

# Promoting Residential Recycling: An Alternative Policy Based on The Regional Recycling Reward System

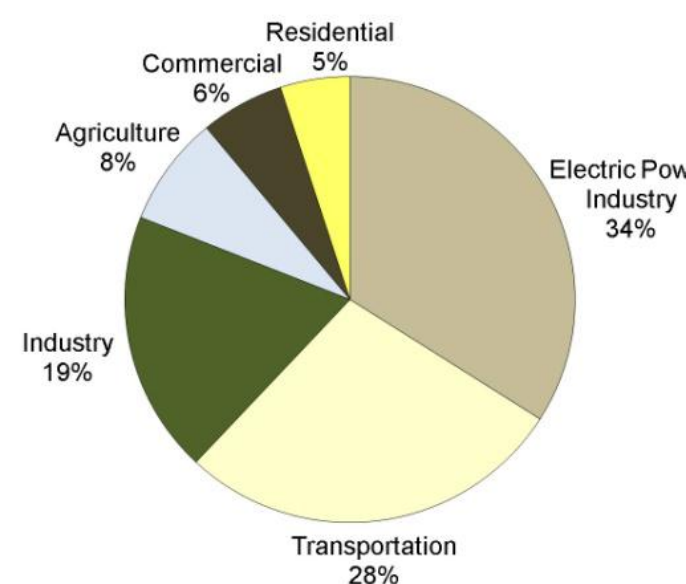
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## Motivations

- **Climate change becomes a severe issue**
  - “The benefits of strong, early action on climate change outweigh the costs.” (The Stern Review, 2007)
  - “Climate change is a prototype example of low probability, high-impact catastrophes.” (Weitzman, 2009)
- **Residential waste plays an important role**

11 percent of global Greenhouse Gas (GHG) emission is from Commercial and Residential Buildings. (IPCC, 2007)



## Existing Literature

- GHG emission restrictions on firms
- The impact of specific factors on household recycling behavior
- Both financial and non-pecuniary environmental valuation increase individuals' recycling rate.

## Current Recycling Policies

- Charge unit-pricing of waste for garbage disposing. Charge tipping fees for waste disposal at landfills.
- Local recycling organizations charge households a fix fee monthly to establish curbside recycling programs.
- Social Welfare Low Incentive
- Established deposit-refund systems
- Limited Materials High Time Cost



## Objective

- **Provide a feasible policy framework that promotes residential recycling behavior.**
  - Propose a policy to setup the Regional Recycling Reward System (RRRS) that provides incentive to stimulate residents' recycling rate.

## Setup of The RRRS

- **Establish**
- **Process**
- **Reward**



## Advantages of The RRRS

- Collecting Statistics
- Locations.
- Materials
- Social Norms



## Theoretical Model

- **Households' Side**

$$e_i n_i + \frac{p(n_i + \sum_i n_{-i})}{N} - [t_r n_i w_i] > \frac{p \cdot \sum_i n_{-i}}{N} - [t_g n_i w_i]$$

(a) (b) (c) (d) (e)

Total Benefit from Recycling  $n_i$  Total Benefit if Not Recycle

- (a): the benefit of recycling  $n_i$  from personal environmental valuation,
- (b): the financial reward of recycling  $n_i$ ,
- (c): the time cost for garbage handling of recycling  $n_i$ ,
- (d): the financial reward household  $i$  will get from free-riding,
- (e): the time cost for garbage handling if not recycle.

