Weight-Based Pricing in the Collection of Household Waste: the Oostzaan Case

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Abstract

This paper provides an empirical analysis of the effects of weight-based pricing in the collection of household waste. Using a comprehensive panel data set on all households in a Dutch municipality we estimate short-run as well as long-run price effects for the amounts of both compostable and non-recyclable household waste. We find significant and sizeable price effects, with the elasticity for compostable waste being four times as large as the elasticity for non-recyclable waste. Long-run elasticities are about thirty percent larger than short-run elasticities.

JEL-classification: D12, Q20.
*Keywords:*Weight-based pricing; household waste; short-run and long-run elasticities.

1 Introduction

The most common way to charge households for waste collection is the fixed fees ("flat-rate") schedule. Clearly, such a pricing scheme hardly provides an incentive to reduce the generation of waste. Whether or not the fee depends on household size or other household characteristics, the household faces no extra costs when it generates an extra amount of waste. With unit-based pricing programs, on the other hand, the household is rewarded financially for waste reduction.

The present paper analyzes a comprehensive data set on households that faced weight-based pricing. We estimate price effects as well as the effects of household characteristics on the amounts of both compostable and non-recyclable household waste. The data set provides detailed information on all households in Oostzaan, the first municipality in The Netherlands to implement weight-based pricing. In the first year after the introduction the amount of waste per household declined by 30 percent. The decline continued in the second year, and then seemed to stabilize in the third year after the introduction.

The Oostzaan case has a number of advantages over earlier studies. First, it is weight-based rather than volume-based. In their analysis of a volume-based pricing program Fullerton and Kinnaman (1996) found that the program had a substantial effect on the volume but little effect on the weight of waste – the weight per bag increased considerably. They argued that a weight-based pricing program is likely to be more effective.[1] Secondly, the data are based on actual waste generation rather than on self-reported questionnaires. Thirdly, we have high-frequency (weekly) data on the weight of two types of waste, compostable and non-recyclable waste. Fourthly, with data on 4,080 addresses, the present survey is much larger than the surveys used before. As the entire population of Oostzaan was included, the data set does not suffer from self-selection bias. Fifthly, the survey has a panel structure in which the addresses are observed for a period of 42 months. This allows us not only to analyze the effects of household characteristics on the amounts of waste, but also to take account of unobserved individual effects. Moreover, with this type of data we can estimate short-run as well as long-run price elasticities. [2]

The paper proceeds as follows. Section 2 summarizes the literature on unit-based pricing programs in the collection of household waste. In section 3, the Oostzaan case and the data set are described. Section 4 presents the econometric specification and the estimation results. In section 5 some topics related to weight-based pricing in Oostzaan - illegal dumping, recycling, and

[1] In some cases a policy aimed at reducing volume rather than weight may be more appropriate, for example if after collection waste is dumped on landfill sites; see *e.g. The Economist*, June 7th 1997, p.92 and June 28th 1997, p.4. In the Netherlands, however, storing waste on landfills is prohibited since 1996. Non-recyclable household waste is now incinerated after collection, in which case weight is the more relevant dimension.

[2] Some earlier papers share some of the advantages mentioned, but no paper shares all of them. In particular, we believe this is the first paper to estimate short-run as well as long-run price elasticities for unit based pricing of household waste collection.

implementation costs - are discussed. Section 6 concludes.

2 Literature

The economic literature on household waste collection can be divided into two classes. The first class of articles – mainly empirical – focuses on consumer response to various pricing schemes (subsection 2.1). The second class – mainly theoretical – uses more comprehensive models in which the behavior of governments, firms, and consumers are analyzed simultaneously (subsection 2.2).

