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Distance and Incentives Matter: The Separation of Recyclable Municipal Waste

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Creation date: 20. 5. 2015

Revision date: 18. 7. 2016

Working paper WP KVE – 01/2016

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Acknowledgements: This article is an outcome of specific research projects no. MUNI/A/1047/2015 and GA15-08032S. We wish to express our gratitude to all of the municipal representatives who provided us with the data regarding their municipal solid waste management. Further thanks go to Martin Dlouhý, Martin Guzi and the colleagues at the department for the suggestions on improving this paper. Preliminary version was presented at the ICEE 2015 conference.

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Abstract

Municipal solid waste represents an increasing environmental issue in modern societies. One way of reducing this waste would be higher separation rate. Multiple studies identify the availability of infrastructure for waste separation facilities (resulting in higher convenience) as the most important factor affecting the willingness to separate. In this paper we compare the effects of two common systems of waste separation: drop-off sites collection and kerbside collection represented by the sack collection. We follow the idea that if reaching the separation site requires less effort, people are more likely to separate and our results prove this. We show that with drop-off sites the paper and plastics separation rate of total municipal solid waste is 7-8%; with kerbside collection system 9-10%. If we add an incentive program, the separated paper and plastics rate can reach more than 15%, which represents a significant increase of the separation rate. Additionally, higher density of drop-off sites can also increase separation rate, but the effect is relatively low, and this approach is often not economical.

Keywords:

Municipal Solid Waste, Recycling, Separation, Kerbside Collection

JEL classification: Q53, H41, R11

CONTENT

Introduction

Municipal solid waste (MSW) is a constant problem for modern societies. The usual method of dealing with the generated MSW in the past was to dump it in a landfill somewhere outside of town. While many western countries began to depart from this approach, in less developed countries this landfilling approach still dominates, which in "out of sight, out of mind" culture often results in the population having very little idea of how much waste is actually produced. The actual MSW generation per capita in the European Union was in recent years around 500 kg (Eurostat, 2014). When considering the environmentally friendly strategies of dealing with MSW, there are generally two available approaches: waste reduction and waste recycling. In waste reduction, the goal is to generate as little waste as possible; in waste recycling, the goal is to recycle as much of the generated waste as possible. The best results are achieved logically by the combination of both.

In this paper we focus only on the second mentioned environmentally friendly strategy, which is waste recycling. The recycling industry has developed significantly over the past decades and today people are often able, without much effort, to practically generate no unrecyclable waste. Civic amenity (CA) sites today offer the possibility of recycling all kinds of waste, from paper, plastics, and glass through biodegradable waste, metals, WEEE (electronic waste), and wood to oils, bulky waste, and various hazardous waste. Especially in larger municipalities, the possibilities for recycling are often almost luxurious.

But the sole availability of facilities where people can discard recyclable waste does not mean that people will start separating generated waste. As Williams and Taylor (2004) put it, the public needs to be educated in order to think of waste as a resource rather than as materials that just need to be thrown away. Kirakozian (2015) provides a comprehensive literature review of the factors affecting household waste recycling. These factors are usually obtained by conducting various questionnaires or interviews among people. Derksen and Gartrell (1993) concluded that probably the most important determinant of recycling behaviour is access to a structured and institutionalized program that makes recycling easy and convenient. The availability of a recycling facility, ease of use, and little effort needed in order to recycle are also indicated as

important factors by Chen and Tung (2009), Oskamp et al. (1991), or McCarty and Shrum (1994). Instead of convenience, some authors, such as González-Torre and Adenso-Díaz (2005) and Belton et al. (1994) mention distance (proximity) to the waste separation facility, but this is in our opinion only a different way of expressing the level of convenience, or the effort needed, although the distance factor might be easier to grasp. Ayalon et al. (2013) provide a comprehensive study of these factors using international survey data.

There are several types of separated waste collection systems, ranging from those far from the waste source and thus inconvenient for the people considering recycling, to those that are right at the waste source and thus a providing a much more convenient solution. According to the observations of many authors, such as Williams and Taylor (2004), González-Torre and Adenso-Díaz (2005), Domina and Koch (2002), Perrin and Barton (2001), Hage et al. (2009), and Ando and Gosselin (2005), people are more likely to separate if they have a more convenient system available, and they are more likely to separate waste if the facility is close, as the short distance requires less effort.

The available types of waste separation infrastructure can be divided into groups based on the level of recycling convenience they provide. González-Torre and Adenso-Díaz (2005) begin with the least convenient and most expensive collection system for separated waste – civic amenity (CA) sites (sometimes referred to as Household Waste Recycling Centre – HWRC). The CA site usually consists of a fenced area with multiple containers for various types of recyclables and has one or more attendants who help people separate their waste correctly. Although this system offers a high quality of separation service, it is also limited by the high investment costs, spatial demand, and the need for an attendant. Therefore CA sites are rarely seen in smaller municipalities that are unable to finance such facilities. Even in relatively large municipalities, there is often only one CA site. As Schultz et al. (1995) note, from the municipal perspective the separation of waste at one central site is the best solution, as it is the least expensive option. However, from the perspective of citizens, this solution adds the personal costs of extra time and effort involved in the transportation of recyclables to the collection spot. Therefore, from the citizen's perspective, a CA site is neither preferred nor a convenient solution.

