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Identifying the key factors in increasing recycling and reducing residual household waste: A case study of the Flemish region of Belgium

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ABSTRACT

The competent waste authority in the Flemish region of Belgium created the 'Implementation plan household waste 2003–2007' and the 'Implementation plan sustainable management 2010–2015' to comply with EU regulation. It incorporates European and regional requirements and describes strategies, goals, actions and instruments for the collection and treatment of household waste. The central mandatory goal is to reduce and maintain the amount of residual household waste to 150 kg per capita per year between 2010–2015. In literature, a reasonable body of information has been published on the effectiveness and efficiency of a variety of policy instruments, but the information is complex, often contradictory and difficult to interpret. The objective of this paper is to identify, through the development of a binary logistic regression model, those variables of the waste collection scheme that help municipalities to reach the mandatory 150 kg goal. The model covers a number of variables for household characteristics, provision of recycling services, frequency of waste collection and charging for waste services. This paper, however, is not about waste prevention and reuse. The dataset originates from 2003. Four out of 12 variables in the model contributed significantly: income per capita, cost of residual waste collection, collection frequency and separate curbside collection of organic waste.

1. Introduction and objective

As long as humans have been living in settled communities, solid waste, or garbage, has been an issue, and modern societies generate far more solid waste than early humans ever did. Daily life in industrialized nations can generate several pounds of solid waste per consumer, not only directly in the home, but indirectly in factories that manufacture goods purchased by consumers. Solid waste management is a system for handling all of this garbage; municipal waste collection is solid waste management, as are recycling programs, dumps, and incinerators. For most industrialized nations today, solid waste management is a multibillion dollar business which is also crucial to survival. Garbage collection agencies remove tons of garbage yearly and sort it for recycling or ultimate disposal. Most cities require citizens to pay for waste collection, while rural areas have dumps and recycling facilities for citizens to bring their garbage to. The end goal is a reduction of the amount of garbage clogging the streets and polluting the environment, whether that garbage is disposed of or recycled into something useful. Solid waste management also is focused on developing environmentally sound methods of handling garbage.

Waste generation has positive income elasticity, its generation grows as income grows. The cities of Western Europe, as well as those of North America, generate more solid waste than they did a century ago (Porter, 2002). In the UK however, waste growth appears to have started to diverge from GDP growth, though the reasons are not yet fully understood (Parfitt and Robb, 2009). According to OECD statistics, municipal waste generation increased by 14% between 1990 and 2000, from 530 to 605 million tonnes. Measured per capita, municipal waste generation increased from 509 to 540 kg, a rise of 6% (de Tilly, 2004). In Western Europe, municipal waste generation measured per capita increased from 476 kg in 1995 to 580 kg in 2003, a rise of 22% (European Environment Agency, 2005).

Within the European Union, policies to address waste issues are increasingly formulated by the European Commission and subsequently enacted by Member States. Council Directive 75/442/EEC (European Council, 1975)[1] urges the European Member States to

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[1] The Directive is amended by: Council Directive 91/156/EEC of 18 March 1991; Council Directive 91/692/EEC of 23 December 1991; Commission Decision 96/350/EC of 24 May 1996; Council Directive 96/59/EC of 16 September 1996; and Council Directive 2006/12/EC of 5 April 2006.

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take appropriate measures to encourage the prevention and the reduction of waste production and to ensure that waste is recovered or disposed of without endangering human health and without using processes or methods that could harm the environment or the resources of future generations. In order to realize these objectives, the obligation for Member States to draw up a waste management plan is mandated.

In the Flemish region of Belgium, the government implemented Council Directive 75/442/EEC (European Council, 1975) in the Waste Decree (Afvalstoffendecreet, 1981). The responsibility for prevention, recovery, collection and treatment rests with the municipalities. Local authorities decide on the terms of waste collection (Article 6, § 1 and 2, Afvalstoffendecreet, 1981). However, the regional government determined what type of waste has to be collected separately in Vlarea (2003). The OVAM, the Flemish competent waste authority, is responsible for drawing up sectoral waste management plans. The 'Implementation plan household waste 2003–2007' (OVAM, 2002) and the 'Implementation plan sustainable management' (OVAM, 2008) incorporate all European and regional requirements and describe strategies, goals, actions and instruments for the collection and treatment of household waste. The plan is binding to local authorities unless otherwise stated (Article 36, Afvalstoffendecreet, 1981). The central mandatory goal for Flemish municipalities was to reduce the amount of residual household waste to 150 kg per capita per year by 2007 (OVAM, 2002). The new Implementation plan wants to maintain the amount of residual household waste to 150 kg per capita per year between 2010 and 2015 (OVAM, 2008).

