Local Policies to Reduce Residential Waste: Are They Effective? Evidence from Wallonia <Preliminary version>

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Abstract

Municipalities in the region of Wallonia in Belgium dispose of several tools to control and induce the decrease of residential solid waste. By 2015, 100% of the municipalities had a marginal pricing and the price is determined according to the unit based pricing system in place. Residual waste is collected at the curbstone in bags and households pay according to the volume of the bag or in containers where household pay according to the volume of the container or its weight or both volume and weight . With a recent panel data set of seven years from 2009 to 2015, we use a fixed effect model to assess the impact of marginal prices and the effect of the different unit based pricing systems on the demand for residential solid waste. Our results show that higher prices are associated with lower demand for residential waste, and that container-weight based systems lead on average to lower quantities of waste disposed in comparison with the bag-volume system.

Keywords: Waste management; Residential solid waste ; Marginal pricing; Unit based pricing.
JEL Codes: Q53, L11, D12

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1 Introduction

Organizing the service In line with European directives, the Region of Wallonia has adopted legislative measures[1] to cut down the generation of waste through prevention actions and the promotion of recycling . Waste management is the responsibility of municipalities, they have to offer services for the disposal of waste to all their residents. The totality of the 262 municipalities provide curbside collection of unsorted solid waste, 60% provide additionally separate collection of organic waste, 79% collect plastics and packaging (PMC) and all of them collect papers and cardboard (P&C). For the fractions of waste that are not collected at the curbside, municipalities have to provide drop-off facilities freely accessible to households.
Financing the service In Wallonia, the *polluter-payer* and the *real-cost* principles determine the level of taxes and tariffs applied to the waste sector. Both criteria guarantee that people will pay the actual economic cost of their waste including collection, recycling and treatment costs. The municipalities possess two main tools to finance the costs of residential waste: (1) A flat tax collected annually regardless of the quantity of waste generated. They cover mainly the costs of curbside collection of recyclables and the operating costs of the drop-off facilities. (2) A variable tax collected per unit of generated solid waste. The calculation of the tax depends on the unit based pricing system adopted by the municipalities, we consider four categories: the bag system where the price depends on the volume of the bag, the container where the fee is levied on the volume of the container for each emptying, the container where the fee is based on the weight of the container, and the container where the fee depends on both the volume and the weight at the time of the emptying.

This paper is related to two different strands of the literature. First, the literature on the economic agent's responsiveness to non-linear pricing (for instance Ito, 2014) and, second the literature on the effects of prices on the quantity of generated household residual wastes. This literature focuses on three main questions: (1) the comparison between cities which introduced a unit based pricing system to those which apply a fixed fee, (2) the comparison between weight-based pricing and price per bag, and (3) the impact of the price level on quantities. Our contribution to this literature is original as we are able to compare both different price levels and different price units. The impacts of unit based pricing has been discussed extensively in the economic literature using either aggregate municipal data or household level data ob-

[1] The Walloon waste plan 2010.

tained through surveys. A group of studies compare cities which introduced a unit based pricing system to those which apply a fixed fee, Fullerton and Kinnaman (1996) found a positive effect due to the introduction of unit based pricing. De Jaeger and Eyckmans (2015), Dijkagraaf and Gradus (2004), Allers and Hoeben (2009) compare between different systems of unit based pricing. Another group of studies tried to estimate the price elasticity based on tariffs charged to households, Gellynck and Verhelst (2008), Dijkgraaf and Gradus (2004), Kinnaman and Fullerton (2000), Isely and Lowen (2007) found a significant negative price elasticity.

In this paper, we exploit this heterogeneity in tariff levels and in tariff structures to measure their impact on the demand for waste by households. This question is particularly relevant for public policy as the reduction of residual (non-recyclable) waste is a top policy priority. For this purpose, we collect data on prices and waste quantities for 258 Walloon municipalities (out 262) for the period of 7 years from 2009 to 2015. With this recent data set, we perform a fixed effect analysis to assess the effect of marginal pricing on the quantity of residual waste generated by households. We show that both the marginal price level and the price structure have an influence on the quantity of residual waste. Our first main result show that a higher marginal price substantially reduces the demand for waste. With an estimated negative price elasticity of 2%, a higher variable fee substantially reduces the quantity of waste. We also show that the price structure defined by the unit based pricing adopted by the municipalities have a significant impact that is also large in magnitude. Containers collection with volume based pricing only is not more effective than collection with bags. It is rather the combination of containers collection with the mixed weight/volume pricing the most effective pricing method to reduce waste. Accordingly, municipalities using containers with volume based pricing can reduce the generated waste by changing their pricing structure and switching to a mixed system. Likewise, they can reduce waste production by re-balancing their tariffs, reducing fixed fees and increasing the variable ones.

