Efficient scale and scope of business models used in municipal solid waste management

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Abstract

Purpose – The paper aims to compare the efficiency of alternative municipal solid waste (MSW) management business models: a single provider against multiple providers.

Design/methodology/approach – In this paper the drivers of MSW management costs are analysed to test the impact of the scale and scope of MSW management services on the average cost. While the business-as-usual scenario foresees a single provider, the alternative scenario foresees multiple providers.

Findings – Based on the empirical data on municipal waste management costs, on average, the size and the average cost of the service are inversely related. This trend is supported using sub-sets defined by the quantity of waste managed. Multiple factors aid in explaining this result, and among others, due to scale and scope, factors such as transition costs increase with the number of players running different services.

Practical implications – The provision of public services of economic interest should favour the participation of more companies wherever possible to the extent that social surplus is produced. However, pursuing this principle to the detriment of efficient service delivery is not ideal. This paper demonstrated that a single-provider waste management business model is efficient under specific conditions, as in this article.

Originality/value – This paper presents an original research methodology for comparatively analysing waste management service efficiency in urban areas and provides adequate evidence using alternative measures of costs according to the phase of the waste management chain, the scale and ultimately the scope of MSW management services.

Keywords Waste management, Business model, Economies of scale, Public procurement, Waste management chain, Circular economy

Paper type Research paper

1. Introduction

Public services of general economic interest are fundamental to the nation's economic development and significantly impact social welfare (Boggio, 2016). The operational efficiency of the municipal solid waste (MSW) management industry has become increasingly significant for achieving sustainable development objectives (Zorpas, 2020). Business and governance models of MSW management need to evolve towards efficiency levels compatible with the achievement of economic and environmental objectives (Kaza *et al.*, 2018). Research has exposed the critical need for assessing different models of governance and organisation, and entrusting services for the governance and delivery of public services (Soukopová *et al.*, 2017). Trade-offs between the competitive dimensions in industrial structures characterised by imperfect competition must also be considered.

Typically, local authorities can choose between three models and procedures: entrusting the service to third parties through public procedures, the provision of the services through

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hybrid public-private firms and in-house provision. Free market and competition rules apply to actors entrusted with providing public services for economic interests as long as these rules do not prevent them from fulfilling their general mission (European Commission, 2022).

Additionally, the principle that underpins European competition and public procurement legislation since the introduction of Directive (2014)/24/EU is important, which is to encourage small- and medium-sized enterprises (SMEs) to participate in public procurement and, thereby, in the provision of public services. However, this principle can be abandoned by considering integrated utilities, which can provide more services at various stages of the chain, owing to the economies of scale and scope resulting from their production efficiency. Sub-dividing large municipalities can be assumed to lead to greater competition, fostering growth among service providers (Sarra *et al.*, 2020). However, on the contrary, a recent empirical study focused on Barcelona revealed that multiple firms can strategically interact to maximise producer surplus at the expense of social welfare (Bel and Sebő, 2021).

MSW management can be regarded as an industry with two or more intertwined phases. The market structure in the first phase is mainly labour-intensive, while the second phase is capital-intensive and supported by enabling infrastructure, such as waste treatment plants. Both phases are subject to the risk of market failure, and in certain circumstances, the market can effectively manage one or more services (Di Foggia and Beccarello, 2018).

The industrial organisation of the collection phase often involves local monopoly configurations justified by the economies of scale resulting from the size of the service and its economies of scope (AGCM - Italian Competition Authority, 2016). Much has been written regarding the existence of scale economies, an important issue with some consensus (Callan and Thomas, 2001), as confirmed in previous analyses that also found scale economies and some efficiency differences between public and private providers (Tickner and Mcdavid, 1986). Early research in the field of economies of scale focused on the inter-relationships of scale, market structure and costs, with scattered evidence in the beginning, based on the little evidence of the existence of certain scale economies (Stevens, 1978).

In this regard, the more recent findings on economies of scale have provided mixed results. For example, a recent study found that less than half (40.4% of the municipalities evaluated), presented negative economies of scale (Llanquileo-Melgarejo and Molinos-Senante, 2021). Another study underscores the drivers of costs under alternative cost definitions (Di Foggia and Beccarello, 2020). Similarly, a third article concluded that population and size are important factors for scale economies, and the implication is uncertain (Wowrzeczka, 2021). This uncertainty is partly due to information asymmetries that complicate comparative analyses. Another factor that concurs with mixed results is the unit of analysis.

Indeed, many studies aimed at understanding the economies of scope in MSW management by focussing on the input factors of firms and very different output variables, failing to differentiate among collection costs, total costs and treatment costs or using per capita cost against costs per unit of waste.

Scale economies in a public service of general interest such as waste management should be evaluated from the perspective of the contracting authority, paying more attention to exogenous factors affecting the organisation of the service that must be used at the same level as the input factors of firms. Indeed, failing to consider the above may result in formally correct results but be biased in practice if the sub-additivity of costs is not considered. Consequently, the contracting authorities may decide it inappropriate to divide the contract into lots to avoid the risk of rendering the execution of the contract excessively technically difficult or expensive and because co-ordinating the different contractors for the lots could risk undermining the proper execution of the contract.