The second type of infrastructure for waste separation is a drop-off site, consisting of a set of large bins for the collection of various recyclables. These sites are usually in public places with easy access for collection trucks. Compared to CA sites they are much cheaper, smaller, and thus more common, making them logically closer to the waste source (dwelling or household).

The third type is kerbside collection of recyclables, representing a separation at the waste source – the household/dwelling. This is the most convenient type of separated waste collection system. A concrete example of such convenient and low-distance solution, requiring little effort to separate the waste, is the blue box recycling program in Canada (Derksen and Gartrell, 1993). This program involves the provision of a plastic bin that is usually positioned at the edge of the property and is used for collecting various recyclables such as paper, plastics, glass. The only effort required is to put the correct waste fraction it into the bin at the edge of the property. In any waste separation system, consumer collaboration is crucial to achieving a higher separation rate. With kerbside collection, the consumer (or the citizen) directly carries out the primary separation and thus reduces the increasing costs of separation later in the process of collection.

In the Czech Republic, the drop-off site is familiarly called a collection or a separation "nest". The kerbside collection system for recyclables has primarily form of a scheduled collection of coloured sacks filled with recyclables from the kerbside, and is often called a sack collection. Compared to the kerbside collection using bins, plastic sacks are for one-time use only, do not require as high initial investment, and can be easily manipulated with. On the other hand, given the nature of the sack, a limited type of recyclables can be collected with this method, with paper (including cardboard) and plastics being the most common. Separated glass is such cases usually collected through the exclusively glass drop-off sites.

Due to the fact that in the Czech conditions the kerbside collection is in most cases used for just paper and plastics separation, in our study we examine only the separation rates of these two types of recyclables. This results in rather low observed levels of separation rates, as paper and plastics represent only a part of all collected recyclables, while the total waste separation rate in the Czech Republic is much higher. According to

MŽP (2015) it is over 30% in the recent years, compared to 10% if considering just paper and plastics, as it includes additional recyclables like glass, yard waste, bulky waste, etc.

In addition to the distance and convenience factor, Schultz et al. (1995) mention several studies showing that introducing any kind of reward for recycling significantly increases the amount of material that people will recycle. Such behaviour was also observed by Williams and Taylor (2004). Introducing a reward related to the amount of separated waste generally greatly increases the amount of separated waste. In the Czech Republic, several municipalities have introduced an incentive program as a next step of the kerbside collection system. In some cases, these rewards can go as high as 50% of the regular yearly flat fee for each person in the household or dwelling. The actual level of the provided rewards, or in this case rather the discount from the usual flat user fee for waste collection, is determined by the amount of separated waste that a dwelling prepares for pick up. In order to correctly assign the amount of separated waste to the dwelling where it came from, people attach a sticker with a unique barcode for each dwelling to the sack, which is then scanned either when the sack is being collected (if the collection truck is equipped with a scale) or at the collection company facility where the sacks are weighed and then emptied. More details about charging programs for MSW collection in the Czech Republic can be found in Šauer et al. (2008) and Slavík and Pavel (2013).

Our research goal was to evaluate whether municipalities with shorter distances to the separated waste collection facility (kerbside collection, higher density of drop-off sites) and/or incentive program have higher separation rates for paper and plastics, and if so, by how much. As a measure we use the separated waste rate, representing the percentage of separated waste (paper and plastics) from the total separated plus residual waste, like for example Bucciol et al. (2015). Also, since it is common to have both a CA site and a drop-off site right next to each other, practically forming just one waste collection facility, we did not test the presence of a CA site as a factor affecting separation rate.

To reach our research goal, we tested the following three separate hypotheses: whether the presence of a kerbside collection system has a positive impact on the separation rate

(H_1); whether the presence of an incentive program has a positive impact on the separation rate (H_2), and whether a higher density of drop-off sites has a positive impact on the separation rate (H_3). Finally, we tested the joint hypothesis of the impacts of all these three factors together.

