EFFICIENCY OF THE CURRENT MUNICIPAL WASTE EXPENDITURE – METHODOLOGY APPROACH AND ITS APPLICATION

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Abstract

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The paper introduces methodology designed in order to evaluate and compare efficiency of chosen municipal waste expenditure via calculating efficiency ratings. First part of the paper briefly describes current situation around environmental protection expenditure in Czech Republic and explains reason why the area of current municipal waste expenditure has been chosen for the efficiency evaluation. Second part is dedicated to the idea of the efficiency evaluation methodology which is based on Cost-effectiveness Analysis (CEA). CEA is working with two aspects of efficiency. First aspect is efficiency of expenditure per capita and second is efficiency of expenditure per municipal waste ton. Data necessary for the analysis together with the sources where these data can be acquired are also introduced. The description of exact process of calculating efficiency ratings for each municipality then follows. Whole methodology is demonstrated on selected sample of municipalities together with the results of efficiency evaluation and their graphical depiction. Last part of the paper discusses problems that might arise while performing this efficiency evaluation together with possible expansions of the evaluation.

efficiency, current municipal waste expenditure, Cost-effectiveness analysis

This article introduces a methodology for evaluating efficiency of current municipal environmental protection expenditure (EPE). The evaluation is done via comparison of the efficiency ratios of examined municipalities. As municipal EPE cover vast area of actions, we have chosen to analyze only the area of municipal waste management.

Furthermore we analyze only the current expenditure, not the capital expenditure. Current expenditure usually consists of regular day-to-day tasks that occur generally in every single municipality[1]. On the other hand, capital expenditure is typically spent on various one-time projects (not regular) that are usually unique and have various lifetime, which makes it hard to make any trustworthy comparisons between municipalities and their individual projects[2]. Moreover, current municipal expenditure makes, based on our calculations, on average 60–70 % of total municipal budgets in Czech Republic. And if we take specifically EPE, current EPE represents, according to MŽP data, on average 51 % of total EPE in the period of 2005–2010. These facts, led us to the choice of analyzing current expenditure instead of the capital ones.

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1   The fact that these tasks have short lifetime makes it relatively easy to make year-to-year comparison, as they occur many times throughout the year.
2   Analyzing capital expenditure requires different techniques of economic analysis, for example taking into account the time factor (project lifespan). Most known evaluation method used to deal with this type of expenditures is Cost-benefit Analysis (CBA).

METHODS AND MATERIALS

First of all, let us explain why we focus on the municipal waste treatment. According to CEPA 2000 classification[3] (Eurostat 2007) which is used also in the Czech municipal budget structure, EPE is divided into 9 categories. However, some of them are much more important in terms of total sum of money than the other. Based on the data provided by the ARIS and ÚFIS[4] we have created table I. There we can see current EPE in the Czech Republic in the period of 2005–2010 divided into four parts. First and largest part is Waste management, second is Protection of biodiversity and landscape, third is Wastewater management and then the remaining 6 CEPA 2000 classification categories.

As we can see from table I., current waste expenditure accounts for roughly one half (49.8 – 52.5%) of the total current EPE in Czech Republic during the period of 2005–2010. This makes waste expenditure clearly the most important current EPE in terms of money. Due to this fact we have decided to examine efficiency of municipalities specifically in this area of EPE.

But as we have mentioned in the introduction, we are analyzing municipal waste expenditure, while the CEPA 2000 category Waste management contains all kinds of waste related expenditures, not just municipal. Category Waste management is, according to the Czech Classification of sector budget structure[5], further divided into 10 categories which are internally marked as:

1) § 3721 – Collection and transport of hazardous waste,
2) § 3722 – Collection and transport of municipal waste,
3) § 3723 – Collection and transport of other waste,
4) § 3724 – Use and disposal of hazardous waste,
5) § 3725 – Use and disposal of municipal waste,
6) § 3726 – Use and disposal of other waste,
7) § 3727 – Waste prevention,
8) § 3728 – Monitoring of waste treatment,
9) § 3729 – Other waste treatment,
10) § 2122 – Collecting and processing of secondary raw materials[6].