Some scholars have empirically evaluated the impact of different regulated business models on MSW management and suggested that their efficiency can be increased by limiting the size of these service areas so that the system encourages large service providers to compete for service allocation in a large number of small areas, thus intensifying the positive effects of market competition (Sarra *et al.*, 2020). However, it could be argued that reducing the size of the areas that can be allocated to a single firm may promote anti-competitive strategies aimed at creating divisions between several theoretically competing operators.

Strengthening market competition and realising economies of scale by integrating organisations (and thus reducing the number of individual economic actors) can be considered appropriate choices for achieving economic and environmental efficiency. First, this idea is supported based on an econometric model that identifies the main determinants of service costs. Then, the focus was on the analysis of multiple case studies, using a sample consisting of the ten most populous Italian cities. Third, a single case comparing a "business-as-usual" model involving a single economic actor with an alternative scenario consisting of four firms was analysed.

Evidence suggests that as the size of the service increases, the average cost tends to decrease. The case study confirms the presence of economies of scale, resulting from the specific factors employed in the production of the service.

The rest of the article is organised as follows. Section 2 presents a literature review and reports on the previously published studies that have explained some of the aspects analysed in this article. Section 3 describes the context and research design as well as the data collection process and the variables in this study. Section 4 presents the results of the econometric analysis and case studies. Section 5 discusses the main considerations and implications arising from the findings. The final section concludes.

2. Background and literature

The complexity of the waste management (WM) industry raises concerns about the technologies it relies upon and the sustainability of its business models (Björklund *et al.*, 1999), which also depend on how contracts between MSW management providers and institutions are structured (Walls, 2005). In light of the challenging environmental goals, the efficiency of MSW management business models has become an increasingly important concern (Kinnaman, 2009); thus, their sustainability as well as their emergent role in local communities is critical (Avilés-Palacios and Rodríguez-Olalla, 2021; Esmaeilian *et al.*, 2018). As such, the relationship between efficiency and economies of scale is attracting more attention at both the political and the organisational levels. Accordingly, the number of studies on the cost of MSW management has grown, such as the analysis of the cost functions (Bohm *et al.*, 2010) or the cost of recycling environmental policies (Da Cruz *et al.*, 2014).

Previous literature has focused on the determinants of demand for MSW management services (Diaz-Farina *et al.*, 2020), organisational forms and modes of supply (Zhang *et al.*, 2015), policy implications (Goddard, 1995), cost structures (Callan and Thomas, 2001; Pérez-López *et al.*, 2016) and the need to develop strategies to achieve sustainability goals. Regarding sustainability goals, geopolitical contingencies make it difficult to reach the binding agreements and credible commitments made by policymakers (Darus *et al.*, 2020).

Different approaches have been proposed to analyse the economic efficiency of MSW collection firms. For example, a recent study identified a relation between costs and environmental efficiency, although this relationship is non-linear, as a rise in the separated waste collection rate increases total costs by a less-than-proportional amount, which provides evidence of the existence of economies of scale (Bartolacci *et al.*, 2019).

Economic and technical efficiency have emerged as prominent factors in explaining costs (lo Storto, 2021). Given the increasing pressure governments face to increase cost efficiency, they may transfer waste disposal services to private firms (Jacobsen *et al.*, 2013). This possibility has raised the dilemma of whether for-profit enterprises are compatible with outcomes that maximise social welfare (Kinnaman, 2009); the available findings are mixed (Bel and Fageda, 2010; Simões *et al.*, 2012).

Empirical evidence based on the existing MSW management business models is important, as it shows how economic and political factors exert different impacts on MSW management via both private and public firms (Plata-Díaz *et al.*, 2014). Other studies indicate that private MSW management operators are not necessarily better performers than public firms (Bel and Fageda, 2010).

Additionally, firm size, inter-firm relations and alternative technologies, as found in studies on green reverse logistics technology (Mugoni *et al.*, 2023), can be argued to significantly impact MSW management strategies (Lombrano, 2009). Considering that the size of firms that perform public services may correspond to a greater propensity to innovate, it is intuitive that advancing MSW business models can improve the net economic benefit they provide (Marashlian and El-Fadel, 2005). Broadly speaking, business models and MSW management methods, such as the organisation of collection services, have received limited attention (Guerrini *et al.*, 2017).

These methods are crucial because they significantly impact the organisation of work (Allesch and Brunner, 2014), and both controllable and non-controllable factors can significantly impact the costs of MSW management (De Jaeger and Rogge, 2013).

Furthermore, the way the service is provided, and the size and density of the population also affect the costs of MSW management due to economies of scale (De Jaeger *et al.*, 2011). The characteristics of the waste produced also play an important role (Chifari *et al.*, 2017; Greco *et al.*, 2015). Worth remembering is that morphological and geographical factors (Passarini *et al.*, 2011), socio-economic conditions (Mazzanti *et al.*, 2008), and policies and legal frameworks (Benito-López *et al.*, 2011) are also central to forming cost structures. Environmental objectives (Beccarello and Di Foggia, 2016), production technologies (Swart and Groot, 2015; Tisserant *et al.*, 2017), and the use of waste management facilities (Chu *et al.*, 2019) also play a role in this process.