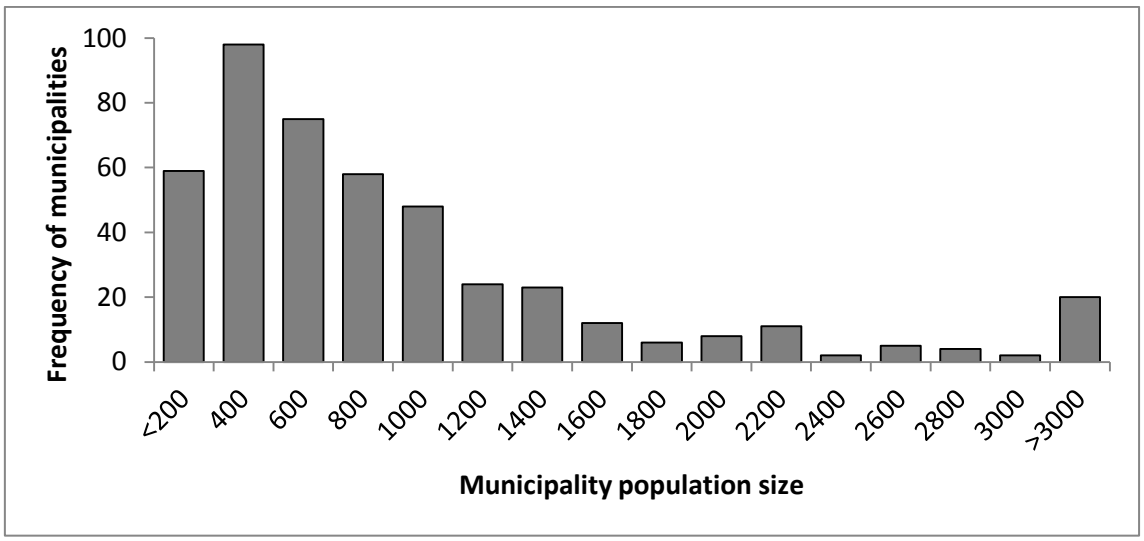
1. Material and Methods

In our research, we used data about the solid waste management of municipalities in the South Moravian Region in the Czech Republic. Our sample consists of 455 municipalities and the data about their solid waste management and other statistical information from 2012. The municipalities were selected based on the data they made available either by returning an email survey or by answering questions during a telephone call. Our sample includes municipalities from the smallest to relatively large ones in the region, as shown in the Figure 1. However, we do not include several largest municipalities, as from practical perspective, each of them represents a unique environment where individual measures in MSWM are often applied, even though some observations are identical regardless of the municipal size.

In our paper we combine qualitative and quantitative data. Quantitative data about municipalities were collected from the Czech Statistical Office, and the waste quantity data were acquired from ISOH – a Czech reporting system collecting data from the waste producers. Further quantitative and qualitative data, like number of drop-off sites in the municipality, presence of kerbside collection, or usage of an incentive program were collected directly from the municipalities (described later). These qualitative data were transformed into the dummy variables in order to use them in the subsequent analysis.

Frequency distribution of municipalities according to their population size in the Figure 1 shows that three quarters of municipalities in our sample (338 out of 455) have population under 1000, and one half has population under 600 (232 out of 455). Compared to the whole Czech Republic, with third quartile municipality population size being 889, and the median size 415, municipalities in our sample are slightly larger.

Figure 1: Frequency distribution of municipality population size of the sample



Source: Author using CZSO data

We collected most of the qualitative data during the telephone calls, when we contacted the persons specifically responsible for solid waste management in the municipalities. Most municipalities in the Czech Republic are rather small (the median population of municipality in our sample is 580, resp. 415 for the whole Czech Republic), with often only one or two part-time employees and a mayor, so there is usually no specialized position for a waste manager. Nevertheless, in all cases, if we were able to reach the municipality (smaller municipalities in particular have very limited office hours), we eventually reached a person with sufficient knowledge about MSWM (although sometimes a little encouragement from our side or a rescheduled telephone call was necessary), whether it was the mayor, the deputy mayor, or some other person with sufficient knowledge of their municipal solid waste management (MSWM). We prepared a standard set of questions about the municipal waste management; the calls usually lasted between 5-15 minutes (roughly 8-9 minutes on average). The majority of the telephone calls took place during the summer and early fall of 2014. Altogether we collected sufficient data for 455 municipalities (673 total in the region), with average population of 923 (median 580) and built-up area of 0.158 km2 (16 hectares). We use the built-up area instead of the total area (9.50 km2 average per municipality), as it represents the actual area where people live (not including the forests, lakes, meadows, etc.), which we see as a more relevant information. Furthermore, each municipality

contains on average 319 dwellings, and 4.12 drop-off sites. Alternatively it is 4.47 sites per 1000 population, resp. 12.94 sites per 1000 dwellings, or 0.26 sites per hectare. More details are provided in the Table 1.

Table 1: Descriptive statistics of the municipalities in the sample

455 municipalities (2012 values)	Bottom value	1st quartile	Median	3rd quartile	Top value	Average
Population	37	301	580	1027	21681	923
Dwellings	14	107	196	340	8456	319
Area (ha)	42	503	783	1215	5484	950
Built-up area (ha)	1.5	7.2	11.7	18.2	212.3	15.8
Drop-off sites	0	2	3	5	113	4.1
Drop-off sites per built-up ha	0	0.17	0.26	0.37	1.74	0.29
Residual MSW (t)	9	59	117	223	4123	196
Residual MSW per capita (kg)	64	170	208	242	1505	219
Paper and plastics (t)	0	4	9	21	642	20
Paper and plastics per capita (kg)	0	11	16	23	84	18

Source: Author using CZSO, ISOH and own data

We point out the top residual MSW per capita value of 1505 kg, which is very high compared to the rest. The reason behind it is that the given municipality has permanent population of approximately 50, but also additional more than 200 recreational dwellings within the cadastre. Therefore the actual amount of people generating waste is much higher than the official count, leading logically to the very high per capita values (using the permanent population). The second highest value, around 1000 kg per capita, was reported in municipality that has a landfill within its cadastre, and the waste management company made a deal to take complete care of the MSWM in this municipality without requiring any payments. As a result, people there generate as much waste as they like, because they are not charged for it in any way, and even people from other municipalities bring in their waste, avoiding charges in their municipality. Besides these two, the highest per capita values were up to 700 kg.

