Krzysztof Wąsowicz

The Effectiveness of Municipal Waste Management in Polish Cities*

Abstract

Objectives: To seek for the optimum economic model for public utility services in the sector of municipal waste management; to present the results of studies regarding the efficiency of companies in the sector of management of municipal waste and the systems that such companies function within.

Research Design & Methods: Multi-criterion rankings with the use of synthetic variable, the structure of which has been based on zeroed unitarisation (method of zeroed unitarisation – MZU). Owing to general financial data, technical and operational data, as well as output data, it was possible to determine rankings of effectiveness for companies in the system of municipal waste management and communes. What is more, a correlation diagram was created – the dependency between the aggregated effectiveness of companies and the aggregated effectiveness of waste management in communes.

Findings: Communes which entrust municipal companies with management of an integrated system for municipal waste management or/and its individual chains feature more properties of operating, economic, and financial effectiveness within the scope of management of municipal waste.

Implications / Recommendations: It is demonstrated that communes which entrust municipal companies with management of an integrated system for municipal waste management – or/and its individual chains – feature more properties of operating, economic, and financial effectiveness within the scope of the management of municipal waste.

Contribution / Value Added: Further extended research into the organisation and management of the municipal waste management system.

Article classification: The article presents an original and innovative analysis of the municipal waste management sector with the use of the developed research method of aggregation and unit efficiency ranking. The purpose is to continue the extended research on the organisation and management of the municipal waste management system.

Keywords: public utility services, municipal waste companies, economic effectiveness, taxonomic methodology

JEL classification: L300

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Introduction

Municipal waste management fits into many areas and fields of science. It includes paradigms of modern economics and public finances. Municipal waste is generated by consumers – inhabitants. Due to its specific nature, commonness, social character, lack of their individual management, despite individual decisions as to consumption and generated by-products, it constitutes a social and economic problem. The social aspect of municipal waste is expressed particularly by the peculiar paradox of transformation of private consumer goods into public anti-goods. The economic nature of municipal waste is related, in particular, to the usage of renewable and non-renewable resources that, during the process of individual consumption, are transformed into waste that pollutes the environment and leads to external costs (Bauer-Nawrocka, 2018).

Nowadays, the developmental challenges mainly concern the choice of the organisational and legal model for the functioning of municipal waste management. According to theory and practice within economy, this selection is between the self-governmental and the market model.

The aim of the study in this article is to assess the effectiveness of companies and systems that implement the tasks of municipal waste management in communes. The intention was to review the hypothesis regarding the advantage of self-governmental form of organisation and implementation of municipal waste management over its market alternative. The analysis assumed the increased significance of municipal companies implementing the tasks of the commune without tenders – in the in-house form – with regard to achieving ecological standards by communes.

The research employed an original method of assessing the integrated effectiveness – such a method allows one to analyse the dependency between operating indicators regarding the condition of municipal waste management in the commune and the financial characteristics (income of the commune from the fee for managing municipal waste, balance sheet, and output data of companies). The research was based on source studies – two questionnaires were prepared for communes and companies respectively.

Conclusions were formulated for further research (with the acknowledgment of a lack of complete data). The most important conclusion is that the self-governmental and the market system of municipal waste management should be complementary to each other rather than competitive, with such competition being detrimental to the community. The self-governmental form of operations of communities and entrepreneurs that implement public utility services is the most natural option and it allows the costs of the unreliable market to be avoided, which is more natural in the case of services and goods of individual rather than collective consumption, such as services of municipal waste management.

Municipal waste management in communes

Waste management is a complex, interdisciplinary concept that also covers activities within the scope of planning, implementation, as well as undertakings and technologies.

Waste management refers to issues and processes such as (Famielec, 2017a):
– regulations, any instructions, norms and standards within the scope of production and utilisation of waste,
– waste management plans at local, regional, national, and interstate levels,
– reporting alarming forms of production and management of waste, i.a. breakdowns covering amounts of generated waste, its composition and types,
– issues connected with determination of properties, composition, toxicity, etc. of waste, and assessments and forecasts as to the amount and type of produced waste,
– collection and transport of waste,

– processing of waste, methods, and technologies to recycle waste and recover raw materials and energy, or to utilise them,

– aspects connected with waste disposal through storing it at landfills, technologies for waste storage, landfill management, etc.

Waste management can be considered from the point of view of processes and subject matters (Poskrobko, 2007). In the case of waste management processes, the prevention of waste production is preferred, while waste storage is the least desired option. The subject matter setting differentiates between various types of waste, such as municipal waste, waste generated by households, as well as waste generated by business entities, mainly service providers, if such waste is similar to the one generated at households in terms of composition and characteristics.

The processes of gathering, transport, and management of municipal waste are not only of public but also of market nature. The market is a set of mechanisms that allows the contact of manufacturers (e.g. waste producer) with purchasers – recipients of waste, secondary raw materials. Entities within the system of municipal waste management should cooperate and have an agreement (Stern, 2010). This should ensure social and financial advantages (including profits) for most or all of the participants in the system, as well as make adjustments to the shortcomings of the market, limiting ineffectiveness. It requires establishing proper institutional structures with the involvement of the state and regional governments. They have various conditions and are integrated in many areas of social and economic life, which has been presented in Figure 1.

