Does Waste Management Policy Crowd out Social and Moral Motives for Recycling?

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June 13, 2012

Abstract

In this paper, we consider households' decision of whether to recycle within a theoretical framework that allows for the inclusion of social and moral motivations. The former comes from valuing social approval while the latter comes from valuing self-image. In the context of our theoretical framework, we introduce a unit pricing system and, separately, mandatory recycling and analyze how each affects the equilibrium in terms of whether a society recycles. We show that a unit pricing system enhances the effect of intrinsic motivation (there is crowding in) while mandatory recycling erodes it (there is crowding out) provided that the marginal utility of self-image falls short of the cost of recycling relative to the environmental benefit of living in a society in which everyone recycles. If mandatory recycling is accompanied by an improvement in recycling services that applies to all recyclables and not just the mandated recyclables, crowding out becomes less likely to occur; if the improved services only apply to the mandated recyclables, there is however no effect on the potential for crowding out. Using an international household-level data set, we find support for the hypothesis that mandatory recycling can lead to crowding out while unit pricing does and, to some extent, can relate the potential for crowding out to higher recycling costs.

Keywords: Unit Pricing, Mandatory Recycling, Social Motivation, Moral Motivation, Crowding in, Crowding out.

JEL Classifications: D03, H31, H41, Q53.

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1 Introduction

Municipal waste constitutes a major source of pressure on the environment and thus represents an important policy target. A main component of municipal waste is household waste: in 2005, for example, households produced over 75% of municipal waste in Korea, Germany, the U.K., Mexico, Belgium, the Netherlands, the Slovak Republic, Luxembourg, Denmark, and Spain; although households contributed less to municipal waste in the other OECD countries for which both municipal waste and household waste figures are available for 2005, household waste still represented a big proportion of municipal waste (OECD, 2008).[1]

The growing concern for municipal waste generation and disposal stems from (i) an increased concern for the environment and environmental sustainability coupled with an increased awareness of the environmental effects of waste generation through its contribution to climate change, surface and ground water contamination, and air contamination, (ii) a reluctance by society to the development of new landfills and incineration facilities, and (iii) a drastic increase in municipal waste (household waste, in particular) over the last decades as a result of higher incomes, more intensive use of packaging materials and disposable goods, and increased purchases of durable material goods, with projection of continued growth despite current efforts to reduce the material content of products and to stimulate the reuse of products and packaging and the recycling of materials and substances.

Within the OECD region, municipal waste generation increased by about 58% from 1980 to 2000 and 4.6% between 2000 and 2005; under the assumption of no new policies, total municipal waste is projected to increase by 38% from 2005 to 2030 and per capita municipal waste by 25% (from 557 kg to 694 kg) over the same period (OECD, 2008). In terms of waste management practices, there have been considerable changes in the amounts of waste being landfilled, incinerated or otherwise treated, and recycled or composted: in the mid-1990s, approximately 64% of municipal waste was destined for landfills, 18% for incineration, and 18% for recycling (OECD, 2001); in 2005, 49% was landfilled, 21% incinerated or otherwise treated, and 30% recycled or composted (OECD, 2007). Although the amount of waste within OECD countries being landfilled decreased not only in relative terms but also in absolute terms (from 346 to 320 million tonnes per year) during the 10-year period, seven countries still landfilled more than 80% of their municipal waste and two almost all of their waste in 2005 (OECD, 2008).

The municipal waste situation in non-OECD countries is much more complicated and poses some real policy challenges. In fact, not only non-OECD countries are expected to experience larger increases

[1] Household waste represented 60% of municipal waste in the U.S., 67% in Japan, 65% in France, 75% in Austria, 49% in Finland, 58% in Hungary, 57% in Ireland, 53% in Norway, 69% in Poland, 67% in Swizerland (OECD, 2008).

in municipal waste generation by 2030 in response to rising incomes, rapid urbanization, and technical and economic development (e.g., around 485 million tonnes or 214% higher than the 2004 level in China and 250 million tonnes or 130% higher than the 2001 level in India) but they also tend to rely on less environmentally friendly forms of disposal (e.g., 48% of municipal waste not being treated in China and 50 to 80% of municipal waste being dumped in Indonesia, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam).

In response to the increasing environmental pressures of municipal waste, many countries have begun to explore ways of reducing and disposing of it more effectively. In targeting one of the main sources of municipal waste, that is, household or residential waste,[2] municipal governments, which tend to be responsible for carrying out waste management and recycling services and for developing waste management programs and can thus have much influence on waste reduction through policies and legislative measures, have grown particularly interested in experimenting with unit pricing systems and improving recycling services. In the U.S., for example, the number of jurisdictions with some sort of pay-as-you-throw or unit pricing program increased from about 1000 in 1993 to almost 7100 in 2006 or about 25% of all U.S. communities, with the largest number of programs (more than 200) available in Minnesota, Iowa, Wisconsin, California, New York, Washington, and Pennsylvania (Skumatz and Freeman, 2007); in Canada, the share of households with access to at least one type of recycling program increased from about 70% in 1994 to 93% in 2006, with paper recycling experiencing the lowest increase from 70% to 88% and plastic recycling the largest increase from 63% to 87% (Statistics Canada, 2008).

With residential solid waste becoming a more important issue to policy-makers, many theoretical and empirical papers have been produced to examine how and to what extent household waste management decisions are affected by government policies and socio-economic variables. Within the theoretical literature on the economics of household waste management,[3] there are models supporting the use of a virgin material tax or a direct tax on households' disposal choices. Other models support the use of a deposit/refund type scheme, particularly in the presence of incentives for illegal forms of disposal, that is, a system consisting of an advanced disposal fee applied either at the production or the purchase point and a recycling subsidy to households that recycle or firms that purchase recycled materials. Unfortunately, deposit/refund systems are complex to administer, and are thus subject to high transaction costs, and may be inappropriate for

[2] In 2005, for example, households' contribution to municipal waste was over 75% in Korea, Germany, the U.K., Mexico, Belgium, the Netherlands, the Slovak Republic, Luxembourg, Denmark, and Spain, 75% in Austria, 69% in Poland, 67% in Japan and Swizerland, 65% in France, 60% in the U.S., 58% in Hungary, 57% in Ireland, 53% in Norway, and 49% in Finland (OECD, 2008).

[3] For a review of this literature, see Choe and Fraser (1998), Fullerton and Kinnaman (2002), and, more recently, OECD (2004).

certain waste types such as food and some types of plastic. Hence, in spite of there being theoretical consensus among economists that deposit-refund mechanisms are efficient, advanced fees and recycling subsidies are not very common and deposit/refund systems are only implemented for beverage containers.

In many theoretical papers, a great deal of interest has been on clarifying the relationship between waste production and recycling and waste management policies such as output taxes, user fees (e.g., Atri and Schellberg, 1995; Dinan, 1993; Fullerton and Kinnaman, 1995; Jenkins, 1993; Wertz, 1976), and collection frequency (e.g., Ferrara, 2003 and 2011). Unit pricing, in particular, has been shown to be socially desirable as the alternative of financing waste collection from general revenues (such as property taxes) or flat fees leads households to view collection as free and, consequently, to overproduce waste (e.g., Fullerton and Kinnaman, 1995). A positive marginal disposal price causes households to both re-allocate their time towards recycling and alter their consumption habits to produce less non-recycled waste. While the theorized effect on consumption patterns has not yet been empirically tested, the effect on recycling has received extensive empirical attention, disputed in some cases (e.g., Jenkins et al., 2003; Nestor and Podolsky, 1998; Reschovsky and Stone, 1994; Van Houtven and Morris, 1999) but substantiated in others (e.g., Ferrara and Missios, 2005; Hong et al., 1993). One unintended possibility is that households shift to illegal disposal. In theory, illegal disposal does not imply user fees are sub-optimal, although the appropriate user fee may be negative rather than positive.[4] Theoretically, free garbage collection is deemed appropriate if the subsidy on legal disposal is close to the direct resource cost (Fullerton and Kinnaman, 1995).

The decision of recycling can be viewed as a decision about whether and to what extent to contribute to a public good, that is, environmental quality. In the absence of public intervention, including economic incentives (e.g., user fees for garbage disposal, recycling subsidies), standard economic theory predicts a suboptimal recycling level as non-recyclers cannot be excluded from the enjoyment of environmental quality and, in fact, they can free ride on the recyclers' contributions. Models that try to explain recycling participation in the absence of financial incentives and/or legal obligation rely on some additional private benefit from contributing to a better environment through recycling.[5] This private gain may come from the desire to be seen by others as a responsible citizen (Höllander, 1990) or to keep up appearances and gain respect in the community through a positive attitude towards environmental issues (Blamey, 1998), may relate to the pleasure (or "warm glow" feeling) of giving (Andreoni, 1990), or may result from a combination

[4] A negative user fee would subsidize consumption and therefore a consumption tax would be required; the inability to tax illegal activity does not result in a second-best solution as, in general equilibrium, only relative taxes matter and the tax on illegal behavior can be zero (Fullerton and Kinnaman, 1995).

[5] More generally, and in the context of the literature on private charity, models that assume altruistic preferences cannot explain the large contributions to public goods that we observe. The limits of altruism are detailed in Andreoni (1988).

of different types of social and moral norms which act through feelings of self-respect, guilty conscience, warm glow, and respect in (and sanctions from) the community (Halvorsen, 2008).[6] Empirically, there is some recent evidence which suggests that moral and social motivations can positively affect households' recycling decisions (Berglund and Matti, 2006; Halvorsen, 2008; Brekke et al., 2010; Ferrara and Missios, 2012).

When allowing for a framework that draws from various social sciences to capture a wider range of motives for environmentally responsible behavior, we have the opportunity of examining and rethinking the interaction among different types of motivation, which is gaining considerable acceptance in the field of economic psychology (e.g., Brekke at al., 2003; Frey, 1997; Thøgersen, 2003). If households have strong moral motives for environmentally responsible behavior, such as sorting waste at source or recycling, any external intervention, including external regulation (commands), can affect intrinsic motivation either through a crowding out, if the intervention is perceived to be controlling, or through a crowding in, if it is perceived to be acknowledging (Frey, 1999). Although there exists some evidence suggesting that, when households have strong moral motives for environmentally responsible behavior, policies relying on economic incentives may be ineffective as they may undermine individuals' sense of civic duty (Frey and Oberholzer-Gee, 1997), there is no evidence to date supporting the hypothesis of a crowding out of personal motives for recycling in the presence of economic incentives or other types of regulation.[7] This is partly attributable to the lack of studies in the area that do consider personal motivation and thus the interaction between personal motives and regulations. In the few studies available, the evidence indicates that either there is no erosion (Halvorsen, 2008; Ferrara and Missios, 2012) or that a large proportion of the positive effect of regulation is attributable to personal norms and self-efficacy beliefs (Thørgeson, 2003).

Understanding the interaction among different types of motivation is key to effective policy making. In fact, to the extent that it is perceived as communicating norms and responsibilities, government regulation can enhance intrinsic motivation in the form of a moral norm. If behavior is motivated by norms and public policy can increase individuals' intrinsic incentives to act, policy results are likely to be dependent upon framing or the way in which policies are presented (Nyborg, 2003), so that appreciating how norms are enforced and the mechanisms linking policy to norm enforcement becomes particularly relevant. With

[6] Additional studies which adopt elements from the psychological literature focusing on moral and/or social norms to explain the existence of voluntary contributions include Brekke et al. (2003), Deci and Ryan (1985), Festinger (1957), Frey (1994), Lindbeck (1997), Nyborg and Rege (2003), Rabin (1998), and Schwartz (1970).

[7] Outside of the recycling literature, empirically supported is also the crowding out of charitable giving by government contributions (Andreoni, 1993) and fundraising activities (Andreoni and Payne, 2011a and 2011b), of church donations by the New Deal (Gruber and Hungerman, 2007), and, more generally, of public goods in the experimental literature (Chan et al., 2002; van Dijk et al., 2002).

this in mind, we consider households' decision of whether to recycle within a theoretical framework that incorporates social and moral motivations. The former comes from valuing social approval which depends on the difference between one's contribution to recycling and the average contribution, the frequency of meeting a recycler, and the difference in one's utility between a society in which everyone recycles and a society in which no one recycles. The latter comes from valuing self-image which depends on the difference between one's contribution to recycling and the morally ideal contribution, the total environmental benefit of recycling if everyone recycles, and the share of recyclers.