2 The waste sector in Wallonia

2.1 Overview

Belgium is a federal state composed of three regions (Flanders, Brussels and Wallonia). Each region has drafted specific rules for organizing waste collection, treatment and recycling. Our focus in this paper will be on the Walloon region. Wallonia is the southern part of Belgium. It has 3.6 million inhabitants and it is divided in 262 municipalities. Within the framework of regional regulations, municipalities have the responsibility to organize the collection for 16 different waste streams. These different waste categories are collected either at the curbside or at drop-off facilities. There is a curbside collection for papers & cardboard and residual waste in every municipality. Some municipalities organize the collection for organic wastes and plastic, metal and cardboard packaging at the curb. Collection is either done in-house by the municipality or delegated to an external contractor, either a private firm or a public supra-municipal company, the so-called "intercommunale". Intercommunales are public companies owned by municipalities. In the waste management sector, there are in total eight intercommunales and each municipality is affiliated to one of them. Affiliation is done simply on a geographical basis. Intercommunales are organizing and managing the treatment of collected waste in partnership with private firms. In addition, some intercommunales are offering waste collection services to municipalities. This service is either directly provided by the intercommunale or delegated to a private contractor.[2]

According to the regulations in place, the public waste management services provided by the municipalities must be self-financed. Municipalities have the legal obligation to apply the *true-cost principle*. Based on that, all the costs associated with the waste management services should be identified and passed through to households in a separate and transparent bill. Municipal waste management services cannot be financed by general taxation or non-dedicated local taxes. Cost recovery and transparency should provide good price signals in order to encourage a more responsible behavior and to increase environmental awareness. The application of the real-cost principle is essential to compare tariffs in the different municipalities.

2.2 Collection of residual and organic wastes

Collection of residual (i.e. non-recyclable) waste at the curbside is carried on a weakly basis in every municipality. The average residual waste per inhabitant was 130 kg per year. Waste should be placed in specific container, either a stamped plastic bag or a specific box (hereafter called container). Bags are provided by the municipalities, containers are provided by the waste collector. Containers may be equipped with weighting chips, in which case the collector

[2]The costs of the collection service can be influenced by the choice of a waste collector, see Gautier and Reginster (2013) for evidences related to the Walloon region.

weighs the waste before emptying and this information is used for pricing (see below).

Actually, more and more municipalities organize separate collection and recycling of organic waste. In 2009, 41% of the municipalities were organizing door-to-door collection of organic waste and this number has increased to reach 58% in 2015. The collection method for organic waste is a bag or a container and some municipalities use a different method for collecting organic waste other than the one used for collecting residual waste.

2.3 Pricing methods

To finance the service, municipalities use a three part tariff composed of (1) a flat fee related to the household's size, (2) a free allowance (bags/weight/lift) and (3) a variable fee for the additional waste produced. Figure 1 represents a typical three-part tariff with a fixed fee F, a free allowance f and a marginal price p.

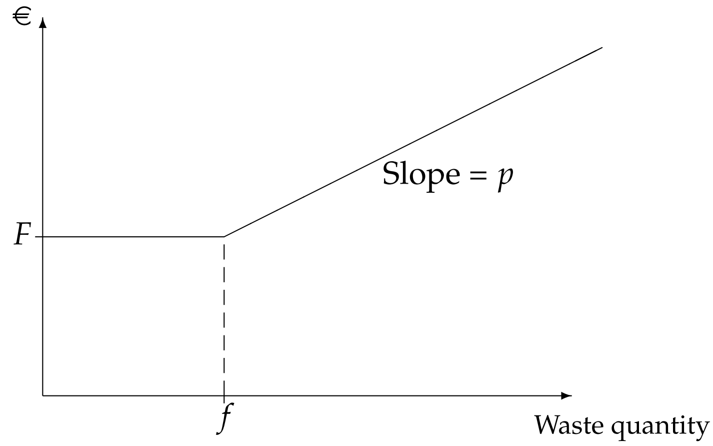

Figure 1: Three-part tariff

There are different pricing units for waste. When waste is collected in bags, municipalities sell stamped bags and the pricing unit is the waste volume (liter). The free allowance consists of a number of free bags. The free allowance is thus expressed in liters and the variable fee in €/liter. When wastes are collected in containers that are not equipped with a weighting chips, the pricing unit is the container lifting. Given that containers have a fixed size (usually 140 liters), the lift of a container of volume V that is charged p_l is equivalent to a price per liter of $\frac{p_l}{V}$. Likewise, the free allowance (a number of free lifts) can be expressed in liters. The pricing unit is the same for bags and containers without chips. When the container is equipped with a chips, there are possibly two pricing units: the waste weight (kilogram) and the container lifting (liter).

