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Gradus, Raymond; Dijkgraaf, Elbert

published in

Waste Management
2019

DOI (link to publisher)

[10.1016/j.wasman.2019.03.059](https://doi.org/10.1016/j.wasman.2019.03.059)

document version

Publisher's PDF, also known as Version of record

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citation for published version (APA)

Gradus, R., & Dijkgraaf, E. (2019). Poorer and less political fragmented Dutch municipalities take tighter waste reduction decisions. *Waste Management*, 88, 328-336. <https://doi.org/10.1016/j.wasman.2019.03.059>

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Poorer and less political fragmented Dutch municipalities take tighter waste reduction decisions

Raymond Gradus^{a,*}, Elbert Dijkgraaf^b

^a School of Business and Economics and Tinbergen Institute, VU University Amsterdam, the Netherlands

^b School of Economics and Tinbergen Institute, Erasmus University Rotterdam, the Netherlands

ARTICLE INFO

Article history:

Received 7 December 2018

Revised 24 March 2019

Accepted 26 March 2019

Available online 30 March 2019

Keywords:

Local government

Fragmentation

Unit-based waste pricing

Greener

Ideological motivation

ABSTRACT

This study investigates the drivers of unit-based pricing systems for waste in the Netherlands using an administrative database from 1999 until 2017. As these unit based pricing systems are effective in reducing waste, more and more Dutch municipalities adopt these programs. Based on their incentive, systems are ranged from green ('weight' or 'bag') to less green ('frequency' or 'volume'), or not green ('flat rate'). In one-third of the municipalities shifts took place from one unit-based pricing system to the other, with 84 percent becoming greener and 16 percent less green. There is some evidence for political motivation of these shifts. Particularly, Social Liberals councilors are in favor of waste pricing, whereas Social Democrats councilors are not in favor. In addition, municipalities in low income and less political fragmented councils are more in favor of waste pricing.

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1. Introduction

There are many studies about municipal decisions and their links with ideology, efficiency and local characteristics. In particular, shifts toward privatization are studied in detail. Analysis of shifts over time shows not only that privatization and contracting out are important phenomena, but also that reverse privatization and contracting in have become more important (Hefetz and Warner, 2004; Pérez-López et al., 2015). Some literature has focused on alternative management structures as cooperation or joint ventures with private companies. Most empirical studies focus on waste management as more and more data are available (i.e. Bel and Mur, 2009; Plata-Díaz et al., 2014). Especially, the influence of political characteristics on contracting-out decisions is one of the most researched issues. Plata-Díaz et al. (2014) confirmed the expected view that Spanish left-wing politicians prefer to use public rather than private waste management forms. Gradus et al. (2014) find that in the Dutch context ideology also matters: if the citizens in a municipality give their vote relatively more to Conservative Liberals and, to a lesser extent, Orthodox Protestants, the likelihood that a service is contracted out to the market is higher. In Gradus and Budding (in press), conservative liberals support for changes to the market, whilst the opposite is true for social

democrats. Reaching agreement on privatization can be more difficult under highly fragmented governments, therefore, a fragmentation index was investigated as well. Remarkably, they found some evidence that political fragmentation increases the ability to outsource, the opposite of what was found by Warner and Hefetz (2002) for US outsourcing. In Europe, political fragmentation continuous to be tested mostly in tax and budgeting issues (see Goeminne et al., 2008). As far as we know, the relationship between an environmental decision and political fragmentation at the municipal level has not been investigated until now.

In the Netherlands, municipalities are responsible for waste collection and separation (Dijkgraaf and Gradus, 2014). They are mandated to collect two types of waste at the curbside: compostable waste and unsorted waste. Municipalities are also obliged by law to collect separated recyclable waste such as compostable waste, plastics, paper and glass. In most municipalities, citizens can deliver them to central collection points. The way Dutch citizens pay for waste collection differs. Most Dutch municipalities still use an annual fixed fee per year. However, in several municipalities the introduction of unit-based pricing of (unsorted) waste is an important measure in increasing the collection of recyclables, and in reducing the amount of environmentally unfriendly, unsorted waste. The main reason is that it introduces a marginal price per unit of waste collected. Marginal costs are zero for citizens with a yearly flat fee, through unit-based pricing citizens have an incentive to reduce waste and sorting recyclables.

In recent decades, an increasing number of Dutch municipalities have implemented unit-based user fees. By 2017, forty-five

* Corresponding author.

E-mail addresses: r.h.j.m.gradus@vu.nl (R. Gradus), dijkgraaf@ese.eur.nl (E. Dijkgraaf).

percent of all Dutch municipalities had implemented such a system. Unit-based pricing systems differ across the Netherlands. There are systems based on weight, number of bags, frequency of collection and volume collected (Dijkgraaf and Gradus, 2004). The weight system is the most effective in reducing waste, as each kilogram of waste results in a higher bill. As bags in the Netherlands are much smaller than bins, the bag system is more effective than the frequency system. With the bag and frequency system, the bill depends on the number of times a bag or a bin is presented at the curbside. Finally, the volume system is the least refined as it allows choice between a small or a large bin, which is the only thing that affects marginal prices. The weight-based system has the largest impact, reducing unsorted waste quantities by approximately 40 percent, followed by the bag system (30 percent) and the frequency system (20 percent) (Dijkgraaf and Gradus, 2014). Importantly, unit-based pricing systems lowers waste collection costs (Dijkgraaf and Gradus, 2015). In particular, the bag-based and frequency-based pricing system have lower costs as their administrative costs are modest.

