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Assessing Italian household preferences for waste sorting systems: The role of environmental awareness, socioeconomic characteristics, and local contexts

Tatiana Cantillo [a,*], Sandra Notaro [b], Nicolao Bonini [b], Constantinos Hadjichristidis [b,c]

[a] Proyectos Técnicos Ltda, Barranquilla, Colombia
[b] Department of Economics and Management, University of Trento, Italy
[c] Centre for Decision Research, University of Leeds, United Kingdom

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ABSTRACT

Efficient Waste Management Systems (WMS) depend on citizens' willingness to sort waste and to cooperate for its improved provision. Thus, it is essential to understand what attributes individuals value the most and what drives WMS preference heterogeneity. In this paper, we investigate how individuals evaluate WMS attributes (e.g., the number of waste sorting categories, the introduction of textile sorting, and the frequency of collection per week) and how the local contexts, socioeconomics, and environmental values shape their preferences. For this purpose, we conducted a discrete choice experiment on a sample representative of the Italian population interviewed through an online panel survey. We collected information on individual's preferences for WMS attributes, environmental awareness, and socioeconomic characteristics. We analyzed the data using hybrid mixed choice models, which allowed us to integrate environmental awareness values into willingness to pay estimations. We found that individuals are willing to pay for waste sorting, even if this implies more effort on their part and increased storage space. In addition, we found that the extent to which individuals support WMS improvements strongly depends on their environmental values, experiences (which are shaped by their local context), and socioeconomic factors. Our results suggest that to increase recycling rates and citizen satisfaction, there is a need for context-specific WMS designs that acknowledge the observed heterogeneity of preferences.

1. Introduction

A circular economy is increasingly seen as a pillar for achieving Global Sustainability Goals. For this reason, several governmental bodies, including the European Union, are putting strong circular economy targets at the top of their policy agenda (Camana et al., 2021). To achieve these goals, we need a waste management system (WMS) that efficiently recovers and separates the waste generated in the economy (Nainggolan et al., 2019). Thus, understanding individual's preferences, attitudes, expected behavior, and willingness towards waste handling and separation is essential for designing a WMS that complies with circularity goals and enhances society's welfare (Cai et al., 2021; Ke et al., 2022; Song et al., 2019).

Because waste sorting is a time, space, and effort-consuming activity that normally leads to low or zero monetary rewards, the factors influencing households to engage in recycling have grabbed scholars' attention in the last years (Berglund, 2006; Gilli et al., 2018; Czajkowski et al., 2019; Aprile and Fiorillo, 2019; Massarutto et al., 2019). Recent literature has found that individuals' willingness to sort waste is shaped by a wide range of motivations, including policy incentives, social norms and pressure, reputational concerns, personal values, warm-glow giving, and trust in the WMS (Cecere et al., 2014; D'Amato et al., 2016; Vassanadumrongdee and Kittipongvises, 2018; Degli Antoni and Vittucci Marzetti, 2019; Jacobsen et al., 2022). Socioeconomic characteristics such as age, income, and gender have also been found as important predictors of waste sorting intention; however, there is no consensus on the directionality of socioeconomic characteristics on recycling participation as the results vary widely across studies (Ke et al., 2022).

The determinants of recycling intention have been extensively analyzed in the literature. However, a gap remains in quantifying the impact of these factors on individuals' utility and WTP for WMS's attributes. Understanding and measuring the effects of these factors on

* Corresponding author.
E-mail address: tatiana.garcia.19@ucl.ac.uk (T. Cantillo).

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WMS preferences is necessary to develop efficient WMS, which internalize welfare distributional impacts and, thus, are supported by all population segments (Ke et al., 2022). In addition, policy makers can use this information to increase individuals' WTP for recycling.

In this paper, using Italy as a case study, we measure the impact of environmental awareness (EA), socioeconomics, and local contextual factors on individuals' preferences and WTP for improved WMS attributes. Thus, our results provide important insights to policy makers on how to design WMS, which increase societal welfare and motivate citizens to engage in recycling, considering the costs and benefits that different population segments perceive for WMS.

Italy constitutes an interesting case study as the recycling rate varies widely across regions, with high recycling rates (around 71%) in the north and medium–low recycling rates in the south (about 54%)[1]. As in Italy the WMS is managed and funded at the local level, this heterogeneity has been linked to differences in the economic and social development across regions, which in turn translates to a diverse capacity to collect and treat the waste (Cerqueti et al., 2021; Di Foggia and Beccarello, 2021; Lombardi et al., 2021; Chakraborty et al., 2022; Romano et al., 2022). Municipalities with a greater density of low-income individuals, which in Italy coincide with areas with a low level of industrialization, have less efficient WMS, namely, less efficient waste management planning, operational monitoring, and a less developed waste recycling system. Therefore, there is a higher risk of a negative impact on the environment and the health of citizens.

The non-efficient waste management systems of less developed areas can be an obstacle to achieving the EU circular economy goals regarding landfill disposal and the percentage of sorted waste collection. Thus, there is a need to implement policies that would encourage individuals in low-recycling rate municipalities to engage in waste sorting. In this research, we exploit the national nature of our data to analyze the WMS attributes that households living in low- and high-recycling rate municipalities value the most. Therefore, our results provide important insights for developing region-tailored WMS policies aimed at reducing and improving the differences in recycling rates across Italian municipalities. In addition, by exploiting the regional differences in waste sorting WTP, a national cross-subsidy system could be implemented to improve the recycling facilities of lagging municipalities. As far as we know, this is the only study that has analyzed how WMS preferences change across regions.

Our research makes several novel contributions to the field. First, it quantifies the impact of EA on WMS preferences, which has not yet been assessed in the literature. In addition, our study departs from previous research by analyzing the impact of environmental attitudes on recycling intention using the well-established New Ecological Paradigm (NEP) scale (Dunlap et al., 2000). The construct validity of the NEP scale has widely been endorsed in the literature (Matsiori, 2020), attesting to its reliability. Second, we analyze to what extent socioeconomics' impact on WMS preferences is driven by their influence on EA values. Previous research examining how socioeconomic characteristics impact recycling intention has rarely assessed the mechanisms underlying socioeconomic groups' heterogeneity of preferences. Thus, our results are highly relevant to understanding why the preferences for WMS attributes vary across socioeconomic groups. Finally, although it is widely acknowledged that individuals' preferences are shaped by their local environment (Benyam et al., 2020), how the local context influences WMS preferences has rarely been assessed. In this investigation, we contribute by analyzing the impact of three location-specific factors (e.g., local recycling rate, population density, and type of collection system) on the WTP for WMS. The rest of the paper is organized as follows. Section 2 reviews the literature on households' preferences for improved WMS. Section 3 introduces the data and experimental design of the present study. Section 4 presents the methodology used. Section 5 presents the results, while section 6 discusses them. Finally, section 7 concludes.

[1] Statistics obtained for the Superior Institute for Environmental Protection and Research available at: https://www.catasto-rifiuti.isprambiente.it/index.php?pg=nazione.

2. Literature review

Due to the public good nature of WMS, individuals' preferences towards WMS are commonly assessed through stated preference (SP) surveys (Ke et al., 2022). By creating hypothetical scenarios, SP surveys allow researchers to uncover consumers' preferences, expected behaviors, and WTP for goods and services that do not have a market value. The most frequently used SP technique for eliciting individuals' WTP for waste sorting and recycling is the contingent valuation method (CVM). Table 1 presents a summary of studies using CVM to evaluate citizens' preferences for improved recycling facilities and WMS, along with the main findings. These studies have primarily focused on analyzing households' WTP for the introduction of waste sorting and recycling programs, and improvements in the waste collection system.

The aforementioned studies have also extensively analyzed the role of demographic characteristics, such as age, gender, education, income, and household characteristics, on recycling intention and WTP (see Table 1). However, the impact of demographics on willingness to sort waste has received mixed results and, in general, was found to have a negligible impact when compared to psychological and institutional factors such as values and attitudes (Aprile and Fiorillo, 2019; Romano et al., 2022). Nonetheless, a caveat in the literature analyzing the impact of socioeconomic characteristics on WMS preferences is their overly descriptive approach; they rarely assess the mechanisms underlying socioeconomic groups' heterogeneity of preferences.

Though helpful, CVM can only capture individuals' preferences for a single attribute, thus, with CVM, it is not possible to calculate the tradeoffs between WMS attributes. Discrete choice models (DCM) overcome this limitation. Thus, DCM have gained increasing popularity for quantifying the preferences and tradeoffs for different WMS design options. Besides cost, the most popular WMS attributes evaluated through DCM include collection frequency, number of waste-sorting categories, expected recycling rate, and type of charging system. Table 2 summarizes past research using DCM to evaluate preferences for WMS and the main findings.