Municipalities can thus use three different unit based pricing and these different tariff structures can be classified in four main categories:

i. Bag-volume based tariffs: waste is collected by bags and households pay according to the volume of the bag .

ii. Container-volume based tariffs: waste is collected by containers and households pay according to the volume of the container.

iii. Container-weight based tariffs: waste is collected by containers and households pay per kilogram of generated waste.

iv. Container-volume&weight based tariffs: waste is collected by containers and households pay per kilogram of generated waste and they pay additionally a fee each time the container is emptied.

In 2015, 56.2% of the municipalities were using the bag-volume, 4.65% the container-volume, 2.71% the container-weight, and 36.43% the container-volume&weight system.

To compare the pricing methods, we will convert weight based pricing into volume based pricing. For that, we will follow Allers & Hoeben (2009) and consider that 1 liter of waste equals 0,133 kg. With such a conversion, we can compare the pricing scheme in all municipalities and express them in a comparable unit, €/liters or €/kilograms and we use the former. Detailed statistics on prices per liter for each system are provided in the following table.

3 Empirical model and Data description

3.1 Data source and description

We collected data from two sources: data on waste quantities and prices were provided by the regional administration in charge of waste policies and regulations[3] and socio-economic data was gathered from the Walloon statistical office (Walstat). In this study, we use the data for the years from 2009 to 2015. We possess data for the 262 municipalities in Wallonia but 4 municipalities

[3] Office Wallon des Déchets (OWD).

Variable	Nb. of obs.	Mean	Std. dev.	Min	Max
Year	1,806	2012	2.0	2009	2015
RW	1,806	132.98	40.03	50.76	221.01
ORG	929	0 .034	0.018	0.0013	0.11
Qty	1,806	150.68	32.28	60.08	279.39
pop	1,806	13632.07	21067.23	1359	203871
density	1,806	319.57	440.25	24	3479
avginc	1,806	16253.82	2174.18	10680	25040
under20	1,806	24.27	1.85	18.8	31.21
above60	1,806	22.75	2.69	14.9	32.7
pbag	1,806	0.612	0.555	0	4
ptag	1,806	0 .022	0.189	0	3
plift	1,806	0.4383	0.7323	0	5.23
pkg	1,806	0.0501	0 .0886	0	0 .73
P	1,806	0 .0204	0 .0106	0	0 .1025
pbag_vol	1,806	0 .0105	0.0096	0	0 .0723
pcont_vol	1,806	0 .00069	0 .00349	0	0 .0367
pwght	1,806	0 .0008	0.0053	0	0 .052
pvol_wght	1,806	0 .0081	0 .0142	0	0 .0976

Table 1: Descriptive statistics

were dropped due to inconsistency in the data and so we ended up with a sample of 258 municipalities which does not induce any sampling biases to our analysis. Descriptive statistics for the main variables are provided in Table 1.

Waste quantities We collect data on waste quantities for the residual unsorted waste (*RW*) and the organic waste (*ORG*) both being expressed in kg per inhabitant. The variable waste (*Qty*) is the sum of residual and organic waste.

Prices and pricing methods We construct dummy variables for bag-volume (*pbag*), container-volume (*cont_vol*), container- weight (*wght*), and container-volume&weight (*vol_wght*). We construct a variable (*chg*) if the municipality changed from a simple volume system (bag or container) to a container weight or weight&volume based pricing during the period, 48 municipalities are concerned . For each pricing method we express the marginal price in liters (*P*) as explained above. We include a binary variable (*ORG*) for the separate collection of waste.

Demographic variables We collect demographic variables that can have an impact on the quantity of waste and that can be proxies for the consumption pattern of households: total population size (*pop*), inhabitants per km^2 (*density*), average income per inhabitant in euro (*avginc*), the proportion of inhabitants under 20 years of age (*under20*) and those above 60 (*above60*).

3.2 Empirical strategy

We specify the following model for the Walloon residential solid waste demand:

$$\ln Q_{it} = \beta_0 + \beta_1 \ln P_{it} + \beta_2 UBP_{it} + \beta_3 ORG_{it} + \beta_5 \ln X_{it} + \alpha_i + \epsilon_{it}$$

Where Q_{it} is the aggregate amount of residual and organic waste for municipality i at time t; P_{it} is the price in euro of a volume of one liter of residential solid waste; UBP_{it} is a set of dummies for the unit based program adopted by the municipality with the bag system being the base category; ORG_{it} is a dummy variable that takes the value one if the municipality has a system of separate collection of organic waste; a vector X_{it} of control variables in line with the current literature; α_i represent the municipality specific effect; and the ϵ_{it} is the idiosyncratic disturbance term.