Over time, the number of municipalities with the greener and more effective weight- and bag-based systems has stabilized or fallen, and the number of municipalities with a frequency system has increased substantially. From this, one can conclude that Dutch municipalities are keen to introduce a unit-based pricing system, but not the most effective one in terms of waste reduction. As the introduction of these unit-based pricing systems may, however, have adverse effects such as illegal dumping and administrative costs, it is important to study these shifts and offer an explanation for this. Importantly, the frequency-based system has lower administrative costs and is good to handle for consumers (Dijkgraaf and Gradus, 2015). As far as is known, there have not been many attempts in literature to explain local policies for unit-based pricing of waste. Some examples of related literature are Kinnaman and Fullerton (2000) and Gradus et al. (2019), where drawing on US municipal data, the drivers for implementing and the optimal user fee for unit-based pricing were estimated. Education and income, especially, are important drivers for implementing a user fee. Interestingly, opposite to Kinnaman and Fullerton (2000), Gradus et al. (2019) found that places with higher per capita income were more likely to implement a user fee. Kinnaman and Fullerton (2000) and Gradus et al. (2019) also found that areas with low population density were less willing to introduce a fee and give as an explanation that rural areas have more opportunities for illegal disposal. Allers and Hoebe (2010) estimated the optimal user fee for the Netherlands, although only the political ideology (measured as the share of right-wing parties) was included as an explanatory variable. They found some evidence that right-wing parties increase the optimal fee, although ideology was not measured in an indirect way.

As unit-based pricing systems differ across the Netherlands with respect to the basis of pricing and we have data on this, the purpose of this paper is to extend the empirical analysis with drivers for shifts of municipalities toward a more advanced or less advanced unit-based pricing system. We interpret these shifts as becoming greener or less green. Moreover, we extend the literature by explaining these shifts through political variables and several fragmentation indexes. We would expect that municipalities with more green councilors and less fragmented councils or boards are more willing to adapt to greener policies. Also socio-economic variables are investigated. This has been done for the US, but not for the Netherlands yet. Hereby, we expect that municipalities with poorer people are also more willing to adapt waste pricing as this lowers the waste fee. If illegal dumping is an issue, one should expect less unit-based pricing in areas with low population density as in these areas more opportunities are present to dump waste.

Fig. 1. Percentage of different unit-based pricing systems, 1999–2017, weighted by the number of municipalities.

The paper is structured as follows: Section 2 describes the shifts over time; Section 3 gives the model and data and a logit analysis explaining the shifts is presented in Section 4. The main conclusion is that municipalities with a less fragmented council are more willing to introduce unit-based pricing for waste. Therefore, we test some other fragmentation indexes as well to see whether our conclusion is driven by the definition of the fragmentation index. Some concluding remarks and topics for future research are presented in Section 5.

2. Shifts in unit-based pricing

In this paper, we describe four different unit-based pricing (UBP) systems: volume, frequency, bag, and weight.¹ In some municipalities, ranging from 80 percent in 1999 to 55 percent in 2017, a flat-rate system has been used. By 2017, 45 percent of all Dutch municipalities had implemented a unit-based pricing system, this share having risen substantially from 16 percent in 1999. The development of different unit-based pricing systems over time is illustrated by Fig. 1.

The volume-based program allows households to choose between different volumes of the collection bin.² Some 6 percent of Dutch municipalities in 1999 and 4 percent in 2017 used this rather crude UBP system. A more refined marginal price results from a frequency-based system, in which the household pays for the number of times the bin is left at the curbside. In some municipalities households have the possibility to choose between different types of bins.³ The share of municipalities using this system increased from 8 percent in 1999 to 28 percent in 2017. In the bag-based system, households buy specially marked bags. This is a more effective pricing system than the frequency-based one, as the volume of the bags is significantly less than that of the bins. The share of municipalities with such a system is stable, although it has decreased somewhat recently. Maximum price incentive results from a weight-based system, where the waste per kilogram is priced. Normally, the collection vehicle weighs the bin before emptying it, and matches this data with the owner's identity, which is stored on a chip integrated onto the collection bin. From Fig. 1 it can be seen that the use of the more refined weight-based system increased at the beginning of this century and decreased slightly after 2005.

¹ Unfortunately, our data set does not contain information on prices.

² Most municipalities using this system supply a standard bin with a volume of 140 L, with the possibility of upgrading to a 240 L bin or of subscribing to more 140 L bins.

³ Therefore, some municipalities combine this frequency-based system with a volume-based system, where households have to pay special tariffs for different bins at the curbside. These combinations are counted as the frequency system. Also the combination between weight and frequency system is counted as a weigh system.

Fig. 2. Percentage of different unit-based pricing systems, 1999–2017, weighted by the number of inhabitants.

Fig. 2 shows the unit-based systems' weighted (by the number of inhabitants) percentages for 1999–2017. The percentages were much lower than for Fig. 1 for all unit-based systems. As UBP systems are used more in smaller municipalities and flat rates are applied to greater degree in large cities, the percentage of inhabitants confronted with unit-based pricing was lower (with 32 percent) in 2017. Nevertheless, the number of large cities with a frequency-based pricing system has increased in recent years. Weighted by the number of inhabitants, its percentage increased from 5 percent in 1999 to 20 percent in 2017. In 2017, more than three million Dutch people were faced with this system.