In this study we did consider only municipal solid waste (waste generally produced by households in the municipalities). We did not consider industrial and commercial waste, which in many developed countries account for the majority of total generated waste. In

the Czech Republic in 2012 was the percentage of the municipal waste approximately 17% of the total waste. Compared to the MSW, industrial and commercial waste streams seem to be notably better developed, as the utilization of this waste was in recent years close to 80%, compared to less than 50% of MSW, and also the landfilling rate of industrial and commercial waste slightly over 10%, compared to more than 50% in case of MSW (MŽP, 2015). From this comparison it is clear that there exists much more room for improvement in case of MSW than in case of industrial and commercial waste. The reasons are both the industrial and commercial waste legislation which is more stringent, and that it is much easier to clearly identify the producer of this waste, unlike with the municipalities, where the producers are the households. Also in case of industrial and commercial waste the payments for waste treatment are notably higher, creating much stronger incentives for the companies to take better care of their waste.

To pursue our research interest and test the related hypotheses, we used simple statistical methods for the comparison of municipalities, and OLS regression technique for estimating the effects of selected variables on the paper and plastics separation rates. We did not cover other types of recyclables, such as glass and yard waste, as these types of waste were not typically collected through kerbside collection in 2012, as explained earlier. If we included them, the total separation rates would be significantly higher, as glass and yard waste are much heavier types of waste compared to plastics or paper.

One of the MSWM characteristics we examined is the presence of an incentive program. In the analysed sample it is dominantly represented by a "reversed" PAYT scheme (Pay-as-you-throw). In the usual PAYT scheme households (units that generate waste) are charged based on the amount of waste they produce – each additional generated waste unit is charged with an additional fee. For more detail on PAYT scheme see Bilitewski (2008) or Dijkgraaf and Gradus (2004). Although this charging method is generally perceived as more just, it has also drawbacks. As multiple studies like Fullerton and Kinnaman (1996) or Bucciol et al. (2015) add, such scheme can lead to the unwanted behaviour like waste stomping, illegal dumping, waste burning, etc.

The incentive system used by the municipalities in our sample overcomes such negatives, as it rewards households based on how much waste they separate, not how much waste they generate. Therefore the households are less likely to exhibit mentioned

inappropriate behaviour. Initially a household pays full annual fee for MSWM. Throughout the year the household actively participates in waste separation that occurs through kerbside collection of recyclables or bring-in, using either sacks or reusable bins. Separated waste is matched to the producing household using stickers with barcodes, house numbers, or some other matching system. Based on the final amount of collected recyclables for each household and after the comparison among them, each household gets a discount from the MSWM fee for the following year. Such discount can be quite significant, as the best households can save up to 70% of the annual fee, according to some local authorities. However, sufficient communication campaign is required to make people understand how the new incentive program works, and also it usually takes a year or two for the people to get familiar with it, in order to achieve good results in waste separation rates.

We have found evidence of comparable incentive program only in Shaw and Maynard (2008), where it was mentioned as one of the possibilities that a municipality was offering to the citizens when designing waste management system. In our opinion, incentives towards reducing waste and increasing separation have a great potential (as shown by our results later), but besides variations of PAYT we have found very little about alternative approaches.

Other minor incentive programs in our sample include a standard PAYT, where households pay per collected residual waste bin, extra fee for each additional bin collection, or a waste fee differentiation depending on the chosen waste collection frequency (practically realized, for instance, by different colour of the sticker on the bin, so the waste collector can clearly identify the bins to collect).

After the necessary transformation of the qualitative data into dummy variables, we used the following variables in our regression analysis:

- Separation rate (dependent variable) – the percentage of separately collected paper and plastics waste fraction in the municipality from the total generated municipal solid waste (including residual waste, recyclables waste fraction, etc.
- Kerbside collection (independent variable) – a dummy variable, 1 if municipality was using kerbside collection for the separate collection of paper and plastics waste fractions, 0 if not

- Incentive program (independent variable) – a dummy variable, 1 if municipality was using some kind of incentive program in order to increase the separate collection of recyclable waste fractions, 0 if not
- Drop-off site density (independent variable) – amount of drop-off sites in the municipality per hectare of built-up area, amount of drop-off sites based on the information provided by the local authorities

2. Results

First we show the results of a statistical analysis of our sample of municipalities divided into the three categories based on their recyclables collection system.

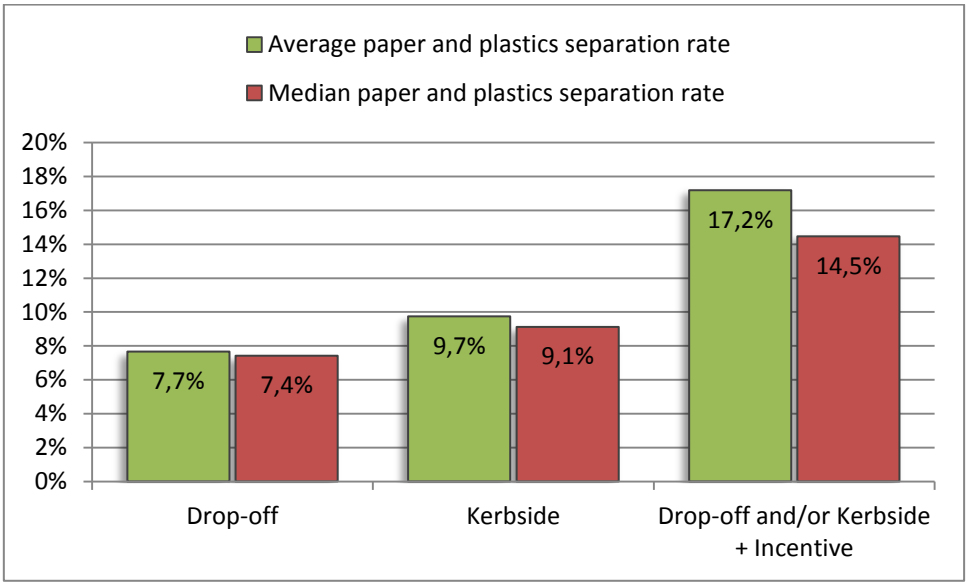
The first category contains municipalities that use only drop-off sites and no kerbside collection or incentive program. 380 municipalities in total were in this category, with average paper and plastics separation rate of 7.7% (median 7.4%). As practically every municipality in our sample has either drop-off sites or kerbside collection of recyclables (due to the legislative requirements), we did not examine separation rates in municipalities without such facilities.

