may be reflected in both its laws and its behavior.

[30]This characterization of the effectiveness of recycling laws is based on the results in Viscusi et al. (2010), which found that the only recycling policies that significantly affected recycling rates were mandatory recycling, the opportunity to recycle, and state recycling plans.

To identify a stronger causal link, we examine survey results concerning bottled water usage and recycling behavior for two states, Oregon and Connecticut, before and after the adoption of a water bottle deposit law in 2009 (see Table 8).[31] The data indicate a nonsignificant drop in demand for bottled water, coupled with a large increase in those reporting they have returned bottles for deposit (from 12 percent to 30 percent). There is also an increase in the mean number of bottles recycled (from 7.6 to 8.8) and an increase in the percentage of respondents in the diligent recycling group (from 71 percent to 86 percent).

The data presented here and in the previous sections suggest that recycling can be substantially increased through environmental regulations that facilitate collection of recyclable materials and provide economic incentives in the form of deposits. The next section discusses the interactions among various recycling policies and the activities to implement them.

Do Recycling Policies Compete with Each Other? The Role of Substitution Effects

Because states that have deposit policies for plastic water bottles also tend to have other strong recycling laws and favorable environments for recycling generally, many researchers have questioned whether the various recycling policies simply cannibalize each other. Although the previous discussion of plastic water bottle deposits indicates that there is some incremental benefit from deposit policies, one cannot rule out the presence of substitution effects that follow from basic economic theory. The main issue is whether any substitution effects are large enough to offset the direct beneficial effect of the policy.

Substitution Effects and Curbside Recycling

The economic debate concerning the potential influence of substitution effects has focused on the introduction of curbside recycling. More specifically, does curbside recycling have a marginal effect on recycling rates if other recycling policies, such as convenient recycling locations and bottle deposit systems, are already in place? If the availability of curbside recycling simply shifts the location of recycling for people who already recycle by taking their waste to a collection center, then there will be no marginal gain from introducing curbside recycling. Similarly, consider a situation in which curbside recycling is followed by the implementation of a bottle deposit system. If prior to the enactment of the refund policy the household was recycling its bottles at curbside, then there would be no net increase in recycling from the bottle deposit policy.

The empirical evidence on the impact of substitution effects on the marginal benefits of curbside recycling policies is mixed. Jenkins et al. (2003) use a sample of households for twenty MSAs and find that curbside recycling boosts the recycling rate for various materials. However, based on an analysis of curbside recycling in California, Beatty, Berck, and Shimshack (2007) concluded that introducing curbside recycling had only a small marginal effect on the amount

[31]This comparison of Oregon and Connecticut before and after the adoption of bottle deposits for plastic water bottles relies on both the 2008 survey in Viscusi et al. (2010) and the 2009 survey analyzed here. The 2009 wave of the survey includes questions not included in the 2008 survey and not discussed in Viscusi et al. (2010), particularly those relating to the availability of different recycling options for the household, such as curbside recycling.

Table 8 Bottled water usage and recycling behavior in Connecticut and Oregon before and after changes in deposit laws

	Before deposit law change		After deposit law change		Significance of *t* test
	N	**Mean**	***N***	**Mean**	
Bottled water use	112	68%	66	61%	
Return any bottles for deposit	68	12%	37	30%	**
Number of bottles recycled out of 10	68	7.6	37	8.8	*
Recycle 0	68	10%	37	5%	
Recycle 1–7	68	19%	37	8%	
Recycle 8–10	68	71%	37	86%	*
Use curbside recycling	68	54%	37	59%	
Use recycling center	68	21%	37	11%	

*Significant at the 10% level; **significant at the 5% level.

Source: Based on the 2008 and 2009 Viscusi and Huber surveys of recycling behavior administered by Knowledge Networks.

that people recycled. Although there was an increase in the amount of material recycled at curbside after the expansion of curbside recycling, there was also a decrease in the amount of material returned to recycling centers. From the standpoint of individual waste disposal decisions concerning plastic water bottles, the provision of an additional mode of recycling in locations that already have a recycling option introduces two new choices: whether to put the material in the garbage or recycle it at curbside and whether to recycle the material at curbside or return for a deposit. If the household uses curbside recycling for materials that would not be returned to the recycling center, it will have already incurred the fixed costs associated with curbside recycling. As a result, returns to the recycling center will become comparatively less attractive, which is what is observed in practice.