Of these 10 categories, only two represent municipal waste expenditure, § 3722 and § 3725. However, they cover majority of total current expenditure on waste management. Figure 1 shows the average shares of current municipal waste expenditures and the rest of the categories that fall under Waste management subsection of the Czech budget structure in years 2005–2010.

From Fig. 1 we can see that current municipal waste expenditure covers 86.1% of total current expenditure on Waste management. If we put this together with information from Tab. I (average share of Waste expenditure category is 51.2%) we can calculate that current municipal waste expenditure represents on average 44.1% of total current EPE in the Czech Republic in years 2005–2010.

Due to the fact that current municipal waste expenditure represents such notable part of total current Czech EPE, we have decided to examine the efficiency of this specific expenditure. In following part we explain the steps of our analysis and the sources where the data necessary for the analysis are available.

In this paper we have chosen to analyze two aspects of efficiency. First aspect is efficiency of expenditure per capita and second is efficiency of expenditure per municipal waste ton. When considering the efficiency criterion, the most efficient unit is one that produces highest output per cost unit, or alternatively has lowest costs per

I: *Shares of current EPE categories on total current EPE in Czech Republic*

| Year	Waste management	Protection of biodiversity and landscape	Wastewater management	Remaining 6 CEPA 2000 categories
2005	52.5%	36.8%	8.8%	1.9%
2006	49.8%	36.9%	11.4%	1.9%
2007	52.1%	36.6%	9.4%	1.9%
2008	51.7%	36.9%	9.7%	1.7%
2009	51.3%	38.7%	8.3%	1.6%
2010	49.5%	39.8%	9.0%	1.7%

Source: ARIS, ÚFIS, adjusted by authors

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3   CEPA 2000 *"is a generic, multipurpose and functional classification for environmental protection. It is used for classifying not only activities for environmental protection, but also products. The activities are generally classified by the environmental domain which is protected (air, waste, nature protection, etc.) and then by type of measure (prevention, reduction, etc.)"* (Eurostat, 2007).
4   ARIS publicly provides information about muicipial incomes and expenditures in the Czech Republic from period 2001 – 2009. Data from year 2010 are provided by successor of ARIS – ÚFIS (ARIS, 2011, ÚFIS 2011).
5   Czech Attachment to Ordinance no. 323/2002 Coll, Part C
6   Although §2122 belongs to the different section in the budget structure, according to CEPA 2000 it falls under the waste management category with the rest of the listed paragraphs.
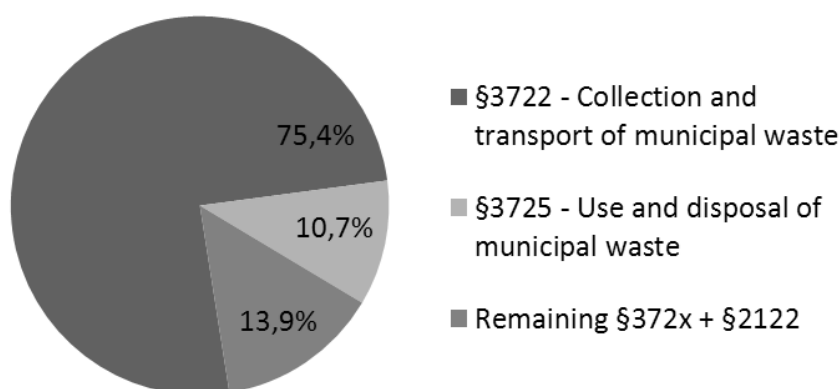
1: *Composition of current Waste management expenditure, 2005–2010 average*
Source: MŽP, adjusted by authors

output unit (Ochrana 2006). In this paper we use the second option.

We need following data about each municipality for analyzing efficiency of municipal waste expenditures:

- population,
- municipal waste expenditure,
- amount of municipal waste.

Data on population of each municipality can be acquired from Czech Regional Information Service – RIS[7]. Data on municipal waste expenditure are available from public database ARIS. And data on municipal waste amount come from database ISOH[8] (until 2009) and ISPOP[9] (from 2010 further on). However, these last databases provide publicly only aggregated data, and in order to get data about municipalities one has to request them directly from the database operators. So as we can see, all data necessary in order to examine the first aspect of efficiency are publicly available, while acquiring data for the second aspect of efficiency requires some interaction with the responsible authorities.

