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Assessing factors that influence waste management financial sustainability

Francesca Bartolacci *, Antonella Paolini, Anna Grazia Quaranta, Michela Soverchia

University of Macerata, Department of Economics and Law, Via Armaroli, 43, 62100 Macerata, Italy

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ABSTRACT

This article examines the financial sustainability of waste management activities to understand whether and how choices oriented toward environmental protection and contextual factors influence waste management companies' revenues and costs, which, in turn, affect their financial sustainability and, thus, their ongoing viability.

To achieve this purpose, a three-year empirical analysis on 880 Italian municipalities was conducted. Financial sustainability was evaluated with reference to waste management companies working in these territories, and a set of quantitative and qualitative data was considered to investigate possible influencing factors.

The results show that separate waste collection may positively influence companies' financial performance, while municipalities' territorial extension negatively impacts profitability. Lastly, there is no evidence of a relationship between companies' financial sustainability and the potential presence of waste disposal plants or the geographical areas in which they operate. For the analyzed companies, thus, it seems that it would be more convenient to expand business by boosting separate waste collection activities than by enlarging the territories served.

These findings can support firms' decisions regarding environmental and financial issues, both of which are crucial for long-term sustainability. It can also help policy makers detect appropriate tools to support companies in implementing European Union waste management targets.

1. Introduction

The collection and disposal of municipal solid waste (MSW) is a strategic issue for countries around the world, given the enormous increase in the quantity of waste produced in recent decades due to augmented consumption, despite occasional decreases caused by the economic crises. This topic has important social, environmental, and financial effects due to the various involved actors: the governments responsible for defining waste management (WM) policies, the companies that carry out waste collection and disposal, and the citizens whose behaviors must comply with the governments' strategies. A tradeoff between environmental and financial implications should be accomplished through the responsible behavior of all stakeholders (Fisher-Vanden and Thorburn, 2011).

According to the European Union (EU), member states should monitor the full waste cycle from production to disposal following the hierarchical principle, whose aim is to prevent waste's negative environmental impacts: it advocates, in order of priority: reuse, recycling, other kinds of recovery (e.g. for energy production) and, finally, disposal (Gharfalkar et al., 2015). The hierarchical principle is not a new approach, though it has been strengthened through Directives 2006/12 and 2008/98 and recently reinforced by EU institutions with the circular economy action plan and new legislative proposals on waste (Eurpopean Commission, 2015; European Parliament, 2017). In brief, considering that member states often experience a lack of natural resources, but abundant waste, they should seek ways to use waste more efficiently, defining policies to promote the conversion of waste into resources that may be re-introduced into the economic system as secondary raw materials (Cossu and Williams, 2015).

Within this context, the present article focuses on Italian municipalities governing WM services in their territories according to specific policies, which should comply with the circular economy principles. The aim of this study is to understand whether and how WM choices oriented toward environmental protection

* Corresponding author.
E-mail addresses: francesca.bartolacci@unimc.it (F. Bartolacci), antonella.paolini@unimc.it (A. Paolini), annagrazia.quaranta@unimc.it (A.G. Quaranta), michela.soverchia@unimc.it (M. Soverchia).

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and contextual factors influence WM companies' revenues and costs, which in turn affect their financial sustainability and ongoing viability. Revenues derive from selling recovered materials and produced energy and from fees paid by citizens, while costs derive from recurring operations (short-term evaluation) and investments (long-term evaluation), both related to waste collection, treatment, and disposal (Lohri et al., 2014). Thus, financial sustainability is strictly connected to firms' ability to preserve and improve such important utilities by realizing the WM policies defined by the municipalities, which should be increasingly compliant with the circular economy principles.

To consider the environmental implications of WM choices, we focus, first, on the separate waste collection carried out by each company in the served territories. Environmental sustainability is a wider concept that we have no claim to measure. Rather, we consider the activities required to start recycling as a pre-condition for compliance with the above mentioned hierarchical principle of the circular economy. Separate waste collection is essential for waste reuse, recycling, and recovery; thus, it can improve the environmental sustainability of a territory's human and economic activities.

Assessing the factors that could influence WM companies' financial sustainability is a particularly significant aim, given the future need to achieve EU environmental targets, as WM firms are among the most important for helping to realize these objectives. For this purpose, we have conducted a longitudinal empirical study of a group of companies providing MSW collection and disposal services to 880 municipalities accross various Italian regions over the years 2012, 2013, and 2014. This represents an improvement to a previous study on the relationship between the environmental practices and financial performances of Italian WM companies (Bartolacci et al., 2018), compared to which this article is based on more municipalities and variables, and uses a more refined methodology.

This article is structured as follows: Section 2 reviews the literature on financial impact assessment in WM; Section 3 briefly presents the main aspects of the Italian WM sector and companies; Section 4 describes the research methodology; Section 5 analyses the results of the conducted empirical study; conclusions are given in Section 6.

2. Literature review

The financial impacts of policies related to environmental protection have been increasingly investigated in recent years; however, few studies have focused on the WM sector (Lucato et al., 2017; Qi et al., 2014).