The second category contains municipalities that use only kerbside collection system for paper and plastics but no incentive program or drop-off sites. There were 7 municipalities in this category, with an average paper and plastics separation rate of 9.7% (median 9.1%). This suggests that kerbside collection of paper and plastics has higher potential for waste separation, although the sample is rather small – most of the municipalities that have kerbside collection combine it with drop-off sites at some more exposed sites (55 in our sample). However, we need to mention that the kerbside collection is generally more expensive than drop-off sites, and thus having only kerbside collection instead of drop-off sites might not be economical, unless the higher separation rates and related convenience compensate the increased costs.

The third category contains municipalities that implemented some kind of incentive factor with either drop-off sites or kerbside collection. There were 10 municipalities in this category, with an average separated paper and plastics rate of 17.2% (median 14.5%). Compared to the municipalities with just drop-off sites and/or kerbside

collection, this is a notable increase in the achieved separation rate, showing the potential of incentives.

Figure 2: Average and median paper and plastics separation rates



Source: Author

If we look at the municipalities that have both kerbside collection and drop-off sites together with incentive program, average paper and plastics separation rate for these 6 municipalities was 21.0%. Compared to the municipalities with just drop-off sites, this represents an almost triple increase in the average separation rate.

We continued with the econometric analysis and tested our three hypotheses:

- Municipalities with kerbside collection system have higher separation rate (H_1)
- Municipalities with incentive program have higher separation rate (H_2)
- Municipalities with higher density of drop-off sites have higher separation rate (H_3)

We tested each hypothesis separately and then we tested the joint hypothesis that can be formally written as

$$separation\ rate = \beta_0 + \beta_1 kerbside + \beta_2 incentive + \beta_3 drop - off\ density + \varepsilon$$

Results of the econometric models are in the Table 2. The calculated adjusted R^2 values were rather low, but the significance of the examined factors was very strong in all

cases. As we were using relative values and dummy variables in the analysis, OLS technique was a sufficient estimation method.

Table 2: Estimated effects of collection systems and incentives on separation rates (in %)

	Kerbside collect. model	Incentive program model	Drop-off sites density model	Joint model
Kerbside collection	2.88866*** (0.650948)			2.63010*** (0.645375)
Incentive program		9.26468*** (1.55733)		8.03539*** (1.54823)
Drop-off sites density (per hectare)			3.20662*** (1.16050)	3.94619*** (1.11524)
Constant	7.70156*** (0.251649)	7.92965*** (0.230874)	7.19501*** 0.413008	6.40894*** (0.418391)
No. of observations	455	455	455	455
Adj. R^2	0.039	0.070	0.014	0.099

*, **, *** stand for statistical significance of the coefficient at 10%, 5%, 1%; standard errors in parentheses

The results of an OLS regression reveal something like a base level of separation rate of paper and plastics to MSW within the examined sample at approximately 7% (represented by a constant). This can be interpreted as that if there is a drop-off site in the municipality (98% of the municipalities in our sample have at least one drop-off site), the paper and plastics separation rate in the municipality would be at this level.

The first model tests H_1. Our results indicate that kerbside collection increases separation rate by 2.9%. Considering the base level of separation represented by the constant (7.7%), this means that a kerbside collection system increases the paper and plastics separation rate by almost 40%. Multiple studies, for instance Ashenmiller (2011), Dahlén et al. (2007), or Dahlén and Lagerkvist (2010), confirm significant impact of door to door separation systems on waste separation (in this case similar to the kerbside collection), and estimate the increase in separation rates of up to 100%. Our acquired result is statistically significant and this factor has a strong impact on the overall municipal separation level. We confirm H_1.

The second model tests H_2. Our results indicate that incentive program increases separation rate by 9.3%. This makes the total separation rate more than double than the base rates, represented by the constant (7.9%). An incentive program is generally accompanied by a kerbside collection system, which is often perceived as a necessary

step for introducing an incentive program. Allers and Hoeben (2010) or Bucciol et al. (2015) identified the positive impacts of incentive programs as well, with the latter calculating the combined effect of kerbside collection and incentive on the separation rate to be almost 17%, although additional recyclables were included in the study. Our result is statistically significant and has an even stronger impact on the overall municipal separation level than the previous factor. We confirm H_2.