As an appropriate method for efficiency analysis we have chosen Cost-effectiveness Analysis (CEA). This method is in general accepted[10] as a way to measure efficiency in cases when we have data about costs expressed in monetary units, but the utility is defined in natural units and is difficult to be expressed in monetary form. This suits our case. The basic idea of CEA is to create ratio of costs (C) and outputs expressed in natural units, usually called effect (E), for which:

$$CEA = \frac{C}{E} \to min. \qquad (1)$$

When calculating these values for each examined unit, we get dataset of C/E ratios (CEA_j where $j = 1, …, n$). As we analyze two aspects of efficiency – expenditure per capita with E_1 standing for population, and expenditure per municipal waste ton with E_2 standing for municipal waste ton – we calculated two values (ratios C/E_1 and C/E_2) for each analyzed municipality.

In order to make clearer interpretation of the calculated results, we have decided to distribute the examined municipalities into several efficiency categories. We have chosen to create these categories based on their position to the weighted average C/E ratio of the whole examined sample of municipalities. C/E ratio of the whole sample is calculated as a division of the sum of sample's costs and the sum of sample's effects. In order to calculate the C/E ratio for the whole sample, let us assume that

$$C = \{C_{ij}\},$$

$$E = \{E_{kj}\},$$

then $CEA = \{CEA_{ijk}\}$ is a three-dimensional matrix of C/E ratios,
where
$i = 1, …, 10$ ..is waste expenditure category (budget structure paragraph)
$j = 1, …, n$ .....is number of units in analyzed sample (municipalities)
$k = 1, 2$ ....is first or second aspect of efficiency that we analyze.

But as we analyze only the expenditure on municipal waste (sum of § 3722 and § 3725), we can further consider two-dimensional matrix. The

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7   Regional Information Service publicly provides various current statistical data about Czech municipalities (RIS 2011).
8   Database ISOH publicly provides statistical data about waste production in Czech territorial entities from years 2002 – 2009 (ISOH 2011).
9   ISPOP is complex information system created in order to fulfill legislative duty of Czech economic subjects to report the defined information about their impact on the environment (ISPOP 2011).
10 See for example Boardman (2006) or Levin, McEwan (2001), Ochrana (2006) or Soukopová, Bakoš (2010)

general model for calculating C/E ratio for the whole sample is then

$$CEA_{S_k} = \frac{\sum_{j=1}^{n} c_j}{\sum_{j=1}^{n} E_{kj}},$$ (2)

where CEA_{Sk} is C/E ratio of the whole sample for the effect E_k.

Once we have C/E ratio of the whole sample for both E_k effects (CEA_{Sk}), we calculate an "efficiency rating" (ER) for each municipality in respect to the both CEA_{Sk}. Creating this efficiency rating (ER) is not necessary when working with just single one efficiency aspect – the results would be exactly the same, just with the different measures. However if we want to get complex ER that consists of various measures, we need to create a "common denominator" which unifies these various measures. And that is exactly what our ER calculation is designed to.

This efficiency rating is calculated by simple division.

$$ER_{jk} = \frac{CEA_{jk}}{CEA_{s_k}},$$ (3)

where ER_{jk} is efficiency rating for j-unit (municipality) and k-effect (E_k). Further we will consider efficiency ratings $ER_1 = \{ER_{j1}\}$ and $ER_2 = \{ER_{j2}\}$.

ER of the whole sample (ER_{Sk}) is obviously 1,0. Following Tab. II defines five efficiency categories based on their position to the ER_{Sk}.

Presented methodological approach is based on the work of Boardman (2006) and mainly follows the authors' own research (Soukopová, Struk, 2011) and (Soukopová, Bakoš, 2010). With these efficiency

II: *Five defined categories of efficiency*

	Category reference	Definition of category for ER$_{jk}$	Definition of category for ER$_j$
1)	Highly efficient	$ER_{jk} < 70\%$ of ER_{Sk}	$ER_j < 140\%$ of ER_S
2)	Above average efficient	ER_{jk} 70% to 90% of ER_{Sk}	ER_j 140% to 180% of ER_S
3)	Average efficient	ER_{jk} 90% to 110% of ER_{Sk}	ER_j 180% to 220% of ER_S
4)	Below average efficient	ER_{jk} 110% to 130% of ER_{Sk}	ER_j 220% to 260% of ER_S
5)	Highly inefficient	$ER_{jk} > 130\%$ of ER_{Sk}	$ER_j > 260\%$ of ER_S