In general, higher collection frequency has been linked to higher WTP levels, with the exception of Nainggolan et al. (2019), who found that a less frequent system was preferred. In addition, growing research has found that, on average, individuals positively evaluate increases in the number of categories to sort at home. This is a very interesting result as it implies that individuals receive non-monetary rewards from sorting waste at home, which exceeds their costs in terms of effort, space and time. Thus, psychological factors such as habits, attitudes, perceptions, values, and social and subjective norms must play a key role in understanding individual's willingness to sort waste (Massarutto et al., 2019, Czajkowski et al., 2019, Agovino et al., 2019; Degli Antoni and Vittucci Marzetti, 2019).

Considering the importance of psychological factors on recycling behavior, a stream of research has aimed to estimate the impact of these variables on waste-sorting preferences. Some studies have directly used indicators of these unobservable factors to measure their effect on WTP estimates. An example is Aprile and Fiorillo (2019), who used indicators of environmental concern to empirically measure its impact on recycling behavior in Italy. Another example is Afroz et al. (2009), who used indicators of the attitudinal variables of waste management concern and satisfaction with the system to measure their impact on improved WMS preferences. Others have used more sophisticated factor analysis techniques to measure these latent variables. For instance, Vassanadumrongdee and Kittipongvises (2019) used factor analysis to estimate the impact of latent traits, such as perception of inconvenience, pro-environmental attitudes, and subjective norms towards waste-sorting,

Table 1
CV studies evaluating preferences for improved WMS and recycling.

Reference	Region	Objective	WTP	Attributes impacting WTP
Afroz et al., 2009	Dhaka, Bangladesh	WTP to improve the WMS	13 TK (USD 0.18)	(1) Age + (2) Education *ns* (3) Income +(4) Household size *ns* (5) Concern + (6) Satisfaction *ns* (7) Door-to-door collection +
Blaine et al., 2005	Lake County, OH, United States	WTP for curbside recycling	1.59 USD	(1) Income + (2) Female + (3) Age +(4) Past participation +
Huhtala, 2010	Finland	WTP for recycling	12 EUR	(1) Income - (2) Number of children + (3) Female +
Benyam et al., 2020	Queensland, Australia	WTP to avert domestic food waste	30.42 AUD	(1) Education + (2) Income + (3) Female –(4) Food waste concern +
Huynh et al., 2022	Mekong River Delta, Vietnam	WTP to reduce solid landfill waste (Recycling)	4.81 USD per month	(1) Age – (2) Female *ns* (3) Education ns (4) Income + (5) Not classified before + (6) Living in cities +
Ferreira and Marques, 2015	Portugal	WTP for recycling	2.54 EUR	(1) Age – (2) Income + (3) Female – (4) Education *ns* (5) Access to selective collection service –(6) Household size *ns* (7) Retired *ns* (8) Unemployed *ns*
Kayamo, 2022	Hawassa city Ethiopia	WTP to improve WMS	26.57 ETB (0.62 USD)	(1) Family size + (2) Distance from dumpsite –(3) Satisfaction – (4) Income +
Kotchen et al., 2009	California, United States	WTP to establish a pharmaceutical disposal program.	2.56 USD per prescription	(1) Age – (2) Male – (3) Democrats + (4) Income *ns*
Song et al., 2012	Macao, China	WTP for e-waste recycling	20.03 MOP (2.5 USD)	(1) Education + (2) Income + (3) Age -
Vassanadumrongdee and Kittipongvises 2018	Bangkok, Thailand	WTP to improve recycling facilities	52.6 THB(1.5 USD) , per month	(1) Socio-economics *ns* (2) Residence time -(3) Satisfaction WMS + (4) Knowledge +(5) Inconvenience – (6) Environmental awareness +(7) Information level -
Song et al., 2019	Macao, China	WTP for resources recycling	18.72 MOP (2.16 USD)	(1) Age *ns* (2) Female *ns* (3) Household size *ns*(4) Income +
Ko et al., 2020	Seoul, South Korea	WTP for recycling	41,234 KRW (USD 36.96)	(1) Income – (2) Living in apartment -(3) Convenience +(4) Recognition of environmental friendliness recycling + (5) Environmental awareness *ns*

Notes: + indicates a positive effect on WTP, - indicates a negative effect on WTP, *ns* indicates a non-significant effect on WTP.

on the WTP for WMS improvements. Overall, the literature has found that psychological traits significantly predict individuals' intention and WTP for recycling.

Nonetheless, the approaches mentioned above may suffer from endogeneity caused by measurement errors and omitted-variables (Czajkowski et al., 2017a). In addition, these approaches do not allow making predictions because the causes of psychological perceptions and attitudes are not integrated into the modeling exercise. Hybrid choice models have become increasingly popular in the environmental valuation literature to overcome these limitations (Vij and Walker, 2016; Ben-Akiva et al., 2002). Hybrid models measure the latent traits using a multiple indicator and multiple causes approach, which accounts for the presence of measurement errors and allows to assess the impact of observable variables, such as socioeconomics, on the studied latent factors. Despite the technical advantages of hybrid choice models, they have rarely been used in the WMS valuation literature. As far as we know, only Czajkowski et al. (2017b) have used this technique to assess the impact of social pressure and moral views on WMS preferences.

On the other hand, to analyze WMS heterogeneity of preferences, many researchers (e.g., Lee et al., 2014; Massarutto et al., 2019; Nainggolan et al., 2019) have relied on the use of latent class models (LCM). LCM divide the population into latent classes with distinctive preferences; however, though useful, these are disadvantageous in relying too much on the researchers' intuition about the drivers of the observed class heterogeneity (Weller et al., 2020). Thus, the literature has widely highlighted the existence of WMS diversity of preferences, but little has been done to quantify the impact of socioeconomics and other drivers of class heterogeneity on the valuation of WMS's attributes. An exception is Czajkowski et al., 2014 who found that individuals engaging in waste sorting had higher WTP for introducing new waste sorting categories.

Finally, although it is widely acknowledged that individual preferences are firmly attached to the local environment (Benyam et al., 2020), few studies have analyzed how localized and contextual factors impact citizens' valuation of public goods, including WMS. An exception is Cai et al. (2020), who studied the differences in WTP for express packaging recycling among urban and rural residents in three provinces of China. However, a more profound and robust analysis can be done if researchers exploit the regional diversity of their data by analyzing, for instance, how WMS preferences change with the characteristics of the population centers where individuals live.

In conclusion, although the literature has examined individuals' WTP for improved WMS, it has limitations, which we aim to endeavor in this research work. First, previous investigations have not analyzed the mechanisms driving WMS's heterogeneity of preferences across different socioeconomic groups. In this paper, we contribute by uncovering socioeconomics' impact on three WMS attributes and analyzing whether socioeconomics influence WMS preferences through their association with EA or other traits common to the demographic group. Second, previous studies measuring the impact of psychological factors on the WTP for WMS have used methodological approaches that do not explicitly account for endogeneity, thus, undermining the reliability of their results. We contribute by measuring the impact of EA on the WTP for WMS using hybrid choice models, a widely accepted technique for modelling latent variables' impact on WTP estimates. Finally, previous studies rarely analyzed how the local environment influences individuals' utility for WMS. Our research contributes by uncovering the impact of municipal population density and recycling rate on WMS's preferences.

3. Data and experimental design

Our research is built upon a national stated preference survey of Italian households carried out online in April 2020 with the support of a

Table 2
DCM studies evaluating preferences for improvements in the WMS.

