

# **Household Waste Prevention and Recycling: A Cross-Country Empirical Analysis**

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# Household Waste: Background

- Waste generation is one of the five areas of household consumption identified as a major source of pressure on the environment
- Household waste constitutes one of main components of municipal waste
  - in 2005, households produced over 75% of municipal waste in Korea, Germany, the U.K., Mexico, Belgium, the Netherlands, the Slovak Republic, Luxembourg, Denmark, and Spain

# Household Waste: Background

- The growing concern for municipal waste generation and disposal stems from three important phenomena:
  - increased concern for the environment and environmental sustainability coupled with increased awareness of the environmental effects of waste generation
  - reluctance by society to the development of new landfills and incineration facilities
  - drastic growth in municipal waste (household waste, in particular) over the last decades

# Household Waste: Background

- Within the OECD region, municipal waste generation increased by about 58% from 1980 to 2000 and 4.6% between 2000 and 2005
- Without 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

# Household Waste: Background

- In non-OECD countries, the municipal waste situation is much more complicated and poses some real policy challenges
- Not only non-OECD countries are expected to experience larger increases in municipal waste generation by 2030 but they also tend to rely on less environmentally friendly forms of disposal

# Household Waste: Background

- 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 (household or residential waste), municipal governments have grown particularly interested in experimenting with unit pricing systems and improving recycling services

# Household Waste: Background

- In the U.S., 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
- 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

# Household Waste: Background

- To assist policy makers in the design of efficient policies that effectively induce households to minimize waste through waste prevention and/or recycling, a better understanding of household behavior is however necessary

# Questions Considered

- Whether user fees have significant effects on waste prevention (e.g., refillable containers) relative to flat fees
- Whether user fees for waste disposal have significant effects on waste recycling rates relative to flat fees and whether these effects vary significantly by material and/or by type of unit pricing (e.g., weight-, volume-, frequency-based)

# Questions Considered

- Whether the presence of a recycling program significantly affect the effect of a user fee system on recycling and, if so, whether there is significant variation across materials
- The extent to which household waste recycling decisions depend on the attributes of recycling programs (e.g., door-to-door, drop-off, frequency of pick up) and whether there is significant variation across materials

# Questions Considered

- How general attitudes towards the environment (e.g., environmental awareness, membership in environmental organization) influence waste recycling levels and whether the presence of economic incentives and/or other forms of governmental intervention (e.g., mandatory recycling) erodes or enhances the relevance of intrinsic motivation

# Dependent Variables

- Two waste-related activities are considered
  - recycling
    - participation for each of the five materials considered (glass, plastic, aluminum, paper, food)
    - intensity for each material
  - waste prevention
    - participation considering recycling logos in purchasing decisions
    - intensity for refillable containers

# Explanatory Variables

- Country dummies
- Socio-demographic variables
  - Qualitative/Categorical:
    - married, male, age (4), education (4), employment status (6), ownership, house, garden, urban, suburban, tenure in primary residence (3)
  - Quantitative:
    - number of adults, number of children under 5, number of children between 5 and 18, income (in euros), number of rooms

# Explanatory Variables

- Attitudinal variables
  - environmental:
    - environmental rank, presence of waste generation concern, environmental concern, environmental attitude, importance of environmental benefits
  - social:
    - importance of belief that recycling is a civic duty, importance of being seen as acting responsibly
  - other:
    - presence and importance of mandatory recycling as a factor motivating recycling