The member states of the European Union have a specific hierarchy for handling municipal waste (Figure 2). This hierarchy recommends a desired sequence of actions regarding waste management, with the action that is higher in the hierarchy being always the preferred one. In Polish legislation,

Inhabitant/Customer
Fees/Prices, growth of amount of waste, balance, acceptation, safety, general public interest

Politics/Legislation
Act on closed circulation, regulation on packaging, coalition arrangements, external obligations

Waste management – challenges and impact factors

Economy
Overefficiency of the facility, unforgiving competition, prices on German and global markets, price drops

Ecology
Protection of the climate, protection of resources, selective collection, processing, energy effectiveness
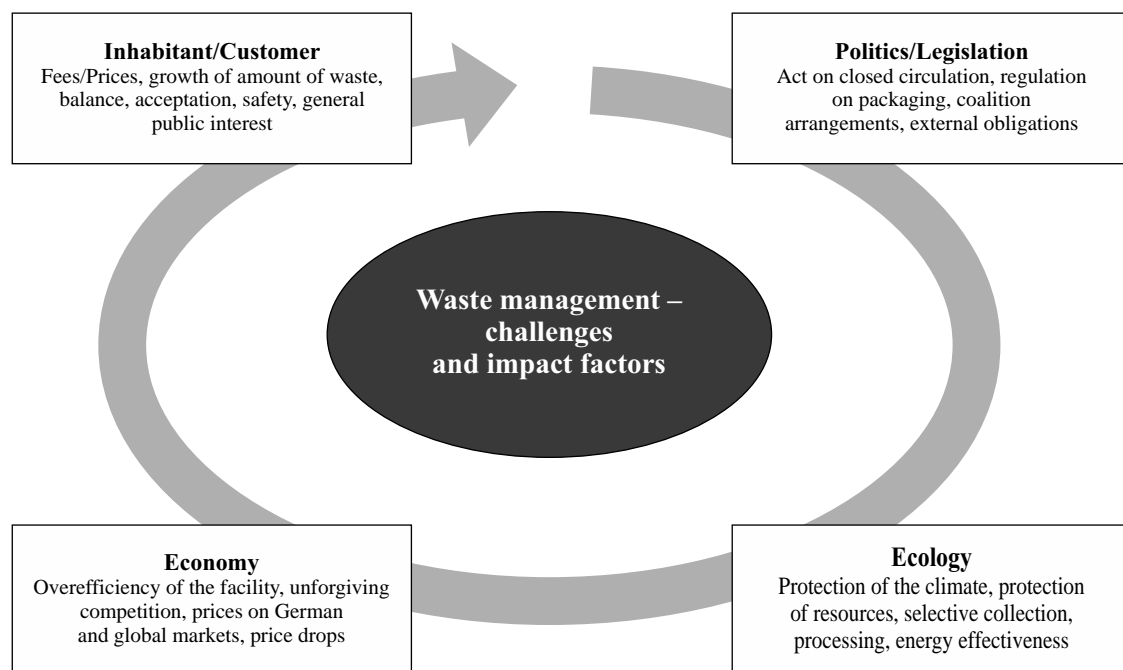
Figure 1. Conditions of waste management

Source: Wąsowicz, Famielec & Chełkowski, 2018.

the principles for the hierarchy of handling waste have been acknowledged in the Act on Waste (Famielec, 2017b).

Bearing in mind the hierarchy for handling waste, storage is the least acceptable – and, in the case of some groups of waste, even prohibited – solution concerning waste management. The development of waste management technology mainly strives for preparing waste for recovery, particularly for recycling. In order to achieve this, the European Union imposes standards regarding the minimum levels of recycling and preparation for re-usage of municipal waste that member states must comply with. The next action in this hierarchy is forwarding waste for energy recovery. By energy recovery one should mainly understand all thermal (incineration) processes that allow recovery of thermal energy (Highfill & McAsey, 1997).

The analysis of the extent connected with individual stages of waste management – according to the hierarchy presented above – is the foundation for the research conducted in this article.

Municipal waste in communes is connected with the idea of charging for municipal waste management. The financing of the municipal waste management system in a commune has currently been based on a public law fee for managing municipal waste. The fee is paid by entities that hold the status of real estate owners and, generally, it constitutes the income of the commune. Funds from the fee for managing municipal waste, pursuant to the act on maintenance of cleanliness and order in communes, have a 'designated character' and can be utilised only for the purposes provided for in the Act, i.e. for the financing of costs related to the functioning of the municipal waste management system. The financing of public procurement
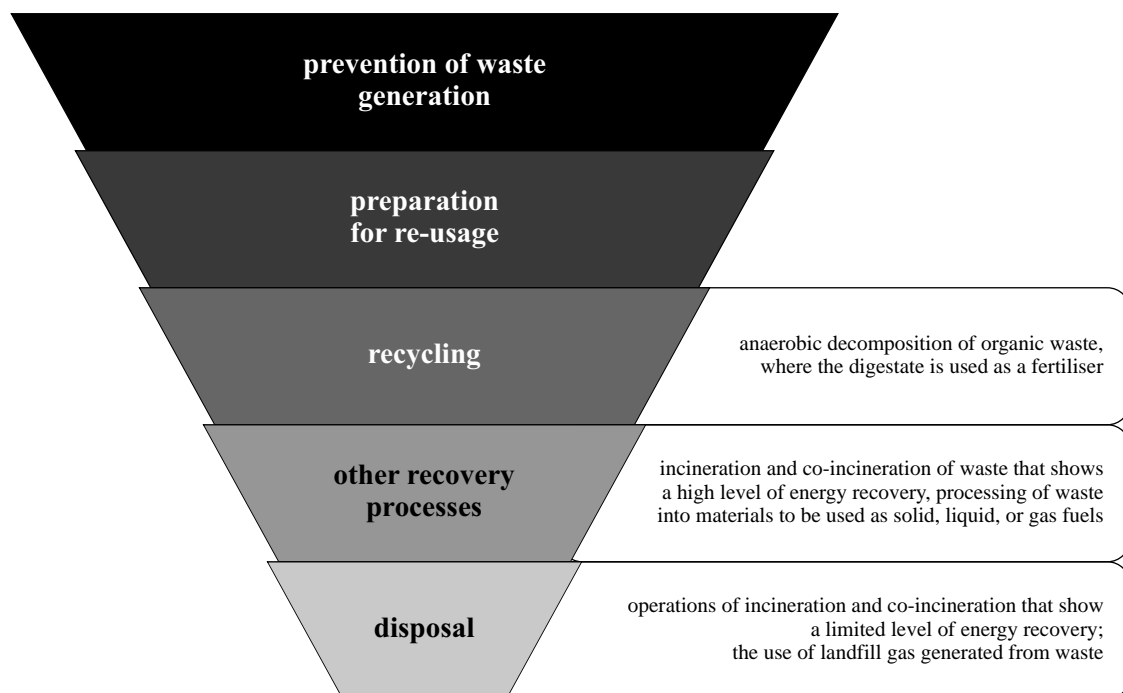