Author	Region	Attributes	Description	Mean WTP
Nainggolan et al., 2019	Denmark	(1) Hazardous waste(2) Plastics(3) Bio-waste(4) Time used(5) Recycling rate (6) Frequency	(1) Disposed locally(2) Required to sort(3) Required to sort(4) Minutes(5) Percentage(6) Twice a week, Once a week, Fortnightly	(1) *ns*(2) 551.5 DKK/year (3) −120 DKK/year (4) 17 DKK/ year(5) 9 DKK/ year(6) −133.75 DKK/year Base 458.23 DKK/year
Karousakisa and Birol, 2008	London, United Kingdom	(1) Categories (2) Compost(3) Textiles(4) Frequency	(1) Number of categories(2) Collection of compost(3) Collection of textiles(4) Times per month	(1) 2.48 GBP/ month(2) 6.19 GBP/ month(3) 0.823 GBP/ month(4) 0.25 GBP/ month
Benyam et al., 2020	Queensland, Australia	(1) Frequency (2) Methane reduction(3) Odour(4) Landfill lifespan	(1) Fortnightly over weekly(2) Percentage(3) Moderate over mild(4) Years	NA
Czajkowski et al., 2014	Podkowa Lesna, Poland	(1) Categories (2) Frequency	(1) 1 category 2 categories 3 categories (2) Once every week Once every 2 weeks Once every 4 weeks	(1) Base 16.99 PNL/ month 36.12 PNL/ month(2) 30.01 PNL/ month 22.30 PNL/ month Base
Huynh et al., 2022	Mekong River Delta, Vietnam	(1) Recycle rate (2) CO2 reduction (3) Categories	(1) Percentage (2) Percentage(3) 0 categories Two categories Three categories	(1) 5.09 USD/ month(2) 9.61 USD/ month(3) Base 0.23 USD/ month 0.25 USD/ month
Massarutto et al., 2019	Italy	(1) Collection and frequency (2) Location of disposal(3) Charging methods(4) Recycling rate	(1) Curbside collection every 5 days Curbside collection every 3 days Open-access Street bins(2) Italy Abroad(3) Based on house	(1) −44 EUR/year Base −34 EUR/year (2) 19 EUR/ year Base(3) 23 EUR/ year

Table 2 (*continued*)

Author	Region	Attributes	Description	Mean WTP
			characteristics Based on the waste collected (4) High Medium Low	Base(4) 77 EUR/ year Base −81 EUR /year
Ko et al., 2020		(1) Biodegradable bags(2) Days and Frequency	(1) Biodegradable disposal bags(2) Weekday 1 time per week Weekday 3 times per week Weekend 1 time per week Weekend 2 times per week Always	(1) 350 KRW/ month(2) 194 KRW/ month – 41 KRW/ month 48 KRW/ month 160 KRW/ month
Lee et al., 2017	South Korea	(1) Recyclables sorting(2) Food waste sorting(3) Disposal method (4) Frequency (5) Hygiene	(1) Required to sort(2) Required to sort(3) Designated disposal spot over door-to-door collection (4) Daily collection over the designated day(5) Clean over unclean	NA
Sakata, 2007	Kagoshima, Japan	(1) Categories (2) Recycling rate (3) Charging methods(4) Reduction of dioxin	(1) Number of categories(2) Percentage(3) Flat Free up to 100 waste bags Waste bag(4) Close to 0 New guideline Old guideline	(1) −203.14 yen /year (2) 53.78 yen /year(3) not estimated (4) not estimated

Notes: NA indicates that the study did not estimate a multinomial logit model.

professional market research company specialized in opinion surveys. Because the contract with the market research company contemplated all questionnaires compiled, there is a null non-response rate. We collected 605 questionnaires. After cleaning the data by removing protesters, we analyzed the data of 547 respondents from 272 municipalities.

The survey was developed based on widely-accepted guidelines for discrete choice experiments (Riera et al., 2012; Johnston et al. 2017) and was structured in three parts. In the first section, we collected information on the WMS. In the second section, we described the attributes and levels of the DCM. Subsequently, we presented 12 choice situations. In the final section we collected attitudinal indicators of pro-environmental values and socio-demographic characteristics.

In Italy, WMS is managed at the local level (municipality). In all regions, households pay a municipal waste management tariff (TARI[2]) which comprises fixed costs (determined based on the costs of the service, i.e., investments and depreciations) and variable costs (to finance

[2] In Italian *Tassa sui rifiuti.*

waste transport, collection recycling, and disposal) related to the amount of waste produced. For households, the TARI is calculated based on the surface of the house and the family size. In some municipalities, the quantity of residual waste produced and recycled is also considered. Each municipality sets the TARI with respect to the quantity and quality of waste produced. Thus, municipalities with a higher average TARI tend to have lower recycling rates (Confcommercio, 2020; Lombardi et al., 2021). This was reflected in our data, as a significant negative correlation was found between the municipal recycling rate and the TARI paid[3].

Table 3 portrays the descriptive statistics from the respondents in our sample and from their municipality, including general contextual variables (recycling rate and population density) and attributes of the WMS (TARI paid in 2020, type and frequency of collection), compared with the Italian census data, when applicable. In terms of WMS attributes, the average TARI paid in 2020 by the respondents in our sample was 274€, but the exact amount varied widely across respondents as the standard deviation was 147€. Regarding socioeconomics, our sample was representative of the Italian population, except that it was slightly more educated.

Following a review of the literature and after performing a focus group with participants recruited from the general population, we included four attributes in our choice modeling experiment: additional waste sorting categories, the introduction of textile sorting[4], frequency of collection per week, and costs in the form of a percentage increase in the TARI. It is noteworthy to mention that we informed respondents that the materials to be sorted in the additional categories were to be chosen from cans, cardboard, and transparent glass. A summary of attributes and levels, which were also selected based on the literature and the focus group discussion, is presented in Table 4. Following purely utilitarian views, there is no rationale for individuals to positively evaluate the first two attributes, i.e., additional waste-sorting categories and the introduction of the textile collection, as they both imply for the households an increase in effort, time, and space. Thus, these variables provide a key to understanding how non-utilitarian factors influence the WTP and engagement in recycling. In this investigation, we focused on EA values as the rationale for sorting waste is linked to environmental sustainability targets.

To measure EA, we used the NEP scale (Dunlap et al., 2000). The construct validity of NEP has been widely tested with positive results, making it one of the most popular measures of environmental values and attitudes (Matsiori, 2020). Lately, it has also been used to estimate the impact of pro-environmental attitudes on WTP estimates (see Tylliana-kis and Ferrini (2021), Bartczak (2015), and Faccioli et al. (2020), among others). The revised NEP scale consists of 15 items and uses a 5-point Likert response scale (see table A.1 in the appendix). After performing exploratory factor analysis, item 6 of the revised NEP scale was deleted from our study as it did not provide a significant loading to the latent construct in our sample (see table A.2 in the appendix).

Finally, an efficient design (Rose and Bleimer, 2009) developed with the Ngene software (ChoiceMetrics, 2018) was used to generate the 12 choice situations. The priors were obtained through a pilot survey involving 100 respondents. The design of the pilot was also constructed through an efficient design, using priors from the literature. In addition, although cost levels were presented as a percentage increase of the TARI, we also calculated a family estimate of the value in euros and presented it in the choice cards alongside the percentage increase. An example of a choice card is shown in Fig. 1.

[3] The correlation size was −0.17, the Pearson's product moment correlation coefficient was −4.05.

[4] At the time of the research, in Italy textile materials were to be thrown into undifferentiated waste; they were not recycled. As of January 1, 2022, through legislative decree 116/2020, the obligation to separate textile waste came into effect, put forward by three years the implementation of one of the decrees contained in the "Package of directives on the circular economy" adopted by the European Union in 2018. However, the entire supply chain is still not truly operational and functional.

4. Methodology

Our methodological approach is built upon the use of hybrid choice models, which have gained increasing recognition for assessing the impact of latent variables (LVs) in WTP estimates such as attitudes, perceptions, and values (Walker, 2001). Hybrid models allow researchers to estimate and include LVs in the utility function, and thus to compute their impact on WTP values. In addition, they are considered superior to two-step factor analytical approaches, as they simultaneously estimate the LVs and the coefficients of the utility function, thus avoiding endogeneity biases (Vij and Walker, 2016). Furthermore, the LVs are estimated using a multiple causes and multiple indicators (MIMIC) approach, which allows for uncovering how socioeconomic and other observable variables shape LVs. Therefore, the MIMIC approach generates a valuable framework for making predictions.

Hybrid choice models comprise three components. The first is the discrete choice part, which models individuals' utility based on the random utility theory (Walker, 2001). The second and third are the measurement and structural equations of the MIMIC framework, which models the LVs. Below we explain in detail each of these components in the context of our case study.

4.1. Discrete choice model

Following the random utility theory, the utility that an individual i obtains for the proposed changes on the WMS j and the status quo s in each choice situation k can be modelled as:

$$U_{ijk} = \theta c_{jk} + \beta X_{jk} + \alpha EA_i X_{jk} + \delta S_i X_{jk} + \varepsilon_{ijk} + \epsilon_i \quad (1)$$

$$U_{isk} = \theta c_{sk} + \beta X_{sk} + \alpha EA_i X_{sk} + \delta S_i X_{sk} + \varepsilon_{isk} + \gamma_i$$

Where c_{jk} and c_{sk} are the costs of the proposed improvements in the WMS and of the status, thus θ is the marginal utility of income. X_{jk} and X_{sk} are vectors of the alternatives' attributes (i.e., frequency of collection, the introduction of textile sorting, and additional sorting categories). β is the vector of baseline coefficients of the WMS attributes X. EA_i is the latent variable *environmental awareness* (EA) measured via the NEP scale, thus α is a vector of coefficients measuring EA's impact on the preferences for WMS's attributes X. Similarly, S_i is a vector of socioeconomics and contextual characteristics of the individuals, and δ is a vector of coefficients measuring the impact of demographics and the surroundings on the preferences for X. ε_{isk} are independent but identically distributed (IID) Gumbel error components reflecting all unobservable idiosyncratic factors influencing individual's preferences. Finally, ϵ_i and γ_i are error terms $N(0, \sigma^2_{panel})$ with a twofold function. First, ϵ_i and γ_i capture the correlation effect among observations of the same individual, so-called pseudo-panel effect (Hess et al., 2008; Cantillo et al., 2007). Secondly, ϵ_i and γ_i capture the correlation of the alternatives proposing a change in the WMS $j = (1, 2)$, thus relaxing the assumption of Independence from Irrelevant Alternatives (IIA) (Walker, 2001).