The implementation plan includes the provision of unique recycling services to suit the variety of residential conditions. In the literature, a reasonable body of information has been published on the effectiveness and efficiency of a variety of policy instruments, but the information is complex, often contradictory and difficult to interpret, giving significant problems to those responsible for developing waste strategies and policies (Martin et al., 2006).

According to Noehammer and Byer (1997) each local authority has to adapt to its own socio-economic conditions, so it is not possible to develop one waste collection system that could be adopted by all. There is no single, ideal design and the characteristics and needs of the community should dictate the scheme's design (Williams and Kelly, 2003). Also Tucker et al. (2000) state that the local context is important and that any successful change in the design of one scheme may not necessarily be replicable elsewhere. Shaw et al. (2006) on the contrary argue that regional differentiation may be less important than previously perceived. Their data show a similar pattern of recyclable materials occurrences in household waste across broad geographical and socio-demographic ranges. They conclude that given the apparent consistencies in material occurrence and recovery, the adoption and implementation of waste collection schemes that share common objectives (with respect to the range and quantities of materials that are recovered) are feasible. These broad similarities also offer considerable scope for performance enhancement through exchange of best practice, based on the cumulative experience of the waste management community.

The objective of this paper is to identify key factors in residual household waste minimization for the Flemish region of Belgium, using binary logistic regression. Reaching the mandatory goal of 150 kg residual household waste per capita per year is used as dependent variable. Independent variables that could explain a municipality's chance of reaching this goal are derived from literature. Findings from this case-study add to the knowledge of waste management policy instruments.

2. Background

Flanders is the northern region of Belgium, situated between the Netherlands and France, and bounded by the North Sea (see Fig. 1). It has 6.0 million inhabitants, with a population density of 444 inhabitants/km^2. It is subdivided in 308 municipalities (NIS, 2004). Through the 'Implementation plans household waste 2003–2007 and sustainable management 2010–2015', the Flemish Government directs environmental policy. However, the municipalities remain responsible for prevention, collection and treatment of household waste. This has resulted in a wide variety of policy approaches. The municipalities decide to some degree on fees, receptacles and type and frequency of collection. However, municipalities are encouraged to adhere to the objectives through instruments put forward in the implementation plan. The Flemish authorities subsidize municipalities who implement suggested instruments. Early adopters receive a significant subsidy. The level of subsidization then diminishes through the years.

The main objective of the 'Implementation plans household waste 2003–2007 and sustainable management 2010–2015' is to reduce and maintain residual household waste to 150 kg per capita per year. Residual household waste consists of mixed household waste collected through curbside collection, bulky household waste and municipal waste such as street-cleaning residues, waste from markets and illegal dumping (OVAM, 2002). To reach this objective, a variety of instruments are put forward. The 'polluter pays' principle is selected as the adequate economical instrument to reach this goal. A price of € 1.50 per bag of 60 l is recommended in order to encourage citizens to reduce the amount of residual waste and encourage recycling efforts. The option of recycling is made available through a curbside recycling program for several recyclables such as paper and cardboard, PMD (plastic bottles and flasks, metal packaging and drink cartons) and in some municipalities even organic waste, glass and other recyclables. Furthermore, each municipality has to have a drop-off facility. All of these activities are conducted to make it convenient for citizens to reduce waste through recycling.

Fig. 1. Map of Belgium. Flanders is the northern part.

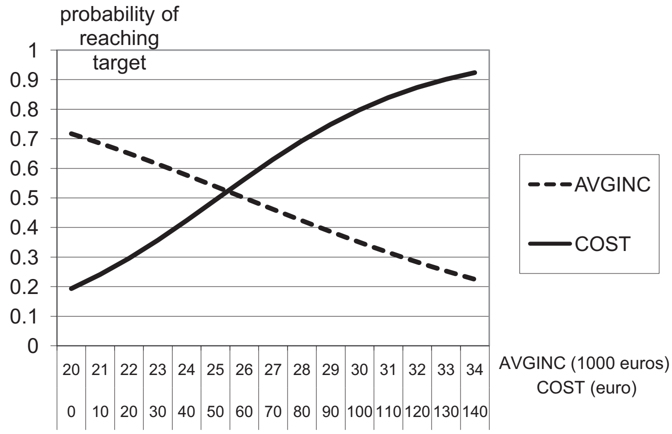

Fig. 2. Probabilities as a function of range for the variables average income and yearly cost of household waste collection. The range for the 2 parameters is the one from the database and the probability is set on 0.5 for the average value (for the data, see Appendix).