Source: Authors

III: *Dataset for efficiency analysis, year 2008*

j	Municipality	Population (E_1)	Municipal waste expenditure (thousands CZK)	Municipal waste amount (t) (E_2)
1	Hořice	9 074	8 174.76	2 281.12
2	Milevsko	9 128	3 943.03	1 842.15
3	Choceň	9 145	0.00	4 146.75
4	Ivančice	9 347	6 167.92	3 137.11
5	Nová Paka	9 369	5 416.11	2 033.59
6	Štětí	9 543	6 432.19	2 084.25
7	Mohelnice	9 628	8 023.96	2 972.15
8	Frýdlant nad Ostravicí	9 674	9 682.70	3 736.33
9	Chotěboř	9 906	3 165.00	2 317.37
10	Nové Město nad Metují	9 941	4 205.06	2 040.49
11	Litovel	10 063	6 813.86	2 321.41
12	Čáslav	10 093	8 516.46	2 685.86
13	Litomyšl	10 143	6 328.88	1 984.15
14	Studénka	10 168	5 483.82	1 750.33
15	Lanškroun	10 235	220.87	2 401.40
16	Hlinsko	10 253	4 067.45	2 632.90
17	Kuřim	10 492	6 410.08	2 416.13
18	Nové Město na Moravě	10 708	9 233.09	2 523.59
19	Domažlice	10 946	11.02	3 472.01
20	Boskovice	10 965	6 968.61	2 440.54

Source: Data from RIS, ARIS, MŽP

categories we can create distribution of analyzed municipalities according to their calculated ER. And as we have two ER for each municipality, we can put them together in order get one complex ER. Let us assume that both of these ratings have same weight. The complex rating – ER_j – can be then calculated by simple adding of ER_{j1} (expenditure per capita) and ER_{j2} (expenditure per municipal waste ton). We do the same adding also with both ER_{Sk}, which then acquires value $ER_S = 2.0$. Municipalities are then sorted based on their ER_j in respect to the ER_S into categories defined in Tab. II.

In order to demonstrate the way of measuring efficiency that we describe in this paper, we have chosen a sample containing every Czech municipality with population between 9 and 11 thousand with current expenditure and municipal waste amount data from year 2008. Data about our sample of municipalities are in Tab. III.

As we can see, there are 20 municipalities with population within the limits we have set. However, if we look at the data more closely, some of them are quite far from the rest of the sample. It is the case for municipalities 3, 15, and 19. These three municipalities have very low expenditure when compared to the rest of the sample. Municipality 3 does not even have any expenditure in this area according to ARIS. This in general has two reasons. These municipalities are either extremely efficient in terms of current municipal waste expenditure, or the acquired data are simply incorrect. In our opinion the latter is much more probable and therefore we have decided to exclude these three municipalities from the further analysis.

Now that we have dataset of 17 municipalities, we can continue with calculating C/E ratios and ER based on our model.

RESULTS

Calculating CEA_{jk} (C/E ratios) for each of the examined units (municipalities in our case) creates a dataset. When we create descending order from this dataset, we are able to see clearly how efficient is every single unit we analyze. And not to forget that we analyze two aspects of efficiency, therefore we end up with two datasets of C/E ratios. Tab. IV shows unsorted results.