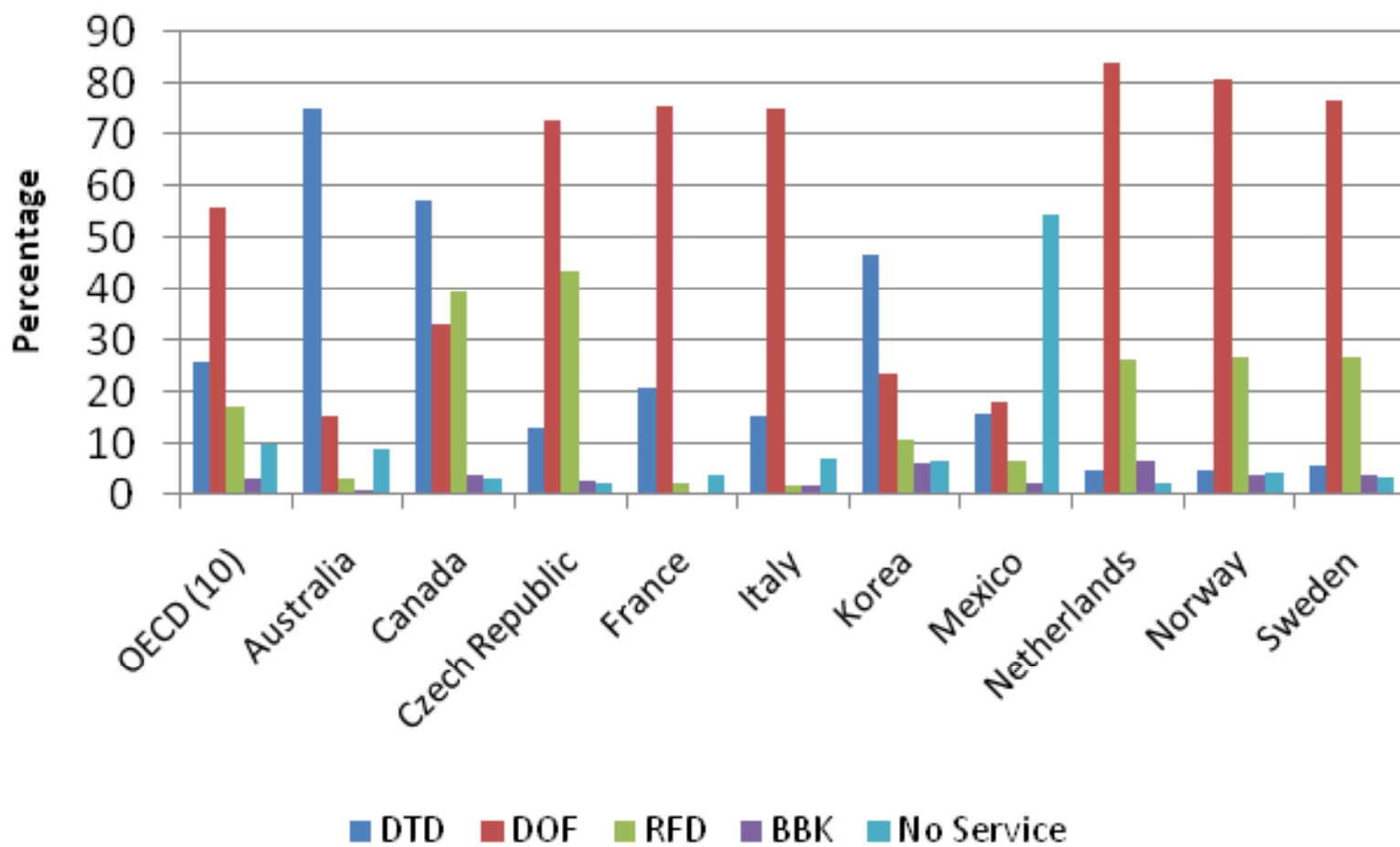
# Explanatory Variables

- Policy Variables
  - presence of unit pricing system (weight-, volume-, frequency-based)
  - presence of recycling program (door-to-door, drop off, bring back with refund, bring back without refund)
  - frequency of collection
    - mixed waste
    - door-to-door recycling program

# Explanatory Variables

- Variables interacting the presence of unit pricing (weight- or volume-based) with
  - presence of any recycling program (door-to-door/drop-off/bring back with refund/bring back without refund)
  - attitudinal variables (mandatory recycling, civic duty, responsible citizen)
  - socio-demographic variables (income, ownership, house, number of rooms, garden, urban/suburban)