The literature includes several studies of the costs and benefits of different WM choices, focusing particularly on such alternatives as recycling, biogas production, landfill, and other waste disposal processes. In these works, the authors highlight the availability of several options associated with the implementation of a MSW management system. Further, to identify an optimal solution, various technical, economic, environmental, and social aspects must be considered. Hence, analyses are usually conducted according to a broad evaluation framework of WM companies' performance, which examines various issues.

Costi et al. (2004) present a decision support system designed to help municipal decision makers develop integrated incineration, disposal, treatment, and recycling programs. The main goal is to plan MSW management by defining the refuse flows to be sent to recycling or to different treatment or disposal plants. In the analysis, the authors consider all possible WM costs and economic benefits resulting from the recovery of materials and energy.

Rubio-Romero et al. (2013) analyze the economic viability and profitability of potential biogas cogeneration from MSW produced in Andalusia. The results show that a cogeneration system could help promote efficient waste collection and biogas exploitation. In addition, the income generated could help finance the investment made in the cogeneration plants, saving money that could benefit public entities.

Santibañez-Aguilar et al. (2015) propose a mathematical programming model for the optimal planning of the supply chain associated with the MSW management system to maximize the economic benefit while accounting for technical and environmental issues. The results show that it is possible to implement a distributed processing system to reuse MSW while maximizing the net supply chain profit.

Morin et al. (2010) investigate the financial results in terms of income produced by managing the organic fraction of MSW and municipal wastewater sludge through anaerobic digestion for a 150,000 inhabitant municipality. Zamorano et al. (2007) analyze the financial viability of landfill gas, assessing the costs and sales revenues of electricity generation.

With the aim of modeling and analyzing decision making in situations involving multiple stakeholders, Karmperis et al. (2013) survey decision support models commonly used in the MSW sector, such as life cycle assessment, cost-benefit analysis, and multi-criteria decision making. The authors suggest using a combination of these models to maximize their strengths and minimize their weaknesses, without neglecting any environmental, social, or economic aspects. Regarding the cost-benefit analysis model, they suggest conducting a financial analysis including an evaluation of financial sustainability.

The literature more strictly related to WM services and the financial impacts of specific variables, such as separated waste collection, population density, and the presence of disposal or treatment plants, focuses mainly on cost analyses (Abrate et al., 2014; Bartolacci et al., 2017; Bel and Fageda, 2010; Callan and Thomas, 2001; Greco et al., 2015; Larsen et al., 2010; Ohlsson, 2003). These authors often examine costs advantages in relation to the contextual variables and WM choices mentioned above.

Bartolacci et al. (2017) highlight the positive effects of separate waste collection rates in terms of the reduction of production costs for Italian WM companies, after adjusting the mean values of these costs to remove the impact of size factors. The findings show that even the population density factor has a significant effect on production costs, whereas the interaction between separate waste collection rate and population density is not statistically significant.

In the analysis of the impacts of the contextual factors, the costs of transport activities related to the extension of the served area assume an important role. Hiete et al. (2011) show that increased transport costs considerably reduce recycling rate, as recycling requires longer transport distances than disposal. Marinković et al. (2010) analyze the relationships between environmental impacts and transport distance, given the relevant influences on WM choices.

According to Ripa et al. (2017), one of the main burdens of WM is the transport of waste outside the region due to the lack of local treatment plants. The authors try to design and analyze six strategies that differ substantially in terms of separate waste collection rates, transportation routes, and options for the disposal of residual waste. The results show that it is possible to improve the environmental and economic efficiency of the WM chain locally, thereby strengthening the entire WM process.

The analysis conducted in the present study allow us to identify, on one hand, studies analyzing the impact of specific variables on WM costs, and, on the other hand, scientific contributions concerning WM companies' financial sustainability, which hardly ever analyzes aspects, e.g. contextual ones, that may influence revenues and costs. Rather, as highlighted, financial sustainability analysis is generally included in a broader evaluation framework of WM

companies' performance; hence, there is a lack of literature concerning the impact of specific determinants on financial sustainability, least of all in the case of the Italian WM companies. Therefore, this article is part of the literature more strictly connected with the analysis of the financial impacts caused by specific contextual variables and WM choices and seeks to provide a more comprehensive analysis beyond cost assessment. By achieving the aim described in the first section, this study can help to fill the literature gap concerning WM companies' ongoing viability. This condition relates to the realization of WM policies that ensure such important public utilities to the community, given their environmental and social implications.

3. Waste management sector in Italy

The Italian legislator defines MSW management as a local public utility with economic relevance that can be run by municipalities themselves or by companies (municipally-controlled or private). In either case, the municipality remains ultimately responsible for the MSW services because it sets the main strategic objectives and assesses the final results (Bognetti and Robotti, 2003).

In Italy, national legislation has supported improvements in the separate waste collection rate and separate waste collection per capita, though there is still a significant gap among geographical areas (Agovino et al., 2016), as shown by statistics from the Italian Institute for Environmental Protection and Research (ISPRA; Table 1).