In the context of our theoretical framework, we introduce a unit pricing system and, separately, mandatory recycling and analyze how each affects the equilibrium in terms of whether a society recycles. We show that, under a unit pricing system, a society in which no one recycles moves to an equilibrium in which everyone recycles (there is crowding in); however, under mandatory recycling, a society in which everyone recycles moves to an equilibrium in which no one recycles provided that the marginal utility of self-image falls short of the cost of recycling relative to the environmental benefit of living in a society in which everyone recycles (there is crowding out). If mandatory recycling is accompanied by an improvement in recycling services (e.g., from drop-off to curbside pick-up) that applies to all recyclables and not just the mandated recyclables, crowding out becomes less likely to occur; if the improved services only apply to the mandated recyclables, there is however no effect on the potential for crowding out.

In the second part of the paper, we test the hypotheses derived from the theoretical formulation using an international data set that was put together in February 2008 as part of an OECD project aiming at better understanding household decisions in consumption areas identified as contributing to environmental problems, including waste generation and recycling (OECD 2011). Although the empirical literature on municipal waste management is fairly extensive, much of it focuses on the effects of socio-demographic variables and unit pricing systems, with some recent attempts to quantify the role of attitudes and the importance of cultural and social influences in the decision-making process. The most up to date review of the literature is available in a recent comprehensive study of the determinants of recycling and waste prevention (Ferrara and Missios, 2012).

2 Model

We consider a society with a continuum $[0, 1]$ of households facing the decision of whether to recycle. We assume that, if a household chooses (as opposed to being mandated) to recycle, it recycles everything that is recyclable. This assumption is most reasonable when the same collection and disposal service is in place for the different types of non-mandated recyclables (e.g., same drop-off center) and no separation requirements exist.

Households receive utility from private consumption (x), self-image (m), social approval (s), and environmental quality (e) which depends on the average contribution to recycling ($\overline{\gamma}$). In line with theoretical studies of social or moral motivation, we represent household i's preferences with a utility function (U) that is additive in its arguments and linear in private consumption, social approval, and self-image.[8] Formally,

$$U_i = x_i + \beta_i s_i + \delta_i m_i + e\left(\overline{\gamma}\right), \tag{1}$$

where β_i and δ_i are parameters with values ranging between zero and one that capture the importance of social and moral motives; the closer to one β_i and δ_i are, the more satisfaction a household derives from social approval and self-image. As individuals that are more concerned about social approval are also likely to be more concerned about self-image (moral and social motives tend to move in unison), we can express δ_i in terms of β_i as $\delta_i = \xi\beta_i$, where ξ is a positive constant.

We assume that β_i is uniformly distributed on $[0, 1]$ and introduce r to denote the value of β_i such that households with $\beta_i < r$ choose not to recycle and households with $\beta_i > r$ choose to recycle. In other words, r identifies the household that is indifferent between recycling and not recycling. Introducing γ as the dichotomous parameter that gives whether a household recycles ($\gamma = 1$ if it recycles and $\gamma = 0$ otherwise), we can express the average contribution to recycling as $\overline{\gamma} = 1 - r$.

Households have a fixed amount of income (I) they allocate between private consumption, which we assume to be the numeraire, and recycling efforts, which entail a cost equal to $c(\theta)$. Specifically, household i's budget constraint is given by

$$I = x_i + c(\theta), \tag{2}$$

where θ is an efficiency parameter exogenous to households that reflects institutional or technical issues as in Brekke et al. (2003). An increase in θ corresponds to an improvement in service. We thus assume that the cost of recycling is decreasing in θ, $c'(\theta) < 0$, but at a decreasing rate, $c''(\theta) > 0$.

As in Rege (2004), we appeal to the empirical finding in the sociological literature that people tend to socialize more often with their peers (Fisher, 1982), a phenomenon that is referred to as viscosity in the biological literature, and introduce the same assumption as in Myerson et al. (1991) that a person faces a positive probability $k \in (0, 1)$ of meeting someone from the same peer group. The assumption implies that a recycler meets a recycler with probability $k + (1 - k)(1 - r)$ while a non-recycler meets a recycler

[8] See Rege (2004) and Nyborg and Rege (2003) for studies on social motivation and Brekke et al. (2003) for a study on moral motivation.

with probability $(1-k)(1-r)$. Even if the share of the population that recycles is very small, recyclers may meet with a positive frequency.

Self-image is a function of the difference between household i's contribution to recycling and the morally ideal contribution, the total environmental benefit of recycling if everyone recycles, and the share of recyclers, that is,

$$m_i = (\gamma_i - 1) e(1)(1-r). \tag{3}$$

The specification builds on the idea that a negative self-image results when actual behavior falls short of the morally ideal behavior, which we assume to correspond to recycling,[9] and that moral motivation is triggered by awareness of consequences, as reflected in the external or environmental benefit of recycling in a morally ideal society, and ascription of responsibility (Schwartz, 1970), which increases with the share of the population engaged in recycling.[10]

Social approval is instead a function of the difference between household i's contribution and the average contribution to recycling, the frequency of meeting a recycler, and the difference in household i's utility between a society in which everyone recycles and a society in which no one recycles, that is,

$$s_i = \begin{cases} (1-\overline{\gamma})[k + (1-k)(1-r)]\lambda & \gamma_i = 1 \\ -\overline{\gamma}(1-k)(1-r)\lambda & \gamma_i = 0, \end{cases} \tag{4}$$

where λ denotes the difference in household i's utility between a society of recyclers and a society of non-recyclers which is given by

$$\lambda = e(1) - c(\theta) > 0. \tag{5}$$

The specification is closest to that in Rege (2004) but is consistent with other specifications from social exchange theory (Homans, 1961; Blau, 1964) according to which individuals face social disapproval when their actions negatively affect others: the more costly their actions are and/or the more people adhere to the social norm, the more disapproval they face.

Substituting for x_i from (2) into (1) and using that $\overline{\gamma} = 1 - r$, we obtain

$$\begin{aligned} U_i^r &= I - c(\theta) + \beta_i r[k + (1-k)(1-r)]\lambda + e(1-r) & \gamma_i = 1 \\ U_i^{nr} &= I - \beta_i (1-k)\lambda(1-r)^2 - \delta_i e(1)(1-r) + e(1-r) & \gamma_i = 0. \end{aligned} \tag{6}$$

The difference in household i's utility between recycling and not recycling is then given by

$$\Delta U_i = U_i^r - U_i^{nr} = -c(\theta) + \beta_i [1 - k - (1-2k) r]\lambda + \delta_i e(1)(1-r), \tag{7}$$

[9] In Brekke et al. (2003), individual i' morally ideal behaviour is endogenously derived as that which maximizes social welfare under the assumption that everyone acts like individual i.

[10] The positive relationship between perceived individual responsibility and share of the population behaving according to moral ideals is discussed in Nyborg et al. (2006) and empirically supported, for the case of glass recycling, in Brekke et al. (2010).

which, by construction, is positive for $\beta_i > r$ and negative for $\beta_i < r$. For $\beta_i = r$,

$$\Delta U_i = -c(\theta) + r[1-k-(1-2k)r]\lambda + \xi r e(1)(1-r) = 0. \tag{8}$$

We note, by inspecting (8), that $r = 0$ is not a Nash equilibrium and that $r = 1$ is a Nash equilibrium if and only if $k \leq \frac{c(\theta)}{\lambda}$. At $r = 0$, $\Delta U_i = -c(\theta) < 0$; at $r = 1$, $\Delta U_i = -c(\theta) + k\lambda$ which must be non-positive for no one to opt for recycling as implied by $r = 1$. Solving (8) for r, we find the Nash equilibria that entail $r \in (0,1)$ as

$$r_1 = \frac{1}{2}\left\{\frac{(1-k)\lambda + \xi e(1) + \sqrt{[(1-k)\lambda + \xi e(1)]^2 - 4[(1-2k)\lambda + \xi e(1)]c(\theta)}}{(1-2k)\lambda + \xi e(1)}\right\}, \tag{9}$$

which is positive for $k < \frac{1}{2}\left[1 + \xi\frac{e(1)}{\lambda}\right]$ and negative for $k > \frac{1}{2}\left[1 + \xi\frac{e(1)}{\lambda}\right]$, and

$$r_2 = \frac{1}{2}\left\{\frac{(1-k)\lambda + \xi e(1) - \sqrt{[(1-k)\lambda + \xi e(1)]^2 - 4[(1-2k)\lambda + \xi e(1)]c(\theta)}}{(1-2k)\lambda + \xi e(1)}\right\} > 0. \tag{10}$$

We summarize the results in

Proposition 1 *Let $A = \frac{1}{2}\left[1 + \xi\frac{e(1)}{\lambda}\right]$. With r_1 and r_2 defined as in (9) and (10),*

- *there exists a Nash equilibrium in which no one recycles iff $k \leq \frac{c(\theta)}{\lambda}$;*
- *there exists a Nash equilibrium, $r_1 \in (0,1)$, in which a share of the population $(1-r_1)$ recycles iff $k < \frac{c(\theta)}{\lambda} < \frac{1}{2}\frac{\left(A-\frac{k}{2}\right)^2}{(A-k)}$;*
- *there exists a Nash equilibrium, $r_2 \in (0,1)$, in which a share of the population $(1-r_2)$ recycles iff $\frac{c(\theta)}{\lambda} < \frac{1}{2}\frac{\left(A-\frac{k}{2}\right)^2}{(A-k)}$ or $A < k < \frac{c(\theta)}{\lambda}$.*

Proof. Equation (7) implies that $\Delta U_i = 0$ if $\beta_i = r_j$ $(j = 1,2)$. For $\beta_i > r_j$, $\Delta U_i > 0$; for $\beta_i < r_j$, $\Delta U_i < 0$. For $r_1 < 1$, $\frac{2}{3}A > k < \frac{c(\theta)}{\lambda}$; for $r_1 > 0$, $k < A$. If $k < A$, the existence of r_1 requires that $\frac{c(\theta)}{\lambda} < \frac{1}{2}\frac{\left(A-\frac{k}{2}\right)^2}{(A-k)}$. As $\frac{1}{2}\frac{\left(A-\frac{k}{2}\right)^2}{(A-k)} - \frac{2}{3}A = \left[\frac{1}{6(A-k)}\right]\left(-A^2 + \frac{3}{4}k^2 + kA\right)$ which is negative for $k < \frac{2}{3}A$, $r_1 \in (0,1)$ is a Nash equilibrium if and only if $k < \frac{c(\theta)}{\lambda} < \frac{1}{2}\frac{\left(A-\frac{k}{2}\right)^2}{(A-k)}$. For r_2, we consider both the case when $k < A$ and the case when $k > A$. In the former case, the existence of r_2 requires that $\frac{c(\theta)}{\lambda} < \frac{1}{2}\frac{\left(A-\frac{k}{2}\right)^2}{(A-k)}$; furthermore, for $r_2 < 1$, either $k < \frac{2}{3}A$ or $\frac{c(\theta)}{\lambda} < \frac{2}{3}A < k < A$. In the latter case, r_2 always exists and, for $r_2 < 1$, $k < \frac{c(\theta)}{\lambda}$. We thus have that $r_2 \in (0,1)$ is a Nash equilibrium if and only if $\frac{c(\theta)}{\lambda} < \frac{1}{2}\frac{\left(A-\frac{k}{2}\right)^2}{(A-k)}$ or $A < k < \frac{c(\theta)}{\lambda}$. ■

3 Public Policies

In this section, we consider two policies governments have resorted to over the years to curb the waste disposal problem, namely, mandatory recycling and user charges for mixed waste. To ensure model tractability and given the focus of the section on policy performance in terms of crowding in and crowding out of social and moral motives, we assume that households are homogenous in how social and moral motives matter in their decision making. Specifically, we assume that $\beta_i = \beta$ and $\delta_i = \delta$ for any i and use r to denote the share of the population that recycles.