The policy mix instituted by the Flemish authorities is implemented in varying degrees by local authorities. This gives variability that makes it possible to assess which instruments have a significant impact on reaching the goal of reducing the amount of residual household waste to 150 kg per capita per year. Binary logistic regression will be used to determine the relevant variables.

3. Methodology

3.1. Data collection

The model contains 10 variables and 3 dummy variables. For each variable, data were gathered from the municipalities to set up the model in order to get insights in what factors contribute significantly to decrease the amount of residual waste to 150 kg per capita per year. In this way, the study differs from others, since the amount is a target set by the Flemish waste authority and the model will reveal those factors that will help to reach that target for the Flemish situation.

All 308 municipalities in the Flemish region were surveyed. For the data analysis, nine coastal municipalities were left out. Coastal tourism creates an extra amount of waste in a few months, which has a negative impact on the outcome of the model. The total amount of waste created does not reflect the amount of household waste originating from the native inhabitants. Specific actions such as a higher frequency of recycling collection during high season or specific receptacles for recyclables on camping sites are set up to tackle this problem (OVAM, 1998). Furthermore, three other municipalities were also excluded as outliers. Their amount of residual household waste/capita was more than three standard deviations higher than the mean value for all municipalities. Finally, another municipality did not fully participate so the necessary information could not be gathered. Consequently this municipality was left out. As a result 295 of the original 308 municipalities were included in the final analysis.

A structured questionnaire was compiled to obtain data on instituted pecuniary incentives and characteristics of waste management programs in place for 2003. Information was collected on the use of a flat rate fee, a pay-by-the-bag system or a weight-based fee, the type of residual waste and recyclable collection methods utilized both curbside and drop-off, the existence of composting programs and descriptive data on waste legislation. In a first step, data were gathered from municipalities' web sites and brochures on waste management. Then these data were verified and completed via telephone interviews with the competent public official of each municipality.

To control for municipality characteristics that can possibly influence waste generation, data on this matter were gathered through the National Institute of Statistics (NIS). Included variables were average income/capita, the area of a municipality per inhabitant and the number of companies.

In order to divide municipalities into a group that already reached the goal of 150 kg/capita residual household waste in 2003 and a group that did not, the amount of residual household waste/capita for 2003 for each municipality was obtained from the regional competent authority, namely OVAM.

3.2. Model specification

Following Pampel (2000) we find that each municipality has a probability of reaching the goal of 150 kg/capita residual household waste, defined as P_i. Several factors will influence the municipality's probability of reaching the goal, gathered in a vector X, so that

$$P_i = F(X, \beta)$$

The set of parameters β reflects the impact of changes in X on the municipality's probability of reaching the goal of 150 kg/capita residual household waste. Use of linear regression with a dichotomous dependent variable is inappropriate. The binary logistic or logit transformation is used because of its desirable properties and relative simplicity. The logit transformation begins by transforming probabilities P_i into odds, O_i. Probabilities vary between 0 and 1, and express the likelihood of an event as a proportion of both occurrences and non-occurrences. Odds express the likelihood of an occurrence relative to the likelihood of a non-occurrence, so that

$$O_i = P_i/(1-P_i) \text{implying that } P_i = O_i/(1+O_i)$$

Second, taking the natural logarithm of the odds, the logit equals

$$L_i = \ln[P_i/(1-P_i)] = b_o + b_1X_i$$

Expressing the probabilities rather than the logit as a function of X gives

$$P_i/(1-P_i) = e^{b_o+b_1X_i} = e^{b_o}*e^{b_1X_i}$$

Solving for P_i gives

$$P_i = \left(e^{b_o+b_1X_i}\right)\Big/\left(1+e^{b_o+b_1X_i}\right) = O_i/(1+O_i)$$

The details on the variables in the vector X are given in Table 1 and justified in the next section.

Only 5.8% of the investigated municipalities use a system of weight-based pricing for residual household waste collection. Most of the municipalities have a once-a-week collection of household waste and a separate collection of organic waste at the curbside (56.6% and 60% respectively).

3.3. Variables in the empirical logit model

Most of the variables included in the empirical model were chosen based on theory and/or evidence from previous studies. Some variables were, however, included based on a hypothesized relationship with the dependent variable. Weight-based pricing, frequency of collection and separate organic curbside collection are chosen as dummy variables due to the fact that these variables can

Table 1
Summary statistics of the regression variables.