At present, the most widely used management option is companies with total or majority municipal control (Italian Competition Authority, 2016; Utilitatis, 2016). These public utility companies operate in a sector that, in Italy, is regulated at the local, regional, national, and supranational levels. They supply public services that satisfy both individual needs (to remove refuse produced) and community needs (to reduce negative environmental impacts and the consumption of natural resources), as the way in which waste is handled and eliminated following collection is a collective concern (Massarutto, 2007). This explains the very important role of WM companies in territories' social and economic development and, thus, the general welfare of communities.

From a business economics perspective, WM companies have characteristics not shared by other public utilities companies. In Italy, citizens living in a particular municipality cannot, for example, choose the company that handles their waste collection service, though they may select among various providers for electricity or other utilities. Furthermore, the service supplied by WM companies has a strong impact on the environment and, therefore, both current users and, more importantly, future generations.

Within the context described above, the Italian WM sector is a long way from industrial consolidation, with a low level of competition (Italian Competition Agency, 2016; Massarutto, 2007) and a high degree of fragmentation (Citroni et al., 2016). As shown in Table 2, it is characterized by a predominance of small and medium companies (Utilitatis, 2016) and a low number of large and very large ones, with the latter often being listed on the stock exchange. All companies operate in the national territory, which consists of approximately 8,000 municipalities with significant differences in terms of, for example, geographical features and population density.

4. Materials and methods

To investigate the impact of choices oriented toward environmental protection and other contextual factors on WM companies' financial sustainability, an empirical analysis of a group of companies providing MSW collection and disposal services to 880 Italian municipalities over the three-year period from 2012 to 2014 was conducted.

We focused on the financial sustainability of companies rather than municipalities, which are ultimately responsible for such utilities, for one important reason: as stated in the previous section, in most Italian municipalities, WM services are delivered by companies. Very few municipalities provide WM services directly, i.e. using their own plants, vehicles, and personnel. Therefore, to assess financial sustainability and get information regarding the dynamics of Italian WM services revenues and costs, companies' financial statements are the most reliable and relevant source of analytical information; the same cannot be said of municipalities' financial statements.

Concerning this issue, it is important to highlight a specific element of the Italian context to which our paper refers. The current legislation on the collection and disposal of waste requires municipalities to fully cover the costs incurred for the realization of WM services by means of a specific tax (TARI) paid by the citizens. Therefore, when municipalities entrust the realization of WM services to a company, the negotiated price is covered by the specific municipal tax. Consequently, if we analyze the municipalities' accounts, we find substantially the same amounts for revenues (the waste disposal tax) and expenses (the price of entrusting the

Table 1
The separate waste collection ratio (SWC) and per capita separate waste collection (PCSWC) in 2012–2014 (ISPRA data base).

	SWC			PCSWC (kg)		
	2012	2013	2014	2012	2013	2014
North	0.53	0.54	0.57	266.02	266.12	280.69
Center	0.33	0.36	0.41	192.35	200.06	223.33
South	0.27	0.29	0.31	122.69	128.55	138.63
Italy	0.39	0.40	0.42	201.91	205.63	220.43

Table 2
Aggregated size values of Italian WM companies (Utilitatis, 2016).

	WM companies (number)	Revenues (in thousands of Euro)	Employees (number)
Very large companies (revenues $\geq$ 100,000 €)	19	4,223,140	31,791
Large companies (revenues $\geq$ 50,000 and < 100,000 €)	20	1,385,619	8,970
Medium companies (revenues $\geq$ 10,000 and < 50,000 €)	186	3,956,568	31,594
Small companies (revenues < 10,000 €)	238	997,306	9,006
Total	463	10,562,633	81,361

service). Conversely, analyzing WM companies' financial results – which can include other types of revenues and costs, such as those derived from recovering and selling recycled materials – yealds a more complete financial sustainability analysis of the overall WM process.

To assess the WM companies' financial sustainability, as the literature suggests (Judge and Douglas, 1998; Khanna and Damon, 1999; Rubio-Romero et al., 2013), we chose to calculate the return on assets (ROA; operating income on total assets), attempting to relate its values with a set of quantitative and qualitative information. Even when the main aim of the analyzed companies is not profit, as is often the case in Italy, where WM companies are mostly owned or controlled by local governments, their financial sustainability is essential to ensure and improve their services and satisfy the community's needs with practices in line with environmental protection (Kalulu and Hoko, 2010).

Given the high fragmentation of the Italian WM sector, to ensure size homogeneity among the selected companies, we analyzed those operating in Italian municipalities with populations greater than 50,000 inhabitants: a threshold considered significant by other studies (Folz, 1995; Savas, 1977). As indicated above, we focused our study on medium-sized mono-utility companies operating within these municipalities. Following these criteria, we analyzed 52 Italian companies providing WM services for 880 Italian municipalities, comprising about 11% of the country's total in terms of both number of municipalities and land area served. Conversely, these companies represent 37% and 42% of the medium-sized Italian companies operating in the Italian WM sector in terms of sales revenues and employee numbers, respectively (Utilitatis, 2016).

The means of the financial values shown in Table 3 confirm that our companies belong to the medium size category and highlight their low (sometime negative) levels of operating income and net profit, given the high production costs compared to the revenues.