To analyze the effect of a mandatory recycling program, we think of households' recyclables as comprising two types: a regulated type for which recycling is mandatory and an unregulated type for which recycling is optional. We assume that mandatory recycling is easily enforced so that no violation occurs. With w denoting the share of recyclables that fall in the regulated category, we can write the average contribution to recycling as

$$\overline{\gamma} = w + (1-w)\, r, \tag{11}$$

self-image and social approval as

$$m_i = \begin{cases} 0 & \gamma_i = 1 \\ (w-1)\, e\,(1)\, r & \gamma_i = 0 \end{cases} \tag{12}$$

and

$$s_i = \begin{cases} (1-\overline{\gamma})\,[k + (1-k)\, r]\,\lambda & \gamma_i = 1 \\ (w-\overline{\gamma})\,(1-k)\, r\lambda & \gamma_i = 0. \end{cases} \tag{13}$$

Mandatory recycling also affects the budget constraint as households are forced to recycle certain types of recyclables and thus incur recycling costs even if they opt for not recycling the unregulated types of recyclables. We assume that the cost of recycling regulated items is $wc\,(\theta)$ while the cost of recycling unregulated items is $(1-w)\, c\,(\theta)$. A household recycling both regulated and unregulated items incurs a cost equal to $c\,(\theta)$ while a household recycling only regulated items incurs a cost equal to $wc\,(\theta)$. The budget constraint when $\gamma_i = 1$ remains unchanged but the budget constraint when $\gamma_i = 0$ becomes

$$I = x_i + wc\,(\theta)\,. \tag{14}$$

Under a unit pricing system for curbside garbage, we modify the budget constraint to include the cost of disposing of waste at the curb as

$$I = \begin{cases} x_i + c\,(\theta) + \alpha p_g g x_i & \gamma_i = 1 \\ x_i + p_g g x_i & \gamma_i = 0, \end{cases} \tag{15}$$

where p_g is the user fee per unit of waste, g is the proportion of consumption that turns into waste, and α is the proportion of waste that cannot be recycled. We assume that the policy-generated revenues are utilized to finance the collection and disposal of waste. In fact, with d denoting the per unit cost of collecting and disposing of garbage, the net revenues amount to

$$(p_g - d)\, g \left[\alpha r \left(\frac{I - c(\theta)}{1 + \alpha p_g g}\right) + (1 - r)\left(\frac{I}{1 + p_g g}\right)\right] \tag{16}$$

which is equal to zero if $p_g = d$.

Taking into account both mandatory recycling and unit pricing, we can express the difference in household i's utility between a society of recyclers ($r = 1$) and a society of non-recyclers ($r = 0$) as

$$\lambda = \left\{\frac{[(1-\alpha) I - (1 - \alpha w) c(\theta)] p_g g - (1 - w) c(\theta)}{(1 + p_g g)(1 + \alpha p_g g)}\right\} + e(1) - e(w) > 0, \tag{17}$$

and the incremental benefit of recycling for a representative household i as

$$\Delta U = \lambda - e(1) + e(w) + \beta\lambda(1 - w) k + \beta\lambda(1 - w)(1 - 2k) r + \delta(1 - w) e(1) r. \tag{18}$$

We can thus derive Nash equilibria in the absence of any policy ($w = p_g = 0$), under mandatory recycling ($0 < w < 1$ but $p_g = 0$), under unit pricing ($w = 0$ but $p_g > 0$), and under both mandatory recycling and unit pricing ($0 < w < 1$ and $p_g > 0$).

In the absence of any policy, the critical r value ($\widehat{r}$) such that the representative household is indifferent between recycling and not recycling is given by

$$\widehat{r} = \frac{c(\theta) - \beta\lambda k}{\beta\lambda(1 - 2k) + \delta e(1)} \tag{19}$$

and the following proposition results

Proposition 2 *Assume* $k < \frac{1}{2}\left[1 + \frac{\delta}{\beta}\frac{e(1)}{\lambda}\right]$.

- *There exists a Nash equilibrium in which no one recycles iff* $k \leq \frac{1}{\beta}\frac{c(\theta)}{\lambda}$.
- *There exists a Nash equilibrium in which everyone recycles iff* $k \leq 1 + \frac{\delta}{\beta}\frac{e(1)}{\lambda} - \frac{1}{\beta}\frac{c(\theta)}{\lambda}$.
- *There exists a Nash equilibrium in which a share of the population* $\widehat{r}$ *recycles iff* $k < \frac{1}{\beta}\frac{c(\theta)}{\lambda} < 1 - k + \frac{\delta}{\beta}\frac{e(1)}{\lambda}$.

Proof. *Equation (18) implies that* $\Delta U = 0$ *if* $r = \widehat{r}$, $\Delta U > 0$ *if* $r > \widehat{r}$, *and* $\Delta U < 0$ *if* $r < \widehat{r}$. *For* $\widehat{r} = 0$ *(no household recycles) to be an equilibrium,* $\Delta U = -c(\theta) + \beta\lambda k \leq 0$, *which requires that* $k \leq \frac{1}{\beta}\frac{c(\theta)}{\lambda}$. *For*

$\widehat{r}=1$ *(every household recycles) to be an equilibrium,* $\Delta U=-c(\theta)+\beta\lambda k+\beta\lambda(1-2k)+\delta e(1)\geq 0$*, which requires that* $k\leq 1+\frac{\delta}{\beta}\frac{e(1)}{\lambda}-\frac{1}{\beta}\frac{c(\theta)}{\lambda}$*. For* $0<\widehat{r}<1$ *(a share of the population* $\widehat{r}$ *recycles),* $0<c(\theta)-\beta\lambda k<\beta\lambda(1-2k)+\delta e(1)$*, which simplifies to* $k<\frac{1}{\beta}\frac{c(\theta)}{\lambda}<1-k+\frac{\delta}{\beta}\frac{e(1)}{\lambda}$*.* ■

If $k>\frac{1}{2}\left[1+\frac{\delta}{\beta}\frac{e(1)}{\lambda}\right]$, ΔU is decreasing in r so that $\Delta U<0$ if $r>\widehat{r}$ and $\Delta U>0$ if $r<\widehat{r}$. If $\Delta U\leq 0$ when $\widehat{r}=0$, then $\Delta U<0$ for $\widehat{r}>0$ and a situation in which no one recycles cannot arise; if $\Delta U\geq 0$ when $\widehat{r}=1$, then $\Delta U>0$ for $\widehat{r}<1$ and a situation in which everyone recycles can also not arise. The only possible Nash equilibrium is $\widehat{r}\in(0,1)$, which requires that $\frac{1}{\beta}\frac{c(\theta)}{\lambda}<1-k+\frac{\delta}{\beta}\frac{e(1)}{\lambda}<k$.

As households may not have the information needed to determine the utility-maximizing strategy, we assume, in line with Nyborg et al. (2006) and Rege (2004), that they learn this strategy through a trial-and-error process that can be represented by the replicator dynamics from the field of evolutionary game theory (Taylor and Jonker, 1978). The replicator dynamics holds that the share of the population adopting a particular strategy grows at a rate that is equal to the difference between the strategy's current payoff and the current average payoff in the population. In the context of our model, the dynamics of the share of recyclers are given by

$$\dot{r}=r\left(U_i^r-\overline{U}\right), \tag{20}$$

where $\overline{U}=rU_i^r+(1-r)U_i^{nr}$. Substituting for $\overline{U}$ into (20), we get

$$\dot{r}=r(1-r)\Delta U_i \tag{21}$$

and the following proposition

Proposition 3 *Assume* $k<\frac{1}{2}\left[1+\frac{\delta}{\beta}\frac{e(1)}{\lambda}\right]$.

- *There is an asymptotically stable equilibrium in which everyone recycles* ($r=1$) *iff* $\frac{1}{\beta}\frac{c(\theta)}{\lambda}<1-k+\frac{\delta}{\beta}\frac{e(1)}{\lambda}$*. If* $r>\max\{0,\widehat{r}\}$*, the share of recyclers starts increasing until everyone recycles.*

- *There is an asymptotically stable equilibrium in which no one recycles* ($r=0$) *iff* $\frac{1}{\beta}\frac{c(\theta)}{\lambda}>k$*. If* $r<\min\{\widehat{r},1\}$*, the share of recyclers decreases until no one recycles.*

Proof. *Equations (18) and (21) imply that the stationary states are determined by*

$$r(1-r)\left[-c(\theta)+\beta\lambda k+\beta\lambda(1-2k)r+\delta e(1)r\right]=0.$$

There are therefore three stationary states: $r=0$*,* $r=1$*, and* $r=\widehat{r}$*. For* $0<r<1$*,* $\dot{r}>0$ *if* $-c(\theta)+\beta\lambda k+\beta\lambda(1-2k)r+\delta e(1)r>0$ *and* $\dot{r}<0$ *if* $-c(\theta)+\beta\lambda k+\beta\lambda(1-2k)r+\delta e(1)r<0$*; hence, for* $0<r<1$*,*

$\dot{r} > 0$ if $r > \widehat{r}$ and $\dot{r} < 0$ if $r < \widehat{r}$. For $0 < \widehat{r} < 1$, $0 < c(\theta) - \beta\lambda k < \beta\lambda(1-2k) + \delta e(1)$, which simplifies to $k < \frac{1}{\beta}\frac{c(\theta)}{\lambda} < 1 - k + \frac{\delta}{\beta}\frac{e(1)}{\lambda}$. ■

When $\widehat{r} < r < 1$, a household is more likely to meet other recyclers and to receive social approval for recycling or disapproval for not recycling; furthermore, a household feels a greater sense of personal responsibility towards the environment and faces a worse self-image when it does not act responsibly. Recycling thus provides greater utility through greater social approval and better self-image.[11] As non-recyclers learn about this, they start recycling. The change in participation (from not recycling to recycling) continues until everyone recycles. When $0 < r < \widehat{r}$, the opposite occurs as a household is less likely to meet other recyclers and feels less environmentally responsible. The incremental benefit of recycling from a small increase in social approval and a small improvement in self-image does not outweigh the incremental cost. As recyclers learn about this, they stop recycling. The change in participation (from recycling to not recycling) continues until no one recycles (see Figure 1).

In neither of the two asymptotically stable equilibria, households experience social approval/disapproval or a negative self-image as they choose the same action. Nevertheless, the utility level when $r = 1$ is higher than the utility level when $r = 0$ and it is therefore socially desirable to move from the zero-participation equilibrium to the full-participation equilibrium. In the subsections that follow, we consider two policies that have been implemented over the years to promote recycling: a mandatory recycling legislation and a unit pricing system. In each case, we consider whether the policy tends to crowd in or crowd out social and moral motives for recycling. Crowding in occurs if $\Delta U > 0$ when $r = 0$ while crowding out occurs if $\Delta U < 0$ when $r = 1$.

3.1 Mandatory Recycling

For simplicity, in this sub-section, we refer to households recycling only the mandated items as the non-recyclers and those recycling everything as the recyclers. Hence, to determine whether mandatory recycling crowds out personal motivation, we consider a society in which $k < \frac{1}{\beta}\frac{c(\theta)}{\lambda^{np}} < 1 - k + \frac{\delta}{\beta}\frac{e(1)}{\lambda^{np}}$, where the superscript appended to λ serves to distinguish between the non-policy case (np), as per (5), and the policy case (p), as per (17). We assume that this society enjoys an asymptotically stable state in which everyone recycles ($r = 1$) prior to the implementation of mandatory recycling.

Under mandatory recycling ($0 < w < 1$) and in the absence of unit pricing ($p_g = 0$), we can write ΔU

[11] Given our modelling of moral motivation or self-image, improving self-image corresponds to eliminating a worse self-image.

when $r = 1$ as

$$\Delta U = (1 - w)\left[-c(\theta) + \beta\lambda^p - \beta k\lambda^p + \delta e(1)\right], \tag{22}$$

where

$$\lambda^p = -(1 - w)\,c(\theta) + e(1) - e(w) > 0. \tag{23}$$

For crowding out to occur, we must have that $\Delta U < 0$ or $k > 1 + \frac{\delta}{\beta}\frac{e(1)}{\lambda^p} - \frac{1}{\beta}\frac{c(\theta)}{\lambda^p}$. As, by assumption, $k < 1 + \frac{\delta}{\beta}\frac{e(1)}{\lambda^{np}} - \frac{1}{\beta}\frac{c(\theta)}{\lambda^{np}}$, we must then have that $1 + \frac{\delta}{\beta}\frac{e(1)}{\lambda^p} - \frac{1}{\beta}\frac{c(\theta)}{\lambda^p} < k < 1 + \frac{\delta}{\beta}\frac{e(1)}{\lambda^{np}} - \frac{1}{\beta}\frac{c(\theta)}{\lambda^{np}}$ which requires that $\left[\frac{\delta e(1) - c(\theta)}{\beta}\right]\left(\frac{\lambda^{np} - \lambda^p}{\lambda^p\lambda^{np}}\right) < 0$, where $\lambda^{np} - \lambda^p = -wc(\theta) + e(w)$. Given that $e(w)$ is concave and $e(w) = wc(\theta)$ when $w = 0$ and $e(w) > wc(\theta)$ when $w = 1$, we know that $e(w) > wc(\theta)$ for $0 < w < 1$ so that $\lambda^{np} - \lambda^p > 0$. Whether mandatory recycling crowds out personal motivation thus depends on the difference between $\delta e(1)$ and $c(\theta)$: the smaller the value of δ is, the less likely it is for crowding out to occur.