We estimate a random parameters logit in WTP space[5] (Train and Weeks, 2005) to capture unobserved preference heterogeneity. We propose a negative log-normal distribution for the cost coefficient θ $-Lognormal(\mu_\theta, \sigma^2_\theta)$ and a normal distribution for the baseline coefficients β $N(\mu_\beta, \sigma^2_\beta)$, whilst the interaction coefficients (α and δ) are considered constant.

[5] To get estimations in WTP space we multiply equation (1) by the cost coefficient.

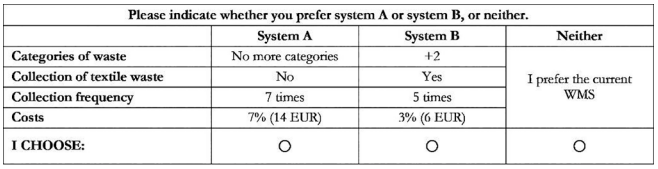
Table 3
Socio-demographic characteristics of respondents compared to the Italian population, WMS attributes, and context-specific variables.

	Variable	Sample range/Categories	Sample distribution			Italian population
			N	Mean	s.d.	Mean
Sociodemographic	Gender	0 if Male	284	0.520		0.482
		1 if Female	263	0.480		0.518
	(Categorical)					
	Age	Age in years. 18 years lower limit, 65 years higher limit		43.40	12.2	
		18–24 years		0.084		0.082
	(continuous)	25–34 years		0.188		0.127
		35–44 years		0.221		0.154
		45–54 years		0.269		0.192
		55–64 years		0.223		0.166
		> 65 years		0.015		0.276
	Bachelor	0 if educational attainment is high-school or lower	323	0.590		0.821
		1 if educational attainment is bachelor's degree or higher	224	0.410		0.179
	(Categorical)					
	Household size	0 if household size is lower than 3 family members	100	0.182		0.58
	(Categorical)	1 if household size is equal or higher than 3 family members	449	0.820		0.41
	Income (Categorical)	0 if annual income after tax is lower than 40,000 EUR	490	0.896		0.923
		1 if annual income after tax is higher or equal to 40,000 EUR	57	0.104		0.077
	Political orientation	0 if center or right	344	0.629		
		1 if left	203	0.371		
	(Categorical)					
WMS attributes	Actual Collection	1 time per week	67	0.122		
	Frequency	2 times per week	121	0.221		
		3 times per week	101	0.185		
	(continuous)	4 times per week	37	0.068		
		5 times per week	66	0.121		
		6 times per week	109	0.199		
		7 times per week	46	0.084		
	Type of Collection	0 if collection type is door-to-door or mixed collection	299	0.547		
		1 if collection type is curbside collection	248	0.453		
	(Categorical)					
	TARI	TARI paid 2020. 30 euros lower limit, 1,000 euros higher limit		274	147	
	(Continuous)					
Context specific variables	Recycling rate	Proportion of waste recycled in 2020 per municipality. 10% lower limit, 87%		56%	17%	
	(continuous)	higher limit (ISPRA, 2020)				
	Population density	1000 habitants per Km^2 in the municipality. 0.1 lower limit, 12.1 higher limit		2.41	2.26	
	(continuous)	(ISTAT, 2022)				

Notes: Source of descriptive statistics for Italian population: Istituto Nazionale di Statistica (2020)

Table 4
Attributes and levels of experiment.

Attribute	Description	Levels
Categories of waste	Number of additional waste sorting categories	***No more categories***
		+***1***: 1 additional category
		+***2***: 2 additional categories
Textile collection	Introduction of textile collection	***Yes***
		No
Collection frequency	Number of times per week the collection of one or more categories of waste is carried out	***3 times***
		5 times
		7 times
Costs	Percentage increase of the annual waste management tariff (TARI)	+ ***3%***: increase by 3%
		+ ***5%***: increase by 5%
		+ ***7%***: increase by 7%
		+ ***10%***:increase by 10%



Please indicate whether you prefer system A or system B, or neither.			
	System A	System B	Neither
Categories of waste	No more categories	+2	I prefer the current WMS
Collection of textile waste	No	Yes	
Collection frequency	7 times	5 times	
Costs	7% (14 EUR)	3% (6 EUR)	
I CHOOSE:	○	○	○

Fig. 1. Example of choice card for respondents that paid a TARI equal to 200 EUR in 2020.

4.2. MIMIC framework: Structural and measurement equations

The latent variable EA is measured following the MIMIC approach, composed of measurement and structural equations. The measurement equations relate the weight that the latent variable EA has in explaining the observable NEP indicators (NEP_{ir}). Specifically, it portrays that each indicator r can be explained by the latent variable EA_i:

$$NEP_{ir} = \gamma_r EA_i + e_{ir} \quad (2)$$

Where γ_r reflects the degree in which the latent variable EA_i explains each of the observable r NEP indicators. e_{ir} is an error term following a normal distribution . As the NEP indicators are measured with a 5-point Likert scale, equation (2) is estimated using an ordered regression.

On the other hand, the structural equation measures the influence of different observable variables, such as socioeconomic characteristics on the latent variable EA:

$$EA_i = \eta S_i + \xi_i \quad (3)$$

Where η is a vector measuring the impact of each observable variable S_i on EA_i, whilst ξ_i is an error term following a normal distribution. Through (3) we can measure the impact of demographics and contextual variables S_i on individual's environmental attitudes. Therefore, to estimate the overall impact of S_i on the preferences for each WMS's attribute X, we need to consider both its direct impact, through δ in (1), and its indirect impact, through η in (3) and α in (1).

Equations 1–3 are estimated using simulated maximum likelihood method (Walker, 2001). We used the package APOLLO in R (Hess and Palma, 2019). One thousand random Halton draws were used in the estimations.

5. Results

To understand the average preferences in our case study, we first estimate random-parameters logit without interaction effects. The results are portrayed in Table 5. In line with previous investigations (i.e., Czajkowski et al., 2014; Massarutto et al., 2019; Benyam et al., 2020), a higher frequency of waste collection is positively valuated by respondents. In our case, individuals are, on average, willing to pay 1.08€ to increase the weekly collection frequency by one day. Our results also show that respondents have an average WTP of 3.68€ and 3.77€ to increase, respectively, by one and two the number of sorting categories. In addition, the introduction of the textile collection is the attribute that individuals, on average, value the most, with a WTP of 6.54€. The positive valuation of extra waste-sorting categories and textile collection supports the thesis that non-utilitarian factors play a key role in explaining WTP estimates for WMS improvements. On the other hand, our results show that, on average, respondents hold lower preferences from the status quo, potentially signaling dissatisfaction with the current WMS.

Concerning preference heterogeneity, the high unobserved heterogeneity of textile sorting and collection frequency is noteworthy, with a standard deviation of 7.77€ and 3.58€, respectively. In contrast, the standard deviation of the addition of one or two sorting categories is lower and less significant. Interestingly, the attribute that was absent in the Italian WMS when the survey was collected, i.e., textile collection, had the highest preference heterogeneity. We believe that the reason behind this might be the lack of experience of individuals toward this attribute, causing skepticism or over-excitement about its environmental benefits and feasibility.

Although the results in Table 5 display the overall picture of WMS's preferences, they do not address the cause of the heterogeneity of preferences for WMS's attributes, nor to what extent context-specific and socioeconomic variables influence WTP estimates. For this purpose, we estimated a hybrid random-parameters logit with interaction effects (see equations 1–3). Results for the discrete choice component are portrayed in Table 6, and for the MIMIC component in Table 7. The description of the covariates can be found in Table 3. It is worth mentioning that the covariates *Population density* and *Recycling rate* were centered at zero to avoid any spurious impact on the alternative specific constant.

Table 5
Random parameters logit results in WTP space.