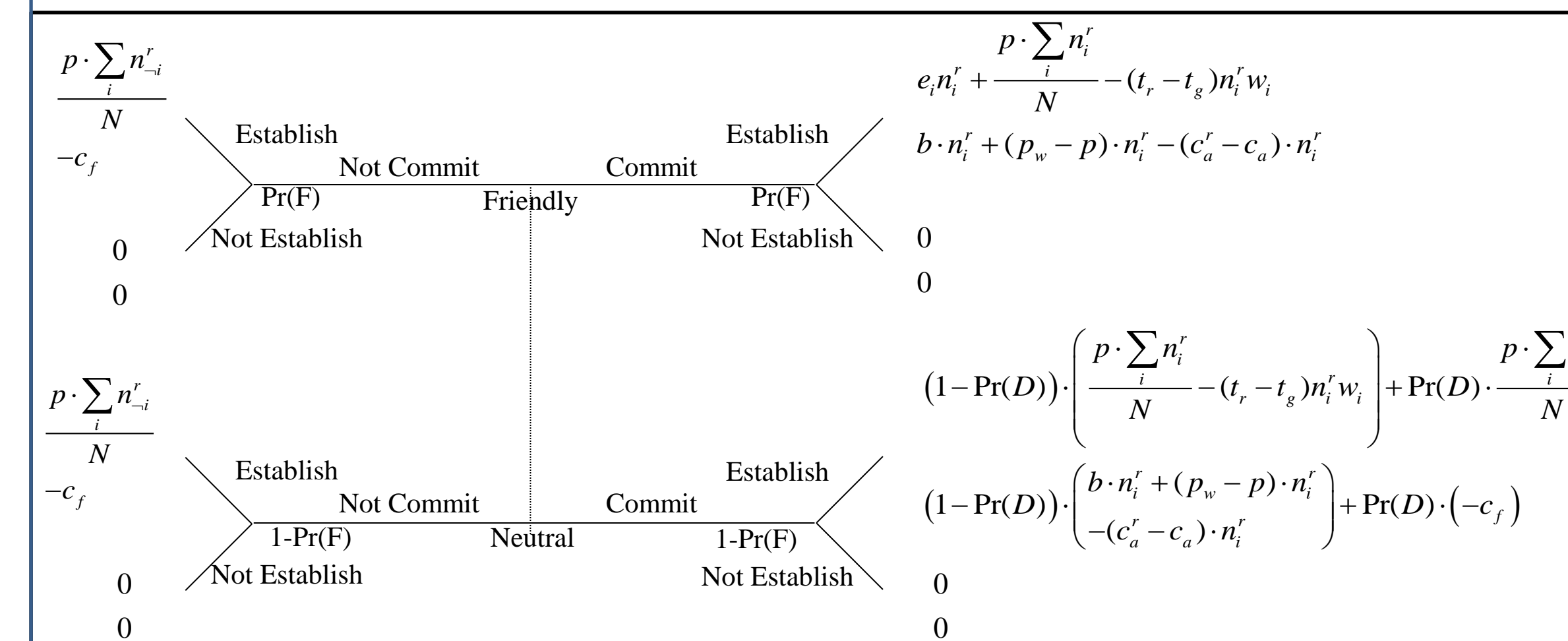
- **Lemma 1.** Household  $i$ 's recycling behavior is independent of other residents' behavior under the RRRS.
- **Lemma 2.** If it is desirable for household to recycle  $n$  units of garbage, then it is desirable to recycle  $n+1$  units of garbage.

- **The policy maker's side**

$$-b \cdot \sum_i (n_i - n_i^r) + (p_w - p) \cdot \sum_i n_i^r - c_a' \cdot \sum_i n_i^r - c_a \cdot \sum_i (n_i - n_i^r) - N \cdot c_f$$

$$> -b \cdot \sum_i n_i - c_a \cdot \sum_i n_i$$

- **Signaling Game**



- **Lemma 3.** All else being equal, neutral type of households will not “Commit” until all friendly type of households “Commit”.

## Equilibrium

**PBE 1:**  $e_i n_i^r + \frac{p \cdot \sum_i n_i^r}{N} - (t_r - t_g) n_i^r w_i < 0$

Pooling PBE: Environmental friendly households do not commit, environmental neutral households do not commit, the policy maker does not establish if the resident does not commit, establishes if the resident commits.

$$e_j n_i^r > (t_r - t_g) n_i^r w_i - \frac{p n_i^r}{N} > 0$$

**PBE 2:**  $\Pr(F) \cdot [b \cdot n_i^r + (p_w - p) \cdot n_i^r - (c_a' - c_a) \cdot n_i^r] + [1 - \Pr(F)] \cdot (-c_f) < 0$

Separating PBE: Environmental friendly households commit, environmental neutral households do not commit, the policy maker does not establish if the resident does not commit, does not establish if the resident commits.

$$e_j n_i^r > (t_r - t_g) n_i^r w_i - \frac{p n_i^r}{N} > 0$$

**PBE 3:**  $\Pr(F) \cdot [b \cdot n_i^r + (p_w - p) \cdot n_i^r - (c_a' - c_a) \cdot n_i^r] + [1 - \Pr(F)] \cdot (-c_f) \geq 0$