With respect to how the competitive environment and business strategies influence agility, adaptability and alignment – which are linked, as reported by a recent study (Garrido-Vega *et al.*, 2021) – there is a paucity of articles focussing on the strategic behaviour of MSW management firms. Some studies have drawn conclusions concerning the degree and type of market competition (Bel and Sebő, 2020, 2021).

3. Methodology

3.1 Context

The waste management industry is a hybrid, regulated and market-driven sector as the main activities in the collection phase are often allocated to legal monopolies, whereas those in the treatment phase, for example of waste electrical and electronic equipment (Roy *et al.*, 2022), can mostly be fulfilled by the market.

Therefore, analysing economic and environmental efficiency based on identifying economies of scale and scope is particularly complicated. As evidence of this, the results in the previous literature do not necessarily reach the same conclusions. There are many reasons for this. Studies have been conducted in different disciplines; also, the type of cost analysed as a dependent variable (e.g. total costs, costs of separated collection, costs of non-segregated collection and sales prices) differs depending on the context. The unit of analysis may contribute to the variance in the results, and the analysed phase plays a large role in this phenomenon.

We refer to the combination of the transaction cost approach, economies of scale and the competitive aspects that are becoming increasingly important in defining how the MSW management industry should function.

The idea of transaction costs is applied in many contexts, from simple situations to more general ideas that consider various methods for allocating resources and coordinating economic activity (Klaes, 2016). Transaction costs are a necessary first step in separating the factor market from the product market. It may be impossible to distinguish between markets in service industries characterised by a supply chain with a significant number of suppliers. Therefore, distinguishing one organisation from another is often difficult when decisions are contractually binding. Furthermore, transaction costs are often difficult to measure and separate by type (Cheung, 2016).

Transaction costs, like production costs, are a wide-ranging designation for a heterogeneous assortment of inputs and transaction functions that may show diminishing, constant or increasing returns; in general, economies of scale are often pronounced. Compared to a theoretical state without transaction costs, transaction costs inevitably reduce social welfare due to the loss of allocative efficiency they incur. Efficiency problems also arise in a more general context. As complicated transactions may include multi-lateral contracts with many parties, transaction costs tend to increase (Niehans, 2016).

Figure 1 is a theoretical approximation of how transaction costs can be delineated within the two-stage waste chain. Figure 1a represents an integrated provider operating at both levels of the supply chain. Figure 1b represents a market structure characterised by several firms that, as in the case of an integrated system, operate in several stages of the supply chain. In this case, the concessionaire must manage contracts with some firms, which, as it is a public service, must be provided at the same level of quality for all citizens. Figure 1c

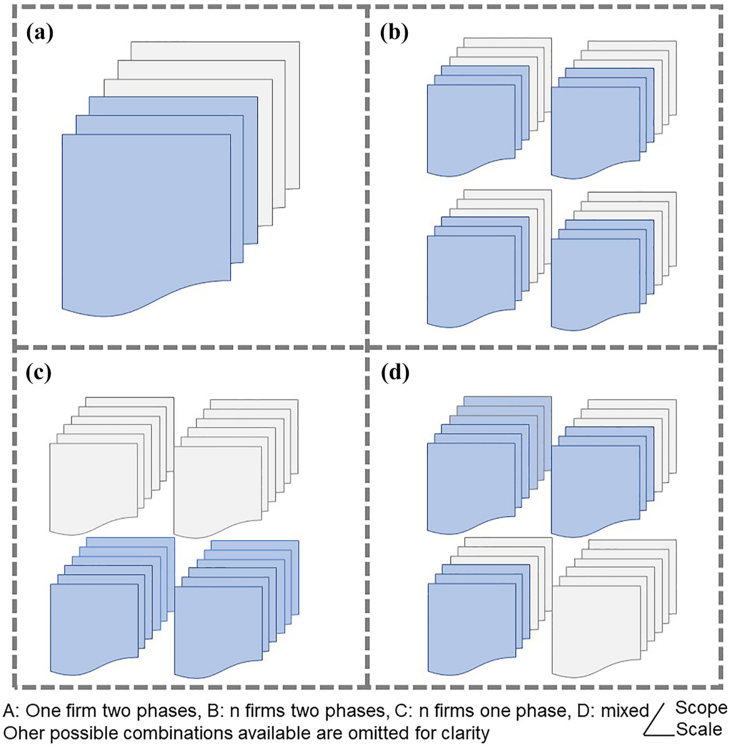

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Figure 1.
Possible service configurations

represents a market structure in which multiple firms specialise in services that take place in only one phase of the supply chain. In this case, a similar situation to that described in Figure 1b arises; however, not only is a coordination point necessary at a horizontal level in the same phase of the supply chain but also an additional element is added consisting of the provision of a service in only one phase of the supply chain. Figure 1d generalises different configurations. Please note that the cases presented in Figure 1 do not include all possible configurations.