Figure 2. Hierarchy of treatment of waste along with the position of processes of processing waste into energy

Source: Wąsowicz, Famielec & Chełkowski, 2018.

for collection of municipal waste or collection and management of such waste constitutes an important element of this system. The concept of the municipal management system in Poland features its self-financing, i.e. the financing of planned costs of the system through fees for managing municipal waste. In order to assess the effectiveness, the following information was compared: the income of commune revenue on fees for managing municipal waste – assigned according to a statement – the monetary proceeds to the budget of the commune from fees for managing municipal waste, and the total current income of the commune. The analysis took into consideration the value of current expenditures of communes for the municipal waste management system, also including the following breakdown: expenses for collection, transport, gathering, recovery, and disposal of municipal waste, as well as expenses for establishing and maintaining points of selective collection of municipal waste.

Figure 3. Communes selected for studies regarding municipal waste management

Source: own analysis.

The test to assess the effectiveness was based on the analysis of selected companies and communes in which they function. The study covered thirty-eight communes (Figure 3) representing capital cities of particular voivodeships, large cities, localities in the Małopolskie Voivodeship, and communes. Based on publicly available data, an empirical database was elaborated to analyse waste management. Information was gathered based on the data included in reports made by the commune administrator, city mayor or president on the implementation of tasks regarding the management of municipal waste for 2018. A questionnaire was prepared in order to analyse the effectiveness of municipal waste management systems. Partial information was obtained from twenty-three communes (60.5% of the test).

Formulation of the basic financial data in the undertakings of municipal waste management

The conducted study selected fifty-two companies that serve a dominating role within the area of thirty-eight distinguished communes. As in the case of cities, a questionnaire was the basic source of information necessary to determine the effectiveness of companies. Responses were provided only by two entrepreneurs, while the whole questionnaire was completed by one company. Thus, the assessment of the effectiveness of companies operating in the sector of municipal waste management was performed based on financial statements filed in the National Court Register, mainly with regard to their financial outcome. Among analysed entities, there are nine commune companies that render their services under an entrustment agreement – so-called in-house – as well as forty-three municipal and private undertakings selected through a tendering procedure.

Municipal waste management companies are characterised by a high share of fixed assets, a relatively low level of foreign sources of financing, and the profits from conducted activity. A cursory analysis has proved that in-house companies generate half the revenue that is achieved by other studied companies. Among the distinguished groups of companies, the revenue of in-house companies is only 17.47% of the total value. Detailed analyses of the value of revenue generated by the analysed companies – by their organisational and legal forms, size, and area of operations – have been presented in Table 1. Limited liability companies constitute 85% of revenue in the group of analysed entities. In the division by company size, twenty-one medium-sized companies form over 61% of the revenue. What is interesting is the fact that the group of large companies (comprised of two companies) generates revenue very similar to twenty-nine small and micro companies. The highest revenue is generated by entities operating in specific cities of the Małopolskie Voivodeship – which is most certainly affected by the number and size of entities from that area – that were subjected to the analysis.

There are significant differences in terms of profits generated by various entities. In the case of the test of companies participating in tenders (a group with more representatives), it is on average about 1.5 million PLN compared to tens of thousands of zlotys of average profit of companies operating as a part of entrustment of services by a regional government unit. International concerns invested hundreds of millions of zlotys in companies operating within Poland. However, it is not reflected by the central tendency, since those values for the population representing tender participants and participants of the so-called in-house model are similar and amount to approximately 27 million PLN. In the case of current assets, there is a larger disproportion in favour of companies operating under tenders. Here, it should be added that entities outside the system of in-house services utilise short-term and long-term sources of financing to a several times greater extent. Such a difference is reflected in measures of the central value as well as in maximum values.