Substitution Effects and Bottle Deposit Programs

The strongest evidence concerning the net impact of financial incentives in the presence of such substitution effects generally focuses on bottle deposit programs. Based on her study of recycling at Santa Barbara, California, redemption centers, Ashenmiller (2009) concluded that the amount of material that was recycled increased after the enactment of bottle deposits. In particular, she found that the California bottle law led to a net increase in recycled material of 36 to 51 percent even in the presence of curbside recycling. The overall implication of the Ashenmiller (2009) and Beatty et al. (2007) California studies is that the substitution effect appears to reduce the efficacy of curbside recycling policies more than it reduces the efficacy of bottle deposit policies.

Viscusi et al. (2010) found that bottle deposits generate a net increase in the number of bottles recycled, controlling for the various recycling laws and their consequences. However, this increase is less than one would expect based on the results in Table 7, which did not

disentangle the marginal policy effects. In particular, based on a multivariate regression analysis, the estimated incremental effect of deposits on plastic water bottles is to increase recycling rates by 1.2 bottles out of every 10 bottles. Thus the marginal effect is smaller than the 1.5-bottle incremental increase in recycling for states with other deposit laws and the 3.2-bottle incremental increase in recycling for states with no deposit laws (as shown in Table 7).

Marginal Effects of Recycling Policies

Recycling laws and deposit policies appear to have quite strong effects on recycling opportunities, even when the effects of other policies are taken into account. As indicated by the regression results in Table A.1, states with mandatory or opportunity to recycle laws have a 0.34 higher probability of mandatory separation of recyclables, a 0.36 higher probability of having curbside recycling, and a 0.28 higher probability of having a recycling area available to those who live in apartments, relative to states with no recycling laws. States with recycling planning laws have a 0.14 higher probability of having mandatory separation and a 0.18 higher probability of having curbside recycling. States with recycling goals alone have no statistically significant effect on any of these various mechanisms to foster recycling behavior relative to states with no recycling laws, consistent with the pattern of the mean results.

The comprehensiveness of bottle deposit policies appears to be an indicator of the degree of stringency of the state's recycling efforts. As shown in Table A.1, states with deposits on bottles other than water bottles are 0.27 more likely to have mandated separation policies, 0.11 more likely to provide curbside recycling, and 0.32 more likely to have recycling available to apartment dwellers. Statistically significant effects are also observed in states with deposits on plastic water bottles because these states have a 0.20 higher probability of mandatory separation, a 0.28 higher probability of community recycling centers, and a 0.15 higher probability of curbside recycling.

Conclusions

The economic analysis presented here illuminates the microeconomics of recycling behavior and offers five principal lessons. First, economic incentives matter. Reducing the time and convenience costs of recycling or increasing the financial reward for recycling both enhance the degree of recycling. Second, the efficacy of these incentives varies across the population. Upper-income groups tend to exhibit high degrees of recycling generally but are less motivated by the modest bottle deposit refund systems in place. In contrast, the very poor may find these bottle deposits to be a motivating income source. Third, the net effect of recycling policies is less than the marginal effect of each policy introduced separately, and substitution effects limit but usually do not fully offset the beneficial effects of additional policies. Thus policies should be judged on their incremental benefits and costs, not on their average performance. Fourth, even without financial inducements, many people choose to recycle because of the warm glow benefits of recycling. Such behavior is most common among those who consider themselves to be environmentalists. However, because these people are self-motivated, the provision of water bottle deposits and similar efforts does not enhance their recycling rates as much as for those who are less motivated.

Finally, for the population at large, a fascinating transformation in behavior occurs with the introduction of incentives to recycle plastic water bottles. One would expect recycling rates to increase in response to such incentives, and this is indeed the case. However, what is most interesting is that the change in the recycling rate exhibits a jump as people shift from being nonrecyclers to diligent recyclers. This phenomenon is consistent with a substantial fixed cost for implementing various disposal modes and a low marginal cost of including additional recyclable materials. This suggests that recycling can be encouraged by either reducing the fixed cost associated with a disposal mode or reducing the variable cost associated with including other recyclables under that disposal mode. The first approach is reflected in the reduction of fixed costs through recycling laws and the establishment of bottle return centers that encourage general recycling. The second approach is reflected in policies that reduce per bottle marginal costs through curbside recycling and increasing marginal benefits through programs such as bottle deposits. A focus on both kinds of costs will be important for a successful effort to increase household recycling.