Figure 1. Collection Services for Glass



### Figure 2. Collection Services for Plastic

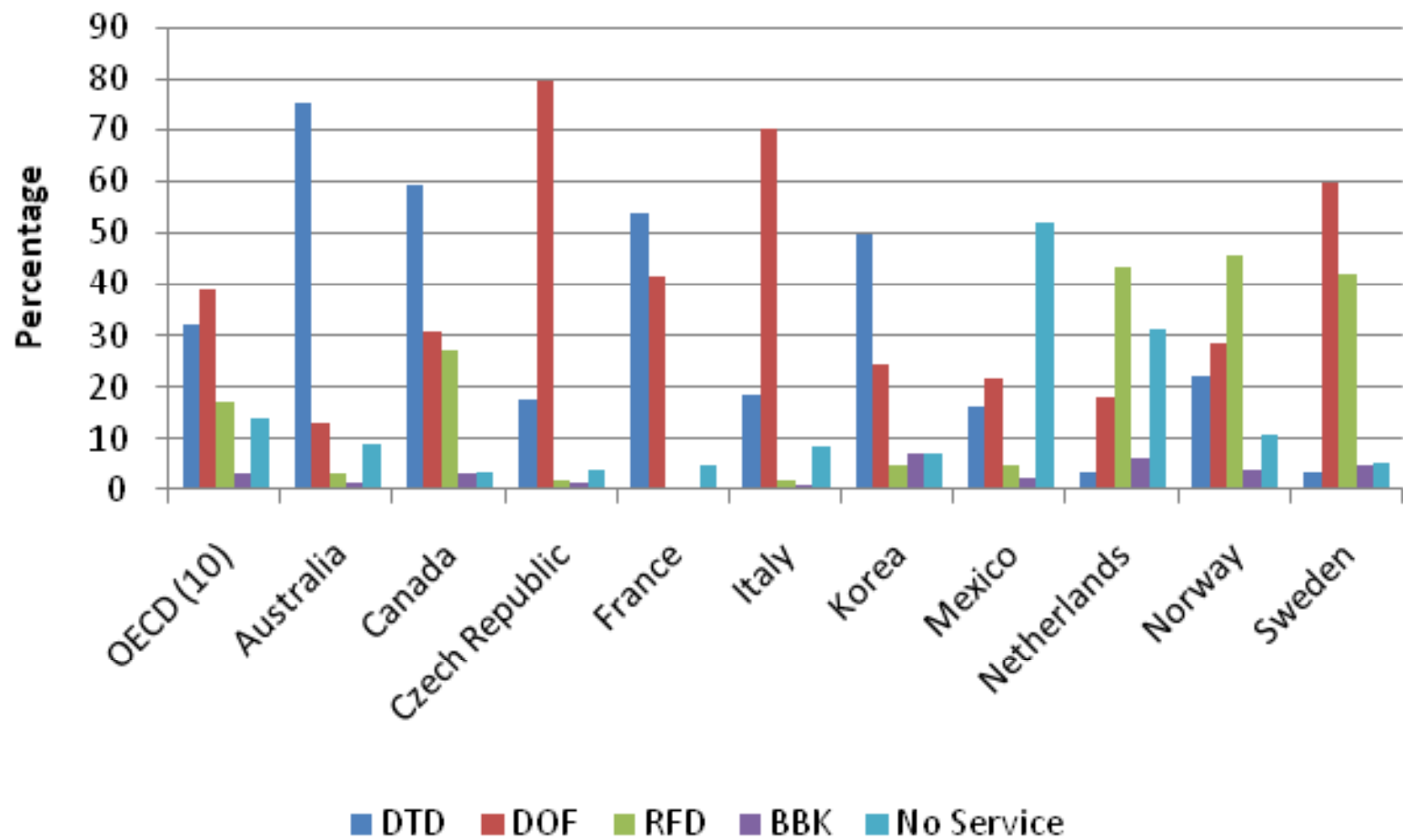