2.1 Consumer behavior and household waste

There exits a large empirical literature on unit-based – mostly volume-based – pricing. For a recent review see Kinnaman and Fullerton (1999). Here we confine ourselves to some articles which have used individual household data. Hong *et. al* (1993) analyzed a particular form of volume-based pricing using a survey of 2,298 households from Portland, Oregon, United States. Households signed a contract with the collector on a maximum number of containers to present per month. Up to this maximum, households pay $12 per container, but for an extra container, households pay $24. Since price depends on quantity, the price per container is endogenous. Hong *et al.* estimated the demand for containers contracted, correcting for the endogeneity of the price, and the participation in recycling activities. They found small responses with respect to changes in prices and income (see also table 1). Rechovsky and Stone (1994) surveyed 1,422 households around Ithaca, New York, who faced a variety of volume-based pricing and recycling rules. The probability of recycling each type of material was estimated as a function of these rules and of demographic characteristics. The authors concluded that curbside pickup of recyclable materials alone would increase recycling more than the implementation of volume-based pricing would do. Both papers used cross sections only. The data of Fullerton and Kinnaman (1996), who analyzed the effects of introducing a price per bag in Charlottesville, Virginia, United States, were collected at two different points in time. Their survey consisted of 75 households which were observed twice for a period of two weeks. The first period of observation was before the new pricing was introduced, while the second period was three months after implementation. The results showed that the volume declined by 37% and the weight by 14%, while the weight-volume intensity increased by 31.7%. Moreover, the weight of recyclable materials increased by 15.7%. Their estimated price elasticity of the amount of household waste measured in kilograms was rather small, -0.058.

Another paper related to the present one is Sterner and Bartelings (1999) who analyzed a weight-based pricing program in a Swedish municipality. However, these authors were unable to estimate price effects due to a lack of price variation (their data did not cover the period before weight-based billing was introduced).

Table 1 reviews some of the elasticities found in earlier studies.

2.2 The economics of household waste management

The second class of articles analyze more comprehensive models of household waste management (for instance, see Jenkins (1991), Sigman (1991), Fullerton and Kinnaman (1995), Kinnaman and Fullerton (1997), Choe and Fraser (1999), and Atri and Schellberg (1995)). Jenkins (1991) and Sigman (1991), for instance, built a theoretical general equilibrium model to determine the optimal fees for household waste collection. The consumers in their models had two disposal options, garbage or recycling. The optimal (positive) fees for households waste collection equal the direct resource costs plus external environmental costs. In Fullerton and Kinnaman's (1995) model consumer have additional disposal options: illicit burning and dumping. The external environmental costs of these options are relatively high as compared with the other options, and it cannot be taxed directly. Fullerton and Kinnaman concluded that with these additional disposal options, the optimal fee structure is a deposit-refund system: a tax on all output combined with a rebate on proper disposal through either recycling or waste collection. In particular, household waste collection should be subsidized in order to prevent illicit burning and dumping which imply high external environmental cost. Similar results were obtained by Atri and Schellberg (1995) using a dynamic general equilibrium model.

An alternative policy instrument for waste management, the 'recycled contents standard', was analyzed by Palmer and Walls (1997). Such a standard requires a certain fraction of the materials used in the production of goods to be recyclable. Palmer and Walls concluded that this policy measure alone cannot lead to an optimal allocation of waste disposal and should be combined with taxes on the final output and other inputs. Choe and Fraser (1998) considered a model in which three agents interact: a firm, a household and a regulator. Four different types of waste are considered. The optimal policy combines an environmental tax, a household waste collection charge, and monitoring and fining illegal waste disposal.

In all of these models, the price sensitivity of household demand for waste collection is a key parameter.

The present paper fits into the first class of articles, and analyzes household behavior conditional on the institutional setting. We note that the potential endogeneity of choosing the weight-based pricing policy is not an issue here. Oostzaan was the first of all 600 Dutch municipalities to implement such a program. The pioneering role of Oostzaan is related to its exceptional position in the political spectrum; see footnote 3.

3 The Oostzaan case

Oostzaan is a countryside village situated 15 kilometers North from Amsterdam.[3] In 1992 the city council agreed to introduce weight-based pricing.[4] The program was implemented in October 1993. As from July 1993, however, household waste was weighed when collected and households received a *pro forma* bill with the virtual amount representing the expenses of collecting their current amount of household waste. During the period July to September 1993, households still paid fixed charges, as they did prior to July 1993.