Attribute	Mean coefficients	Standard deviations
ASC status quo	−3.34***	3.85***
	(0.63)	(0.14)
+1 category	3.68***	0.59
	(0.52)	(0.37)
+2 category	3.77***	1.36**
	(0.51)	(0.55)
Textile collection	6.54***	7.77***
	(0.49)	(0.68)
Frequency	1.08***	3.58***
	(0.16)	(0.27)
Costs	−2.43***	1.60***
	(0.15)	(0.08)
Pseudo-panel		3.17***
		(0.2)
Number of individuals	547	
Number of observations	6564	
Log-likelihood	−4,642.46	
AIC	9310.93	
BIC	9399.19	
McFadden's R2	0.34	

Notes: Standard deviations in parenthesis
** and *** indicate significance levels at 5% and 1%, respectively

Table 6 shows that EA, as measured with the NEP scale, is a significant and important predictor of WMS preferences. The marginal impact of EA on the WTP for 1 and 2 additional categories are 0.8€ and 1.5€, respectively. On the other hand, textile sorting is the attribute that high EA individuals value the most, with a marginal WTP of 2.43€. Finally, the WTP for increasing waste collection frequency also increases with EA values, with a marginal WTP of 0.45€. From these results, we conclude that individuals with higher EA have a significantly higher WTP for improvements in the WMS; particularly, stronger EA leads to higher preferences for increasing the number of waste sorting categories, introducing textile collection, and increasing the frequency of collection, all of which are associated with improved recycling rates. Our results also suggest that increasing EA can constitute an effective policy mechanism to increase the acceptability of introducing new sorting categories in the WMS.

We now turn to Table 7 to understand the impact of demographics on EA values. Curbside collection was not included as a predictor of EA because, theoretically there should not be a link between this covariate and EA. Consistent with the literature (Dunlap et al., 2000), we found significant evidence suggesting that female and political left-wing individuals have higher EA. In addition, in our case study, older and higher-income individuals also have higher EA values. Our results further suggest that individuals living in high recycling rate municipalities develop higher EA values. We recognize that there may be simultaneity in the causality of this relationship as individuals with higher EA values may also tend to recycle more. Nevertheless, as we use municipality data, we can assume that this variable is exogenous to the individual. In contrast, although not significant, individuals living in high population density cities with a household size equal to or bigger than 3 have higher EA values. Finally, an unexpected, though not significant, result emerges from the negative correlation of a bachelor's degree in the construct EA.

We turn back to the discrete choice estimates (Table 6) to understand the impact of socio-demographics and environmental (context-specific) variables on WTP estimates. In doing so, it is important to bear in mind that these variables have a two-way impact on preferences: 1) There is an indirect impact through their influence on EA values, and 2) there is a direct impact capturing other traits specific to the demographic group. The total or net impact of socioeconomics on WMS preferences is calculated by summing the direct and indirect impacts. The direct, indirect, and total impacts are portrayed in table A.3 of the Appendix. In general, we find that the indirect impact of demographics on WMS preferences is lower than their direct impact. Therefore, our results show that, in most cases, the influence of socio-demographic characteristics on WMS preferences through EA values is low when compared to other traits specific to the group. This result is in line with Pienaar et al. (2013), who found that the relationship between socio-demographics and environmental values, measured by the NEP scale, is weak.

We find strong evidence suggesting that socio-demographics and context-specific variables shape individuals' preferences for WMS attributes. We find that women and older individuals are less eager to increase household waste sorting categories. Focusing on direct estimates (Table 6 coefficients), we find that women's WTP for increasing the number of sorting categories by one and two is, respectively, 3.26€ and 1.54€ lower than their counterparts. In addition, a one-year increase in age decreases the WTP for two extra sorting categories by 0.14€, whilst no significant relationship was found between age and one

Table 6
Discrete choice estimates of hybrid mixed logit results in WTP space with all interactions.

Attributes	Means	Standard deviations	Interactions									
			LV	Socioeconomic demographics						Local contexts		
			NEP	Female	Household size	Age	Bachelor	Political left	High Income	Population density	Recycling rate	Curbside collection
ASC status quo	10.18***	1.78**	−0.22	−3.87***	1.66	−0.10*	−5.19***	0.19	1.44	0.02	0.01	−5.21***
	(3.39)	(0.69)	(0.67)	(1.27)	(1.49)	(0.06)	(1.21)	(1.02)	(1.60)	(0.29)	(0.06)	(1.07)
+1 category	5.07	0.82***	0.80**	−3.26***	3.02**	−0.03	−2.3**	1.96	1.01	0.39	−0.03	−1.52*
	(3.32)	(0.20)	(0.39)	(0.95)	(1.19)	(0.06)	(1.06)	(1.20)	(1.18)	(0.24)	(0.03)	(0.79)
+2 category	9.12***	2.92***	1.50***	−1.45*	1.71	−0.14**	−3.36***	0.65	2.25*	0.22	0.01	−1.62*
	(3.2)	(0.68)	(0.50)	(0.88)	(1.28)	(0.05)	(1.17)	(1.06)	(1.32)	(0.25)	(0.04)	(0.9)
Textile collection	10.81***	5.79***	2.43***	−0.99	−1.45*	0.03	−5.16***	−1.59**	−0.51	0.41**	−0.08**	−3.30***
	(2.52)	(0.49)	(0.30)	(1.02)	(0.83)	(0.04)	(0.89)	(0.66)	(1.2)	(0.18)	(0.04)	(0.81)
Frequency	−0.51	2.24***	0.45***	0.08	0.01	0.01	−0.07	1.08***	1.01***	−0.27***	−0.02***	0.01
	(0.66)	(0.28)	(0.11)	(0.26)	(0.01)	(0.01)	(0.27)	(0.17)	(0.38)	(0.04)	(0.01)	(0.20)
Costs	−2.71***	1.81***										
	(0.14)	(0.14)										
Pseudo-panel		3.41***										
		(0.24)										
Number of individuals	547											
Number of observations	6564											
Log-likelihood (Whole model)	−13260.55											
Log-likelihood (Choice component)	−4608.97											
McFadden's R2 (Choice component)	0.35											

Notes: Standard deviations in parenthesis
*, ** and *** indicate significance levels at 10%, 5% and 1%, respectively
Recycling rate and population density were centered at zero

Table 7
MIMIC coefficients of hybrid mixed logit results in WTP space with all interactions.

Measurement equations		Structural equations	
NEP 1	0.43***	Female	0.22***
	(0.10)		(0.10)
NEP 2 (r)	1.44***	Age	0.02***
	(0.13)		(0.00)
NEP 3	1.92***	Recycling rate	0.01*
	(0.20)		(0.00)
NEP 4 (r)	0.38***	Population density	0.03
	(0.10)		(0.02)
NEP 5	3.01***	Household size	0.16
	(0.33)		(0.13)
NEP 7	1.71***	Bachelor	−0.10
	(0.16)		(0.09)
NEP 8 (r)	1.60***	High Income	0.34**
	(0.15)		(0.17)
NEP 9	1.08***	Political orientation	0.45***
	(0.13)		(0.09)
NEP 10 (r)	1.29***		
	(0.13)		
NEP 11	0.91***		
	(0.12)		
NEP 12 (r)	1.61***		
	(0.15)		
NEP 13	1.88***		
	(0.19)		
NEP 14 (r)	1.21***		
	(0.13)		
NEP 15	2.93***		
	(0.31)		

Notes: Standard deviation in parenthesis.
*, ** and *** indicate significance levels at 10%, 5% and 1%, respectively.
(r) indicates that the scale has been reversed.

additional category. Nonetheless, it is important to note that these population segments also report higher EA values; thus, their indirect impact on waste sorting categories goes in the opposite direction. Moreover, the indirect impact of gender and age on WMS preferences through EA is significantly lower than its direct impact. Indeed, females' positive indirect impact on the WTP for one and two additional sorting categories is only 0.18€ and 0.33€, respectively, while the positive indirect impact of age on the WTP for two additional categories is only 0.03€.

Families with three or more members and high-income households also have higher WTP for increasing waste sorting categories. These population segments also tend to have higher EA, thus their direct impact on WMS is reinforced by their indirect impact through EA. Particularly, individuals with an income higher than 40,000€ evaluate the addition of one and two sorting categories 1.01€ and 2.25€ more than their counterparts, respectively, but if we account for its indirect impact, this estimation increases to 1.28€ and 2.76€. On the other hand, families of three members or more are willing to pay 3.02€ more to introduce one additional sorting category. This estimation increases to 3.15€ if we acknowledge family size's positive impact on EA.