The phases that make up this network industry as well as the main functions – and consequently the different services within the two resulting phases – can be seen in Figure 2. Figure 2 shows operations in one or more phases. Figure 2 also includes an additional phase (the generation of urban waste), as it is increasingly important in organising citizen activities that extend beyond mere communication and awareness campaigns. The two arrows are significant. The arrow in the upper part of Figure 2 shows the path of waste; that in the lower part reflects the circular economic process.

Therefore, the relationship between efficiency and economies of scale is more important at both policy and market organisation levels, and thus, the number of relevant studies on the cost of MSW management has increased (Pérez-López *et al.*, 2016; Sarra *et al.*, 2017). The economic literature has often focused on the determinants of demand for MSW management services (Diaz-Farina *et al.*, 2020), organisational forms and mode of supply (Zhang *et al.*, 2015), and cost structures of MSW management (Callan and Thomas, 2001; Pérez-López *et al.*, 2016) as well as the need to develop MSW management strategies to achieve sustainability goals.

3.2 Research design

The analyses were developed at two levels to increase the robustness of the results; two research questions were developed to investigate this topic.

RQ1. What is the relation between the size of the service and the cost? An econometric analysis based on 54% of Italian municipalities was developed to identify the

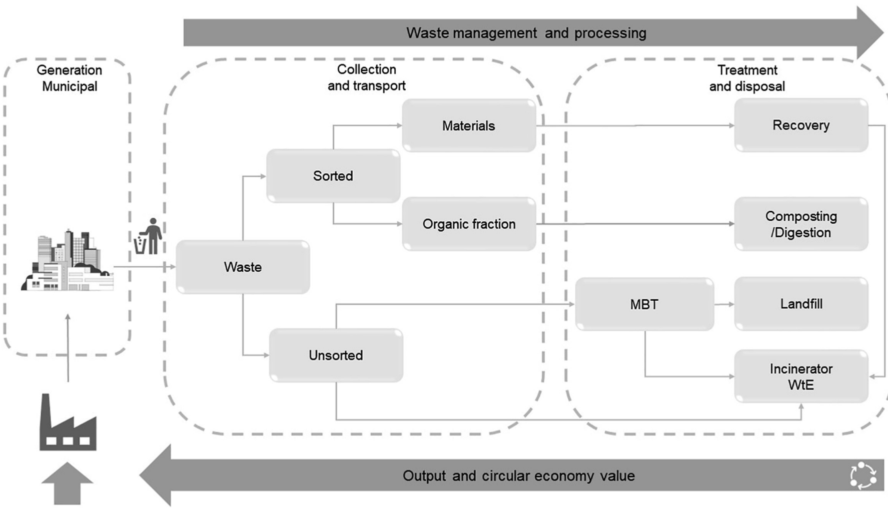

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Figure 2. Waste management chain

impact of the determinants of MSW management costs. Then, a sensitivity analysis of different samples was performed by dividing the sample into 3, 5, 10, 15 and 20 sub-samples. The hypothesis is an inverse relationship between scale and cost.

RQ2. Which factors impact the optimisation of MSW management services? A case study was used to test the best option between assigning MSW management to a single firm or dividing the city into four lots and assigning the service to four firms. The observed cost was reclassified, based on the 56 sub-services (see Annex 1 for additional details) that constitute the service. An alternative scenario in which four firms provide MSW management services was simulated for comparative purposes.

This scenario first considered the organisational structure of the incumbent, which is divided into four branches referring to four sub-areas of the city of Milan. Then, a hypothetical total cost was calculated, based on the four existing operating divisions. The case study analysis aimed to shed light on the operating and organisational factors that have received little attention thus far in MSW research on scale and scope. The hypothesis is that a single contractor is expected to provide MSW management services more efficiently due to organisational issues and transaction costs.

3.3 Data collection and variables

The official data from the municipal waste cadastre published by the Italian national environmental protection institute (ISPRA) and openly accessible from the ISPRA web portal were used to run the analyses. The cadastre database contains data referring to the cost of MSW management, treatment options and waste production at the municipality level. Similarly, the data available in the public balance sheets of the city of Milan were used. Only municipalities with available data were included in the sample. The morphological and geographical data were retrieved from the Italian Statistics Institute portal, which contains the data on all Italian municipalities, which are publicly available for download. We aimed to increase the robustness of the analysis at the sub-sample level by rerunning the econometric analysis using comparable municipalities by size, as reported in the sensitivity analysis.

Table 1 contains the key statistics for the variables used in this analysis. The data refer to 2019, as it was the last available certified period at the time of data collection (see Figure 3).