It is important to understand how the waste collection in Oostzaan is organized. The weight-based pricing only applies to the curbside collection of waste. Two types of waste are collected separately: compostable waste (GFT) and non-recyclable (or solid) waste (which is also referred to as rest waste, RST).[5] For each type of waste each household has a separate container. About 7 percent of the households, however, share a GFT container

[3] In 1996, the municipality counted 3,309 households. Approximately 10 percent of the dwelling stock are apartment buildings, while more than 80 percent of the dwellings have a garden.

[4] The largest political party in Oostzaan is *Groen Links* (Green Left), which is the most environmentally orientated political party in the Netherlands. Nationwide, *Groen Links* received only 3.5 percent of the votes in the parliamentary elections of 1994.

[5] Compostable waste includes organic waste and yard waste. It is usually called GFT, which is the Dutch abbreviation for vegetables, fruit and yard waste. In The Netherlands, weight-based pricing is generally referred to as DIFTAR.

with one or more other households.

Households have the opportunity to dispose recyclable materials, small chemical waste and large volume units differently.[6] For instance, large volume units of waste, not fitting in the container, can be collected after making an appointment with the municipality. This collection is not free of charges. For recyclable paper there is a free curbside collection program organized by local associations, such as sports clubs. This paper program existed already before the introduction of weight-based pricing.[7] A number of recyclable materials, such as glass, small chemical waste, textiles and tins can be hauled to special containers, placed at various locations in the municipality. The use of these containers is free of charge (apart from the time input that is required). Furthermore, the municipality stimulates home composting by subsidizing the purchase of home compost containers.

The municipality has contracted a private company for the collection of household waste.[8] During the period of the survey, the company used one single truck with a weighing appliance for collection. [9] All waste containers have a chip containing a unique code which identifies a particular address. During the collection, the contents of the container is weighed and the chip is read, and both are registered by a computer. With this information the municipality can charge households.[10]

[6]There are no laws in Oostzaan that mandate recycling.

[7]With this activity these clubs earn some extra money. The local authority subsidizes the collection of paper by covering the expenses of collection and by an extra amount of 5 cents per kilogram of recyclable paper collected.

[8]Browning-Ferris Industries (BFI), a company for waste collection that operates worldwide.

[9]The weighing appliance has been calibrated by the Netherlands Institute for Metrology and Technology (NMI).

[10]The joint GFT containers also have a unique chip code. This code is the same for all households using the joint GFT container.

The weight-based pricing schedule

Before October 1993, the marginal prices for compostable and non-recyclable waste were zero, as households paid only fixed charges. From October 1993, the nominal price was 43 cents per kg. The fixed fees were reduced simultaneouly from approximately 25 to 10 guilders per household per month. On January 1, 1995, the marginal price per kg. was decreased to 41 cents. Households that share a GFT container with other households have a zero marginal price for their GFT waste, but they have to pay extra fixed charges. The price for large volume units was constant: 15 guilders per cubic meter.[11]

The data

The Oostzaan survey consists of three parts: a survey on the demographic characteristics of households, the weighing data on GFT, and the weighing data on RST. The demographic survey consists of 4,080 addresses. It includes variables on household composition, mutations in household composition, moves of households[12], the type of dwelling, and container chip numbers. It comprises the period July 1993 to September 1997. The data on household composition and the mutations in household composition during the sample period have been obtained from the Population Register of Oostzaan. Both types of weighing data are registered during the collection of household waste in the period July 1993 to December 1996. Due to the weighing process, measurement errors are likely to be negligible.

[11] The municipality can be regarded as a non-profit organization with a cost minimizing objective. The main reason for the city council to adjust prices is to avoid either uncovered expenses or positive profits.

[12] We do not have information on the places households move to. In particular, if a household moves within Oostzaan we do not know the new address. All households that move to an address in Oostzaan during the sample period are therefore treated as new households.