Our results also demonstrate that textile collection is less valued by bigger households and individuals from left-wing parties. Focusing on direct estimates (Table 6), left-wing individuals and families with three members or more report a WTP for introducing textile collection that is, respectively, 1.59€ and 1.45€ lower than their counterparts. However, these individuals also report higher EA values; thus, belonging to a left-wing party and a bigger household also positively increases WTP for textile collection through its indirect influence on EA. In fact, for left-wing individuals, the positive indirect impact on WTP for textile collection is 1.09€, almost as high as its negative direct impact.

An unexpected result arises from the lower WTP estimates of extra sorting categories and textile introduction from individuals with a bachelor's degree compared to their counterparts. Indeed, our results suggest that those having a bachelor's degree are willing to pay 2.3€, 3.36€, and 5.16€ less for introducing one and two additional sorting categories and textile collection, respectively. Nevertheless, despite having an overall lower WTP for WMS attributes, individuals with a university degree have a higher WTP to change from the status quo situation.

On the other hand, turning to the frequency of collection, we find that high-income and left-wing individuals, who also report higher EA values, have higher preferences for this attribute. Indeed, left-wing and high-income individuals are willing to pay 1.08€ and 1.01€ more than their counterparts to increase the frequency of collection by one day, respectively. These estimates increase to 1.28€ for left-wing individuals and 1.16€ for high-income individuals if their influence through EA is acknowledged.

Turning to the local context variables *Curbside collection*, *Population density* and *Recycling rate,* we find that they have an important influence in shaping preferences for WMS improvements. In particular, individuals with a curbside collection scheme are less willingness to increase their waste sorting categories compared to those with a door-to-door collection scheme. In particular, individuals practicing curbside collection are willing to pay 1.52€ and 1.62€ less for introducing one and two additional sorting categories, respectively. In addition, those with a curbside collection report a WTP for textile collection of 3.30€ lower. On the other hand, having a curbside collection scheme increases the willingness to change the WMS, as they report lower preferences for the status quo.

Population density and recycling rate are significant predictors of preferences for textile collection and frequency of collection, partly explaining the significant heterogeneity of these attributes (measured by the standard deviation). First, we find that an increase of 1% in the recycling rate and by 1000 habitants per Km^2 in the population density decreases the WTP for a more frequent WMS by 0.02€ and 0.27€, respectively. Second, our results show that individuals living in more densely populated areas and with lower recycling rates have higher WTP for the introduction of textile sorting. A decrease in the recycling rate by 1% and an increase in population density by 1000 habitants per Km^2 increases the WTP for textile collection by 0.08€ and 0.41€, respectively.

Finally, we find the standard deviation of our baseline estimates slightly decreases, portraying that some of the heterogeneity of preferences is captured by the analysis of covariates, namely, values, socioeconomics, and the local context.

6. Discussion

Our study highlights the importance of non-utilitarian factors, socioeconomics, and local contexts in shaping citizens' preferences for WMS, thus supporting previous research on what motivates recycling behavior (Massarutto et al., 2019; Czajkowski et al., 2019). Nevertheless, by analyzing how the local environment and EA shape individuals' willingness to cooperate for an improved WMS, our research marks a departure from the current stream of literature.

We found a significant impact of context-specific variables (curbside collection, recycling rate, and population density rate) on individuals' WTP for WMS attributes, highlighting the importance of experiences and local context in shaping preferences. First, we found that individuals

with a curbside collection scheme value less the introduction of extra-sorting categories and textile collection than those with a door-to-door collection scheme. In a curbside scheme, the collection point is further away from the household, thus the introduction of more categories involves extra effort. Therefore, the collection scheme and the number of waste-sorting categories should be assessed jointly on WMS designs, as they interact together to shape individuals' utility.

In addition, we found that individuals practicing curbside collection have a higher willingness to change the WMS with respect to the status quo, probably signaling dissatisfaction with the current service. This is in line with the findings of a behavioral survey conducted by Calabrò and Komilis (2020) in the city of Reggio Calabria (Italy). The authors found that individuals practicing curbside separation had a lower recycling conscience and satisfaction with the WMS. Another example is Afroz et al., 2009 who found that, in Dhaka (Bangladesh), individuals with a door-to-door waste collection system had higher WTP for improving the WMS as they were, on average, more satisfied with the service provided than their counterparts were. In addition, the increase in recycling rates achieved during the last decade in Italy has been frequently attributed to the introduction of a door-to-door collection scheme (Lombardi et al., 2021, Botti et al., 2020). Thus, shifting to a door-to-door collection scheme can be an effective mechanism to increase citizens' satisfaction and willingness to contribute to waste sorting and improve the quality and quantity of the collected waste. In addition, since individuals with a door-to-door scheme report higher WTP estimates, an increase in taxes could be leveraged to finance the operational cost related to this shift without affecting citizens' wellbeing.

Another relevant finding arises from the interaction of the recycling rate with WMS attributes. We found that individuals living in low recycling rate municipalities have higher WTP for increasing the frequency of waste collection. Thus, our results suggest that individuals in municipalities exhibiting low-efficiency levels perceive that the frequency of collection should be increased to provide a better service. Therefore, municipalities displaying low recycling rates should focus on improving the frequency of waste collection. In addition, our results suggest that textile collection is more valuated by individuals living in low-recycling municipalities. The higher WTP of citizens living in low-recycling municipalities evidences their willingness to cooperate to improve the quality of the WMS and increase recycling rates.

Another interesting result arises from the impact of population density on the WTP for WMS attributes. Specifically, we found that individuals living in municipalities with low population density prefer a more frequent collection system. This is coherent with the literature, which evidences that individuals living in rural areas have higher nature-relatedness values (Bashan et al., 2021) and, thus, higher preferences for sustaining their local environment cleaner. In addition, for individuals living in highly populated cities, a too frequent waste collection system may be burdensome to the extent that it could worsen traffic congestion (Karousakis and Birol, 2008). Thus, policy-makers should acknowledge the characteristics of the local environment when designing waste collection operational frequency, as individuals' preferences for this attribute widely change across contexts, with individuals living in smaller cities preferring a more frequent collection.

In contrast, our results also report that the introduction of textile collection, an attribute that was not present in the Italian WMS when the study was conducted, is more valuated by citizens living in more densely populated municipalities. As the introduction of textile collection in Italy would constitute an innovative WMS policy, our results are consistent with the evidence reporting that individuals living in more populated cities have a higher willingness to implement transformative and novel policies and ideas (Florida et al., 2017; Kunkel et al., 2022). Thus, the introduction of textile sorting should be accompanied by informational and educational campaigns focused on rural residents to enhance textile collection support.

We also evaluate how socioeconomics influences WMS preferences by analyzing the magnitude and direction of its indirect impact through its influence on environmental values, its direct impact, and other demographic-specific characteristics. We found that socioeconomics is a relevant predictor of WTP for WMS attributes, as previously documented in the literature (Romano et al., 2022). Moreover, we found that its indirect impact through environmental values is low compared to its direct impact, which captures other demographic-specific traits influencing decisions. Further investigation is needed to uncover how socioeconomics influences WMS preference directly.

Finally, we found that EA is a significant predictor of WTP estimates, highlighting the importance of non-utilitarian factors in determining individuals' willingness to recycle and contribute to an improved WMS. Particularly, higher EA increased the WTP for introducing additional sorting categories and textile collection, attributes which would lead to a higher quality of waste separation and enhanced environmental benefits. Thus, to increase waste sorting cooperation and support, policy-makers should construct public campaigns aimed at increasing awareness of environmental benefits. Higher environmental awareness will lead to higher support of households for an improved WMS and, thus, increase overall wellbeing through a higher recycling rate and satisfaction with the system.

7. Conclusion

Using Italy as a case study, we examined citizens' preferences for an improved WMS. Overall, we found that individuals positively evaluate WMS improvements, including an increase in waste-sorting categories, a more frequent waste collection, and the introduction of textile recycling. This shows citizens' enthusiasm to cooperate to provide a more efficient and sustainable WMS. In addition, the positive WTP for introducing additional sorting categories can be exploited by policy-makers to increase tax-revenues and reduce the costs associated with separating waste in central facilities. The national government can then use these revenues to invest in recycling facilities in municipalities exhibiting low recycling rates.

We have also analyzed how local contexts, environmental awareness, and demographics shape individuals' preferences. We found that environmental awareness increases WTP for an improved WMS. From a public policy perspective, these factors could be exploited to favor a pro-environmental behavior rather than relying only on economic incentives or bans. For example, environmental education campaigns may be an effective policy to increase WMS cooperation.

In addition, we have uncovered how local contexts influence WMS preferences, highlighting the importance of context-specific WMS designs. Notably, we found that the preferences for the attributes frequency of collection and textile sorting are highly dependent on the characteristics of where individuals live, particularly population density and municipal recycling rate. In addition, our results support the literature evidencing the benefits of introducing a door-to-door collection scheme, as citizens practicing this scheme report higher WTP for waste sorting.