Variable	Mean	Std. Deviation
MSW (1 ≤ 150 kg/capita/year, 0 ≥ 150 kg/capita/year	146.81	35.60
AVGINC: average income	26.30	3.31
AREA: area per capita	3258.44	2592.79
COMP: number of companies	473.68	956.43
FEE: flat user fee	65.68	26.38
COST: yearly cost of curbside collection	51.37	19.59
PERDIR: % of direct costs in total costs of waste management	.68	.23
CREC: number of waste fractions collected at the curbside	21.68	6.21
DOREC: number of waste fractions via drop-off recycling	7.19	1.12
CMASTER: number of compost masters per 1000 inhabitants	.43	.38
Dummy variable	0	1
WEIGHT: weight-based pricing	94.2%	5.8%
FREQ: frequency of collection	56.6%	43.4%
ORGANIC: separate curbside collection	40.0%	60.0%

only take on 2 values, whereas the others can have a range of values.

AVGINC refers to the average income per capita in € 1000. On a country level, increasing per capita income results in the generation of more solid waste (Porter, 2002). The same holds on a municipality level. In the UK however, waste growth appears to have started to diverge from GDP growth, though the reasons are not yet fully understood (Parfitt and Robb, 2009). According to Eurostat statistics the average income in Belgium increased with 23% between 1998 and 2005, on yearly basis from € 29 600 to € 36 700. Measured per capita, municipal waste generation increased during the same period from 530 to 547 kg, a rise of 3.1%. McFarland (1972) determined a small, positive income elasticity of demand for waste collection services of .178. Podolsky and Spiegel (1998) found the strongest relationship between waste quantities and income with an income elasticity of demand for waste collection services of .55. Other studies also found a positive but weaker relationship between income and waste. Throughout the literature, estimated income elasticity of demand for waste collection services include .279 and .272 (Wertz, 1976), .22 (Reschovsky and Stone, 1994), .242 (Richardson and Havlicek, 1978), .262 (Kinnaman and Fullerton, 1997), between .2 and .4 (Efaw and Lanen, 1979), and .41 (Jenkins, 1993). Results of Gellynck and Verhelst (2007) indicate that as the annual average income of people in a municipality increases by € 1 000, the residual household waste collected increases with 1.822 kg/capita. This gives an income elasticity of demand for waste collection services at the mean of the data for residual household waste collection services of .326. While the estimates for income elasticity of demand for waste collection services vary by a factor of almost four, all show waste collection services to be a normal good (Morris and Holthausen, 1994). However, Hong et al. (1993) estimated a positive but statistically insignificant relationship between waste and the wage rate, which can be considered as a proxy for income. Only Cargo (1976) found a negative correlation between waste generation and income.

Furthermore, the more affluent are more likely to be recyclers, be it through a curbside collection scheme or recycling centers (Belton et al., 1994; Domina and Koch, 2002; Gamba and Oskamp, 1994; Jakus et al., 1997; Martin et al., 2006; Oskamp et al., 1991; Perrin and Barton, 2001; Tucker et al., 1998; Vencatasawmy et al., 2000; Vining and Ebreo, 1990). As the more affluent recycle more and thus divert waste to the collection of recyclables, less residual household waste will be collected. However, the results concerning household income and recycling are ambiguous as other studies have not found a significant relationship between income and recycling (Derksen and Gartrell, 1993; Do Valle et al., 2004; McDonald and Ball, 1998; Scott, 1999).

AREA is the area per capita in km^2. Cargo (1976) found that waste generation is positively correlated with population and density. Also Johnstone and Labonne (2004) found that population density and (more ambiguously) the degree of urbanization have positive effects on household waste generation. Dijkgraaf and Gradus (2004) on the contrary found that area per inhabitant increases the waste stream.

COMP gives an indication of the number of companies in a municipality. Residual household waste comprises residual waste from small commercial and industrial activities that cannot be separated from residual household waste because of its small amount. We hypothesize that a municipality with a high number of companies, in particular SMEs, is likely to have a larger amount of residual waste because of this, although assimilated waste (residual waste from SMEs) is considered in a specific implementation plan and is collected and measured separately (OVAM, 2000).

FEE refers to a flat user fee to be paid by households for the collection and treatment of waste. If no flat user fee is due, the value will be 0. Traditional waste management systems charge residents a fixed annual fee for waste collection services. However, this system provides residents with no financial incentive to minimize the total amount of waste they produce. The cost of contributing one additional bag of residual waste to the household is zero, which suggests households will generate more waste than is socially desirable (Kinnaman, 2006). However, this fixed annual fee differs between municipalities and McFarland (1972) found an inelastic price elasticity in the demand for waste collection services based on differences in fixed fees of −.455.