IV: *C/E ratios of examined municipalities*

j	Municipality	CEA$_{j1}$	CEA$_{j2}$
1	Hořice	900.90	3 583.67
2	Milevsko	431.97	2 140.45
4	Ivančice	659.88	1 966.12
5	Nová Paka	578.09	2 663.33
6	Štětí	674.02	3 086.10
7	Mohelnice	833.40	2 699.72
8	Frýdlant nad Ostravicí	1 000.90	2 591.50
9	Chotěboř	319.50	1 365.77
10	Nové Město nad Metují	423.00	2 060.81
11	Litovel	677.12	2 935.22
12	Čáslav	843.80	3 170.85
13	Litomyšl	623.97	3 189.71
14	Studénka	539.32	3 133.02
16	Hlinsko	396.71	1 544.85
17	Kuřim	610.95	2 653.04
18	Nové Město na Moravě	862.26	3 658.72
20	Boskovice	635.53	2 855.35
	Whole sample	647.10	2 646.47

Source: Authors

Next step in our analysis is sorting the results from the lowest to the highest value. As we have two efficiency aspects, each municipality gets two positions in the rankings. With municipalities sorted we can proceed in creating their distribution into five efficiency categories defined in Tab. II. The results are graphically depicted in Fig. 2 and Fig. 3.
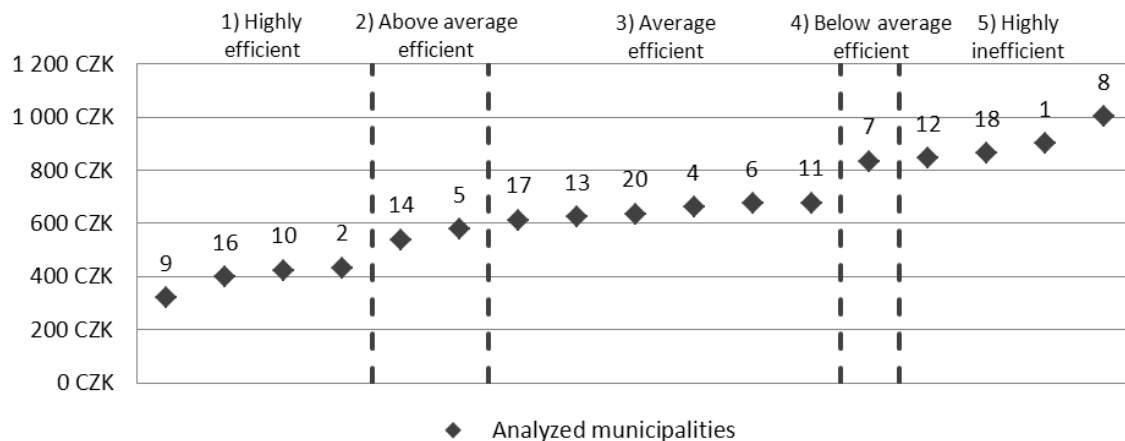
2: *Efficiency evaluation results – expenditure per capita ratios (CEA$_1$)*
Source: Authors
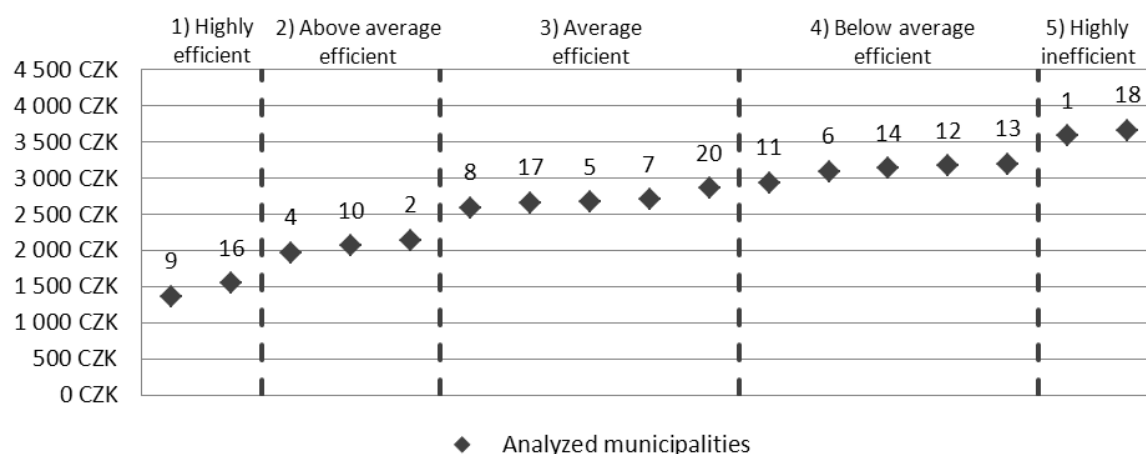
3: *Efficiency evaluation results – expenditure per municipal waste ton ratios (CEA$_2$)*
Source: Authors

Municipalities[11] are positioned according to their calculated C/E ratio, which can be interpreted as municipality's average current expenditure per its citizen – *CEA$_1$* (Fig. 2) and per produced municipal waste ton – *CEA$_2$* (Fig. 3).