The geographical distribution of the selected companies is as follows: 40% in the north of Italy, 23% in the center, and 37% in the south and islands. We considerated a total of 2,640 observations over the three-year period from 2012 to 2014.

The financial data were manually collected from financial statements (including balance sheets, income statements, and notes) from 2012 to 2014 as deposited by companies in the Italian Business Register Office of the Chamber of Commerce (Telemaco database). No other sources were employed to gather financial data, to avoid the validity problems that often occur when using existing sector analysis data.

Regarding the factors affecting companies' financial sustainability, the following information was analyzed. Concerning the quantitative variables, we considered both the separate waste collection ratio (SWC), measured by dividing the separate waste collection weight by the overall MSW, and the separate waste collection per capita (PCSWC) in the served population. Since not all companies report MSW collection information in their financial statements, this information was collected from the official database of the Italian Ministry of the Environment, managed by the ISPRA. We also analyzed the territorial extension values retrieved from the Italian National Institute of Statistics (ISTAT) website, alternatively considering the territorial extension (TE; the total area of all municipalities served by each company expressed in square kilometers) and the population density (PD; the ratio between population and TE). Finally, concerning the qualitative characteristics, we detected the presence of disposal waste plants (e.g. landfill and incineration) based on information provided by financial statements or companies' official websites and the geographical areas in which the companies operate (north, center, and south of Italy).

Table 3
Means of size values of analyzed companies in 2012–2014 (financial statements data in thousands of Euro expect for employees number).

	2012	2013	2014
Employees number	249	253	253
Total assets	39,252.03	37,993.35	37,129.14
Net equity	7,652.38	8,163.79	8,317.91
Production value	29,146.30	29,420.77	29,029.96
Revenues	27,569.47	28,094.20	27,992.54
Production costs	28,705.09	28,268.56	27,854.54
Operating income	−1,135.62	−174.36	137.99
Net profit	−405.29	270.62	4.35

After collecting the financial and environmental data, we calculated the most commonly used descriptive statistics (i.e. mean, standard deviation, variability index related to the maximum, maximum, and minimum values). Then, we attempted to establish the existence of a statistical relationship between ROA and each of these variables. The companies showing anomalous values (outliers) for some or all considered variables were excluded to avoid distorting the results of the subsequent analyses (i.e. the connection, correlation, and regression analyses). More precisely, we investigated:

(a) the existence of a relationship (general connection) between ROA and each of the other variables for every year by constructing the normalized chi-square index;
(b) the direction (positive or negative) of these relationships by constructing *scatter plots*, which yielded evidence of linearity measured by the linear Bravais-Pearson correlation index (r), using IBM SPSS version 23;
(c) the impact of the considered variables (SWC and the TE of the municipalities served, considering for the variables their double definition in all possible ways) on companies' financial sustainability (measured by the ROA) via panel data regressions (Baltagi, 2005; Stock and Watson, 2015). These analyses were realized using STATA 13; and
(d) whether the previously identified model fit improved when some of the considered qualitative characteristics (e.g. the companies' geographical areas, the presence of a waste disposal plant as a landfill, incineration, etc.) were included.

5. Results and discussion

Before investigating the effects of the considered quantitative and qualitative factors on financial sustainability, we calculated the most commonly used descriptive statistics for the variables ROA, SWC, PCSWC, TE, and PD (Tables 4–6). These descriptive statistics illustrate the levels and trends of the investigated variables over the three-year period.

As shown in Table 4, the ROA mean increased over the three years, but more significantly between 2013 and 2014. The related variability index also increased in 2013, but exhibited a very small, negligible decrease in 2014 (from 25% to 37% in 2013 and 32% in 2014), confirming the presence of diverse financial performances among the analyzed WM companies. However, while the maximum values fluctuated, the minimum values increased.

The SWC mean (Table 5) improved gradually over the analyzed period, as did the maximum and minimum values. Nevertheless, the high related variability index, despite a slight decline in 2014, demonstrated that the effort to increase the level of SWC did not include all companies and, thus, all territories served. In fact, a few companies were very close to the minimum value (i.e. a substantial lack of SWC) and, therefore, could not be considered sustainable from an environmental point of view.

The PCSWC mean increased continuously over the considered period (Table 5), coherent with the trend of the previous parameter. The other descriptive statistics exhibited a slightly fluctuating

Table 4
The return on assets ratio (ROA) in 2012–2014.

ROA	2012	2013	2014
Mean	0.01	0.02	0.04
Standard deviation	0.14	0.13	0.07
Variability related to the maximum	0.25	0.37	0.32
Maximum	0.40	0.18	0.38
Minimum	−0.84	−0.76	−0.12

Table 5
The SWC and PCSWC in 2012–2014.

SWC	2012	2013	2014
Mean	0.39	0.40	0.42
Standard deviation	0.21	0.22	0.22
Variability related to the maximum	0.58	0.57	0.55
Maximum	0.72	0.77	0.81
Minimum	0.00	0.01	0.01
PCSWC	**2012**	**2013**	**2014**
Mean	201.80	204.70	218.50
Standard deviation	109.50	107.90	117.30
Variability related to the maximum	0.46	0.49	0.44
Maximum	538.90	487.50	614.60
Minimum	30.70	29.70	35.10

Table 6
The territorial extension (TE) and population density ratio (PD) in 2012–2014.