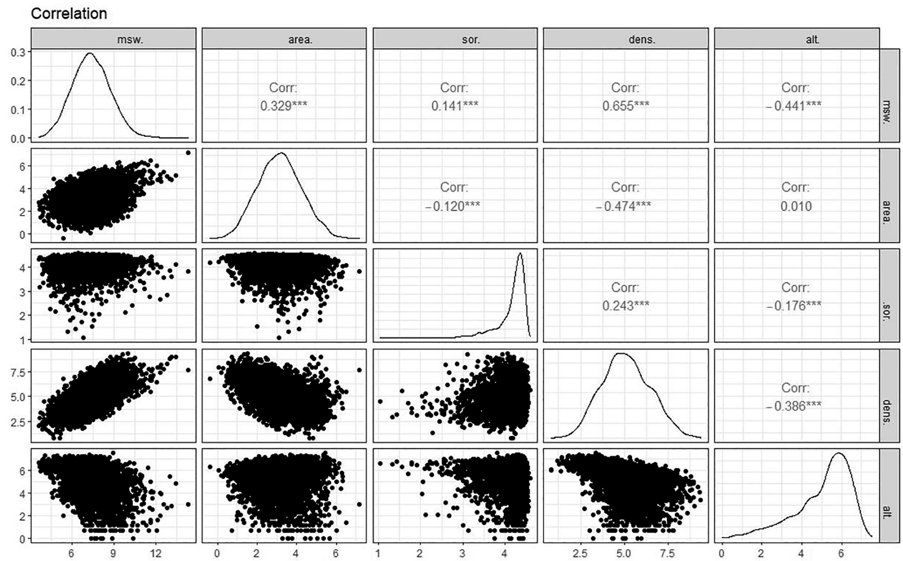
4. Empirical evidence

Figure 4 shows the relationship between costs and the scale of services. As this relationship is influenced by organisational dynamics, the scale of services and costs appear inversely related.

Variable	Label	N	Mean	SD	Min	Max
TC	Cost of waste management per kg	4,169	33.28	11.36	11.99	65.36
DC	Cost of sorted waste management per kg	3,438	20.65	12.08	7.80	107.80
UC	Cost of unsorted waste management per kg	4,047	38.33	24.19	11.24	258.75
msw	Municipal waste generated (th)	4,158	5.43	33.20	0.04	1691.89
sor	Percentage of sorted waste	4,163	66.59	17.47	2.87	97.48
area	Municipality km2	4,169	41.24	57.26	0.67	1287.39
dens	Population density	4,169	419.41	788.21	2.29	11675.83
alt	Altitude	4,169	300.05	272.26	1.00	1816.00
coast	Coastal municipality	4,169	0.17	0.37	0.00	1.00

Source(s): Author's creation

Table 1.
Variables



Note(s): Correlation matrix, scatter plot, and density of the main variables used in this analysis
Source(s): Author's creation

Figure 3. Correlation between the main variables and their relative distribution

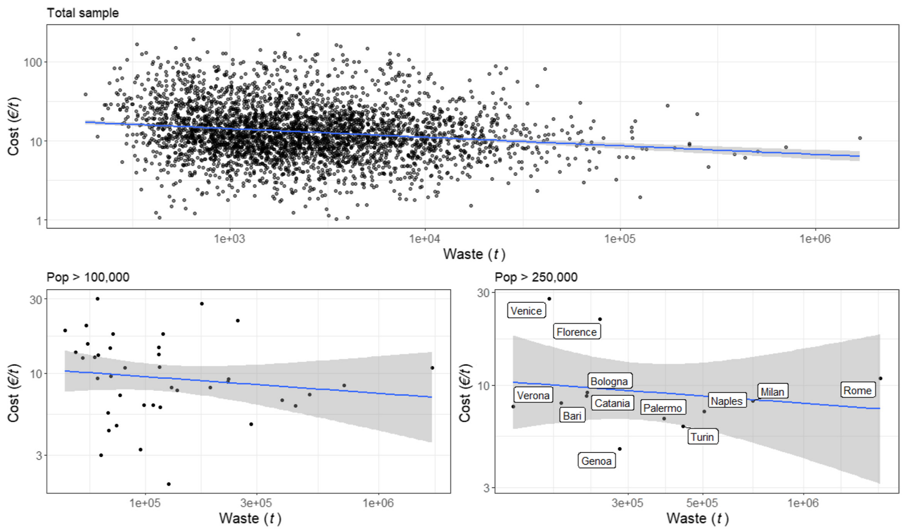


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Figure 4. Scale and costs of MSW management

4.1 Econometric analysis

Applying the model in Equation (1) and shown in Table 2, the determinants of the variations in MSW management costs with respect to organisational size were examined. Other conditions, such as the specific demographic and morphological characteristics of the territory (which, together with the industrial structure of the waste treatment phase, influence

	Model 1 TC	Model 2 SC	Model 3 UC
(Intercept)	5.664***	3.868***	1.789***
	(0.067)	(0.112)	(0.110)
Municipal waste generated	−0.430***	−0.618***	−0.448***
	(0.016)	(0.026)	(0.025)
Municipality km2	0.477***	0.663***	0.426***
	(0.017)	(0.027)	(0.027)
Percentage of sorted waste	−0.114***	−0.414***	0.439***
	(0.013)	(0.022)	(0.021)
Population density	0.407***	0.606***	0.367***
	(0.016)	(0.027)	(0.027)
Altitude	0.024***	0.025***	−0.005
	(0.004)	(0.006)	(0.006)
Coastal municipality	0.314***	0.245***	0.271***
	(0.013)	(0.021)	(0.021)
N	4,152	3,430	4,031
R2	0.322	0.295	0.198

Note(s): ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$. Logarithms (except coastal municipality being a dummy)
Source(s): Author's creation

Table 2.
Econometric analysis

MSW management costs), were considered. Furthermore, whether the average cost of MSW management tends to decrease as the population increases was checked. In Equation (1), the dependent variable is the average cost of management (Eurocents per kg), while the independent variables are the population, size of the area in which the service is provided, percentage of separated collection, population density and altitude, as well as being a coastal municipality or otherwise.