Finally, we have found that socioeconomic variables have a significant impact on WMS preferences. These variables exert both an indirect impact, which emerges through the impact of demographics on environmental values, and a direct impact, which reflects other specific traits influencing decisions. Our results show that the direct impacts are generally higher than the indirect ones, pointing out that socioeconomics affect WMS preferences through specific traits not captured by environmental values. Future research could analyze the means by which demographics influence WTP for WMS.

Overall, this research provides interesting results that policymakers can consider in Italy in organizing better regional WMS systems and incentivizing citizens to increase the recycling rate. It shows how citizen preferences for WMS depend on the local context and socio-economic variables, but non-utilitarian factors emerged as crucial factors in forming WMS preferences. This information is crucial for policy makers

in implementing effective incentives, not only in the Italian context but also in other different countries. It says that incentives in each country need to be adapted to the specific local context, socio-economic situation, and emerging non-utilitarian factors. For example, it is crucial to identify which specific educational campaign will effectively increase the recycling rate in developed and developing countries.

CRediT authorship contribution statement

Tatiana Cantillo: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Sandra Notaro:** Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization, Supervision, Funding acquisition. **Nicolao Bonini:** Writing – review & editing, Funding acquisition. **Constantinos Hadjichristidis:** Writing – review & editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.wasman.2023.03.014.

References

Afroz, R., Hanaki, K., Hasegawa-Kurisu, K., 2009. Willingness to pay for waste management improvement in Dhaka city, Bangladesh. J. Environ. Manage. 90 (1), 492–503. https://doi.org/10.1016/j.jenvman.2007.12.012.

Agovino, M., Cerciello, M., Musella, G., 2019. The effects of neighbour influence and cultural consumption on separate waste collection. Theoretical framework and empirical investigation. Ecol. Econ. 166 https://doi.org/10.1016/j.ecolecon.2019.106440.

Aprile, M.C., Fiorillo, D., 2019. Intrinsic incentives in household waste recycling: The case of Italy in the year 1998. J. Clean. Prod. 227, 98–110. https://doi.org/10.1016/j.jclepro.2019.04.184.

Bashan, D., Colléony, A., Shwartz, A., 2021. Urban versus rural? The effects of residential status on species identification skills and connection to nature. People and Nature. 3, 347–358. https://doi.org/10.1002/pan3.10176.

Bartczak, A., 2015. The role of social and environmental attitudes in non-market valuation: An application to the Białowieża Forest. Forest Policy and Economics. 50, 357–365. https://doi.org/10.1016/j.forpol.2014.09.011.

Ben-Akiva, M., McFadden, D., Train, K., Walker, J., Bhat, C., Bierlaire, M., Bolduc, D., Boersch-Supan, A., Brownstone, D., Bunch, D.S., Daly, A., De Palma, A., Gopinath, D., Karlstrom, A., Munizaga, M.A., 2002. Hybrid Choice Models: Progress and Challenges. Mark. Lett. 13 (3), 163–175. http://www.jstor.org/stable/40216632.

Benyam, A., Rolfe, J., Kinnear, S., 2020. Willingness to pay for a domestic food waste diversion policy option in regional Queensland, Australia. J. Clean. Prod. 270 https://doi.org/10.1016/j.jclepro.2020.122485.

Berglund, C., 2006. The assessment of households' recycling costs: The role of personal motives. Ecol. Econ. 56 (4), 560–569. https://doi.org/10.1016/j.ecolecon.2005.03.005.

Blaine, T.W., Lichtkoppler, F.R., Jones, K.R., Zondag, R.H., 2005. An assessment of household willingness to pay for curbside recycling: A comparison of payment card and referendum approaches. J. Environ. Manage. 76 (1), 15–22. https://doi.org/10.1016/j.jenvman.2005.01.004.

Botti, L., Battini, D., Sgarbossa, F., Mora, C., 2020. Door-to-door waste collection: Analysis and recommendations for improving ergonomics in an Italian case study. Waste Manag. 109, 149–160. https://doi.org/10.1016/j.wasman.2020.04.027.

Cai, K., Xie, Y., Song, Q., Sheng, N., Wen, Z., 2021. Identifying the status and differences between urban and rural residents' behaviors and attitudes toward express packaging waste management in Guangdong Province, China. Sci. Total Environ. 797, 148996 https://doi.org/10.1016/j.scitotenv.2021.148996.

Camana, D., Manzardo, A., Toniolo, S., Gallo, F., Scipioni, A., 2021. Assessing environmental sustainability of local waste management policies in Italy from a circular economy perspective. An overview of existing tools. Sustain. Prod. Consumpt. 27, 613–629. https://doi.org/10.1016/j.spc.2021.01.029.

Cantillo, V., Ortuzar, J.D.D., Williams, H.C., 2007. Modeling discrete choices in the presence of inertia and serial correlation. Transp. Sci. 41 (2), 195–205. https://doi.org/10.1287/trsc.1060.0178.

Cecere, G., Mancinelli, S., Mazzanti, M., 2014. Waste prevention and social preferences: the role of intrinsic and extrinsic motivations. Ecol. Econ. 107, 163–176. https://doi.org/10.1016/j.ecolecon.2014.07.007.

Cerqueti, R., Cinelli, M, Minervini, L.F., 2021. Municipal waste management: A complex network approach with an application to Italy. Waste Managment. 1 (26), pp:597-607. https://doi.org/10.1016/j.wasman.2021.03.035.

Chakraborty, S.K., Mazzanti, M., Mazzarano, M., 2022. Municipal Solid Waste generation dynamics. Breaks and thresholds analysis in the Italian context. Waste Manag. 144, 468–478. https://doi.org/10.1016/j.wasman.2022.04.022.

ChoiceMetrics, 2018. Ngene 1.2. User Manual & Reference guide. Available at: http://www.choice-metrics.com/NgeneManual120.pdf.

Confcommercio, 2020. TARI, INFORMAZIONI UTILI SULLA TASSA SUI RIFIUTI. Available at: https://www.confcommercio.it/-/tari-tassa-sui-rifiuti.

Czajkowski, M., Kądziela, T., Hanley, N., 2014. We want to sort! Assessing households' preferences for sorting waste. Resour. Energy Econ. 36 (1), 290–306. https://doi.org/10.1016/j.reseneeco.2013.05.006.

Czajkowski, M., Vossler, C.A., Budziński, W., Wiśniewska, A., Zawojska, E., 2017a. Addressing empirical challenges related to the incentive compatibility of stated preference methods. J. Econ. Behavior Organization. 142, 47–63. https://doi.org/10.1016/j.jebo.2017.07.023.

Czajkowski, M., Hanley, N., Nyborg, K., 2017b. Social Norms, Morals and Self-interest as Determinants of Pro-environment Behaviours: The Case of Household Recycling. Environ. Resour. Econ. 66, 647–670. https://doi.org/10.1007/s10640-015-9964-3.

Czajkowski, M., Zagórska, K., Hanley, N., 2019. Social norm nudging and preferences for household recycling. Resour. Energy Econ. 58 (C) https://doi.org/10.1016/j.reseneeco.2019.07.004.

D'Amato, A., Mancinelli, S., Zoli, M., 2016. Complementarity vs. substitutability in waste management behaviors. Ecol. Econ. 123, 84–94. https://doi.org/10.1016/j.ecolecon.2015.12.005.

Degli Antoni, G., Vittucci Marzetti, G., 2019. Recycling and Waste Generation: An Estimate of the Source Reduction Effect of Recycling Programs. Ecol. Econ. 161, 321–329. https://doi.org/10.1016/j.ecolecon.2019.04.002.

Di Foggia, G., Beccarello, M., 2021. Designing waste management systems to meet circular economy goals: The Italian case. Sustain. Prod. Consumpt. 26, 1074–1083. https://doi.org/10.1016/j.spc.2021.01.002.

Dunlap, R.E., Liere Primen, D.V., Mertig, A.G., Jones, R.E., 2000. Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale. J. Soc. Issues 56 (3), 425–442.

Faccioli, M., Czajkowski, M., Glenk, K., Martin-Ortega, J., 2020. Environmental attitudes and place identity as determinants of preferences for ecosystem services. Ecol. Econ. 174 https://doi.org/10.1016/j.ecolecon.2020.106600.

Ferreira, S., Cunha Marques, R., 2015. Contingent valuation method applied to waste management. Resour. Conserv. Recycl. 99, 111–117. https://doi.org/10.1016/j.resconrec.2015.02.013.

Florida, R., Adler, P., Mellander, C., 2017. The city as innovation machine. Regional Studies. 51(1), pp. 86-96. https://10.1080/00343404.2016.1255324.