2.1. Shifts

Our large longitudinal data set makes it possible to measure shifts over time. Similar to Hefetz and Warner (2004), and Gradus et al. (2014) for privatization, a transition matrix is constructed, as shown in Table 1, where the different UBP systems are ordered from no marginal pricing ('a flat-rate system') to the most effective marginal pricing ('a weight-based pricing system'). If a municipality shifts above the diagonal, we define this shift as 'greener' and below the diagonal we define it as 'less green'. This matrix includes all shifts, even if a municipality shifted several times as was the case in the period 1999–2014.⁴

Data from 1999 to 2014 are available for 565 Dutch municipalities. In this period, 197 Dutch municipalities (i.e. 35 percent) shifted to a unit-based pricing system one or more times.⁵ In most of these municipalities (151), there was one shift; in 33 municipalities, two shifts took place; in twelve municipalities there were three shifts; and finally, in one municipality there were four shifts. In total, there were 254 switches, of which 214 (italics in Table 1) were toward a greener unit-based pricing system, and 40 (bold in Table 1) were toward a less green unit-based pricing system or a flat system. Thus, 84 percent of shifts were toward 'greener' and 16 percent toward 'less green' unit-based pricing systems. In 368 municipalities, the way the waste fee is calculated did not change during the period 1999–2017 (this is the sum of the numbers on the diagonal). So, in 65 percent of the Dutch municipalities the mode of unit-based pricing was stable over this period.

Let us focus in more detail on the frequency system (see the third column and the third row of Table 1). There were 123 shifts to the frequency system and only 18 shifts away from it. In Dijkgraaf and Gradus (2015) it is shown that the frequency-based

pricing system considerably lowers the amount of unsorted waste and the administrative costs are relatively low. A disadvantage of the weight-based system is the high administrative cost, while a disadvantage of the bag-based system is that it is not easy to operate and to price compostable waste; the frequency-based system does not have such disadvantages.

2.2. Pattern over time

We divided the dataset in two almost equal parts to see whether effects are stable. Therefore, we distinguish between the periods 1999–2007 and 2008–17 (see Tables 2 and 3).

The number of shifts in 2008–2017 is 98, which is relatively small, compared with 159 in 1999–2007. Furthermore, the pattern differs only slightly between the two periods. The share of municipalities becoming greener (i.e. 87 percent) is somewhat larger in the period 2008–2017. Moreover, the frequency system has become more important and other systems, such as the weight and bag system, have become less important. Interestingly, in the latter period the number of municipalities implementing a weight-based or bag-based system decreased compared to the number of municipalities losing these systems. It seems that in that period the negative aspects of these systems, such as administrative cost and the issue of handle waste, become more apparent (see also Dijkgraaf and Gradus, 2015). Another issue is illegal dumping. Based on data to 2006, Allers and Hoebe (2010) suggest that this is not a serious problem in the Netherlands, as one would expect that many municipalities would have abolished user fees if this were the case. Looking at the 2008–17 data, a similar conclusion can be drawn: ten municipalities have stopped applying user charges for unsorted waste. Recently, however, some municipalities as Oostzaan have moved back to the flat system due to administrative problems and illegal dumping.⁶

3. The model and the data

Similar to Gradus et al. (2014), we apply a logit model to test theories on changing unit-based pricing systems. The dependent variable is changing to a greener or a less green unit-based pricing system. In addition, we also test why municipalities change to a frequency system as this is the most popular system. The dummy *Switch_green* is 1 if a municipality switches to a greener system (and zero otherwise).⁷ Likewise, the dummy *Switch_lessgreen* is 1 if a municipality switches to a less green system (and zero otherwise) and the dummy *Switch_frequency* is 1 if a municipality switches to a frequency system (and zero otherwise).⁸

3.1. Political preferences

As political variables, included as explaining variables, the percentage of seats held by the following parties is included, based on the local council elections in 1998, 2002, 2006, 2010 and 2014.⁹

⁶ Oostzaan was the first municipality in the Netherlands to implement weight-based pricing.

⁷ We define shifts (change) to a greener unit-based pricing system as shifts toward a more effective unit-based pricing system (i.e. from 'flat' to 'volume', 'frequency', 'bag' and 'weight', from 'volume' to 'frequency', 'bag' and 'weight', from 'frequency' to 'bag' and 'weight' and from 'bag' to 'weight').

⁸ We define shifts (change) to a less greener unit-based pricing system as shifts toward a less effective unit-based pricing system (i.e. from 'volume', 'frequency', 'bag' and 'weight' to 'flat', from 'frequency', 'bag' and 'weight' to 'volume', from 'bag' and 'weight' to 'frequency' and from 'weight' to 'bag'). The shifts toward a frequency system are the third column in Table 1.

⁹ There were local elections in 1998, 2002, 2006, 2010 and 2014 held at a Wednesday in March. The number of seats varied between 9 (for municipalities with less than 3,001 inhabitants) and 45 (for municipalities with more than 200,001 inhabitants).

⁴ When municipalities merge to form a new municipality, shifts are only included if they take place after the new municipality was installed.

⁵ There were 538 municipalities in 1999 and 388 in 2017 in the Netherlands. The number of municipalities between 1999 and 2017 is 565. This number is higher than the number in 1999 as in subsequent years mergers are included as well.

Table 1

Number of municipalities switching UBP mode and staying the same, 1999–2017.

		To					
		Flat	Volume	Frequency	Bag	Weight	Total
From	Flat	318	45	99	12	23	497
	Volume	14	13	20	1	1	50
	Frequency	6	1	18	10	1	39
	Bag	6	0	3	14	2	25
	Weight	8	1	1	0	5	15
	Total	352	61	144	37	32	626

Table 2

Number of municipalities switching UBP mode and staying the same, 1999–2007.