COST measures the yearly cost of curbside residual household waste collection for a representative household in Euro. Economic literature devoted to designing waste management policies to achieve the efficient quantity of waste and recycling, argues that municipalities should charge according to marginal costs to maximize economic efficiency instead of charging a fixed annual fee (Porter, 2002). The most direct approach is to tax or charge each bag of waste presented by the household. In response to this fee, households could reduce the amount of waste they generate or divert some materials for recycling (Kinnaman, 2006). In practice, communities adopting some form of unit-pricing usually turn to average cost pricing that sets the unit-price equal to the average total cost per unit (Miranda et al., 1996). This is commonly implemented through a bag/tag program. It requires households either to purchase specific garbage bags, or purchase stickers or tags to affix on each of their own garbage containers or bags. Only garbage identified with the bag, sticker, or tag is collected. Results of studies that have estimated the change in disposal behavior by households facing unit-based pricing programs consistently estimated the demand for garbage collection services to be inelastic (Dijkgraaf and Gradus, 2004; Fullerton and Kinnaman, 1996; Hong, 1999; Jenkins, 1993; Kinnaman and Fullerton, 1997; McFarland, 1972; Miranda et al., 1994; Morris and Holthausen, 1994; Podolsky and Spiegel, 1998; Van Houtven and Morris, 1999; Wertz, 1976). However, Hong et al. (1993) found that a user fee does not appreciably affect the quantity of waste produced at the curb. Efaw and Lanen (1979) found a high inelastic price elasticity of demand for waste collection services, if not perhaps zero or even positive in sign. Pay-by-the-bag systems are likely to perform best when there is a comprehensive system in place for collection of segregated materials for recycling (OECD, 2004). Several studies attribute part of the effect of the introduction of a pay-by-the-bag system to accompanying recycling programs. Kinnaman and Fullerton (2000) developed a model of household behavior with empirical implications. Households are predicted to respond to an increase in the value of the user fee by decreasing the quantity of waste presented at the curb. They state that however the implementation of a municipal recycling program diverts some material from waste to recycling, it also frees up additional household resources for consumption, which may result in more waste. Gellynck and Verhelst (2007) found that as the yearly cost of curbside residual household waste collection increases by € 1, the waste collected decreases by .396 kg/capita. This gives a price elasticity of demand at the means of the data for waste collection services of −.139.

WEIGHT is a dummy variable that takes the value of 1 if weight-based pricing is used for residual household waste collection, 0 otherwise. In a weight-based system, garbage trucks are fitted with scales, and collectors weigh each household's garbage and bill that household accordingly. Weight-based fees represent more closely the cost of waste disposal than do volume-based fees, such as unit-pricing by the bag. They also provide a clearer and continuous pricing signal to household producers of waste. Volume based fees provide no additional waste reduction incentive below the lowest level of service, i.e. one bag or bin per collection round (Miranda et al., 1996). Fullerton and Kinnaman (1996) found that the implementation of a price-per-bag program leads to a slight decrease in the weight of waste, but the volume of waste, i.e. number of bags or cans, is characterized by a higher decrease. Efaw and Lanen (1979) called the observation 'stomping', the changes in user fees can be moderated by the household through volume reduction. Weight-based systems eliminate the incentive for households to reduce garbage collection expenses by compacting waste into fewer containers. This is not particularly helpful since most garbage trucks compact household waste anyway. The effects of weight pricing on disposal behavior are roughly equal to those of the bag/tag studies. Linderhof et al. (2001) found a price elasticity of demand for waste collection services of −1.10. Dijkgraaf and Gradus (2004) estimated the price elasticity of demand for waste collection services at −.47.

Some caution should be taken before comparing the elasticities across empirical studies. Some studies use household-level observations before and after the implementation of a curbside charge, and estimate an arc-elasticity. Other studies utilize a cross-section of municipality-level data and derive point elasticities using the mean price and garbage quantity, which can vary across data sets (Kinnaman, 2006).

PERDIR indicates the percentage of direct costs in total costs of the waste management program for a representative household. Direct costs can be directly attributed to the waste services provided, i.e. a fixed annual fee, if any, the costs associated with curbside collection of waste or recyclables and costs of dropping of recyclables at a drop-off center. Indirect costs are other general municipal taxes paid by households with no direct link to waste collection. Indirect taxes are used to cover municipal expenses not covered by direct taxes. Gellynck and Verhelst (2007) found that as the percentage of direct costs increases, the waste collected decreases by .159 kg/capita.