On the basis of the initial analysis, one can conclude that in-house companies feature a much smaller volume of financial values. As

Table 1. The structure of revenue of analysed companies by organisational and legal form, amount of revenue, and area of operations in 2018

Division criteria	Type of company		Number of companies	Share in the total value of revenue [%]
Organisational and legal form	Limited liability companies		48	85.98
	Joint-stock companies		4	14.02
Revenue*	Micro		5	1.77
	Small		24	18.17
	Medium		21	61.04
	High		2	19.02
Area of operations**	Voivodeship	Małopolskie	12**	21.77
		Podkarpackie	2	2.70
		Śląskie	3	5.48
		Opolskie	1	1.21
		Dolnośląskie	6**	8.73
		Lubuskie	1	1.01
		Wielkopolskie	6**	10.89
		Łódzkie	2	2.01
		Świętokrzyskie	2	4.62
		Lubelskie	1	1.84
		Mazowieckie	4**	15.93
		Kujawsko-Pomorskie	1	1.80
		Zachodniopomorskie	3	5.94
		Pomorskie	6	10.12
		Warmińsko-Mazurskie	2	0.83
		Podlaskie	4	5.12

* Applied criterion of amount of revenue on sales – turnovers for: micro – below EUR 2 million; small – from EUR 2 to 10 million; medium EUR 10 to 50 million; large – over EUR 50 million, at exchange rate of EUR 1 = PLN 4.27.
** ALBA SA, ENERIS EKOLOGICZNE CENTRUM UTYLIZACJI Sp. z o.o., SUEZ Polska Sp. z o.o., REMONDIS Kraków Sp. z o.o. operates within the area of more than one of the analysed cities. The revenue of those companies was presented proportionally by individual voivodeships.

Source: own analysis based on obtained financial data.

in the assessment based on the number of individual entities, the analysis of fundamental financial values indicates that solutions applying the entrustment model are uncommon in Poland. Apart from the MPO Sp. z o.o. in Kraków, the entities in that group must be qualified as medium-sized and small companies in the sector of municipal waste management. The achieved financial values are at a level lower than in the case of, e.g., private entities rendering services under a tender won in a particular commune.

Studies within the area of the municipal waste management system

In the situation of market economy, entities are obligated to effectively utilise their owned financial, material, and personal resources as well

as to acquire new customers and maintain current ones, enhance technological processes, and manage their business in an efficient way. It requires determining whether the conducted business activity brings intended effects, and indicating directions for future development. Such approach combines with the notion of effectiveness, which must be understood as the best performance in production and distribution of goods and services at specific costs or the lowest possible costs for particular effects. Furthermore, it can be brought to rational management, i.e. in business activity one must operate in such a way that given specific measures they achieve the maximum degree of implementation of the goal or, given particular progress, they utilise as little resources as possible. In such cases, effective activity involves the application of one out of two principles of rational management, i.e. the rule of the maximisation of obtained results with owned resources, or the rule of the minimisation of incurred funds and costs for implementation of the scheduled tasks.

Effectiveness can be considered in terms of various aspects of the management process, i.e. technical, economic, environmental, etc. Compared to other companies, companies that render public utility services (e.g. municipal waste management) are subject to additional liability to a certain community. Thus, another type of effectiveness can be distinguished – social effectiveness (Wąsowicz, 2018).

In this sense, in order to ensure reliability and efficiency of waste management in a city, one must not rely solely on economic indicators for a company. The effectiveness of public utility activities might be measured by acknowledging three reference points (Figure 4). In this elaboration, the analysis has been made from the perspective of a company and a commune.

The assessment of the effectiveness of the waste management system in the analysed communes has been conducted on the basis of an analysis regarding the degree of collection of the fee for managing municipal waste, the adequacy of the fee for managing municipal waste, and the distribution of current expenditures of the analysed communes for the system. The achieved levels of recycling are a very significant indicator of effectiveness – the quality of waste management in a particular commune. One can, without a doubt, conclude that the higher the level of recycling for the fraction of raw materials in a particular year in the commune, the more effective and efficient the waste management system is. The dynamics of an increase in levels of recycling for the raw material fraction and for construction/demolition waste is also a significant indicator – it shows the degree under which the share of waste subjected to recycling

Effectiveness of public utility activities can be measured by acknowledging three reference points:

the organiser of the public utility market, i.e. the regional government unit (most often a commune)

the direct producer or supplier, i.e. a public utility company

the consumer of such services (inhabitant of a particular city/town)

The analysis was conducted from the perspective of a company and a commune

Figure 4. Measurement of effectiveness of public utility activities

Source: own analysis.

in a particular commune has changed throughout the years. The high value of this indicator testifies to the modernisation of the waste management system in the commune towards more efficient recycling and preparation for re-usage. From the point of view of system effectiveness, the possibly high level of recycling should be achieved at a possibly low utilisation of resources. Thus, comparing the unit cost of operations of the municipal waste management system with the degree of recycling indicates the amount of financial resources necessary to achieve the levels of recycling.

Points of selective collection of municipal waste (Polish abbreviation: PSZOK) are an important element of communal waste management systems. The greater the amount of waste collected at a point of selective collection of municipal waste per one inhabitant of the commune, the more efficient the waste management system is. The proposition of an indicator determining expenditures of the commune to organise points of selective collection of municipal waste, calculated per capita, should express the 'involvement' of the commune in the increase of selectively accumulated waste that can be used in the processes of recycling and preparation for re-usage. The determination of expenditures for points of selective collection of municipal waste – with regard to the amount of waste ending up at PSZOKs – shows that the effort and resources needed to collect waste at such points (a lower value of this relation stands for greater efficiency of selective collection compared to incurred costs). However, it should be highlighted that the effects of resources spent on points of selective collection of municipal waste can often become noticeable after some time from the date of their establishment, since the efficiency of operations of such an element of the waste management system in a commune is also influenced by the approach of the society, which must be properly shaped through relevant educational activities.