		To					
		Flat	Volume	Frequency	Bag	Weight	Total
From	Flat	365	33	63	9	18	488
	Volume	10	17	5	1	1	34
	Frequency	5	1	18	0	1	25
	Bag	4	0	1	16	2	23
	Weight	5	0	0	0	7	12
	Total	389	51	87	26	29	582

Green Left, Socialist Party, Social Democrats, Progressive Liberals, Christian Democrats, Reformed Political Party, Christian Union and Conservative Liberals.^{10,11} This approach is different from Allers and Hoebe (2010), where only one variable for political ideology was used.¹² The so-called local parties are used as a benchmark because they do not have a common ideological orientation (Boogers and Voerman, 2010). Moreover, the share of aldermen from each political party as an explanatory variable is also included, based on the same elections shown above.¹³ In a sense, the approach of Elinder and Jordahl (2013) is followed, and there is a distinction between general political preferences as expressed by the voters (represented by the share of seats of each political party on the municipal council) and those of the ruling parties (shown in our analysis by the aldermen). In both estimations, Conservative Liberals are expected to be less green, in contrast with the Green Left and, to a lesser extent, the Christian Union and Progressive Liberals.¹⁴

Data on these political characteristics (seats and aldermen) in election years were collected from the *Gids Gemeentebesturen*

(Guide to Municipal Boards), which is published by the Vereniging van Nederlandse Gemeenten (Association of Dutch Municipalities), as well as through an internet search.¹⁵

3.2. Fragmentation variables

We test whether political fragmentation plays a role in local environmental decisions. As reaching agreement seems more difficult under highly fragmented governments, our expectation is that more fragmented governments are less green. Goeminne et al. (2008) show for Flanders that fragmented municipalities (measured by the number of parties in the board) are more optimistic in projecting tax revenues and therefore will have larger deficits. Similar to Flanders, municipalities in the Netherlands have a parliamentary system consisting of the local council (the legislative body) and the board of aldermen (the executive body).¹⁶ The board of aldermen is responsible for preparation and execution of policies, however the municipal council is the decision-making body with regard to environmental policy. Therefore, we test the influence of fragmentation by including two fragmentation indexes: one for the board and one for the council.

First, we calculate the board fragmentation as the number of political parties in the board of aldermen divided by the number of aldermen.¹⁷ In addition, we calculate political fragmentation in the municipal council by dividing the number of political parties in the council by the number of seats.¹⁸ Second, we measure fragmentation by the (absolute) number of political parties in the board. For Flanders, Goeminne et al. (2008) found in 1989–2006 that the average number of parties obtaining representation in the board is 1.7–1.9. On average there are almost three parties governing a municipality in the Netherlands. The average number of parties in municipal councils is larger at almost six. Furthermore, we also

¹⁰ Green Left: GroenLinks (GL); Socialist Party: SP; Social Democrats: PvdA; Progressive Liberals: D66; Christian Democrats: CDA; Reformed Political Party: SGP; Christian Union: CU (in 1998, the CU consisted of two parties – RPF and GPV); and Conservative Liberals: VVD. The SGP and CU are orthodox Protestant parties.

¹¹ We take (almost) all parties which are present in the National Parliament. It should be noted that the populist and anti-Islam Party for Freedom (PVV) of Geert Wilders and Party for the Animals (PvdA) are almost non-existent on a local level. In the 2010 and 2014 local election, the PVV only had seats in the cities of The Hague and Almere, while on a national level the PVV got 15 percent of the votes in the 2010 parliamentary elections. In 2010, the PvdA got one seat in six municipalities (Amsterdam, The Hague, Leiden, Apeldoorn, Groningen and Buren). This number increased slightly to 10 in 2014. Before 2010 the PvdA and PVV did not have any seat.

¹² Unfortunately, Allers and Hoebe (2010) did not specify how the share of right-wing parties, the variable they used, was composited. However, some suggest that parties are progressive in environmental issues and conservative on other issues (for example the CU), and therefore it is better to measure the political affiliation directly.

¹³ After every local election the members of the council negotiate the number of aldermen and their political affiliation. In principle, they are elected for four years and in the data the aldermen elections by municipal council just after the local elections are included. In principle, this nomination is until new elections are called, although in a limited number of municipalities aldermen and their affiliations changed during the four years. However, no information on this is available in the data we have.

¹⁴ The Dutch political parties have different preferences with respect to environmental issues. There is consensus in The Netherlands about the position of most parties on an environmental zero to ten scale. For example, based on an evaluation of 2012 election manifestos, some environmental groups jointly with the TV program *Vroege Vogels* gave the Green Left a score of 8.5 for environmentally friendly policy proposals, while the Conservative Liberal VVD was only given a score of 3.9 (see <https://vroegevogels.bnnvara.nl/nieuws/groene-rapportcijfers-voor-de-politiek>).

¹⁵ We thank Tjerk Budding for preparing these political data.

¹⁶ The mayor is also part of the Dutch municipality board. However, he/she is appointed by the central government and his/her executive power is limited.

¹⁷ The number of aldermen depends normally on the number of inhabitants. For example, Amsterdam has the maximum, with eight aldermen. However, a municipality has ample power to extend the number of aldermen also by limiting their working time.

¹⁸ Some municipalities have more than one local political party, which is defined as a party not represented in the National Parliament. However, we count them as one. Furthermore, this index could be larger than one because aldermen can represent more than one political party.

Table 3

Number of municipalities switching UBP mode and staying the same, 2008–2017.