When the marginal utility of self-image falls short of the cost of recycling everything relative to the environmental benefit of living in a society of recyclers, that is, $\delta < \frac{c(\theta)}{e(1)}$, mandatory recycling can crowd out personal motivation for recycling by reducing the utility benefit of living in a society of recyclers over and above the utility benefit of living in a society of non-recyclers. As households take this reduction into account, they start caring less about social approval and stop recycling unregulated items. The share of the population falls until the asymptotically stable state in which no one recycles ($r = 0$) is reached (see Figure 1). This new equilibrium with zero recycling of unregulated items would result even if mandatory recycling were to be eliminated unless policy reversal were to occur at $r > \widehat{r}$ as given in (19). If, however, $\delta > \frac{c(\theta)}{e(1)}$, self-image becomes a sufficiently relevant consideration in recycling decisions to outweigh the reduction in the social approval benefit of recycling (see Figure 2). We summarize the results in

Corollary 4 *Consider a society in which* $k < \frac{1}{2}\left[1 + \frac{\delta}{\beta}\frac{e(1)}{\lambda}\right]$ *and* $k < \frac{1}{\beta}\frac{c(\theta)}{\lambda^{np}} < 1 - k + \frac{\delta}{\beta}\frac{e(1)}{\lambda^{np}}$. *Assume that this society is in the asymptotically stable state in which everyone recycles* ($r = 1$). *If* $k > 1 + \frac{\delta}{\beta}\frac{e(1)}{\lambda^p} - \frac{1}{\beta}\frac{c(\theta)}{\lambda^p}$, *where* $\delta < \frac{c(\theta)}{e(1)}$, *and the government introduces mandatory recycling that affects a fraction* w *of all recyclable materials, it moves society to the asymptotically stable state in which no one recycles unregulated items* ($r = 0$). *This crowding out of personal motives persists when the policy change is reversed if the share of the population recycling has fallen below* $\widehat{r}$.

3.1.1 Mandatory Recycling and Variations on Cost Considerations

In this section, we consider variations on recycling costs and how these variations impact the potential for crowding out or crowding in of mandatory recycling. There are essentially three possible cases we look at: (1) a cost equal to $c(\theta)$ is incurred independently of how much is recycled; (2) the government introduces a better service for mandated recyclables; (3) the government introduces a better service for mandated recyclables that also extends to non-mandated recyclables. In case (1), $c(\theta)$ appears in the budget constraint when $\gamma_i = 0$ (that is, when only mandated recyclables are recycled) as well as when $\gamma_i = 1$ (that is, when both mandated and non-mandated recyclables are recycled). In case (2), $wc(\theta_w)$ is incurred for mandated recyclables and $(1-w)\,c(\theta)$ is incurred for non-mandated recyclables, where $\theta_w > \theta$ so that $c(\theta_w) < c(\theta)$. In case (3), $c(\theta_w)$ applies to both mandated and non-mandated recyclables. We consider each of the three cases in some detail below.

CASE 1. In this case, the budget constraint is given by (2) independently of whether households recycle only the mandated items or everything that is recyclable. The incremental benefit of recycling everything is then equal to

$$\Delta U = (1-w)\left[\beta k \lambda^p + \beta (1-2k) \lambda^p r + \delta e(1) r\right], \tag{24}$$

where

$$\lambda^p = e(1) - e(w) > 0. \tag{25}$$

When $r = 1$, ΔU is always positive as $k < 1$; when $r = 0$, ΔU is always positive as $k > 0$. There is thus no crowding out of personal motivation but there is crowding in.

CASE 2. In this case, the budget constraint is given by

$$I = \begin{cases} x_i + wc(\theta_w) + (1-w)\,c(\theta) & \gamma_i = 1 \\ x_i + wc(\theta_w) & \gamma_i = 0. \end{cases} \tag{26}$$

The incremental benefit of recycling everything is then equal to

$$\Delta U = (1-w)\left[-c(\theta) + \beta k \lambda^p + \beta (1-2k) \lambda^p r + \delta e(1) r\right], \tag{27}$$

where

$$\lambda^p = -(1-w)\,c(\theta) + e(1) - e(w) > 0. \tag{28}$$

Implementing a better collection service for mandated recyclables does not have any effect on the potential for a crowding out, nor does it create a potential for a crowding in, of personal motivation under mandatory recycling.

CASE 3. In this case, the budget constraint and incremental benefit of recycling everything are given by

$$I = \begin{cases} x_i + c(\theta_w) & \gamma_i = 1 \\ x_i + wc(\theta_w) & \gamma_i = 0 \end{cases} \tag{29}$$

and

$$\Delta U = (1-w)\left[-c(\theta_w) + \beta k \lambda^p + \beta(1-2k)\lambda^p r + \delta e(1) r\right], \tag{30}$$

where

$$\lambda^p = -(1-w)c(\theta_w) + e(1) - e(w) > 0. \tag{31}$$

Implementing a better collection service for every recyclable when introducing mandatory recycling for certain types of recyclables reduces the potential for a crowding out and gives rise to the possibility of a crowding in. With $c(\theta_w) = \xi c(\theta)$, where $0 < \xi < 1$, we have crowding out if $1 + \frac{\delta}{\beta}\frac{e(1)}{\lambda^p} - \frac{\xi}{\beta}\frac{c(\theta)}{\lambda^p} < k < 1 + \frac{\delta}{\beta}\frac{e(1)}{\lambda^{np}} - \frac{1}{\beta}\frac{c(\theta)}{\lambda^{np}}$ and crowding in if $\frac{\xi}{\beta}\frac{c(\theta)}{\lambda^p} < k < \frac{1}{\beta}\frac{c(\theta)}{\lambda^{np}}$. A necessary, although not sufficient, condition for crowding out is then that $\frac{1}{\beta\lambda^p\lambda^{np}}\left[(\lambda^p - \lambda^{np})\delta e(1) - (\lambda^p - \xi\lambda^{np})c(\theta)\right] > 0$; similarly, a necessary, although not sufficient, condition for crowding in is that $\frac{1}{\beta\lambda^p\lambda^{np}}\left[(\lambda^p - \xi\lambda^{np})c(\theta)\right] > 0$.

Assuming that $\delta < \widetilde{\delta} = \frac{c(\theta)}{e(1)}$, that is, crowding out is feasible in the absence of a better collection service, if w is sufficiently low such that $\lambda^p - \xi\lambda^{np} > \lambda^p - \lambda^{np} = (1-\xi)c(\theta) + \xi w c(\theta) - e(w) > 0$ ($w < \underline{w}$ in Figure 3), we have that $(\lambda^p - \lambda^{np})\delta e(1) - (\lambda^p - \xi\lambda^{np})c(\theta) < 0$ and $(\lambda^p - \xi\lambda^{np})c(\theta) > 0$ so that there is no potential for a crowding out but there is potential for a crowding in. If w is sufficiently high such that $(\lambda^{np} - \lambda^p) > (\xi\lambda^{np} - \lambda^p) = -(1-\xi)e(1) - \xi w c(\theta) + e(w) > 0$ ($w > \overline{w} > \underline{w}$ in Figure 3),[12] crowding out can arise if $\delta < \widehat{\delta} = \frac{(\xi\lambda^{np} - \lambda^p)}{(\lambda^{np} - \lambda^p)}\frac{c(\theta)}{e(1)} < \xi\frac{c(\theta)}{e(1)} < \widetilde{\delta} = \frac{c(\theta)}{e(1)}$.

When the introduction of mandatory recycling for specific types of recyclables is accompanied by an improvement in collection services for all recyclables (e.g., from drop-off depot to curbside collection), mandatory recycling is less likely to result in a crowding out of personal motivation. The reduction in the potential for a crowding out is reflected in the difference between $\widetilde{\delta}$ and $\widehat{\delta}$; in other words, the smaller reduction in the incremental benefit of recycling that comes from social approval can be offset with a lower concern for a negative self-image.

3.2 Unit Pricing

To determine whether unit pricing crowds in personal motivation, we consider a society in which $k < \frac{1}{\beta}\frac{c(\theta)}{\lambda^{np}} < 1 - k + \frac{\delta}{\beta}\frac{e(1)}{\lambda^{np}}$ and assume that this society enjoys an asymptotically stable state in which no one recycles ($r = 0$) prior to the implementation of unit pricing.

[12] The two conditions can be written as $(1-\xi)c(\theta) > e(w) - \xi w c(\theta) > (1-\xi)e(1)$. Given that $e(w) - \xi w c(\theta) > 0$ for $0 < w < 1$, is increasing in w for $w < \overset{*}{w} = f\left(f^{-1}(w)\right)$, where $f(w) = e(w) - \xi w c(\theta)$, and decreasing for $w > \overset{*}{w}$, and given that $e(w) - \xi w c(\theta) > (1-\xi)e(1) > (1-\xi)c(\theta)$ for $w = 1$, the two conditions are satisfied for $w < \overset{*}{w}$, that is, along the upward-sloping portion of $f(w)$. As $e(1) > c(\theta)$, the condition $e(w) - \xi w c(\theta) = (1-\xi)c(\theta)$ is satisfied at a lower w ($\underline{w}$) than the condition $e(w) - \xi w c(\theta) = (1-\xi)e(1)$; hence, $\overline{w} > \underline{w}$.

Under unit pricing ($p_g > 0$) and in the absence of mandatory recycling ($w = 0$), we can write ΔU when $r = 0$ as

$$\Delta U = \lambda^p - e(1) + \beta k \lambda^p, \tag{32}$$

where

$$\lambda^p = \left\{ \frac{[(1-\alpha) I - c(\theta)] p_g g - c(\theta)}{(1+p_g g)(1+\alpha p_g g)} \right\} + e(1) > 0. \tag{33}$$

For crowding in to occur, we must have that $\Delta U > 0$ or $k > \frac{1}{\beta}\left[\frac{e(1)-\lambda^p}{\lambda^p}\right]$. As, by assumption, $k < \frac{1}{\beta}\frac{c(\theta)}{\lambda^{np}}$, we must then have that $\frac{1}{\beta}\left[\frac{e(1)-\lambda^p}{\lambda^p}\right] < k < \frac{1}{\beta}\frac{c(\theta)}{\lambda^{np}}$ which requires that $\frac{e(1)}{\beta}\left(\frac{\lambda^{np}-\lambda^p}{\lambda^p \lambda^{np}}\right) < 0$ or that $\lambda^{np} - \lambda^p = -\frac{(1-\alpha)p_g g I}{(1+p_g g)(1+\alpha p_g g)} - \frac{\alpha p_g g c(\theta)}{(1+\alpha p_g g)} < 0$.

Unit pricing crowds in social motivation for recycling by increasing the utility benefit of living in a society of recyclers over and above the utility benefit of living in a society of non-recyclers. As households take this increase into account, they start caring more about social approval and decide to recycle. The share of the population increases until the asymptotically stable state in which everyone recycles ($r = 1$) is reached (see Figure 1). This new equilibrium with 100 percent recycling participation would result even if unit pricing were to be eliminated unless policy reversal were to occur at $r < \widehat{r}$ as given in (19). We summarize the result in

Corollary 5 *Consider a society in which* $k < \frac{1}{2}\left[1 + \frac{\delta}{\beta}\frac{e(1)}{\lambda}\right]$ *and* $k < \frac{1}{\beta}\frac{c(\theta)}{\lambda^{np}} < 1 - k + \frac{\delta}{\beta}\frac{e(1)}{\lambda^{np}}$. *Assume that this society is in the asymptotically stable state in which no one recycles* ($r = 0$). *If* $k > \frac{1}{\beta}\left[\frac{e(1)-\lambda^p}{\lambda^p}\right]$ *and the government introduces unit pricing, it moves society to the asymptotically stable state in which everyone recycles* ($r = 1$). *This crowding in of personal motives persists when the policy change is reversed if the share of the population recycling has increased above* $\widehat{r}$.