CREC is the number of waste fractions collected through the curbside recycling program, whereas DOREC gives the number of fractions collected through drop-off recycling. These collected fractions differ between municipalities. For instance glass is not collected through a curbside recycling program in every municipality. Households may recycle more materials that are included in local collection programs. Any increase in recycling presumes that this option is available and that residents find it more convenient than disposing waste through various illegal or undesirable means (Fullerton and Kinnaman, 1996). Noehammer and Byer (1997) found that the range of materials collected is an important design variable of a curbside recycling-scheme. The amount of effort, time and storage space demanded from the householder for recycling will increase with the degree of sorting and preparation of materials prescribed by the scheme. Participation is higher with binary sorting or commingled collection, i.e. separation of recyclables from non-recyclables, than multi-sorting or segregated collection, i.e. separating different recyclables (Bruvoll et al., 2002; Chung and Poon, 1994; Noehammer and Byer, 1997; Oskamp et al., 1996; Thomas, 2001). However, Shaw et al. (2006) found that the success of curbside recycling is not necessarily directly related to the range of materials collected. Furthermore, Harder et al. (2006) and Woodard et al. (2006) found that the participation rate is higher in schemes that collected more types of materials. When only one material is included in the curbside scheme, the emphasis of the whole collection system is still on waste collection. When more materials are incorporated into the collection of recyclables, the population may shift their perception of the process from one of waste collection with a limited recycling service to a system dominated by recycling with minimal actual 'residual waste' (Woodard et al., 2006).

FREQ is the frequency of collection service. It has the value of 1 if mixed household waste collection is once-a-week, 0 if waste collection is every other week. Early work focused on the effect of collection frequency on the overall amount of waste collected. Wertz (1976) found that the frequency of service could influence the amount of waste collected. On the contrary, Kemper and Quigley (1976) found no significant relationship between the number of collection visits per year and the annual quantity of waste discarded. More recent research focuses on the effect of collection frequency on the recovery of recyclables. Findings point to a gain in recovery when the collection frequency of recyclables is increased (Everett and Peirce, 1993; Noehammer and Byer, 1997; Platt et al., 1991). However, reducing the collection frequency does not necessarily have a huge impact upon recovery (Tucker et al., 2000; Woodard et al., 2001). Nevertheless, some authorities are moving toward a kind of recycling dominated system by reducing the frequency of collection of residual waste to every other week, while also increasing the frequency and range of recyclable materials collected, so that the public perceives collection of the recyclable fraction as being the main element of the system (Woodard et al., 2006). Gellynck and Verhelst (2007) found a significant impact from differences in the number of collection visits. A weekly collection of residual household waste yields higher amounts of waste than an every other week collection round.

ORGANIC is another dummy variable that will take the value of 1 if separate curbside collection of organic waste is in place, 0 otherwise. What would induce a household to generate or throw away less waste (source reduction) hinges on at least two elements: the incentive built into the unit-pricing structure for waste collection and disposal, and the availability of convenient (and legal) alternatives such as recycling and yard waste collection or composting programs (Folz and Giles, 2002). One of the major components of household waste is organic material such as kitchen and garden waste, typically comprising 43% by weight of an average household's waste in Flanders (OVAM, 2002) and may include vegetables, fruit, cooked and processed foods, weeds, grass, leafs and other garden waste. Gellynck and Verhelst (2007) show that the implementation of a curbside collection program for organic waste has a significant negative impact on the average amount of residual waste generated.

CMASTER measures the number of compost masters per 1000 inhabitants. Compost masters are volunteers that completed a course on composting and are willing to train other people in proper composting methods. Reschovsky and Stone (1994) state that an incentive to participate in composting yard and food waste is likely to generate substantial savings for a locality. One approach that can be adopted by local authorities is to minimize the kitchen and garden waste components of household waste entering the collection stream, through the provision of subsidized waste digesters or compost bins to residents. Home composting has the potential to make a significant contribution to household waste minimization (Bench et al., 2005).

4. Results

About 53% of the municipalities had reached the goal of 150 kg/capita residual household waste in 2003. The amount of residual household waste collected ranged from 67.9 to 259.7 kg per capita. The results of the empirical model characterizing a municipality's probability of reaching the goal are given in Table 2.

The overall model is statistically significant with χ^2 being 65.558, significant at the .001 level. Correct classification of municipalities as either reaching or not reaching the goal of 150 kg/capita residual household waste based on the explanatory variable information is an important measure of goodness-of-fit. The model correctly classified 219 of 295, or 74% of the municipalities. Four out of the 12 initial independent variables in the model contributed significantly to the classification.

An increase of AVGINC by € 1000 per household per annum lowers the logged odds of reaching the goal by .155. This means that odds are reduced by a multiple of .856 or by 14.4%. Consequently the probability of reaching the goal of 150 kg/capita residual household waste is reduced by 3.9%.