The effectiveness of municipal waste management companies has been determined based on the indicator analysis of available financial data (due to the lack of technical and exploitation data). The analysis has utilised profitability indicators that, due to their synthetic nature, can be applied in the assessment of entity effectiveness. However, owing to the specific social role of public utility companies, the primacy of generated profit is inconclusive. That is why the indicator of accumulated profit of companies operating within a particular commune to the size of expenditures for the waste management system should fall within a specific limited range.

The equities profitability indicator is the most adequate measure of advantages achieved by owners of such a business entity. Bearing in mind the fact that, in the case of market economy, capital can be invested in various undertakings, the possibility to assess the effectiveness of its investment in particular undertakings is of crucial significance for the owner of such capital.

Another group of indicators that creates a chance to compare the effectiveness of companies in the sector of municipal waste management is the group of financial indicators regarding the efficiency of operations, also called activity indicators. The activity indicator, connected with the use of assets, was distinguished.

Public utility companies owned by a regional government unit are subject to protection against two hazards that also discipline the managerial processes in private entities, i.e. protection against being taken over and against bankruptcy. Thus, when determining the effectiveness of management, it is also appropriate to assess the ability of a company to pay its liabilities.

In order to function and provide public utility services, companies in the selected sector must have assets. Fixed assets are the basic element that influences the effects of company operations. When utilised in a rational way, they shape an optimum level of production capacities of the company and lower unit costs. High productivity of fixed assets held by a company should be the general goal of management. This elaboration has distinguished between the relation between fixed assets and total assets as a measure of effectiveness (with acknowledgment of the specific nature of the sector).

The purpose of rational management in municipal waste management companies must not only be focused on increasing the effectiveness in the economic area, but also in the quality of life of the society, which requires, apart from financial criteria, e.g. ethical or environmental criteria that ensure better and more complete satisfaction of needs of a local community. Rational decisions can then be understood as actions and decisions that acknowledge the requirements of high economic effectiveness and increase the quality of life of the society. This is the context in which considerations regarding the effectiveness of entities in this sector should be presented. Unfortunately, the lack of responses from companies that received the questionnaire prevented a more complete analysis of the issue.

The analysis of the effectiveness of entities in the municipal waste management system with the application of taxonomic and statistical methods

The assessment of the effectiveness measures for companies that operate in differently organised municipal waste management systems in individual communes utilised a multi-criterion ranking. In order to create a ranking of communes and companies characterised by multiple criteria, the analysis applied synthetic variable, the structure of which was based on the method of zeroed unitarisation (MZU). MZU requires several steps. In the first stage, diagnostic variables X_j are divided into stimuli, inhibitors, and neutral variables; next, they are normalised into variables Z_j (Młodak, 2006).

For stimuli and inhibitors, the normalisation formulae are, respectively, (1) and (2):

$$z_{ij} = \frac{x_{ij} - \min\limits_{i} x_{ij}}{\max\limits_{i} x_{ij} - \min\limits_{i} x_{ij}}, \ X_j \in S \quad (1)$$

$$z_{ij} = \frac{\max\limits_{i} x_{ij} - x_{ij}}{\max\limits_{i} x_{ij} - \min\limits_{i} x_{ij}}, \ X_j \in D \quad (2)$$

In the case of the neutral variable, if the range of nominal values $<b_{1j};b_{2j}>$ is known, the normalisation formula is as follows:

$$z_{ij} = \begin{cases} \dfrac{x_{ij} - \min\limits_{i} x_{ij}}{b_{1j} - \min\limits_{i} x_{ij}}, & \text{when} \quad x_{ij} < b_{1j} \\[2ex] \qquad 1 \ \text{when} \ x_{ij} \in \left[b_{1j};b_{2j}\right] \\[2ex] \dfrac{x_{ij} - \max\limits_{i} x_{ij}}{b_{1j} - \max\limits_{i} x_{ij}}, & \text{when} \quad x_{ij} < b_{2j} \end{cases}, X_j \in N \quad (3)$$

The next stage of the MZU involves the aggregation of normalised variables, e.g. through arithmetical means:

$$Q_i = \frac{1}{k}\sum_{j=1}^{k} z_{ij} \quad (4)$$

Values of the Q_i synthetic variable are normalised in the range [0,1] and allow for being organised according to the intensity of the analysed phenomenon. The higher the value of the Q_i variable achieved by an item (closer to 1), the higher rank it will have in the ranking of the analysed items (and vice versa).

In the area of the effectiveness of municipal waste management of communes, ten properties can be treated as stimuli, four properties as inhibitors, and four as neutral variables. Properties in the case of which the higher the value, the higher the effectiveness, included: the level of recycling and preparation for re-usage of municipal fractions – paper, metals, glass, and plastics; the level of recycling, the preparation for re-usage, and the recovery with methods other than safe for the construction and demolition waste which constitutes municipal waste; the relation of proceeds from fees for managing municipal waste to the current income of the commune; the relation of expenditures of the commune for the municipal waste management system to general expenditures of the commune; the amount of waste at the point of selective collection of municipal waste with regard

to the number of inhabitants; the expenditures for the point of selective collection of municipal waste per capita; the expenditures for the municipal waste management system per capita; the dynamics of changes of recycling levels with methods other than safe with regard to the construction and demolition waste which constitutes municipal waste; the dynamics of recycling municipal fractions – paper, metals, glass, and plastics.