4 Empirical Analysis

From the theoretical analysis of the previous section, there are a number of hypotheses that we obtain, namely,

1. unit pricing does not result in a crowding out of personal motivation for recycling;
2. mandatory recycling can result in a crowding out of personal motivation for recycling;
3. the more convenient recycling is, the less likely it is for mandatory recycling to crowd out personal motivation for recycling.

In this section, we test the first two hypotheses and attempt to informally address the third hypothesis with a household-level data set that was put together by Lightspeed Online Research Inc. for the OECD in February 2008 through a web-based panel involving 10,251 respondents across ten countries (Australia, Canada, Czech Republic, France, Italy, Korea, Mexico, Netherlands, Norway, and Sweden).[13] In addition to sections on socio-demographic and attitudinal characteristics, the online questionnaire included sections on five areas of environment-related household consumption identified as contributing to, and likely intensifying, environmental problems (that is, waste generation and recycling, energy use, organic food consumption, personal transport, and water use) and thus constituting obvious policy targets.

The variables of interest to us in this study come or are constructed from questions included in the sections on waste and socio-demographic characteristics. We list these variables, along with descriptions, means, and standard deviations in Table 1. In computing means and standard deviations, we consider the three scenarios that are of relevance in the estimation of the probability of recycling 100 percent of recyclable materials: (1) no policy, that is, neither unit pricing nor mandatory recycling (4,860 observations); (2) no unit pricing (7,821 observations); (3) no mandatory recycling (5,473 observations). Upon a comparison of means across the three scenarios, we can easily conclude that the three subsets of observations have nearly identical profiles; in other words, there is no particular feature among the observations that are unique to a given scenario that is sufficiently strong to affect the profile of the corresponding sample subset. Furthermore, although not shown in Table 1, the profiles of the three scenarios are in line with the overall sample profile.

Among socio-demographic and household characteristics, we have: gender (MALE = 1 if male), age (AGE), university-level education (UNIV = 1 with a Bachelor's Degree, at a minimum), household size (HSHD_SIZE), income (INCOME_CONT = mid-point income in euros),[14] type of residence (HOUSE = 1 if house), ownership of residence (RESOWNR = 1 if owner), number of rooms excluding bathrooms (ROOMS), and type of area (URBAN = 1 if urban). Based on Table 1 figures, about 50 percent of our respondents are male and about 33 percent of them have a university degree, the average age of respondents is 43 years, households have, on average, four members and an annual after-tax income of $30,000, the

[13] In light of possible sample bias (due to the means of implementation of the survey) and strategic bias (due to the nature of the survey), the OECD performed several qualitative data checks on socio-demographic variables and other variables specific to the five areas of household consumption considered in the survey. The results of the data corroboration can be found at http://www.oecd.org/dataoecd/55/19/44101274.pdf.

[14] In question 11 of Part A of the questionnaire (on socio-demographic characteristics), twelve income ranges are given, with the first two corresponding to the first decile of a country's income distribution, the last two corresponding to the last decile, the third to the second decile, the fourth to the third decile, and so on so forth. In constructing INCOME_CONT, we take the mid-point of each income interval for each country and divide it by the country's IMF nominal exchange rate coded as currency units per euro.

primary residence has, on average, five rooms (excluding bathrooms), is located in an urban area in 45 percent of the cases, and is owned in about 65 percent of the cases.

To control for cultural and institutional differences across countries that may have an impact on recycling decisions, we introduce country dummies, with Sweden as the reference country; hence, AU = 1 if from Australia, CA = 1 if from Canada, CZ =1 if from Czech Republic, FR = 1 if from France, IT = 1 if from Italy, KO =1 if from Korea, ME =1 if from Mexico, NL =1 if from Netherlands, and NO = 1 if from Norway. Although not shown in Table 1, the distribution of observations across countries under the three scenarios is consistent, for the most part, with the sample distribution across countries; the only country for which there exist discrepancies is Korea which claims 10 percent of the observations when we consider the entire sample, 2 percent under no policy, 3 percent under no unit pricing, and 7 percent under no mandatory recycling.

In terms of policy variables, we have unit pricing (USERFEE = 1 under system) and mandatory recycling (MANDATED = 1 under program). The former comprises both weight- and volume-based user charges which, when mandatory recycling is not in place, apply in 11 percent of the cases (see Table 1). The latter comes from a question on motives for recycling which includes whether recycling is mandated by the government. In answering the question, a respondent is given several options ranging from "not at all important" to "very important" plus the "not applicable" option. We assume that mandatory recycling is, or is perceived to be, in place if it is deemed to be a fairly important or a very important motive for recycling; in other words, if a respondent chooses the "not applicable," the "not at all important," or the "not important" option, we take recycling not to be mandatory. When unit pricing is not in place, mandatory recycling is present in 38 percent of the cases (see Table 1).

We also include indicators for the presence of different types of recycling services available for recyclable X, where X = GLAS (glass), PLST (plastic), MTAL (aluminum), and PAPR (paper). Specifically, we have indicators for the presence of door-to-door collection (RCYCLCOLDTD_X = 1 with collection for X), a drop-off program (RCYCLCOLDOF_X = 1 with program for X), a refundable deposit system (RCYCLCOLRFD_X = 1 with system for X), and a non-refundable deposit system (RCYCLCOLBBK_X = 1 with system for X). Independently of which scenario and of which recyclable material we consider, a non-refundable deposit system is not a common service. On the other hand, a refundable deposit system is uncommon for aluminum and even more so for paper but not for glass and plastic which benefit from the service in about 20 percent of the cases. The most common service across the four recyclable materials is the drop-off center with an access rate ranging between 40 percent for plastic and about 60 percent for glass. Door-to-door collection of recyclables is also common with an availability rate ranging between about 20 percent for glass and over 40 percent for paper (see Table 1).

To capture intrinsic motivation for recycling, we go back to the question on motives for recycling which include (1) a sense of civic duty (moral motive) and (2) a desire to be seen as acting responsibly (social motive). For each of the two motives, we assign a value of 1 to the options "not applicable," "not at all important," and "not important," a value of 2 to the option "fairly important," and a value of 3 to the option "very important." We then construct INTRINSIC to measure the importance of personal motivation in recycling decisions as the arithmetic average of the values of the two motives. On average, intrinsic motivation for recycling is fairly important as its mean value, which is given in Table 1, is 2. To assess the presence of crowding in or crowding out effects of waste management policies, we introduce two interaction variables: MAN_INT, which is the product between MANDATED and INTRINSIC, and UF_INT, which is the product between USERFEE and INTRINSIC.

In addition to intrinsic motivation for recycling, and in line with the theoretical setup which allows for environmental quality as an argument of the utility function, we include an environmental index (ENVPURCH_INDX) ranging between 1 and 4 that measures a respondent's attitude towards the environment based on a set of four questions about how often paper with recycled content (e.g., stationery), products with reduced toxic content (e.g., environmentally friendly cleaning products), refillable containers (e.g., bottles, washing detergents), and reusable shopping bags are used as opposed to their alternatives. Hence, we assign a value of 1 to the "never" option, a value of 2 to the "occasionally" option, a value of 3 to the "often" option, and a value of 4 to the "always" option; we add up the values across the four questions or products and divide by 4 to get the mean regularity with which a respondent engages in an environmentally sound activity and use this mean figure as a proxy, based on stated behavior, of the respondent's attitudes towards the environment. Based on Table 1 figures, respondents have, on average, a positive attitude towards the environment in that they often opt for environmentally sound activities such as using refillable containers and buying paper with recycled content.

[TABLE 1]

Finally, for our dependent variable, we use the questions on recycling participation and recycling intensity for each of the four above noted recyclables to construct RECL100_X (where X = GLAS, PLST, MTAL, PAPR), which takes on a value of 1 if a respondent indicates 100 percent recycling and 0 otherwise, and employ a univariate probit model to estimate the probability of recycling 100 percent of X as a function of the above given explanatory variables. We focus on the probability of recycling 100 percent to be as consistent as possible in the empirical formulation to the theoretical setup. For a similar reason, we estimate the model under two scenarios: when there is no unit pricing and we are interested in whether mandatory recycling crowds out intrinsic motivation for recycling; when there is no mandatory recycling and we are interested in whether unit pricing crowds out intrinsic motivation for recycling.

We provide the results of the estimation in Table 2 and the marginal effects in Table 3. As the focus of this paper is on whether waste management policies tend to erode personal motivation for recycling, we only briefly discuss the effects of socio-demographic and household characteristics which have received extensive attention in the literature on the determinants of recycling behavior. For simplicity, we may refer to the dependent variable as the probability of recycling, or simply recycling, even though it is the probability of recycling 100 percent; accordingly, whenever we speak of the effect on the probability of recycling or simply on recycling, we intend to speak of the effect on the probability of recycling 100 percent.

As in Ferrara and Missios (2012), the evidence suggests the presence of institutional and cultural elements in recycling decisions which explain variation across countries: in general, respondents in Sweden are more likely to recycle 100 percent than respondents in any other country. Male respondents are about 3 to 4 percent more likely to recycle aluminum. Being older or having a university degree increases the probability of recycling glass, aluminum, and paper. On the other hand, the size of the household has a negative effect on the recycling of glass and, to a lesser extent (that is, not consistently across the three scenarios), on the recycling of the other materials, but the size of the house as reflected in the number of rooms excluding bathrooms has a positive effect on glass and plastic recycling. Owning the primary residence reduces recycling, although, if we think of ownership as an indicator of neighborhood attachment, we would expect homeowners to recycle more. Living in an urban area does not matter and income has a positive effect only on glass recycling.

Having recycling services in place is a strong determinant of the probability of recycling everything, a finding which resonates with that in Ferrara and Missios (2012) about recycling services impacting both recycling participation and intensity, but neither unit pricing nor mandatory recycling has any significant influence. Of the various recycling services considered in the analysis, the door-to-door is the most relevant with a marginal effect that ranges between 20 percent for glass and plastic and 30 percent for aluminum. The drop-off service is also of relevance with a marginal effect around 12 to 14 percent for glass, plastic, and paper recycling and around 17 to 19 percent for aluminum recycling. The presence of a refundable deposit system is of significance only for glass, plastic, and aluminum recycling but its effect relative to the effects of the door-to-door and drop-off programs varies across the three materials. Specifically, a refundable deposit system is less influential than the other two services for glass, more influential than the drop-off service but comparable in impact to the door-to-door service for plastic, and less influential than the door-to-door service but comparable in impact to the drop-off service for aluminum. The presence of a non-refundable deposit system, on the other hand, only affects the probability of recycling aluminum but not to the same extent as the other services.

Other important determinants of recycling are environmental attitudes and personal motives. At the 1 percent level of significance, a marginal change in environmental attitudes towards often engaging in environmental activities (e.g., using refillable containers and buying products with recycled content) yields an increase in the probability of recycling everything of over 10 percent whereas a marginal change in personal motives above fairly important increases the probability of recycling everything between 7 and 9 percent for glass, plastic, and paper and by 4 percent for aluminum.[15]

Finally, when we look at the coefficients of the interactions between policies and personal motives (UF_INT and MAN_INT), which are key variables in the empirical analysis for the purpose of providing some empirical validity to our theoretical results, we find that unit pricing does not reduce intrinsic motivation for recycling but mandatory recycling does in two of the four cases. Specifically, the estimated coefficient of UF_INT is negative only for plastic recycling but never statistically significant; however, the estimated coefficient of MAN_INT is positive only for aluminum recycling but not statistically significant, negative but statistically insignificant for plastic recycling, and both negative and statistical significant for glass and paper recycling. For glass and paper recycling, the presence of mandatory recycling as an important motive for recycling reduces the marginal effect of intrinsic motivation for recycling by 44 percent for paper and 56 percent for glass: the effect decreases from 7.1 percent to 3.1 percent for glass recycling and from 8.5 percent to 4.8 percent for paper recycling. We take these findings to suggest that, while unit pricing does not crowd out moral and social motives for recycling, mandatory recycling can. The findings thus provide support for the first and second hypotheses derived from our theoretical analysis about crowding out of personal motivation never occurring under unit pricing but being possible under mandatory recycling; however, the findings, as they stand, do not allow for a statistically meaningful discussion of the reasons why crowding out may occur under mandatory recycling in some cases (i.e., glass and paper) but not in others (i.e., plastic and aluminum).