Figure 3. Collection Services for Aluminum

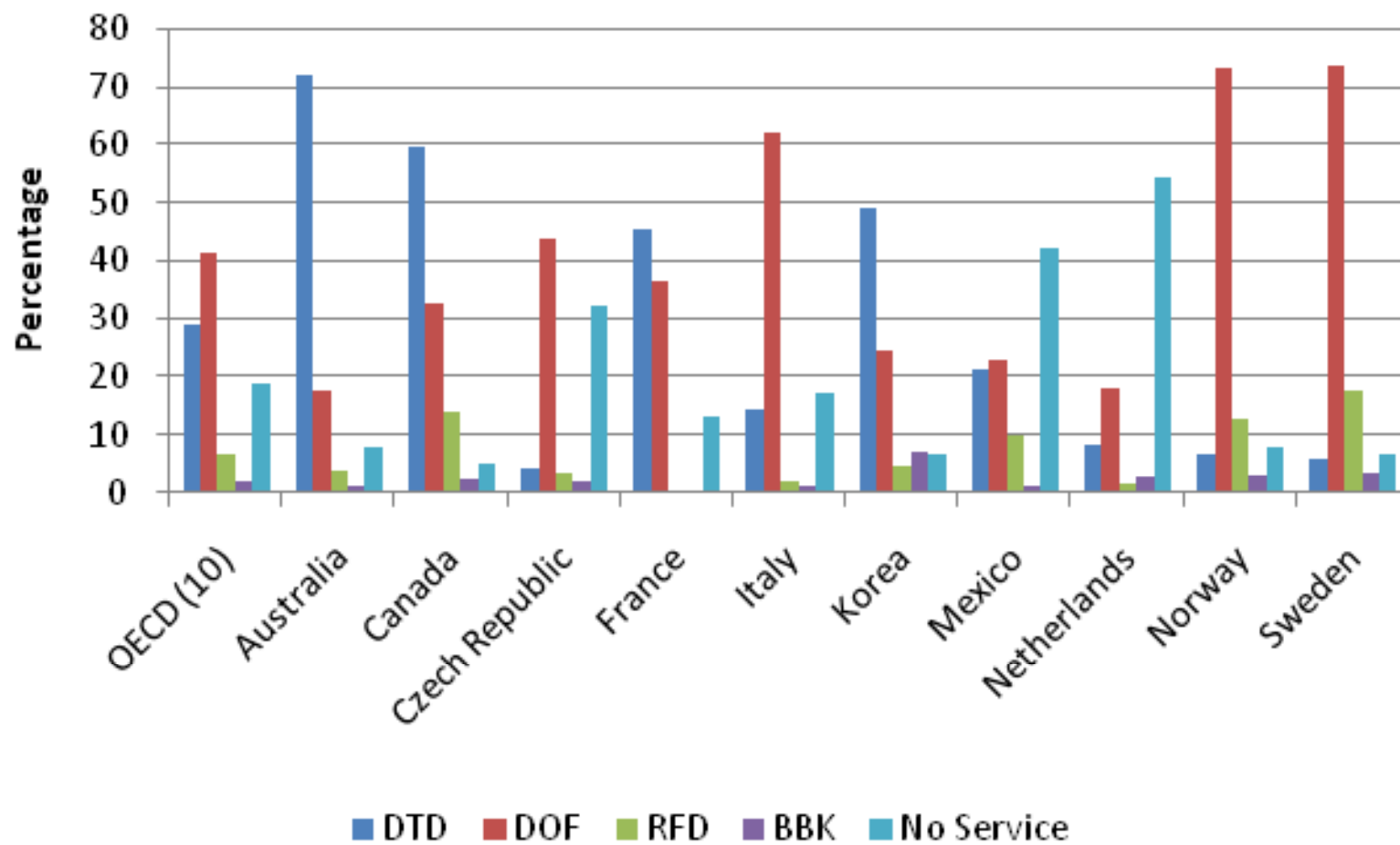


Figure 4. Collection Services for Paper