TE (km^2)	2012	2013	2014
Mean	606.40	609.25	610.16
Standard deviation	775.96	775.91	776.05
Variability related to the maximum	0.68	0.68	0.68
Maximum	2806.12	2806.12	2806.12
Minimum	12.13	12.13	12.13
PD (inhabitants/km^2)	**2012**	**2013**	**2014**
Mean	1076.10	1106.27	1103.40
Standard deviation	1641.30	1683.80	1677.90
Variability related to the maximum	0.62	0.62	0.62
Maximum	8075.20	8310.50	8220.50
Minimum	67.40	67.80	67.90

trend, which again confirmed that the increase in PCSWC was not a widespread phenomenon with regard to the quantity of separate waste collected and the populations served by the companies.

Table 6, concerning the TE and PD, highlights the high heterogeneity of the geographical contexts in which the companies collected waste with respect to both the sizes of the served areas and the densities of their populations.

To robustly establish the possible existence of a relationship between the ROA values and each of the other variables, it was necessary to exclude two outliers.

The results of the further statistical analysis showed an acceptable general level of connection between the ROA values and those of all variables considered as its possible determinants.[1]

For each analyzed year, the direction (positive or negative) of the relationship between ROA and its possible explicative variables was analyzed via scatter plots (Figs. 1–4), which provided information about both the minor/major linearity levels measured using the Bravais-Pearson correlation index. In more detail, by analyzing the scatter plots and their related r index values, we can make the following observations:

[1] The values of the normalized chi-square and their significance levels are available on request.

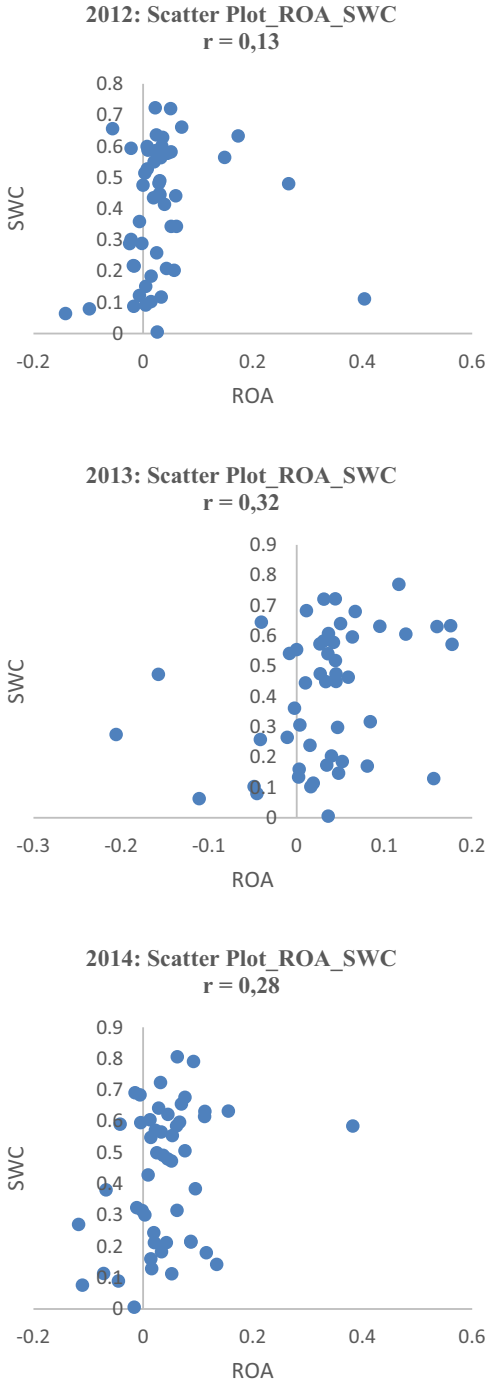

Fig. 1. Relations between ROA and SWC in 2012–2014.

- the direction of the relationships between ROA and SWC and PCSWC is positive and moderately linear, particularly in 2013;
- the direction of the relationship between ROA and TE is negative and slightly linear over the three-year period; and
- the direction of the relationship between ROA and PD is positive and slightly linear over the three-year period.

Given the above, as we described in Section 4, letter (c), we estimated the following four functions' parameters:

$$ROA_{kt} = \beta_0 + \beta_1 SWC_{kt} + \beta_2 TE_{kt} + \varepsilon_{kt} \quad (1)$$

$$ROA_{kt} = \beta_0 + \beta_1 SWC_{kt} + \beta_2 PD_{kt} + \varepsilon_{kt} \quad (2)$$

