



“Gheorghe Asachi” Technical University of Iasi, Romania



THE ROLE OF WASTE COLLECTION CENTERS IN A CIRCULAR ECONOMY SCENARIO: AN EMPIRICAL STUDY ON THE CITIZENS' PERCEPTION

Marco Savastano^{1*}, Mattia Belcastro¹, Francesco Dentale²

¹Management Department, Sapienza University of Rome, Via del Castro Laurenziano 9, Rome, 00161, Italy

²Department of Dynamic and Clinical Psychology, Sapienza University of Rome, Via degli Apuli 1, Rome, 00185, Italy

Abstract

At a global level, due to the large diffusion of plastic and electronic products, people are disposing growing quantities of municipal solid waste (MSW), and its composition is more complex than ever before. Effective waste management behaviors, policies and technologies enable a variety of benefits in the multi-dimensional perspective of social, environmental and economic sustainability. Urban waste collection centers represent fundamental incentives for the separate collection of municipal waste, aimed at promoting actions that facilitate the contributions by citizens. In this context, the present study has a twofold purpose: to shed light on the current situation of separate collection initiatives and waste collection centers in Italy by analysing, in a preliminary phase, reference public data concerning six representative cities; to investigate the awareness and perception of quality of these initiatives in the perspective of citizens-users as well as their accuracy and frequency of use. Data collected through an online survey with a sample of 164 respondents were statistically analyzed through multiple regressions and allowed to test the predictive models concerning respectively the correlations among the variables of information and accuracy in the separate collection, and quality of service and frequency of use of collection centers. The results showed that the perceived accuracy is better predicted by information variables rather than by quality evaluation variables. Conversely, the frequency of use variable is better predicted by quality evaluation variables rather than by information variables.

Keywords: circular economy, citizens' perception, European Union regulations, municipal solid waste management, separate waste collection, waste collection centers

Received: February, 2019; Revised final: May, 2019; Accepted: August, 2019; Published in final edited form: October, 2019

1. Introduction

Municipal solid waste (MSW) is one of the prominent consequences of modern cities and lifestyle. Solid waste reflects the culture of the place where it is produced and its management directly affects the health of the people and the environment surrounding it (Buenrostro et al., 2014; Cocarta et al., 2009; Ionescu et al., 2015; Ortiz-Rodriguez et al., 2018; Vergara and Tchobanoglous, 2012). Rapid urbanization and economic growth largely impact on the generation of municipal solid waste through a continuous process and at an unprecedented rate.

Waste management prediction, options as well as conversion technologies are currently popular topics for discussion among policy makers, regulators, scholars and waste management industries (Buratti et al., 2015; Kolekar et al., 2016; Parkes et al., 2015; Shekdar, 2009; Singh and Ordoñez, 2016; Troschinetz and Mihelcic, 2009).

The amount of waste generation represents an indicator of the urbanization, industrialization and socio-economic development of a country. For instance, due to the recent high economic growth and rapid urbanization in China, the generation of this type of waste is a significant concern for the local

* Author to whom all correspondence should be addressed: e-mail: marco.savastano@uniroma1.it; Phone: +393334651337

government in order to protect public health (Chhay et al., 2018; Ghinea et al., 2016).

By considering the total waste generated in the EU, urban waste accounts between 7% and 10% according to the European Commission (Eurostat data). However, it is one of the most complex fraction to be managed and the overall organization and management methods generally represent good indicators of the quality of the entire waste management system of a Country, impacting at the same time on its health and environmental quality levels (Warunasinghe and Yapa, 2016). Urban waste is difficult to be managed due to its characteristics represented by the following factors: (i) extremely complex and inhomogeneous composition; (ii) close proximity to citizens; (iii) high public visibility and (iv) impact on the environment and human health. As a consequence, urban waste management requires a highly structured organization that includes an efficient collection system, an effective sorting system and adequate tracking of waste streams. In addition, the active involvement of citizens and businesses, as well as adequate infrastructures for the specific composition of waste based on a stable financing system are needed.

1.1. Municipal waste management in the European Legislation

Countries that established efficient municipal waste management systems generally achieve better results in overall waste management, including achieving high recycling targets (EU Directive 851, 2018 Of the European Parliament and of the Council of 30 May 2018, amending EU Directive 98 2008 on waste.). In this context, growing attention, both in the fields of science and policy making, has been recently given to the concept of Circular Economy (Bartolacci et al., 2017; Fava et al., 2018; Ferronato et al., 2019; Rada et al., 2017; 2018).

Although both scholars and practitioners have presented it as a novelty, it is worth nothing that it builds on the legacy of predecessors and reference models such as waste recycling and separation, industrial ecology, green economy and Life Cycle Assessment. Some concepts find their origin in the 1980's, such as the concepts of waste hierarchies (i.e. 3R's, 4R's etc.). The 3R's concept, for instance, has become commonplace in many international and national waste regulations (Reike et al., 2018). The waste hierarchy establishes a priority order from prevention, preparation for reuse, recycling and energy recovery through the disposal, such as landfilling. This principle aims to encourage the options that deliver the best overall environmental outcome (European Commission, 2015).

The aim of the new directives of the European Union package (i.e. Directives (EU) 2018/849,850,851 and 852) is to tackle the problem of waste recycling, typical of a linear economy model, through specific measures. On this topic, Directive (EU) 2018/849 states that "waste management in the

Union should be improved, with a view to protecting, preserving and improving the quality of the environment, protecting human health, ensuring prudent, efficient and rational utilization of natural resources and promoting the principles of the circular economy" (European Commission, 2018). The report "Closing the loop - An EU action plan for the Circular Economy" published by the European Commission (2015) sets the guidelines for the conversion from the current economic model of production to a new one that maximizes the efficient use of resources and reduces waste, through specific objectives and policies. One of the main drivers of this transformation comes from the rise of the recycling targets for urban and packaging waste. Consistently with this objective, Directive (EU) 2018/851 introduces the obligation to achieve at least the recycling of the 55% by 2025, 60% by 2030 and 65% by 2035 of all urban waste produced during the year (Directive (Eu) 2018/851, p. 21 – (c), (ii) (e)). Thus, incentives for the separate collection of municipal waste becomes a fundamental choice aimed at promoting actions that facilitate the contributions by citizens, sustained through the dissemination on the territory of facilities such as urban waste collection centers. The sorting of waste through these Collection Centers - defined in the DM 8 April 2008 of the Italian Ministry for Environment forms the basis of the integrated urban waste management system, and represents an indispensable tool to increase the visibility of these policies on the territory Collection Centers, by functioning as an intermediate point, represent in the waste management system the place where MSW already differentiated by users at home, is further sorted by specialized employees prior to be transferred to the recovery centers. For this reason, central governments and local administrations need to strongly encourage the use of these centers and provide current and prospect users with widespread informative actions and by enhancing the quality of these services.