The third model tests H_3. Our results indicate that additional drop-off site per built-up hectare of municipal area increases separation rate by 3.2%. A density of one drop-off site per built-up hectare is in practice quite high; in our sample is the average density 0.29 sites per hectare of built-up area, resp. one drop-off site per area of a circle with 105 m radius. Therefore, achieving notable increase in separation rates by adding further drop-off sites might not be very economical, as, especially in larger municipalities, a lot of additional sites are needed. First few drop-off sites tend to work well, but with increasing density, especially in small municipalities, average yields of the sites decrease very fast. Again, acquired result is statistically significant, but the examined impact is not very strong in practice compared to the previous factors. We confirm H_3.

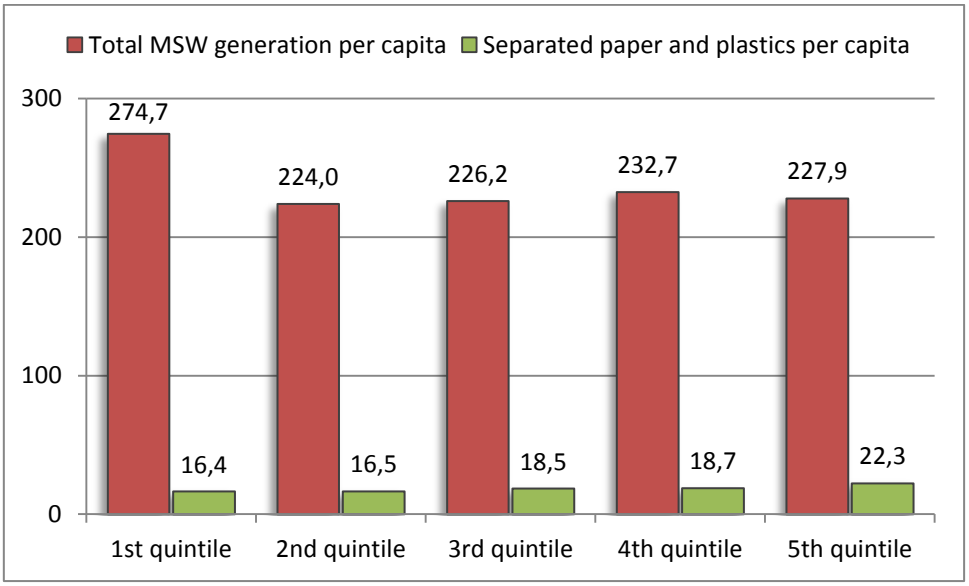
The final joint model includes all three examined factors together. It shows again that all of the examined factors are statistically significant. Based on this model it is possible to estimate the paper and plastics separation rate for a municipality with information about the presence of the factors. For example, a municipality with one drop-off site per hectare of built-up area, a kerbside collection system, and an incentive program should have, according to the model, paper and plastics separation rate around 21%.

Here we note that in our sample only 11 out of 455 municipalities did not have drop-off sites – therefore the constant in the regression model can be used as a proxy for municipality with only with drop-off sites (the constant in the joint model excluding these 11 municipalities was 6.42, which is practically identical to the joint model of the full sample). None of these eleven municipalities have an incentive program, but seven have kerbside collection. Average separation rate of this subgroup was 7.8% – comparable with municipalities with only drop-off sites (see Figure 2). There are four municipalities that do not have drop-off sites or kerbside collection at all – average

separation rate for them is 4.4%, and the separation is conducted through occasional mobile collection of recyclables (with possible use of some municipal property as a temporary storage facility). Nevertheless, this subgroup of municipalities is very marginal, and represents less than 1% of the used sample, and the results thus might not be significant.

Furthermore, we have looked at the difference between waste generation of the municipalities that use some kind of incentive programs in MSWM and those that do not. In case of municipalities without any incentive program, the average municipal value of total generated MSW (residual MSW plus collected paper and plastics) per capita was 235 kg, with paper and plastics accounting for 21 kg. In case of municipalities with some kind of incentive program was the average municipal value of total MSW generated per capita 181 kg, out of which 32 kg was paper and plastics. In case of total MSW the value decreased by 24% (resp. 30% for just residual MSW), while in case of recyclables the value increased by 47% (the regression model suggests even higher effect of incentive program with over 60% increase in the separation rate). Both of these differences between municipalities with and without incentives are quite notable.

Figure 3: Average amount of waste per capita (in kg) according to the municipality size



Source: Author

Finally, we have examined whether the amounts of generated MSW and collected recyclables change with the size of the municipalities, in this case divided into quintiles (Figure 3, values represent averages from individual municipal values). In case of the total generated MSW (here the sum of residual MSW, paper and plastics) we observe a slightly higher (20%) generated amount among the smallest municipalities. In our opinion this is caused partially by the fact that these smallest municipalities often include second homes or cottages, where people generate waste, but do not count towards permanent population. Higher amount of generated MSW per capita is also consistent with observation of Struk (2016) in 2008-2012 Czech data. In case of the rest of the sample, average values are stable and vary only by few per cent. In case of separated paper and plastics per capita, we can see an increasing trend with the municipality size, with the increase between the first and the fifth quintile being approximately 36% on average. This is most likely caused by generally better separation options in larger municipalities with more drop-off sites, at least one CA site. Also, due to the higher population density, distances to the closest separation options are shorter, which equals to the higher convenience.

3. Discussion

Our examination of the effects of several attributes of municipal waste separation systems proved what has been suggested by other research in this area. From a psychological perspective, it is natural for a rational individual to prefer solutions that require less effort over those that require more. Additionally, appropriate incentive can significantly increase the probability that individuals would act in certain ways.