[TABLES 2 and 3]

[15] Marginal effects are computed at mean values. The mean value of ENVPURCH_INDX is 2.90 so that a marginal change is towards 3.00 which is the value the index takes on when environmental activities are performed often. The mean value of INTRINSIC is 2.00 so that a marginal change is above 2.00 which is the value the index takes on when personal motives are fairly important.

Based on our theoretical results, mandatory recycling is more likely to yield a decrease in the positive effect of personal motives on the probability of recycling 100 percent when the disutility from a negative self-image is low and/or the cost of recycling is high. As there are no a-priori or theoretical reasons to suspect that there is variation across different recyclables in how self-image affects preferences, we focus on recycling cost differences to attempt to explain why the perception of mandatory recycling crowds out personal motives for glass and paper recycling but not for plastic and aluminum recycling. Building upon our cost function which is decreasing in θ, a parameter that captures the convenience of the recycling services in place so that an increase in convenience through a service improvement (e.g., a shift from a drop-off program to a door-to-door program) reduces the cost of recycling, we use the marginal effect of a recycling service, whenever it is statistically significant, as a proxy of convenience and define the cost of using the service as the reciprocal of its marginal effect. To account for the presence of different services for a given material, we compute a weighted measure of convenience for each material using the shares of households with access to the different services as the weights (see Table 4); hence, we obtain a measure of the aggregated cost of recycling a particular material as the reciprocal of the weighted marginal effects of the various services available for the material.

[TABLE 4a]

Given that the question at hand is about mandatory recycling and whether there exist cost considerations that would explain why it results in crowding out for some materials but not for others, we consider cost differences across the four recyclables for the scenario without unit pricing, although we also report the differences for the scenario without mandatory recycling (see Table 4b). In line with our theoretical predictions, we expect the cost of recycling glass and paper to be higher than the cost of recycling plastic and aluminum. Our measures of cost in the absence of unit pricing, which we provide in Table 4b, are however consistent with our expectations only in part: aluminum recycling is the least costly but plastic recycling is more costly than paper recycling. While the above exercise of cost comparisons may be instructive, it is based on the effect of having a service for a given material and does not capture the cost implications of correlation possibilities in recycling services across the four materials. The following considerations are illustrative of the potential for an upward bias in cost estimates when the presence of a service is the sole cost trigger: (i) waste management policies targeting recycling may be introduced simultaneously for different types of materials and, in the specific case of drop-off service, centres may be placed in the same area even when co-mingling different materials is not permitted; (ii) recycling may entail fixed costs associated, for example, with the collection of information about available collection services and the purchase of additional bins so that the incremental cost of recycling an additional material may decrease when another material is already being recycled; (iii) economies of scope may exist as sorting a particular material is equivalent to sorting, at least partially, the other materials.

[TABLE 4b]

5 Conclusions

In this paper, we consider the household's decision of whether to recycle in a theoretical framework that allows for social and moral motives. Social motivation comes from valuing social approval which depends on the difference between one's contribution to recycling and the average contribution, the frequency of meeting a recycler, and the difference in one's utility between a society in which everyone recycles and a society in which no one recycles. Moral motivation comes from valuing self-image which depends on the difference between one's contribution to recycling and the morally ideal contribution, the total environmental benefit of recycling if everyone recycles, and the share of recyclers.

By capturing a wider range of motives for environmentally responsible behavior, we have the opportunity of examining and rethinking the interaction among different types of motivation. Understanding this interaction is key to effective policy making. In fact, to the extent that it is perceived as communicating norms and responsibilities, government regulation can enhance intrinsic motivation in the form of a moral norm. If behavior is motivated by norms and public policy can increase individuals' intrinsic incentives to act, policy results are likely to be dependent upon framing or the way in which policies are presented. With this in mind, we introduce a unit pricing system and, separately, mandatory recycling and study how each affects the equilibrium in terms of whether a society recycles.

Within our framework, we obtain that, under a unit pricing system, a society in which no one recycles moves to an equilibrium in which everyone recycles. Under mandatory recycling, a society in which everyone recycles moves to an equilibrium in which no one recycles provided that the marginal utility of self-image falls short of the cost of recycling relative to the environmental benefit of living in a society in which everyone recycles. While the former policy increases the benefit of living in a society in which everyone recycles over and above the benefit of living in a society in which no one recycles, the latter decreases it by reducing the benefit of social approval. However, the more important self-image is and/or the more convenient recycling is, the less likely it is for the reduction in the social approval benefit that results under mandatory recycling to move a society from an equilibrium characterized by everyone recycling to an equilibrium in which no one recycles, that is, the less likely it is for mandatory recycling to crowd out intrinsic motivation for recycling. Furthermore, we obtain that, if mandatory recycling is accompanied by an improvement in recycling services (e.g., from drop-off to curbside pick-up) that applies to all recyclables and not just the mandated recyclables, crowding out becomes less likely to occur; if the improved services only apply to the mandated recyclables, there is however no effect on the potential for crowding out.

In the second part of the paper, we test the hypotheses derived from the theoretical formulation using household-level data collected in 2008 in ten countries. Specifically, we apply the binary probit estimation procedure to estimate the probability of recycling 100 percent of each of four recyclables (glass, plastic, aluminum, and paper) as a function of standard socio-demographic characteristics, an environmental attitude index based on purchasing habits, a personal motivation index based on both a desire to be seen as acting responsibly and a sense of civic duty, indicators for the presence of different types of recycling services, an indicator for the presence of government intervention in the form of either unit pricing or mandatory recycling, and, mostly importantly, an interaction term between the personal motivation index and the indicator for government intervention.

The empirical findings are consistent with the theoretical result that unit pricing does not result in crowding out but mandatory recycling can. In fact, for glass and paper recycling, the estimated coefficient of the variable interacting the personal motivation index with the indicator for the presence of mandatory recycling is negative and statistically significant suggesting that mandatory recycling reduces the effect of personal motivation on the probability of recycling 100 percent. To be precise, for glass recycling, the marginal effect of personal motivation on the probability of recycling 100 declines from 7.1 to 3.1 percent; for paper recycling, it declines from 8.5 to 4.8 percent.

In an attempt to explain why mandatory recycling results in crowding out for some recyclables but not for others, we rely on the theoretical result that links the potential for crowding out to the cost of recycling. In particular, we use the marginal effects of the different recycling programs available for a given material as proxies for how convenient they are and multiply these marginal effects by the share of households with access to each program to obtain a weighted measure of convenience. We then use the reciprocal of this weighted measure of convenience to derive an aggregated measure of the cost of recycling the material. While the absolute value of this measure may not be truly representative of the cost of recycling the material, its relative value is indicative of how convenient or inconvenient recycling the material is relative to recycling a different material. Based on these values, we then have that glass recycling is the most costly and aluminum recycling is the least costly but plastic recycling is more costly than paper recycling. If cost considerations affect the potential for crowding out, we expect glass and paper recycling to be more costly than plastic and aluminum recycling. The cost comparison does not therefore fully support the theoretical result but we can attribute this misalignment to the narrow definition of cost that relies on whether a service for a particular material is in place.

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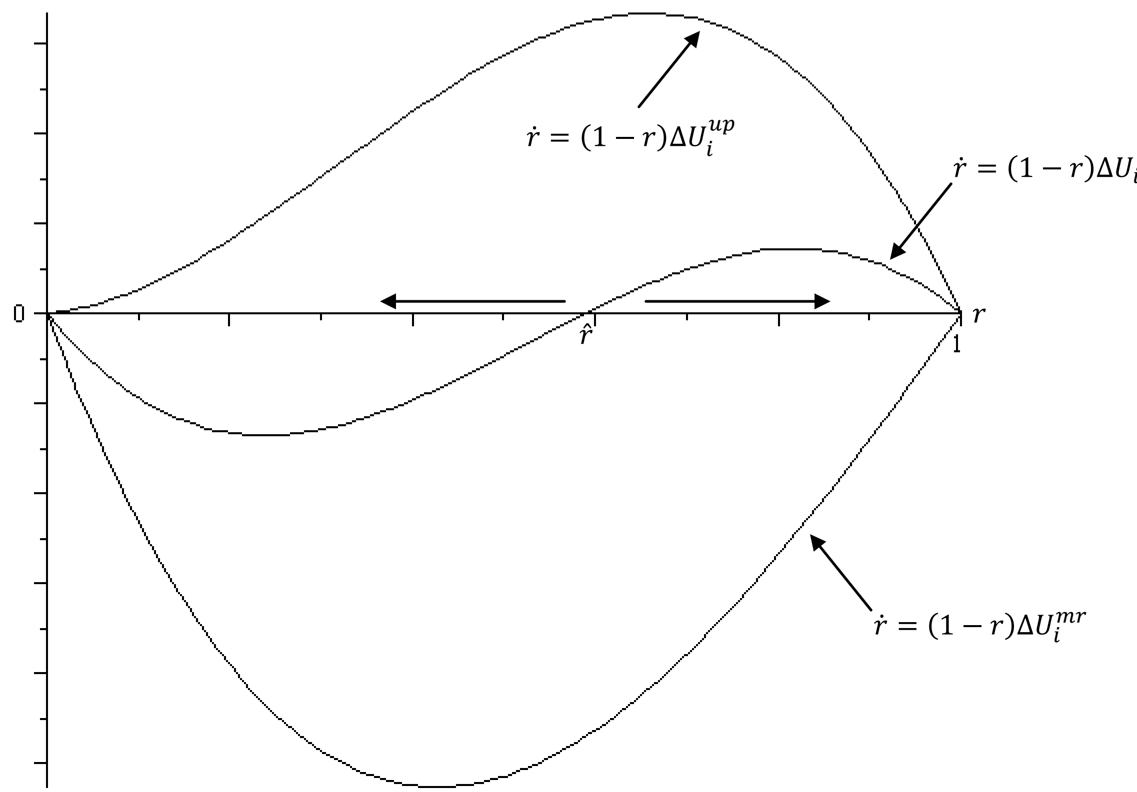

Figure 1. Dynamics of the share of recyclers under no policy (with 0, $\hat{r}$, and 1 as possible equilibria), mandatory recycling (mr), and unit pricing (up).

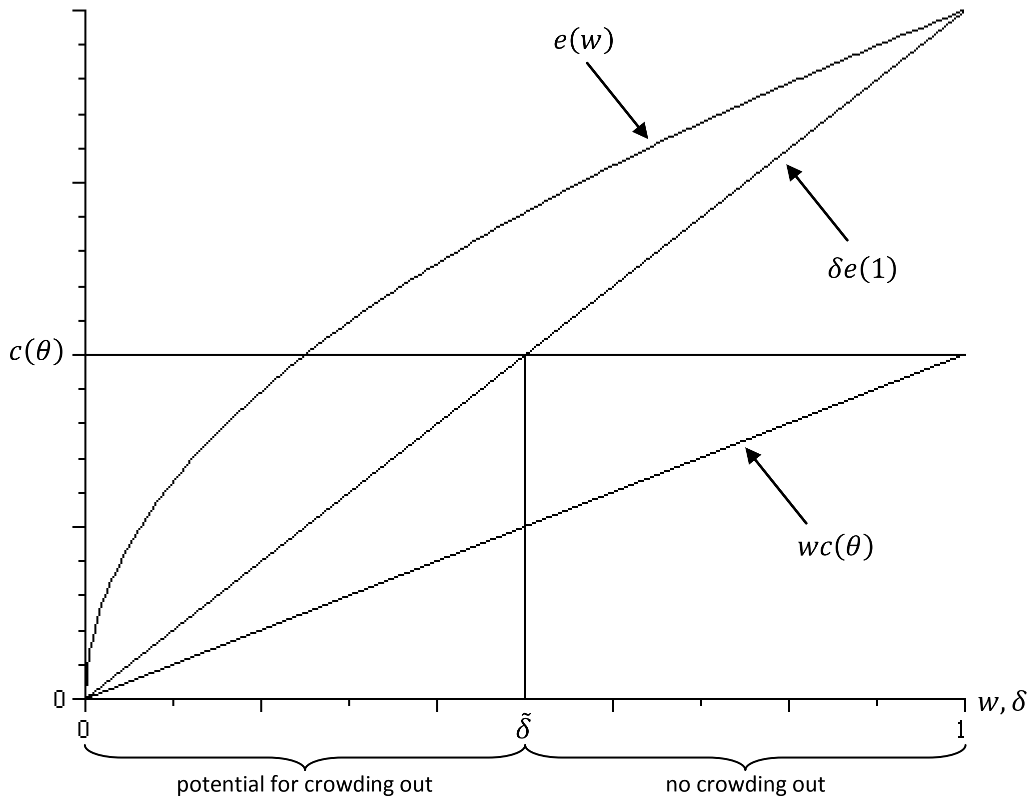

Figure 2. Potential for Crowding out of Personal Motivation under Mandatory Recycling.