A complete information must illustrate on one hand the functionality of the service provided (i.e. location of the centers, opening hours, what fractions can be conferred, methods of use, regulation, etc.); on the other one, it must highlight the main benefits deriving from these practices in terms of social, environmental and economic impacts (according to the traditional *triple bottom line* framework at the base of sustainable development strategies (Elkington, 1994; Slaper and Hall, 2011).

1.2. Research questions and objectives

As illustrated, among the priorities in the area of municipal solid waste management (MSWM) appears the increase in separate waste collection up to 65%, to be pursued through the preferential recourse to one or more of the following mechanisms: door-to-door collection; the promotion of waste collection centers; the implementation of incentive systems for service users/citizens; the preparation of guidelines to standardize the waste collection on the territory;

users/citizens training and information (ISPRA, 2018). Based on these priorities, this study focuses on investigating, through the analysis of both secondary and primary data, what is the current state of implementation of separate collection as well as the creation of waste collection centers in the major municipalities in the North, Central and South of Italy. The main purpose as well as final contribution of this work is to understand and evaluate how this implementation is perceived by the citizens of these municipalities in terms of quality of services and completeness of the information received. Starting from these challenging objectives, the research questions that guided the development of the present work were formulated as follows:

- RQ1: What is the current situation concerning the differentiated waste management and the implementation of Waste Collection Centers in the most representative Italian cities?
- RQ2: What is the overall evaluation, in terms of quality of services, completeness of information, accuracy and frequency of use of separate collection facilities, based on the perception of citizens from the most representative Italian cities?

In order to answer these questions, this manuscript is based on a two-phases study. The first phase is based on the elaboration of data concerning differentiated waste management and waste collection centers in Italy searched through the public databases of ISPRA (Institute for Environmental Protection and Research) and Istat (National Institute of Statistics). The study examines data from a sample of 6 selected cities (Turin, Milan, Bologna, Rome, Naples and Palermo) based on their size (> 200.000 inhabitants) and their geographical position (the macro-areas of North, Central and Southern Italy).

Despite the great importance of this topic of interest at European and global level, represented by several specific innovations in the European regulation and industrial policies, the impact that the implementation of tools aimed at increasing separate waste collection in a context of change from a linear to a circular economy paradigm have in the perception, attitude and behavior of citizens appear to have received limited investigation by the existing literature (Gutberlet et al., 2017; Lakatos et al., 2018; Ragazzi et al., 2017). Indeed, on the one hand the existing studies on this topic are mainly represented by extensive reports – as the ones carried out respectively by the European Commission on the attitudes of Europeans towards waste management and resource efficiency (European Commission, 2014), and ISTAT about the behaviors and satisfaction of a sample of Italian families concerning differentiated waste collection and municipal policies (Istat, 2018) – which although rigorous and generalizable, analyse the phenomena investigated only on a descriptive level. In addition, the authors did not find any report focused on the perception of citizens regarding waste collection centers and related policies. On the other hand, the academic literature on these specific settings presents a limited number of interesting studies

investigating similar issues but in very different contexts as well as countries (outside the EU), therefore characterized by dissimilar regulations, cultures and habits. For instance Folz and Giles (2002), investigated the impact of "Pay-As-You-Throw" policies on household waste disposal and recycling behaviors among the population of U.S. cities based on average quantities of materials disposed or recycled in these municipalities; more recently Warunasinghe and Yapa (2016) carried out a survey with 50 households examining the status of solid waste management (SWM) household level in a peri-urban area of Sri Lanka and obtaining evidence on the willingness of the people in the participation and their level of awareness about the environmental and health hazards associated with disorganized management of solid waste; Starovoytova and Namango (2018) conducted an empirical case study on SWM at a University college in Kenya, obtaining relevant insights on the level of knowledge, attitudes, and practices of students and vendors concerning SWM, which can be improved through significant and sustained behavioral change, achievable by environmental education. Other studies analyzed the topic of environmental awareness from the perspective of the enterprises (discussed into details in section 3).

The aforementioned body of literature represents a fundamental starting point and source of inspiration for the present work. Its specific contribution and added value reside in the understudied context considered (Italian municipalities), in the novelty of directives and policies of reference, and in the specific focus on urban collection centers. To achieve this result, the second quantitative phase (which builds on the preliminary results of the first one) was developed through an online survey with citizens from the 6 representative Italian cities taken into account. The questionnaire was structured on the basis of the research objectives as well as the models presented in the methodology section.

The remainder of the paper is structured as follows: The next section presents a review of the literature according to the topics of circular economy and environmental awareness. Section 3 describes the conceptual models and the methodology used to build the questionnaire items and to reach the final sample for the online survey. Next, the results obtained are presented and discussed in section 4. The paper is finalized with conclusions and final remarks.

2. Circular economy and environmental awareness

The circular economy (CE) concept is of great interest to institutions, scholars and practitioners because it is viewed as an operationalization for businesses and governments to implement the much debated concept of sustainable development (Fortuna et al., 2012; Ghisellini et al., 2016; Merli et al., 2018; Murray et al., 2017; Prieto-Sandoval et al. 2018; Sihvonen and Ritola, 2015).. As observed above, the

concept of circular economy focuses on the 3Rs of “reducing”, “reusing” and “recycling” materials and energy. The various R frameworks are considered by many authors as the “how-to” of CE and thus a core principle of it (Kirchherr et al., 2017; Reh, 2013; Zhu et al., 2010a; Zhu et al., 2010b). Accordingly, the core European Union Waste Framework Directive was structured based on the 4R framework, which introduces ‘Recover’ as the fourth R. This focus on the multiple “Rs” of the circular economy was found to have a close relationship with environmental awareness (which is connected to the degree of information obtained/owned) and behavior (influenced by many cultural and contextual factors). Liu and Bai (2014) in their study about environmental awareness and the behavior of firms in developing the circular economy reported that environmental awareness has been described in the literature as a multi-dimensional construct (Maloney and Ward, 1973).