An increase in COST by € 1 raises the logged odds of reaching the goal by .028. Odds then increase by a multiple of 1.028 or by 2.8%. As a consequence the probability of reaching the goal increases by .7%.

In Fig. 1, the probabilities are shown as a function of range for the variables COST and AVGINC.

The odds of reaching the goal are 67.8% lower for municipalities with a weekly collection of residual household waste than for municipalities with an every other week collection. At the sample mean, municipalities with a weekly collection of residual household waste have a 26% less probability of reaching the goal than municipalities with an every other week collection. Hence, a weekly collection of waste yields higher amounts of waste than an every other week collection.

Odds are 579% higher for municipalities with a separate curbside collection of organic waste than municipalities that do not collect organic waste separately at the curb. At the sample mean, municipalities with a separate curbside organic waste collection have a 37% higher probability of reaching the goal than municipalities that do not collect organic waste separately at the curb.

Calculation of standardized coefficients following Menard (1995) and Long (1997) indicates that the implementation of separate curbside collection of organic waste has the strongest influence on reaching the goal of 150 kg/capita residual household waste. The frequency of collection of residual household waste, the yearly cost of curbside residual household waste collection and the average income per capita have a less strong but fairly equal impact on whether the goal of 150 kg/capita residual household waste is reached (see Table 3).

Table 2
Factors affecting a municipality's probability of reaching 150 kg per capita per year. Average income, yearly cost of curbside collection, frequency of collection and separate curbside collection of organic waste contribute significantly to the classification (Sign. < 0.05).

Variables	Parameter estimate bi	Standard error	Sign.	O_i
Area	.000	.000	.389	1.000
Average income	−.155	.051	.002	.856
Number of companies	.000	.000	.250	1.000
Flat user fee	.005	.006	.419	1.005
Cost of curbside collection	.028	.010	.006	1.028
% of direct costs in total costs of waste management	−.093	.994	.925	.911
Drop-off recycling	−.005	.024	.828	.995
Fractions collected at the curbside	−.102	.138	.459	.903
Frequency	−1.132	.331	.001	.322
Weight	.877	1.084	.419	2.402
Organic: separate collection	1.916	.398	.000	6.791
Compost master	−.095	.280	.733	.909
Constant	2.824	1.858	.129	16.839
$\chi^2 = 65.588$			.000	

5. Discussion

Increasing per capita income results in the generation of more solid waste. This result supports with earlier findings on country level (Porter, 2002) or on municipal level (Efaw and Lanen, 1979; Gellynck and Verhelst, 2007; Jenkins, 1993; Kinnaman and Fullerton, 1997; McFarland, 1972; Podolsky and Spiegel, 1998; Reschovsky and Stone, 1994; Richardson and Havlicek, 1978; Wertz, 1976).

Economic literature on waste management illustrates the effectiveness in reducing the amount of residual household waste of 'pecuniary incentives', evolving from a fixed annual fee (McFarland, 1972) over unit-pricing by the bag (Fullerton and Kinnaman, 1996) to weight-based fees (Miranda et al., 1996). As Gellynck and Verhelst (2007) found for this case using multiple linear regression, there is no significant influence from a fixed annual fee, nor from the implementation of a weight-based fee. Analysis of this case using binary logistic regression supports the conclusion that the implementation of a pay-by-the-bag system has a significant influence on the amount of residual household waste collected and is a useful instrument in helping municipalities to reach the goal of reducing this amount to 150 kg per capita per year. However it is worth noting that the model applies to 2003. When using a pay-by-the-bag system, citizens have more incentives to produce less waste. However Sterner and Bartelings (1999) report on a weight-based billing system in Sweden, states that average waste per household had declined by 35%.

Municipalities with a weekly collection of residual household waste have a lower probability of reaching the goal of 150 kg per capita per year. This is in line with findings of Wertz (1976), Platt et al. (1991), Everett and Peirce (1993) and Gellynck and Verhelst (2007). The result is explained intuitively because compared to recycling, throwing away waste as residual household waste is less time and space consuming. Furthermore, a higher frequency of collection prevents other negative side effects, as there are foul odors, problems with rodents and other pests as well as a lack of space.

Municipalities with a separate curbside organic waste collection have a higher probability of reaching the goal of 150 kg per capita per year. As the organic waste fraction, both yard waste and waste from fruit and vegetables, makes up nearly 40% of the total

Table 3
Standardized coefficients for the significant independent variables. The implementation of separate curbside collection of organic waste has the strongest influence. The other 3 variables have a fairly equal impact on reaching the goal.

	b	B*Menard	B*Long
AVGINC	−.155	−.391	−.521
COST	.028	.418	.557
FREQ	−1.132	−.428	−.570
ORGANIC	1.916	0.718	.957

municipal solid waste weight in Flanders (OVAM, 2002), this finding is reasonable.