For the analysis, 1,167 addresses have been dropped, mainly for the following reasons. First, some addresses are not used as living accommodations. Secondly, in a number of cases the correct household size could not be reconstructed with the available information. Thirdly, since we aim to estimate the demand equations including individual effects, we restrict our sample to households with at least two periods of observation. The resulting address sample consists of 2,913 different addresses. Due to moves of households, we often observe more than one household at the same address during the period July 1993 to December 1996. As a result, we have data on 3,459 different households.

The number of periods a household is observed varies between 2 and 42, with an average of 37 observations per household. We thus have an unbalanced panel. The total number of observations $\sum_{i=1}^{N} T_i = 127,851$, where $i = 1, \ldots N$ refers to the households and T_i is the number of observations on household i. Table 2 shows summary statistics for the final sample. Table 3 shows the development of the average amounts per household for nine different types of waste.

The next section provides a detailed econometric analysis of the data.

4 Econometric analysis

We will estimate reduced-form demand equations for waste collection. The approach largely follows Fullerton and Kinnaman (1994) and Fullerton and Kinnaman (1996), with two major differences. First, we distinguish between compostable waste (GFT) and non-recyclable waste (RST), and estimate separate equations for each type. Secondly, we consider a much longer period of time with repeated observations on each household. This allows us to distinguish between short-run and long-run price effects by including lagged quantity as a right hand side variable. We specifiy

$$q_{it} = \alpha_{0i} + \alpha_1 Z_t + \beta P_{it} + \gamma(y_{it} - F_{it}) + \delta' X_{it} + \phi q_{it-1} + \epsilon_{it}. \qquad (1)$$

Here q_{it} is the weight of the waste collected for household i in period t; P_{it} and F_{it} are the marginal price and the fixed charges, respectively, and y_{it} is household income. Z_t are variables which vary over time but not across households and X_{it} is a vector of household characteristics. ϵ_{it} is an error term; $\alpha_{0i}, \alpha_1, \beta, \gamma, \delta$, and ϕ are parameters to be estimated.

Some remarks on econometric issues are in order. First, the data set does not contain direct information on household income. Therefore, the term $\gamma(y_{it} - F_{it})$ is absorbed in the household and time specific terms $\alpha_i + \epsilon_{it}$.[13] Secondly, the availability of panel data allows us to include a household specific constant term. Hausman specification tests indicated strong rejection of the random effects specification. We therefore present the results for the fixed effects estimator. Thirdly, the inclusion of a lagged dependent variable generally induces a bias in the estimates. However, since we use up to 42 observations per household, the bias will be small; see Hsiao (1986, pp. 74-75). Finally, note that we cannot include explanatory variables which show no variation over time for all households (such as the type of dwelling) as the effect is absorbed in the individual effects. Estimation results are in Table 4. For comparison, we also report the results with $\phi = 0$ imposed.

We focus on the specification with the lagged dependent variable in-

[13]Theoretically, the parameter γ could be estimated on the basis of variation in the fixed fees F_{it} alone. However, this turned out not to be feasible due to the very high negative correlation between the marginal price P_{it} and the fixed fee F_{it} in the data. Using an entirely different data set – a macro time series of annual data on household waste in kilograms and disposable income per capita in The Netherlands, 1960-1996 – we estimated an income elasticity of 0.60 (t-value: 9.1).

cluded, which turns out highly significant and equals about 0.2 in both cases. The marginal price coefficients are -0.329 and -0.135 for compostable waste and non-recyclable waste, respectively. The t-values are unusually high but in line with the very large number of observations.

The implied short-run and long-run elasticities evaluated at the sample mean are

	GFT	RST
Short-run	-1.10	-0.26
Long-run	-1.39	-0.34

Thus we find that the price response for compostable waste (GFT) is much larger than the response for non-recyclable waste (RST). This is likely to be related to the fact that for compostable waste an alternative for curbside collection – home waste composting – is more easily available than for non-recyclable waste. Moreover, we find that for both types of waste long-run elasticities exceed (in absolute value) their short-run counterparts by about 30 percent. This is an important result as it indicates that the effects of weight-based pricing will sustain in future periods.