With reference to enterprises, Zsóka (2008) showed that the dimensions of environmental awareness include environmental knowledge, values, attitudes and willingness to act, as well as actual behavior (Zsóka, 2008). Furthermore, Sakr et al. (2010) investigated environmental awareness from five dimensions, including the dissemination of information, knowledge and the contractors’ environmental responsibilities (Liu and Bai, 2014; Sakr et al., 2010).

The concept of Environmental perception has been described in the literature as the relationship human beings have with the environment, which determines the attitudes of the people in favor of or against it (Starovoytova and Namango, 2018). Moreover, an increased environmental knowledge leads to an enhanced environmental awareness. For decades, institutions have tried to deal with environmental issues, arguing that technological innovation would have eliminated practices that degrade the natural environment; however the gap between the state of health of the environment and the technological progress is always increasing to the detriment of the former (Barr, 2017). For this reason, waste management increasingly takes the form of regulations or incentives by setting standards, regulations, objectives but also rewarding waste disposal systems and “pay as you throw” taxation (Vergara and Tchobanoglous, 2012).

Citizens have more and more responsibility in the planning and decision-making process within the waste management system, both as a decisive part with their active participation (Rowe and Frewer, 2000) and because of their role as consumers and users of waste management services. Therefore, the study of citizens’ perception on this topics is essential for policy-makers in the decision-making process for achieving environmental objectives (Dahlén and Lagerkvist, 2010; Folz and Giles, 2002; Reichenbach, 2008; Starovoytova and Namango, 2018; Wiedemann and Femers, 1993).

3. Methodology

The preliminary goal of this research was to explore, through the analysis of reliable archival data, the percentage amounts of separated waste collection and the number of urban waste collection centers available per inhabitant in some of the most representative Italian cities. Thus, the first phase of the work is based on the elaboration of the data from two highly reliable sources: the Italian waste cadaster managed by the ISPRA, and the report on “Separate waste collection: behavior and satisfaction of citizens and policies for the cities” published by Istat (Istat, 2018). The purpose is to answer the RQ1 and shed light on the current situation of separate collection initiatives and waste collection centers in Italy.

Based on these preliminary evidences presented in section 4.1, it was possible to build up the second phase of this study, based on the analysis of data collected through an online survey on the perceptions of citizens-users, aiming at achieving the following objectives:

- evaluate the presence of eventual differences among northern, central and southern Italian municipalities according to the different variables of *information* (perception of the quality and completeness of information received about separate waste collection and waste collection centers); *quality of services* (perception of the overall quality of separate waste collection and waste collection centers) and self-reported behavior with respect to the separate waste collection process (accuracy and frequency).
- to assess how the variables of the perceived *information* and *quality of services* are predictive of the accuracy and frequency characterizing the waste sorting implemented by the users.

3.1 Conceptual model and variables

The prediction model of this study includes multivariate analysis of variance and multiple regression analyses. In this work we were interested in investigating the predictors of perceived accuracy of the waste sorting (represented by the construct ACC_WS), which represents the dependents variable of the first model; and the predictors of the frequency of use of waste collection centers by citizens-users (represented by the construct TIPFR), which represents the dependent variable of the second model. The predictors, included in both models, were specified as follows:

A. Information variables:

- INFOCIT: represents the perception about the information obtained by the user-citizen concerning the proper waste separate collection process;
- INITER: represents the awareness of the local initiative present in the territory perceived by the user-citizen (e.g. door-to-door collection; recycling facilities etc.).

B. Quality evaluation variables:

- EVAL: describes the overall evaluation on the usefulness and quality of service concerning specifically the waste collection centers;
- PEQU: describes the perceived quality (in terms of innovation, efficacy and effectiveness) of the separate collection of waste services offered by local administrations.

3.2. Questionnaire

An ad hoc multiple-choice questionnaire was developed as the data collection tool in order to operationalize the model variables into items to be answered by citizens through an online survey. For the development of the research instrument the authors referred to both items and positive evidences retrieved from relevant and recent studies in this field (ISPRA, 2018; Istat, 2018; Starovoytova and Namango, 2018; Warunasinghe and Yapa, 2016). Likert-type scales represent the most frequently type used in survey instruments to ensure reliability and validity of measurements (Edwards and Smith, 2016; Hinkin, 1998). In our questionnaire 5-point Likert scales and specific labeling of points were adopted to indicate the degree of agreement, frequency and relevance. For instance, the multiple-items that measured the D.V. “TIPFR” was as follows: “How often do you confer these types of waste in municipal collection centers?”, presenting a 5-point Likert scale ranging from “never” to “very often”.

The outcome variable ACC_WS, on the contrary, was measured on a 10 points continuous scale ranging from “Insufficient” to “excellent”, according to the following item: “Use the following scale to self-assess your degree of accuracy and care in making separate waste collection”. Dicotomic items were also included in the final questionnaire.

3.3. Sample

Invitations with a link to the online questionnaire were transmitted through the several channels (e-mail, social media, etc.) The sampling strategy was conducted beginning with convenience sampling (inviting colleagues and relatives living in the municipalities chosen), snowball sampling (for those initially invited to distribute the link to other acquaintances) and purposive sampling (directly contacting members of specialized groups of interest on specific waste issues).

The final sample accounted a total of 164 respondents from all the 6 municipalities taken into account. The distribution of the sample in macro-areas is shown in Fig. 1. The municipalities were codified as follows: North (respondents from Turin, Milan and Bologna); Center (respondents from Rome); South (respondents from Naples and Palermo). The sample resulted adequate for further statistical analyses (see next sections).