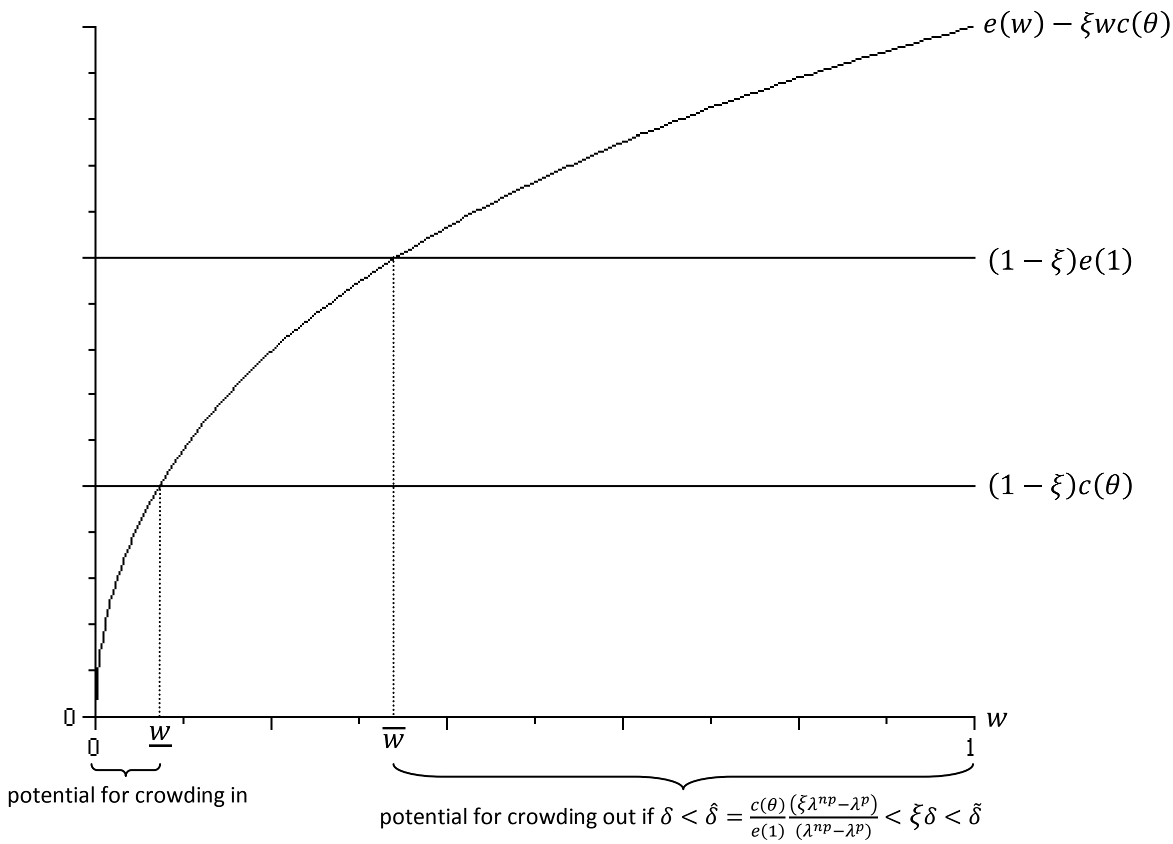

Figure 3. Potential for Crowding in/out of Personal Motivation under Mandatory Recycling and Improved Collection Service for Recyclables.

Table 1. Summary statistics under no policy (NP), no unit pricing (NO UP), or no mandatory recycling (NO MAN).

VARIABLE with DESCRIPTION		MEAN (SD) NP	MEAN (SD) NO UP	MEAN (SD) NO MAN
Socio-Demographic & Household Characteristics				
MALE	Male Indicator	0.50 (0.01)	0.49 (0.01)	0.50 (0.01)
AGE	Age in Years	42.56 (0.20)	43.76 (0.16)	42.25 (0.19)
UNIV	University Degree Indicator	0.33 (0.01)	0.33 (0.01)	0.34 (0.01)
INCOME_CONT	Income in Dollars	28819.83 (304.38)	31220.75 (250.38)	28397.86 (282.44)
HHSIZE	Household Size	3.79 (0.02)	3.77 (0.02)	3.87 (0.02)
RESOWNR	Residence Ownership Indicator	1.37 (0.01)	1.35 (0.01)	1.36 (0.01)
ROOMS	Number of Rooms (excluding Bathrooms)	4.91 (0.03)	4.96 (0.03)	4.87 (0.03)
HOUSE	House (detached or semi-detached) Indicator	0.56 (0.01)	0.56 (0.01)	0.56 (0.01)
URBAN	Urban Area Indicator	0.45 (0.01)	0.43 (0.01)	0.45 (0.01)
Recycling Services Indicators				
RCYLCOLDTD_GLAS	Door-to-Door Service for Glass Indicator	0.23 (0.01)	0.25 (0.00)	0.24 (0.01)
RCYLCOLDTD_PLST	Door-to-Door Service for Plastic Indicator	0.30 (0.01)	0.32 (0.01)	0.30 (0.01)
RCYLCOLDTD_MTAL	Door-to-Door Service for Aluminum Indicator	0.26 (0.01)	0.28 (0.01)	0.27 (0.01)
RCYLCOLDTD_PAPR	Door-to-Door Service for Paper Indicator	0.41 (0.01)	0.45 (0.01)	0.41 (0.01)
RCYLCOLDOF_GLAS	Drop-Off Service for Glass Indicator	0.59 (0.01)	0.59 (0.01)	0.57 (0.01)
RCYLCOLDOF_PLST	Drop-Off Service for Plastic Indicator	0.41 (0.01)	0.40 (0.01)	0.41 (0.01)
RCYLCOLDOF_MTAL	Drop-Off Service for Aluminum Indicator	0.43 (0.01)	0.44 (0.01)	0.42 (0.01)
RCYLCOLDOF_PAPR	Drop-Off Service for Paper Indicator	0.48 (0.01)	0.46 (0.01)	0.47 (0.01)
RCYLCOLRFD_GLAS	Refundable Deposit System for Glass Indicator	0.19 (0.01)	0.18 (0.00)	0.19 (0.01)
RCYLCOLRFD_PLST	Refundable Deposit System for Plastic Indicator	0.18 (0.01)	0.19 (0.00)	0.18 (0.01)
RCYLCOLRFD_MTAL	Refundable Deposit System for Aluminum Indicator	0.07 (0.00)	0.07 (0.00)	0.07 (0.00)
RCYLCOLRFD_PAPR	Refundable Deposit System for Paper Indicator	0.02 (0.00)	0.02 (0.00)	0.02 (0.00)
RCYLCOLBBK_GLAS	Non-Refundable Deposit System for Glass Indicator	0.03 (0.00)	0.03 (0.00)	0.03 (0.00)
RCYLCOLBBK_PLST	Non-Refundable Deposit System for Glass Indicator	0.02 (0.00)	0.03 (0.00)	0.03 (0.00)
RCYLCOLBBK_MTAL	Non-Refundable Deposit System for Aluminum Indicator	0.02 (0.00)	0.02 (0.00)	0.02 (0.00)
RCYLCOLBBK_PAPR	Non-Refundable Deposit System for Paper Indicator	0.01 (0.00)	0.02 (0.00)	0.02 (0.00)
Policy Variables				
USERFEE	User Fee for Garbage Collection Indicator			0.11 (0.00)
MANDATED	Mandatory Recycling Indicator		0.38 (0.01)	
Attitudinal Characteristics				
ENVPURCH_INDX	Environmental Attitude Index	2.90 (0.01)	2.89 (0.01)	2.89 (0.01)
INTRINSIC	Intrinsic Motivation Index	2.00 (0.01)	2.09 (0.01)	2.00 (0.01)
Interaction Variables				
UF_INT	Interaction between USERFEE and INTRINSIC			0.22 (0.01)
MAN_INT	Interaction between MANDATED and INTRINSIC		0.85 (0.01)	

Table 2. Univariate probit estimation results under no policy (NP), no unit pricing (NO UP), and no mandatory recycling (NO MAN).

VARIABLE	Coefficients for Glass			Coefficients for Plastic			Coefficients for Aluminum			Coefficients for Paper		
	NP	**NO UP**	**NO MAN**	**NP**	**NO UP**	**NO MAN**	**NO NP**	**NO UP**	**NO MAN**	**NP**	**NO UP**	**NO MAN**
AU	-0.147	-0.307***	-0.154*	-0.142	-0.278***	-0.177**	0.060	-0.107	0.053	-0.238***	-0.357***	-0.249***
	(0.095)	(0.075)	(0.092)	(0.094)	(0.074)	(0.090)	(0.094)	(0.075)	(0.090)	(0.091)	(0.072)	(0.087)
CA	-0.359***	-0.339***	-0.373***	-0.334***	-0.358***	-0.361***	-0.146	-0.200***	-0.153*	-0.355***	-0.393***	-0.353***
	(0.092)	(0.072)	(0.088)	(0.091)	(0.072)	(0.087)	(0.092)	(0.072)	(0.087)	(0.089)	(0.071)	(0.085)
CZ	-1.388***	-1.380***	-1.383***	-0.901***	-0.916***	-0.922***	-1.499***	-1.586***	-1.510***	-0.897***	-0.956***	-0.885***
	(0.097)	(0.084)	(0.092)	(0.095)	(0.081)	(0.090)	(0.132)	(0.120)	(0.127)	(0.094)	(0.083)	(0.090)
FR	-0.347***	-0.453***	-0.344***	-0.222***	-0.324***	-0.252***	-0.480***	-0.566***	-0.485***	-0.345***	-0.443***	-0.334***
	(0.083)	(0.066)	(0.081)	(0.087)	(0.069)	(0.084)	(0.087)	(0.070)	(0.084)	(0.083)	(0.067)	(0.080)
IT	-0.432***	-0.419***	-0.437***	-0.436***	-0.386***	-0.460***	-0.366***	-0.358***	-0.384***	-0.395***	-0.382***	-0.377***
	(0.084)	(0.065)	(0.080)	(0.086)	(0.067)	(0.082)	(0.085)	(0.066)	(0.081)	(0.083)	(0.065)	(0.079)
KO	-1.187***	-1.012***	-1.120***	-1.089***	-0.822***	-0.921***	-0.548***	-0.406***	-0.457***	-0.973***	-0.716***	-0.879***
	(0.166)	(0.109)	(0.110)	(0.164)	(0.107)	(0.108)	(0.161)	(0.107)	(0.110)	(0.169)	(0.108)	(0.109)
ME	-1.705***	-1.777***	-1.691***	-1.529***	-1.547***	-1.543***	-0.727***	-0.788***	-0.758***	-1.208***	-1.226***	-1.202***
	(0.114)	(0.098)	(0.106)	(0.109)	(0.093)	(0.103)	(0.106)	(0.089)	(0.098)	(0.110)	(0.094)	(0.103)
NL	-0.206***	-0.240***	-0.175**	-1.012***	-1.018***	-0.987***	-1.325***	-1.289***	-1.187***	0.000	-0.062	0.037
	(0.082)	(0.066)	(0.076)	(0.089)	(0.071)	(0.082)	(0.124)	(0.094)	(0.104)	(0.084)	(0.067)	(0.078)
NO	-0.504***	-0.514***	-0.502***	-0.708***	-0.746***	-0.710***	-0.442***	-0.456***	-0.453***	-0.204**	-0.213***	-0.207**
	(0.093)	(0.070)	(0.089)	(0.096)	(0.072)	(0.092)	(0.096)	(0.072)	(0.092)	(0.097)	(0.073)	(0.093)
MALE	0.020	0.034	-0.017	-0.032	0.013	-0.053	0.109***	0.105***	0.076*	-0.068*	0.000	-0.076**
	(0.041)	(0.031)	(0.038)	(0.040)	(0.031)	(0.038)	(0.043)	(0.033)	(0.040)	(0.040)	(0.031)	(0.038)
AGE	0.003*	0.003**	0.003**	-0.002	-0.002*	-0.001	0.006***	0.007***	0.007***	0.011***	0.009***	0.010***
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)
UNIV	0.193***	0.186***	0.175***	0.072	0.066*	0.055	0.109**	0.141***	0.081*	0.104**	0.092***	0.087**
	(0.045)	(0.035)	(0.042)	(0.045)	(0.035)	(0.042)	(0.047)	(0.036)	(0.043)	(0.044)	(0.034)	(0.042)
INCOME_CONT	0.000**	0.000***	0.000**	0.000	0.000**	0.000	0.000*	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
HHSIZE	-0.042***	-0.045***	-0.042***	-0.034**	-0.035***	-0.024	-0.023	-0.034**	-0.016	-0.034**	-0.025*	-0.019
	(0.017)	(0.013)	(0.016)	(0.016)	(0.013)	(0.015)	(0.018)	(0.014)	(0.016)	(0.017)	(0.013)	(0.015)
RESOWNR	-0.189***	-0.151***	-0.178***	-0.265***	-0.137***	-0.239***	-0.117**	-0.097**	-0.102**	-0.143***	-0.095***	-0.106**
	(0.047)	(0.037)	(0.045)	(0.047)	(0.037)	(0.045)	(0.051)	(0.040)	(0.047)	(0.047)	(0.037)	(0.044)
ROOMS	0.022**	0.026***	0.030***	0.020*	0.022***	0.026***	0.002	0.017*	0.013	-0.001	0.002	0.002
	(0.011)	(0.009)	(0.011)	(0.011)	(0.009)	(0.010)	(0.012)	(0.009)	(0.011)	(0.011)	(0.008)	(0.010)
HOUSE	0.015	0.062	-0.014	0.019	0.070*	-0.007	0.136**	0.130***	0.089*	0.026	0.051	0.016
	(0.051)	(0.040)	(0.047)	(0.051)	(0.040)	(0.047)	(0.056)	(0.043)	(0.050)	(0.051)	(0.040)	(0.047)
URBAN	0.067	0.016	0.067	0.039	-0.009	0.033	0.043	-0.001	0.036	0.070	0.031	0.064
	(0.044)	(0.034)	(0.041)	(0.044)	(0.034)	(0.041)	(0.048)	(0.037)	(0.044)	(0.044)	(0.034)	(0.041)
RCYLCOLDTD_X	0.525***	0.516***	0.505***	0.481***	0.510***	0.505***	0.839***	0.868***	0.796***	0.581***	0.618***	0.549***
	(0.063)	(0.049)	(0.059)	(0.058)	(0.045)	(0.055)	(0.060)	(0.048)	(0.057)	(0.058)	(0.048)	(0.055)