Equation (1): Econometric analysis

$$\log(cost) = \alpha + \beta_1 \log\ (msw) + \beta_2 \log\ (area) + \beta_3 \log\ (sor) + \beta_4 \log\ (dens) + \beta_5 \log\ (alt) + \beta_6 cost + \varepsilon \quad (1)$$

The equation is reiterated in three variants, as shown in Table 2, which contains three columns corresponding to the three models, specifically.

(1) Model 1 refers to the total cost of the MSW management service;

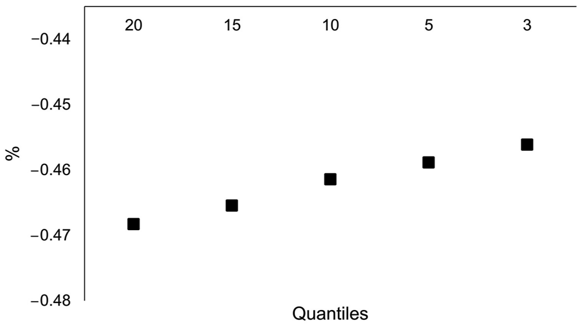
(2) Model 2 refers to the management costs of sorted waste;

(3) Model 3 refers to the management costs of residual waste.

Regarding Model 1, Figure 5 shows the results of the sensitivity analysis performed to test the robustness of the results.

Considering the results shown in Table 3, it appears that an inverse relation between the scale of the service and the cost exists in the types of costs considered when developing the three models.

Figure 5 presents a sensitivity analysis of the elasticity of the average cost of production in terms of the amount of waste handled, which seems to confirm the general hypothesis that asserts that the MSW sector tends to be characterised by economies of scale. The coefficient for the full population was − 0.46. As the number of intervals increases, the coefficient, although based on limited data, tends to increase. At this point, we conduct a comparative evaluation of the cost of collection and transport of the main Italian cities, which represents



Note(s): See Annex 2 for additional details
Source(s): Author's creation

Figure 5. Average cost reduction due to scale

One firm. Figure 1 (a)	More firms. Figure 1 (b, c, d)
• Economies of scope • Coordination among the grantor and the concessionaire • Reduction of transaction costs resulting from fewer contracts • Equity and same quality of the service provided to citizens • Technological innovation given that positive linkages between size and innovation can occur in presence of high sunk costs • Quality standardisation that derives from the same organisation of inputs • Economies of scale especially in the collection phase	• Competitive environment • Lower bargaining power of the concessionaire • More symmetric information and performance comparison among competitors • Low market concentration that if not properly regulated may lead to inefficiency in the medium-term due to the loss of market attractivity for potential efficient firms • Reduced risks of market foreclosure • level playing field

Source(s): Author's creation

Table 3. Opportunities of alternative scenarios

the segment of urban MSW management most affected by the dynamics of company organisation and the consequent optimisation of services. Such an analysis allows a comparative assessment based on a scenario defined by sub-dividing the city of Milan into four sub-areas to simulate the organisation of MSW management services and examine the impact of transaction costs.

Given that the analysis is limited to the main Italian cities and a small number of observations, we proceed with a bottom-up approach that reconstructs the costs using information published on the website of the Municipality of Milan, including the 2019 financial statements of the incumbent, explanatory notes, and the service contract between the Municipality and the incumbent. The scenario in which four firms provide MSW management services would imply a 6% increase in production costs compared to that of the incumbent.

5. Discussion

Economies of scale can play a significant role in defining business models (Di Foggia and Beccarello, 2021) even though they may seemingly conflict with the common knowledge that policymakers should favour SMEs in the provision of public services to create new opportunities and support the growth of SMEs, which in turn can make a significant economic contribution. It is worth emphasising that the involvement of SMEs in public procurement allows contracting authorities to broaden their base of potential suppliers and to benefit from the increased competition for public contracts. However, such positive externalities in terms of efficiency and market development gains vanish in certain circumstances. Indeed, the arguments regarding the presence of economies shall be contextualised to fit with the cases. Considering that a few studies have stated that the existence of scale economies, to a certain level, does not indicate that it can be generalised to all cities. In fact, most studies have analysed samples only with no or just a few large municipalities. In contrast, this article deeply analyses the MSW cost structure in a 1.38-million inhabited city, suggesting that the MSW service is large and complex enough to require specific analyses.

In cities where public or private incumbent monopolies have long-run MSW management services, policymakers should not allow for excessive exemptions, such as splitting a city's area into several sub-areas to allow more firms to participate in MSW management. Nevertheless, it is possible to argue that splitting the municipal area into several sub-areas or the MSW management service into sub-services each, or some of them corresponding to many, may encourage anti-competitive strategies. This action limits the number of lots in which a single economic operator can run the service and may even lead to covert agreements between competitors, which would in turn worsen social welfare, for example, due to transaction costs (Cheung, 2016; DaSilva and Trkman, 2014) that have received little attention in MSW management studies.