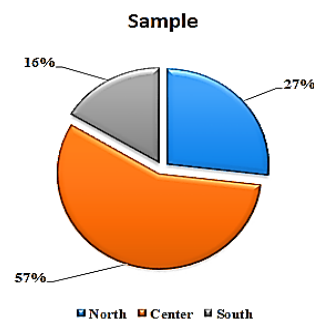


Fig. 1. Survey sample divided into macro-areas

3.4. Data analysis

In order to analyze data as a function of the different aims of the present study we applied the following analyses:

I. *Multivariate Analysis of Variance in order to test mean differences among the variables included in the models;*

II. *Multiple regression analysis in order to test the predictive power of information and quality variables on accuracy and frequency of waste collection.*

4. Results and discussion

4.1. Separate collection and waste collection centers in Italy: preliminary results

In industrialized nations waste tends to be managed formally at a municipal or regional scale (Vergara and Tchobanoglous, 2012). The management of MSW in Italy is obtained through an integrated system, divided into Optimal Territorial Areas. These areas are based on the cooperation among local authorities, with legal, regulatory autonomy, within the organizational and budgetary resources allocated to it by the municipalities, the Province, and the Region (Buratti et al., 2015). Our analysis examines data from a sample of 6 Italian municipalities with a population of over 200,000 and geographically representative of the Italian territory because of their distribution. The time series includes available data between the years 2012 and 2016.

The percentage of separate waste collection in the time period considered (Fig. 2) shows an overall increasing trend - starting from the northern cities with percentages that vary between 42.1% in Turin (2016) and 57.6% in Milan (2016) – passing through the center – 42% in Rome (2016) - up to the south - with significant relevance for the city of Naples 31.3% (2016). The city of Palermo 7.2% (2016) is the only one showing a slightly negative trend among the considered municipalities and time period. By analyzing data concerning the collection centers, in 2017 these areas were used for the provision of urban waste by 45.5% of households throughout Italy at least once. At the regional level, 65.2% of families in the North-East, 57.1% of those residing in the North-West

and 41.3% of the families of the Central Italy. In the South and the Islands, respectively 25.1% and 27.4% of households used those spaces for waste disposal (Istat, 2018).

The percentage variation of separate collection at the considered time t_1 compared to the previous year t_0 , is a useful indicator to measure and evaluate the effectiveness of the introduction of new administrative policies of waste management. Fig. 3 shows a progressive positive variation for the cities of Naples (2013: -1.46%; 2014: 8.37%; 2015: 10.00%; 2016: 29.34%) and at the same time a decreasing trend for the city of Rome (2013: 20.73%; 2014: 19.53%; 2015: 9.30%; 2016: 8.25%). The remaining cities of Turin, Milan, Bologna show ups and downs of growth and degrowth. Furthermore, it is worth noting that the city of Palermo shows only negative values.

About the municipal collection centers, which represent one of the new tools included in the European directives increase the separate collection of MSW and implement policies that encourage the transition to a circular economy, Fig. 4 shows the population with the number of stable collection centers present in the territory. This analysis allows to

compare the average availability of collection centers computed per number of citizens. The evidence indicates a substantial differentiation, from a ratio of 97,000: 1 in Bologna and Naples, to 205,000: 1 in Rome, up to 270,000: 1 in Milan. Currently, there are no fixed collection centers in Palermo. In this case lower is the ratio between the number of inhabitants per urban collection center, greater is the availability and therefore the effectiveness of this waste collection system (used mainly for bulky waste and WEEE).

Therefore, concerning this first objective of the present study, the results show an overall increasing trend of separate collection throughout the Italian peninsula. However, this growth is fluctuating and not yet completely incisive. The objectives set by the European circular economy package are therefore still very distant and complex to reach. The North-South Italy differential analysis highlights also at this stage the structural gap characterizing the southern cities, especially due to a lack of investments (for example reduced number of plants for anaerobic/aerobic integrated treatment of the organic fraction from differentiated collection and incineration plants) (ISPRA, 2018).