		To					Total
		Flat	Volume	Frequency	Bag	Weight	
From	Flat	245	12	36	3	5	301
	Volume	4	26	19	0	0	49
	Frequency	1	0	41	10	0	52
	Bag	2	0	1	17	0	20
	Weight	3	1	1	0	7	12
	Total	255	39	98	30	12	434

include the relative size of parties in our third variable representing fragmentation. In allowing for differences in the relative size of parties, the effective number of political parties can be calculated (see Mueller, 2003, p. 273). As a formula:

$$C = 1 / \sum_{i=1}^n x_i^2, \quad (1)$$

where x_i is the share of the seats (or board members) of i -th party (normally ordered in size) in a municipality. In political science this is often called the Laakso-Taagepera index and this is the inverse of the Herfindahl index of the size of political parties.

Fig. 3 shows the absolute and the effective number of political parties in the council during election years.

This shows the increasing Dutch political fragmentation in the last decades especially in the effective number of political parties. This increased from 3.6 in 2002 to 4.6 in 2014.

3.3. Socio-economic variables

As suggested by Kinnaman and Fullerton (2000), population density (the number of inhabitants per hectare), income and household size are included in the estimations. Kinnaman and Fullerton (2000) expected communities with lower population density to have less unit-based pricing. It could be argued that with lower population density the opportunities to dump waste might be larger. In addition, Gradus et al. (2019) show that US local governments with poorer inhabitants have more unit-based pricing as in such case waste fees are smaller. Interestingly, Gradus et al. (2019) found strong results that municipalities with a large household size are less willing to introduce unit-based pricing, as large families oppose marginal pricing more as they produce more waste. To test this for the Netherlands, we include also a household size variable. In Homsy and Warner (2015), based on data from 1497 US municipalities, it was shown that large cities and rural areas have a higher adoption of environmental policies. To test this effect, the number of inhabitants are included as exogenous variable.¹⁹

Data for the number of inhabitants, population density, income and household size come from Statistics Netherlands (CBS). Institutional data on unit-based pricing have been derived from Agentschap NL. We have data for the years 1999–2017 and 7652 observations. See Table 4 for descriptive statistics and the Appendix A for the variable definitions.

4. Results

4.1. Basic model

Table 5 show the estimation results for the three endogenous variables. Hereby, we estimate two separate logit models per endogenous variable. In the first logit model we include socio-

Fig. 3. Absolute and effective number of political parties.

economic variables, two fragmentation indexes (one for the council and one for the board), and the share of seats of political parties in the council. In the year of the election (1998, 2002, 2006, 2010 and 2014), the results for the previous election are taken.²⁰ In the second logit model we replace the share of seats by the share of aldermen. To test for lack of fit, we apply the Andrews goodness-of-fit test (Andrews, 1988). If the test is passed, the hypothesis that the model is not correctly specified is rejected.

If shifts to a (greener) UBP system are investigated (switch_green in Table 5), most socio-economic variables, the fragmentation index for the council and a number of political variables, especially for the council, are significant (at least at the 5 percent level). Except for the political variables, the difference between council estimation and aldermen estimation is small. In council estimation, the population variable is negative and significant (at the 1 percent level), so that smaller municipalities have a larger probability of becoming green. In aldermen estimation, this effect is still available, although it is less significant (at the 10 percent level). For income strong results occur and this is in line with Kinnaman and Fullerton (2000) and Gradus et al. (2019) show for US. Also in the Netherlands, municipalities with less income per capita have a larger probability of waste pricing. Also, for household size we get some significant results. In the case of the council, we find a negative and significant effect (at the 5 percent level). However, in the case of the board, we find only a significant effect at the 10 percent level, although the sign is in accordance with our hypothesis.

Interestingly, for council fragmentation we find a significant (at the 1 percent level) and negative sign, so less fragmented councils have a higher probability of becoming greener. For a fragmented board of aldermen, we do not find this effect. This indicates that the decision about the waste pricing system is mainly made by the council. For political variables, less evidence is found. Only the attitude of the Progressive Liberals in the council towards a greener municipality turns out to be positive and significant at 1 percent (compared with local parties, which are the reference group), whereas the attitude of the Socialist Party turns out to be

¹⁹ To test for nonlinear scale effects, the squared number of inhabitants is tested as well. None of the squared variables is significant. We report therefore only the linear results. Also if the logarithm of inhabitants is used, similar results occur.

²⁰ It should be noticed that by taking the year before the possibility of endogeneity between waste pricing and political outcomes is tackled as well.

Table 4
Descriptive statistics.

	Mean	Minimum	Maximum	Std. Dev.	Observations
Switch_green	0.024	0.00	1.00	0.15	7652
Switch_lessgreen	0.004	0.00	1.00	0.06	7652
Switch_frequency	0.014	0.00	1.00	0.12	7652
Inhabitants	37.56	0.93	844.95	60.29	7652
Population density	0.71	0.003	5.35	0.86	7652
Household size	2.43	1.66	3.68	0.21	7652
Income_cap	31.66	17.50	68.12	4.03	7652
Pol_frag_council_basis	0.29	0.05	0.60	0.09	7652
Pol_frag_board_basis	0.89	0.25	2.00	0.21	7652
Pol_frag_council_#	6.02	1.00	12.00	1.73	7652
Pol_frag_board_#	2.95	1.00	7.00	0.88	7652
Pol_frag_council_c	4.07	0.80	9.22	1.37	7652
Pol_frag_board_c	2.80	1.00	6.00	0.83	7652
Council_PvdA	0.16	0.00	0.53	0.10	7652
Council_GL	0.04	0.00	0.38	0.05	7652
Council_D66	0.04	0.00	0.31	0.06	7652
Council_SP	0.02	0.00	0.43	0.05	7652
Council_CU	0.04	0.00	0.42	0.06	7652
Council_SGP	0.03	0.00	0.42	0.07	7652
Council_CDA	0.21	0.00	0.74	0.09	7652
Council_VVD	0.16	0.00	0.52	0.08	7652
Ald_PvdA	0.19	0.00	1.00	0.19	7652
Ald_GL	0.03	0.00	0.50	0.09	7652
Ald_D66	0.04	0.00	0.50	0.10	7652
Ald_SP	0.01	0.00	0.60	0.06	7652
Ald_CU	0.04	0.00	0.67	0.10	7652
Ald_SGP	0.03	0.00	0.67	0.09	7652
Ald_CDA	0.25	0.00	1.00	0.19	7652
Ald_VVD	0.17	0.00	0.75	0.18	7652

