Appendix III:

Pay as You Throw: An attempt of quantitative comparison of Czech and German experience

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The paper presents a part of the work on the EU-5th Framework project „Pay As You Throw – PAYT“. It is an attempt to compare the Czech and the German experience with introducing the PAYT system based on quantitative data from both countries. Standard methods of statistical analyses are applied.

1. Characteristics of data sources in the Czech Republic

In 2000 the team from Department of environmental economics, The University of Economics in Prague, worked out a study for the Ministry of Environment on economic aspects of managing the solid municipal waste, actually its residual (unclassified) particles. A detailed questionnaire was set and over 350 thousand municipalities in the Czech Republic took part in draft. Not all of these municipalities filled in and sent back the questionnaire. Some of the questionnaires contained apparent mistakes so they were excluded out of further compilation. Over all 178 municipalities were included at the end.

Even if this investigation was pointed in different directions, we think that the gathered data can also be partly used for demonstration of creation stochastic models of solid communal waste capacity and amounts for removing it in municipalities where PAYT does exist. Also it is possible to show the behaviour of the same quantities there, where PAYT is not established and is replaced by payment or tax per head.

We think that the base stone of all thoughts if PAYT yes or no, is:

a) Capacity of leftover (unclassified) waste produced in certain area and within certain time unit

b) Total costs for cleaning or disposing of all solid communal waste produced in certain area and within certain time unit.

All in presumption of:

- Stable capacity of all waste produced in certain area within certain time unit (STATIC MODEL)
- Increasing or decreasing capacity of all waste produced in certain area within certain time unit (DYNAMIC MODEL).

2. Comparison of economic level of areas with PAYT and without PAYT

In the following text we based our comparison on the data of 178 traced municipalities in the years 1999 - 2000. Notice, that only data from the year 1999 reflects reality, the year 2000 is a presumption. The whole file was divided into two particular files. Based on the criteria if the filed municipality uses, when receiving payments for solid communal waste, the PAYT system or not. In these years we made basic calculations with standard methods of descriptive statistics. Results are shown in Table 1 and 2.

Table 1: Number of people included in the research in the years 1999- 2000

	1999	2000
Number of people with PAYT	2,465,513	2,179,361
Number of people without PAYT	413,988	544,169

Basic data for comparison of production of residual (mixed) waste, and in dependence on it the payments and expenses, are in Table 2.

Table 2: Dynamics of basic data in years 1999 – 2000

Year	1999 PAYT	1999 NO-PAYT	2000 PAYT	2000 NO-PAYT
Average capacity of waste per person for one year in tons	0.268	0.345	0.248	0.350
Expenses for neutralization of one ton of waste per one year in CZK	1 497.52	998.02	1 727.74	1 045.64
Average citizen payment per year in CZK	272.29	288.09	299.82	281.76
Average expenses for liquidation of illegal dumps for one person in CZK	96.93	14.49	11.70	12.14

From Table 2 it is evident that in municipalities, which have PAYT, citizens produce roughly one quarter less residual (mixed) communal waste than in municipalities where the payment for neutralising solid communal waste is done by lump sum (tax per head). This advantage is on the other hand atoned for the fact that the system PAYT is more expensive on average for about 50 %. Payments paid by citizens per year are not diametrically different for municipalities, which use PAYT and which do not use PAYT. As for the expenses for illegal dump liquidation, in the year 1999 there were recorded high expenses in those municipalities which used PAYT. Expenses for liquidation of illegal dumps there were much higher than in municipalities, which do not have PAYT. As in the next year we can see that those expenses are only slightly different (consider that those expenses are only presumption, not facts) we can assume that in the year 1999 some municipalities liquidated illegal dump from past years or the PAYT existence contains the risk of producing illegal dump waste, which the municipalities cannot predict seriously. For this reason it would be necessary to conduct further research directly focused on problems of PAYT.

As municipalities, which were included in the research create very heterogeneous unit in their comparable size and in managing the solid communal waste we divided those which practise PAYT into classes according to the number of citizens. We created six groups and results from research from the year 1999 are in Table 3.