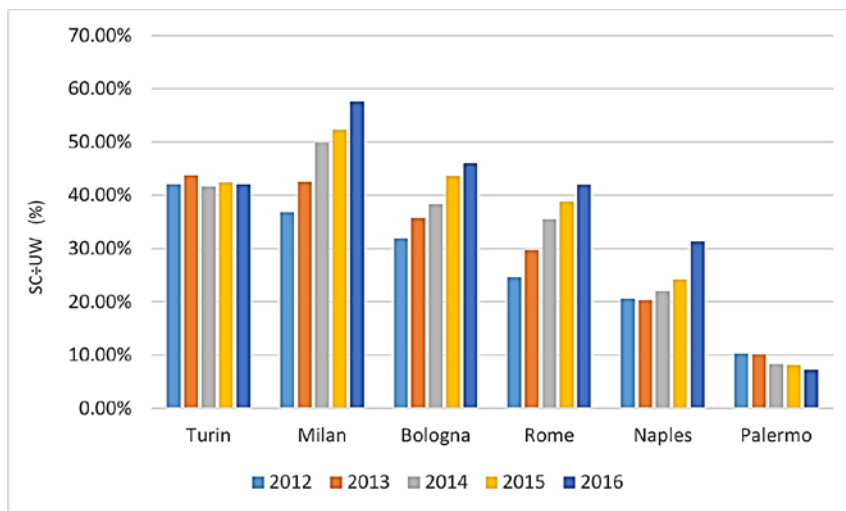


Fig. 2. Trend of the separate collection of municipal waste

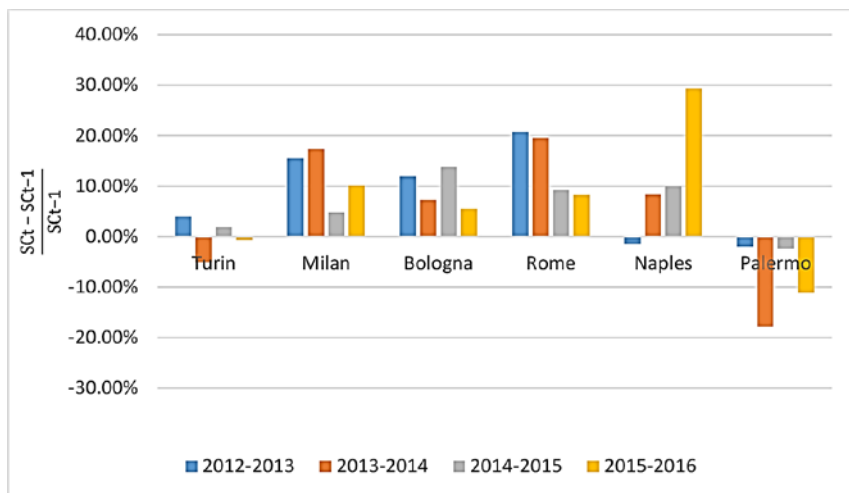


Fig. 3. Percentage variation in the separate collection of municipal waste

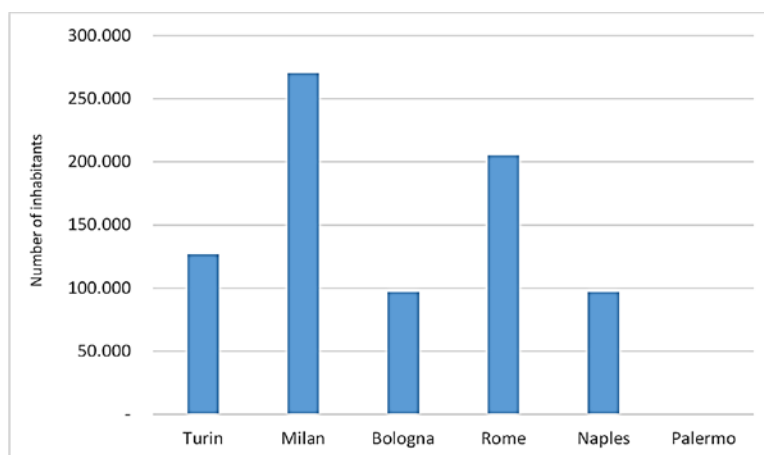


Fig. 4. Number of inhabitants per municipal Collection Center

In the following sections, the results obtained by analyzing the data collected through the online survey will be presented and discussed with reference to our research objectives and questions.

4.2. Descriptive statistics and correlations

Table 1 shows the descriptive statistics (means, standard deviations, asymmetry and kurtosis and internal consistency) of the variables relating to the information/awareness area about the separated waste collection service (INFOCIT, INITER), the quality evaluation area (EVAL, PEQU) and finally to the area of accuracy and frequency of behaviors (ACC_WS, TIPFR). The resulting values of asymmetry and kurtosis are substantially between -1 and 1, indicating that all the variables examined are approximated to the normal distribution. Cronbach’s alpha of the factors computed by multiple items is also reported indicating an adequate level internal consistency for them. Table 2 shows the correlations among the accuracy and frequency variables and the information and quality evaluation area variables. It is worth noting that ACC_WS correlates significantly only with the quality of the information related to the services (INFOCIT) and with the evaluation of the services concerning the waste collection centers (EVAL), with a moderate effect size in the first case and small in the

second one. Moreover, the frequency of use of waste collection centers by citizens-users (TIPFR) correlates significantly with the two indicators of quality evaluation of services with moderate effect size for EVAL and small for PEQU , while it does not correlate with the indicators related to service information (INFOCIT and INITER) .

4.2. Average differences among the macro-areas of North, Center and South

To assess whether the subjects from northern, central and southern Italy show different mean values according to the variables taken into consideration in the present study (i.e. variables in the areas of information, quality assessment of separate waste collection services and the accuracy and frequency with which separate collection is carried out), an analysis of multivariate variance (MANOVA) was conducted, including the residence of respondents (north, center and south) as an independent variable and INFOCIT, INITER, EVAL, PEQU, ACC_WS and TIPFR as dependent variables.

The results of the analysis show a significant multivariate effect of residence variable on the dependent variables considered [F (12, 304) = 11.42, p = .00] with a considerable effect size (Eta square = .31).

Table 1. Descriptive statistics

Variables	Mean	SD	Skewness	Kurtosis	Internal consistency
INFOCIT	2.54	.94	.55	-.36	-
INITER	.77	.27	-1.06	.29	.75
EVAL	3.30	1.14	-.21	-.79	-
PEQU	2.26	.82	.55	-.40	.94
ACC_WS	7.61	1.64	-1.09	1.18	-
TIPFR	1.94	.59	.63	.37	.79

Table 2. Correlations among all variables

	INFOCIT	INITER	EVAL	PEQU
ACC_WS	.31**	.11	.19**	.13
TIPFR	.04	.0	.32**	.22**

** Correlation is significant at the .01 level (2-tailed); * Correlation is significant at the .05 level (2-tailed)

Particularly, as the results presented in Table 3 indicate, the effects of the place of residence are significant on the INFOCIT, EVAL, PEQU and ACC_WS variables, while they are not significant on the remaining two dependent variables (INITER and TIPFR). By taking into account the post hoc comparisons, conducted through the Sidak test, it emerges that the subjects from northern municipalities show higher average scores in the variables INFOCIT [Mean Difference (North vs. Center) = .91, $p = .00$; Mean Difference (North vs. South) = .62, $p = .01$], EVAL [Mean Difference (North vs. Center) = .68, $p = .00$; Mean Difference (North vs. South) = .99, $p = .00$], PEQU [Mean Difference (North vs. Center) = 1.27, $p = .00$; Mean Difference (North vs. South) = .68, $p = .00$] and ACC_WS [Mean Difference (North vs. Center) = .65, $p = .09$; Mean Difference (North vs. South) = .98, $p = .04$], if compared to those from the center and south of Italy, with significant differences for all comparisons except for ACC_WS between north and center. On the contrary, the mean scores of the subject's form center and south areas differ significantly only concerning the PEQU variable [Mean Difference (Sud vs. Center) = .59, $p = .00$]. Overall, these results suggest that the degree of information on separate collection services, the perceived quality of these services and the (self-assessed) accuracy with which this process is conducted by users is higher in the northern cities than in the central and southern ones. These evidences confirm the data presented in section 4.1 related to the inhomogeneous geographic distribution of urban waste collection centers in the different Italian areas. Indeed, from other studies it resulted that more

information encourage families to differentiate waste more and more efficiently. With reference to the year 2017, ISTAT provided an overview of the opinions of Italian families on the actions and policies that would increase the rate of participation in separate waste collection. To improve, both in quantitative and qualitative terms, the participation in separate waste collection, 93.4% of families would like more information on how to separate waste; the 93.3% more numerous and efficient recycling and composting centers; the 83.3% deductions and/or tax or tariff reductions, already existing in some areas of the country (Istat, 2018).