In municipal waste separation the key factor of participation is the convenience of separation. In this case, the convenience is usually interpreted as the perceived availability of separation sites (Derksen and Gartrell, 1993; Chen and Tung, 2009), or alternatively the distance to the nearest waste separation site (González-Torre and Adenso-Díaz, 2005). In our opinion, perceived availability and the distance to the nearest site are basically the same thing – whether the effort needed to reach a site is for me, as an individual considering separating the waste, acceptable. If I accept the effort needed, I will separate, if I do not accept the needed effort, I will not separate my waste.

The willingness of people to separate their waste can be defined as a function of the perceived availability/distance to the nearest separation site. This hypothesis has been examined in many studies with results containing approximate numbers acquired using various kinds of surveys and depending on the factors present. From our perspective, this hypothesis logically follows human rationality and is quite intuitive, and has been proven by many conducted empirical researches. The only difference between the results is the actual magnitude of the effect of distance, as it is affected by many variables that might be related to the specific place where the research took place.

We did not examine whether individuals decide to separate waste, but how much they separate. But the psychology behind this is basically the same. With less effort needed/more convenient separation system/less distance to the nearest separation site and, eventually, a proper incentive, people will probably participate in separation more often, resulting in a higher recyclables separation rate. We chose to test this through three hypotheses, with different convenience and incentives for the households regarding waste separation. Our empirical results prove that our expectations hold with strong significance.

The generally most convenient separation system – the kerbside collection represented in our sample by the kerbside collection of paper and plastics – showed the highest paper and plastics separation rates. Such results confirm previous studies, for instance by Barr et al. (2003), who concluded that access to the kerbside recycling (in our case in the form of the sack collection) greatly enhances recycling behaviour, and by Folz (1991), who concluded that the participation of public is almost twice as high with kerbside separation system compared to the drop-off sites system. The increased density of drop-off sites also proved to be a possible means for increasing separation rates, although it would take a great amount of drop-off sites to match the impact of a kerbside collection system – which is generally not economical. Nevertheless, any improvement in this area is welcome, as long as the acquired benefits outweigh the related costs.

An interesting related observation reported by the local representatives is the fact that the sole visibility of kerbside recycling (in our case, a sack filled with recyclables at the edge of the property) may motivate others (i.e. neighbours) to take part in the separation

process. The "created" social pressure on the non-participants can be perceived as another benefit of kerbside separation system that tends to work in smaller municipalities with limited anonymity of the people.

Finally, if an incentive program for waste separation is present in the municipality, the willingness of the people to separate waste tends to increase dramatically, as shown in our results. Schultz et al. (1995) observed that basically any kind of reward for the separation is effective, be it a large or small reward in absolute terms. Even better results were observed if the rewards were distributed through a lottery, in which bigger rewards were provided to a small group of winners. This concept works directly with the human tendency to overestimate small winning probabilities, but as long as it serves the purpose of increasing the separation rates and people are participating of their own free will, we do not consider this to be any kind of a problem.

Conclusions

We examined the effects of various municipal waste separation systems on the actual waste (paper and plastics) separated rates. We compared the separation systems of drop-off sites, kerbside collection (in our case in the form of sack collection), and the impact of related incentives. Our findings are in accordance with the relevant theory and prove that the less effort needed for separation/more convenient option for separation/less distance to the nearest separation site, the more likely people are to separate their waste. Moreover, if appropriate incentives are present, separation rates can increase dramatically. Our calculations showed that a separation infrastructure consisting of drop-off sites resulted in approximately 7% paper and plastics separation rates (calculated from the sum of the residual waste and the separated paper and plastics waste fractions). In using kerbside collection system instead, paper and plastics separation rate was approximately 9%.

We also examined the effect of presence of an incentive program, mainly in the form of provided discount from annual waste management fee based on individual waste separation. Our results confirmed a significant contribution to the overall separation rates, as municipalities combining either drop-off sites or kerbside collection of recyclables with an incentive program had the separated paper and plastics rates on

average of more 17%, which is almost double if compared to just kerbside collection, and ever more if compared to the drop-off sites. However, very important is the key role of sufficient communication of the way how the new incentive program works from the local authorities. Without it, people might not understand it appropriately (or it will take unnecessary long time), and the actual results might fall far behind the expectations. Impacts of analysed factors on the waste separation rates were examined also in the regression analysis, and were found to be statistically significant in all models.

Our observations can be utilized by municipalities planning to significantly improve their separation rates. Especially introducing incentive programs has a great potential to increase the waste separation, without necessarily high investments from the municipality. However, the expected benefits should be always compared against the additional costs that are usually connected with a solution providing better results in each municipality, as what works very well in one, might not be economical at all in the other.

Bibliography

ALLERS, M. A., and HOEBEN, C. (2010) Effects of unit-based garbage pricing: a differences-in-differences approach. *Environmental and Resource Economics*, 45(3), 405-428.

ANDO, A. W., and GOSSELIN, A. Y. (2005) Recycling in multifamily dwellings: does convenience matter?. *Economic Inquiry*, 43(2), 426-438.

ASHENMILLER, B. (2011) The effect of bottle laws on income: new empirical results. *American Economic Review*, 101(3), 60-64.