As was found by Gellynck and Verhelst (2007) for this case using multiple linear regression, there is no significant influence from the area per capita, the number of companies in a municipality, the number of compost masters per 1000 inhabitants, the number of waste fractions collected through the curbside recycling program nor through drop-off recycling.

However, Gellynck and Verhelst (2007) found that the percentage of direct costs to total costs of the waste management program for a representative household has a significant influence on the amount of residual waste collected, concluding that the 'polluter pays' principle is an effective instrument in reducing the amount of residual household waste. However its effect does not significantly impact a municipality's probability of reaching the goal of 150 kg/capita residual household waste. This may indicate that the implementation of the 'polluter pays' principle beyond residual household waste can have some influence on the amount of residual household waste collected but is not sufficiently strong to substantially reduce the amount of waste. It is an instrument better suited to fine tune the waste management policy.

The implementation of a pay-by-the-bag system and separate curbside collection of organic waste, together with bringing back the frequency of mixed household waste collection to an every other week collection proofs to be a good policy mix to gain substantial reductions in the amount of mixed household solid waste collected and consequently raising a municipality's probability of reaching the goal of 150 kg/capita mixed household solid waste.

Furthermore the model reveals that residual waste amounts will further decrease when municipalities install a high recycling program: the more fractions are collected at the curbside, the less waste will end up in the residual waste bags. In revealing the influence of source prevention the model could contain another dummy variable: a certain amount per year could be set as a standard for prevention campaigns in municipalities (e.g. € 10 000). Municipalities with a lower budget take on the value of 0, those with a higher budget the value of 1.

In considering further developments, the model could contain the following independent variables: communications and public engagement activities by municipalities and behavioral variables – e.g. the level of participation in recycling collections or using a home compost bin. Furthermore, it is worth considering in future research to adapt the model in order to accommodate different types of dependent variables (e.g. a different mandatory level of residual waste).

6. Conclusions

Using binary logistic regression, key factors in residual household waste minimization for the Flemish region of Belgium were identified. Reaching the mandatory goal of 150 kg residual household waste per year per capita was used as dependent variable. Independent variables that could explain a municipality's chance of reaching this goal were derived from the literature.

The model correctly classified 74% of the municipalities. Four out of 12 variables in the model contributed significantly. Higher per capita income lowers a municipality's chance of reaching the goal. An increase in the cost of residual waste collection, changing from weekly to an every other week residual waste collection and introducing separate curbside collection of organic waste increase a municipality's chance of reaching the goal. We conclude that binary logistic regression is an appropriate tool for identifying key factors in a waste management plan. The implementation of separate curbside collection of organic waste has the strongest influence. This is not surprising as the organic waste fraction, both yard waste and waste from fruit and vegetables, makes up about 40% of total municipal waste weight in Flanders (OVAM, 2002). Frequency of residual household waste collection, yearly cost of curbside residual household waste collection and the average income per capita have a fairly equal impact.

Using multiple regression analysis, Gellynck and Verhelst (2007) found that the percentage of direct costs to total costs of the waste management program has a significant impact. This finding was not supported using binary logistic regression. This variable captures also pay-as-you-throw policies for recyclables. Future research could focus on this particular aspect of the waste management policy as the effect of introducing the 'polluter pays' principle for recyclables is not well understood and the results using the percentage of direct costing as a proxy are ambiguous. Furthermore, a specific policy mix for areas with tourist visitors should be assessed.

Appendix. (Fig. 2).

COST	AVGINC		P_i (COST)		P_i (AVGINC)
0	20	−1.428	0.19341	0.93	0.717075
10	21	−1.148	0.240855	0.775	0.684602
20	22	−0.868	0.295671	0.62	0.650219
30	23	−0.588	0.357094	0.465	0.6142
40	24	−0.308	0.423603	0.31	0.576885
50	25	−0.028	0.493	0.155	0.538673
60	26	0.252	0.562669	0	0.5
70	27	0.532	0.629949	−0.155	0.461327
80	28	0.812	0.692536	−0.31	0.423115
90	29	1.092	0.748758	−0.465	0.3858
100	30	1.372	0.797703	−0.62	0.349781
110	31	1.652	0.839161	−0.775	0.315398
120	32	1.932	0.873471	−0.93	0.282925
130	33	2.212	0.901322	−1.085	0.252561
140	34	2.492	0.923579	−1.24	0.224436

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