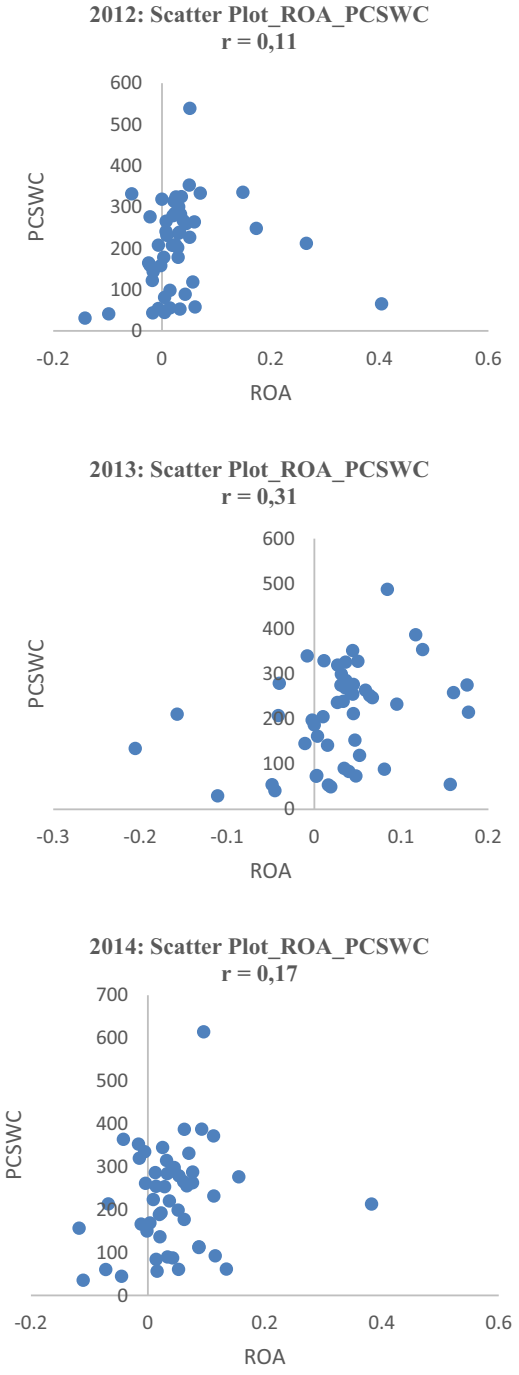

Fig. 2. Relations between ROA and PCSWC in 2012–2014.

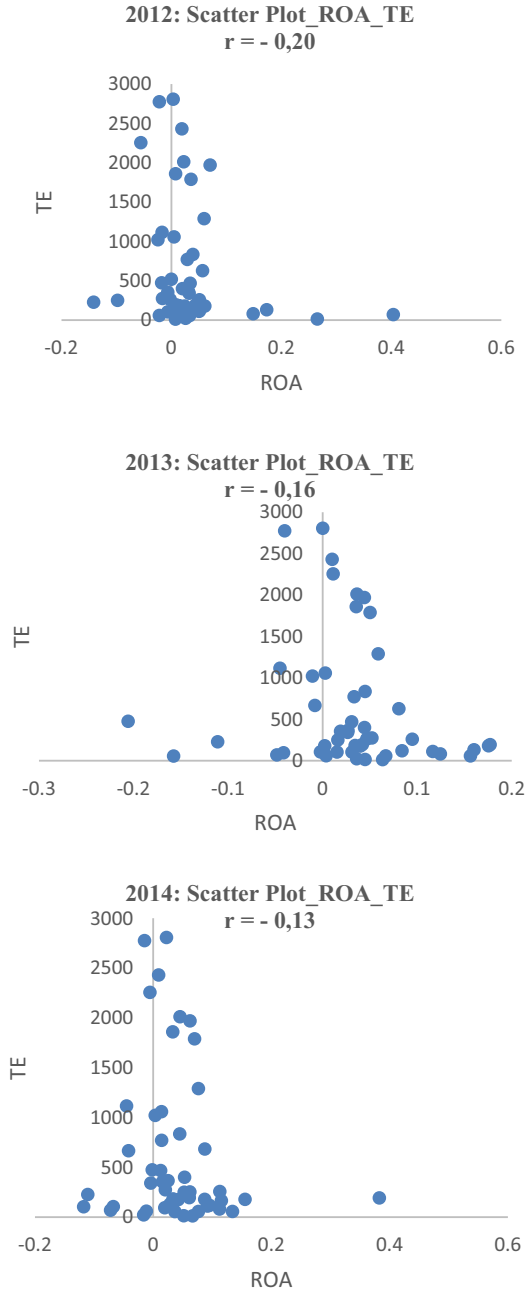

Fig. 3. Relations between ROA and TE in 2012–2014.

$$ROA_{kt} = \beta_0 + \beta_1 PCSWC_{kt} + \beta_2 TE_{kt} + \varepsilon_{kt} \quad (3)$$

$$ROA_{kt} = \beta_0 + \beta_1 PCSWC_{kt} + \beta_2 PD_{kt} + \varepsilon_{kt} \quad (4)$$

where $k = 1, \cdots, K$ are the companies analyzed and $t = 1, \cdots, T$ are the time periods considered. We applied ordinary least squares (OLS)-pooled, fixed effects, and random effects approaches.