Table 5
Estimation results different switches.

	Switch_green		Switch_lessgreen		Switch_frequency	
	Council	Aldermen	Council	Aldermen	Council	Aldermen
Inhabitants	−0.01***	−0.01*	−0.02*	−0.03**	−0.01	0.00
Population density	−0.29*	−0.26*	0.07	0.21	−0.48**	−0.42*
Household size	0.55**	0.45*	0.16	−0.49	0.23	0.03
Income per capita	−0.10***	−0.09***	−0.14***	−0.10**	−0.10***	−0.09***
Pol_frag_council_basis	−4.61***	−3.90***	−2.92	−3.26	−3.80**	−3.51***
Pol_frag_board_basis	−0.71*	−0.40	−1.07	−1.52	0.28	0.63
Council_PvdA	−0.94		−4.45**		−2.19*	
Council_GL	−1.27		8.14**		−0.01	
Council_D66	6.05***		−0.17		5.43***	
Council_SP	2.53*		2.94		1.40	
Council_CU	0.54		1.21		−1.60	
Council_SGP	1.32		1.22		2.26	
Council_CDA	0.84		2.65		−0.75	
Council_VVD	0.00		2.71		−1.23	
Ald_PvdA		−0.40		−1.52		0.63
Ald_GL		−1.00**		0.23		−1.72***
Ald_D66		−0.72		1.98		−0.48
Ald_SP		1.12		−		0.73
Ald_CU		1.25		0.00		−0.17
Ald_SGP		0.07		3.32**		−0.39
Ald_CDA		−0.92		−0.84		−0.57
Ald_VVD		0.40		3.51***		−0.63
Andrews statistic	17.98	21.29	1,136.02	1,829.88	41.34	26.64
- probability	0.06	0.02	0.00	0.00	0.00	0.00

Note: ***/**/* means significance at 1%/5%/10%.

positive and significant at 10 percent. Interestingly, for Green Left no significant results are found in council estimation. For the council estimation we even found a negative effect for Green Left. It should be noticed that this occurs only in the less_green estimations, where the number of switches is relatively small.

When shifts to a less green UBP system are investigated (switch_lessgreen in Table 5), also income and a number of political variables are significant and political fragmentation is not significant anymore. Interestingly, the sign for income is similar to the sign for a shift toward a greener municipality. For poorer

municipalities it seems also difficult to move back, reinforcing the argument that financial motives are quite important when citizens are relatively poor. For Social Democrats we found a negative and significant effect. Surprisingly, the attitude of the Green Left in the council turns out to be positive and significant (at the 5 percent level). For aldermen, we find that municipalities with more Conservative Liberals and Reformed Political Party aldermen have a higher probability of shifting to a less green policy. In general, aldermen of these parties are more conformist than ideologically motivated (see also Boogers and Voerman, 2010).

When shifts to the frequency-based system are investigated (switch_frequency in Table 5), the estimations for most variables are similar to the shifts to a greener system and therefore we only focus on the differences. The population density variable is now significant (at the 5 percent level in the council estimation and 10 percent level in the aldermen estimation). It seems that the frequency-based system is more acceptable for less densely populated municipalities. It might be that the households of these municipalities have more space to put down several containers (see Dijkgraaf and Gradus, 2004). With respect to political variables the effect for the number of council seats for the Progressive Liberals still exists giving an indication that this party is in favor of unit-based pricing.

So, it seems that poorer and less council fragmented municipalities are more willing to shift towards a (greener) unit-based pricing system. For political parties some (but less) evidence is found. Only for Progressive Liberals (positive) do we find more robust effects. In addition, for poorer municipalities it seems more difficult to move back to a less green UBP system as well. It seems that frequency-based pricing systems have been introduced more in less densely populated areas as this gives more opportunities to place containers.

4.2. Other fragmentation indexes

As we get some strong results for fragmentation in Table 5, we test the robustness of our results by including some other fragmentation indexes. In Table 6, we measure fragmentation by the absolute number of political parties in the council or the board of aldermen. In Table 7, we measure fragmentation by the effective number of political parties.

Remarkably, most results in Table 6 are similar to Table 5. Let us focus on the differences. If shifts to a greener UBP system are investigated, we get some weaker results for the population variable, which is no longer significant. In addition, for household size we obtain weaker results, as it now is no longer significant. If shifts towards a greener UBP system are investigated, the Social Democrats are now significant and negative. If shifts towards a frequency system are investigated, the Social Democrats are also

significant and negative. Interestingly, for Social Democrat's aldermen we see the opposite, however only in case of switch_frequency. For switch_frequency we also find a positive and significant effect for the political fragmentation of aldermen. In case of fragmentation measured by the effective number of political parties (see Table 7), one important difference is notable: in none of the estimations political fragmentation of the council is significant.