4.3. Multiple regression: predictors of accuracy and frequency of the separate collection

To evaluate the predictive capacity of the variables concerning the service-related information area (INFOCIT and INITER) and those concerning evaluation of the quality of the service (EVAL and PEQU), two regressions were conducted (the first on the accuracy criterion and the second on the frequency criterion). The resulting predictive models are shown in the Figs. (5-6). The first multiple regression analysis accounted for significant portion of accuracy of waste selection variance ($R^2 = .14$), indicated an adequate fit of the model. As shown in Table 4, the variables concerning the information (INFOCIT and INITER) significantly predict the accuracy employed by the subjects in the separate collection activities, while the variables concerning the perceived quality of the service do not offer significant contributions to its prediction.

Table 3. MANOVA as a function of city of residence

	City of residence	Mean	SD	F (2, 157)	P	Eta square
INFOCIT	North	3.14	1.01	16.75	.00	.18
	Center	2.23	.72			
	South	2.52	.94			
INITER	North	.70	.26	2.19	.12	.03
	Center	.81	.25			
	South	.76	.32			
EVAL	North	3.88	.98	8.54	.00	.10
	Center	3.20	1.12			
	South	2.89	1.09			
PEQU	North	3.10	.76	63.24	.00	.45
	Center	1.83	.51			
	South	2.42	.67			
ACC_WS	North	8.16	1.29	3.58	.03	.04
	Center	7.51	1.67			
	South	7.19	1.90			
TIPFR	North	1.93	.59	1.46	.24	.02
	Center	1.91	.55			
	South	2.13	.70			

Table 4. Regression 1: includes the variables of information and quality evaluation as predictors and the self-assessed accuracy (ACC_WS) as the criterion

Predictors	Beta	t	p (t)	R ²	F	df	p (F)
INFOCIT	.34	3.92	.00	.14	6.24	4, 155	<.001
INITER	.15	1.92	.05				
EVAL	.14	1.69	.09				
PEQU	-.08	-.87	.39				

In particular, a better perception of the information related to the service (INFOCIT) goes along with a higher accuracy in the separate collection (ACC_WS). Moreover, the more the subjects are informed about the services available in their territory (INITER), the more the accuracy of their separate collection increases, even if the result presents a tendential significance only. On the contrary, neither the overall evaluation on the usefulness and quality of service concerning the waste collection centers nor the perceived quality of the separate collection significantly predict the self-assessed accuracy of the subjects involved in the research. Fig. 5 represents these results through the first predictive model.

The second multiple regression analysis accounted for significant portion of frequency of use of the collection centers variance ($R^2 = .13$), indicated an adequate fit of the model. Moreover, as shown in Table 5, the information variables do not offer unique contributions to the frequency of use of the collection centers (TIPFR), while the variables concerning the perceived quality of the service offer significant contributions to its prediction.

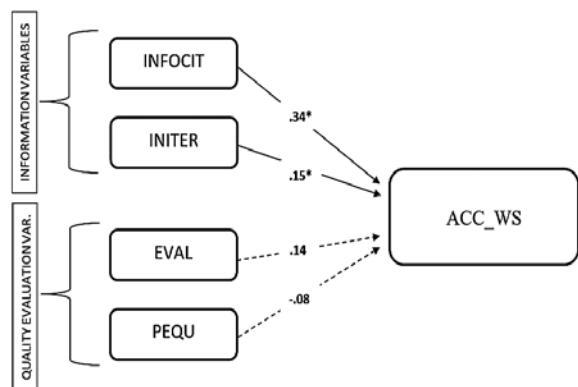


Fig. 5. Predictive Model 1

In particular, neither the perception of the information degree related to the service (INFOCIT) nor the awareness of the local initiative present in the territory (INITER) predict the frequency of use of waste collection centers by citizens (TIPFR). On the contrary, both the overall perception quality of the separate collection services (PEQU), and the overall evaluation on the usefulness and quality of waste collection centers (EVAL) significantly predict the frequency of use of the subjects involved in the research (TIPFR). Fig. 6 represents these results through the second predictive model.

The results from the multiple regressions conducted suggest that the self-reported accuracy in

the separate collection (ACC_WS) is linked to the evaluation of the information received regarding the waste management services (INFOCIT) as well as to the awareness of the local initiative present in the territory perceived by the user-citizen, while it does not seem to be associated with the overall evaluation on the usefulness and quality of the service (EVAL). At the same time, with reference to the second predictive model, the frequency of use of waste collection centers by citizens-users for the separate collection (TIPFR) results linked to the perception of the overall quality and usefulness of the services, while it seems to be independent from the quality and degree of the information received about them.

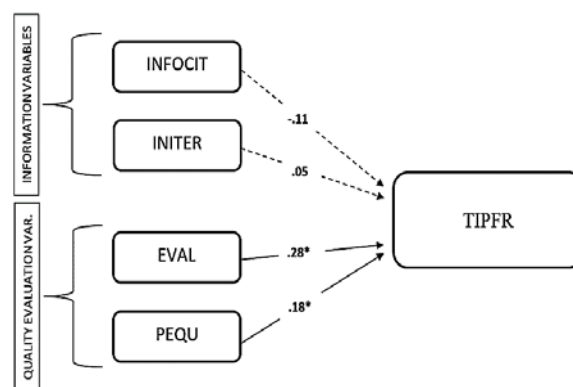


Fig. 6. Predictive Model 2

Overall, results of regression analyses suggest that the predictors of the information area offer a unique contribution in predicting ACC_WS, while they do not add anything in predicting TIPFR. Conversely, the predictors of the perceived quality of services have a unique impact on TIPFR, but do not add anything in predicting ACC_WS. In line with the literature analyzed in section 2, these results indicate that in order to improve accuracy in the behavior of separate collection by users it is necessary to adopt regulatory or incentive actions (Vergara and Tchobanoglous, 2012), as well as to provide adequate information in an appropriate way. In support of this conclusion, it can be added that the implementation of the separate collection according to the territory under examination can be very complex, requiring both adequate information tools and infrastructures for the users to carry out the separate collection carefully and to use frequently the urban collection centers. To improve this frequency, evidences indicate that users should perceive a good quality of services. This perception resulted on average higher in northern cities than in central and southern ones

Table 5. Regression 2: includes the variables of information and quality evaluation as predictors and the frequency of use of the collection centers (TIPFR) as the criterion

Predictors	Beta	t	p (t)	R ²	F	df	p (F)
INFOCIT	-.11	-1.30	.20	.13	5.58	4, 157	<.001
INITER	.05	.67	.51				
EVAL	.28	3.46	.01				
PEQU	.18	1.97	.05				

4. Conclusions

In conclusion, this study presents some significant results that offer an overview of the way separate collection services, and specifically the use of urban waste collection centers, are perceived in some important Italian cities, as well as of the perceived accuracy and frequency characterizing these settings. Particularly, it is important to highlight that the predictive models tested indicate that the accuracy seems to be influenced by the information available on waste collection services, while the frequency seems to be more closely linked to the perception of the quality of these services.