In the years 1994, 1995, and 1996 the amounts of waste were significantly lower than before. Note that these effects are additional to the price effects, as price has been included as an explanatory variable. The decrease seems to be permanent for GFT, for RST the decrease dissipated in recent years. One possible explanation is that the introduction of weight-based pricing and the extensive public debate that preceded it temporarily boosted environmental awareness in Oostzaan. A permanent effect may have been that GFT is now home composted rather that put on the curbside.[14] Another ex-

[14] As noted before, the purchase of a home compost container was subsidized by the

planation is that RST waste is likely to be much more sensitive to increases in household income than GFT waste (average disposable income increased by approximately 8 percent during the sample period). The amount of GFT is primarily determined by the garden area of the household (which does not change for a given address), and by the amount of food, a necessary good with a low income elasticity.

A two person household produces 2.0 kg more GFT waste and 1.6 kg more RST waste than a single-person household. The share of women in the household significantly increases the amount of RST waste produced. This is probably related to the relatively low labor force participation rate of women in The Netherlands: women are at home much more than are men. An additional infant increases the amount of RST waste by more than 2 kg per month. Apparently, even in Oostzaan with an above average environmental concern, cloth diapers have not fully replaced disposable diapers. The temperature has a positive effect on the amount of GFT waste presented, probably reflecting increased yard maintenance. The third quarter shows negative effects for both types of waste, which is likely to be a holiday effect; the third quarter includes the summer school holidays.

5 Illegal dumping, recycling, and costs

The results of the previous section showed that the implementation of the weight-based pricing program in Oostzaan had a strong effect on the amount of waste presented for collection. The methods used by households to bring about the reduction include choosing products with less packaging when

municipality. However, this subsidy already existed long before the introduction of weight-based pricing, so that the subsidy cannot explain the decrease in GFT waste.

shopping, using permanent shopping bags rather than plastic bags, using cotton diapers or diaper services rather than using disposable diapers, drying-up disposable diapers before putting them into the waste bin, composting, and bringing glass, paper, textiles, and tins to the special containers (PME Consultancy, 1994).

In addition, the program may have triggered adverse behavioral effects. In Oostzaan these effects have been thoroughly investigated (PME Consultancy, 1994). About 4 to 5 percent of the waste is brought to neighbouring municipalities, to employers, or to relatives and friends who live in municipalities without weight-based pricing (for comparison: in the first year after the introduction of weight-based pricing the amount of waste collected by the municipality decreased by about 30 percent). The municipality provides households opportunities to report any misconduct of waste littering or illegal dumping. All the reported misconducts are checked by controllers from the municipality. In many cases the infringing household is traced by investigating the contents of the waste bag littered. The household then has to pay for the waste collection and is fined as well. This system of monitoring and fining illegal dumping appears to be very effective in terms of deterrence: Illegal dumping is virtually non-existent. Sewage samples did not show any evidence of illegal waste dumping.

Fullerton and Kinnaman (1996) found that the recyclable materials increased with 15 percent due to the introduction of a price per container. Although information on the amounts of recyclable waste is not available on a household level, we do have the aggregate amounts for the municipality of Oostzaan; see table 3. There was a large increase for glass (36 percent) and tins (600 percent). Recall that the separate curbside collection program for paper already existed before the introduction of weight-based pricing. Also note that the collection of large volume units and refrigerators is not free of charge.

An important policy issue regarding the implementation of a weight-based pricing program is how its cost compare to the costs of a traditional fixed fees pricing program. For Oostzaan this issue has been investigated in depth as well; see table 5. The table reveals that the net costs of waste collection and processing did not increase as a result of the new system: The increased costs for collection, control and administration were compensated by the reduction in processing costs resulting from the lower total amount of waste. Note that table 5 only considers direct monetary costs and benefits.