VARIABLE	Coefficients for Glass			Coefficients for Plastic			Coefficients for Aluminum			Coefficients for Paper		
	NP	NO UP	NO MAN	NP	NO UP	NO MAN	NO NP	NO UP	NO MAN	NP	NO UP	NO MAN
RCYLCOLDOF_X	0.378*** (0.055)	0.364*** (0.044)	0.344*** (0.052)	0.302*** (0.053)	0.313*** (0.042)	0.315*** (0.050)	0.543*** (0.053)	0.552*** (0.043)	0.504*** (0.050)	0.357*** (0.058)	0.356*** (0.047)	0.308*** (0.055)
RCYLCOLRFD_X	0.239*** (0.057)	0.181*** (0.045)	0.255*** (0.053)	0.538*** (0.063)	0.554*** (0.049)	0.526*** (0.059)	0.497*** (0.089)	0.433*** (0.043)	0.499*** (0.081)	0.157 (0.194)	-0.125 (0.155)	0.130 (0.161)
RCYLCOLBBK_X	-0.091 (0.128)	-0.077 (0.097)	-0.067 (0.117)	-0.006 (0.144)	-0.073 (0.108)	0.009 (0.126)	0.429*** (0.166)	0.206* (0.124)	0.312** (0.140)	-0.036 (0.181)	-0.042 (0.134)	0.000 (0.154)
ENVPURCH_INDX	0.353*** (0.035)	0.334*** (0.027)	0.351*** (0.033)	0.329*** (0.035)	0.344*** (0.028)	0.316*** (0.033)	0.370*** (0.039)	0.350*** (0.030)	0.344*** (0.036)	0.346*** (0.035)	0.376*** (0.028)	0.334*** (0.033)
INTRINSIC	0.175*** (0.035)	0.179*** (0.033)	0.175*** (0.034)	0.180*** (0.034)	0.176*** (0.033)	0.181*** (0.034)	0.118*** (0.036)	0.113*** (0.035)	0.122*** (0.036)	0.224*** (0.034)	0.220*** (0.033)	0.225*** (0.034)
USERFEE			-0.041 (0.216)			0.052 (0.213)			0.076 (0.221)	-1.951*** (0.183)		0.141 (0.214)
UF_INT			0.065 (0.102)			-0.013 (0.101)			0.019 (0.104)			0.034 (0.101)
MANDATED		0.048 (0.111)			-0.091 (0.114)			-0.210* (0.122)			0.166 (0.112)	
MAN_INT		-0.102** (0.049)			-0.009 (0.050)			0.062 (0.053)			-0.095** (0.049)	
Constant	-1.327*** (0.182)	-1.287 (0.147)	-1.328*** (0.174)	-0.938 (0.181)	-1.182*** (0.149)	-1.025*** (0.174)	-2.190*** (0.197)	-2.144*** (0.159)	-2.157*** (0.185)	-1.951*** (0.183)	-2.108 (0.149)	-1.982*** (0.174)
Number of Observations	4860	7821	5473	4860	7821	5473	4860	7821	5473	4860	7821	5473
Log Likelihood	-2730.31	-4585.77	-3061.85	-2756.97	-4562.47	-3096.24	-2379.35	-3996.18	-2738.96	-2799.81	-4646.56	-3156.19
Wald χ^2 Statistic	970.79	1295.06	1116.89	930.96	1319.85	1034.21	922.34	1410.18	1024.71	754.01	1105.20	833.21

Notes: (1) *, **, and *** indicate significance at the 10%, 5%, and 1%, respectively; (2) standard errors (in brackets) are robust.

Table 3. Marginal effects under no unit pricing and no mandatory recycling.

VARIABLE	Glass		Plastic		Aluminum		Paper	
	NO UP	**NO MAN**	**NO UP**	**NO MAN**	**NO UP**	**NO MAN**	**NO UP**	**NO MAN**
MALE	0.013	-0.007	0.005	-0.020	0.035***	0.025*	0.000	-0.029**
	(0.012)	(0.015)	(0.012)	(0.015)	(0.011)	(0.013)	(0.012)	(0.014)
AGE	0.001**	0.001**	-0.001*	0.000	0.002***	0.002***	0.004***	0.004***
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
UNIV	0.074***	0.069***	0.026*	0.021	0.048***	0.027*	0.035***	0.033**
	(0.014)	(0.017)	(0.014)	(0.016)	(0.013)	(0.014)	(0.013)	(0.016)
INCOME_CONT	0.000***	0.000**	0.000**	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
HHSIZE	-0.018***	-0.016***	-0.014***	-0.009	-0.011**	-0.005	-0.009*	-0.007
	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.005)	(0.005)	(0.006)
RESOWNR	-0.060***	-0.070***	-0.053***	-0.091***	-0.033**	-0.034**	-0.037***	-0.040**
	(0.015)	(0.017)	(0.014)	(0.017)	(0.013)	(0.016)	(0.014)	(0.017)
ROOMS	0.010***	0.012***	0.008***	0.010***	0.006*	0.004	0.001	0.001
	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.004)
HOUSE	0.025	-0.005	0.027*	-0.003	0.044***	0.029*	0.020	0.006
	(0.016)	(0.018)	(0.015)	(0.018)	(0.014)	(0.016)	(0.015)	(0.018)
URBAN	0.006	0.026	-0.004	0.013	0.000	0.012	0.012	0.024
	(0.013)	(0.016)	(0.013)	(0.016)	(0.012)	(0.015)	(0.013)	(0.016)
RCYCLCOLDTD_X	0.203***	0.199***	0.199***	0.196***	0.312***	0.283***	0.236***	0.207***
	(0.019)	(0.023)	(0.018)	(0.021)	(0.017)	(0.021)	(0.018)	(0.021)
RCYCLCOLDOF_X	0.142***	0.133***	0.122***	0.121***	0.188***	0.169***	0.137***	0.116***
	(0.017)	(0.020)	(0.016)	(0.019)	(0.015)	(0.017)	(0.018)	(0.020)
RCYCLCOLRFD_X	0.072***	0.101***	0.218***	0.206***	0.159***	0.182***	-0.047	0.050
	(0.018)	(0.021)	(0.019)	(0.023)	(0.027)	(0.031)	(0.057)	(0.063)
RCYCLCOLBBK_X	-0.030	-0.026	-0.028	0.003	0.073	0.111**	-0.016	0.000
	(0.038)	(0.045)	(0.041)	(0.048)	(0.046)	(0.053)	(0.051)	(0.058)
ENVPURCH_INDX	0.132***	0.137***	0.133***	0.121***	0.118***	0.113***	0.145***	0.125***
	(0.011)	(0.013)	(0.011)	(0.013)	(0.010)	(0.012)	(0.011)	(0.013)
INTRINSIC	0.071***	0.069***	0.068***	0.069***	0.038***	0.040***	0.085***	0.084***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)	(0.012)	(0.013)	(0.013)
USERFEE		-0.016		0.020		0.025		0.054
		(0.084)		(0.082)		(0.075)		(0.083)
UF_INT		0.025		-0.005		0.006		0.013
		(0.040)		(0.038)		(0.034)		(0.038)
MANDATED	0.019		-0.035		-0.070*		0.064	
	(0.044)		(0.044)		(0.040)		(0.043)	
MAN_INT	-0.040**		-0.003		0.021		-0.037**	
	(0.019)		(0.019)		(0.018)		(0.019)	

Notes: (1) *, **, and *** indicate significance at the 10%, 5%, and 1%, respectively; (2) standard errors (in brackets) are robust.

Table 4a. Access to recycling programs under no unit pricing and no mandatory recycling.

PROGRAM	Glass		Plastic		Aluminum		Paper	
	NO UP	NO MAN	NO UP	NO MAN	NO UP	NO MAN	NO UP	NO MAN
RCYCLCOLDTD_X	25.02	24.15	32.09	29.89	28.32	27.13	44.62	40.80
RCYCLCOLDOF_X	59.25	57.06	40.21	40.75	43.59	42.06	45.76	46.99
RCYCLCOLRFD_X	17.90	18.67	18.80	17.78	7.07	7.24	1.83	2.17
RCYCLCOLBBK_X	2.89	3.03	2.56	2.59	2.10	2.21	1.59	1.74

Note: figures are shares of households out of 7,821 under no unit pricing and out of 5,473 under no mandatory recycling.

Table 4b. Cost comparisons under no unit pricing and no mandatory recycling.

	Glass		Plastic		Aluminum		Paper	
	NO UP	NO MAN	NO UP	NO MAN	NO UP	NO MAN	NO UP	NO MAN
RCYCLCOLDTD_X	5.080	4.807	6.387	5.859	8.836	7.679	10.531	8.446
RCYCLCOLDOF_X	8.414	7.589	4.906	4.930	8.195	7.108	6.269	5.451
RCYCLCOLRFD_X	1.289	1.886	4.097	3.662	1.124	1.317	0.000	0.000
RCYCLCOLBBK_X	0.000	0.000	0.000	0.000	0.000	0.245	0.000	0.000
Weighted Convenience	0.148	0.143	0.154	0.145	0.182	0.163	0.168	0.139
Weighted Cost	6.765	7.002	6.498	6.920	5.508	6.116	5.952	7.196

Note: figures corresponding to recycling programs are products of marginal effects and shares of households with access to programs.