In this context, the evolution of specific regulations (i.e. EU Action Plan) is expected to lead to a strong increase in the number of collection centers, in the percentage of separate collection as well as in recycling, reuse and energy generation activities. This will also depend on the investments made by public institutions in infrastructures and information. Consequently, citizens' awareness of these issues will increase, as will their degree of knowledge and frequency of use of these services.

The present research faces also some limitations. Among those it is possible to highlight that participants are recruited from only six municipalities, although selected as the most populated and located three main macro-areas of the country (north, center and south Italy), limiting the generalizability of results. Moreover, the limited number of participants may have reduced the statistical power of the study. Finally, the lack of objective evaluations to measure the variables included in the model may have biased our results.

Future studies are called to make a comparison between the perception of citizens-users and objective measures relating to the abovementioned three dimensions. Furthermore, the enlargement of the sample, together with the investigation of additional municipalities sited in different areas, would improve the power of statistical tests and the external validity of the results.

References

- Barr S., (2017), *Household Waste in Social Perspective: Values, Attitudes, Situation and Behaviour*, 1st Edition, Routledge, UK.
- Bartolacci F., Del Gobbo R., Paolini A., Soverchia M., (2017), Waste management companies towards circular economy: What impacts on production costs?, *Environmental Engineering and Management Journal*, **16**, 1789-1796.
- Buenrostro O., Márquez L., Ojeda S., (2014), Environmental perception of solid waste management in the municipalities of PÁtzcuaro region, Mexico, *Environmental Engineering and Management Journal*, **13**, 3097-3103.
- Buratti C., Barbanera M., Testarmata F., Fantozzi F., (2015), Life Cycle Assessment of organic waste management strategies: an Italian case study, *Journal of Cleaner Production*, **89**, 125-136.
- Chhay L., Reyad M. A. H., Suy R., Islam M. R., Mian M. M., (2018), Municipal solid waste generation in China: influencing factor analysis and multi-model forecasting, *Journal of Material Cycles and Waste Management*, **20**, 1761-1770.
- Cocarta D.M., Rada E.C., Ragazzi M., Badea A., Apostol T., (2009), A contribution for a correct vision of health impact from municipal solid waste treatments, *Environmental Technology*, **30**, 963-968.
- Dahlén L., Lagerkvist A., (2010), Pay as you throw: Strengths and weaknesses of weight-based billing in household waste collection systems in Sweden, *Waste Management*, **30**, 23-31.
- Edwards M. L., Smith B. C., (2016), The effects of the neutral response option on the extremeness of participant responses, *Incite*, **6**, 177-192.
- Elkington J., (1994), Towards the Sustainable Corporation: Win-Win-Win Business Strategies for Sustainable Development, *California Management Review*, **36**, 90-100.
- European Commission, (2014), Attitudes of Europeans Towards Waste Management and Resource Efficiency, On line at: https://ec.europa.eu/commfrontoffice/publicopinion/fla sh/fl_388_en.pdf.
- European Commission, (2015), Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions. Closing the loop - An EU action plan for the Circular Economy. European Commission, Vol. 2, On line at: https://eur-lex.europa.eu/resource.html?uri=cellar:8a8ef5e8-99a0-11e5-b3b7-01aa75ed71a1.0012.02/DOC_1&format=PDF.
- European Commission, (2018), Official Journal of the European Union, On line at: <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0849&from=IT>.
- EU Directive 98, (2008), Directive 2008/98 / EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain directives, On line at: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32008L0098>.
- EU Directive 851, (2018), Directive (EU) 2018/851 of the European Parliament and of the Council of 30 May 2018, On line at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.150.01.0109.01.ENG.
- Fava F., Totaro G., Gavrilescu M., (2018), Green and circular economy ecomondo 2017: 21th international trade fair of material and energy recovery and sustainable development, *Environmental Engineering and Management Journal*, **17**, 2285-2286.
- Ferronato N., Rada E.C., Gorrity Portillo M.A., Cioca L.I., Ragazzi M., Torretta V., (2019), Introduction of the circular economy within developing regions: A comparative analysis of advantages and opportunities for waste valorization, *Journal of Environmental Management*, **230**, 366-378.
- Folz D.H., Giles J., (2002), Municipal experience with "Pay As You Throw" policies: findings from a national survey, *State and Local Government Review*, **34**, 105-115.
- Fortuna M., Simion I. M., Ghinea C., Cozma P., Apostol L. C., Hlihor R. M., Fertu D. T. Gavrilescu M., (2012), Analysis and management of specific processes from