To conclude, income per capita is robust and it implies that municipalities with poorer inhabitants are more willing to introduce unit-based pricing. Also, for council fragmentation we found rather robust effects except for the effective number of parties. So, there is evidence that less fragmented Dutch municipalities change more to waste pricing. For the shifts towards a frequency-based system also population density is robust, so that less densely populated municipalities change more towards this system. Finally, less evidence is found for political variables. Social Liberals councilors are in favor of unit-based pricing and to a lesser extent Social Democrats councilors are against it. For aldermen less robust effects are found.

5. Conclusions and discussion

Dutch municipalities have increasingly implemented unit-based user fees for unsorted waste. It is shown that between 1999 and 2017, in 35 percent of Dutch municipalities a shift took place, mostly to a greener system (84 percent), with fewer to a less green system (16 percent). In 2017, 45 percent of municipalities had a unit-based pricing system, of which 24 percent had a frequency-based system.

Based on logit models, income and fragmentation of the council are important for explaining shifts toward a unit-based pricing system. Interestingly, poorer municipalities are more eager to introduce such a system. Remarkably, poorer municipalities also less eager to switch back as this leads to higher costs. In addition, we found evidence that political fragmentation decreases the ability to introduce unit-based pricing, although for the effective number of political parties we did not find significant effects. Some evidence is found for political parties as well. In particular, the share

Table 6
Estimation results different switches (number of parties in board and council as fragmentation indicator).

	Switch_green		Switch_lessgreen		Switch_frequency	
	Council	Aldermen	Council	Aldermen	Council	Aldermen
Inhabitants	0.00	0.00	−0.01	−0.01	0.00	0.00
Population density	−0.26*	−0.24	0.08	0.21	−0.47**	−0.43**
Household size	0.28	0.19	−0.15	−1.02*	0.06	−0.14
Income per capita	−0.11***	−0.11***	−0.15***	−0.12**	−0.11***	−0.10***
Pol_frag_council_#	−0.19**	−0.16**	−0.31	−0.34**	−0.18*	−0.15*
Pol_frag_board_#	0.08	0.22*	0.27	0.43	0.33***	0.51***
Council_PvdA	−1.89**		−4.59**		−2.73**	
Council_GL	−1.89		8.11**		−0.64	
Council_D66	5.46***		−0.20		5.08***	
Council_SP	2.43*		3.06		1.19	
Council_CU	0.24		1.05		−1.80	
Council_SGP	0.67		1.05		1.76	
Council_CDA	0.68		2.54		−0.73	
Council_VVD	−0.70		2.08		−1.70	
Ald_PvdA		0.22*		0.43		0.51***
Ald_GL		−1.57***		−0.17		−2.28***
Ald_D66		−1.84		0.99		−1.78
Ald_SP		0.33		−		−0.21
Ald_CU		0.71		−2.45		−0.83
Ald_SGP		−0.46		2.95*		−1.12
Ald_CDA		−1.78*		−1.75		−1.47
Ald_VVD		0.11		3.84***		−0.90
Andrews statistic	15.63	18.74	1,402.54	1,700.34	17.21	664.25
– probability	0.11	0.04	0.00	0.00	0.07	0.00

Note: ***/**/* means significance at 1%/5%/10%.

Table 7

Estimation results different switches (effective number of parties in board and council as fragmentation indicator).

	Switch_green		Switch_lessgreen		Switch_frequency	
	Council	Aldermen	Council	Aldermen	Council	Aldermen
Inhabitants	0.00	0.00	−0.01	−0.01	0.00	0.00
Population density	−0.27*	−0.28*	0.07	0.21	−0.47**	−0.46**
Household size	0.30	0.19	−0.13	−0.95	0.08	−0.15
Income per capita	−0.12***	−0.12***	−0.16***	−0.12***	−0.12***	−0.12***
Pol_frag_council_c	0.00	0.06	−0.24	−0.25	0.04	0.06
Pol_frag_board_c	−0.04	0.08	0.09	0.16	0.23	0.43***
Council_PvdA	−2.72***		−5.03***		−3.84***	
Council_GL	−3.57*		7.79**		−2.49	
Council_D66	4.84***		0.40		3.96*	
Council_SP	1.63		3.03		0.11	
Council_CU	−0.49		1.31		−3.00	
Council_SGP	0.08		1.12		0.85	
Council_CDA	0.60		2.77		−0.96	
Council_VVD	−0.77		2.74		−2.12	
Ald_PvdA		0.08		0.16		0.43***
Ald_GL		−2.03***		−0.26		−2.83***
Ald_D66		−2.24*		1.12		−2.22
Ald_SP		−0.09		–		−0.76
Ald_CU		0.23		0.00		−1.47
Ald_SGP		−0.90		3.08*		−1.73
Ald_CDA		−2.37**		−1.42		−2.21*
Ald_VVD		−0.07		3.74***		−1.16*
Andrews statistic	12.49	25.00	777.76	997.42	12.49	777.39
- probability	0.00	0.00	0.00	0.00	0.25	0.00

Note: ***/**/* means significance at 1%/5%/10%.

of seats in the council for a left-wing party such as the Progressive Liberals (positive) and Social Democrats (negative) are important to explain whether a greener unit-based pricing system is introduced. Interestingly, less (and in some cases even opposing) evidence is found for Green Left, although their size is relatively small in the Netherlands. This might indicate that this finding is not reliable. For the number of aldermen and their political affiliation, less evidence is found.