AYALON, O., BRODY, S., and SCHECHTER, M. (2013) Household waste generation, recycling and prevention. *OECD Studies on Environmental Policy and Household Behaviour Greening Household Behaviour: Overview from the 2011 Survey*, 219-245.

BARR, S., FORD, N. J., and GILG, A. W. (2003) Attitudes towards recycling household waste in Exeter, Devon: quantitative and qualitative approaches. *Local Environment*, 8(4), 407-421.

BELTON, V., CROWE, D. V., MATTHEWS, R., and SCOTT, S. (1994) A survey of public attitudes to recycling in Glasgow (UK). *Waste Management & Research*, 12(4), 351-367.

BILITEWSKI, B. (2008) From traditional to modern fee systems. *Waste management*, 28(12), 2760-2766.

BUCCIOL, A., MONTINARI, N., and PIOVESAN, M. (2015) Do not trash the incentive! Monetary incentives and waste sorting. *The Scandinavian Journal of Economics*, 117(4), 1204-1229.

CHEN, M. F., and TUNG, P. J. (2009) The moderating effect of perceived lack of facilities on consumers' recycling intentions. *Environment and Behavior*. XX(X), 1-21.

DAHLÉN, L., and LAGERKVIST, A. (2010) Evaluation of recycling programmes in household waste collection systems. *Waste Management & Research*, 28(7), 577-586.

DAHLÉN, L., VUKICEVIC, S., MEIJER, J. E., and LAGERKVIST, A. (2007) Comparison of different collection systems for sorted household waste in Sweden. *Waste Management*, 27(10), 1298-1305.

DERKSEN, L., and GARTRELL, J. (1993) The social context of recycling. *American Sociological Review*, 58(3), 434-442.

DIJKGRAAF, E., and GRADUS, R. H. J. M. (2004) Cost savings in unit-based pricing of household waste: The case of The Netherlands. *Resource and Energy Economics*, 26(4), 353-371.

DOMINA, T., and KOCH, K. (2002) Convenience and Frequency of Recycling Implications for Including Textiles in Curbside Recycling Programs. *Environment and Behavior*, 34(2), 216-238.

EUROSTAT. (2014) Environment database, section waste generation and treatment, Available at epp.eurostat.ec.europa.eu/portal/page/portal/environment/waste/.

FOLZ, D. H. (1991) Recycling program design, management, and participation: a national survey of municipal experience. *Public Administration Review*, 51(3), 222-231.

FULLERTON, D., and KINNAMAN, T. C. (1996) Household responses to pricing garbage by the bag. *The American Economic Review*, 86(4), 971-984.

GONZÁLEZ-TORRE, P. L., and ADENSO-DÍAZ, B. (2005) Influence of distance on the motivation and frequency of household recycling. *Waste Management*, 25(1), 15-23.

HAGE, O., SÖDERHOLM, P., and BERGLUND, C. (2009) Norms and economic motivation in household recycling: empirical evidence from Sweden. *Resources, Conservation and Recycling*, 53(3), 155-165.

KIRAKOZIAN, A. (2015) Household Waste Recycling: Economics and Policy. *GREDEG Working Paper Series*, No. 2015-09.

MCCARTY, J. A., and SHRUM, L. J. (1994) The recycling of solid wastes: Personal values, value orientations, and attitudes about recycling as antecedents of recycling behavior. *Journal of Business Research*, 30(1), 53-62.

MŽP (2015) Souhrnná data o odpadovém hospodářství ČR v letech 2009 – 2014. Available at http://www.mzp.cz/C1257458002F0DC7/cz/odpadove_hospodarství_data_2014/$FILE/OODP-Souhrnna_data_za_CR-20150914.pdf.

OSKAMP, S., HARRINGTON, M. J., EDWARDS, T. C., SHERWOOD, D. L., OKUDA, S. M., and SWANSON, D. C. (1991) Factors influencing household recycling behavior. *Environment and Behavior*, 23(4), 494-519.

PERRIN, D., and BARTON, J. (2001) Issues associated with transforming household attitudes and opinions into materials recovery: a review of two kerbside recycling schemes. *Resources, Conservation and Recycling*, 33(1), 61-74.

SHAW, P. J., and MAYNARD, S. J. (2008). The potential of financial incentives to enhance householders' kerbside recycling behaviour. *Waste Management*, 28(10), 1732-1741.

STRUK, M. (2016) Development of Municipal Solid Waste Generation and Expenditures: Case of Czech Municipalities. In *Entrepreneurship, Business and Economics-Vol. 2*. Springer International Publishing. 399-416.

ŠAUER, P., PAŘÍZKOVÁ, L., and HADRABOVÁ, A. (2008) Charging systems for municipal solid waste: Experience from the Czech Republic. *Waste Management*, 28(12), 2772-2777.

SCHULTZ, P. W., OSKAMP, S., and MAINIERI, T. (1995) Who recycles and when? A review of personal and situational factors. *Journal of Environmental Psychology*, 15(2), 105-121.

SLAVÍK, J., and PAVEL, J. (2013) Do the variable charges really increase the effectiveness and economy of waste management? A case study of the Czech Republic. *Resources, Conservation and Recycling*, 70, 68-77.

WILLIAMS, I. D., and TAYLOR, C. (2004) Maximising household waste recycling at civic amenity sites in Lancashire, England. *Waste Management*, 24(9), 861-874.