6 Conclusion

In this paper we found that in the Oostzaan case weight-based pricing has a strong effect on the amount of waste presented for collection. For compostable and non-recyclable waste we found short-run price elasticities of -1.10 and -0.26, respectively. Long-run price elasticities are about 30 percent larger for both types of waste, suggesting that the effects of weight-based pricing are permanent. The elasticities found here are larger than those in earlier studies on volume-based pricing. The amounts of some of the recyclable materials that can be dropped off free of charge increased substantially. In the Oostzaan case, weight-based pricing appears to be cost effective. The problem of illegal dumping is small, due to an effective monitoring and fining system.

Of course one can question how representative Oostzaan is to the rest of the country, continent, or world. As suggested by the policital affiliation of Oostzaan, its citizens seem to be more than average environmentally conscious. This may partly explain the success of the program. On the other hand, environmentally conscious individuals could be expected to produce relatively small amounts of garbage and recycle large amounts in the absence of a fee, leaving little room for additional garbage reduction or recycling once weight-based pricing was implemented. This, however, would only serve to underestimate the impact of weight-based pricing.

Practical problems limit the implementation of weight-based pricing to communities with a certain degree of social control and a relatively small number of apartment buildings. However, there many such municipalities in The Netherlands and elsewhere.

References

Atri, S. and T. Schellberg (1995): "Efficient Management of Household Waste: a General Equilibrium Model", *Public Finance Quarterly*, 23, pp.3-39.

Choe, C. and I. Fraser (1999): "An Economic Analysis of Household Waste Management", *Journal of Environmental Economics and Management*, 38, pp. 234–246.

Fullerton, D. and T.C. Kinnaman (1994): *Household Demand for Garbage and Recycling Collection with the Start of a Price per Bag*, NBER Working Paper 4670.

Fullerton, D. and T.C. Kinnaman (1995): "Garbage, Recycling, Illicit Burning and Dumping", *Journal of Environmental Economics and Management*, 29, pp. 78-91.

Fullerton, D. and T.C. Kinnaman (1996): "Household Responses to Pricing Garbage by the Bag", *American Economic Revew*, 86, pp. 971-84.

Fullerton, D. and T.C. Kinnaman (1999): *The Economics of Residential Solid Waste Management*, NBER Working Paper 7326.

Hong, S., R.M. Adams, and H.A. Love (1993): "An Economic Analysis of Household Recycling of Solid Waste", *Journal of Environmental Economics and Management*, 23, pp. 136-46.

Hsiao, C. (1986): *Analysis of Panel Data*, Cambridge University Press.

Jenkins, R. (1991): *Municipal Demand for Solid Waste Disposal Services*, Ph.D. dissertation, University of Maryland.

Kinnaman, T.C. and D. Fullerton (1997): *Garbage and Recycling in Communities with Curside Recycling and Unit-Based Pricing*, NBER Working Paper 6021.

Morris, G.E. and D.C. Byrd (1990): *The Effect of Weight- or Volume-Based Pricing on Solid Waste Management*, paper prepared for the EPS conference, January.

Palmer, K. and M. Walls (1997): "Optimal Policies for Solid Waste Disposal: Taxes, Subsidies, and Standards", *Journal of Public Economics*, 65, pp. 193-207.

PME Consultancy (1994): *Preventing Waste Pays* (in Dutch), Zeist.

Rechovsky, J.P. and S.E. Stone (1994): "Household Incentives to Encourage Waste Recycling: Paying for What You Throw Away", *Journal of Policy Analysis and Management*, 13, pp. 120-39.

Sigman, H. (1991): *A Comparison of Public Policies for Lead Recycling*, mimeo, Department of Economics, UCLA.

Skumatz, L. and C. Beckinridge (1990): "Variable Rates in Solid Waste", in *Handbook for Solid Waste Officials*, vol. 2, EPA 530-SW-90-084B, Washington D.C., June.

Sterner, T. and H. Bartelings (1999): "Household Waste Management in a Swedish Municipality: Determinants of Waste Disposal, Recycling and Composting", *Environmental and Resource Economics*, 13, pp. 473-491.