Table 3: Basic data for waste managing in the year 1999 according to size category

Size of municipality	Number of municipalities	Number of citizens	Amount of waste in tons	Expenses (costs) for disposal in CZK
- 1000	39	14,593	3,952	4,395
1001-5000	27	77,017	36,311	20,257
5001-10000	12	87,485	44,421	28,414
10001-20000	14	211,122	102,215	73,389
20001-90000	16	609,662	174,856	202,024
900001 -	3	1,383,134	273,818	651,723
Total	111	2,465,513	635,573	980,202

Table 3: second part

Size of municipality	Citizen payments in CZK	Expenses for liquidation of illegal dump in CZK	Waste per one citizen in tons	Payment per one citizen in CZK	Expenses per one ton in CZK	Payment per one ton in CZK
- 1000	2,568	1,875	0.271	176	1,112	650
1001-5000	113,590	1,342	0.471	176	558	374
5001-10000	21,057	626	0.508	241	640	474
10001-20000	57,759	1,825	0.484	274	718	565
20001-90000	176,351	214,002	0.287	289	1,155	1,009
900001 and more	378,180	17,653	0.198	273	2,380	1,381
Total	649,505	237,323	0.268	272	1,498	1,022

From a detailed analysis of data in Table 3 it is obvious that the greatest amount of waste per head is produced by citizens of small and medium size towns (1000 - 20000 citizens). It is a paradox because in these towns PAYT is applicable in the easiest way because in these towns family houses and small rental houses most prevail. On the other hand in bigger cities and the capital where land coverage is much denser a tendency to lower the waste production per person is visible.

As to the amount of payments which citizens of certain size categories pay, then the highest taxes are paid by those who produce the least waste. Only citizens of small municipalities in the Czech Republic produce low amount of waste and pay the least for it. But there is also massive support from the municipality by subsidizing the waste disposal.

If we look at the expenses, we see can that where the citizens produce more waste its neutralization per one unit (ton) is much cheaper. This fact is caused by high expenses for transportation and neutralization of unclassified communal waste. In the case when removing capacities of residual (mixed) communal waste are not filled there is a great growth of expenses in relation to the amount of waste.

3. Results of simple relations

Based on empirical facts simple correlation coefficients were calculated, which should reveal the existence of linear relation between tracked relative indices. Based on fact that it is most desired that the amount of residual (mixed) communal waste will decrease when basic effective variables are:

- payment in CZK per one citizen for one year
- payment in CZK per one ton for one year
- expenses in CZK for disposing one ton of residual (mixed) waste in CZK for one year.

Final results of simple correlation coefficients calculated from data of municipalities who apply PAYT are in Table 4.

Table 4: Correlation coefficients of municipalities with PAYT

Variable	Residual (mixed) waste per person for one year in kilos
Payment in CZK per one person for year	0.0033
Payment in CZK per one ton of residual (mixed) waste for year	-0.3897
Expenses in CZK for disposing one ton of residual (mixed) waste per year	-0.3563

From the values of individual correlation coefficients it is obvious that between the production of residual (mixed) waste in kilos per person for year and one person years payment in CZK is no linear relation. Two other tracked indices show together with the index of residual (mixed) waste per person for year very little and brief linear relation.

Because of the introduced reason above we will follow only two models where there was at least a small relation evidenced.

$$Y_i = 788.999 - 0.294\, x_i ,$$

Where y is residual (mixed) waste in kilos per one person for year

And x are expenses in CZK for disposing one ton of residual (mixed) waste per year

And following a test of hypothesis:

$$H_0 : ß_1 = 0$$

$$H_1 : ß_1 \neq 0$$

By the relevant t-test the zero hypothesis has been denied so we can say that at a level of importance of 95 % is value of parameter b_1 not zero. We can evaluate this relation as statistically important for the announced reason. If the expenses for neutralizing 1 kilo of residual (mixed) waste increased by one CZK then the amount of waste produced by one person would decreases by 0.294 kilos.

$$Y_i = 726.921 - 0.350\, x_i ,$$

Where:

y is residual (mixed) waste in kilos per one person for year

x is payment in CZK for one ton of residual (mixed) waste per year.

Also in this case the relevant t-test statistically proved to have an important linear relationship and the results tell us that in case of increasing payments by one CZK per one ton of residual (mixed) waste will decrease the production of this waste by 0.350 kg.

Both results confirm the relationships described before which were based on interpretation of results of the average values of tracked indices.