The following were qualified as inhibitors (the lower the value, the higher the effectiveness): the relation of current expenditures of the commune for the municipal waste management system to the amount of commune waste; the cost-effectiveness of the point of selective collection of municipal waste (expenditures for the point of selective collection of municipal waste/amount of waste at the point of selective collection of municipal waste); two synthetic indicators – (the current expenditures of the municipal waste management system/amount of commune waste)/the achieved degrees of recycling of fractions of waste, i.e. paper, metals, glass, and plastics; and the current expenditures of the commune for the municipal waste management system/amount of commune waste)/the achieved degrees of recycling with methods other than safe for the construction and demolition waste which constitutes municipal waste.

Neutral variables (the highest effectiveness if the values fall within a specific set) included: the proceeds from fees for managing municipal waste to expenditures for the municipal waste management system (a distinguished set around 1 – from 0.99 to 1.01); the proceeds from fees for managing municipal waste with reference to expenditures for collection and transport of waste (the optimum value of the set falls within the range from 1 to 1.15); the planned cost of the municipal waste management system and expenditures for the municipal waste management system (this is also a range oscillating around 1, yet with higher 'marginal values' – from 0.90 to 1.1); the total net profit of companies from a particular commune with regard to expenditures for the municipal waste management system (assuming that the specific

nature of public utility services limits the value of profits within a specific range from 0.01 to 0.05). The results of the effectiveness ranking for twenty-three communes (out of thirty-eight that received the questionnaire) have been presented in Table 2.

Table 2. The ranking of communes according to the level of effectiveness of the municipal waste management system in 2018

Rank	Value of composite variable	Communes
1	0.6217	Zakopane
2	0.5932	Kraków
3	0.5819	Poznań
4	0.5802	Olsztyn
5	0.5611	Opole
6	0.5428	Pruszków
7	0.5401	Gdynia
8	0.5379	Tychy
9	0.5337	Wrocław
10	0.5322	Katowice
11	0.5246	Przemyśl
12	0.5091	Tarnów
13	0.4985	Jelenia Góra
14	0.4803	Wieliczka
15	0.4777	Rzeszów
16	0.4742	Nowy Targ
17	0.4601	Białystok
18	0.4568	Słupsk
19	0.4287	Warszawa
20	0.4131	Nowy Sącz
21	0.4122	Konin
22	0.3873	Lublin
23	0.3569	Łódź

☐ – Communes with the municipal waste management system based on a model other than the in-house model.

▨ – Communes with the municipal waste management system based on a model with a commune company without an in-house tender.

Source: own analysis.

According to Table 2, in the area of effectiveness the best results were achieved by the following communes: Zakopane, Kraków, Olsztyn. The other end of the ranking included: Łódź, Konin, and Lublin. Communes that implemented the in-house model are on the 1st and 2nd rank in the ranking and take places from 10 to 14 and 17. By analysing only the first and the last ranks, it is possible to conclude that communes which apply that model feature **higher effectiveness** than cities which apply the tendering model. In the case of central ranks from 10 to 17, among which six out of eight analysed communes apply the in-house model, it is justified to conclude that the companies feature **effectiveness that is not lower** than in the case of communes which apply alternative solutions for the municipal waste management system.

In the area of effectiveness of municipal waste management, six companies have the characteristics of stimuli, one reflects an inhibitor, and one – a neutral variable. The group of stimuli included the value of net revenue on sales, the yield of equity (profitability of equities), the total utilisation (rotation) of assets, the share of fixed assets in total assets, and the degree of the completion of the questionnaire by the company. It means that the higher the value of distinguished indicators, the higher the effectiveness of the analysed entity. The inhibitors included the relation between financial costs and total liabilities, while the indebtedness ratio was adopted as the neutral variable in the range (50%-67% according to the theory of financial management of enterprises).

The results of the ranking have been presented in Table 3. In the area of financial effectiveness, the best results were achieved by the following companies: Miejskie Przedsiębiorstwo Oczyszczania Sp. z o.o. in Kraków, ALBA S.A., and SUEZ Polska Sp. z o.o. The winner of the ranking is the only representative of in-house entities in the first ten ranks of the ranking. The next ten ranks also include only one company from the entrustment model – LECH Sp. z o.o. Other companies operating in that system are ranked in the third, fourth, and fifth ten of the ranking. Thus,

it may be concluded that companies that operate in house are not more effective in the financial aspect than other companies. The first rank of Miejskie Przedsiębiorstwo Oczyszczania Sp. z o.o. in Kraków is the proof of skilful financial management of a company conducted by high-class managers.

Here, it should be added that effectiveness measured with the exclusion of missing technical and exploitation data does not constitute a full assessment of the value of companies in the in-house model.

Spearman's rank correlation coefficient was calculated in order to analyse whether the orderings of companies and communes are compliant, which means that the effectiveness of the commune translates into the effectiveness of companies that operate in such a commune[1]:

$$r_s = 1 - \frac{6\sum_{i=1}^{n}\left(d_x - d_y\right)^2}{n\left(n^2 - 1\right)} \quad (5)$$

where:
d_x, d_y – the ranks of the company in the rankings according to the effectiveness of the commune and own effectiveness,
n – the number of companies in the ranking.
The r_s coefficient takes values from –1 to 1 and its positive value stands for ordering compliance of items, while a negative value – for non-compliance (opposite rankings).