For every model, we conducted a variety of tests: (i) White's test and non-parametric Wald's test to verify the homoscedasticity assumption, (ii) Chow test to verify the structural stability, and (iii) Ramsey RESET test to verify the correct specification. We concluded that model (1) yields the best results in terms of basic assumptions validation and tests (data available on request).

We also implemented tests between the different estimators to determine which would be the most suitable for adequately estimating the parameters. In Fig. 5 we report the Hausmann test results, which clearly show the preferability of the random effects estimation of the model (1) parameters. Fig. 6 presents the estimates of the model (1) parameters, the related significance levels, and the R^2 values. Disregarding the negligible value of the constant, it seems that, for the analyzed companies: (i) the SWC may explain the ROA, exhibiting a significant positive relationship, and (ii) the TE may explain the ROA, showing a significant negative relationship.

Finding (i) reveals that the SWC and the ROA change in the same direction, though through a non-linear relationship. This means that, if one variable increases, so, too, does the other (albeit) with potentially different intensities. In particular, this result seems to exclude that an increase in terms of separate waste collection may be associated with an ROA decrease. Considering the

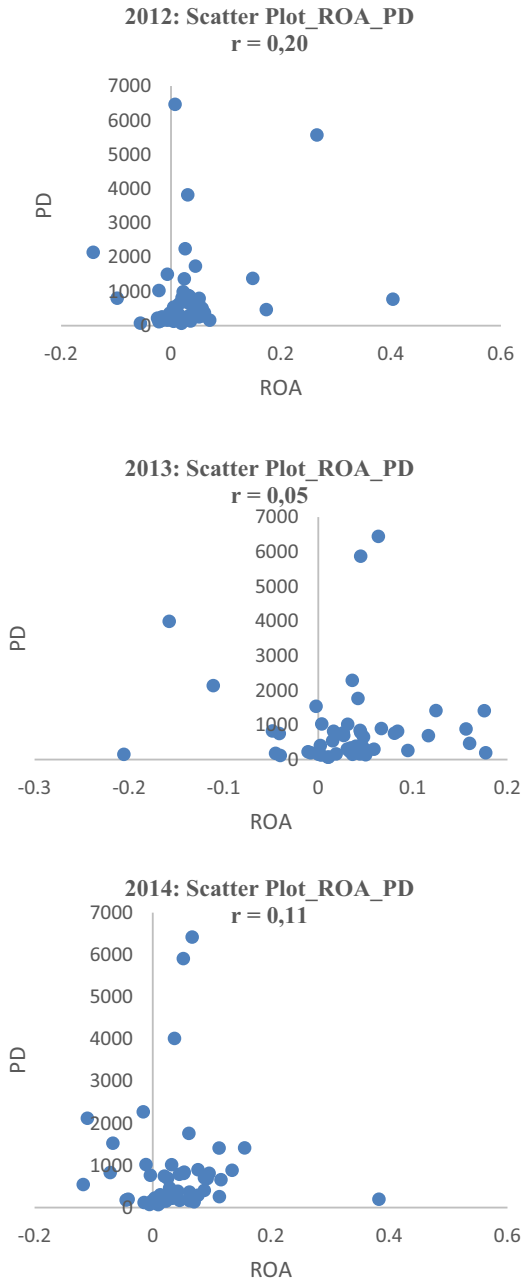

Fig. 4. Relations between ROA and PD in 2012–2014.

EU targets concerning more efficient usages of waste, this is a very interesting finding, as separate waste collection represents an unavoidable step towards reuse, recycling, and recovery that needs to be pushed. This finding seems particularly interesting for the analyzed sector, which is, in Italy, composed almost exclusively of companies owned or controlled by local governments. These firms are not profit-oriented, thus a low (but positive) level of ROA represents a financially sustainable situation: even if activities related to SWC are expensive, they can be improved without worsening the company's financial sustainability. It could probably be obtained, on the cost side, by economies of scale, and on the revenue side, by using and selling SWC products as secondary raw materials. Obviously, in terms of financial performance, a combination of both would be desirable.

Further, according to finding (ii), the TE may explain the ROA, showing a significant negative relationship. This is likely related to the fact that the expansion of served territories implies an increase in several costs associated with WM activities and linked, for example, to logistics aspects (costs for transportation, personnel, vehicle maintenance, etc.). Considering results (i) and (ii) together, the beneficial effect of SWC on companies' financial sustainability is perhaps even more evident. In fact, both SWC and TE growth imply an increase in activitiy volume, which inevitably involves increased costs; however, as the relationship with the profitability (ROA) is positive for SWC and negative for TE, it seems that, for the analyzed companies, the higher costs deriving from the augmentation of SWC are covered by revenues. The same is not ture for TE growth, which apparently involves only increased costs (or perhaps also increase revenues, but not to a degree sufficient to ensure the company's financial sustainability). Hence, in terms of business expansion, WM companies may find it more convenient to increase separate waste collection activities than to extend served territories.

These results do not conflict with any of the following: (1) those of Bel and Fageda (2010), who find that a high rate of SWC does not appear to increase total costs, despite bringing important environmental improvements; (2) those of Ohlsson (2003), who consider the distance driven in kilometers, closely related to the TE, a significant variable affecting collection costs; or (3) those of Larsen et al., (2010), who consider long-distance transport a limitation that could make recycling materials less convenient.