From Fig. 2 and Fig. 3 we can see how efficient are the municipalities from the sample in either expenditure per capita or expenditure per municipal waste ton terms. But in order to calculate the overall efficiency of municipalities including both analyzed efficiency aspects we need to calculate ER that would be in same scale and same measure. The process of doing that has been described in previous chapter. The results ($ER_j = ER_{j1} + ER_{j2}$) are in Tab. V.

Graphical depiction of the results from Tab. V with municipalities sorted from the most to the least efficient is in Fig. 4. As before, we have also added borders of the efficiency categories defined in Tab. II, so that we can clearly see which municipality belongs to which efficiency category together with the ER value differentiation between the municipalities.

In Fig. 4 we can see many similarities with previous two Figures. This is not surprising as it is in fact the sum of first and second efficiency
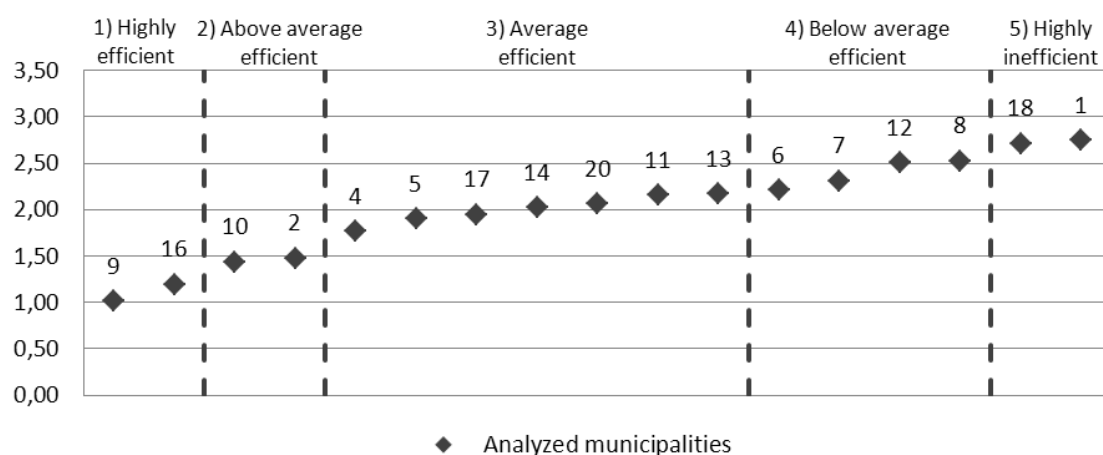
V: *Efficiency ratings of examined municipalities*

j	Municipality	ER$_{j1}$	ER$_{j2}$	ER$_j$
1	Hořice	1.39	1.35	2.75
2	Milevsko	0.67	0.81	1.48
4	Ivančice	1.02	0.74	1.76
5	Nová Paka	0.89	1.01	1.90
6	Štětí	1.04	1.17	2.21
7	Mohelnice	1.29	1.02	2.31
8	Frýdlant nad Ostravicí	1.55	0.98	2.53
9	Chotěboř	0.49	0.52	1.01
10	Nové Město nad Metují	0.65	0.78	1.43
11	Litovel	1.05	1.11	2.16
12	Čáslav	1.30	1.20	2.50
13	Litomyšl	0.96	1.21	2.17
14	Studénka	0.83	1.18	2.02
16	Hlinsko	0.61	0.58	1.20
17	Kuřim	0.94	1.00	1.95
18	Nové Město na Moravě	1.33	1.38	2.71
20	Boskovice	0.98	1.08	2.06

Source: Authors

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11 Numbers above the dots in Fig. 2 refer to *j*-number of municipality in Tab. IV.

4: *Results of efficiency evaluation – complex efficiency rating (ER$_j$)*
Source: Authors

aspect value for each municipality. Therefore if the municipality attains close position in terms of both efficiency ratings, it subsequently attains about the same position also in the complex rating[12].