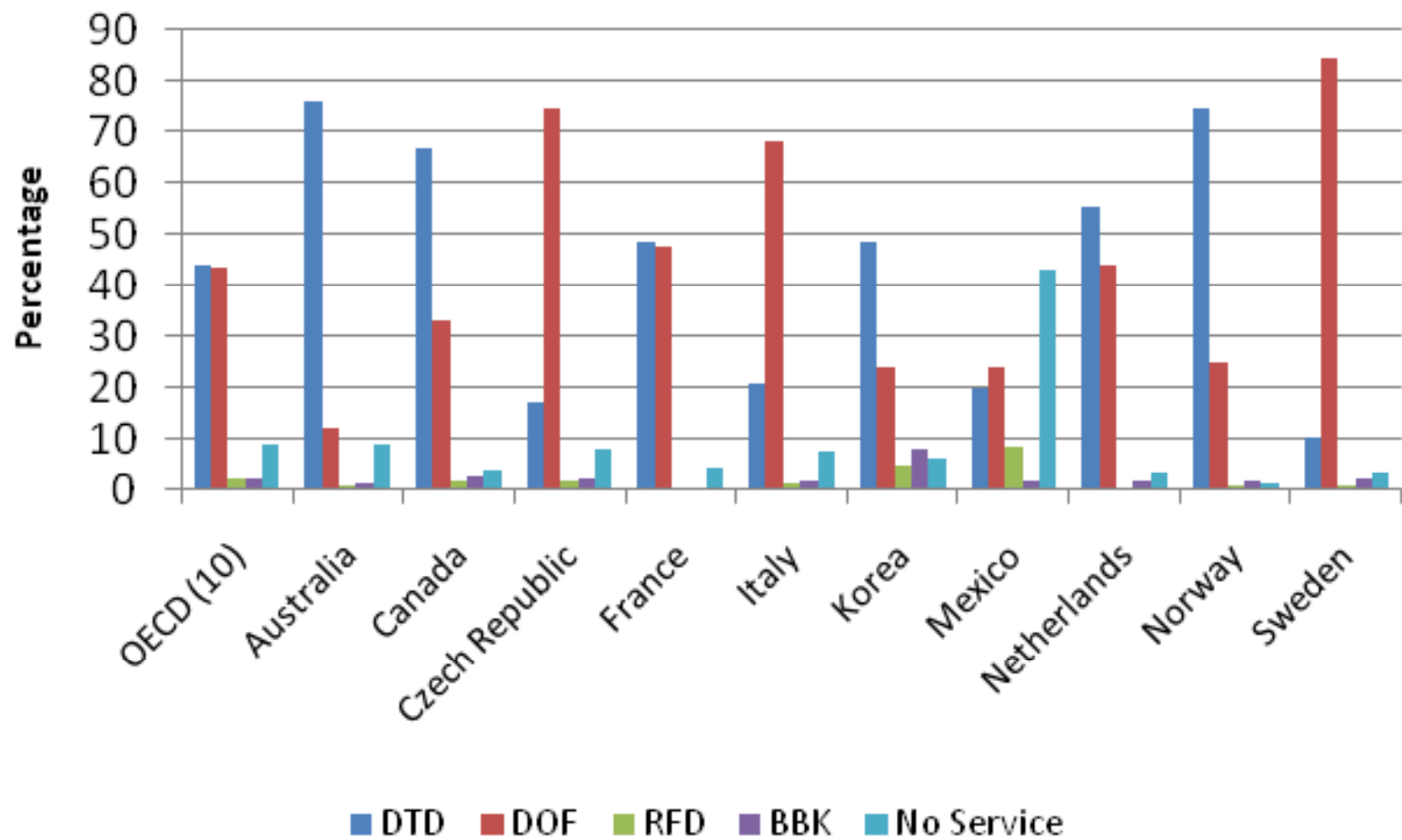
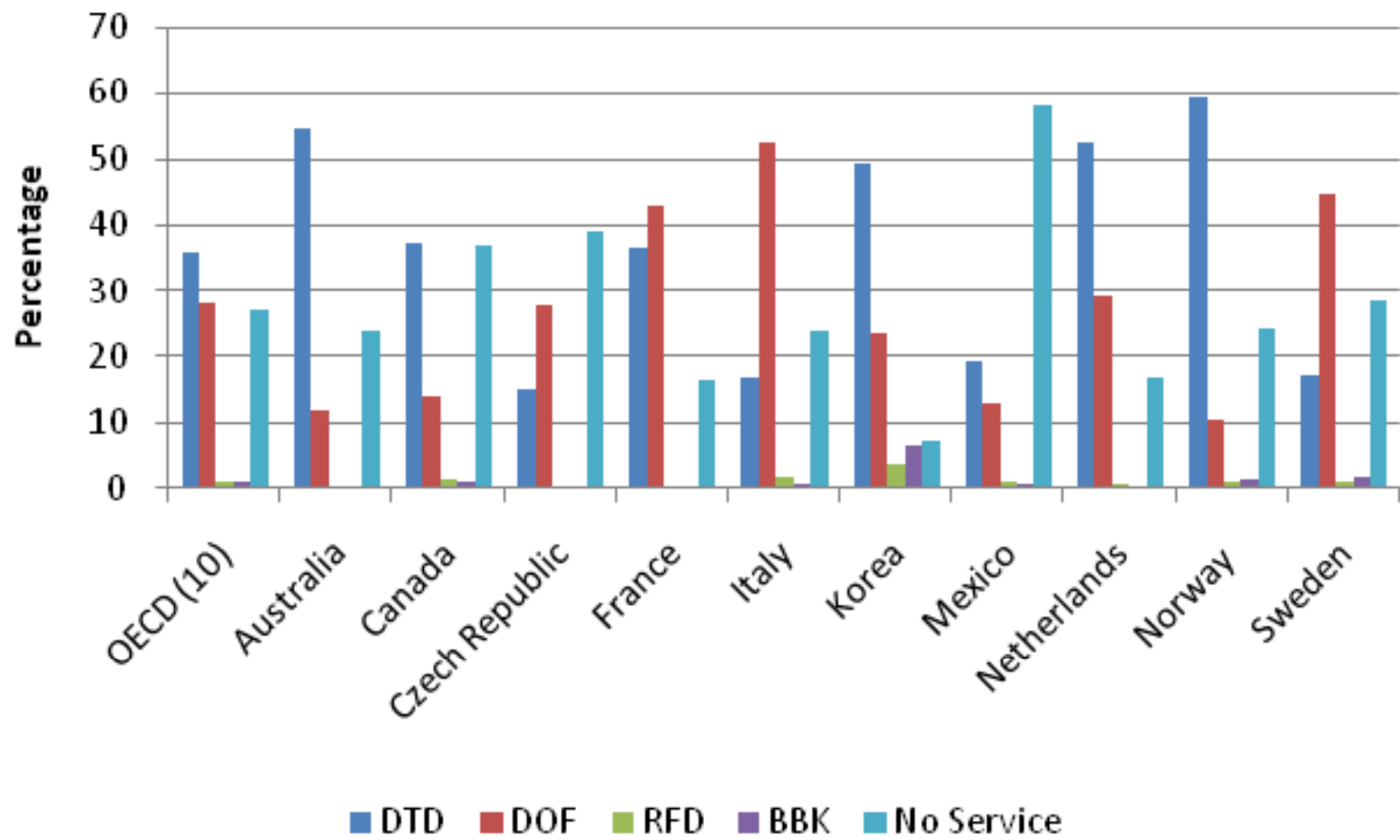
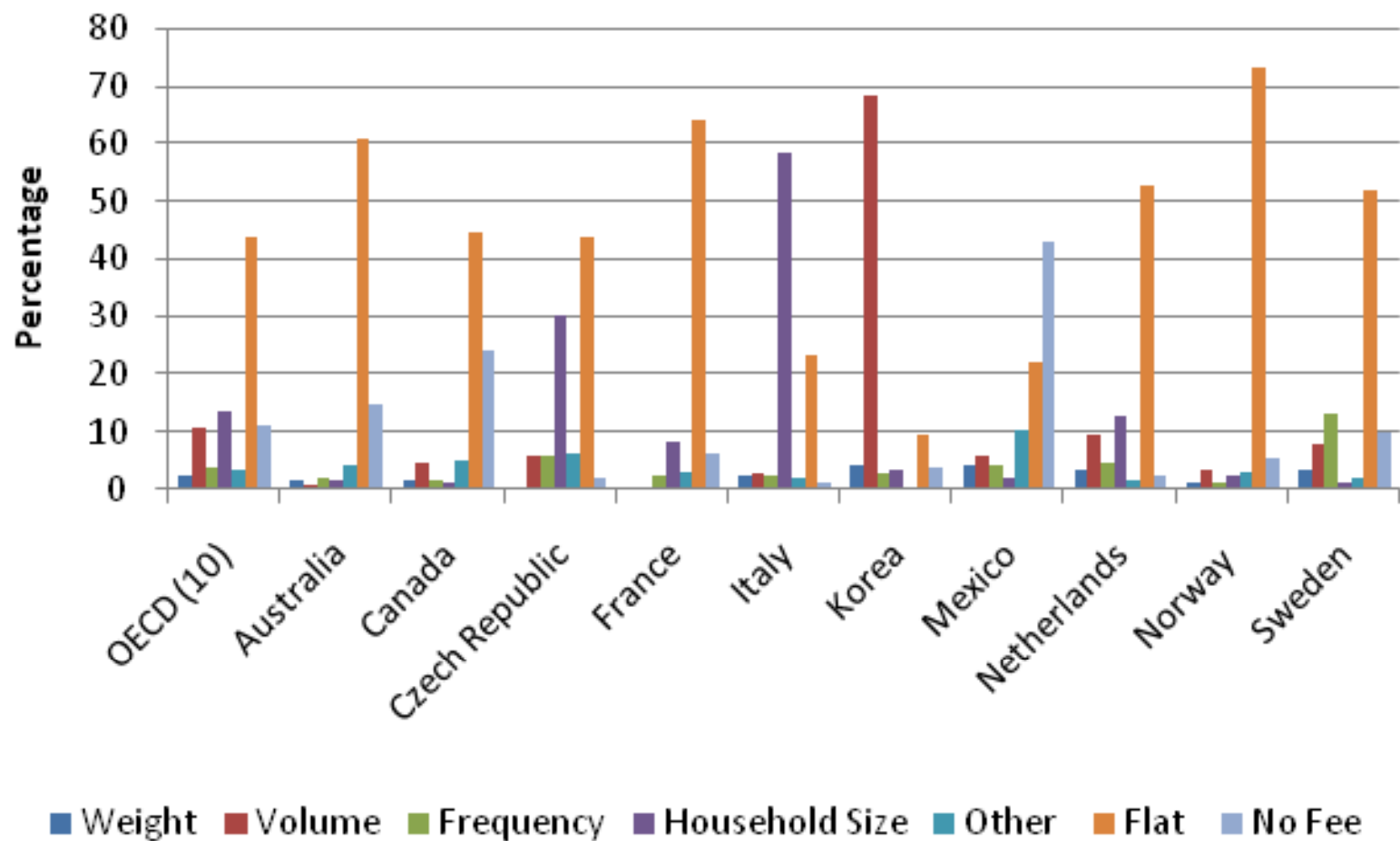