As indicated in Section 4, the analysis continued by considering some qualitative characteristics, which may affect the financial sustainability of WM companies. Thus, with the aim of improving the regression results in terms of R^2, we consider the following characteristics:

- typology A: company operating in the north of Italy;
- typology B: company operating in the center of Italy;
- typology C: company operating in the south and islands of Italy;
- typology D: company with a waste disposal plant;
- typology E: company without a waste disposal plant;
- typology F: company operating in the north of Italy with a waste disposal plant;
- typology G: company operating in the north of Italy without a waste disposal plant;
- typology H: company operating in the center of Italy with a waste disposal plant;
- typology I: company operating in the center of Italy without a waste disposal plant;
- typology L: company operating in the south and islands of Italy with a waste disposal plant; and
- typology M: company operating in the south and islands of Italy without a waste disposal plant.

Implementing model (1) on the data for the companies belonging to each of the above indicated typologies does not produce any improvement in R^2 values. Therefore, referring to the results obtained via our data set, it seems that none of the qualitative characteristics, separately or jointly employed, could better explain the level of financial sustainability of the Italian WM companies.

These results seem not to be in line with those literature contributions showing cost reductions related to the use of a disposal plant (for example, a landfill or incinerator) (Bel and Fageda, 2010; Callan and Thomas, 2001).

6. Conclusions

Despite WM being a strategic issue for all countries because of its environmental, social, and economic implications, the literature

	Coefficients (b) fixeff	(B) .	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
SWC	.4175246	.3288654	.0886592	.5049478
TE	-2.122824	-.2638012	-1.859023	5.188475

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 0.14
Prob>chi2 = 0.9331

Fig. 5. Hausmann test results.

Random-effects GLS regression — Number of obs = 150
Group variable: num — Number of groups = 50

R-sq: within = 0.8985 — Obs per group: min = 3
between = 0.1697 — avg = 3.0
overall = 0.7147 — max = 3

Wald chi2(2) = 14.58
corr(u_i, X) = 0 (assumed) — Prob > chi2 = 0.0007
theta = .85476822

ROA	Coef.	Std. Err.	[95% Conf.	Interval]
SWC	.3288654	.0968388	.1390648	.518666
TE	-.2638012	.0975939	-.4550818	-.0725205
_cons	-2.98e-07	1.51e-07	0.000000	5.92e-07
sigma_u	8.0728651			
sigma_e	3.7473			
rho	.82272878	(fraction of variance due to u_i)		

Fig. 6. Model (1) random effects parameters' estimates, significance levels and R^2 values.

analyzing the financial sustainability of companies operating in the field of waste collection and disposal is rather limited. Furthermore, this body of literature fails to focus on the relevant determinants and, to the best of our knowledge, overlooks Italian companies.

This article aimed to fill this gap by assessing the financial sustainability of the companies in charge of waste collection and treatment services in specific territories according to municipal policies. In particular, we tried to identify the factors that may affect the equilibrium between revenues and costs, paying attention to both environmental protection (specifically, separate waste collection) and some contextual factors. This aim is significant because financial sustainability is strictly linked to companies' ongoing viability and, thus, their ability to continue delivering and improving their services over time, with the aim to implement WM policies efficiently.

The results of the analysis of 880 Italian municipalities show that SWC may explain the ROA of WM companies, presenting a significant positive relationship. This may mean that using and selling separate waste collection products as secondary raw materials may increase revenues and/or decrease costs, improving profitability and, therefore, financial sustainability. In other words, the revenues (derived mainly from selling recovered materials and produced energy and from fees paid by citizens) can cover costs related to waste collection and disposal, improving the ability to preserve and expand such important public utilities in the studied territories. Meanwhile, municipalities can be confident in WM companies' capacities to support the implementation of policies designed to achieve good environmental performance in terms of high levels of separate waste collection and, thus, recycling.

The conducted empirical analysis highlights that TE may also influence the ROA, although, in this case, the relationship is negative. This is likely because, as the territories served expand, higher transport and labor costs reduce ROA, resulting in a negative impact on financial sustainability. Consequently, greater territorial extension can attenuate the economic advantages obtained by recovering materials. This may lead municipalities to believe that SWC and WM choices focused on limited territories are better for limiting transport and, more generally, logistics costs. However, our results suggest that the negative impact of an extended

territory on financial sustainability can be weakened by pushing separate waste collection activities. Considering the EU targets, this is an interesting result that is useful for policy makers, who could, for example, develop networks among municipalities with small territories to increase separate waste collection quantities and balance transport and logistics costs. Thus, possibilities to widen the geographical area served should not be disregarded.

While it seems that none of the considered qualitative characteristics, whether separately or jointly employed, can better explain the financial sustainability of the investigated Italian WM companies.

Our results are important for supporting companies' decisions regarding environmental and financial issues, both of which are crucial for their long-term sustainability. The findings may also be useful for helping policy makers detect appropriate tools to support companies in implementing EU requirements in terms of, for example, SWC, which is still far from meeting planned targets in some areas of Italy.

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