Wertz, K.L. (1976): "Economic Factors Influencing Households' Production of Refuse", *Journal of Environmental Economics and Management*, 2, pp. 263-72.

Table 1: *Review of elasticities in volume-based pricing literature*

Study	Area[a]; year	elasticities		
		own-price	cross-price[b]	income
HOUSEHOLD SURVEYS				
Hong *et al.* (1993)	Portland, Oregon; 1990	-0.03		0.049
Fullerton and Kinnaman (1996)	Charlottesville, Virginia 1992	-0.226 [v]		
		-0.058[w]	0.073 [w]	
AGGREGATE MUNICIPALITY DATA				
Wertz (1976)		-0.25		0.242 to 0.279
Morris and Byrd (1990)		-0.26		
		-0.22		
Skumatz and Beckinrigde (1990)		-0.14		
EPA(1990)	Perkasie PA		0.49	
	Illion, NY		0.48	
	Seattle 1985-86		0.06	
	Seattle 1986-87		0.10	
Jenkins (1991)		-0.12		0.41

[a] All studies use data from the United States.

[b] The elasticity of the recyclable amount of waste with respect to the price of waste collected at the curbside.

[v] based on volume of household waste

[w] based on weight of household waste

Table 2: *Summary statistics of Oostzaan sample*

Variable description	mean	standard deviation	minimum	maximum
Household variables				
Household size	2.54	1.18	1	9
Age of oldest household member	50.6	16.1	18	96
Share of women in household	0.519	0.261	0	1
0-2 years	0.107	0.309	0	1
2-6 years	0.120	0.325	0	1
6-12 years	0.127	0.333	0	1
12-18 years	0.121	0.327	0	1
Amounts of waste				
Compostable waste in kg	9.93	16.49	0	298.5
Non-recyclable waste in kg	18.15	20.30	0	262.5
Real marginal prices in ct/kg				
Non-recyclable waste	33.90	10.18	0	39.45
Compostable waste	31.64	12.95	0	39.45
Real fixed charges in Dfl. per month				
Non-recyclable waste	9.91	3.72	8.13	22.32
Compostable waste	8.85	3.21	8.13	22.32
Time variables				
February	0.07	0.26	0	1
March	0.07	0.26	0	1
April	0.07	0.26	0	1
May	0.07	0.26	0	1
June	0.07	0.26	0	1
July	0.10	0.30	0	1
August	0.10	0.29	0	1
September	0.10	0.29	0	1
October	0.09	0.29	0	1
November	0.09	0.29	0	1
December	0.09	0.29	0	1
1994	0.30	0.46	0	1
1995	0.28	0.45	0	1
1996	0.26	0.44	0	1
Type of dwelling dummy variables				
Won A (semi-detached)	0.14	0.35	0	1
Won B (dwelling for the elderly)	0.02	0.15	0	1
Won C (flat apartment ground level)	0.03	0.18	0	1
Won D (flat apartment higher floor)	0.06	0.23	0	1
Won E (houseboat)	0.01	0.08	0	1
Won F (detached)	0.17	0.38	0	1
Won G (part of a company)	0.01	0.12	0	1
Won H (caravan)	0.002	0.04	0	1
Won I (summerhouse)	0.0003	0.02	0	1
Temperature	13.8	6.7	1.6	27.1
Diftar (1 during weight-based pr.; 0 before)	0.919	0.273	0	1
Joint container for GFT waste	0.068	0.252	0	1

The temperature data are highest daily temperatures in the measurement station nearest to Oostzaan. On the basis of daily observations we calculated monthly averages for the period July 1993 to December 1996. Source: Royal Netherlands Institute for Meteorology (KNMI).

Table 3: *Average amounts for nine types of waste*(kg per household)

type of waste	1992-93	1993-94	1994-95	1995-96
total waste	384.7	270.7	230.0	223.0
non-recyclable waste	151.2	77.7	69.0	65.8
compostable waste	102.7	56.3	35.2	33.5
recyclable paper	84.6	81.5	77.5	77.2
recyclable glass	22.7	30.9	32.0	28.3
recyclable textiles	4.2	4.6	4.4	4.7
recyclable tins	0.8	5.7	4.8	4.2
small chemical waste	0.8	0.5	0.7	0.4
large volume units	13.8	10.6	5.1	7.1
refrigerators	0.8	0.5	0.5	0.4

For the period before weight-based pricing we only have half-year aggregate data. The columns apply to the period July 1 up to June 30 of the next year.