For other socio-economic variables, we also get some interesting results. It seems that population density is a driver for choosing a frequency-based pricing system. Less densely populated municipalities are more willing to introduce a greener unit-based pricing system. In accordance with our prior, we found that municipalities with a large household size are less willing to introduce unit-based pricing and also to switch it back.

Let us further discuss these conclusions. As waste pricing leads to lower waste fees, this seems an important driver for implementing these schemes in poorer municipalities. Interestingly, in recent years the Dutch number of municipalities with a frequency-based pricing system has risen considerably, as the administrative costs are relatively low and the reductions in unsorted waste is still sizeable. Smaller places in the Netherlands tend to adopt more unit-based pricing for waste, in contrast to the United States where smaller municipalities lag across a range of sustainability policy adoption (Homsy and Warner, 2015). As the Netherlands is one of the most densely populated countries in the world, this may explain the higher use of UBP compared to the US where small communities are more likely to be rural.

Introducing these fees has been motivated by green behavior as it gives citizens an incentive to better sort recyclables and to reduce unsorted waste. However, most results show weak evidence that political ideology influences the adoption of variable waste fees. There is evidence that municipalities with more political fragmentation were less likely to adopt effective unit-based pricing programs. This is in line with most scholars who have investigated similar problems on budgeting and outsourcing, and show that political fragmentation decreases the ability to take “tough” decisions (Warner and Hefetz, 2002; Goeminne et al., 2008). For the Netherlands, we find furthermore that fragmenta-

tion of the council is more influential than fragmentation of the board. This indicates that the decision about the waste pricing system is mainly made by the council.

The debate on the impact of waste fees on illegal disposal is still open as data on illegal dumping are not readily available. It is shown that illegal disposal may be an issue in the Netherlands as some early innovators, such as the municipality of Oostzaan, moved back to a flat system due to illegal disposal. By contrast, in the Swiss city of Lausanne, Carattini et al. (2018) show that four years after the introduction of a unit-based pricing system, illegal disposal remained a minor issue.

There are many avenues to explore for future research. In our estimations, less evidence is found for fragmentation of the board compared with the council. Therefore, it would be interesting to study in more detail the decision-making process for unit-based pricing of waste in the Netherlands. Second, an interesting issue to study is also the decision process for unit-based pricing systems in certain delivery forms. In Dijkgraaf and Gradus (2008) based on data until 2005, the penetration of unit-based pricing systems in public delivery is less, but it would be worthwhile to update this data. Third, it is important to collect more detailed information on other environmental decisions as well. In addition, Dijkgraaf and Gradus (2017) show an increasing number of municipalities with curbside collection of recyclables and special types of containers. In some municipalities, curbside collection of recyclables has expanded and households have to bring unsorted waste to pick-up points. Although based on 2007–12 data, there are indications that raising this frequency is not very effective; it would be worthwhile collecting data for a longer period and matching it with data for political fragmentation. Fourth, this would also provide an opportunity to study the interrelation between unit-based pricing systems and, for example, mandatory recycling, as has been done by Yang and Innes (2007). Finally, one municipality's decisions could be influenced by those of a neighboring municipality (Zafra-Gómez and Chica-Olmo, 2018). This could be tested using spatial models, although we have some indication for waste costs that this effect is not strong (Gradus et al., 2018). However, we could not test this as we have no complete data for the necessary distances between municipalities.

Appendix A. Variable definitions

Switch_green	Dummy with value 1 (and zero otherwise) if municipality moves to a greener UBP system (in the order Flat, Volume, Frequency, Bag, Weight)
Switch_lessgreen	Dummy with value 1 (and zero otherwise) if municipality moves to a less green UBP system (in the order Flat, Volume, Frequency, Bag, Weight)
Switch_frequency	Dummy with value 1 (and zero otherwise) if municipality moves to a frequency UBP system
Income (/1000)	Average spendable income per capita in Euro's (/1000)
Inhabitants (/1000)	Number of inhabitants per 1 January (/1000)
Population density	Number of inhabitants divided by surface area of municipality
Household size	Number of inhabitants divided by number of households
Pol_frag_council_basis	Number of parties in municipal council divided by number of seats
Pol_frag_council_#	Number of parties in municipal council
Pol_frag_council_c	1 divided by the sum of squared shares of parties in municipal council
Pol_frag_board_basis	Number of parties in municipal board divided by number of aldermen
Pol_frag_board_#	Number of parties in municipal board
Pol_frag_board_c	1 divided by the sum of squared shares of parties in municipal board
Council_PvdA	Share in total number of seats in council from PvdA
Council_GL	Share in total number of seats in council from Green Left
Council_D66	Share in total number of seats in council from D66
Council_SP	Share in total number of seats in council from SP
Council_CU	Share in total number of seats in council from CU
Council_SGP	Share in total number of seats in council from SGP
Council_CDA	Share in total number of seats in council from CDA
Council_VVD	Share in total number of seats in council from VVD
Ald_PvdA	Share in total aldermen from PvdA
Ald_GL	Share in total aldermen from Green Left
Ald_D66	Share in total aldermen from D66
Ald_SP	Share in total aldermen from SP
Ald_CU	Share in total aldermen from CU
Ald_SGP	Share in total aldermen from SGP
Ald_CDA	Share in total aldermen from CDA
Ald_VVD	Share in total aldermen from VVD

Appendix B. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.wasman.2019.03.059>.

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