Since we express the quantities and the prices in logarithm, β_1 can be interpreted as the price elasticity of demand. Kinnaman and Fullerton (2000) showed that this elasticity has a negative sign. We expect the volume-weight and the weight based systems to outperform the bag system. The sign of ORG is not clearly predetermined however we expect that municipalities that collect the compostable waste separately create more awareness and encourage people to adopt more conscious behavior.

For the estimation of our model, we have a balanced panel data set. Since we have data for (almost) the whole population of interest and not a random sample, the municipalities fixed effect model (FE) would be more appropriate than the municipalities random effect model (RE). Moreover, the FE allows the regressors to be correlated with the municipalities specific effects and thus corrects for the endogeneity that could result if the prices were determined based on unobservable constant factors that characterize the municipalities.

4 Results of the empirical model

The coefficients of the empirical model are presented in Table 2 together with the standard errors which are robust to auto-correlation. It can be seen that most of the estimators are statistically significant and have the expected sign.

Policy Variables Our coefficient for prices is negative and significant at the 1% level. A unilateral test of $H_1 : \beta_1 < -1$ yields a test static of -5.034, thus we can conclude that the demand for waste in Wallonia is elastic at the 5% confidence level.

The unit based pricing program has a great impact on waste quantities holding prices fixed; the municipalities where pricing is based on weight or on volume&weight have on average, 20.62% and 15.25% respectively, less waste than the municipalities that use the bag system. It is worth noting that the average prices for the weight pricing system are higher than the volume&weight pricing system. We also include interaction effects between the prices and the UBP systems in our model, and they are jointly significant at the 1% level. We find that only the coefficient of the container-volume system is individually significant: the price effect is important when municipalities are using this system compared to the bag system.

We also control for the effects that might be attributed to the change from a volume based system whether a container or a bag to one of the two systems based on weight. We find that there is a short run effect to the adoption of a unit based pricing based on the weight rather than only the volume.

The coefficient on the variable ORG is negative and significant, which shows that a separate collection of compostables contributes to an overall waste reduction. The collection of an additional waste flow at the curbstone has an important incentive effect.

Demographic Variables The marginal effect of density is not constant, the marginal increase in density decreases residential waste but after 82.26 km^2 the quantity of waste increases. According to Callan and Thomas (2006) rural towns may engage in reuse activities and more composting which leads to lower disposal of waste.

We find that income elasticity of demand is non-constant, it is at first negative and then it becomes positive with a turning point of 17,654 euros. This can be interpreted as follows: (1) if income is a proxy for education then higher income is associated with higher environmental consciousness, (2) the wealthiest consume more and thus generate more waste though this later effect is not large in magnitude.

Dependent Variable: ln Qty			
Explanatory Variables	Pooled OLS	Random Effect	Fixed Effect
ln P	-6.398	-2.563	-2.033
	(2.108)	(0.755)	(0.602)
cont_vol	0.034	0.043	0.012
	(0.077)	(0.032)	(0.035)
wght	-0.058	-0.233	-0.230
	(0.114)	(0.049)	(0.053)
vol_wght	-0.283	-0.199	-0.165
	(0.046)	(0.037)	(0.039)
ORG	-0.042	-0.066	-0.087
	(0.027)	(0.024)	(0.029)
ln density	0.018	-0.234	-1.668
	(0.079)	(0.084)	(0.580)
ln densitysq	0.002	0.024	0.190
	0.007	0.007	0.061
ln avginc	-3.600	-7.088	-8.529
	(4.194)	(2.880)	(3.122)
ln avgincsq	0.163	0.356	0.436
	(0.216)	(0.148)	(0.161)
under20	0.008	-0.007	-0.009
	(0.008)	(0.006)	(0.006)
above60	0.021	0.008	-0.005
	(0.005)	(0.004)	(0.006)
pcont_vol	10.568	-1.926	-3.498
	(3.596)	(1.298)	(1.478)
pwght	-1.569	1.996	2.170
	(5.045)	(2.545)	(2.442)
pvol_wght	5.622	2.137	1.617
	(2.186)	(1.023)	(0.948)
chg	-0.124	-0.088	-0.082
	(0.021)	(0.017)	(0.018)
cons	23.918	40.918	50.493
n	1806	1806	1806

Table 2: Results of the regression models. Standard errors robust to heteroskedasticity and serial correlation are reported between parentheses.

5 Conclusion

In this paper, we have done a preliminary assessment of the role of marginal pricing on the demand for residual waste by households. So far, we did not have fully exploited the richness of our database and the diversity of pricing structures used in Wallonia. In the future, we plan to incorporate other elements of the tariff structure and in particular, we want to investigate the role of the free allowance. With the free allowance, wastes have a zero marginal cost up to the limit and a positive marginal cost afterwards. When the free allowance is low, households enter more quickly in the positive marginal cost zone and we expected that to have a negative impact on the quantity of waste.

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