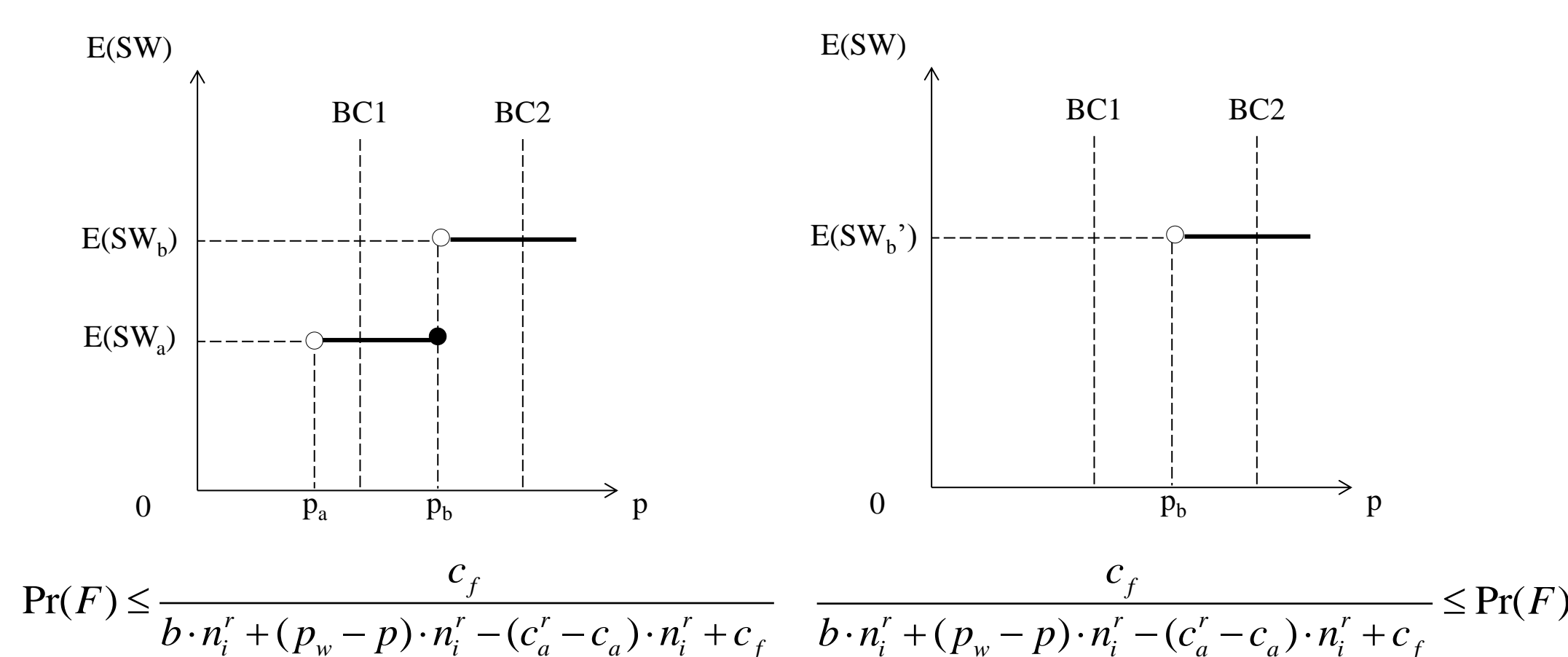
Separating PBE such that environmental friendly households commit, environmental neutral households do not commit, the policy maker does not establish if the resident does not commit, establishes if the resident commits.

**PBE 4:**  $\frac{p n_i^r}{N} - t_r n_i^r w_i > 0$

Pooling PBE such that both environmental friendly and neutral households commit, the policy maker does not establish if the resident does not commit, establishes if the resident commits.

## Social Welfare

- In **PBE 1** and **PBE 2**, the social welfare remains the same as under the current system. Normalize it to 0.
- In **PBE 3**, both types of residents commit to recycling, the total gain:
 
$$\Pr(F) \cdot \sum_i e_j n_i^r + p \cdot \sum_i n_i^r - \sum_i (t_r - t_g) n_i^r w_i + [1 - \Pr(F)] \cdot p \cdot \sum_i n_i^r + \Pr(F) \cdot [b \cdot \sum_i n_i^r + (p_w - p) \cdot \sum_i n_i^r - (c_a' - c_a) \cdot \sum_i n_i^r] + [1 - \Pr(F)] \cdot (-c_f) \cdot N$$
- In **PBE 4**, both types of residents commit to recycling and fulfill the commitment, the total gain:
 
$$\sum_i \left( e_j n_i^r + \frac{p \cdot \sum_i (n_i^r + n_i^m)}{N} - (t_r - t_g) (n_i^r + n_i^m) w_i \right) + \sum_i (n_i^r + n_i^m) \cdot [b + (p_w - p) - (c_a' - c_a)]$$
- **Lemma 4.** Given the conditions for the PBEs to exist, the total gains in PBE3 and PBE4 are both positive.
- **Lemma 5.** The social benefit is larger in PBE4 than in PBE 3.



## Conclusion

- **By setting an appropriate per unit rewards rate of recycling, at least the environmental friendly residents will commit to recycling under RRRS.**
- **Once the RRRS is established, it will enhance the residential recycling rate and, therefore, increase social benefit.**



## List of Variables

$-b$	per-unit negative marginal effect of non-recycled items to the environment
$n_i$	the amount of garbage deposited by resident $i$
$c_a$	average cost of picking up garbage
$n_i^r$	household $i$ 's amount of recycling
$p_w$	per-unit revenue paid from processor to the local policy maker
$p$	per-unit price the local policy maker paid to residents
$c_a'$	average cost of processing the recycled items
$c_f$	fixed cost of establishing the RRRS
$e_i$	non-pecuniary environmental valuation of household $i$
$t_r$	the average time cost for residential garbage depositing
$t_g$	the average time cost for recycling
$n_{-i}^r$	recycled garbage by all other residents in household $i$ 's designated region
$w_i$	wage rate for household $i$

## Acknowledgement

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