Figure 5. Collection Services for Food



**Figure 6. Charges for Mixed Waste Collection**



# Results: Recycling

- Decisions of recycling different materials are positively correlated (glass, plastic, aluminum, and paper, in particular)
- Country fixed effects are significant
  - Sweden tends to enjoy a higher recycling participation rate than any other country but Korea
  - Sweden tends to have a higher recycling intensity

# Results: Recycling

Variable	Participation	Intensity
AUSTRALIA	– (FO) + (PL, AL, PA)	– (GL, PL, PA, FO)
CANADA	– (FO) + (PL)	– (GL, PL, PA, FO)
CZECHREP	–	–
FRANCE	–	–
ITALY	– (GL, PL, AL, PA) + (FO)	– (GL, PL, AL, PA) + (FO)
KOREA	+ (GL, PL, AL, FO)	– (GL, PL, PA) + (FO)
MEXICO	– (GL, PL, AL, PA)	–
NETHERLANDS	– (GL, PL, AL)	– (GL, PL, AL)
NORWAY	– (GL, PL, AL) + (PA, FO)	– (GL, PL, AL) + (FO)

# Results: Recycling

- Socio-demographic variables
  - being married/living as a couple has a positive effect on recycling participation and, to a lesser extent, intensity
  - men recycle more aluminum
  - elderly individuals tend to recycle less plastic but more aluminum, paper, and food
  - households with children recycle less glass
  - more educated individuals tend to recycle more glass
  - unemployed individuals tend to recycle less aluminum
  - income has a positive effect only on aluminum recycling

# Results: Recycling

Variable	Participation	Intensity
STATUS_MARRIED	+ (GL, PL, AL, PA)	+ (PL)
GENDER_MALE	– (PL, PA) + (AL)	+ (AL)
AGE_CLASS_1 (18 to 24)	– (AL, PA, FO) + (PL)	– (AL, PA, FO) + (PL)
AGE_CLASS_2 (24 to 34)	– (AL, PA) + (PL)	– (AL, PA, FO) + (PL)
AGE_CLASS_3 (35 to 44)	+ (PL)	+ (PL)
AGE_CLASS_4 (45 to 54)	+ (PL)	+ (PL)
ADULTS		
UNDER5	– (GL, PL, PA)	– (GL, PL)
BETWEEN5AND18	– (GL)	– (GL)

# Results: Recycling

Variable	Participation	Intensity
EDUC_CLASS_1 (no HS)	– (GL, PA)	– (GL, AL, PA)
EDUC_CLASS_2 (HS)	– (GL, AL)	– (GL, AL)
EDUC_CLASS_3 (some PS)	– (GL)	– (GL)
EDUC_CLASS_4 (BA)	– (GL)	
EMPL_FULLTIME	+ (PL, AL)	+ (AL)
EMPL_PARTTIME	+ (AL)	+ (AL)
EMPL_RETIRED	+ (PL, AL, FO)	+ (AL)
EMPL_HOMEMAKER	+ (AL, PA)	+ (AL)
EMPL_STUDENT	+ (AL)	+ (AL)
EMPL_LEAVE	– (FO)	

# Results: Recycling

Variable	Participation	Intensity
OCCUP_1 (liberal profession)	– (PA) + (FO)	– (GL, PL, AL) + (FO)
OCCUP_2 (executive)	– (AL)	– (GL, AL)
OCCUP_3 (self employed)	– (GL)	– (GL, AL)
OCCUP_4 (salaried employee)		
OCCUP_5 (manual worker)	+ (PL, AL, PA)	+ (AL)
INCOME_CONT	+ (AL)	+ (AL)

# Results: Recycling

- Household characteristics
  - ownership tends to increase glass recycling and recycling intensity for plastic, aluminum, and paper
  - having a house (detached or semi-detached) tends to reduce the probability of recycling glass, plastic, and paper but to increase food recycling participation and intensity
  - the number of rooms increases glass, paper, and food recycling
  - the presence of a garden increases food recycling and recycling participation for glass and plastic
  - living in an urban or suburban area has a negative effect only on food recycling
  - length of tenure in primary residence increases recycling

# Results: Recycling

Variable	Participation	Intensity
ROWNR	+ (GL)	+ (GL, PL, AL, PA)
RESTYPE_HOUSE	– (GL, PL, PA) + (FO)	+ (FO)
RESROOMS	+ (GL, PA, FO)	+ (GL, PA, FO)
GARDEN	+ (GL, PL, FO)	+ (FO)
AREADESC_URBAN	– (FO)	– (FO)
AREADESC_SUBURBAN	– (FO)	– (FO)
RESYRS_CLASS_1 (< 2)	– (GL, PL, AL, FO)	–
RESYRS_CLASS_2 (2 to 5)	– (GL, AL, FO)	– (GL, PL, AL, FO)
RESYRS_CLASS_3 (6 to 15)	– (GL, PL, AL, PA)	– (GL, PL, AL, PA)

# Results: Recycling

- Attitudinal characteristics
  - individuals' environmental attitudes have a strong and positive effect on both recycling participation and intensity
  - the extent to which recycling is considered to be beneficial for the environment is an important motive for recycling
  - social considerations are relevant but through a sense of civic duty and not through a social pressure to act responsibly
  - individuals for whom mandatory recycling is a consideration in their recycling decisions tend to recycle more