- environmental engineering and protection based on sustainability indicators, *Environmental Engineering and Management Journal*, **11**, 333-350.
- Ghinea C., Drăgoi E. N., Comăniță E. D., Gavrilesco M., Câmpean T., Curteanu S., Gavrilesco M., (2016), Forecasting municipal solid waste generation using prognostic tools and regression analysis, *Journal of Environmental Management*, **182**, 80-93.
- Ghisellini P., Cialani C., Ulgiati S., (2016), A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems, *Journal of Cleaner Production*, **114**, 11-32.
- Gutberlet J., Careno S., Kain J.-H., de Azevedo A.M.M., (2017), Waste picker organizations and their contribution to the circular economy: Two case studies from a Global South Perspective, *Resources*, **6**, 52.
- Hinkin T.R., (1998), A brief tutorial on the development of measures for use in survey questionnaires, *Organizational Research Methods*, **1**, 104-121.
- Ionescu G., Rada E.C., Cioca L.I., (2015), Municipal solid waste sorting and treatment schemes for the maximization of material and energy recovery in a latest EU member, *Environmental Engineering and Management Journal*, **14**, 2537-2544.
- ISPRA, (2018), Municipal waste report 2018, On line at: http://www.isprambiente.gov.it/en/publications/reports/municipal-waste-report-2018?set_language=en.
- Istat, (2018), Separate Waste Collection: Citizens' Behaviour And Satisfaction, Policies Of Cities, On line at: <https://www.istat.it/en/archivio/218765>.
- Kirchherr J., Reike D., Hekkert M. (2017), Conceptualizing the Circular Economy: An Analysis of 114 Definitions, *Resources, Conservation and Recycling*, **127**, 221-232.
- Kolekar K. A., Hazra T., Chakrabarty S. N., (2016), A review on prediction of municipal solid waste generation models, *Procedia Environmental Sciences*, **35**, 238-244.
- Lakatos E.S., Cioca L.-I., Dan V., Ciomos A.O., Crisan O.A., Barsan G., (2018), Studies and investigation about the attitude towards sustainable production, consumption and waste generation in line with circular economy in Romania, *Sustainability*, **10**, 865
- Liu Y., Bai Y., (2014), An exploration of firms' awareness and behavior of developing circular economy: An empirical research in China, *Resources, Conservation and Recycling*, **87**, 145-152.
- Maloney M.P., Ward M.P., (1973), Ecology: Let's hear from the people: An objective scale for the measurement of ecological attitudes and knowledge, *American psychologist*, **28**, 583.
- Merli R., Preziosi M., Acampora A., (2018), How do scholars approach the circular economy? A systematic literature review, *Journal of Cleaner Production*, **178**, 703-722.
- Murray A., Skene K., Haynes K., (2017), The circular economy: an interdisciplinary exploration of the concept and application in a global context, *Journal of Business Ethics*, **140**, 469-380.
- Ortiz-Rodriguez O.O., Rivera-Alarcón H.U., Villamizar-Gallardo R.A., (2018), Evaluation of municipal solid waste by means of life cycle assessment: Case study in the South-Western region of the department of Norte de Santander, Colombia, *Environmental Engineering and Management Journal*, **17**, 611-619.
- Parkes O., Lettieri P., Bogle I.D.L., (2015), Life cycle assessment of integrated waste management systems for alternative legacy scenarios of the London Olympic Park, *Waste Management*, **40**, 157-166.
- Prieto-Sandoval V., Jaca C., Ormazabal M., (2018), Towards a consensus on the circular economy, *Journal of Cleaner Production*, **179**, 605-615.
- Rada E.C., Cioca L.I., (2017), Optimizing the methodology of characterization of municipal solid waste in EU under a circular economy perspective, *Energy Procedia*, **119**, 72-85.
- Rada E.C., Ragazzi M., Torretta V., Castagna G., Adami L., Cioca L.I., (2018), Circular Economy And Waste To Energy, *AIP Conference Proceedings*, **1968**, 030050.
- Ragazzi M., Fedrizzi S., Rada E.C., Ionescu G., Ciudin R., Cioca L.I., (2017), Experiencing urban mining in an Italian municipality towards a circular economy vision, *Energy Procedia*, **119**, 192-200.
- Reh L., (2013), Process engineering in circular economy, *Particuology*, **11**, 119-133.
- Reichenbach J., (2008), Status and prospects of pay-as-you-throw in Europe – A review of pilot research and implementation studies, *Waste Management*, **28**, 2809-2814.
- Reike D., Vermeulen W.J.V., Witjes S., (2018), The circular economy: New or Refurbished as CE 3.0?-Exploring Controversies in the Conceptualization of the Circular Economy through a Focus on History and Resource Value Retention Options, *Resources, Conservation and Recycling*, **135**, 246-264.
- Rowe G., Frewer L.J., (2000), Public participation methods: A framework for evaluation, *Science, Technology and Human Values*, **25**, 3-29.
- Sakr D.A., Sherif A., El-Haggag S.M., (2010), Environmental management systems' awareness: an investigation of top 50 contractors in Egypt, *Journal of Cleaner Production*, **18**, 210-218.
- Shekdar A.V., (2009), Sustainable solid waste management: An integrated approach for Asian countries, *Waste Management*, **29**, 1438-1448.
- Sihvonen S., Ritola T., (2015), *Conceptualizing ReX for Aggregating End-of-life Strategies in Product Development*, The 22nd CIRP Conf. on Life Cycle Engineering, Procredia CIRP, Sydney, Australia, **29**, 639-644
- Singh J., Ordoñez I., (2016), Resource recovery from post-consumer waste: important lessons for the upcoming circular economy, *Journal of Cleaner Production*, **134**, 342-353.
- Slaper T.F., Hall T.J., (2011), The Triple Bottom Line: What Is It and How Does It Work?, *Indiana Business Review*, **86**, 4-8.
- Starovoytova D., Namango S., (2018), Solid Waste Management at University Campus (Part 4/10): Perceptions, Attitudes, and Practices of students and vendors, *Journal of Environment and Earth Science*, **8**, 108-142.
- Troschinetz A.M., Mihelcic J.R., (2009), Sustainable recycling of municipal solid waste in developing countries, *Waste Management*, **29**, 915-923.
- Vergara S.E., Tchobanoglous G., (2012), Municipal Solid Waste and the Environment: A Global Perspective, *Annual Review of Environment and Resources*, **37**, 277-309.
- Warunasinghe W.A.A.I., Yapa P.I., (2016), A Survey on Household Solid Waste Management (SWM) with Special Reference to a Peri-urban Area (Kottawa) in Colombo, *Procedia Food Science*, **6**, 257-260.
- Wiedemann P.M., Femers S., (1993), Public participation in waste management decision making: Analysis and management of conflicts, *Journal of Hazardous Materials*, **33**, 355-368.

- Zhu L., Zhou J., Cui Z., Liu L., (2010a), A method for controlling enterprises access to an eco-industrial park, *Science of the Total Environment*, **408**, 4817-4825.
- Zhu Q., Geng Y., Lai K.H., (2010b), Circular economy practices among Chinese manufacturers varying in environmental-oriented supply chain cooperation and the performance implications, *Journal of Environmental Management*, **91**, 1324-1331.
- Zsóka Á.N., (2008), Consistency and “awareness gaps” in the environmental behaviour of Hungarian companies, *Journal of Cleaner Production*, **16**, 322-329.