Appendix

Given the policy decisions of the community planner, household \(i, i = 1, \ldots, n\), is assumed to maximize utility by choosing recycling effort, \(e_i\), and the composite good, \(z_i\), subject to its budget constraint. Household solid waste, \(w_i\), is generated as a function of consumption according to \(w_i = \lambda z_i\), where \(0 < \lambda < 1\). Furthermore, household solid waste cannot be entirely recycled, so that \(r_i \in [0, r_i^{\text{max}} < w_i]\), where \(r_i\) is the amount of private recyclables generated per month and \(r_i^{\text{max}}\) is the maximum amount of recyclables that can be generated for a given \(w_i\). Preferences are given by

\[
u_i = u(z_i, l_i, g_i, G; \theta_i)
\]

where \(l_i\) is the fraction of non-market time spent in leisure, \(g_i = w_i - r_i\) is the net amount of waste generated by the household, \(G = \Sigma_i (w_i - r_i)\) is the total net amount of waste generated in the community, and \(\theta_i\) is a vector of household-specific demographic characteristics. There is a tradeoff between leisure and the effort required to clean, sort, store and deliver the recyclables (either to the curb or to a centralised drop-off site). We assume the tradeoff is given by \(l_i = 1 - e_i\), where maximum leisure is normalized to unity.

We assume that \(u\) is strictly increasing in \(z_i\) and \(l_i\), and weakly decreasing in \(g_i\) and \(G\).\(^1\) We further assume that recycling effort translates into recyclables according to

\[
\begin{align*}
    r_i &= \begin{cases} 
    r(e_i) & \text{curbside recycling} \\
    \max(0, r(e_i) - c_i) & \text{dropoff recycling} 
    \end{cases} 
\end{align*}
\]

where \(r\) is strictly increasing, concave and \(r(0) = 0\). The functions in (A2) are capped from above by \(r_i^{\text{max}}\), which corresponds to a maximum amount of curbside effort \(e_i^{\text{max}}(\text{curb}) = r^{-1}(r_i^{\text{max}})\) or drop-off effort \(e_i^{\text{max}}(\text{drop}) = r^{-1}(r_i^{\text{max}} + c_i)\). The positive constant \(c_i\) represents the additional

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\(^1\) We further assume that conditions on \(u_i\) are such that sufficient second-order conditions for utility maximization hold, ensuring a well-defined solution.
effort, primarily in terms of transportation costs, required for drop-off recycling. Figure A1 depicts a stylized example of the functional relationship between $e_i$ and $r_i$.

The household budget constraint is represented by $y_i \geq p z_i + \tau_i \phi_i$, where $y_i$ is household income, $p$ is $z_i$’s corresponding price index, $\tau_i = t - s_i$ is the recycling fee, $t$, net of any savings, $s_i$, associated with reduced garbage expense in communities with a variable-pricing scheme, and $\phi_i$ is a binary variable equal to one if household $i$ voluntarily signs up for a CRP (or is automatically signed up by virtue of a community mandate) and zero otherwise.2

The household recycling choice results in either an interior solution or one of two possible corner solutions. Begin by assuming an interior solution. The household supplies optimal recycling effort, $e_i^*$, up to the point where its marginal recycling benefits are equal to its marginal disutility of foregone leisure, i.e., $-(u_{g,i} + u_{G,i})r_e = u_{l,i}$. Because the curbside fee and the additional effort required for drop-off are fixed for a given household, this condition characterizes an interior solution for both drop-off and (mandatory or voluntary) curbside recycling.

The conditions for corner solutions (i.e., where the household either recycles nothing or recycles everything possible), however, depend on which of the three program types is offered.3 When only drop-off recycling is available, the household chooses not to recycle if $-(u_{g,i} + u_{G,i})r_e < u_{l,i}$ at $e_i = c_i$ and recycles everything possible if $-(u_{g,i} + u_{G,i})r_e \geq u_{l,i}$ at $e_i = e_i^{\text{max}}(\text{drop})$. With mandatory curbside recycling, the household chooses not to recycle if $-(u_{g,i} + u_{G,i})r_e < u_{l,i}$ at $e_i = 0$ and recycles at the maximum possible level if $-(u_{g,i} + u_{G,i})r_e > u_{l,i}$.

2 To keep the model simple, we abstract from the possibility that households receive revenue from the sale of drop-off recyclables (e.g., selling aluminum cans or newspapers). We note, however, that the revenue from drop-off recycling could be incorporated into the budget constraint in a straightforward manner.

3 We assume that policymakers always offer drop-off recycling, which is motivated by the empirical observation that the great majority of communities in our sample offer drop-off services.
at $e_i = e_i^{\text{max}}$ (curb). When voluntary curbside recycling becomes available, a household not currently using drop-off recycling will sign up for the CRP if the gain in utility from participating in the CRP is greater than the loss in utility associated with foregone leisure and income. A household that currently uses drop-off recycling will sign up for the CRP if the gain in utility associated with the increase in leisure outweighs the loss in utility associated with foregone income attributable to paying the curbside recycling fee. Once a household signs up for a voluntary CRP, they will either recycle at effort levels $e_i^*$ or $e_i^{\text{max}}$ (curb).

Figures A2 and A3 depict the various possible household-level solutions for mandatory curbside and drop-off recycling, respectively. In Figure A3, the discontinuity depicted in the marginal benefit curve for drop-off recycling $-(u_{e_i,r_e})$ reflects the additional fixed cost per household associated with drop-off recycling as compared to curbside recycling.

Next, we link the utility specification in (A1) to the household’s WTP for curbside recycling. Begin by considering the indirect utility function $v_i = v(p, \tau_i, \phi_i, y_i, \theta_i)$ resulting from constrained maximization of (A1). Assuming $v$ is strictly increasing in $y_i$, one can invert any reference $v_i$ with respect to $y_i$ to produce the household’s expenditure function, $m_i = m(p, v_i, \theta_i)$. In this case, we set the reference $v_i$ equal to the maximum utility given that the household does not participate in a CRP, $v_i^0$. WTP for curbside recycling is then derived by subtracting the household’s minimum expenditure when it participates in the CRP, $m_i = m(p, v_i^0, \theta_i | \phi_i = 1, \tau_i = 0)$, from its minimum expenditure given that the CRP does not exist, $m_i = m(p, v_i^0, \theta_i | \phi_i = 0)$. In other words, WTP for household $i$ is defined by the amount of income the household would willingly forego so as to participate in a CRP and maintain the original utility level $v_i^0$. 
Figure A1. Curbside and Drop-off Recycling-Effort Functions.
Figure A2. Possible Household Choices with Mandatory Curbside Recycling.

(a) Interior Solution

(b) Left-Hand Side Corner Solution

(c) Right-Hand Side Corner Solution
Figure A3. Possible Household Choices with Drop-off Recycling.

(a) Interior Solution

(b) Left-Hand Side Corner Solution

(c) Right-Hand Side Corner Solution