In this study, the value of the rank correlation coefficient of 0.099 is the indicator of the low ordering of compliance of companies and communes at the national level, and such dependency has no statistical significance (p-value > 0.1). Figure 5 presents the correlation diagram in which points represent companies with their corresponding effectiveness of the commune in which they operate (horizontal axis) and the aggregate effectiveness of their own activities (vertical axis).

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[1] Only those companies for which the aggregated effectiveness indicator was calculated were acknowledged here and, at the same time, such a ratio was calculated for the commune in which the company operated.

Table 3. The ranking of municipal waste management companies according to the level of their efficiency in 2018

Rank	Value of composite variable	Company
1	0.5007	Miejskie Przedsiębiorstwo Oczyszczania Sp. z o.o. – Kraków
2	0.4835	ALBA S.A
3	0.4757	SUEZ Polska Sp. z o.o.
4	0.4348	Suez Zielona Energia Sp. z o.o.
5	0.3989	MPO m.s. w Warszawie Sp. z o.o.
6	0.3762	REMONDIS Szczecin Sp. z o.o.
7	0.3752	Eneris Surowce S.A.
8	0.3741	ENERIS S.A.
9	0.3617	ENERIS EKOLOGICZNE CENTRUM UTYLIZACJI Sp. z o.o.
10	0.3341	Suez Północ Sp. z o.o.
11	0.3237	Zakład Gospodarowania Odpadami Komunalnymi Sp. z o.o. – Olsztyn
12	0.3235	LECH Sp. z o.o.
13	0.3211	KOM-EKO S.A.
14	0.3177	Przedsiębiorstwo Gospodarki Komunalnej Sp. z o.o. – Koszalin
15	0.3159	SIMEKO Sp. z o.o.
16	0.3116	Miejskie Przedsiębiorstwo Gospodarki Komunalnej – Rzeszów Sp. z o.o.
17	0.3094	Zakład Zagospodarowania Odpadów w Poznaniu Sp. z o.o.
18	0.3050	REMONDIS Kraków Sp. z o.o.
19	0.3049	Miejskie Przedsiębiorstwo Oczyszczania Łódź Sp. z o.o.
20	0.3047	Trans-Formers Karpatia Sp. z o.o.
21	0.3020	Przedsiębiorstwo Gospodarki Komunalnej Sp. z o.o. in Słupsk
22	0.2898	Przedsiębiorstwo Usług Komunalnych S.A. – Kalisz
23	0.2861	Przedsiębiorstwo Gospodarki Odpadami Sp. z o.o. – Kielce
24	0.2742	MPGK Katowice Sp. z o.o.
25	0.2712	ALBA Sp. z o.o.
26	0.2717	FCC Polska Sp. z o.o.
27	0.2698	Przemyska Gospodarka Komunalna Sp. z o.o.
28	0.2686	Zakład Utylizacji Sp. z o.o. – Gdańsk
29	0.2684	MPO Białystok Sp. z o.o.
30	0.2623	Przedsiębiorstwo Gospodarki Komunalnej w Suwałkach Sp. z o.o.
31	0.2612	Miejskie Przedsiębiorstwo Gospodarki Komunalnej Sp. z o.o. – Jelenia Góra
32	0.2609	Miejskie Przedsiębiorstwo Gospodarki Komunalnej Sp. z o.o. – Tarnów
33	0.2537	Miejski Zakład Oczyszczania w Pruszkowie Sp. z o.o.
34	0.2532	MASTER-ODPADY I ENERGIA Sp. z o.o.
35	0.2527	PGKiM Sp. z o.o. in Konin
36	0.2503	AVR Sp. z o.o.

Table 3 – continuation

Rank	Value of composite variable	Company
37	0.2487	Miejskie Przedsiębiorstwo Oczyszczania Sp. z o.o. in Toruń
38	0.2459	Miejskie Przedsiębiorstwo Oczyszczania Sp. z o.o. Szczecin
39	0.2458	Eko Dolina Łężyce Sp. z o.o.
40	0.2430	BESKID ŻYWIEC Sp. z o.o. Żywiec
41	0.2401	Zakład Komunalny Sp. z o.o. – Opole
42	0.2347	Zakład Gospodarki Komunalnej i Mieszkaniowej w Malborku Sp. z o.o.
43	0.2234	Rejonowe Przedsiębiorstwo Gospodarki Komunalnej – Myślenice
44	0.2208	Zakład Unieszkodliwiania Odpadów Komunalnych Sp. z o.o. – Białystok
45	0.2115	Zakład Utylizacji Odpadów Sp. z o.o. – Myślenice
46	0.2113	Zakład Gospodarki Komunalnej w Wieliczce Sp. z o.o.
47	0.2111	Ekosystem Sp. z o.o.
48	0.2106	Przedsiębiorstwa Usług Komunalnych Sp. z o.o. – Tarnów
49	0.2101	Gdańskie Usługi Komunalne Sp. z o.o.
50	0.2001	Przedsiębiorstwo Gospodarki Odpadami EKOMAZURY Sp. z o.o.
51	0.1922	Zakład Gospodarki i Usług Komunalnych Spółka z o.o. – Lubań
52	0.1799	Inneko Sp. z o.o.