# Results: Recycling

Variable	Participation	Intensity
ENVRANK	– (AL, PA, FO)	– (GL, AL, PA)
WSTE_CNCRN	– (AL)	– (AL) + (GL)
ENVCNCRN_IND	+ (GL, PL, AL, FO)	+ (PL, AL, FO)
ENVATTIT_IND	– (FO) + (GL, PL, AL)	+ (GL, PL, AL)
MTVRCYLENVR_LRKT	+	+
MTVRCYLDUTY_LRKT	+ (GL, PL, PA)	+
MTVRCYLRESP_LRKT		– (FO)
MTVRCYLMAND	+ (GL, PL, PA)	+ (GL, PL, PA)
MTVRCYLMAND_LRKT	+ (FO)	– (GL) + (FO)

# Results: Recycling

- Policy variables
  - volume-based charges are, for the most part, significant (particularly, in the intensity decision)
  - weight- and frequency-based charges are significant only for food recycling
  - when observations with curbside collection for recyclables are excluded from the analysis, user fees tend to be more significant in the intensity decision
  - having any type of service for recycling increases recycling
  - frequency of collection (of both recyclables and mixed waste) reduces recycling

# Results: Recycling

Variable	Participation	Intensity
WSTCHRG_WEIGHT	+ (FO)	+ (FO)
WSTCHRG_VOL	+ (PA, FO)	+ (GL, AL, PA, FO)
WSTCHRG_FREQ		+ (FO)
COLLFREQ_CLASS_1 (>1)	– (PL, AL, FO)	–
COLLFREQ_CLASS_2 (1)	–	–
RCYCLCOLDTD_X	+	+
RCYCLFREQ_X_1 (>1)	– (PL, AL, PA)	– (GL, PL, AL, PA)
RCYCLFREQ_X_2 (1)	– (AL, PA)	– (GL, PL, AL)
RCYCLCOLDOF_X	+	+
RCYCLCOLRFD_X	+	+
RCYCLCOLBBK_X	+	+ (PL, AL, PA, FO)

# Results: Recycling

## ORDERED PROBIT Estimates – Intensity Decision

Material	Weight		Volume		Frequency	
	DTD	No DTD	DTD	No DTD	DTD	No DTD
GLASS	0.27	0.58*	0.49*	0.84***	0.33	0.69**
PLASTIC	0.11	0.40	0.34	0.68**	0.23	0.56*
ALUMINUM	0.47	0.62*	0.52*	0.74**	0.45	0.67*
PAPER	0.30	0.52	0.56**	0.83**	0.33	0.56
FOOD	0.77***	1.18***	0.71**	1.16***	0.70**	1.09***

# Results: Recycling

## ORDERED PROBIT Estimates – Intensity Decision

Material	Door-to-Door Collection					
	Service		More than Weekly		Weekly	
	UP	No UP	UP	No UP	UP	No UP
GLASS	0.71***	0.70***	-0.32***	-0.21*	-0.15**	-0.15**
PLASTIC	0.91***	0.91***	-0.39***	-0.37***	-0.18***	-0.17***
ALUMINUM	1.30***	1.30***	-0.44***	-0.34***	-0.21***	-0.15**
PAPER	0.76***	0.78***	-0.13*	-0.10	-0.08	-0.04
FOOD	0.90***	0.90***	0.02	0.18**	-0.03	-0.03

# Results: Recycling

BINARY PROBIT Marginal Effects – Participation Decision				
Material	Type of Recycling Service			
	DTD	DOF	RFD	BBK
GLASS	0.11***	0.11***	0.05***	0.03***
PLASTIC	0.21***	0.15***	0.12***	0.07***
ALUMINUM	0.43***	0.34***	0.22***	0.15***
PAPER	0.16***	0.11***	0.05***	0.03**
FOOD	0.37**	0.26***	0.16***	0.26***

# Results: Recycling

- Interaction effects
  - unit pricing (weight- or volume-based) tends to interact
    - negatively with the presence of any type of recycling service
    - negatively with the presence of mandatory recycling as a relevant factor in recycling decisions
    - positively with living in an urban or suburban area
    - negatively with ownership

# Results: Recycling

Variable	Participation	Intensity
UF_INCOME	+ (PL, FO)	
UF_RESROWNR	– (AL, PA)	– (GL, PA)
UF_HOUSE	– (FO) + (GL, PL)	– (FO)
UF_RESROOMS	– (FO)	
UF_GARDEN	+ (AL)	
UF_URSUB	+ (GL, PL)	
UF_SERVICE_X	– (PL, AL, FO)	– (FO)
UF_MANDATED	– (GL, PL, AL)	– (GL, PA)
UF_MTVRCYLDUTY_LRKT		
UF_MTVRCYLRESP_LRKT	+ (FO)	+ (FO)

# Results: Waste Prevention

- Country fixed effects are significant
  - in Sweden,
    - individuals are more likely to consider recycling logo/label information in purchasing decisions
    - individuals tend to use/purchase refillable containers less regularly

# Results: Waste Prevention

Variable	Participation	Intensity
AUSTRALIA	–	+
CANADA	–	+
CZECHREP	NA	
FRANCE	–	+
ITALY	–	
KOREA	–	+
MEXICO	–	+
NORWAY	–	
NETHERLANDS	–	+

# Results: Waste Prevention

- Socio-demographic variables
  - male individuals are more likely to take recycling logo information into account in purchasing decisions but less likely to purchase/use refillable containers
  - elderly individuals are more likely to take recycling logo information into account in purchasing decisions and tend to purchase/use refillable containers
  - less educated and poorer people do not tend to take recycling labels into account