Gilli, M., Nicolli, F., Farinelli, P., 2018. Behavioural attitudes towards waste prevention and recycling. Ecol. Econ. 154, pp. 294-305.https://doi.org/10.1016/j.ecolecon.2018.08.009.

Hess, S., Rose, J.M., Hensher, D.A., 2008. Asymmetric preference formation in willingness to pay estimates in discrete choice models. Transp. Res. E 44, 847–863.

Hess, S., Palma, D., 2019. Apollo: a flexible, powerful and customisable freeware package for choice model estimation and application. J. Choice Model. 32, 100170.

Huhtala, A., 2010. Income effects and the inconvenience of private provision of public goods for bads: The case of recycling in Finland. Ecol. Econ. 69 (8), 1675–1681. https://doi.org/10.1016/j.ecolecon.2010.03.018.

Huynh, X.T.D., Khong, T.D., Loch, A., Khai, H.V., 2022. Solid waste management program in developing countries: contingent valuation methodology versus choice experiment. Environ. Dev. Sustain. https://doi.org/10.1007/s10668-022-02572-4.

Ispra, 2020. Dati comunali di produzione e raccolta differenziata. Available at: https://www.catasto-rifiuti.isprambiente.it/index.php?pg=downloadComune.

Istat, 2022. PRINCIPALI STATISTICHE GEOGRAFICHE SUI COMUNI. Available at: https://www.istat.it/it/archivio/156224.

Jacobsen, L.F., Pedersen, S., Thøgersen, J., 2022. Drivers of and barriers to consumers' plastic packaging waste avoidance and recycling – A systematic literature review. Waste Manag. 141, 63–78. https://doi.org/10.1016/j.wasman.2022.01.021.

Johnston, R.J., Boyle, K.J., Adamowicz, W.V., Bennett, J., Brouwer, R., Cameron, T.A., Hanemann, W.M., Hanley, N., Ryan, M., Scarpa, R., Tourangeau, R., Vossler, C.A., 2017. Contemporary Guidance for Stated Preference Studies. J. Assoc. Environ. Resour. Econ. 4 (2), 319–405.

Karousakis, K., Birol, E., 2008. Investigating household preferences for kerbside recycling services in London: A choice experiment approach. J. Environ. Manage. 88 (4), 1099–1108. https://doi.org/10.1016/j.jenvman.2007.05.015.

Kayamo, S., 2022. Willingness to pay for solid waste management improvement in Hawassa city, Ethiopia. J. Environ. Manage. 302 (A) https://doi.org/10.1016/j.jenvman.2021.113973.

Ke, J., Cai, K., Yuan, W., Li, L., Song, Q., 2022. Promoting solid waste management and disposal through contingent valuation method: A review. J. Clean. Prod. 379 (1), 134696 https://doi.org/10.1016/j.jclepro.2022.134696.

Ko, S., Kim, W., Shin, S., Shin, J., 2020. The economic value of sustainable recycling and waste management policies: The case of a waste management crisis in South Korea. Waste Manag. 104, 220–227. https://doi.org/10.1016/j.wasman.2020.01.020.

Kotchen, M., Kallaos, J., Wheeler, K., Wong, C., Zahller, M., 2009. Pharmaceuticals in wastewater: behavior, preferences, and willingness to pay for a disposal program. J. Environ. Manage. 90 (3), 1476–1482. https://doi.org/10.1016/j.jenvman.2008.10.002. Epub 2008 Nov 25 PMID: 19028416.

Kunkel, L.C., Breetz, H.L., Abbott, J.K., 2022. 100% renewable electricity policies in U.S. cities: A mixed methods analysis of adoption and implementation. Energy Policy 167, 113053. https://doi.org/10.1016/j.enpol.2022.113053.

Lee, M., Choi, H., Koo, Y., 2017. Inconvenience cost of waste disposal behavior in South Korea. Ecol. Econ. 140, 58–65. https://doi.org/10.1016/j.ecolecon.2017.04.031.

Lombardi, G.V., Gastaldi, M., Rapposelli, A., Romano, G., 2021. Assessing efficiency of urban waste services and the role of tariff in a circular economy perspective: An empirical application for Italian municipalities. J. Clean. Prod. 323, 129097 https://doi.org/10.1016/j.jclepro.2021.129097.

Massarutto, A., Marangon, F., Troiano, S., Favot, M., 2019. Moral duty, warm glow or self-interest? A choice experiment study on motivations for domestic garbage sorting in Italy. J. Clean. Prod. 208, 916–923. https://doi.org/10.1016/j.jclepro.2018.10.140.

Matsiori, S.K., 2020. Application of the New Environmental Paradigm to Greece: A critical case study. Economic Analysis and Policy. 66, 335–344. https://doi.org/10.1016/j.eap.2020.02.010.

Nainggolan, D., Branth Pedersen, A., Smed, S., Haile Zemo, K., Hasler, B., Termansen, M., 2019. Consumers in a Circular Economy: Economic Analysis of Household Waste Sorting Behaviour. Ecol. Econ. 166 https://doi.org/10.1016/j.ecolecon.2019.106402.

Pienaar, EF., Lew, DK., Wallmo, K., 2013. Are environmental attitudes influenced by survey context? An investigation of the context dependency of the New Ecological Paradigm (NEP) Scale. Social Science Research. 2013. 42(6), pp. 1542-54. https://doi.org/10.1016/j.ssresearch.2013.07.001.

Riera, P., Signorello, G., Thiene, M., Mahieu, P.A., Navrud, S., Kaval, P., Rulleau, B., Mavsar, R., Madureira, L., Meyerhoff, J., Elsasser, P., Notaro, S., De Salvo, M., Giergiczny, M., Dragoi, S., 2012. Non-market valuation of forest goods and services: Good practice guidelines. J. For. Econ. 18, 259–270. https://doi.org/10.1016/j.jfe.2012.07.001.

Romano, G., Virginia Lombardi, G., Rapposelli, A., Gastaldi, M., 2022. The factors affecting Italian provinces' separate waste-collection rates: An empirical investigation. Waste Manag. 139, 217–226. https://doi.org/10.1016/j.wasman.2021.12.037.

Rose, J.M., Bleimer, M.C.J., 2009. Constructing Efficient Stated Choice Experimental Designs. Transp. Rev. 29 (5) https://doi.org/10.1080/01441640902827623.

Sakata, Y., 2007. A choice experiment of the residential preference of waste management services – The example of Kagoshima city, Japan. Waste Manage. 27 (5), 639–644. https://doi.org/10.1016/j.wasman.2006.03.007.

Song, Q., Wang, Z., Li, J., 2012. Residents' behaviors, attitudes, and willingness to pay for recycling e-waste in Macau. J. Environ. Manage. 106, 8–16. https://doi.org/10.1016/j.jenvman.2012.03.036.

Song, Q., Zhao, S., Lam, I., Zhu, L., Yuan, W., Wang, C., 2019. Understanding residents and enterprises' perceptions, behaviors, and their willing to pay for resources recycling in Macau. Waste Manag. 95, 129–138. https://doi.org/10.1016/j.wasman.2019.06.009.

Train, K., Weeks, M., 2005. Discrete Choice Models in Preference Space and Willingness-to-Pay Space. In: Scarpa, R., Alberini, A. (Eds.), Applications of Simulation Methods in Environmental and Resource Economics. The Economics of Non-Market Goods and Resources, vol 6. Springer, Dordrecht. https://doi.org/10.1007/1-4020-3684-1_1.

Tyllianakis, E., Ferrini, S., 2021. Personal attitudes and beliefs and willingness to pay to reduce marine plastic pollution in Indonesia. Mar. Pollut. Bull. 173 (B), 113120 https://doi.org/10.1016/j.marpolbul.2021.113120.

Vassanadumrongdee, S., Kittipongvises, S., 2018. Factors influencing source separation intention and willingness to pay for improving waste management in Bangkok, Thailand. Sustainable Environ. Res. 28 (2), 90–99. https://doi.org/10.1016/j.serj.2017.11.003.

Vij, A., Walker, J.L., 2016. How, when and why integrated choice and latent variable models are latently useful. Transp. Res. B Methodol. 90, 192–217. https://doi.org/10.1016/j.trb.2016.04.021.

Walker, J.L., 2001. Extended Discrete Choice Models: Integrated Framework, Flexible Error Structures, and Latent Variables [Doctoral dissertation, MIT]. MIT Research Repository. https://dspace.mit.edu/handle/1721.1/32704.

Weller, B., Bowen, N., J. Faubert, S., 2020. Latent Class Analysis: A Guide to Best Practice. Journal of Black Psychology. 46(4), pp.287-311. https://doi.org/10.1177/0095798420930932.