Furthermore, we did a comparison of the behaviour of tracked indices in municipalities, which do not use PAYT system. The results of simple correlation coefficients from municipalities, which do not apply PAYT are in Table 5.

Table 5: Correlation coefficients of municipalities without PAYT

Variable	Residual (mixed) waste in kilos per person for year
Payment in CZK per person for one year	0.3408
Payment in CZK per one ton of residual (mixed) waste for year	- 0.4278
Payment in CZK for disposing one ton of residual (mixed) waste per year	- 0.5031

From values of correlation coefficients in Table 5 it is obvious that in this case in the municipalities, which do not apply PAYT there is small direct linear relation between production of residual (mixed) waste in kilos per one person for year and payment in CZK, which is paid by citizen for disposing produced residual (mixed) waste. Between production of residual (mixed) waste per year and payment in CZK for disposing one ton of residual (mixed) waste such as the expenses for disposing one ton of residual (mixed) waste there is stronger but the same indirect linear relation.

Constructed simple linear regresive models have in case of municipalities not applying PAYT these forms:

$$Y_i = 209.360 + 0.427x_{i,}$$

Where:

y is residual (mixed) waste in kilos per one person for year

x is payment in CZK for one ton of residual (mixed) waste per year.

If the payment per person increases by one CZK, then the amount of waste produced by one person will increases by 0.427 kilos. Citizens in this case follow the idea "the more I pay, the more waste I will produce".

$$Y_i = 479.258 - 0.178x_i$$

Where

y is residual (mixed) waste in kilos per one person for year

x are expenses in CZK for disposing one ton of residual (mixed) waste per year.

If the expenses for disposing one ton of residual (mixed) waste increase by one CZK, then the production of one citizen will decrease by 0.178 kilos.

$$Y_i = 408.148 - 0.172x_i ,$$

Where:

y is residual (mixed) waste in kilos per one person for year

x is payment in CZK for one ton of residual (mixed) waste per year.

If the payment for disposing one ton of residual (mixed) waste by one CZK increases, the production of waste by one person will decrease by 0,172 kilos.

After comparing both systems we can say, that municipalities with PAYT have stronger stimulation mechanisms for its citizens to sort their waste and by that way decrease the capacity of their un-recyclable residual (mixed) waste.

4. Situation in area of disposing household waste in sovereign state of Saxony

By the end of the last century, between the year 1996 and 1997 the sovereign state of Saxony was already trying to figure out the effective model of transportation and neutralization of household waste in certain municipalities. They conducted research in some cities and their parts which investigated the behaviour of citizens before applying PAYT and after applying it checking the production of residual (mixed) waste and motivation to sort out waste. The goal of this research was to create a model, which would enable to calculate the payments for disposing household waste. We included altogether 11 areas into our study, in names:

Dresden, Heinrich Mann Straβe 44 - 68 (altogether 515 citizens)
Dresden, Finsterwalderstraβe 2 - 10 (altogether 152 citizens)
Dresden, Prohliser Alle 9 - 17 (altogether 486 citizens)
Mitweida, Dr. Roth Straβe, B. Brecht Straβe (altogether 486 citizens)
Riesa-Groβenhain, Plauener/Zwickauer Straβe (altogether 569 citizens)
Riesa-Groβenhain, Glauchauer/Zwickauer Straβe (altogether 583 citizens)
Neustadt, Friedrich Engels Straβe (altogether 194 citizens)
Neustadt, Bruno Dictal Ring (altogether 209 citizens)
Pirna- Copitz (altogether 1503 citizens)
Zwickau, Eckerbach E1 - E4 (altogether 7010 citizens)
Chemnitz, Yorckgebiet (altogether 7760 citizens).

Altogether 19,467 citizens of BRD were involved in this experiment that is 9,994 households. Average size of each household was 1,9 person. Average size of apartments were between 46.0 – 64.3 m^2. More detailed information in Table 6.