# Results: Waste Prevention

Variable	Participation	Intensity
STATUS_MARRIED		
GENDER_MALE	+	-
AGE_CLASS_1 (18 to 24)	+	+
AGE_CLASS_2 (24 to 34)	+	+
AGE_CLASS_3 (35 to 44)	+	
AGE_CLASS_4 (45 to 54)	+	
ADULTS		
UNDER5		
BETWEEN5AND18		

# Results: Waste Prevention

Variable	Participation	Intensity
EDUC_CLASS_1 (no HS)	–	
EDUC_CLASS_2 (HS)	–	
EDUC_CLASS_3 (some PS)		
EDUC_CLASS_4 (BA)		
EMPL_FULLTIME	–	
EMPL_PARTTIME	–	
EMPL_RETIRED		
EMPL_HOMEMAKER	–	
EMPL_STUDENT		
EMPL_LEAVE		
INCOME_CONT	+	

# Results: Waste Prevention

- Household characteristics
  - individuals with a garden tend to consider recycling labels and use/purchase refillable containers
  - individuals living in urban or suburban areas are less likely to use/purchase refillable containers

# Results: Waste Prevention

Variable	Participation	Intensity
RESTYPE_HOUSE		
GARDEN	+	+
AREADESC_URBAN		-
AREADESC_SUBURBAN		-

# Results: Waste Prevention

- Attitudinal characteristics
  - individuals with greater concern for environmental problems or who believe that recycling is beneficial for the environment or that it is a civic duty tend to engage more in waste prevention activities
  - individuals who rank environmental concerns high in order of importance or show a stronger attitude towards the environment are more likely to rely on recycling labels

# Results: Waste Prevention

- Attitudinal characteristics (cont.)
  - individuals who want to be seen by others as responsible citizens make greater use of refillable containers
  - the presence of mandatory recycling as an applicable factor motivating recycling induces individuals to pay attention to recycling labels but, the more important the factor is, the less likely they are to rely on recycling labels

# Results: Waste Prevention

Variable	Participation	Intensity
ENVRANK	–	
WSTE_CNCRN		
ENVCNCRN_INDX	+	+
ENVATTIT_INDX	+	
MTVRCYLENVR_LRKT	+	+
MTVRCYLDUTY_LRKT	+	+
MTVRCYLRESP_LRKT		+
MTVRCYLMAND	+	
MTVRCYLMAND_LRKT	–	

# Results: Waste Prevention

- Policy variables
  - unit pricing (weight-, volume-, or frequency-based) matters only for how often refillable containers are used/purchased
  - the presence of recycling services is, for the most part, statistically insignificant in both the participation decision and the intensity decision

# Results: Waste Prevention

Variable	Participation	Intensity
USERFEE		+
COLLFREQ_CLASS_1	-	NA
COLLFREQ_CLASS_2		NA
RCYCLCOLDTD_X	+(AL)	
RCYCLFREQ_X_1 (>1)	-(GL) +(AL)	NA
RCYCLFREQ_X_2 (1)		NA
RCYCLCOLDOF_X	+(AL)	+(AL)
RCYCLCOLRFD_X		+(AL)
RCYCLCOLBBK_X	-(GL)	

# Policy Implications

- Discussion of policy implications focuses on
  - country-specific dummies
  - attitudinal characteristics
  - pricing instruments
  - collection of recyclables
  - frequency of collection

# Country Dummies

- Evidence that some countries (e.g., Sweden) have consistently a more environmentally conscious behavior
  - closer look at such countries as differences may arise from policy differences at other stages of the product chain or differences in the provision of collection and disposal services

# Attitudinal Characteristics

- Environmental and social considerations do matter in waste management decisions
  - informational measures that focus on environmental aspects of waste generation and social motives for responsible waste management can be effective

# Pricing Instruments

- Economic incentives do not seem to reduce intrinsic motives for environmentally responsible behavior and, in some instances (e.g., food recycling participation), tend to increase them
  - acceptability of pricing instruments can be enhanced through informational campaigns that clearly communicate how pricing policies can contribute to the alleviation of the environmental problems resulting from waste production

# Pricing Instruments

- Unlike weight- and frequency-based fees, volume-based fees tend to be an effective policy
- Economic incentives through volume-based fees, however, seem to be mostly relevant in the intensity decisions about recycling and waste prevention
  - user fees (based on volume) should not be considered in areas where individuals do not tend to participate in recycling activities

# Pricing Instruments

- Unit pricing and door-to-door collection of recyclables are not complements of one another
- Unit pricing is, in general, more effective in the recycling intensity decision without respondents with curbside collection of recyclables
- Curbside collection of recyclables is always effective
  - unit pricing may be the redundant policy and increasing recycling may be more easily achievable with policies that focus on the time cost of recycling as opposed to policies that stress the money benefit of recycling

# Pricing Instruments

- Even when curbside recycling is absent and user fees (whether weight-, volume-, or frequency-based) are more effective in the recycling intensity decision, volume-based user fees tend to perform better
  - if a unit-pricing system is being contemplated, a volume-based system may be the best option

# Collection Program for Recyclables

- The presence of any type of service increases recycling participation and intensity but has mostly no effect on waste prevention
- Marginal effects are larger for a door-to-door service, followed by a drop-off system, a refundable deposit program, and a bring back without refund system
  - there are benefits to be realized with each type of recycling service and administrative cost considerations will have to be factored in

# Frequency of Collection

- Individuals tend to recycle less as mixed waste is collected more frequently
- Individuals tend to recycle less as recyclables are collected more frequently (with door-to-door collection)
  - mixed waste should be collected less frequently
  - if a door-to-door program is employed, recyclables should be collected less frequently