Analysing the city of Milan enabled the determination of the efficiency of the business model by including costs sourced from public information regarding the incumbent, and the results conveyed that a single firm was more efficient than four firms. The main reasons highlighted include the differences, especially regarding the separated collection of materials (e.g. street-sweeping activities and bin-emptying activities), given that the production factors, employees, means of production and containers required are proportional in the two scenarios analysed in this article. However, this study found several issues related to transaction costs. Furthermore, the results indicate that the incumbent is more efficient from an economic standpoint.

The services causing the greatest cost burden are those related to collection, which include the sorting of bulky waste, durables, batteries, pharmaceuticals and spent toner cartridges, the collection of residual and differentiated waste with dedicated containers, the collection of residual and differentiated waste in cemeteries, the cleaning of markets, the collection and disposal of small items containing asbestos, the separated collection of used clothing, the separated collection of used oil and some sweeping activities such as cleaning the banks of watercourses, collecting leaves, cleaning tree rows and their areas, mowing and weeding pavements, and washing tunnels, arcades and sub-ways. Similarly, other activities, including on-demand services, have been shown to experience a significant increase in costs. Some production factors are not divisible or shareable between firms, which would entail the duplication of that production factor and therefore its cost.

Evidence suggests that entrusting MSW management services to a single firm may positively affect the community given the potential cost savings (−6%) and, thereby, the waste tax that citizens pay to finance them. The main drivers increasing production costs are the need for personnel and means of production – namely, vehicles – to provide the same level of service if they were to be provided by several firms. The above results are correlated with strategic management and uncertainty-coping strategies, given that uncertainty plays a substantial role in strategic decision-making processes and increases the risk and ambiguity of innovation (Beraha *et al.*, 2018), which is needed to improve the performance of the MSW management industry.

Interestingly, a recent study focussing on the city of Barcelona showed that dividing the region into four lots discriminated in terms of quality and, furthermore, differentiated service quality. The study analysed the effects of competition by focussing on the strategic behaviour of firms and illustrated the incentive to strategically determine the quality, based on the operating distance from competitors, which is an approximation of competitive pressure. This is, therefore, a risk if the principle of universality of service quality is to be respected. It is important to avoid triggering strategic behaviours that increase service quality only in the most relevant and directly comparable areas (Bel and Sebő, 2021).

However, both positive and negative aspects should be noted to exist even when a single firm provides the service, as shown in Table 3.

The results also provide information on the compatibility of such strategic behaviour of firms with the principle of universality of service. This is an essential element and a principle that cannot be derogated from and a risk that may emerge. A further risk lies in the information asymmetries between local authorities and contractors, which could reduce the efforts of the latter in neighbourhoods farthest from those where there is more competition.

The main contribution of this paper is threefold. From a theoretical perspective, it summarises the previous literature on economies of scale and scope in MSW management and provides thought-provoking results that further the discussion on competitive policy and the regulation of public services. From a managerial perspective, the results offer new insights into critical organisational and operating factors that may emerge in running such services, which, due to transaction and other costs, may lead to sub-optimal levels of output and economic inefficiency. This paper also has policy implications given that the abovementioned considerations can serve as a reference for public decision-makers in designing municipal strategies that consider economic and social welfare outcomes. Managerial and practical perspectives are also straightforward for both bit utilities and SMEs, which shall analyse in detail the organisational and transaction costs they may experience in running this service in complex circumstances.

Our results also suggest that additional research is needed to evaluate the relation between scale and MSW management costs, which is a public service of general interest. Its effectiveness should be evaluated from a contracting authority – often municipality – perspective, not only from the firm perspective, paying more attention to the exogenous factors affecting the organisation of the service. Indeed, failing to consider the above may result in formally correct results but bias in practice if the sub-additivity of costs is not considered. In fact, a paradox may emerge. When analysing samples of firms the results of relatively small-scale economies may suggest the optimal size that, if put into practice in relatively large cities, resulted in multiple firms operating conjunctively, paving the way to transition costs and organisational failures that lead to negative externalities: one pitfall relates to costs, and the other downside refers to different quality levels that may occur in different parts of the cities because the service is run by different companies, and other hypothetical problems emerge in the potential strategic behaviour of firms and difficulties in regulating more firm issues.

6. Conclusion

This paper investigates the scale and scope of MSW management business models in terms of their economic efficiency to provide empirical evidence to support both the debate and the design of competitive waste management policy strategies. On one hand, it is generally recognised that the broad participation of SMEs in the provision of public services is a public policy goal. On the other hand, monopolistic competition outperforms other models in certain circumstances – for example, in that of integrated utilities, which can provide more services at more stages of the supply chain, owing to economies of scale and scope resulting from their optimised and streamlined production models.