Table 6: Average production of residual (mixed) waste and sorted paper in different areas before beginning and after end of the experiment

Area	Mixed residual waste 1	Mixed residual waste 2	Paper1	Paper2	Inhabitants
1	3.48	0.67	1.58	2.31	515
2	4.40	3.52	0.81	1.45	152
3	3.68	2.41	1.28	1.80	486
4	1.22	0.25	0.62	0.64	486
5	5.68	1.31	0.71	1.25	569
6	4.48	1.29	0.97	1.43	583
7	3.60	1.14	X	0.97	194
8	2.80	0.87	X	0.97	209
9	4.90	1.38	1.07	1.33	1,503
10	3.72	0.59	1.79	1.80	7,010
11	4.10	0.34	1.14	1.86	7,760

Legend:
„Mixed 1“ means the production of unsorted waste before the beginning of the experiment in kilos per one person a week,
„Mixed 2“ means production of unsorted waste during the experiment in kilos per one person a week,
„Paper1“ means production of sorted paper before beginning of the experiment in kilos per one person a week,
„Paper2“ means production of sorted paper during the experiment in kilos per one person a week.

It is rather difficult to compare the results received in Germany and the Czech Republic because both these researches were pointed in different directions and so it is very hard to define universal and comparable base. While in the Czech Republic the purpose was to point out the possible influence of individual factors of waste economics on production of waste in individual municipalities and with all consequences, the project in Germany was targeted on creating models for payments construction. There are tracking changes in the structure of household waste from unsorted ones to separate sorts of secondary waste recovery for recycling too.

The next big problem, which has made the possibility of comparing more difficult, is the classification of household waste in both tracking states, which is not uniform. Therefore it was urgent to compare residual (mixed) (unsorted)

household waste and if need be paper waste only, because in other sorts there were partial differences.

From individual types of results it is evident, that average production of residual (mixed) (unsorted) household waste was before beginning of the experiment 3.97 kilos per person by week (that is 206.29 kilos per year). During the experiment there was radical decline to 0.66 kilos per person per week (that's 34.52 kilos per year). Total decline in production of residual (mixed) (unsorted) household waste was 83.3%.

For detailed inquiry of individual types of sorted waste there were not details about all areas included in the experiment at disposal. Therefore it was urgent to track the reduction so that both objectives and cubic comparability will be guaranteed. Therefore we gave up the statistic analysis in detail and applying regressive apparatus, because disposable row of values for analysis was not sufficient.

As for bio-waste, its production per week developed from 0.86 kilos per person before the beginning of the experiment to 1.69 kilos per person by week during the experiment that means growth by 96 %. Production of light covering grew up from 1.38 kilos to 1.74 kilos per person per week that means 28.5 %. Collection of old glass grew up from 0.70 kilos to 0.97 kilos per person per week that means growth by 37.7 %.

But according to the analysis of these results in detail we have to state, that huge decline in inhabitant production of residual (mixed) unsorted waste in tracking localities didn't balance with the growth of sorted waste in components above. It grew up, but not so strongly like the decline of residual (mixed) waste. It is necessary to say, which overall effects the establishing of PAYT were. For explaining there are three (or more) possibilities:

1. Radical decline in producing of waste owing to overall changes in consumer's behaviour of households owing to many influences (upbringing, promotion, economic situation, etc.)
2. A big part of the residual (mixed) waste moved into other regions in municipality, where a PAYT experiment was not applied, but total quantity of residual (mixed) waste didn't change (for proving we have not enough necessary data).
3. Radical growth of the number and the size of illegal dumps (the project count with it too).

5. Rating of results for comparing both states

Considering overall results from BRD and the Czech Republic we can use Table 7, which shows basic drifts in both states.

Table 7: Changes in behaviour of inhabitants when PAYT introduced

	Czech w./ PAYT	Saxony w./ PAYT	Czech No-PAYT	Saxony No-PAYT
Average production of residual (mixed) waste /1 person per year in kilos	268.00	34.52	345.00	206.29
Average production of bio-waste /1 person per year in kilos		87.78		44.72
Average production of light covering /1 person per year in kilos		39.52		19.76
Average production of paper /1 person per year in kilos		90.48		70.72
Average production of old glass /1 person per year in kilos		50.44		36.40
Average production of overall waste /1 person per year in kilos		302.74		377.89

From results in Table 7 it is evident, that overall level of producing household waste is in both states practically the same. But it is true, that in application of PAYT system in Saxony a more expressive economic stimulation of single households for waste sorting happens, so that total waste is separated into types, which are suitable for the further processing of similar secondary material.

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