DISCUSSION

In this part of the paper we point out a caveat that arises when collecting data and then we discuss further possibilities of using this efficiency evaluation methodology.

When looking back at the collected data, we have excluded 3 municipalities due to the very low expenditure when compared to the rest of the sample. In our opinion this is caused by insufficient knowledge of the budget structure and the correct way of reporting the relevant expenditure by the person responsible for the data insertion. We find the second option, that municipalities in fact have such low expenditure on municipal waste management, highly improbable.

This note raises another question. Are the data that we have collected correct and do they really represent the reality? Well, according to legislation they should[13]. But as we have seen, sometimes municipalities show no current expenditure on municipal waste. The same applies to the produced amount of municipal waste as well. Therefore we at least try to exclude such municipalities that report their expenditures incorrectly in order not to spoil the analysis. However, this is possible only in cases where the expenditure is notably different when compared to the rest of the sample. But all

in all, based on our experience, such "unreliable" municipalities usually represent only small fraction of the sample. And as we try to exclude most of them, efficiency analysis performed in this way should produce trustworthy results.

When concerning the use of this kind of analysis, it is designed to compare the efficiency of municipalities among each other within chosen sample. With representative sample can be these results generalized also to a larger unit. And not to forget that this methodology is not limited just to the area of waste management, it should work in any area where inputs can be exactly measured in terms of money and outputs in corresponding natural units.

With large datasets consisting of municipalities of various sizes or locations, we can perform partial analyses of, for example, municipalities of equal size or municipalities belonging to the same location. The result would then be a finding about connection between efficiency and certain size of municipality, or connection between municipality location and its efficiency. Or we can simply try to find any regularities or patterns connected with the analyzed data, especially when analyzing data from multiple years. So as we can see, possibilities for the use of this methodology are quite wide.

The Cost-efficiency analysis can be used as modified CEA method as was done in the methodology for the efficiency evaluation of the municipal environmental protection expenditure (Soukopová, Struk, 2011 and Soukopová, Bakoš,

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12 This can be clearly seen in case of municipalities 9 and 16, which both acquired exactly same positions in all three presented Figures.

13 Sometimes municipalities report expenditure just in one of the two paragraphs that we have analyzed, although common sense tells us that both of these paragraphs should contain expenditure as the tasks these paragraphs represent are connected. Therefore we have decided to analyze these expenditures from these two paragraphs together as one. This way it is for us irrelevant in which of these two paragraphs do municipalities report their municipal waste expenditures as long as it is at least one of them.

2010). The modified CEA method comes to similar conclusions as CEA in this case study.

CONCLUSION

In this paper we have described a methodology for evaluating efficiency of current municipal waste expenditures based on CEA evaluating method. It has focused on calculating and comparing the efficiency ratios and subsequently efficiency ratings of municipalities in terms of expenditure per capita and expenditure per municipal waste ton. We have constructed a general model for calculating both of these results as well as calculating a complex result. Then we have defined five efficiency categories into which can be analyzed municipalities distributed based on the result they have acquired. The use of the methodology has been demonstrated on a sample of 20 municipalities. Provided Figures show an example of the graphical outcome of our methodology.

SUMMARY

Paper "Efficiency of the current municipal waste expenditure – methodology approach and its application" deals with the topic of efficiency evaluation of municipal expenditures. It introduces a methodology for evaluating efficiency of current municipal waste expenditure. Paper first describes sources of relevant data for the efficiency evaluation (public databases ARIS, ÚFIS, RIS, ISOH, ISPOP) and the possible issues with these data. Then it describes created methodology, which is based on CEA evaluating method and is further developed in order to evaluate two aspects of efficiency – expenditure per capita and expenditure per municipal waste ton. A model for calculating efficiency ratios for both of these aspects is then created. The use of the model is demonstrated on sample of Czech municipalities with population between 9 and 11 thousand and the data about expenditure and municipal waste production from the year 2008. After the calculation of the results, analyzed municipalities are distributed into five defined efficiency categories based on the acquired results. Last part of the paper discusses issue with the reliability of the used data and proposes further possibilities for the use of this methodology.

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