A novel contribution of this paper is in its effort to analyse and test the same hypothesis across different conditions. From a national perspective, based on an econometric analysis of a significant sample of Italian municipalities, the results confirm the presence of an inverse relation between the scale and the average cost of the service. This finding is important considering that as the size of the service increases by 1%, the average cost of MSW management services decreases by 0.46% nationwide. From the results, the inverse relation between service scale and costs can also be inferred to persist even under different hypotheses, as confirmed by our scenario analysis.

To fine-tune the analysis and provide useful insights that benefit managers and local administrators, a simulation has been carried out for the city of Milan by testing whether the service costs were lower when run by a single firm compared to when run by four different firms. The evidence suggests that MSW management is more efficient when carried out by a single firm given the industry structure, resource and labour force optimisation, and lower transaction costs, which, in certain circumstances, overcome the efficiency gains of the market, envisaged by economic theory.

The simulation revealed that dividing the city into sub-areas may lead to diseconomies, thus undermining economic efficiency and general service quality and creating undesirable consequences for social welfare and the equal treatment of citizens. Therefore, there are cases where contracting authorities shall decide that it is not appropriate to divide the contract into lots due to the risk of rendering the execution of the contract excessively technically difficult or expensive and because coordinating the different contractors could risk undermining the proper execution of the contract to the detriment of equity and quality.

This study has certain limitations. The results are extendable and relevant to other cities only when the spatial and socio-economic characteristics are comparable given that the factors used to identify whether a single firm is more efficient can lead to varied results in cities characterised by non-homogeneous conditions or in larger multi-centric cities. In fact, the land of the city of Milan is flat, with an altitude of approximately 130 metres, on an administrative area of approximately 181.7 square kilometres, with a population of slightly less than 1.4 million inhabitants: 7,315 inhabitants per square kilometre. Consequently, a very different situation with respect, for example, to Rome: approximately 2,860,889 residents in 1,285 km^2, 2.226 inhabitants per square kilometre and varied land characteristics. In such urban conditions, the results in terms of optimal business organisation may significantly change, preventing our results from being extended to geographically significantly different cities.

In the context of large cities, both the advantages of dividing the municipal area into smaller sub-areas – or the service into more lots – to facilitate the potential entry of smaller operators and the *a priori* advantages related to the existence of economies of scale need to be further studied and contextualised to avoid a strategic drift in municipal waste service planning.

The future research should focus on two topics. First, the activities that comprise waste management services should be broken down to investigate the opportunities presented by and costs of alternative forms of management for each sub-service according to scale and other exogenous factors. Second, provided that cross-sectional studies struggle due to sampling reasons, an analysis of the impact of economies of scale and scope in large cities is needed using case study approaches.

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Annex 1

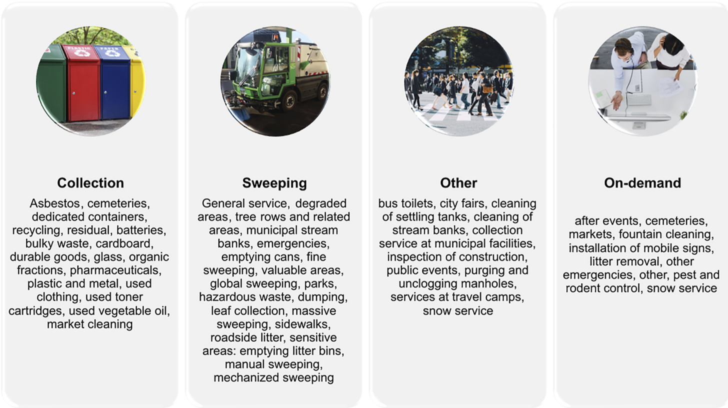

Figure A1.
Taxonomy of sub-services classified by scope that make up the municipal waste management service examined in this article

Annex 2

Table A1.
Reiteration of model

Sub-data	20	15	10	5	3	Sample
[1]	−0.31372	−0.33094	−0.31634	−0.37158	−0.37862	−0.42978
[2]	−0.32611	−0.37511	−0.43249	−0.40171	−0.44498	
[3]	−0.48359	−0.41878	−0.43975	−0.48186	−0.54488	
[4]	−0.38682	−0.37266	−0.35493	−0.47869		
[5]	−0.37478	−0.40508	−0.48093	−0.56061		
[6]	−0.52579	−0.4231	−0.4811			
[7]	−0.30548	−0.52618	−0.41572			
[8]	−0.40513	−0.43573	−0.54459			
[9]	−0.4777	−0.48171	−0.52883			
[10]	−0.45353	−0.38149	−0.61994			
[11]	−0.45757	−0.57469				
[12]	−0.5055	−0.52394				
[13]	−0.35008	−0.46211				
[14]	−0.55512	−0.58765				
[15]	−0.58066	−0.68303				
[16]	−0.55199					
[17]	−0.46168					
[18]	−0.57222					
[19]	−0.54199					
[20]	−0.73681					
Mean	−0.46831	−0.46548	−0.46146	−0.45889	−0.45616	−0.42978
Mean 3	−0.37448	−0.37494	−0.39619	−0.41838		
Mean 5	−0.377	−0.38051	−0.40489			
Mean 10	−0.43344					
N	208	278	417	834	1,390	