Table 4: *Fixed effects estimation results* (t-values in parentheses)[a]

Variables	LSDV		LSDV[b]	
	GFT	RST	GFT	RST
marginal price	-0.374 (69.95)	-0.273 (45.35)	-0.329 (57.48)	-0.135 (21.65)
lagged dependent variable			0.203 (75.16)	0.222 (82.68)
two persons	1.344 (5.046)	2.431 (8.095)	2.010 (9.235)	1.567 (5.419)
three persons	2.367 (7.331)	6.477 (17.79)	3.007 (10.97)	4.566 (13.03)
four persons	3.066 (8.108)	8.031 (18.83)	3.952 (12.45)	5.887 (14.36)
more than four	4.538 (8.583)	11.799 (19.79)	4.647 (10.29)	8.806 (15.39)
age	-0.616 (3.870)	-1.873 (10.43)	0.061 (1.077)	-0.964 (5.590)
age squared	0.006 (5.418)	0.010 (8.459)	-0.0003 (0.528)	0.003 (2.145)
share of females	0.699 (1.476)	2.588 (4.849)	1.362 (3.715)	1.796 (3.499)
0-2	1.119 (3.257)	3.209 (8.285)	1.489 (5.339)	2.181 (5.901)
2-6	0.263 (1.010)	-0.841 (2.863)	0.391 (1.722)	-0.536 (1.909)
6-12	0.583 (2.118)	-0.566 (1.824)	0558 (2.317)	-0.471 (1.604)
12-18	0.110 (0.431)	0.063 (0.219)	0.270 (1.155)	
temperature	0.323 (31.69)	0.242 (21.04)	0.299 (30.14)	0.189 (17.48)
1994	-4.044 (21.05)	-2.366 (10.92)	-3.050 (20.26)	-0.882 (4.239)
1995	-5.411 (19.69)	-1.500 (4.839)	-4.262 (29.09)	-0.144 (0.487)
1996	-5.785 (15.43)	-0.198 (0.468)	-4.483 (30.76)	1.134 (2.819)
second quarter	0.561 (3.760)	-0.937 (5.569)	0.071 (0.499)	-0.735 (4.747)
third quarter	-2.769 (14.01)	-3.194 (14.32)	-3.120 (17.25)	-2.594 (12.34)
fourth quarter	-0.908 (6.507)	-0.392 (2.489)	-1.472 (13.97)	-0.223 (1.504)
Adjusted R^2	0.46	0.55	0.48	0.59
$F[N;N_T - (N+k)-1]$	32.73	45.78	33.54	52.05
N	3,459	3,459	3,437	3,437
N_T	127,581	127,581	124,100	124,100

[a]Dependent variable: amount of waste in kilograms per month.

[b]This specification includes the lagged dependent variable as an explanatory variable. As a consequence, the first observation of each household is excluded from the regression as are households with less than three observations.

Table 5: *Costs of waste collection in Oostzaan*[a]

cost component	1992	1994	1995	1996
processing non-recyclable waste	288	111	129	123
processing compostable waste	76	32	38	38
other costs	664	955[b]	887[b]	805[b]
total costs	1028	1098	1054	966
number of households	3300	3291	3353	3407
total costs per household	0.312	0.334	0.314	0.283

[a]Source: city counsil of Oostzaan (private communication) and PME Consultancy (1994). Nominal Dutch Guilders in thousands. During the period 1992-1996, the value of the Dutch Guilder varied between USD 0.50 and USD 0.62.

[b]This includes the following annuity costs of investments in weight-based pricing technology: truck (55), identification chips on bins (18), software (11), and locks on bins (36).