☐ – Company rendering services under a won tender.
▨ – Commune company without an in-house tender.

Source: own analysis.

The line visible in the chart represents the regression function with the following equation: $y = 0.1984 + 0.2207 \cdot x$. Its positive inclination confirms that higher effectiveness of communes is reflected by higher effectiveness of companies (an increase in aggregate effectiveness of communes by 0.1 will improve, on average, the aggregated effectiveness of companies only by about 0.022), but this dependency has no statistical significance (p-value for the regression coefficient is 0.276).

The above considerations prove that the analysis of the effectiveness of communes in municipal waste management confirms the advantage of the in-house model. The lack of a reflection of company effectiveness in the study results, above all, from the selection of available data. Since it was impossible to correlate the achieved financial values with other measures, a thorough analysis of the effectiveness of companies was prevented. A significant conclusion that resulted from the analysis of company effectiveness is that regardless of the organisational and legal form, the type of ownership, or the system model that the company operates in, effective management can be achieved through high financial effectiveness. An additional conclusion is that the effectiveness of a commune does not translate into the effectiveness of enterprises.
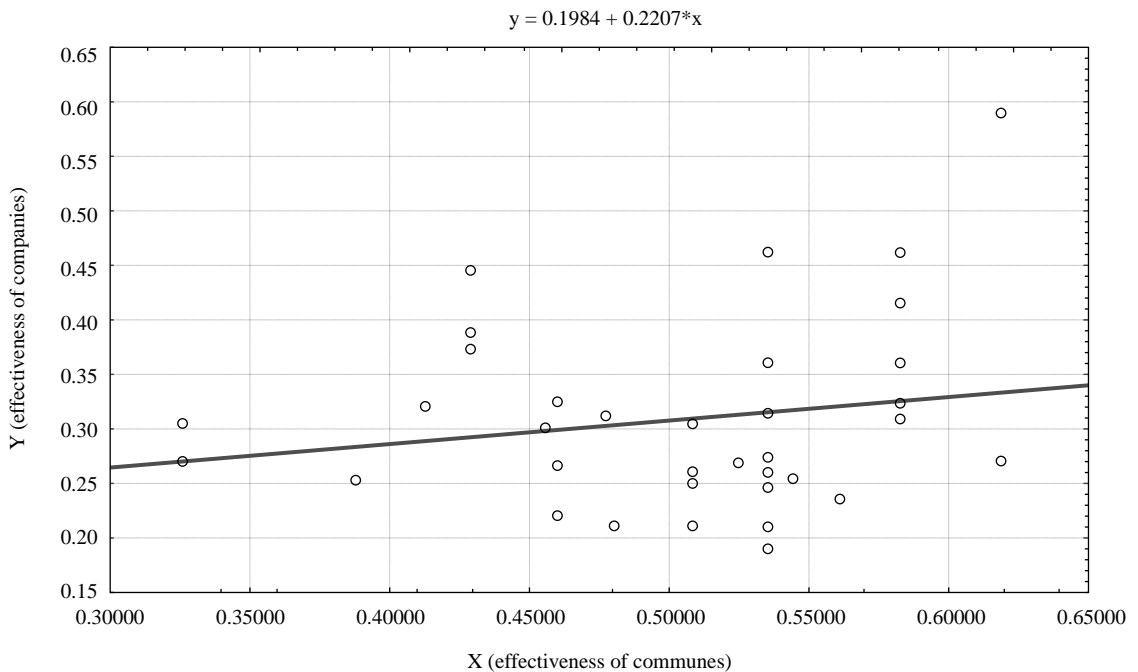
$$y = 0.1984 + 0.2207*x$$

Figure 5. The correlation diagram presenting the relationship between the aggregated effectiveness of an enterprise and the aggregated effectiveness of communes

Source: own analysis based on Tables 2 and 3.

Conclusion

This article was the attempt at associating the analysis of municipal waste management in communes with the operational and financial activities of selected companies – representatives of every commune subjected to the study. They received a purposefully elaborated questionnaire for the study. Among others, the questions in the questionnaire referred to: owned facilities, the amount of waste gathered and processed at their own waste facilities, the effects of recovery and recycling, the equipment, the manner of performing tasks in favour of the commune, the number of served real properties, and general financial data. All the information is publicly available and it should be included in reports addressed to the commune and the Marshal's Office. Only two completed questionnaires were received

from the companies, including one completed only partially. Financial statements (published in the National Court Register) were used to acquire data that was utilised to assess the financial effectiveness of the analysed companies and the correlation of that effectiveness with selected characteristics of the operating effectiveness of communes.

For the analysis, multi-criterion rankings were applied with the use of synthetic variable, the structure of which was based on zeroed unitarisation (method of zeroed unitarisation – MZU). Owing to general financial data, technical and operational data, as well as output data, it was possible to determine the rankings of effectiveness both for companies in the system of municipal waste management and for communes.

A correlation diagram was created – the dependency between the aggregated effectiveness

of companies and the aggregated effectiveness of waste management in communes.

Being aware of the difficult obstacles regarding the acquisition of reliable data and the complex technical and technological dependency of municipal waste management in communes on financial management of companies – the majority of which were commercial companies (obligated to gain earnings through generation of profits) – the final conclusion was conceived of: communes which entrust municipal companies with the management of an integrated system for municipal waste management or/and its individual chains feature more properties of operating, economic, and financial effectiveness within the scope of the management of municipal waste.

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