From a methodological perspective, our exploration of recycling behavior at the household level illustrates the wide range of economic insights that can be derived from examining a combination of state-level legal data and representative household data.

Appendix

Table A.1 reports a series of probit regressions predicting the availability of recycling opportunities, including whether the household is subject to a mandatory separation law, whether there is a community recycling center, whether there is curbside recycling for the household, and whether the apartment in which the respondent lives provides a recycling area. The set of six explanatory variables includes the different recycling legal regimes where the excluded category is states with no recycling law. In addition, the equations include deposit law variables both for states with water bottle deposits and for states with general bottle deposit laws that do not include water bottles. All states with water bottle deposit laws also have deposit laws for other types of bottles. The omitted deposit law category is states in which there is no deposit law.

Because the coefficients have all been transformed to correspond to marginal effects, the coefficients can be readily interpreted. For example, controlling for the other laws and deposit policies, a mandatory or opportunity to recycle law increases the probability that the household is subject to a mandated separation policy by 0.34. Living in a state with a deposit regime increases the probability that the household is subject to a mandated separation policy by about 0.20 to 0.27. None of the recycling methods has a statistically significant effect on households where state laws only specify a recycling goal. This result is consistent with the finding in Viscusi et al. (2010) that such laws do not boost recycling rates overall.

The regressions in Table A.1 coded as zero show the responses of those who did not know if they had the particular recycling opportunity. However, it would also be instructive to see how the results are affected by restricting the responses to those who are informed of their recycling opportunities. Thus the results in Table A.2 exclude the "don't know" responses. The different sample sizes in Tables A.1 and A.2 reflect the number of respondents who did know about the particular recycling opportunity. These sample size differences indicate that recycling opportunities in close proximity, such as recycling for apartments and curbside recycling, are better

Table A.1 Probit regressions predicting availability of recycling opportunities[a]

	Mandated separation	Community center	Curbside recycling	Apartment with recycling
Mandatory or opportunity to recycle	0.344 (0.063)***	−0.017 (0.062)	0.360 (0.048)***	0.275 (0.149)*
State requires recycling plan	0.135 (0.060)**	0.056 (0.060)	0.178 (0.057)***	−0.156 (0.159)
State requires a recycling goal	0.139 (0.148)	−0.023 (0.129)	−0.149 (0.141)	−0.212 (0.255)
Deposit law does not cover water bottles	0.266 (0.064)***	−0.093 (0.064)	0.113 (0.060)*	0.322 (0.133)**
Deposit law covering water bottles	0.201 (0.054)***	0.284 (0.048)***	0.153 (0.050)***	0.116 (0.122)
Observations	608	608	608	114

[a]Reported coefficients are marginal effects. Robust standard errors in parentheses.
*Significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.
Source: Estimates by the authors using the 2009 Viscusi and Huber survey of recycling behavior administered by Knowledge Networks.

Table A.2 Probit regressions predicting availability of recycling opportunities[a]

	Mandated separation	Community center	Curbside recycling	Apartment with recycling
Mandatory or opportunity to recycle	0.415 (0.065)***	−0.002 (0.058)	0.322 (0.049)***	0.275 (0.148)*
State requires recycling plan	0.162 (0.067)**	0.128 (0.057)**	0.153 (0.057)***	−0.148 (0.160)
State requires a recycling goal	0.157 (0.157)	−0.029 (0.125)	−0.169 (0.146)	−0.213 (0.256)
Deposit law does not cover water bottles	0.303 (0.069)***	−0.091 (0.071)	0.151 (0.055)**	0.319 (0.132)**
Deposit law covering water bottles	0.282 (0.062)***	0.205 (0.042)***	0.162 (0.048)***	0.110 (0.122)
Observations	514	434	559	113

[a]Reported coefficients are marginal effects. Robust standard errors in parentheses.
*Significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.
Source: Estimates by the authors using the 2009 Viscusi and Huber survey of recycling behavior administered by Knowledge Networks. The samples for each regression exclude the "don't know" respondents for the particular dependent variable.

known to respondents than legal requirements (mandated separation) and more distant recycling options (community center).

The results in Table A.2 are similar to those in Table A.1, with some coefficients increasing in magnitude and others decreasing. The most notable difference is that the variable for states requiring a recycling plan now has a statistically significant positive effect on whether respondents indicate that there is a community recycling center.

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